BREAKTHROUGH INSTITUTE

NUCLEAR COGNITION

Public attitudes, elite opinion, and the next generation of nuclear energy communications

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EXECUTIVE SUMMARY

Nuclear energy is perhaps the most controversial technology ever created. Since the initial commercialization of nuclear reactors in the late 1950s, the technology has been broadly misunderstood by the public, while public opinion has been broadly misunderstood by elites.

Members of the public are apt to conflate nuclear energy with nuclear weapons, associate it with fossil fuels, and overestimate the risks associated with nuclear accidents and waste disposal. They also underestimate how much energy nuclear produces, its environmental benefits, and its remarkable record of safe operation. Elites, in turn, have consistently overestimated how much the public knows and cares about nuclear energy while failing to appreciate the degree to which public opinion, when offered, is mostly just a proxy for various partisan, ideological, and cultural identities rather than indicating well-formed opinions about the technology itself.

This report plumbs the voluminous and diverse research on nuclear attitudes going back 50 years, with the goal of extracting actionable insights for nuclear communications — particularly in the US context. We find that nuclear energy is a low-salience issue for the American public. Most people think about nuclear energy only when pollsters ask them to offer an opinion about it. When asked, about as many people express support for nuclear energy as opposition, but few have strong opinions.

When responding to surveys, the public is prone to associate nuclear energy with its most salient negative associations — waste, accidents, and radiation. However, perceived benefits are a stronger predictor of nuclear support or opposition, and long-term fluctuation in public attitudes is strongly associated not with concerns about pollution or climate change, nor even the risks of nuclear energy, but with perceptions of energy scarcity.

Insofar as public opinion about nuclear energy is polarized, that polarization has been cued by political elites. Elite opinion toward nuclear energy (in contrast to public attitudes) has been characterized by strong, consistent, and ideologically coherent attitudes. From the 1960s onward, elite opinion became increasingly fractured along the fault lines of cultural worldviews. Nuclear energy became absorbed into this polarization of elite opinion, and public opinion followed suit. Egalitarian worldviews aligned with anti-nuclear sentiment, and hierarchical/individualist worldviews aligned with nuclear support. On both sides of the divide, polarization increased with education and political engagement.

Alongside this sorting of attitudes, a new cognitive structure for thinking and talking about energy was developed, largely by opponents of nuclear energy, that has come to define the terms in which all energy sources and technologies are discussed. This cognitive structure reduces energy sources and technologies to two binary categories: (1) energy sources that are clean, cheap, abundant, simple, small, and natural and (2) those that are dirty, expensive, scarce, complex, large, and unnatural. A solar panel on the roof of a home is the dominant prototype for the first category of energy, and an oil well or coal-burning power plant is the prototype for the second.

The characteristics of those categories fit together conceptually even when the facts do not. Solar and wind are seen as "cheap" even if the electricity they produce is expensive, because nobody owns the wind or the sun. They are perceived as "clean" even if they require large land and material intensity, because they don't involve combustion and air pollution. And they are viewed as "natural" even though they are manufactured in factories, because they harness the sun and the wind rather than fuels that must be mined and refined.

By contrast, fossil fuels are considered expensive even if the energy they produce is cheap, because they are scarce and the fuel can be owned. And they are considered unnatural because they are mined or extracted, refined, and combusted.

Although nuclear energy does not fit neatly into either category, it is associated mostly with the second because it is produced in large plants and uses a fuel source that is mined and refined; it does not combust that fuel, but it does create heat to boil water; it does not pollute the air, but its environmental risks are widely known; and it is not any more or less natural than any other technology, but the splitting of atoms is seen by many as fundamentally unnatural.

In the decades since nuclear attitudes realigned along cultural fault lines, and the binary schema of energy sources was constructed in the 1970s, little has happened that might shift opinion among either elites or the public. Energy prices have remained low. Western nations have built few reactors. The basic technological and institutional contexts in which nuclear energy has been deployed and operated have remained largely unchanged.

In spite of this relative stasis, two recent developments suggest the possibility of significant shifts in both public and elite opinion.

First, climate change has created an opening for egalitarian elites to reconsider nuclear energy. The public is prone to assume that nuclear energy emits greenhouse gases, but virtually all elites know that it does not. As the scale of clean energy necessary to address climate change has

become clear, along with the challenge of doing so without nuclear energy, many elites concerned about climate change have begun to take a second look.

Second, a new generation of much smaller advanced reactors is on the verge of commercialization. These reactors have many characteristics common to the clean-energy category. They are small, simple, manufactured, and developed by start-ups and entrepreneurs rather than government scientists. Many can run on recycled fuel, which makes them functionally limitless.

Taken together, these two developments represent a singular opportunity to redefine nuclear energy and garner the levels of public acceptance and popularity that renewable energy receives today, and that nuclear received in the first decades of its development.

Restarting the conversation about nuclear energy will require the right audience, messengers, messages, and technology. The recommendations that follow do not assume that better communications and messaging are all that is needed. To the contrary, public support would surely be helped by greater transparency, consultation, and outreach by the nuclear industry in its relationship with communities that surround existing and proposed plants. And the advanced nuclear industry will need to deliver on its commitment to finishing projects on time and on budget. But as these technologies approach commercialization, the work of seizing this opportunity needs to begin now.

Three key guiding principles for communicating about nuclear energy emerged from this analysis:

Principle 1: Highlight benefits rather than dismissing risks

Nuclear advocates consistently overestimate the public's fears about nuclear energy and underestimate the importance of its perceived benefits. This often leads to reinforcing fears rather than allaying them. In reality, perceived benefits better predict public acceptance of nuclear energy than perceived risks. Nuclear advocates therefore would be better served making less efforts to confront misperceptions and more efforts to highlight benefits, especially those associated with next-generation reactors.

Principle 2: Shift the prototype to advanced technologies

Transforming public opinion requires changing the mental prototype of nuclear energy. Mental prototypes matter for public attitudes about energy issues. Solar energy, for example, has benefited from its dominant prototype being a few rooftop solar panels rather than large-scale, land-intensive solar farms. Similarly, small advanced reactors can offer a new mental prototype of nuclear energy, one that not only is more broadly appealing but also resonates with egalitarian worldviews.

Principle 3: Target egalitarian elites

Transforming attitudes about nuclear requires such egalitarian opinion leaders to become outspoken in their support for nuclear energy. Although climate change has produced grudging acceptance of existing nuclear power sources among environmental elites, gaining their more full-throated support requires a vision of nuclear energy that aligns with — rather than challenges — their vision of an ideal society. This entails a vision of nuclear energy that is "small," "simple," decentralized, community-based, and in harmony with nature.

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INTRODUCTION: AN ANTIDOTE TO FATALISM

During the past decade, a growing cohort of analysts, scientists, climate advocates, and policy makers has recognized that nuclear energy represents an important climate mitigation tool. Closures of existing nuclear plants around the world have reliably resulted in higher carbon dioxide emissions. And a wealth of academic and governmental studies has found that any plausible pathway to "deep decarbonization" entails not only keeping existing plants in operation but also substantial additional deployment of new nuclear capacity.[1]

The annals of historical, sociological, psychological, cognitive, and public opinion research, however, offer abundant reason to be pessimistic about this prospect. Nuclear energy may well be the most controversial technology ever created. The modern environmental movement was born in no small part out of fears of all things nuclear — weapons and energy — in the decades after World War II. The controversy surrounding nuclear energy also practically gave birth to the academic study of risk perception. Nuclear energy has been both the prototype for understanding the social, cultural, ideological, and ultimately subjective nature of risk perception and an outlier — a technology that, Paul Slovic observed almost 30 years ago, "stands apart in having qualities that make it fearsome and hard to manage socially and politically."[2]

Unsurprisingly, decades of polling have returned high levels of unfavorable attitudes toward nuclear energy among the American public. Since the 1970s, public favorability has failed to rise meaningfully beyond 50 percent, and top-of-mind associations skew negative, focused on weapons, waste, and accidents.[3,4]

Recent years have also revealed a paradox of sorts. On the one hand, despite the growth of renewable energy, nuclear energy remains the largest source of clean, low-carbon energy globally.[5] Along with hydroelectric development in a few well-resourced nations, nuclear also remains the only technology with a demonstrated capability to deeply decarbonize a modern economy. And yet public concern about climate change in the United States is inversely correlated with support for nuclear energy. Climate change may well represent the strongest argument in favor of nuclear power, but those who are most concerned about climate change are the least likely to support it.

In response to such findings, nuclear advocates have often voiced their frustration with the public at large, arguing that its dread is plainly irrational. In 2019, for example, Joshua S. Goldstein, Staffan A. Qvist, and Steven Pinker wrote in *The New York Times* that progress "depends on overcoming an irrational dread among the public and many activists."[6] The juxtaposition of the reality of nuclear safety and the irrational public is an enduring and ubiquitous trope in the broader conversation about nuclear energy and public opinion, and understandably so. However, it is also far from clear what calls for greater rationality, which have a long history and abysmal track record, might achieve.

Beneath the seemingly monolithic cognitive and psychological barriers to support for nuclear energy, however, there is also reason to think that public attitudes toward it may be more dynamic, less fixed, and more open to evolution and reconsideration than might at first appear. Public opinion about nuclear energy is less strongly held than many presume. Nuclear energy, like many issues of policy relevance, has a remarkably low level of salience in the public mind. Asking members of the public what they think about nuclear often prompts them to form an opinion on the fly.

The truth is that most people don't think much about nuclear energy one way or another. Survey results are routinely overinterpreted and reveal little in the way of clear or consistent preferences. A public that has little understanding or experience with nuclear technology, and that is understandably disengaged with debates about nuclear energy specifically (and energy more broadly) instead uses a variety of shortcuts when asked to offer an opinion.

Risk perception is undeniably a significant factor in nuclear attitudes. But reducing nuclear attitudes to safety fears, rational or not, ignores the fact that risk perception is driven by a host of other psychological factors. These include the relationship between risk and perceived benefits; the complex relationships among cultural worldviews, institutions, and technology; marked demographic differences in nuclear attitudes; and evolutions in elite opinion, from which much of the public takes its cues.

For all the powerful associations that come with it, nuclear energy inhabits a liminal space in the cognitive landscape of energy and climate opinion. It is neither a fossil fuel nor a renewable resource. It is a clean-energy technology of potentially limitless scale that has historically been strongly opposed by environmentalists but supported by climate change skeptics. And it is a technology that has typically required strong centralized state development and regulation that are opposed by liberals and supported by conservatives.

This cognitive no-man's land suggests that public perception of nuclear energy may be more amenable to change than many have long imagined. New technology, new business models, new applications, changes in context, and broader changes in so-called elite opinion might bring substantial shifts to both public and elite opinion about nuclear energy. In this report, we take a fresh look at the research on nuclear attitudes over the past half-century — with a predominant focus on the United States — and attempt to integrate decades of survey research with findings from a number of different disciplines, including social psychology, anthropology, history, cognitive science, and political science, to offer a fuller and more holistic view of public opinion about nuclear energy. We consider the conditions that would be necessary to sustain the substantially higher levels of support needed to deploy new nuclear technology at levels consistent with meaningfully contributing to climate change mitigation. Finally, we suggest frames that nuclear proponents will need to deploy to shift public opinion meaningfully toward broad acceptance of nuclear energy.

Of course, our recommendations do not assume that better technology and better messaging are all that are needed. As many have noted, public trust and support stand to benefit from greater transparency, consultation, and outreach by the nuclear industry in its relationship with communities that surround existing and proposed plants.

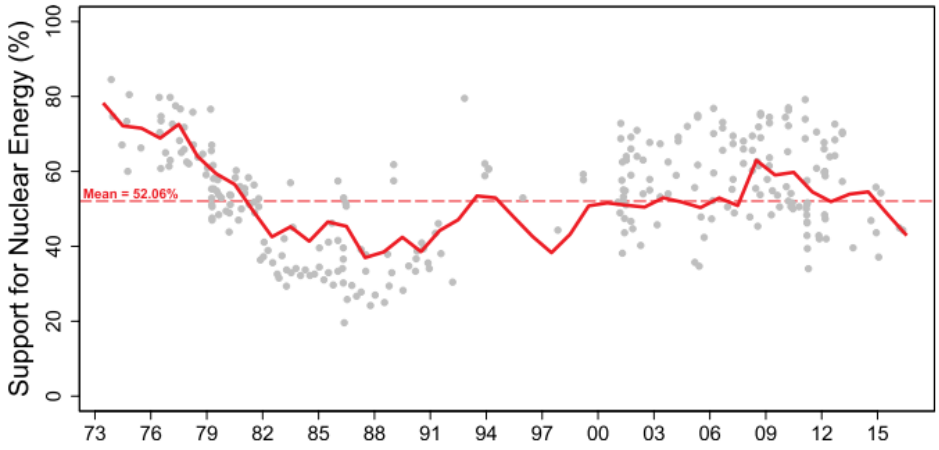
Nor do our recommendations assume that public opposition is the only, or even greatest, barrier to nuclear deployment. Nuclear's economic woes in the United States are well known, driven by a combination of forces, including utility deregulation, regulatory fragmentation and instability, cheap natural gas, and a long-standing failure to reduce costs through serial production. Indeed, the US approach of decentralized development and construction of one-of-a-kind reactors in deregulated markets amid regulatory upheaval could scarcely be better suited to maintain the high construction costs that countries such as France and South Korea have escaped.[7]

But we do assume that public opinion is important. For one, the impact of bad economics and public opposition are not mutually exclusive. In the US context, construction delays and the overall weak state of the industry in the wake of the Three Mile Island accident in 1979 offered anti-nuclear groups a vulnerable target. Looking ahead, public opinion may become increasingly relevant with the commercialization of more cost-competitive advanced reactors.

WHAT PEOPLE THINK ABOUT NUCLEAR AND HOW LITTLE THEY THINK ABOUT IT

From the highest possible vantage, there are two eras of public opinion on nuclear energy in the United States, and one gave way to the other in the late 1970s. Prior to 1977–1978, surveys consistently found that large majorities of Americans, 70–80 percent, supported nuclear energy. But amid accidents at Three Mile Island in 1979 and then Chernobyl in 1986, along with a burgeoning anti-nuclear movement, falling oil prices, and rising costs associated with plant construction, support for nuclear fell precipitously in the United States and many other nations. Some surveys in the mid-to-late 1980s found public support below 40 percent in the United States.[8]

Support for nuclear energy in the United States rebounded in the early 1990s to approximately 50 percent. Since that time, support has been relatively stable, briefly falling below 40 percent in the late 1990s and rising as high as 60 percent in 2010.[9] As of 2019, according to both Gallup and Pew surveys, the percentages of Americans who support and oppose nuclear energy were identical, at 49 percent.[10,11]



US public support for nuclear energy, 1973–2016.[12]

Since the early 1990s, nuclear energy has been mostly an afterthought for most of the public, and for public opinion researchers. From the early 1990s through the early 2000s, survey researchers rarely asked about the topic at all. Since then, survey activity has picked up again, but public engagement with the issue has not. Survey results suggest an evenly divided public, but it is mostly a public that doesn't appear to think much about nuclear energy. That is in part because there has not been much to think about. Since the late 1980s, there has been little in the way of new nuclear construction,[13] and America's existing civilian nuclear facilities have operated without

incident. Energy prices during this period have remained low and today represent a relatively small share of household expenditures.

The low salience of nuclear energy in the public mind makes attitudes tracked through survey research instruments difficult to interpret. Despite substantially lower favorability levels in the United States compared with the early decades of the postwar era, support for nuclear energy in the United States remains quite high by international standards. According to the most recent study comparing nuclear opinion across a large number of countries, as of 2005 (when American support for nuclear was only slightly higher than it is today), the United States was second only to South Korea in its nuclear favorability level out of the 18 countries surveyed (12 of which have active commercial reactors).[14] In addition to this comparatively high rate of overall acceptance, the United States ranks fourth in both its ratio of acceptance to opposition and its ratio of strong acceptance to reluctant acceptance.[15] Consider also that only a modest share of Americans is so averse to nuclear energy that it favors shutting down all operating plants.[16]

Fundamentally, though, the data suggest that most Americans have neither well-informed nor deeply held convictions about nuclear energy. Opinions on nuclear energy give every indication of being ill-informed and weakly held. Surveys are likely asking a fair share of respondents to think about and formulate an opinion on nuclear energy for the first time.

