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Energy Choices and Risk Beliefs: Is It Just Global Warming and Fear of a Nuclear Power Plant Accident?

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A survey of 3,200 U.S. residents focused on two issues associated with the use of nuclear and coal fuels to produce electrical energy. The first was the association between risk beliefs and preferences for coal and nuclear energy. As expected, concern about nuclear power plant accidents led to decreased support for nuclear power, and those who believed that coal causes global warming preferred less coal use. Yet other risk beliefs about the coal and nuclear energy fuel cycles were stronger or equal correlates of public preferences. The second issue is the existence of what we call acknowledged risk takers, respondents who favored increased reliance on nuclear energy, although also noting that there could be a serious nuclear plant accident, and those who favored greater coal use, despite acknowledging a link to global warming. The pro-nuclear group disproportionately was affluent educated white males, and the pro-coal group was relatively poor less educated African-American and Latino females. Yet both shared four similarities: older age, trust in management, belief that the energy facilities help the local economy, and individualistic personal values. These findings show that there is no single public with regard to energy preferences and risk beliefs. Rather, there are multiple populations with different viewpoints that surely would benefit by hearing a clear and comprehensive national energy life cycle policy from the national government.

KEY WORDS: Energy; global warming; nuclear accidents; preferences; risk; waste management

1. INTRODUCTION

The health, environmental, economic, and political risks associated with climate change are an international policy challenge. Nations have been developing policies such as reductions in greenhouse gas emissions, conservation, economic incentives for a reduction in fossil fuel use, public education programs, and many other responses.(1) The United States arguably has lagged in policy development. However, as the world's largest economy and a massive energy user, the United States's actions are important, and public support or at least acquiescence to increasing dependence on renewable energy sources and nuclear fuel and reducing reliance on fossil fuels are important considerations for public policy formation.

This article describes the results of a mid-year 2009 survey funded by the U.S. Department of Energy of 3,200 U.S. residents. We randomly sampled 800 participants from around the United States, and 2,400 participants who lived in six 100-mile-radius regions containing many nuclear and coal-fueled electricity generating and waste management facilities.

The purposes of the research summarized in this article were to answer two multi-part research questions:

(1) What is the association between some common risk beliefs about coal and nuclear energy and public preference to rely more on

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these sources for electricity generation? Are global warming and a serious nuclear power plant accident the strongest risk belief correlates of preferences? If not, what risk beliefs are stronger or equal correlates?

(2) What are the characteristics of people who agree that coal causes global warming and that nuclear power plants could have a serious accident and yet also want to increase reliance on those sources of electrical energy? We label these respondents acknowledged risk takers.

These two questions were formulated after a year 2008 survey[2] measured public preferences for biomass, coal, hydroelectric sources, natural gas, nuclear, oil, solar, and wind as sources of electrical energy and examined the associations between these preferences and respondent demographic characteristics, trust, and several other assumed correlates of those preferences. The year 2008 survey found anticipated associations about energy preferences and risk beliefs, that is, those who believed that fossil fuels and nuclear power plants were "harmful" or "extremely harmful" to humans and the environment were less likely to support greater reliance on them. Yet there were a considerable number of exceptions—people who perceived harm and yet wanted greater reliance on these sources of energy. These acknowledged risk takers, we expected, would be influenced by other risk beliefs associated with nuclear and coal as fuels, and by their personal histories.

With regard to risk beliefs for coal, for example, coal mining and the management of coal wastes might be a stronger risk belief than global warming. With regard to personal history, the 2008 survey found an age cohort effect that was correlated with preferences for nuclear and coal (as well as oil), but not biomass, hydroelectric, natural gas, solar, and wind. Proponents of greater reliance on nuclear, oil, and coal sources disproportionately were 65+ years old and relatively few were less than 35 years old. These findings, in turn, suggested the relevance of work by Kahan,[3] which adds cultural and historical dimensions to trying to understand public preferences.

By history, we mean experiencing the promise of fossil fuel and nuclear power during the 1940s through the early 1960s. U.S. residents who are now 65+ years old frequently heard that coal and oil represented great national wealth that would be used to increase living standards and address long-standing social and economic problems.[4] During the 1950s, President Eisenhower endeavored to change public opinion about the use of nuclear materials for weapons, asserting that nuclear fuel would bring abundant and inexpensive energy to be used for world peace.

Younger Americans may have heard these messages, but they did not live through the exciting years when the messages were first aired. Our assumption was that these messages have left an indelible impression on what is now the 65+-year-old population, leading to the age cohort effect observed in the year 2008 survey.

That 2008 survey, however, had none of the questions posed by Kahn[3] and his colleagues, nor did it have political party affiliations, and had only the most general questions about risk beliefs. It could not answer the two research question posed here.