One indicator of nuclear's low salience is the frequency of "don't know," "no opinion," and "unsure" answers. Despite the psychological desire to appear knowledgeable and informed to oneself and the survey administrator, polling on nuclear power often turns up large numbers of such responses. In a 2012 nationwide survey, for instance, "unsure" was selected more than twice as frequently as any other answer choice.[17]

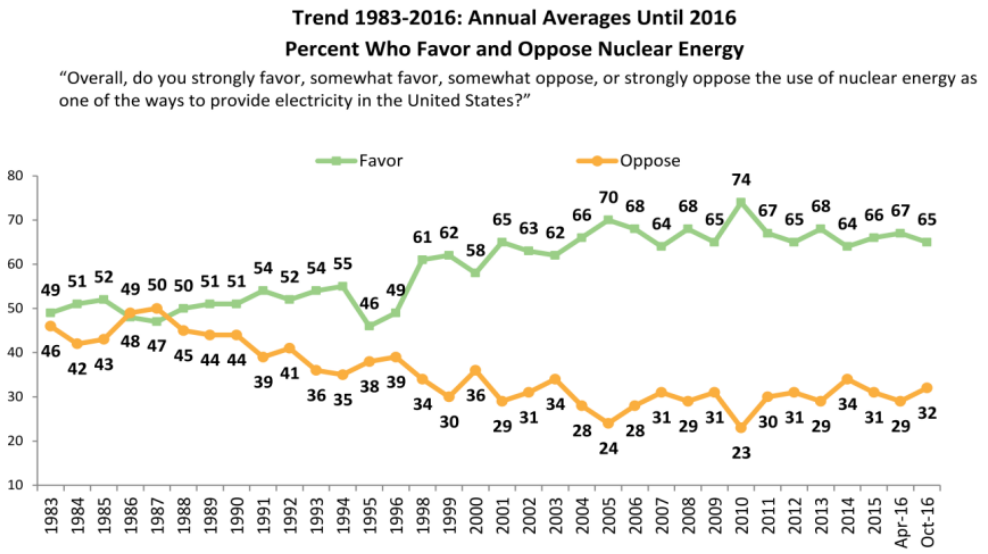
Another indicator of low salience is the public's strikingly thin knowledge of nuclear's environmental impacts. In one recent US survey, more than half of the sample indicated a belief that nuclear energy contributes to climate change — 27 percent categorized nuclear as a "very major" or "major cause" of climate change, and 29 percent said it was a "moderate cause."[18] This general finding has been reproduced by numerous polls over time. In 2003, for instance, approximately 70 percent of the American public either believed that nuclear generation emits greenhouse gases or were not sure.[19] Americans aren't alone, of course; ignorance of nuclear's lack of emissions has been documented internationally.[20] Such findings also invite overinterpretation. It's unlikely that respondents expressing the view that nuclear energy releases greenhouse gases are firmly convinced of this fact. More likely is that these results reflect a vague impression that nuclear energy is dirty or polluting in some way.

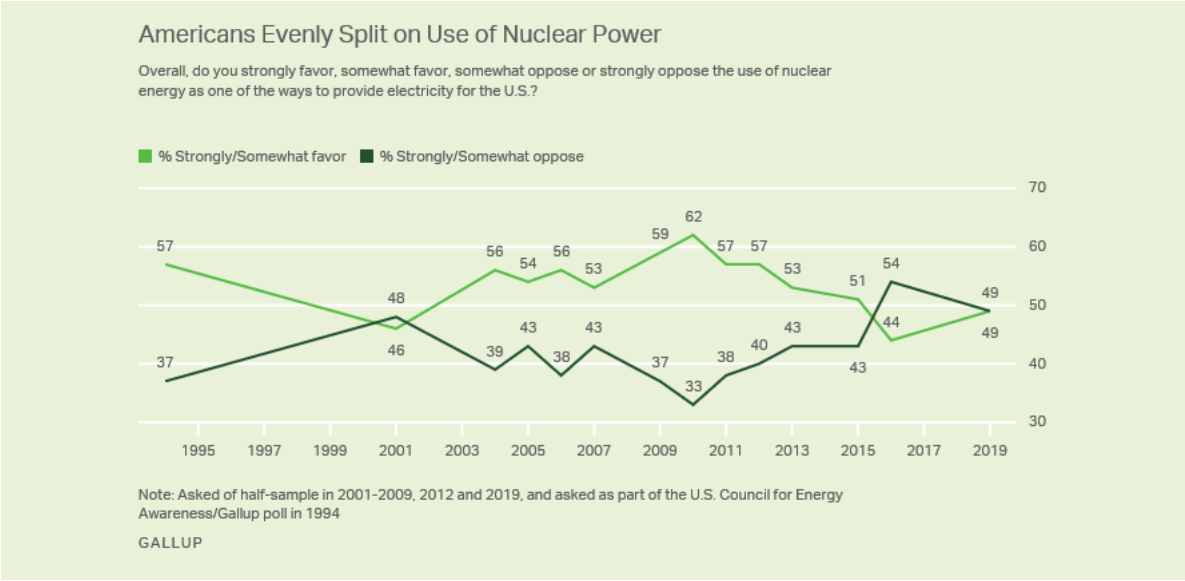
The susceptibility of polling results to question-wording effects also suggests that opinions are often weakly held. When survey questions include a rationale for supporting nuclear energy — even one as simple as "generating electricity"[21] — support is markedly higher. For reasons that are not entirely clear, survey items about nuclear that specifically reference generating electricity consistently return higher support (a finding documented as early as the 1970s[22]) and are predictably favored by the nuclear industry in its polling.[23] This question wording may simply be cueing respondents to consider a familiar benefit they value, but it may also reduce the likelihood that respondents will conflate nuclear energy with nuclear weapons, given that studies find this to be a frequent association.[24]

The influence of the "electricity" question wording may be at least partly responsible for the eyebrow-raising difference between the results from mainstream polling organizations and those produced by, or on behalf of, the Nuclear Energy Institute (the industry's leading advocacy organization), which has shown steadily rising support for nuclear energy since the early 1980s.[25] However, Gallup polling results for this same item nonetheless return a very different result[26] (figure below).

The logical incoherence of survey results also attests to nuclear energy's low salience. One survey first asked respondents if they supported nuclear energy, and then later in the survey asked if they wanted to increase or decrease the United States' reliance on it. Of those who indicated they were *opposed* to nuclear energy, nearly 20 percent said they wanted to *increase* reliance.[27] That so many respondents say they oppose nuclear energy but also want more of it makes no logical sense, especially if you assume that people have well-formed views. Such inconsistent responses are likely the result of superficial features of survey questions and question ordering.

A final, albeit more indirect indication of nuclear energy's low salience is the frequency with which survey respondents indicate they believe it should be kept at its current level. For example, when asked to respond to this item — "What percent of our electricity should come from nuclear energy, which currently provides about 20% of total U.S. electricity?" — participants overwhelmingly said 20 percent (with a mean of 19.9 percent).[28] Some respondents likely hold an affirmative belief that existing nuclear plants should not be shut down, and that, as the authors commented, "nuclear energy [should] remain an important part of the country's electricity mix, providing about 1/5th of the nation's electricity." However, it is also likely that many people are simply splitting the difference between increasing and decreasing its share. When in doubt, they think, keep it the same.

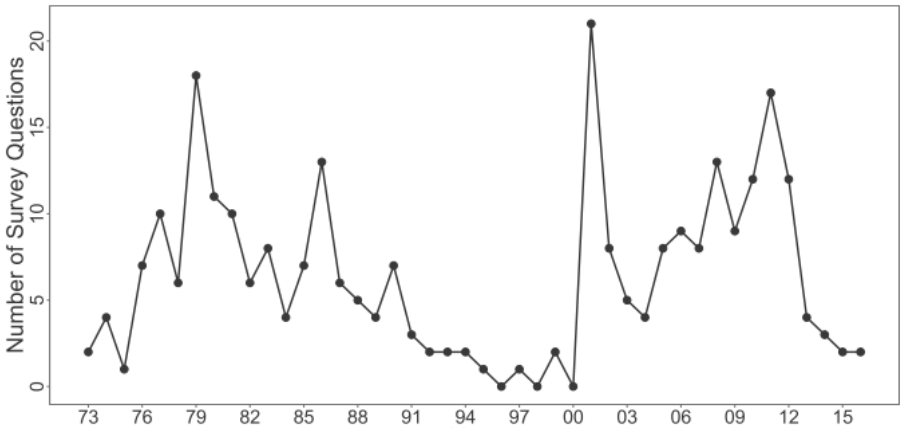




Polling results from the Nuclear Energy Institute versus Gallup using the "provide electricity" item.[29,30]

For pollsters, the media, and the public alike, nuclear fades to the background unless something brings it to the fore. In this way, members of the public are not unlike pollsters themselves, whose interest in nuclear has vacillated historically and changed rapidly — no doubt in response to various kinds of foregrounding events — and provides a useful proxy for nuclear's overall salience.

Pollsters' interest in nuclear energy closely aligns with major nuclear accidents — Three Mile Island in 1979, Chernobyl in 1986, and Fukushima in 2011[31] — each of which was accompanied by a spike in the annual number of survey questions. Intriguingly, pollsters fielded the greatest number of questions about nuclear energy in response to heightened concern about nuclear weapons — in response to 9/11 and fears that Saddam Hussein was developing weapons of mass destruction.



Trends in the annual number of survey questions about nuclear coincide with accidents, 1973–2015.[32]

What is true of nuclear is likewise true of energy issues in general: In the absence of an energy crisis or foregrounding event, the public simply doesn't think much about energy issues, and neither do pollsters.

And when energy issues lose salience, not only are there less available polling data, but survey results themselves change in a way that reflects the public's declining adherence to established political views of energy production and policy. Eric Smith, who has produced one of the most comprehensive treatments of public opinion on energy and the environment, found that from 1977 to 1998 (a period of declining and low overall energy salience), people's survey responses became less and less coherent in relation to the ideological categories into which political elites have divided positions on energy.[33] Increasingly, people supported a combination of energy-development and energy-conservation measures, e.g., drilling for oil in domestic nature reserves and cutting living standards.[34] Although there is nothing logically inconsistent about these ideas, the fact that public opinion diverged from the dominant fault lines of political debate suggests that the public had become less attentive to energy issues.

Based on the survey data, it might be most accurate to describe the public's relationship to nuclear energy as one of "nonattitudes,"[35] Philip Converse's famous shorthand for issues about which survey questions often force respondents to generate opinions on the fly.

Of course, energy issues are not alone in this regard. Low knowledge, low coherence, low stability, high question-wording effects, and high status quo-retaining responses are qualities and patterns that typify public opinion about many issues of political relevance,[36,37] especially those distant from people's daily experience. Nonetheless, this fact all too often gets lost in conversations about what the public thinks about nuclear energy.

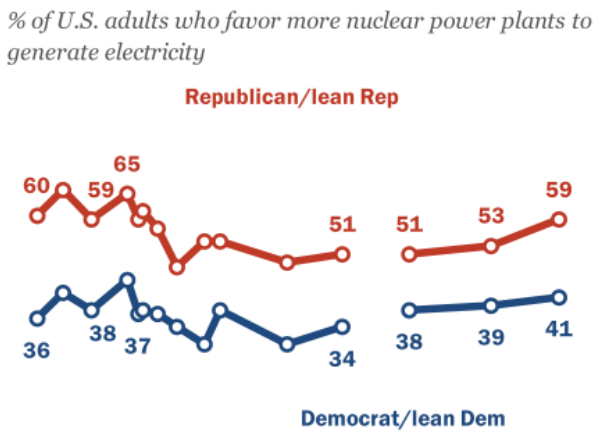
Demographics and Ideology

Although most Americans do not appear to have thought very often about nuclear energy, if they have done so at all, they express markedly different opinions across both ideological and demographic lines. Those expressing relatively high levels of support for nuclear energy are more likely to be older, White, and male and identify as Republican and conservative. Women, people of color, Democrats, and liberals all express lower support on average.

Politics

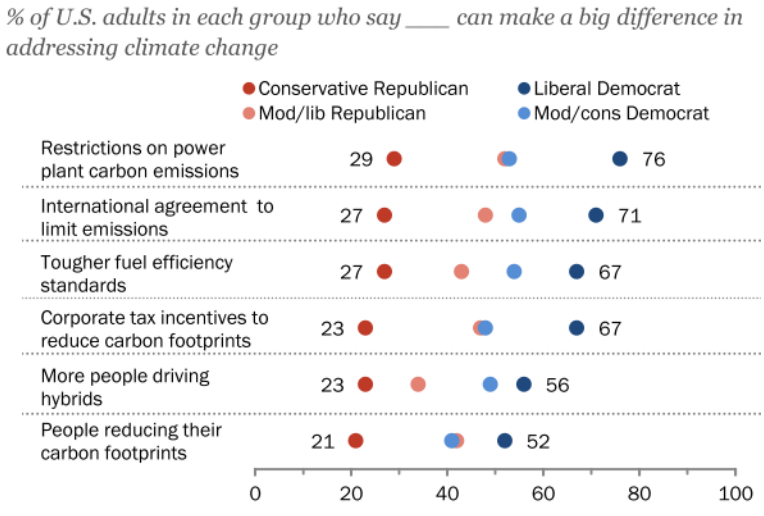
As of 2018, Pew found a 14-point gap between Republicans (53 percent) and Democrats (39 percent) in support for expanding the use of nuclear power, and a 19-point gap between those identifying as conservative Republicans and liberal Democrats (57 and 38).[38]

The partisan gap has remained remarkably consistent during 2008—2018 despite fluctuations in overall nuclear favorability: Support among Democrats and Republicans has consistently shifted in the same direction, rising and falling simultaneously. This finding bucks a robust trend of increasing polarization on a multitude of political issues since the turn of the 21st century.[39] It is especially notable that nuclear's partisan gap has remained consistent as polarization with regard to climate change has steadily increased.[40]



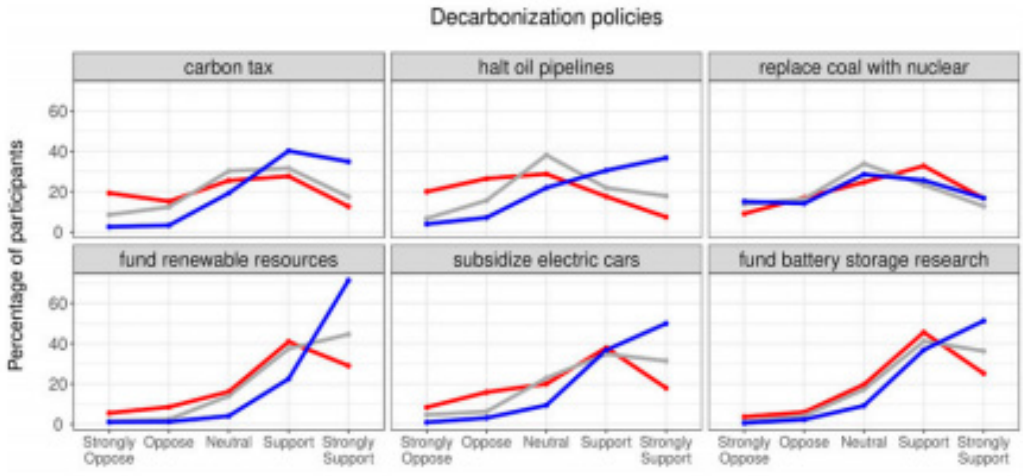
Consistency of partisan gap in support of nuclear, 2008–2019.[41]

While nuclear's roughly 20-point partisan/ideological gap between conservative Republicans and liberal Democrats is nothing to dismiss, this gap is far smaller than support for various climate policies, despite the controversy surrounding nuclear. For example, in 2016 Pew found an average partisan/ideological spread of approximately 40 points in beliefs about the efficacy of various climate actions, including restrictions on power plant emissions, international climate agreements, tougher fuel-efficiency standards for cars, and corporate tax incentives (figure below).[42] Further, a 2018 Brookings survey found a partisan gap in support for a carbon tax that is roughly double the 15-point partisan-only gap for expanding nuclear — 60 percent of Democrats supported a carbon tax compared with 30 percent of Republicans.[43]



Significant partisan spread in support of select climate mitigation actions, 2016.[44]

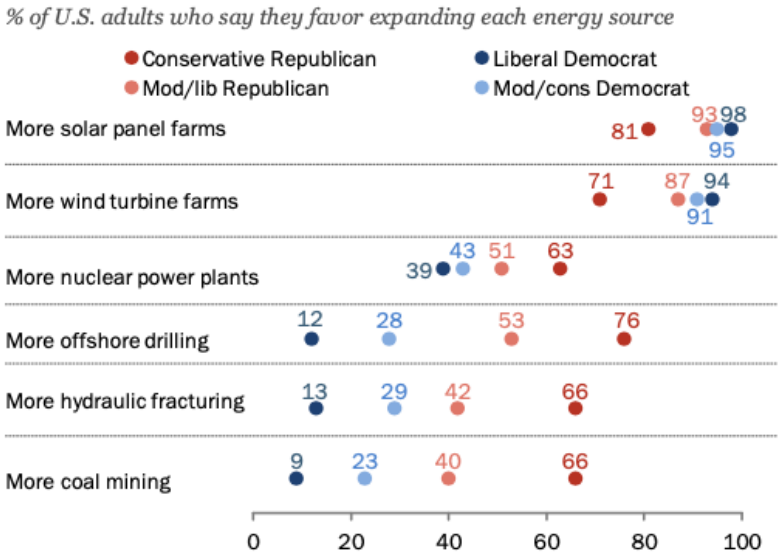
In contrast, a 2020 paper found that replacing coal with nuclear had the smallest partisan gap among the surveyed decarbonization policies (figure below).[45]



Smaller partisan gap for replacing coal with nuclear than for other decarbonization policies, 2020.[46]
Note: red lines = Republican; blue lines = Democrat; gray lines = Independent.

Nuclear's partisan gap is also modest compared with that of other energy sources, especially fossil fuels. The partisan gap in support of expanding the use of nuclear energy is in the neighborhood of 16 points, whereas the gap for expanding fossil fuels (more offshore drilling, fracking, and coal mining) is almost three times as wide.[47] Nuclear's partisan gap is about the same as for solar and wind, although nuclear is less popular overall. In 2019, expanding solar power was supported by 98 percent of liberal Democrats, 95 percent of moderate Democrats, 93 percent of moderate Republicans, and 81 percent of conservative Republicans.[48]

In other words, nuclear is closer to fossil fuels in both its pattern of political support and its aggregate public favorability, but closer to solar and wind in its degree of political polarization.



Modest partisan gaps in support for nuclear compared with fossil fuels, but lower overall support than for solar and wind, 2019.[49]

Race and Gender

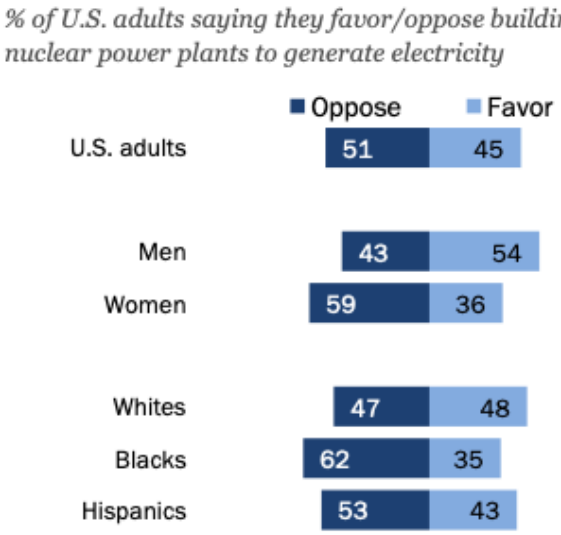
Among the most widely cited facts about the demographics of nuclear opinion is the gender divide, which far exceeds all other demographic gaps. Women express opposition to nuclear energy far more frequently than men, even after controlling for political party affiliation.[50] A 2018 Pew survey found that roughly 35 percent of women support expanding nuclear energy compared with around 53 percent of men — an 18-point gap, four points wider than the partisan one.[51]

Nuclear's gender gap is wider than for any other energy source, roughly 18 points, compared with around 15 points for offshore oil drilling, 10 for fracking, and 5 for expanding solar and wind energy.[52] It is also far wider than the gender gap for attitudes about climate change and most environmental issues more broadly.[53,54]

Nuclear's gender gap in the United States was documented as early as the 1970s.[55] Based on an extensive review of available polling data between 1975 and 1976, Melber et al. found that "Sex differences in response to nuclear power questions were more clear-cut and consistent than those associated with any of the other demographic classifications."[56]

The gender gap has remained fairly consistent over the last 50 years despite declining support overall. In the mid-1970s, there was a 19-point gender gap (65 and 46 percent support for men and women, respectively[57]), and the gap today is roughly the same (53 versus 35 percent).[58]

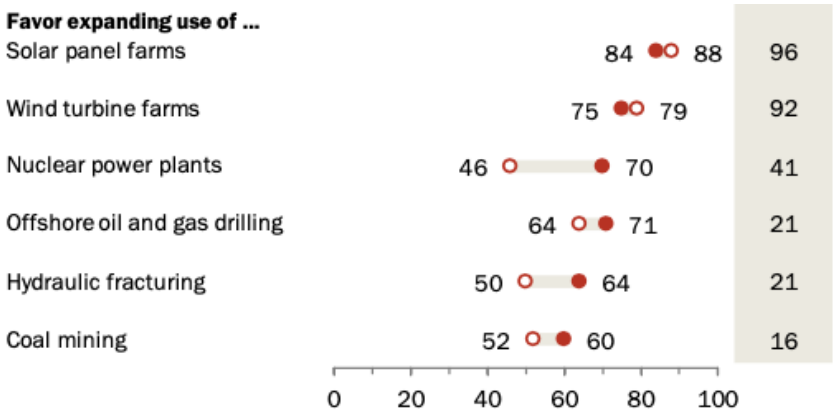
Gaps between ethnic groups are roughly equivalent to the magnitude of the political divide but far less so than for gender. Based on 2015 data obtained from Pew, African Americans and Hispanics are less likely to support nuclear energy than Whites (35, 43, and 48 percent, respectively).[59] Notably, the gender gap varies considerably across ethnic groups. Based on 2015 data, the gender gap is roughly 20 points for Whites (42 percent for women, and 63 percent for men), 10 points for African Americans (33/42), and 7 points for Hispanics (40/47).[60] This difference between gender gaps across ethnic groups results from the high rate of support among White men in particular. Whereas approximately 63 percent of White men support nuclear, support is virtually identical among White women and people of color (African Americans and Hispanics), at roughly 40 percent.



Race and gender breakdown of support for expanding nuclear energy, 2015.[61]

There is also substantial overlap between the gender and political gaps in nuclear support. Whereas White men are half as likely to support nuclear as the rest of the population, they are also substantially more conservative. White men are about 35 percent more likely to identify as either conservative or very conservative, and 80 percent more likely to identify as very conservative.[62]

At the same time, there is a sizeable gender gap among Republicans. A 2019 Pew survey found that 70 percent of Republican men favor expanding nuclear energy compared with only 46 percent of Republican women — a 24-point divide, and the largest of any of the surveyed energy sources.[63]



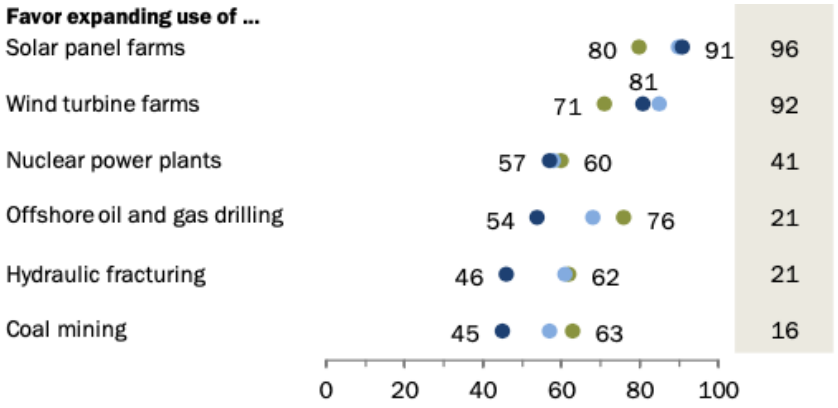
Large gap among Republican women and men in support for nuclear energy.[64]
Note: red circles = men; white circles = women.

Age

Although the anti-nuclear movement was born out of the generational politics of the baby boom, the generational politics of nuclear energy today looks much as it did in the 1960s and '70s. Younger cohorts are likelier to oppose nuclear energy, and older cohorts are likelier to support it.[65,66] Americans older than age 65 — despite being adults during all major nuclear accidents — support nuclear with greater frequency.

Although this age gap may be largely a reflection of greater support among Republicans, who are older on average than Democrats, age gaps exist within partisan identity groups as well. A 2018 Pew survey found that younger Republicans are less likely to support nuclear than their older counterparts by 11 percentage points.[67]

However, the age gap that survey research has documented is generally small, and a recent Pew survey found essentially no age gap at all — a mere three-point spread between millennials and younger, and boomers and older.[68] Further, the survey found that nuclear energy had a smaller age gap that all other energy sources. Finally, an age gap has not been found in all surveyed countries, including Japan.[69]



Lack of age gap in support of nuclear energy compared with other energy sources, 2019.[70]
Note: dark blue dots = millennial and younger; light blue dots = Gen Xer;
green dots = boomer and older.

As with top-line findings and trends in public opinion about nuclear energy, appreciating nuclear's low public salience offers an important corrective to the overinterpretation of partisan and demographic differences in expressed attitudes. In the absence of well-informed or strongly held views about nuclear, the public uses various mental shortcuts in forming their impressions. Humans are, by nature, "cognitive misers."[71] So on most topics, especially those distant from our daily lives, most of us make judgments with little information based on various cues and heuristics. The following chapters identify what these heuristics are, where they have come from, and how they operate.

KEY POINTS

In their support for nuclear energy, the American public is currently split down the middle. Surveys in 2019 by both Gallup and Pew found that the percentages of Americans who support and oppose nuclear energy was identical, at 49 percent.

Prior to 1977–1978, nuclear energy enjoyed support from a large majority of Americans: 70–80 percent. But with a burgeoning anti-nuclear movement, the accident at Three Mile Island, rising energy security, falling oil and gas prices, high rates of nuclear plant construction, and robust media coverage of nuclear energy and its challenges, favorability soon began its downward march and never returned to anything like its former height. Since the 1970s, nuclear favorability has seldom risen meaningfully above 50 percent.

Those expressing relatively high levels of support for nuclear energy are more likely to be older, White, and male and identify as Republican and conservative. Women, minorities, Democrats, and liberals all express lower support on average.

While nuclear's roughly 20-point partisan/ideological gap between conservative Republicans and liberal Democrats is nothing to dismiss, it is far smaller than the partisan gap associated with many other energy- or climate-related policies.

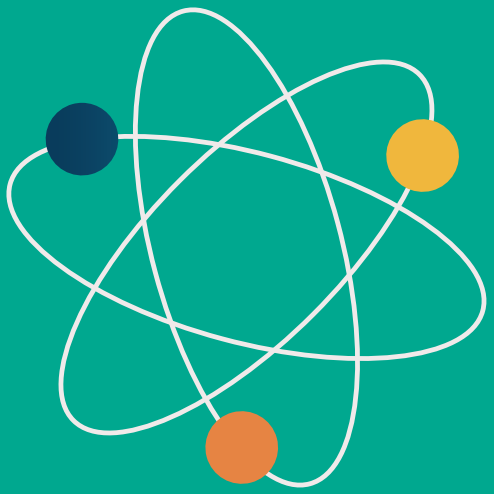
Nuclear's partisan gap is also modest compared with that for other energy sources. The partisan gap for fossil fuels is far larger, and for solar and wind it is roughly the same.

Nuclear energy, and energy issues in general, have low salience for the public. Survey questions about nuclear energy ask for opinions about a topic the public knows and has thought little about, often prompting respondents to formulate attitudes on the fly.

The low salience of public opinion about both energy issues in general and nuclear in particular should be kept firmly in mind as an antidote to overinterpreting survey data.

Humans are, by nature, "cognitive misers" — they are capable of and inclined toward making judgments with little information based on superficial cues and mental shortcuts. Understanding what and how people think about matters distant from their daily lives, such as nuclear energy, is in large part a matter of uncovering which heuristics are at play and how they operate.

RISK AND BENEFIT PERCEPTION – WHY THE ROLE OF FEAR IS OVERESTIMATED



Much of the research and commentary about nuclear energy in the public mind takes opposition as the central phenomenon worthy of explanation — Why don't people like it? While this negatively framed question risks underestimating nuclear's low salience, strong opposition among important segments of the public is nonetheless a key feature of nuclear attitudes.

Fear of public health impacts from accidents, waste, and weapons, while not the only factor, has formed the bedrock of public opposition to nuclear energy. In surveys, those who believe the safety risks of nuclear energy to be high are far more likely to oppose it,[72,73] and respondents consistently rank nuclear as the least safe energy source.[74] Study after study have underlined the fact that the public considers nuclear energy unsafe, often intensely so.

Studies have also found that the public's perception of nuclear's danger to public health far exceeds what experts have calculated its risks to be.[75] Using a clever experimental design, Abdulla et al.[76] recently asked participants to generate their ideal energy mix for reducing carbon emissions. They split participants into two groups — one that received both the calculated risk and the name of each energy source, and one that received only the risk data. The participants who were told about nuclear energy by name included 40 percent less in their portfolio.

Inaccurate perception of nuclear risk is consistent with research showing that risk perception in general is not "rational" in the strictest sense — more precisely, it is non-mathematical or non-actuarial. That is, risk perception is not based on an attempt to quantify risk by coordinating the likelihood of an adverse event over a specific time frame with the deleterious impact of such an event (multiplying probability with magnitude). Rather, it is based on heuristics and mental shortcuts that abundant psychological research has shown are central to human cognition.

Public attitudes toward nuclear energy offer a striking illustration of how risk perception works. Given nuclear energy's co-evolution with nuclear weapons, its long association with cancer, and the social and institutional contexts in which it has been developed and operated, nuclear energy would seem almost engineered to trip our internal alarms. But while demands that the public abandon irrational fears of nuclear energy are unlikely to be heeded, the nature of risk perception also suggests that nuclear attitudes are highly contingent and hence subject to change. Thus, the fixation on (mis)perceived risk can result in overlooking the importance of perceived benefits and the interplay between risk and benefits. Public perception of nuclear energy as high risk is not the inevitable by-product of the technology's inherent features, and hence does not doom it to low favorability.

Knowledge and the Failure of the Rationalist Account

As with issues such as climate change, it is understandable that many imagine that public misperceptions about nuclear risk are the result of insufficient education and information. But this "rationalist account" — variously referred to as the "awareness hypothesis"[77] or the "knowledge deficit model"[78] — finds mixed empirical support. Among the lay public, for example, a meta-analysis found that general scientific knowledge does not well predict attitudes toward nuclear and might even predict opposition to it.[79]

One study did find a significant reduction of nuclear risk perception with higher levels of scientific literacy and quantitative reasoning skills, but the effect was strongest among ideologically conservative participants.[80] Further, these variables predicted greater polarization: better knowledge and cognitive sophistication pushed ideological groups apart, not together. This finding is consistent with public opinion research on climate change and a number of other highly contentious environmental issues, suggesting that both general scientific and domain-specific knowledge are strongly associated with more extreme views on both sides of an issue. More accurate views do not follow from better understanding or scientific literacy. Rather, those with higher levels of science literacy and domain knowledge turn out to be better able to find evidence to justify their ideological priors, and hence are prone to express stronger opinions.

Education level may be a better predictor of nuclear attitudes than scientific knowledge. A meta-analysis found more education to be a predictor of lower risk perception, albeit a weak one.[81] And a 2015 Pew survey found that support for nuclear was higher with greater educational attainment; support among those with a postgraduate degree was 12 points higher than among those with a high school degree or less.[82] This is despite the fact that nuclear support is higher among Republicans overall,[83] who are less likely to have a college education, and underlines that other factors are more significant drivers of nuclear attitudes. But this poll also found little difference between those with science and non-science degrees, and those with more or less science knowledge.[84] These findings suggest that the mechanism through which education shapes attitudes is not through knowledge directly relevant to nuclear risk perception.

Another interesting finding at odds with a simplistic rationalist account comes from a UK survey in 2008. Respondents who affirmed the benefits of nuclear for energy diversification and lack of greenhouse gas emissions were actually *less* likely to register an opinion about whether society should rely on nuclear, selecting a "don't know" or "unsure" response.[85] One possible explanation is that being informed makes one appreciate the complexity of such issues and therefore less inclined to express an affirmative stance.