2. LITERATURE BACKGROUND AND EXPECTATIONS

2.1. Research Question 1: Preferences for Reliance on Nuclear and Coal and Risk Beliefs

During the last two decades, hundreds of public opinion polls have asked questions about public preferences for alternative fuel sources, including biomass, coal, hydro, natural gas, nuclear, oil, solar, and wind, as well as conservation. We have not read all of these. However, we have read many of them, as well as review papers and analyses.[2,5–19] With regard to coal and nuclear, these show that 40–60% of U.S. residents want more reliance on nuclear energy; and 20–35% want more use of coal. For example, in a 2007 sample of U.S. residents, Ansolabehere *et al.*[14] found that 19% wanted more reliance on coal and 36% more reliance on nuclear. In the year 2002 study with the same questions, the fractions were 17% and 28%, respectively. In 2008, Greenberg[2] observed that 33% favored more reliance on coal and 47% on nuclear. In contrast, over 90% want greater reliance on solar and wind.[2,14]

Because of widespread media coverage of global warming, there is reason to assume that belief that fossil fuels contribute to global climate change is the strongest risk correlate of preference for more renewables and nuclear and less coal.[5,20–22] Some recent research has supported this assumption. For example, Bickerstaff *et al.*[6,23] noted that people have a different reaction to nuclear power when its role in reducing global climate change is suggested. Thus,

we expected that belief that coal use contributes to global warming would lead to less support for coal and increased support for nuclear energy.

Similarly, because of widespread coverage of problems at Chernobyl and Three Mile Island, as well as movies, documents, and documentaries,[6,24–26] there is reason to assume that fear of an accident at a nuclear power plant is the key risk belief driving opposition to nuclear energy.[11,27] Evidence for the pervasiveness of this nuclear accident concern comes from a 1996 *Frontline* interview of psychiatrist Robert DuPont.[24] As part of a program called "Nuclear Reaction" DuPont assert asserted that "the major health effect, adverse health effect of nuclear power is not radiation. It's fear. And siting them away from the people, we insured that they would be maximized." Whether you do or do not agree with DuPont's statements, the key point is the emphasis on a nuclear plant accident. In short, at this time global warming and fear of a serious nuclear power plant accident appear to be the signature risk beliefs that should be associated with preferences for reliance on coal and nuclear energy.

Yet some studies show that other risks may be equally important to the public or even greater concerns than these two signature ones. For example, concerns about the management of coal waste, such as those surrounding the serious collapse of a coal impoundment in Tennessee in December 2008 that received enormous media attention,[22,28,29] may be important drivers of opposition to coal, as are coal mining accidents and acid rain. In addition, concerns about nuclear waste management, transport of nuclear materials, and uranium mining might be a bigger concern than a power plant accident.[7,30–34]

2.2. Research Question 2: Characteristics of Acknowledged Risk Taking Respondents

Five sets of correlates were investigated to try to better understand the acknowledged risk takers. Age, as described earlier, was anticipated to be a strong predictor of preferences for coal and nuclear energy. Yet so were other demographic attributes. A "white male effect" was anticipated, in other words, affluent and college educated white males were expected to prefer nuclear power more than their counterparts. White males as a group have had more access to power and information, and an economic-related interest in maintaining cheaper energy. Also, they tend to be relatively trusting of technology and to be relatively less worried about many hazards.[35–38] With regard to coal, based on the earlier study[2] relatively poor individuals were expected to be disproportionately in the group of coal proponents.

Second, we investigated the role of cultural, social, and political identity in explaining preferences. Kahan *et al.*[3] characterize white males as disproportionately likely to be hierarchical (believe in ordered authority rather than egalitarian distribution of power) and individualistic (self-focused rather than communitarian). Anything that threatens the U.S. market system that U.S. white males have disproportionately managed, such as relying on fuels that undermine the economy, should be disproportionately important to individualistic and hierarchical people.

To represent the demographic, political, and cultural identify in the study, it was essential that we include indicators of political identification (self-identify as Democrat, Republican, and Independent)[3,11,39] and questions about discrimination, constraints that should be posted on how individuals spend their wealth, and the implications of the decline of the traditional family. We anticipated that cultural identity would predict support for the various energy sources and specifically expected that hierarchical and individualistic values would lead to increased support for coal and nuclear energy.

Third, we investigated the effects of values about the environment and trust. More support for nuclear energy and coal, that is, for large centralized systems, was expected from respondents who trust private and public authorities that manage energy facilities.[40–44] We also expected these respondents to less strongly identify with environmental protection than their counterparts and to be more optimistic about the state of the environment in 25 years.

Fourth, we expected an effect of respondent location on energy source preferences. Studies show that the public focuses on hazards that affect them, their family, and their friends.[45–47] Consequently, many people living near nuclear waste management sites, nuclear laboratory facilities, and nuclear power plants should be expected to be more supportive of greater reliance on these energy sources because many have worked at one or have a family member, friend, or neighbor who has. In addition, if the energy facilities contribute to the respondents' income and/or the tax base of their jurisdiction, then they should be more supportive. To determine if there was a host halo effect, we selected a sampling pattern that

deliberately included those who live near energy facilities.