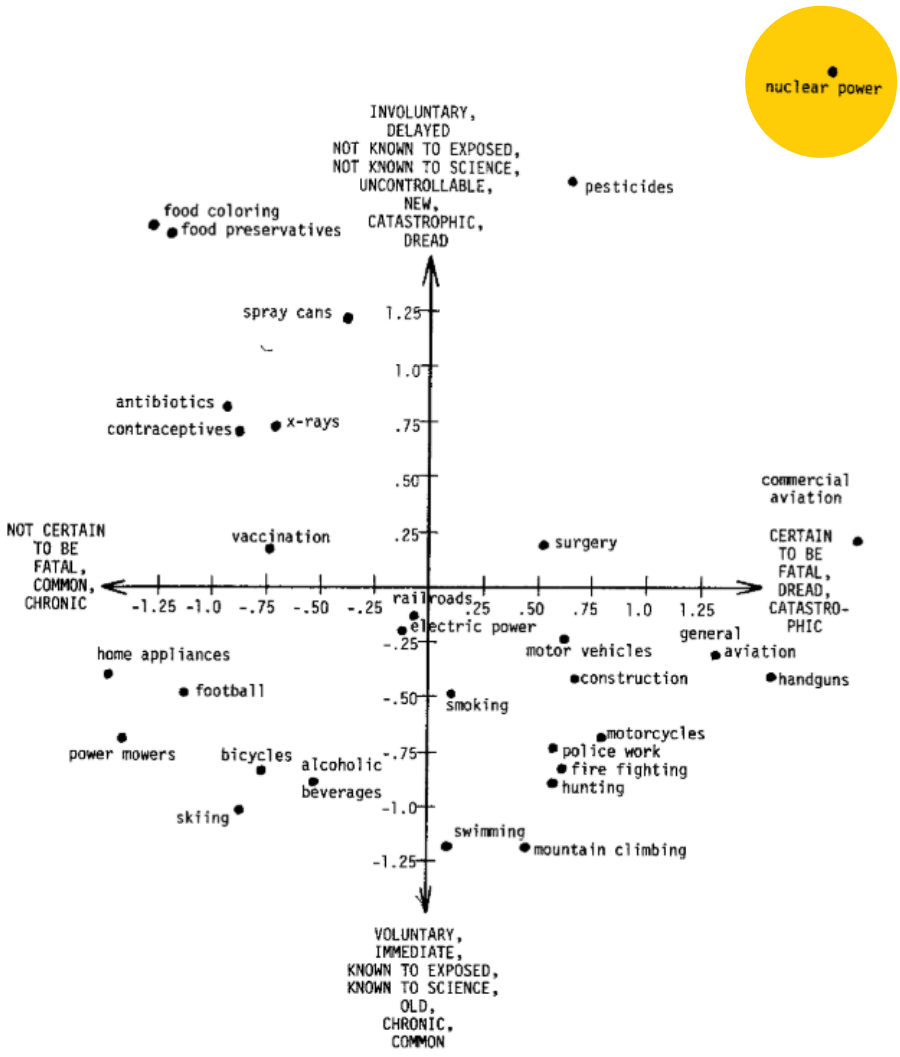
The Psychology of Risk Perception

Nuclear energy has featured so prominently in the academic risk perception literature precisely because it is so feared by the public. For social scientists, understanding why nuclear energy is feared to such a degree offers a window into the cognitive processes through which people assess all manner of risk.

Nuclear energy, in fact, played a central role in the founding of risk perception research, with the publication of Chauncey Starr's seminal article, "Social Benefit versus Technological Risk" in 1969.[86] Starr's methods were economic and behavioral rather than psychological, but his findings hinted at psychological dynamics.[87] He argued, for instance, that the public is far more willing to accept risks from voluntary activities as well as hazardous activities whose benefits are salient.[88] Neither of these findings, he believed, worked in nuclear's favor.

Building on this work, Baruch Fischhoff and colleagues created an influential psychological model for subjective risk perception, which became known as the "psychometric paradigm."[89] In a landmark study, participants were asked to rate the level of risk posed by various hazards, and to rate those risks according to a list of characteristics. They found that risk characteristics could be clustered into two dimensions, which they later called "unknownness" and "dread." Hazards high on the unknownness dimension were involuntary, associated with new and complex technology, and had negative consequences that were delayed and believed to be impossible to gauge, even by scientists. Hazards that received high scores on the dread dimension, meanwhile, were perceived to be inevitably fatal to large numbers of people in the event that something went wrong.

In their seminal study, Fischhoff and colleagues found that nuclear energy received the highest aggregate rating of unknownness and dread, by a wide margin (figure below).[90] Summarizing their findings, Goodfellow et al. wrote, "Nuclear energy also scores significantly higher in the dimensional terms than any other activity or technology surveyed, suggesting that it occupies an extreme position psychologically — almost a worst-case combination of an unknown technology with fearful effects if something goes wrong."[91] Numerous subsequent studies have corroborated and elaborated on nuclear's extreme position in risk perception.[92]



Nuclear energy occupies an extreme position in both dimensions of risk perception, 1978.[93]

What Does the Public Fear?

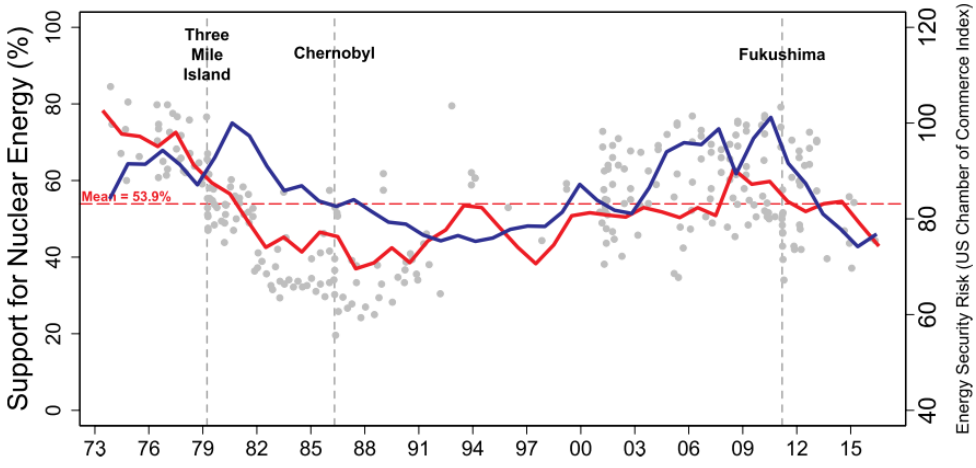
There is no question that much of the public considers nuclear energy unsafe. But precisely what fearsome events or scenarios grip the public's imagination? What is the public's mental model of the hazards posed by nuclear energy?

Association with nuclear weapons is certainly among them — an association that was doubtlessly cemented during the Cold War. A 2015 study found "war" and "bomb" to be among the most frequent top-of-mind associations with nuclear energy,[94] and arguments about proliferation risk are a centerpiece of anti-nuclear advocacy, as captured by Smith's famous quote: "Nuclear energy

was conceived in secrecy, born in war, and first revealed to the world in horror. No matter how much proponents try to separate the peaceful from the weapons atom, the connection is firmly embedded in the minds of the public."[95]

Arguably more central, however, is concern about catastrophic accidents. In many studies and surveys, fear of nuclear accidents correlates with opposition to nuclear power.[96] And there is strong evidence for the dominant narrative in public opinion research on nuclear energy that accidents mark inflection points in public opinion and are central drivers of longitudinal trends.[97,98] For instance, support for nuclear fell both domestically and internationally after Three Mile Island,[99] Chernobyl,[100] and Fukushima.[101,102,103] In the policy literature, nuclear accidents have been pointed to as prototypical examples of "focusing events"[104]: rare, sudden, unfortunate, and shocking events that serve to increase the salience of an issue and potentially catalyze policy change. The Fukushima accident functioned in this way in Japan, in response to which the government committed to decreasing its reliance on nuclear power.

However, a closer look suggests that the relationship between major accidents and fear of nuclear energy is not so straightforward. Historically, public support has indeed fallen after accidents, but it had also been trending downward prior to each one — an unaccountable coincidence. In the decade before the Three Mile Island accident, public support had fallen by between 10 and 20 points.[105] Support for nuclear was also falling before Fukushima.[106]



Support for nuclear energy (red line) in relation to major nuclear accidents, 1973–2016.[107]

Nonetheless, overattribution of public opinion to accidents — implicit or explicit — is common, even among reputable polling organizations. About Chernobyl, Lydia Saad wrote for Gallup, "Two months later, as information was still seeping out of the Soviet Union about the severity of the disaster, 73% of Americans told Gallup they would be against the construction of a nuclear facility in their area. This was up from 60% in 1979 and 45% in 1976."[108] In reality, the data don't support such a strong causal explanation, as favorability declined more in the few years before the accident than it did following it.[109] Some polls even saw support for nuclear climb in the 6 months following the accident despite falling perceptions of safety.[110] One comprehensive historical analysis also found no effect — i.e., that the trend in support after Chernobyl could not be distinguished from other fluctuations.[111]

The impact of accidents is also highly variable and susceptible to national context. As mentioned, despite the severity of the Chernobyl accident, it is not clear whether it had much of an effect on US public opinion, and whatever impact it may have had was certainly less than that of Three Mile Island. International research has found that geographical distance from the site of the accident is an influential variable on the impact on public opinion.[112,113] But physical distance isn't the only mediating variable — so too is the number of nuclear plants currently under construction in a given country: the more plants under construction, the greater the impact of an accident in another country.[114] A reasonable interpretation is that it's not so much physical distance that matters as it is *psychological distance*.

There is ample evidence that other hazards nuclear energy presents may loom equally large in the public's mind, if not larger. For instance, in 2016, the UT Energy Poll found that, of those who oppose nuclear energy, more respondents identified their greatest concern as "the effects of nuclear radiation in my community" and "nuclear waste storage" than a "power plant meltdown," each by over a 10-point margin.[115] In another study, supporters and opponents of nuclear energy largely agreed about the likelihood of an accident but disagreed about the seriousness of nuclear's other hazards.[116] This isn't a new finding, nor is it one specific to the United States. Over decades, expressed fear of nuclear waste has often been found to exceed fear of nuclear plants, which Paul Slovic documented as far back as 1993[117] and again in 2000,[118] based on data collected in the United States, Canada, and France.

Putting Nuclear Fear in Perspective

The research on nuclear energy and risk perception might easily be read as deterministic or essentialist. That is, fears of catastrophic accidents and radioactive waste associated with a highly complex technology beyond the understanding of laypeople doom it to high risk perception among the public. But such a deterministic view is not consistent with the literature. In fact, a recent replication of the original study by Fischhoff and colleagues documented a significant shift in nuclear energy's position in the two-dimensional risk perception space. While nuclear energy still generated high dread ratings, participants considered its risks to be far less unknown and unknowable.[119]

Shift in nuclear risk perception, 1978–2016.[120]

Moreover, an important distinction should be made between the question of why people consider nuclear energy so risky and why they consider the risk it presents is so unacceptable. Some research indicates that risk perception may not be as important as how objectionable people

feel it is to be a victim of it. Friedman found that the public's risk perceptions of hazards were generally accurate, but that their level of concern about those risks had more to do with value judgments.[121] Respondents acknowledged, for instance, that the likelihood of dying from a terrorist attack is very low but nonetheless commonly said they were "very worried" about it. The acceptability of a hazard, then, depends highly on who is involved and who has control.

This finding may well apply to nuclear energy: Many members of the public may know that it "objectively" presents low risk but still consider it high risk because of the political and institutional contexts in which that risk is imposed. The public's perceptions of the risks associated with nuclear energy, in other words, may be less a matter of knowledge than values — the topic of the following chapter.

The Neglected Role of Benefit Perception

Largely missing from the voluminous literature on nuclear risk perception is a discussion of perceived benefits. Fear-based explanations for nuclear opinion necessarily minimize the presence of positive associations and the role of perceived benefits. And positive associations of nuclear energy, contrary to conventional wisdom, are prevalent. In fact, positive associations are nearly as common as negative ones. In research spanning decades, elicited top-of-mind associations have consistently revealed a mixture of attitudes that leans only slightly negative, both in the aggregate and from individual respondents.[122,123] This finding runs counter to the idea that entrenched negative associations of weapons, waste, and accidents occupy all of Americans' mental landscape. Negative associations may be common and "firmly embedded in the minds of the public,"[124] but there is more to nuclear opinion than what Americans don't like about it.

Perceived risk and perceived benefit are, of course, deeply entwined. High-risk activities often have large benefits and vice versa. In people's minds, however, precisely the opposite holds: risky activities are often judged as having little benefit and vice versa. That is, if people are very uncomfortable with a particular risk, they will often downplay the benefits associated with it; conversely, when they are very committed to or otherwise desirous of a particular benefit, they will often downplay the risks associated with it.

While far more work has been done on nuclear risk perception, benefit perception has been found to be one of the strongest predictors of acceptance of nuclear energy. A large meta-analysis, for example, found that its acceptance is better predicted by perceived benefits and costs

than by perceived risks.[125] This underlines the fact that explanations for nuclear energy's public support based entirely on risk perception and aversion are insufficient.

So what benefits does the public attach to nuclear energy? Many decades of public opinion research on nuclear energy make the answer (or at least an important part of it) fairly obvious: the public values nuclear energy as a bulwark against energy insecurity. For the public, it may not be safe, but it is reliable.

A look at the drivers of historical trends in public support offer indirect but strong evidence that providing a reliable supply of energy is what the public most values about nuclear energy. Concerns about energy prices and perceived energy abundance have been a major force in public opinion since pollsters first began asking the public about energy. Based on survey data between 1977 and 1988, Eric Smith found that inflation and gas prices — and not the overall health of the economy (median income and GDP) — correlate with support for offshore oil drilling.[126] When energy is perceived to be costly and scarce, support for energy development goes up.

The same has been found for nuclear energy in particular. After controlling for the accident at Three Mile Island, Smith found that support for building nuclear power plants correlates with inflation and high gas prices.[127] A more recent analysis comprising nearly a half-century of polling data came to a similar conclusion. Gupta and colleagues looked at the relationship between public support for nuclear energy and energy security while controlling for the three major accidents. They found that a central dynamic in historical shifts in public support for nuclear energy is the countervailing forces of accidents and energy security, concluding that "energy security risk explains approximately as much of the variation in support for nuclear energy as does the cumulative impact of all three of the nuclear accidents."[128]

Recent polling data corroborated the importance of energy security in support for nuclear. According to the 2016 University of Texas at Austin Energy Poll, the top reason for supporting nuclear power is that it provides a "steady, reliable source of energy."[129] A full 80 percent of respondents supporting nuclear cited this as their top reason, compared with only 20 percent who cited its lack of emissions. The same trend was found by Jenkins-Smith and colleagues based on a 2016 survey, although nuclear's other benefits did not lag all that far behind.[130] International research has turned up the same phenomenon. A 2011 survey among the Swiss public found that energy security was a better predictor of support than risk perception.[131]

Overall, the data suggest that public support for nuclear energy is significantly shaped by the perceived trade-off between energy security and nuclear safety. When the danger of energy security seems clear and present, the safety dangers of nuclear seem more acceptable.

Research on benefit perception offers an important corrective to simplistic and deterministic accounts based on fear. Although lessening the public's fear of nuclear energy would surely help build support, some commentators and advocates have arguably become more fixated on public fears than the public is. Aversion to nuclear energy is not an immovable obstacle rooted in humans' innate irrationality. Rather, the relationship between perceived risks and benefits is bidirectional. How people feel about the benefits of nuclear energy is as important as how they feel about the risks. Nuclear fears are neither innate nor irrational but rather contingent and contextual, and hence, subject to change.

KEY POINTS

Nuclear energy is a fearsome technology. Study after study have underlined the fact that the public considers nuclear energy unsafe, often intensely and unacceptably so.

The public believes the risks it poses are "involuntary, unknown to those exposed or to science, uncontrollable, unfamiliar, catastrophic, severe (fatal) and dreaded."132

Accidents play a major role in public risk perception and support for nuclear energy. Fear of accidents correlates with opposition to nuclear power, and accidents mark inflection points in public opinion and are major drivers of longitudinal trends. But they aren't the only thing that matters, and they don't matter uniformly.

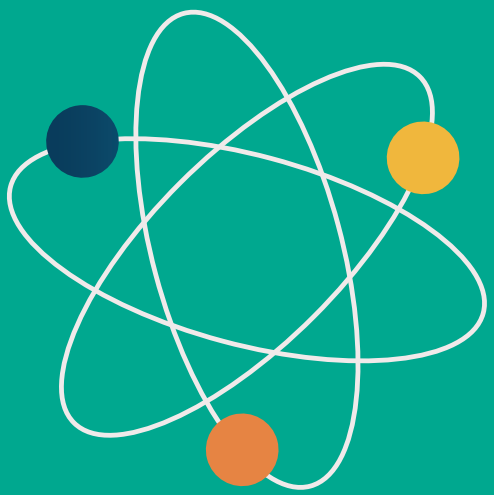
Although fear is doubtlessly integral to public opinion on nuclear energy, the risk perception literature can easily be misinterpreted to mean that nuclear energy's high risk perception is the inevitable by-product of the technology's inherent features. In fact, risk perception of nuclear energy has evolved significantly in some ways.

A fixation on perceived risk misses the importance of perceived benefits. In fact, acceptance of nuclear energy is better predicted by perceived benefits than perceived risks. Further, perceived risks and benefits are deeply entwined psychologically: the more beneficial something seems, the less risky it appears.

Research on benefit perception offers an important corrective to simplistic and deterministic accounts based on fear. While lessening aversion to nuclear energy would surely help build public support, some commentators and advocates have arguably become more fixated on public fears than the public is.

Many decades of public opinion research suggest that reliability is what the public most values about nuclear energy. Polling finds that the top reason for supporting nuclear is that nuclear power provides a steady, reliable source of energy. Historically, research has found that energy security risk has boosted support for nuclear about as much as accidents have suppressed it.

CULTURAL WORLDVIEWS AND ELITE CUES — HOW NUCLEAR BECAME POLITICAL

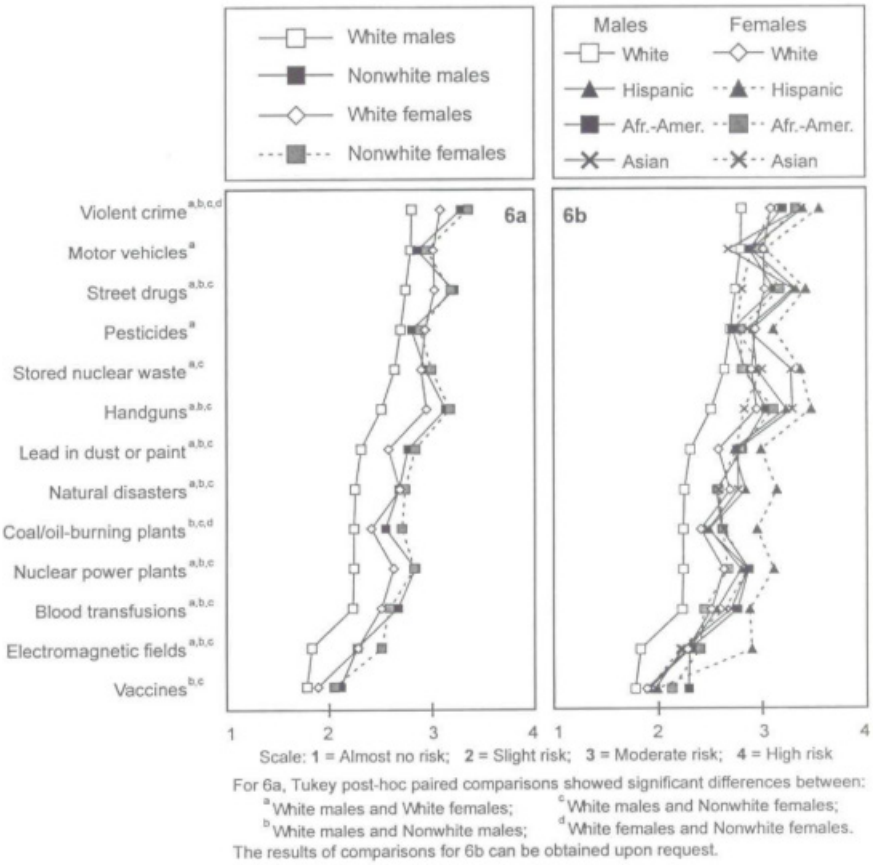


Fewer women support nuclear than men, and this sizeable gender gap has arguably been the most persistent feature of public opinion about nuclear energy over many decades. The gender gap predates the fall in public support for nuclear energy in the late 1970s and is entangled with most other significant features of public opinion about the issue, including partisanship, ideology, and ethnicity.

The gender gap has been found consistently across national contexts, including the UK,[133] Sweden,[134] France,[135] Japan,[136] Australia,[137] and South Africa.[138] In the United States, White men are much more likely to support nuclear energy than are any other group. This has led some to argue that "gender gap" is a misnomer. The gender gap, some scholars have argued, is better described as the "White male effect." But the gender gap persists across most other demographic categories. Republican men are more likely to support nuclear energy than are Republican women, and African American and Hispanic men are more likely to support nuclear energy than are African American and Hispanic women. Both college-educated men and men who dropped out of college are more likely to support nuclear energy than are their respective female counterparts.

Nuclear is not unique in this regard. Research over the last several decades has found that men —particularly White men — tend to be less concerned about a remarkable multiplicity of hazards,[139,140] including environmental risks (e.g., ozone depletion and climate change), health risks (e.g., cigarette smoking and drinking alcohol), non-technological risks such as natural disasters, and violence (terrorism and gun violence).[141,142]

In theory, the gender gap could be attributed in part to biological sex differences. Males, after all, have been found to take more risks than females overall.[143] But differences among males suggest that biological factors alone cannot account for the observed differences. African American and Hispanic men, for instance, are much less likely to support nuclear energy than are White men. By contrast, White women are about as likely as African American and Hispanic men to support nuclear. And even among White men, there is significant variation in nuclear risk perception. A 2000 study found that highly risk-skeptical White men comprise around 30 percent of the White male population.[144]



The "White male effect" of risk perception across a wide range of hazards.[145]

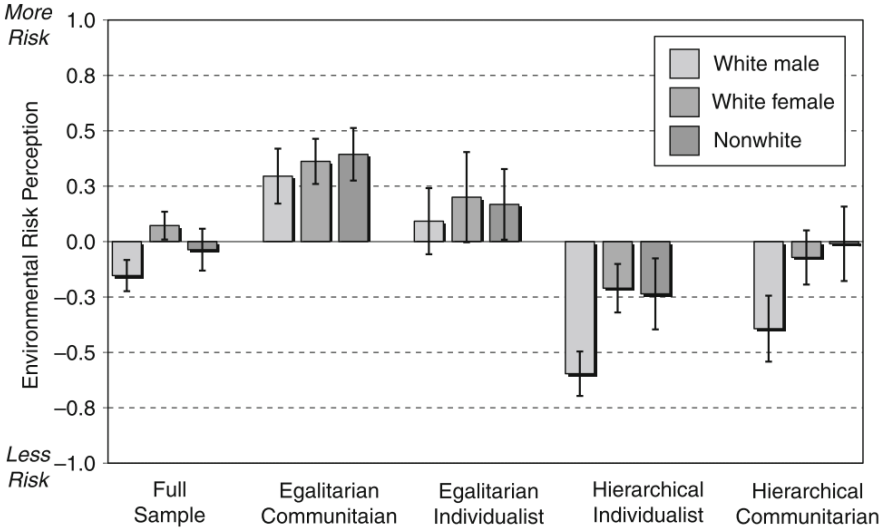
Cultural Worldviews

Support for and opposition to nuclear energy clearly sit at the intersection of demographics, ideology, and identity. Supporters are more likely to be conservative, older, White, and male. Opponents are more likely to be liberal, younger, non-White, and female. From the late 1970s onward, the decline in support for nuclear energy coincided with a period during which attitudes about nuclear energy came increasingly to be mapped onto broader cultural conflicts related to social authority, inclusion, and equity.

Risk perception, in other words, cannot be disentangled from worldview. Who we believe controls technologies like nuclear energy, who we perceive to benefit from them, and who is subject to their risks, real and perceived, have a lot to do with whether we consider the risks to be acceptable, irrespective of their magnitude.

The ideological and demographic divisions around nuclear energy reflect underlying differences in cultural worldviews. Cultural theory suggests that people are prone to fear activities or technologies that they see as threatening to their worldview and way of life while dismissing risks associated with activities that are central to their worldview.

Dan Kahan mapped risk perception of nuclear energy and environmental hazards onto two dimensions: a "hierarchical—egalitarian" dimension that reflects people's beliefs about the acceptability of social stratification and differential social roles and power, and an "individualist—communitarian" dimension that captures differences in beliefs about how subject an individual should be to social constraints, including government interventions. Kahan concluded that those who hold hierarchical and individualist values are prone to dismiss these risks because to acknowledge them would undermine strongly held beliefs about the autonomy of markets, the competence of technocratic authorities, and the importance of economic growth. Those who rate high on egalitarian and communitarian values, by contrast, are more sensitive to environmental risks precisely because they are more skeptical of markets, traditional social and economic elites, and economic growth. In summary, Kahan found that almost all the gender and racial variations in attitudes toward nuclear energy and other environmental risks can be explained by cultural worldview.[146]



Relationship between cultural worldview and environmental risk perception, including nuclear.[147]
Note: *Y*-axis represents *z*-scores.

At the same time, the power and privilege of White men as a group — not just differences in worldview — are also at issue. After all, a hierarchical worldview justifies greater societal power and privilege for White men, and the worldview survey explicitly asks about race and gender. Indeed, Kahan found that even when men and women hold equally strong hierarchical values, men are less concerned with environmental risk, in theory because of their greater personal stake in maintaining existing social hierarchies.[148]

But how did nuclear energy, a technology invented little more than 50 years ago, become so strongly implicated in the contemporary landscape of cultural worldviews and conflict?

Elite Opinion

Despite finding consistent divisions along demographic, partisan, and cultural lines, research on worldviews and attitudes toward nuclear should not be misconstrued to suggest a public composed of hyperpolarized ideologues. In fact, foundational political science research emphasizes that most people are largely free of stable, coherent ideologies.[149] Although the public may have become somewhat more ideologically sophisticated over the last 50 years,[150] possibly in connection with the increasing political polarization of American society, a half-century of opinion data have largely confirmed this finding of "ideological innocence."[151,152] That is, most people don't form attitudes toward individual policy matters by forging their own conceptual connections between the issue and their abstract political commitments, nor do such commitments reliably ensure consistent attitudes across issues and over time. Further, the role of ideology in forming opinions is invariably smallest for issues with low political salience, such as nuclear, since the public has little opportunity to consider what specific view their ideological commitments would dictate.

Even so, worldviews and ideologies are valuable in understanding attitude formation about nuclear. Their highest value may be in explaining attitudes among elites, experts, and activists — those who have formed the strongest connections between their worldviews and specific policy positions. And this is great value indeed. While a large body of research attests to the importance of public opinion in shaping public policy outcomes,[153] so-called elite opinion has been shown again and again to be highly influential over what the public thinks about an issue.[154,155] In fact, trends in elite opinion formation often precede corresponding shifts among the public[156] — most notably, trends in polarization.[157,158] Cues from political elites (from both one's own party and the opposition) may be the primary shortcut that members of the public use to determine

their policy views. The position of one's political party on an issue has been shown to dictate one's view more strongly than one's broader political beliefs or the policy itself.[159,160]

The nature of public and elite opinion is different. The stable, well-formed ideologies that are largely absent from the public are the defining characteristic of the thinking of political elites. Indeed, the "ideological innocence" of the public has been so captivating and disconcerting to political scientists, political psychologists, and pundits precisely because it sharply contrasts with their own ideological sophistication and preoccupation.

Mastering an ideology — mapping abstract ideological commitments onto individual issues and establishing coherence among opinions across a range of issues — is an impressive intellectual achievement, one that depends on a degree of knowledge, political sophistication, and motivation that is less common among the general public than it is among political elites. Worldviews, after all, do not uniquely determine a particular policy position on a given issue, nor is there necessarily only one worldview that is consistent with a given policy position. Instead, these connections must be forged.

The fact that public nuclear attitudes are not firmly tied to deeply rooted worldviews points to their mutability, at least in theory — an optimistic implication for clean-energy advocates. But this potential for shifting attitudes, history teaches, lies mostly in the hands of the kinds of people who have shaped how the public has come to view the technology in the first place.

The more an issue becomes a point of debate among elites, the more salient it becomes for the public. And this conflict prompts the public to take sides in line with their political group membership, based on signals from both the politicians they identify with ("in-group cues") and those they oppose ("out-group cues"). Climate change provides a case in point. Elites were instrumental in coding it as a liberal issue — one associated with precisely the kinds of policy reforms that liberals had been advocating for decades, and therefore a threat to a conservative vision for the country.[161] The partisan polarization about climate change among the public lagged the rise in debate among elites and steadily grew over the next several decades.

Evaluating how entrenched opinion on nuclear may be, and thus how subject to change, may be more a question of how elites have arrived at their views about nuclear energy and what might be necessary for them to change their minds.

Egalitarian Elites and the Politicization of Nuclear Energy

The polarization of public opinion on nuclear has a long history, beginning with the anti-nuclear movements in Europe and the United States that emerged in the 1960s and '70s.[162] The anti- nuclear movements were thoroughly ideological, concerned as much or more about political power as nuclear power. Opposition to nuclear was tied up with distrust of institutions perceived to be inegalitarian. As Jerry Mander wrote in 1978, "If you accept nuclear power plants, you also accept a technoscientific-industrial-military elite. Without these people in charge, you could not have nuclear power."[163] Outspoken nuclear opponents of that era did not want these people in charge.

Baumgartner and Jones offer a compelling account of how the venue for debate about nuclear energy in the United States progressively shifted from pre-1965 to 1979 from elite to public (figure below). The chronology is clear-cut — elite nuclear opponents highlighted dissent about issues of nuclear safety among marginal experts, media coverage increased and became more negative, Congress and the courts became involved, and finally, public opinion responded. As they write, "Far from anticipating or causing the changes in venue which we have identified with respect to nuclear power in the United States, public attitudes toward nuclear power responded to elite activity."[164]

TRACING THE DEMISE OF A POLICY SUBSYSTEM: VENUE SUCCESSION FOR NUCLEAR POWER

Date	Event	Source
Pre-1965	Tight Control by AEC/JCAE; positive images	Hamm 1983; Figures 1–3
1965	Internal questioning of safety at AEC	Campbell 1988
1966	Slope of regulatory activity becomes positive	Figure 2
	Amount of media coverage begins to expand	Figure 1
1968	Negative press coverage exceeds positive	Figure 1
1969	Negative Congressional hearings exceed positive	Figure 3
1971	Court of Appeals rules that EIS applies to AEC	Campbell 1988
1972	Union of Concerned Scientists begin to intervene in licensing hearings	Campbell 1988
1972	California antinuclear initiative	Kuklinski et al. 1982
1973	Nader's court suit	
1974	AEC reorganized into NRC and ERDA	Campbell 1988
	Only 15 Nuclear plants ordered after 1974	
1975	Nuclear stock prices fail to recover after nadir	Figure 4
	Congressional hearings per year exceed 40	Figure 3, Table 1
1977	Joint Committee on Atomic Energy disbanded	
1978	Public opinion on building local plants becomes negative	Rankin et al. 1984
1979	Three Mile Island	
1979	Public opinion on nuclear power becomes negative	Rankin et al. 1984

Evolution of controversy over nuclear energy from elite to public debate, pre-1965–1979.[165]

In their account, the shift in venue from elite to public sphere was something approaching a deliberate strategy by nuclear opponents. It also reflected a more general process in political conflicts: "a pluralist system provides opportunities for those on the losing side of a policy debate to find a more favorable venue for the consideration of their issue."[166]

To gain the upper hand, nuclear opponents needed to shift the image of nuclear energy so that it could galvanize key constituencies — from a technical issue and the purview of experts to one of urgent public consequences and deep social meaning. The success of the anti-nuclear movements in recentering the public's focus on nuclear energy — from economic growth, progress, and energy independence to fears of apocalyptic accidents and repressive social authorities — has been deftly and comprehensively narrated by notable scholars, including Weart, Balogh,[167] Joppke,[168] Nelkin and Pollack,[169] and Wellock.[170] Their accounts all emphasize the influence of prominent elites in catalyzing this shift in image.

Opponents of nuclear succeeded by finding trusted elites to contest the then-mainstream acceptance of nuclear energy among scientists, policy makers, and regulators. Most instrumentally, anti-nuclear activists found scientists who did not share the majority view about nuclear energy. They were often life scientists, but they were also physical scientists who had broken with the Cold War political consensus over concerns about escalating nuclear weapons testing and proliferation.

The role of these scientists was not the education of the public about technical matters. Rather, they traded on their expertise while making plain that their convictions about nuclear energy flowed from a far-reaching critique of American corporate capitalism. "Who owns the air? Who owns the water? Who owns the earth? Who controls our resources?" Barry Commoner, a cellular biologist and leading ecologist of the time, thundered at a 1979 anti-nuclear rally: "The electric utilities, the oil companies — they decide whether we get radiation with our power. They decide whether we get carcinogens in our food…"[171] In this way, anti-nuclear elites and activists challenged mainstream scientific claims about nuclear energy, amplified messages from dissenting experts, and leveraged broader dissatisfaction among the public. They succeeded in mapping the issue onto deeper and more strongly held convictions about the social and cultural changes that were dividing the public in the United States and across the developed world.

Whereas those most familiar with the technology have tended to be the least averse to its risks, the further one gets from a detailed knowledge of nuclear technology, the more risk-averse one tends to become, even within the sciences. Studies find that STEM professionals tend to perceive

nuclear to be riskier than do nuclear experts, as do university-based scientists versus those who work at federal or private laboratories, and as do life scientists versus physical scientists.