The fifth set of indicators was risk beliefs about coal and nuclear energy. In addition to global warming and a serious nuclear power plant accident, we added three more about coal and four about nuclear energy that were mentioned earlier and detailed later.

3. DATA AND METHODS

3.1. Sample

During the period June 23, 2009 to August 14, 2009, a phone survey written by the first author was administered by the Bloustein Survey Research Center. Containing 26 questions, many with subparts, it was designed to take 17–18 minutes and be conducted using landline telephones with a random digit dialing (RDD) protocol. Following American Association for Public Opinion Research standards, the RDD protocol is designed to give all working land line residential telephone numbers the same chance of being contacted for an interview. Listed, unlisted, and not-yet-listed landline numbers are included, which eliminates "listing" bias. Phones that are not in service, nonresidential, and other "bad numbers" were excluded. Limitations of RDD landline surveys are that they do not reach those that only rely on cell phones, those without phones, or those who use answering machines and other devices to screen callers. These limitations can reduce the sample of poor and younger people.[48,49]

Every sample underestimates some demographic groups and overestimates others. The regional samples should be as representative of their regional populations as possible. Therefore, after examining the demographic results, we weighted the samples by white-nonwhite and age (18–44, 45–64, 65+). Yet, it is not possible to fully correct by weighting because not all factors that influence results are weighted. Response and cooperation rates for RDD surveys have been dropping in the United States from over 50% to now 20%.[48,49] We used an 11 call-back design to try to obtain at least a 20% response rate and a 30% cooperation rate.

3.2. Locations

Sampling locations were chosen to focus on areas with major coal and nuclear energy production, laboratory, and waste management facilities. This selection was made because new energy facilities are highly likely to be built at sites that already have them.[7,50,51] It is important to learn the preferences of those who live near these locations.

After much deliberation, six regions were chosen, each with a radius of 100 miles. Four of the six include a U.S. Department of Energy (DOE) nuclear waste management and/or laboratory site: Hanford [WA], Los Alamos [NM], Oak Ridge [TN], and Savannah River [SC].[52] These regions also included coal facilities. The other two of the six regions represented the west and east coasts of the United States, respectively. These two do not have large DOE waste management facilities. However, they had nuclear power and coal facilities. The first included parts of eastern Pennsylvania, New Jersey, Delaware, Maryland, and a small part of New York State. This region included five nuclear power plants and more than a dozen coal facilities. The second was in west central California, including the Diablo Canyon nuclear power plant at San Luis Obispo and coal facilities. Overall, these six regions included four of the major DOE waste management and laboratory facilities, more than dozen nuclear power plants, and more than two dozen coal facilities.

Regions with radii of 100 miles were required to include a diversity of nuclear and coal facilities. Areas within approximately 20 miles of nuclear facilities typically have many employees and the relatives and friends of those who work at the energy facilities.[2,33] Furthermore, energy facilities typically contribute to local economies through employee purchases at local retail outlets and to local government taxes. It was important not to lose a host halo effect. Accordingly, the survey recorded county of residence, which then was used to represent the effect. Furthermore, respondents were asked about their personal familiarity with local energy facilities to capture this local influence.

3.3. Questions

To answer the research questions respondents were asked if the United States should increase, keep the current level, or decrease its reliance on coal and nuclear for electricity generation. As noted earlier, this type of question has been used in prior studies.[2,14]

Nine questions asked respondents to indicate their reaction to some commonly heard assertions about nuclear and coal use. Respondents were asked if they strongly agree, agree, disagree, or strongly

disagree with the following statements (scale was 1–5): (1) coal use causes global warming; (2) coal waste is not safely managed; (3) coal mining degrades animals, plants, land, and water; (4) coal mining is dangerous to workers; (5) nuclear power plants could have a serious accident; (6) nuclear waste is not safely managed; (7) nuclear facilities are vulnerable to terrorist attack; (8) nuclear material transport is dangerous to those who live along the transport path; and (9) uranium mining degrades animals, plants, land, and water. "Neither agree nor disagree" was a response of 3.

The remaining questions were about demographics, trust, environmental values, political and social values, and local effects, and were used to answer the second research question. Our respondents were asked to indicate if they were of Latino or Hispanic origin and what race they consider themselves to be (white, black, Asian, Native American, and Indian). Gender was recorded by the surveyor and respondents were asked to indicate their age on their last birthday, the last grade they completed, and their total annual family income in five income categories beginning with less than $25,000 and ending with $100,000 or more. The five categories were collapsed for analysis into three (<$50,000, $50,000–99,999, and ≥$100,000).