So it was life scientists based in the academy and outside of government who were the primary spokespersons for the anti-nuclear and environmental movements. Not coincidentally, this cohort held strongly egalitarian and communitarian values. This ideological tendency was so strong that Jane Flegal found that climate researchers held such extreme egalitarian/communitarian values that they could not even be placed on a map reflecting the diversity of cultural worldviews among the general public.[172]

Similar dynamics appear to have influenced media coverage. Historically, media coverage of nuclear energy has been tilted heavily toward accidents and fears about nuclear weapons.[173] While this may simply be a function of the age-old adage that "If it bleeds it ledes," recent analysis of media coverage by political scientist Eric Merkley encompassing nuclear energy and a range of other technical and scientific issues (e.g., vaccines, GMOs [genetically modified organisms], and climate change) found that coverage of nuclear energy consistently diverged from mainstream scientific assessments of risk and reliably emphasized marginal disagreements over robust scientific consensus. Coverage of climate change, by contrast, was consistently more accurate in its portrayal of expert opinion.[174] This observation aligns with research showing that media coverage is mostly a function of elite cues.[175]

None of these findings suggests that either the anti-nuclear movement, the scientific community, or the media has engaged in a bad-faith conspiracy. To the contrary, the criticisms of nuclear energy and American society were sincerely held and often empirically grounded. Rather, the point is that the anti-nuclear movement very effectively aligned its arguments with the egalitarian worldviews of opinion leaders — particularly politically active scientists and mainstream journalists — and that elite opinion drove broader public opinion more than reflected it.

Elite cues have almost certainly contributed to support for nuclear energy among Republicans and conservatives as well. This may have resulted in part from strong support for nuclear energy by Republican presidents. President Reagan increased funding for nuclear energy by nearly 40 percent during his administration,[176] even as he cut funding for solar and conservation by two-thirds and slashed the budgets of virtually all other federal energy programs. The administration of President George W. Bush similarly touted a nuclear renaissance while withdrawing from the Kyoto Protocol accord[177] and opposing policies to regulate carbon emissions domestically. Conservative support was further boosted by the fact that opposition had become strongly associated with liberal, Democratic, and environmental leaders.

KEY POINTS

Fewer women support nuclear than men, and this sizeable gender gap has arguably been the most persistent feature of public opinion about nuclear energy over many decades. It holds across many demographic categories in the United States and a number of surveyed countries.

The starkest demographic divide is between White men and the rest of the population. Nuclear is not unique in this regard. White men tend to be less concerned about a remarkable multiplicity of hazards, environmental and non-environmental, which has been referred to as the "White male effect" on risk perception.

The White male effect and other demographic and ideological divisions around nuclear energy reflect underlying differences in cultural worldview, given that people are prone to fear activities or technologies that they see as threatening to their worldview while dismissing risks associated with activities that are central to their worldview.

Dan Kahan found that almost all the gender and racial variation in attitudes toward nuclear energy and other environmental risks can be explained by cultural worldviews. Those with "hierarchical" and "individualist" worldviews are prone to dismiss these risks because they undermine strongly held beliefs about markets, technocratic competence, and economic growth.[178] Those with "egalitarian" and "communitarian" worldviews, by contrast, are more sensitive to environmental risks precisely because they are more skeptical of markets, traditional social and economic elites, and economic growth.

The greatest value of worldviews and ideologies in understanding nuclear attitudes may be in explaining attitudes among elites, experts, and activists, who have more coherent and stable political ideologies than members of the lay public. Cues from political elites — from both one's own party and the opposition — may be the primary shortcut that members of the public use to determine their policy views.

Nuclear opponents succeeded by finding dissenting scientific elites who connected anti-nuclear arguments with a far-reaching critique of American capitalism and broader egalitarian antiestablishment sentiment. Life scientists with strongly egalitarian and communitarian values were the primary spokespersons for the anti-nuclear and environmental movements.

Elite cues have almost certainly contributed to support for nuclear energy among Republicans and conservatives, especially owing to strong support for nuclear energy from Republican presidents. Reverse cueing — in response to opposition to nuclear energy from liberal, Democratic, and environmental leaders — likely contributes to conservative support as well.

HOW "RENEWABLES" MADE NUCLEAR SEEM LIKE FOSSIL FUEL

Through roughly the first two decades after the first commercial nuclear reactor went online in 1957, the Shippingport Atomic Power Station, nuclear energy was not a particularly controversial technology. It was broadly supported across partisan lines. It was widely viewed positively, associated with the future, prosperity, and American scientific and technological prowess.

During the late 1970s and early 1980s, however, support for nuclear energy fell dramatically. Its advocates and opponents increasingly sorted themselves ideologically and by political party. Energy resources, previously perceived as abundant, were viewed as scarce; energy consumption, once seen as a blessing, was something to be minimized; and forward-looking progressives and technologists increasingly looked to renewable energy, not nuclear power, as the technology of the future.

While it is clear that increasingly polarized public attitudes about nuclear energy followed elite opinion, that tells us little about why environmental elites were so successful at shifting attitudes. They undoubtedly leveraged the way risk perception works, drew attention to nuclear accidents, and capitalized on evolving cultural worldviews. But to do this, they needed to develop a powerful set of new cognitive frames, concepts, narratives, and categories for both nuclear energy specifically and energy issues more broadly, including fossil fuels and renewables. Well before Three Mile Island, environmentalists had begun to deploy these new cognitive structures, allowing them to tap into the egalitarian values of baby boomers raised in the abundance of the postwar economic boom, concerns about energy scarcity after the Arab oil embargo, and fears about nuclear safety.

Understanding the new cognitive structures that came increasingly to shape and define energy debates in the United States (and Europe) and why they have been so powerful offers a final, critical window into public opinion about nuclear energy, how it has evolved, and in what ways it might be amenable to change.

Two Kinds of Energy

Most polling about energy has tended to ask Americans about how they feel about specific energy technologies without delving into the broader contexts in which they think about energy. Given how little most Americans appear to think about energy, it should not surprise us to learn that they actually tend not to think about energy technologies individually in the way that energy experts and policy wonks often do. Rather, they compare energy sources with each other in relation to characteristics they value.

Drawing on a decade of survey research conducted between 2003 and 2011, Ansolabehere and Konisky suggested that most people use what they dub a "consumer model" to evaluate energy choices, determining them based on valued attributes.[179] Paramount among those attributes, they argued, are cost and harm (or, put another way, economic cost and social cost). While it might seem trivially obvious that Americans want cheap and clean energy, they argue that this basic orientation well captures the systematic variation in the public's attitudes toward energy sources.

Ansolabehere and Konisky's evidence is that beliefs about the comparative costs and harms of energy sources are better predictors of attitudes than any other variable — better than the demographic lines along which public opinion on nuclear is usually sliced and diced: party identification, race, gender, age, education, income, and region.[180] They found that partisanship and demographics explain a modest fraction, but perceived costs and harms explain some 75 percent of the variance in energy preferences.[181] And while support for individual energy sources shifted over time, along with shifting beliefs about their costs and harms, the desired attributes themselves had not. The authors argue that the public establishes their energy preferences by deciding what trade-off between perceived cost and harm is optimal — that is, how much harm they are willing to avoid at what cost.

In theory, Ansolabehere and Konisky's "consumer model" of energy preferences would give rise to four possible categories: cheap and clean, cheap and dirty, expensive and clean, and expensive and dirty. For most people, however, there appear to be only two types: cheap and clean, and dirty and expensive. Specifically, the public believes that fossil fuels have high economic and social costs and that solar and wind do not. They hold this belief despite the fact that, until recently, fossil fuels were much cheaper than solar and wind. Consequently, public support for renewables is far higher than for fossil fuels. Sixty percent support bringing more renewables online compared with only 30 percent for fossil fuels.[182]

Ansolabehere and Konisky are likely correct that the public cares primarily about these two energy attributes. But there is little evidence, even in their own data, that most people perceive a potential trade-off between them. While Ansolabehere and Koninsky would likely object to this interpretation, their findings suggest that what they have posited as a two-dimensional model of energy preferences is, cognitively speaking, actually a binary categorical scheme: "cheap and clean" versus "dirty and expensive" — i.e., good and bad.

How the "Renewables" Category Changed Energy Cognition

Ansolabehere and Koninsky raise a puzzling question: Why do people think fossil fuels are more expensive than solar and wind, when the opposite was true until recently? The explanation, they suggest, is simply incorrect information.[183] However, they also speculate that people assume that renewables are cheap "probably because the sun and wind are natural and ever-present" and therefore inexpensive.[184]

They are surely correct that perceptions of scarcity and abundance play a role in perceived cost. Scarce means expensive in the logic of capitalism, and often in people's daily lives. The sun and wind are inexhaustible; ergo, solar and wind energy are cheap to produce. But they fail to notice the role of the constructed "renewables" category in marrying fossil-fuel extraction to pollution in people's minds.

The development of "renewables" as a category has been so successful that it is now accepted by both opinion elites and the public at large to be a "natural kind": a mirror of reality rather than a construct that embeds within it an argument and a value system. The category can masquerade as a natural kind in part because it seemingly admits to a simple definition that fully determines category membership, one that even children can understand. The US Department of Energy, targeting kids, puts it this way: "Renewable energy comes from things that won't run out — wind, water, sunlight, plants, and more. These are things we can reuse over and over again."[185]

The answer to the puzzle identified by Ansolabehere and Koninsky can be found in the cognitive structure of the renewables category. Wind and solar energy are clean because they don't involve digging fuel out of the ground or combusting it and don't produce air pollutants. They are cheap because they are, by definition, ubiquitous and inexhaustible and cannot be owned. Fossil fuels, by contrast, are perceived to be expensive because they are scarce, exhaustible, and can be owned by private interests. And they are perceived as dirty because the fuels must be dug out of the

ground and burned. It is the logic of the category (its "entailments" in the lexicon of cognitive science) that gives rise to perceptions of cost, not incorrect information.

Like most cognitive categories, especially value-laden ones, the coherence and seemingly sharp boundaries of renewables quickly falls apart on closer examination. Although the sun and wind themselves are unlimited over human timescales, their intermittency and other constraints limit the efficiency with which they can be captured over vast geographic areas and converted into useful energy.

The renewables category also puts the material requirements of large-scale deployment of solar and wind in the cognitive background. The extraction of iron, silicon, and rare-earth minerals to produce solar panels and wind turbines are not cognitively salient because they are not fuels that are transformed into energy, nor is pollution mentally associated with those inputs. But as *The Bulletin of the Atomic Scientists* notes: "Unless you're planning to live without electricity and motorized transportation, you need more than just wind, water, sunlight, and plants for energy. You need raw materials, real estate, and other things that *will* run out one day. You need stuff that has to be mined, drilled, transported, and bulldozed — not simply harvested or farmed. You need nonrenewable resources."[186]

Where does that leave nuclear? In one sense, it is off the cognitive map created by "renewables" versus other energy sources. Its fuel is extracted but not combusted. Uranium is plentiful, if not inexhaustible. It does not pollute, and at least until relatively recently, produced electricity at costs well below those of wind and solar energy. But by creating a category for clean-energy sources that marries extraction with pollution, environmentalists and their allies encouraged the impression that nuclear belongs in the "dirty and expensive" category along with fossil fuels.

The strategy worked. Much of the public sees nuclear energy as more like fossil fuels than renewable energy. Nuclear has polling numbers comparable with fossil fuels,[187] and survey participants commonly ascribe to nuclear most of the key qualities commonly ascribed to them. For instance, about 50 percent categorize nuclear as "old,"[188] and significant percentages of survey respondents tell pollsters they believe that nuclear reactors emit greenhouse gases. Ansolabehere and Koninsky also found that the public views nuclear as expensive, as it does fossil fuels, and these beliefs have remained consistent over time. In fact, between 2002 and 2011, nuclear energy was considered the second most expensive energy source — slightly less expensive than oil, but more expensive than natural gas, coal, hydroelectric, solar, and wind power.[189]

So powerful is the cognitive category environmentalists constructed that empirical claims about the cost and environmental impacts of renewables are unlikely to find much purchase among most elite audiences or the public at large. The category itself — what it highlights, backgrounds, and entails — mostly trumps empirical evidence.

The Intersection of Cultural Theory and Cognitive Science

The boundaries of the "renewables" category have been debated. For some, biomass doesn't qualify, for example, because burning biomass releases greenhouse gases and air pollutants even though it meets the common definition of a fuel with essentially limitless supply. Such debates underline the fact that there is more to the renewables category than the official definition. Debates about category membership are ubiquitous and an inevitable artifact of human cognition and social life, but they are more common among categories that embed value judgments and have social or ideological meaning,[190] like "science" or "freedom."

The divergence in attitudes toward nuclear and renewable energy was marked not simply by shifting attitudes toward their economic and social costs. The polarization and decline in support for nuclear energy were attended by a broader decrease in public trust in social authority and changing attitudes toward technology and the environment.

As egalitarian and communitarian worldviews became more prominent, an underlying cognitive structure for energy grew up along with them. This structure served as a foundation for the cultural meanings that have been projected onto renewable energy. It cleaved the complicated world of energy systems, energy technologies, and energy economics into a fundamentally dichotomous and oppositional cognitive framework, dividing egalitarian and communitarian energy preferences from those of hierarchicalists and individualists. A preliminary cognitive—linguistic analysis of elites' pro-renewable energy and anti-nuclear argumentation[191] elucidates this framework: two categories of energy sources that create links between two constellations of attributes.

The first category, which includes solar and wind, comprises energy sources that are understood as small, simple, understandable, safe for humans and the environment, comparatively inexpensive, decentralized, flexible and modular, forward-looking, symbolic of technological innovation, abundant, and natural or in harmony with nature. The second category, including fossil fuels and nuclear, is defined by precisely the opposite features.

Type 1: "Renewables"	Type 2: Fossil Fuels and Nuclear
• Small	• Big
• Simple and understandable	• Complex and obscure
• Safe for humans	• Dangerous to humans
• Harmless to environment	• Harmful to the environment
• Cheap, cost-effective	• Expensive
• Decentralized	• Centralized
• Flexible, movable, and particularized	• Fixed
• New, innovative, and future-oriented	• Old
• Abundant	• Scarce
• In harmony with nature	• Out of harmony with nature
• Developed and run by small companies, start-ups, entrepreneurs, or communities	• Developed and run by government scientists, the military, or corporations

Not only do these categories have more to them than risks and benefits, or costs and harms, they are more than mere laundry lists of opposing features. Cognitively, several features cluster together: small, simple/understandable, controllable, and flexible/movable/particularized. These features describe something familiar, approachable, and amenable to interaction. Renewables are cheap in this framework because they are "natural," meaning that they do not have to be mined, refined, or transformed. The fuel, such as it is, is abundant and free, and because renewables are small, flexible, and simple, you can situate them anywhere. In addition, they are seen as "futuristic" because they are small (miniaturized), modular, manufactured, and decentralized.

Technologies that are small, controllable, and flexible are safer since they are less likely to spin out of control. They are also understandable, which means that their operation does not require outsourcing control to experts who must be both able to understand complex technology and trusted to deploy it in the public interest. And they can operate in harmony with nature.

Appeals to what is natural are ubiquitous in debates over how humans should live and how societies should be organized, including environmental debates, in which the concept of naturalness is most often deployed in contrast with some form of human action. Renewables are often conceptualized as the quintessentially natural energy source: solar and wind merely harness nature's flows, absorbing the energy that nature creates on its own.

"Meddling with nature," by contrast, is the catch-all explanation for all environmental problems. Nuclear energy, like genetic engineering, involves modifying a fundamental building block of our world. The tremendous technical difficulty of achieving nuclear fission, the amount of energy released compared with the size of the atom, and the destructive potential of nuclear reactions are all taken as evidence of its unnaturalness — something that humans were never intended to do.

While there is little empirical research on how concepts of "unnaturalness" inform anti-nuclear attitudes, what little there is attests to its substantial influence. In a study of both citizens and politicians in Sweden, the perception that nuclear energy is unnatural was a much better predictor of risk perception than the traditional psychometric dimensions of dread and unknownness.[192]

This categorical scheme has also encoded an unflattering distinction between "simple" solar and wind technology and "complex" nuclear energy. Anti-nuclear advocates have maligned nuclear power as a very complicated way "just to boil water,"[193] an epigram popularized by Ralph Nader. The Union of Concerned Scientists wrote that although "[t]he basic principle ... is simple: the heat produced by a controlled nuclear reaction is used to create steam pressure that drives a power-generating turbine ... the technology required to implement this principle efficiently and safely is enormously complex."[194]

In this view, nuclear reactors are large, complex machines hidden away behind acres of concrete and tons of steel, operated by armies of lab coat—clad scientists and engineers. This picture contrasts with "simple" renewable energy technologies. So-called soft-energy pioneer Amory Lovins, for example, described renewable energy as "easy to understand and use without esoteric skills" and "accessible rather than arcane." Mark Jacobson, advocate of renewables-only decarbonization, described wind turbines as "merely poles in the ground."

In summary, renewables are conceptualized as not only natural but also small, simple, and controllable. These are all features of what cognitive science has called "basic-level categories," which have a special cognitive distinction. "Dog" is a classic example of a basic-level category, compared with the subordinate category of "Rottweiler" or superordinate "animal." Basic-level categories are cognitively primary: children learn them first, and they appear most frequently in language. They also bear the most direct relationship to daily life, as one interacts with members of basic-level categories through well-rehearsed physical actions (e.g., there is a common action for petting dogs in general, not different actions for individual breeds). And when asked to name an object, its basic-level classification comes to mind first.

Elites' arguments supporting renewables are littered with invocations of basic-level features. Although basic-level categories or features don't inherently inspire a positive evaluation, their psychological primacy means they carry a sense of the familiar and approachable. This readily explains the fact that energy sources conceptualized as having basic-level features are also considered safe to humans and harmless to the environment.

Even though solar and wind energy do not necessarily qualify as basic-level categories in a technical sense, it is worth pointing out that people do indeed have deeply embodied experiences with the sun and wind, and many have experience with solar panels. The same cannot be said about atoms as materials for fission, or about nuclear reactors.

In addition to basic-level features having universal resonance, the key attributes in the renewables category resonate most strongly with a communitarian and egalitarian vision in which communities can opt out of the systems they find abhorrent. In this vision, the scale, impersonality, hierarchy, and inequities of modern society are replaced by intimacy, self-sufficiency, mutual responsibility, equality, and harmony. This vision can be realized only if some unspecified "we" can generate energy.

The personification of different energy sources likewise embodies the egalitarian and communitarian version of the us-versus-them dichotomy. Representing "them" is the government scientist, member of the military, or corporate CEO — members of powerful groups of the established order whose work feels distant, inaccessible, and mysterious. By contrast, representing "us" are members of the "community" — experts, certainly, but ones who are working to better the world rather than maintaining the status quo: entrepreneurs, innovators, inventors, and members of civil society who embody the qualities of enthusiasm, discovery, freedom, possibility, and social responsibility.

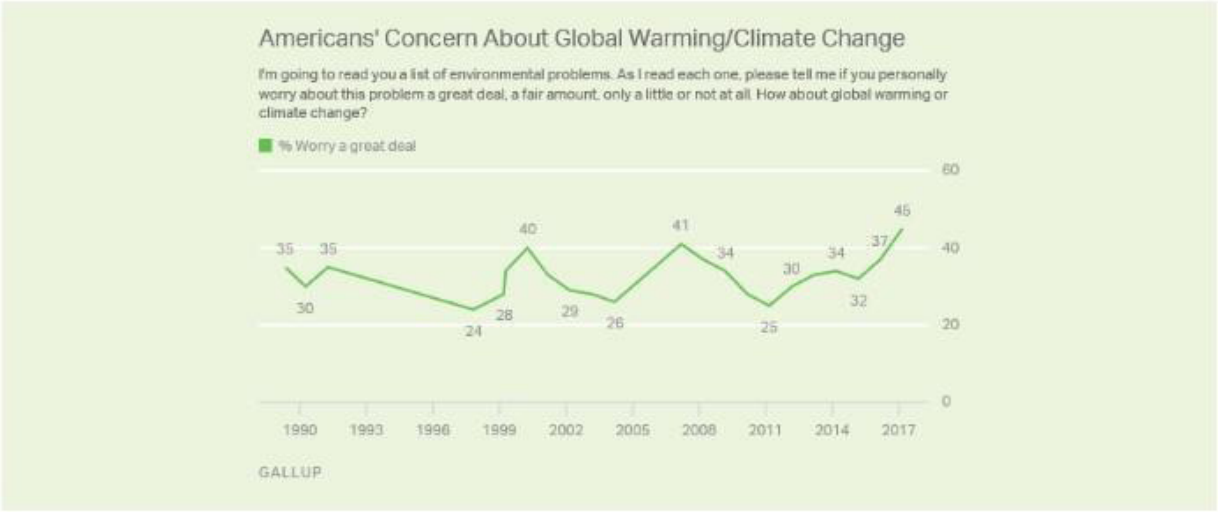
The Complex Relationship Between Attitudes About Climate Change and Nuclear Energy

Well before global warming emerged as a public issue in the early 1990s, the environment that defined public and elite opinion about nuclear energy was shaped by concerns about energy scarcity, the Cold War nuclear arms race, and conventional air pollutants in the decades after World War II. In the 21st century, new concern about climate change has led some to suggest that a large shift in attitudes toward nuclear energy might follow, particularly among those most concerned about environmental problems.

To date, however, evidence for this proposition is at best anecdotal. Several prominent environmental advocates have publicly embraced nuclear energy. But the continuing low salience of the climate issue and its strong coding along cultural and identity lines suggest that concern about climate change may not catalyze a significant shift in nuclear attitudes, at least absent strong messages from prominent climate activists or climate-concerned lawmakers.

Abundant research on public opinion and climate change calls into question the likelihood that concern about climate change is sufficiently acute to motivate significant behavioral or attitudinal change in general. The climate is a low-priority issue for the public at large[195] and even ranks fairly low on the list of environmental issues the public is most concerned about.[196] Willingness to pay — which indicates the degree to which concern actually translates into acceptance of the trade-offs that meaningful action requires — is also arguably low.[197]

It is true that climate concern has been on the rise during the past five years, a trend that has received much media attention, with pronouncements that the surge is "unprecedented."[198] However, such interpretations fail to consider that the current level of climate concern is roughly where it was in 1990, 2000, and 2008.[199]



Apparent thermostatic shifts in climate concern in the United States, 1990–2017.[200]

Popular wisdom holds that the peaks and valleys of climate concern are tied to economic cycles (that people care less about the environment in downturns), but research has shown that politics has a stronger impact.[201] And contemporary climate politics certainly furnishes a plausible hypothesis for the recent rise in climate concern, which has come mostly from Democrats. Since 2015, Pew found a 22-point surge since 2016 in the share of Democrats saying that climate change should be a top priority for the president and Congress, with little movement among Republicans.[202]

Democrats are following the lead of their politicians, who have made climate change central to the party's brand and agenda, and are displaying a "thermostatic" response to President Trump's ostentatious climate change skepticism — that is, Democrats may be reporting to pollsters greater concern because they feel that the president cares too little, even if they don't consider climate change a high-priority issue and aren't willing to accept trade-offs. In a thermostatic account, "I'm very concerned" simply means "Politicians aren't concerned enough," and there is plenty of evidence to suggest that what the public considers "enough" is fairly modest, at least in relation to the scale of action needed to make a meaningful dent in carbon emissions. This explanation is consistent with the fact that the political polarization of climate change has increased.

Empirical tests of the effectiveness of climate change messages in shifting attitudes about nuclear energy have generated less than impressive results — and sometimes no effect at all. A 2010 survey of OECD countries found that a climate change message increased support for nuclear energy by only 5 points among US respondents, which interestingly was the smallest increase among all surveyed countries.[203] There is also a vein of research from the UK, where the government has emphasized the role of nuclear energy in tackling climate change. A psychological experiment in the United Kingdom, for example, found no effect of climate change framing on the willingness to endorse nuclear energy.[204]

Studies consistently emphasize that the public prefers other solutions for climate change over nuclear. A 2007 Gallup survey found that, by a wide margin, "Supporting the construction of a nuclear energy plant near your home" was the least popular of seven provided climate solutions.[205] One study did find that more participants expressed a willingness to accept nuclear energy when it was framed as a climate solution, but their responses to a battery of questions indicated that this acceptance was highly reluctant and conditional, and very few shifted to a preference of nuclear over renewables.[206] Another study found that participants would be willing to accept nuclear energy as a climate solution only if there was no other option.[207] While these studies are somewhat dated, their core finding is likely still valid, given the relative

stability in nuclear attitudes over the last two decades. That is, when nuclear energy is framed as a climate solution, it tends to make people think about solutions they prefer.

What about presenting an argument that combines climate change with the cost of energy — one that simultaneously corrects the misunderstanding that renewables are cheap and that nuclear produces emissions? A vision painting nuclear as clean and, if not cheap, then at least not far from the energy sources that the public thinks are so inexpensive? Here, too, the results are not encouraging. Providing information that corrects the misperception that renewables are cheap increased support for nuclear by a modest 4 percent, but it had the disadvantage of decreasing support for renewables by nearly 25 percent.[208]

Further, other benefits of nuclear energy may well be more compelling. Reviewing the literature, Shirley Ho writes, "Though the general public may reluctantly accept nuclear energy for climate change mitigation, research suggests that messages emphasizing the benefits of nuclear power for energy security and economic growth appear to have a greater impact on public acceptance of the technology."[209] A 2011 Swiss survey, for instance, found that the perception that nuclear is important for ensuring a reliable energy supply was a better predictor of support for nuclear than either risk perception or nuclear's benefits for climate change mitigation.[210] In fact, nuclear's perceived benefits for energy security had a five times greater impact on public acceptance than its perceived benefit for climate mitigation.[211]

Moreover, among those most concerned about climate change, there is a strong *inverse* correlation between climate concern and support for nuclear.[212] That is, the people who care most about climate change are the least likely to support nuclear power, both in the United States and abroad.[213] This is hardly surprising since the demographics of the climate-concerned public and the anti-nuclear public are closely aligned — for example, women are more likely to express concern about both climate change and nuclear energy.[214] It also reflects the historic alignment between the environmental movement and nuclear opposition. At best, it appears that concerns about climate change, among those for whom the issue is most salient, merely soften such opposition. Truelove and Greenberg found that respondents with strong environmentalist views, while less likely to support nuclear outright, were more likely to indicate an openness to it and ascribe that openness to their concern about climate change.[215]

Although concern about climate change may not shift nuclear attitudes as much one would hope, the reverse may be more promising — support for nuclear could be leveraged to shift attitudes toward climate change. Highlighting nuclear as a key climate solution may increase support among otherwise skeptical audiences for climate mitigation. Kahan has found that

emphasizing nuclear energy as a solution to climate change increases acceptance of and concern about climate change among hierarchical individualists and self-identified conservatives.[216]

Feldman and Hart similarly presented Republican respondents with several low-carbon energy policies (renewable energy investment, a revenue-neutral carbon tax, fuel-efficiency regulations, expansion of nuclear power), framing each one differently — as solutions to either pollution, energy dependence, or climate change. Strikingly, nuclear expansion was the only policy for which the climate framing did not decrease support.[217] In effect, positive attitudes toward nuclear among Republicans were sufficient to overcome aversion to climate change mitigation policy.

A New Prototype — Could Small Nuclear Be Beautiful Too?

Whereas the cognitive prototype of nuclear energy is a large, centralized nuclear power station set far away from those who depend upon it, the prototype for renewable energy is a few solar panels mounted on a single-family suburban home. When people see a solar farm, they are likely to conceptualize it as a large array of rooftop solar panels put together rather than viewing rooftop panels as a solar farm in miniature. However, the next generation of nuclear reactors — as well as the continued growth of renewable energy — might upend these prototypes and how the public categorizes nuclear energy.

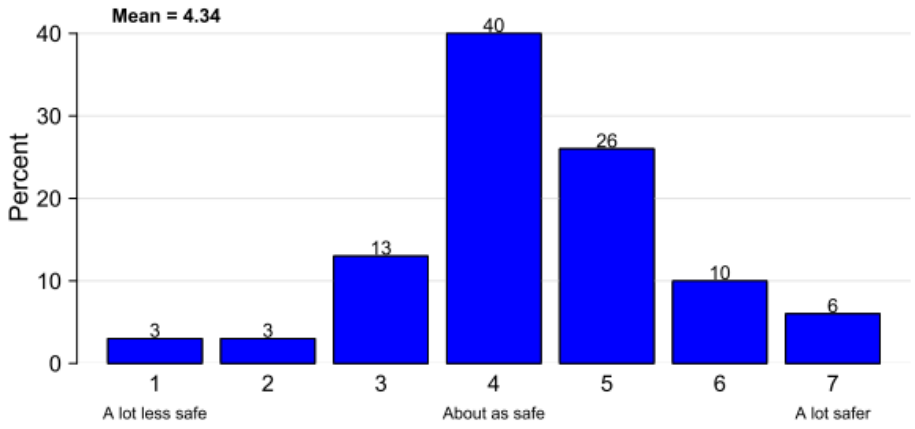
In practice, scaling up renewable energy to even begin to account for meaningful shares of electrical generation has entailed literally scaling it up. The vast majority of renewable energy generation is produced by large, industrial-scale facilities located far away from the load centers they serve. Renewable energy, in other words, has proven to be every bit as big and centralized as the conventional sources of electricity it has displaced. It is manufactured, deployed, owned, and operated by large utilities and corporations and has required complex technocratic management to integrate it into power systems.

By contrast, small advanced nuclear reactors potentially deliver on much of the promise of decentralized energy systems that solar and wind once seemed to offer and that they continue to be associated with. Owing to their size and high power density, small reactors can be fully integrated into the communities that they power, typifying the sort of energy technology that Amory Lovins famously characterized as a "neighborhood technology run by people you know who are at your own social level."[218] These reactors, powered by an abundant fuel that can be recycled and creates little waste and no pollution, would fit comfortably within the cognitive model of what makes a technology both clean and cheap.

At the same time, small advanced reactors need not be deployed in this hyperlocalized, small-scale way in order to be cognized as belonging to this category. After all, solar and wind have continued to enjoy their "small is beautiful" image despite their increasingly large-scale deployment.

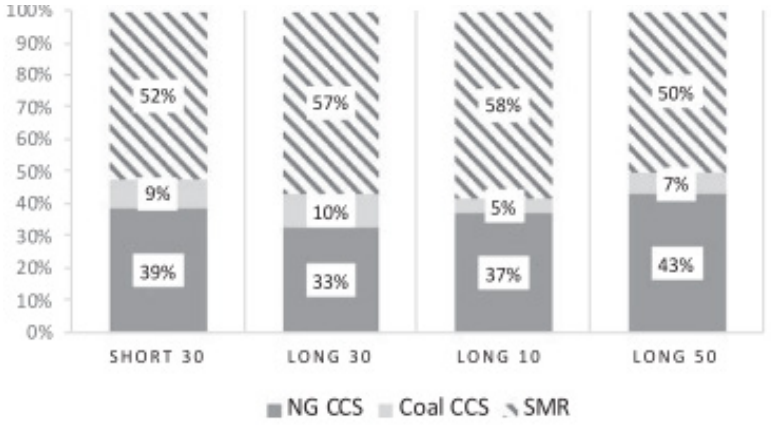
Such small modular reactors (SMRs) are manufactured like wind turbines rather than constructed like bridges, dams, and other large and complicated public works projects. Therefore, they place nuclear more firmly in the category of things that are both less dependent on technocratic and centralized institutions and more amenable to learning, innovation, and entrepreneurship. New SMRs born of start-up culture, not in national laboratories, might sever nuclear energy's long association with nuclear weapons, the military-industrial complex, and large utilities and corporations.

Survey research on public attitudes toward SMRs has been scant. But what little research has been conducted suggests that new advanced technologies might significantly reset public perceptions of nuclear energy. In one survey, after reading a short explanation of SMRs (with the caveat that "the technology is relatively new and untested, so it is difficult to evaluate how safe and cost-effective they might be as a replacement for full-sized reactors"), participants expressed a stronger preference for SMRs over traditional reactors on average.[219] In another study, after reading both an introduction to SMRs and lengthy arguments for and against them, participants considered them safer than traditional reactors and were significantly more likely to support the construction of new nuclear plants if they were SMRs[220] (figure below).



Public perceptions of the safety of SMRs versus traditional nuclear reactors, 2015.[221]

SMRs also do well compared with other emerging clean-energy sources. In one study, far more participants preferred SMRs over both natural gas and coal with carbon capture and storage (CCS). The gap is also significantly larger than the polling gap between nuclear and natural gas and coal without carbon capture.[222]



Preference among three energy technologies: natural gas with carbon capture and storage (CCS), coal with CCS, and small modular nuclear reactors.[223]
Notes: LONG = respondents read long description of technologies; SHORT = respondents read short description of technologies; 10, 30, or 50 = hypothetical siting distance in miles for nuclear reactor.

Of course, one should be cautious about extrapolating from these findings. All things being equal, one should expect high levels of support for a hypothetical new technology with broadly desirable features. There are methodological challenges in gauging hypothetical attitudes — in this case, about a new technology that participants have no experience with or knowledge of. Moreover, the difference between support for SMRs and traditional reactors is not overwhelming. Although a 2019 poll by ecoAmerica found more than a 20-point difference between support for traditional reactors and "new" nuclear technology (from 54 to 77 percent),[224] their results lie outside what more rigorous research has produced. The ecoAmerica item was phrased as "Assuming claims [about "new nuclear"] are true, would you support moving to better nuclear technology?" This phrasing flirts with tautology and is tantamount to asking respondents whether they support using better versions of something.

Nonetheless, the research on acceptance of advanced nuclear reactors certainly should not be dismissed. Some available studies take pains to address potential threats to validity by providing counterarguments[225] and investigating response stability.[226] And their findings are consistent: people prefer SMRs.