With regard to political, social, and cultural identify, we asked respondents to self-identify as a Democrat, Independent, Republican, or another party. Six questions about social and cultural orientation were borrowed from Kahan *et al.*'s research.[3] Three questions were drawn from the Communitarianism-Individualism scale: "Too many people expect society to do things for them that they should do for themselves"; "The government interferes too much in our everyday lives"; and "People who are successful in business should have a right to enjoy their wealth as they see fit" and three were drawn from the Egalitarianism-Hierarchy scale: "The United States would be better off if the distribution of wealth was more equal"; "Discrimination against minorities is still a very serious problem in the U.S."; and "A lot of problems in our society result from the decline in the traditional family, where the man works and the woman stays home."

Five questions asked about trust and concern about the local environment. Three probed trust of owners/operators of nuclear and coal facilities, and federal and state agencies that regulate these facilities. These questions combined competence to manage health, safety, and the environment as well as to communicate information to the public. The fourth question asked respondents to indicate if they think the environment of their state as a whole will be better, the same, or worse 25 years from now. The last asked each respondent to classify his or her identification with the environmental movement as "active," "supportive but not active," "neutral," and "not concerned."

We anticipated that a halo effect would be captured by several questions. Anyone who lived in one of the counties within 20 miles of one of the DOE sites was placed in a "host county" group. Respondents were asked if they, a family member, or friend worked at one of the four sites. Finally, respondents were asked to gauge the economic impact of nearby energy facilities. They were asked if the impact on the local economy was extremely positive, somewhat positive, somewhat negative, or extremely negative. Both positive and negative was a permitted voluntary answer.

4. RESULTS

4.1. Preliminary

The response rate to the survey was 23.4% and the cooperation rate was 40.6%. These rates were slightly higher than we had anticipated.[48,49] As noted earlier, the results were weighted by region-specific age and white-nonwhite ratios. A total of 29 million people lived in the six areas (100 miles area radii), or a little less than 10% of the national population.

The proportion of participants in each subset of the sample who favored increasing, decreasing, or retaining current reliance on coal and nuclear energy sources is found in Table I. Results from the total sample showed that about 25% of participants wanted to increase reliance on coal, and 66% preferred to decrease dependence on it. The analogous proportions were 48% and 46%, respectively, for nuclear.

Table I shows that there was not a notable difference among the study areas, although the nuclear-centered regions, especially the host areas (those within 20 miles of nuclear facilities), were less favorably disposed to coal and more favorable to increasing reliance on nuclear power.

Table I also indicates that the proportion of respondents in the stay-the-same category was small. To focus on increasing reliance respondents, the

Table I. Public Preference for Coal and Nuclear Fuel Sources, United States, 2009 (%)

Source	Increase Reliance	Stay the Same	Decease Reliance
Total sample ($n = 3{,}200$)			
Coal	25	9	66
Nuclear	48	6	46
National sample ($n = 800$)			
Coal	28	11	62
Nuclear	45	7	48
Four nuclear-centered regions ($n = 1{,}600$)			
Coal	23	9	68
Nuclear	52	5	44
West and east coast sites ($n = 800$)			
Coal	25	8	66
Nuclear	45	6	49
Host counties ($n = 329$)			
Coal	21	9	70
Nuclear	62	5	33

stay-the-same and decrease reliance answers were combined in the analyses that follow.

4.2. Question 1: Preferences for Reliance on Nuclear and Coal and Risk Beliefs

Table II shows the relationships between preference for nuclear and coal and risk beliefs. The contingency coefficient is a measure of association between two variables. For dichotomous variables the maximum is 0.707.

Belief that coal use causes global warming, as expected, was related to preferences for coal. The minority who favored coal were much less persuaded that coal use causes global warming than those who wanted to reduce coal (44% vs. 72%). Belief that a serious nuclear power plant accident could occur was related to less preference for nuclear power.

Table II, however, points to a much more complex set of risk beliefs than merely beliefs about global warming or a nuclear power plant accident. For example, ecological degradation was a slightly stronger correlate of coal-related preferences than global warming. With regard to preference for use of nuclear energy, Table II shows a relationship with beliefs about the possibility of a nuclear plant accident, but other risk beliefs, such as about nuclear waste management, nuclear material transport, and uranium mining had just as strong or stronger relationships with preference for increased reliance on nuclear energy.

Table II. Relationship Between Preference for Coal and Nuclear and Selected Risk Beliefs (Numbers in Table Indicate Agreement with Statement)

Risk Beliefs and Preferences[a]	Increase Reliance (%)	Do Not Increase Reliance (%)	Contingency Coefficient[b]
Preferences for reliance on coal energy and			
Coal use causes global warming	44	72	0.279**
Coal waste is not safely managed	51	71	0.223**
Coal mining degrades animals, plants, land, and water	50	78	0.292**
Coal mining is dangerous to workers	77	91	0.238**
Preferences for reliance on nuclear energy and			
Nuclear power plants could have a serious accident	70	92	0.361**
Nuclear waste is not safely managed	39	88	0.401**
Nuclear facilities are vulnerable to terrorist attack	63	87	0.316**
Nuclear material transport is dangerous to those who live along the transport path	49	86	0.394**
Uranium mining degrades animals, plants, land, and water	57	87	0.359**

**$P < 0.01$.

[a]Risk beliefs measured on a 1–5 scale where 1 = strongly agree and 5 = strongly disagree.

[b]The contingency coefficient measure of association between categorical variables. For a comparison of dichotomous variables, the maximum association is 0.707.

In addition, the risk beliefs are correlated but not perfectly. For example, the rank correlation between the risk belief that coal waste is not safely managed and coal use causes global warming was 0.45 ($p < 0.01$, Kendall's tau-B). In other words, none of specific risk beliefs is an adequate single metric for risk beliefs. And overall, we need to know more about respondents than just their risk beliefs about global warming and a nuclear power plant accident to understand their preferences about coal and nuclear fuels.

Table III. Acknowledged Risk Takers and Age Group

Age Group (Years)	Coal, Acknowledged Risk Takers (%)	Nuclear, Acknowledged Risk Takers (%)
18–24	9.9	26.0
25–44	8.3	28.6
45–64	11.1	30.8
65+	11.4	41.7

Note: Numbers derived by dividing number in favor of greater reliance on the energy source and agree about the risk belief by the number in the specific age group. For example, 244/585 = 41.7% in age group 65+ for nuclear energy.

4.3. Question 2: Correlates of Preferences for the Acknowledged Risk Takers

Almost half of the respondents favored increasing reliance on nuclear energy. Over two-thirds (1,003 of 1,473) of those who favored increasing reliance on nuclear energy did so despite acknowledging a risk belief that a nuclear power plant could suffer a serious accident. In other words, 31% of over 3,000 respondents were acknowledged risk takers for nuclear energy. About one-fourth of our respondents favored greater reliance on coal. Forty percent (310 of 774, or about 10% of all respondents) of those who favored greater reliance on coal also acknowledged a risk belief that coal contributed to global warming. These two groups constitute the acknowledged risk takers.

Table III shows a suggestive relationship with age. Those who favor greater reliance on nuclear power despite acknowledging a possible serious nuclear power plant accident increased with age. Almost 42% of those 65+ years or older favored nuclear power despite acknowledging the accident risk compared to 26% among those 18–24 years old. The proportions for coal are less striking. The differences between the 45–64 and 65+ years old populations are minimal (11.1% vs. 11.4%) as are the differences between those 18–24 and 25–44 years old (9.9% vs. 8.3%).

Although age is a good marker for the acknowledged risk taker group, as noted earlier, we expected a larger set of correlates. Tables IV and V show the results for over 30 potential correlates. These were selected from those described in Section 3.3 and were chosen to avoid redundancy and after preliminary tests with cross-tabulations. We also attempted to collapse some of the questions into scales. A set of trust-related questions were collapsed into a scale for coal managers and another for nuclear managers. Cronbach's α for these exceeded 0.80. Conversely, individual questions from the Kahan *et al.*[3] culture questions were not strongly correlated and could not be collapsed into simpler scales.

The first set of variables in the table is demographic indicators (age, race/ethnicity, sex, income, education). These are followed by general preferences and beliefs, then energy-environment preferences and risk, trust of authorities, and the host halo measures.

Tables IV and V present two sets of results. One set is difference-of-proportions or difference-of-means tests (*t*-tests) for each variable. The second is the result of stepwise binary logistic regressions that identify the strongest correlates and the order selected into the statistical model. We present the estimated logistic regression coefficients, or *B* values, and the odds ratios (OR) for each of the regressions. We also tested these variables with other methods to determine if the method influenced the results, and we found the same key variables emerged. The simple stepwise model contains the essence of the results.

Table IV presents the results for the coal-related risk takers. Sixteen of the correlates were significant ($p < 0.01$) and they include a wide range of indicators, as expected. We use the OR from the stepwise regressions to illustrate. With regard to demographic characteristics, those who wanted to increase reliance on coal despite acknowledging the global warming risk belief self-identified as black (OR = 2.42). This was the first variable selected for statistical significance. This group also tended to be Latino (OR = 1.43, step 8), have an income less than $50,000 (OR = 1.36, step 4), be 65+ years old (OR = 1.24, step 10), and be female (OR = 0.89 with male, step 11). Although not incorporated into the model because of interactions with income, these respondents also had lower educational achievement. In short, the acknowledged risk takers for coal are disproportionately economically disadvantaged minority and older women.