Of course, this doesn't mean that the public will invariably attribute to SMRs the basic-level features of simplicity, smallness, and understandability and categorize them with solar and wind. However, the smaller size of SMRs and other design features make them more amenable to such a categorization. At the very least, SMRs could help nuclear advocates challenge the way nuclear energy is conventionally categorized in the public's mind.

KEY POINTS

The public does not generally think about various energy technologies and sources in isolation but rather as a choice between energy that is cheap and clean or expensive and dirty. That is, they do not perceive a trade-off between the different strengths and weaknesses of energy sources.

The construction of "renewables" as a cognitive category has been extremely successful in changing how people think about energy, including nuclear. The category has served to frame nuclear energy as being "like" fossil fuels in that both require fuels extracted from the earth, while deemphasizing the ways in which nuclear has more in common with solar and wind energy. Consequently, survey participants commonly ascribe to nuclear most of the key qualities of fossil fuels.

A cogntitive-linguistic analysis of pro-renewable and anti-nuclear elite argumentation finds a cognitive framework of two categories. The first category comprises energy sources that are cognized as small, simple, understandable, safe for humans and the environment, comparatively inexpensive, decentralized, flexible and modular, forward-looking, symbolic of technological innovation, abundant, and natural (or at least in harmony with nature). The second is defined by precisely the opposite features. The first category is represented by entrepreneurs, innovators, inventors, and members of civil society who embody the qualities of enthusiasm, discovery, freedom, possibility, and social responsibility. By contrast, the second category is personified by a government scientist, member of the military, or a corporate CEO — members of powerful groups of the established order whose work feels distant, inaccessible, and mysterious.

In the past decade, starting with the "nuclear renaissance," although nuclear energy has been reframed as a climate solution, climate change messages have not impressively shifted nuclear attitudes. Further, the people who care most about climate change are the least likely to support nuclear power. However, the reverse strategy may be more promising — support for nuclear could be leveraged to shift climate attitudes. Evidence shows that highlighting nuclear as a key climate solution may increase support for climate action among otherwise skeptical audiences. Nonetheless, emphasizing nuclear's climate mitigation benefits may create more openness to it, if not support, and the increasingly prevalent approach of branding nuclear as "clean" — combining ways to fight air pollution and climate change — may hold promise.

Survey research on public attitudes toward small modular reactors (SMRs) has been scant but suggests that new advanced technologies have the potential to significantly reset public perceptions of nuclear energy. Of course, this does not mean that the public will invariably categorize SMRs with renewables, but they could at least help disrupt the categorical binary.

CONCLUSION RECOMMENDATIONS FOR NUCLEAR COMMUNICATIONS

Viewing the broad sweep of nuclear opinion over the past 50 years places its paradoxical nature in sharp relief.

On the one hand, opinion about nuclear has been largely stable, mostly slow to change, and deeply inscribed along contemporary political, ideological, and cultural fault lines. On the other hand, nuclear attitudes are not firmly held by most people, and they have been influenced by events and evolving social and cultural values as well as cognitive frameworks that are relatively recent and mostly arbitrary.

While decades of social science research suggests that nuclear energy's low favorability ratings are a product of its singularly dread-inspiring characteristics, it is also viewed about as favorably as fossil fuels, which feature no such characteristics. And while nuclear became a touchstone in America's culture war, most people know little about it and care even less. Nuclear is also the antithesis of "small is beautiful" renewable energy technology, but most renewable energy development is large scale, industrialized, and centralized.

Despite the fact that nuclear is a technology that has historically required the heavy hand of government, it has been rejected by those who believe in active government but embraced by libertarians and conservatives. It represents a public good largely developed and operated by the government but has been widely condemned as a corporate conspiracy.

Nuclear energy also produces no carbon dioxide or air pollutants but has been monolithically opposed by environmentalists and supported by climate skeptics. Opposition to nuclear energy was foundational to modern environmentalism, yet it does not fit comfortably into any of the categories that have come to define contemporary debates about climate change and clean energy.

Clearly, nuclear sits in a liminal space — cognitively, culturally, psychologically, and politically. In the public mind, it is neither fossil fuel nor clean energy. It evokes fears and carries meanings that are long detached from any context that most of the public has ever known or experienced. A small cohort resists it passionately. But for most people, it is something taken for granted — they don't particularly want it to go away, but they don't want more of it either. In summary, it is the legacy of a past era of energy development that may not be a problem but that most people don't see as a particularly important part of our energy future.

What the paradoxical, liminal, partial, and perhaps most important, low-salience nature of nuclear opinion suggests is that public attitudes about nuclear energy might be quite open to

revision. This revision will require a technology for which most of the relevant facts have been on the ground for decades — particularly in advanced developed economies. However, except for the Fukushima accident and a handful of over-budget projects, nothing particularly relevant has happened that might lead most people to give much thought to nuclear energy, much less revise their opinion of it.

Most existing nuclear plants have been in place for decades, operate without incident, and in a decade or two will quietly be retired. Brief discussions of a nuclear renaissance have largely evaporated in the face of daunting challenges. These include those associated with restarting long-dormant supply chains and building complicated new reactors that are effectively first-of-a-kind while a new generation of small advanced reactors is still in the design and licensing phase.

As noted earlier, climate change, because it remains relatively low salience for most people and is so embedded within existing partisan and cultural fault lines for those who do care about it, has not yet demonstrated much ability to shift opinion about nuclear energy. However, it does appear to have moderated opposition to nuclear energy in some quarters and might create space for reconsidering nuclear energy in relation to new reactor technology.

Where, then, does that leave clean-energy advocates hoping to wrest nuclear free from its enduring negative associations and public ambivalence, especially among certain cultural groups? Inscribing new meanings and associations onto nuclear energy will arguably require both a change in context and a change in technology. A new context may come from increasing focus on addressing climate change and nuclear energy's unparalleled track record of reducing emissions and displacing fossil fuels. But what is needed for nuclear communicators is not merely a new way to talk about nuclear's value so much as something new to discuss. Offering this is a new generation of reactors that are smaller, safer, and allow for radically different institutional arrangements, business models, economic possibilities, and practical applications.

RECOMMENDATIONS

Clean-energy advocates need a set of broadly shared best practices for communicating about nuclear — frames, messages, narratives, and categories that are meant to not only increase receptiveness but fundamentally disrupt how people conceptualize nuclear. The need for such best practices does not entail any particular communications initiative or campaign. It does not mean, for example, a campaign of pronuclear messages targeting the general public. But it does mean that nuclear advocates need to better coordinate their messaging if they hope to change the conversation.

Three key guiding principles for communicating about nuclear energy emerge from this report:

1) Highlight benefits rather than dismissing risks

2) Shift the prototype to advanced technologies

3) Understand the difference between elite and public opinion

Highlight Benefits Rather Than Dismissing Risks

Elites and experts consistently overestimate public fears about nuclear energy and underestimate the salience of its benefits. The result is a negative feedback loop whereby elites refuse to embrace nuclear due to exaggerated perceptions of its public unpopularity, in turn depriving key public segments of elite cues that might increase its popularity. Too often, nuclear advocates reinforce these dynamics rather than allaying them, fixating on risk perception as the central barrier to increasing support rather than putting the benefits of nuclear energy front and center in their communications. The result is ineffective or counterproductive communication that ends up reinforcing elite perceptions that nuclear energy is unpopular with the public and that public opinion is defined by fear of nuclear accidents, waste, and radiation exposure. But perceived benefits better predict public acceptance of nuclear energy than perceived risks. Nuclear advocates would be better served making less effort to confront misperceptions and more effort to highlight benefits — especially those associated with next-generation reactors.

DON'T

- Lead with safety assurances.
- Argue about death counts from past accidents.
- Argue that radiation is beneficial or omnipresent.
- Argue about whether there should be thresholds for low-level radiation exposure.
- Compare nuclear's risks with those of other energy sources.
- Compare nuclear's risk with those of familiar activities.
- Compare nuclear's risks with those of climate change or argue that nuclear denial is climate denial.

Attempts at risk myth-busting can easily come across as quibbling, contrarian, and condescending and may actually elevate risk perception. For example, activating a comparative risk frame (*X* is riskier than *Y*) is likely to be met with rejection or defensiveness. And, given the modest and complex effect of climate concern on nuclear support, holding hostage the audience's self-image as someone who cares about climate change will accomplish nothing.

DO

- Define solar, wind, and nuclear as a single category of clean and abundant energy sources in contrast to dirty fossil fuels.
- Celebrate the decades of low-cost, reliable, clean electricity that nuclear has provided.
- Remind audiences that nuclear is one of the largest sources of clean energy, providing 20 percent of US electricity, 80 percent in France, and over 50 percent in many other countries.
- Remind audiences that nuclear is the original clean-energy technology.
- Emphasize that nuclear is key to America's energy security and a bulwark against resurgent oil and gas prices.
- Characterize nuclear fuels as abundant and inexhaustible.
- Emphasize that the United Nations and the Intergovernmental Panel on Climate Change (IPCC) have concluded that nuclear energy will be a key technology that we will need for the fight against climate change.
- Emphasize that we need a diverse portfolio of technologies, including solar, wind, and nuclear to ensure a reliable and safe clean-energy future.
- If the topic is raised, acknowledge nuclear accidents as industrial accidents in a category with factory explosions, dam failures, and other energy production accidents, all of which are serious.

The category of "clean energy" has the advantage of transcending the renewable/nonrenewable scheme, and it can carry various positive connotations beyond mere lack of carbon emissions and pollution. Further, expanding the conversation from how much more nuclear infrastructure we should build to include how much we already have (something the public generally underestimates) can engender a sense of familiarity and therefore comfort. Regarding benefits, the public finds compelling energy security, independence, low prices, and abundance. Mention of climate change should avoid zero-sum debates about energy sources and focus instead on how different energy sources work together. If safety concerns are raised, they should be acknowledged and legitimized in principle, in the context of the message that risks can be managed much as risks are managed in other aspects of modern infrastructure.

Shift the Prototype to Advanced Technologies

Advanced nuclear technologies provide a singular opportunity to start a new conversation about nuclear energy, one that directly appeals to the cultural groups that have traditionally opposed it and are still most wary of it. Advanced nuclear technologies mesh well with an energy vision that is "small," "simple," decentralized, and community-based, spearheaded by people that resonate as a socially conscious "us" rather than a status quo—defending "them."

Small, modular, advanced nuclear technologies possess most of the characteristics needed to move nuclear from the "dirty and expensive" category to the "clean and cheap" category. Achieving such a reclassification, however, will require nuclear advocates to carefully reconsider a range of terminology and concepts inherited from the legacy nuclear industry and to define nuclear differently in relation to both renewable energy and fossil fuels.

DON'T

- Attack renewable energy to promote nuclear energy.
- Insist upon the need for "baseload" power, centralized energy, or energy density.
- Center the discussion on government scientists, the military, or national laboratories.
- Talk of "splitting atoms" and nuclear "fleets."

Nuclear advocates have consistently tried to better nuclear's reputation by comparing it with other energy sources; however, criticizing renewables will not win any converts among egalitarians. Nor will emphasizing the need for the kinds of centralized energy systems that this group

dislikes. Further, "energy density" may be attractive to experts, but it is less compelling for most others and can cue safety concerns. Messages should also avoid emphasizing people (e.g., government scientists) who are part of institutions seen as part of the established social order. As discussed, egalitarians are liable to distrust the people and institutions that have brought nuclear energy to the world. Finally, in sharp contrast with the naturalistic language used to describe solar and wind, nuclear is commonly described with violent language, terms associated with the military, and talk of modifying the fundamental units of nature — all of which are likely to trigger aversion in this group.

DO

- Contrast new nuclear with old nuclear.
- Emphasize that new reactors are often small and simple in design, have no moving parts, and cannot "melt down."
- Stress that new advanced nuclear technologies are manufactured like wind turbines, not large public works projects like traditional reactors.
- Emphasize the benefits of micro-reactors as local energy sources for small communities that are off the grid.
- Describe nuclear as a technology that harnesses energy from the decay of naturally occurring radioactive elements.
- Characterize nuclear waste as fuel that can be recycled, not toxic waste that must be disposed of.
- Center the discussion on start-ups, entrepreneurs, engineers, private firms, and innovation.

This re-prototyping strategy need not involve casting aspersions on traditional nuclear, but it does entail underlining the value of nuclear innovation. Messages that the next-generation nuclear reactors are simpler, smaller, more adaptable to local needs, and have made significant safety innovations all help egalitarian and communitarian audiences picture nuclear energy as part of their vision for an ideal society. The same is true for talking about the human face of these new technologies, which should focus on the qualities of optimism, excitement, innovation, entrepreneurialism, and commitment to serving the common good —trying to change the world, not maintain the status quo.

Target Egalitarian Elites

The distinction between elite and public opinion is indispensable to understanding nuclear attitudes, and indeed, public opinion in general. Broadly, elites are engaged, relatively knowledgeable, highly polarized along ideological lines, and stable in their views — simultaneously expert at defending their ideological priors in the face of contradictory evidence and ascribing great importance to a willingness to change their opinions based on new information. Public opinion, by contrast, is less informed, coherent, stable, interpretable, ideological, and engaged in environmental or energy discussions. Elite opinion (especially of partisan elites) leads public opinion more than it follows it.

The distinction is important for nuclear advocates who hope to create a new conversation. For nuclear advocates, it is paramount to be clear about the intended audience. Messages targeting lay audiences are best focused on the benefits of nuclear energy the public cares most about — that it is abundant, reliable, secure, and clean. Members of the lay public likely care more about nuclear's benefits than they do about "energy democracy" or "decentralized energy." Certainly, concepts of naturalness, smallness, simplicity, entrepreneurialism, and innovation have wide appeal, but most people would be willing to support nuclear energy without tying it to a revolutionary vision. Precisely the opposite is true for egalitarian elites, for whom ideology is paramount. For them, the question is not whether nuclear energy is good in the instrumental sense of the benefits outweighing the risks, but rather whether it fits into the moral order, social arrangements, and aesthetics of an ideal society.

Shifting public opinion on nuclear power arguably requires changing the opinion of egalitarian elites and ideally making them spokespeople for nuclear's value. Elite cues have and likely will continue to drive nuclear public opinion, so making inroads among these elites may be the only way to meaningfully shift public opinion. Indeed, the right cues from egalitarian elites would likely prove more valuable in shifting opinion among egalitarian publics than would generalized messages targeting public opinion about the benefits of nuclear energy. Government, industry, and business elites have historically been the primary advocates and spokespersons for nuclear energy, but among the left-leaning public, these groups are unlikely to be convincing messengers and are more likely to inspire skepticism. The messenger often trumps the message.

Given the well-documented power of out-group cues, making egalitarian elites into advocates of nuclear energy could theoretically erode support among most conservative groups, but this is unlikely in practice. Whereas out-group cues from liberal elites have driven much of the climate

denial among conservative members of the public, the same has not been true for energy attitudes. Solar and wind enjoy robust bipartisan support despite their centrality to the discourse around climate change.

Shifting elite opinion will require changing both what advocates talk about and how they talk about it. For egalitarian elites, climate change matters immensely. While there is little evidence that framing nuclear as a climate solution much shifts public opinion, including among egalitarian publics, ample evidence shows that climate change has played a key role in shifting opinion among egalitarian elites.

A broad range of climate scientists and prominent environmental advocates have become vocal proponents of nuclear energy owing to concerns about climate change. Many more have become at the very least more accepting of nuclear energy, if not advocates for similar reasons. During the past decade, a nascent pronuclear civil society movement has become a regular participant in public discussions of climate solutions, and even some traditional environmental NGOs have shifted their posture toward nuclear energy to various degrees.

But while climate change has opened the door to changing opinion about nuclear energy among egalitarian elites, still lacking is a technology and vision that egalitarian elites might believe in. That would mean a context for, and application of, a technology that comports reasonably well with the moral, social, and aesthetic arrangements egalitarians seek in the world. Most environmental elites have now accepted (albeit grudgingly) that closing existing nuclear plants is antithetical to efforts to rapidly cut carbon emissions — demonstrating that meaningful opinion change is indeed possible. But this shift falls far short of accepting, much less advocating for, a major expansion of nuclear energy.

Small advanced nuclear reactors offer a range of attributes that are far more amenable to an egalitarian worldview and hence to shifting opinion among these elites in a significant and lasting way. Emphasizing these attributes in ways that fit comfortably within, rather than challenging, egalitarian preferences and ideological commitments offers the most likely path to broader public acceptance of nuclear energy. Hence, the work of re-prototyping nuclear energy by moving advanced nuclear to the center of public communications and advocacy — alongside the development and commercialization of new reactors consistent with that prototype — likely holds the key to softening opposition and growing substantially greater public acceptance of nuclear energy in the coming decades.

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