Politically they tended to identify with the Democratic Party (OR = 1.14, step 12), and they are not active supporters of environmental protection (OR = 0.81, step 9). Their views about government and social justice are intriguing. They agree that society would be better off if wealth were more equally distributed (OR = 0.81 where 1 = strongly agree and 5 = strongly disagree, step 2), and yet agree that wealthy people should be able to spend their

Table IV. Binary Logistic Regression of Preference for Coal as an Energy Source

Variables ($n = 2{,}939$)	Average Proportions or Values		Stepwise (Wald)		
	Yes	No	*B*-Value	Odds Ratio	[Step]
Demographic					
Age 25–44 (1 = yes, 0 = no)	0.410	0.402			
Age 65+ years (1 = yes, 0 = no)	0.216	0.180*	0.213**	1.24	[10]
White (1 = yes, 0 = no)	0.637	0.796**			
Black (1 = yes, 0 = no)	0.268	0.111**	0.883**	2.42	[1]
Latino (1 = yes, 0 = no)	0.181	0.110**	0.360*	1.43	[8]
Male (1 = yes, 0 = no)	0.445	0.489	−0.115*	0.89	[11]
Annual income $ <50,000 (1 = yes, 0 = no)	0.558	0.395**	0.305*	1.36	[4]
Annual income $100,000 plus (1 = yes, 0 = no)	0.138	0.182			
Less than high school education (1 = yes, 0 = no)	0.141	0.070**			
College graduate (1 = yes, 0 = no)	0.216	0.393**			
General preferences and beliefs					
Identifies as Republican (1 = yes, 0 = no)	0.167	0.253**			
Identifies as Democrat (1 = yes, 0 = no)	0.419	0.309**	0.082*	1.14	[12]
Society would be better off if wealth was more equally distributed (1 = SA, . . . , 5 = SD)	2.34	3.01**	−0.209**	0.81	[2]
Problems in society result from decline in traditional family where man works and woman stays home (1 = SA, . . . , 5 = SD)	2.85	3.05*			
Government interferes too much in our everyday lives (SA = 1, . . . , SD = 5)	1.86	2.32**	−0.160**	0.85	[6]
Discrimination is a serious problem in the United States) (1 = SA, . . . , 5 = SD)	2.30	2.24			
Wealthy people should be able to spend their resources as they choose (1 = SA, . . . , 5 = SD)	1.92	2.32**	−0.200**	0.82	[5]
Too many people expect society to do things for them that they should be doing for themselves (1 = SA, . . . , 5 = SD)	1.50	1.59			
Energy-environment preferences and beliefs					
Respondent is active supporter of environmental protection (1 = yes, 0 = no)	0.184	0.239*	−0.317*	0.73	[9]
Environment will be better in 25 years (1 = yes, 0 = no)	0.239	0.258			
Respondent prefers greater reliance on solar and wind sources (1 = yes, 0 = no)	0.910	0.910			
Respondent preference for proportion of energy investment in conservation technologies (0–1).	0.438	0.458			
Coal waste is not safely managed (1 = SA, . . . , 5 = SD)	2.50	2.47			
Coal mining degrades animals, plants, land, and water (1 = SA, . . . , 5 = SD)	2.68	2.59			
Coal mining is dangerous to workers (1 = SA, . . . , 5 = SD)	2.03	2.09			
Trust of owners, operators, and regulators					
Respondent trusts owner/operators of nuclear facility to manage and communicate information (1 = SA, . . . , 5 = SD)	3.03	3.33*	−0.097*	0.91	[3]
Respondent trusts federal agencies to manage and communicate information (1 = SA, . . . , 5 = SD)	2.60	3.00**	−0.095*	0.91	[7]
Respondent trusts state government to manage and communicate information (1 = SA, . . . , 5 = SD)	2.65	2.97**			
Host halo					
Respondent, family member, or friend works at a nearby energy facility (1 = yes, 0 = no)	0.100	0.129			
Respondent assesses economic impact of nearby energy facilities as positive (1 = extremely positive, . . . , 5 = extremely negative)	2.16	2.49**			
Constant			−0.024	0.98	
Nagelkerke *R*2			0.110		

*$P < 0.05$, **$P < 0.01$.

B is the estimated logit coefficient; odds ratio is the Exp(*B*); (*x*) is the order incorporated into the model.

SA = strongly agree, SD = strongly disagree.

Table V. Binary Logistic Regression of Preference for Nuclear Fuel as an Electrical Energy Source

Variables ($n = 2{,}784$)	Average Proportions or Values		Stepwise (Wald)		
	Yes	No	*B*-Value	Odds Ratio	[Step]
Demographic					
Age 25–44 (1 = yes, 0 = no)	0.368	0.419**			
Age 65+ years (1 = yes, 0 = no)	0.243	0.156**	0.561**	1.75	[2]
White (1 = yes, 0 = no)	0.813*	0.764**	0.059*	1.06	[9]
Black (1 = yes, 0 = no)	0.096	0.140**			
Latino (1 = yes, 0 = no)	0.086	0.131**			
Male (1 = yes, 0 = no)	0.574	0.446**	0.419**	1.52	[3]
Annual income $<50,000 (1 = yes, 0 = no)	0.364	0.432**			
Annual income $100,000 plus (1 = yes, 0 = no)	0.209	0.163**			
Less than high school education (1 = yes, 0 = no)	0.048	0.090**			
College graduate (1 = yes, 0 = no)	0.427	0.353**	0.218*	1.24	[7]
General preferences and beliefs					
Identifies as Republican (1 = yes, 0 = no)	0.277	0.230**			
Identifies as Democrat (1 = yes, 0 = no)	0.289	0.333*			
Society would be better off if wealth was more equally distributed (1 = SA, . . . , 5 = SD)	3.23	2.81**	0.065*	1.07	[8]
Problems in society result from decline in traditional family where man works and woman stays home (1 = SA, . . . , 5 = SD)	2.93	3.07*			
Government interferes too much in our everyday lives (SA = 1, . . . , SD = 5)	2.18	2.28			
Discrimination is a serious problem in the U.S. (1 = SA, . . . , 5 = SD)	2.35	2.24*			
Wealthy people should be able to spend their resources as they choose (1 = SA, . . . , 5 = SD)	1.75	2.00**	−0.129**	0.88	[5]
Too many people expect society to do things for them that they should be doing for themselves (1 = SA, . . . , 5 = SD)	1.51	1.61*			
Energy-environment preferences and beliefs					
Respondent is active supporter of environmental protection (1 = yes, 0 = no)	0.217	0.241			
Environment will be better in 25 years (1 = yes, 0 = no)	0.292	0.239**			
Respondent prefers greater reliance on coal	0.250	0.238			
Respondent prefers greater reliance on solar and wind sources (1 = yes, 0 = no)	0.926	0.902*	0.528**	1.70	[6]
Respondent preference for proportion of energy investment in conservation technologies (0–1)	0.442	0.436			
Nuclear waste is not safely managed (1 = SA, . . . , 5 = SD)	3.02	2.55**	0.295**	1.34	[1]
Nuclear facilities are vulnerable to terrorist attack (1 = SD, . . . , 5 = SA)	3.77	3.64*			
Nuclear material transport is dangerous to those who live along the transport path (1 = SA, . . . , 5 = SD)	3.67	3.33**			
Uranium mining degrades animals, plants, land, & water (1 = SA, . . . , 5 = SD)	3.74	3.45**			
Respondent trusts owner/operators of nuclear facility to manage and communicate information (1 = SA, . . . , 5 = SD)	2.86	3.26**	−0.111**	0.090	[4]
Trust of owners, operators, and regulators					
Respondent trusts federal agencies to manage and communicate information (1 = SA, . . . , 5 = SD)	2.63	2.89**	−0.052*	0.093	[10]
Respondent trusts state government to manage and communicate information (1 = SA, . . . , 5 = SD)	2.74	2.95**			
Host halo					
Respondent lives in host county (1 = yes, 0 = no)	0.104	0.102			
Respondent, family member, or friend works at a nearby energy facility (1 = yes, 0 = no)	0.140	0.121			
Respondent assesses economic impact of nearby energy facilities as positive (1 = extremely positive, 5 = extremely negative	2.11	2.23*			
Constant			−0.391	0.68	
Nagelkerke *R*2			0.110		

*$P < 0.05$, **$P < 0.01$.

B is the estimated logit coefficient; odds ratio is the Exp(*B*); (*x*) is the order incorporated into the model.

SA = strongly agree, SD = strongly disagree.

resources as they choose (OR = 0.82, step 5), and perhaps this is linked to their belief that government interferes too much in our everyday lives (OR = 0.85, step 6).

Although the acknowledged risk takers apparently had some issues with government interference, they disproportionately trusted owner/operators of coal facility (OR = 0.91, where 1 = strongly agree and 5 = strongly disagree, step 3), and federal (OR = 0.91, step 7) and state government regulators of these facilities. And perhaps this is partly explained by their tendency to believe that coal facilities have a positive impact on the local economy.

Sometimes what is not statistically significant is equally noteworthy. In case of the coal acknowledged risk taker group, they are not distinguished from their counterparts about reliance on solar, nuclear power, or investing in conservation. They do not have a different view about the health of the environment in 25 years, and their beliefs about coal waste management, ecological degradation associated with coal waste, and worker risk from coal mining are not distinguishable from their counterparts.

What stands out about the coal acknowledged risk taker group is that this relatively small number of people (10% of the sample) are not distinguished by risk beliefs or fuel preferences but are strongly distinguished by race/ethnicity, socioeconomic status, age, opinions about wealth and government roles, and trust of government officials.

The results for nuclear power also demonstrate strong correlations with demographic characteristics (Table V). The acknowledged risk taker group for nuclear energy tended to be 65+ years old (OR = 1.75, step 2), male (OR = 1.52, step 3), college graduates (OR = 1.24, step 7), and white (OR = 1.06 step 9).

In several ways the results for coal and nuclear were quite different. Pro-nuclear respondents were male, not female, and white, not black or Latino. They tended identify as Republican, not Democrat, and had annual income in excess of $100,000 not less than $50,000. Another interesting difference is that those who wanted greater reliance on nuclear energy were more optimistic that the environment would be better in 25 years, whereas this variable was not a significant predictor among pro-coal respondents.

The nuclear acknowledged risk taker group showed significant correlations with risk beliefs. Most notably, this group disproportionately does not believe that nuclear waste is not safely managed (OR = 1.34, step 1), which was the first variable selected and the group prefers greater reliance on solar and wind energy (OR = 1.70, step 6).

These acknowledged nuclear risk takers were disproportionately both individualistic and hierarchical on all six measures; for example, they did not believe that society would be better off if wealth was more equally distributed (OR = 1.07, step 8), and they did agree that wealthy people should be able to spend their wealth as they choose (OR = 0.88, step 5).

In several ways, the coal and nuclear groups were similar. Both populations were older, trusted authorities responsible for the energy facilities, and they believed that local energy facilities had a positive economic impact on the local economy. Yet, overall, the two groups are quite different with regard to socioeconomic status and race/ethnicity.

5. DISCUSSION

This research investigated two major questions. However, first we had to determine preferences for coal, nuclear, as well as solar, wind, and other sources of energy. The results were similar to the results obtained from a year 2008 survey.[2] For example, over 90% favored greater use of solar and wind, and about half wanted greater reliance on nuclear fuel. There was one exception. The fraction who favored greater dependence on coal dropped from 33% to 25% in a year. One likely contributing factor to this drop was a major coal impoundment collapse in Kingston, Tennessee, in December 2008, which flooded a valley with liquid coal waste and caused considerable angst against the industry, which was ongoing during the survey.[28,29] We have some evidence to support this assertion. Respondents were asked to indicate if during the last year they had heard or seen any news reports about coal. Among those who had not, 29% wanted more reliance on coal. This compared to 14% among those who had heard of the coal impoundment break in Tennessee. This finding highlights the fluid nature of preferences for energy sources.

The first of the two research questions examined the association between energy preferences for coal and nuclear energy and risk beliefs about coal and nuclear power. As expected, the two signature risk beliefs were predictive. Yet other risk beliefs about the coal and nuclear energy fuel cycles were stronger correlates or equal correlates.

About 30% of the respondents favored increased reliance on nuclear energy, despite acknowledging that there could be a serious accident. And about

10% favored greater reliance on coal, although acknowledging the belief that coal use contributes to global warming. The strongest correlates of these two groups were socioeconomic status and race/ethnicity. The acknowledged nuclear risk taker group was affluent educated white males, and the coal group was relatively poor less educated African-American and Latino females. The three consistent factors across both groups were older age, trust in those who manage the energy facilities, and belief that the energy facilities help the local economy. In addition, we found some evidence that coal and especially nuclear supporters were more likely to have individualistic values. Overall, our results contribute to the accumulating body of research and theory on the relationship between preferences for energy sources, demographic characteristics, cultural values, trust, and risk beliefs.

There are six important limitations to report, all attributable to the limitations of what can be accomplished in a single RDD survey. First, although we asked about family income and asked respondents to indicate how the nearest large coal or nuclear site impacted the local economy, we did not ask other questions about respondents' personal energy costs and more generally how important economic factors were in their reaction to coal and nuclear energy. Nor did we ask if they believed that they were making a short-term tradeoff of risk for economic benefit. Furthermore, we did not ask respondents about their personal history with coal and nuclear energy. For example, did they ever live in a home heated by coal? Do they recall speeches about the value of coal and nuclear energy? Did their parents and other relatives and family friends speak positively or negatively about these sources of energy?

A second limitation is that we asked nine risk belief questions about nuclear power and coal. Time permitting, we would have asked more than twice as many. We focused on human exposure and ecological risk beliefs, and, for example, did not ask about economic-related ones, such as the possibility that electricity could be rationed, prices could substantially increase, a terrorist attack could disable part of the electrical grid, and others.

Third, all of the risk belief questions had a negative tone, that is, asked about public health and environmental risks. It would have been useful to have interspersed questions that placed a positive tone on nuclear and coal energy.

A fourth limitation was that the sample deliberately was geographically weighted toward locations with major nuclear facilities. We did this because coal and nuclear constitute about 70% of the energy used for electricity. Research suggests that new facilities disproportionately will be located in locations that already have them.[7] It is important to understand the views of those who are most likely to deal with the local effects of these facilities. Yet only 800 of the 3,200 samples were randomly chosen from the entire U.S. population, which means that the results might not be directly comparable to surveys that are a national sample.

Fifth, the focus here was on coal and nuclear energy. Arguably, at least oil, natural gas, and hydroelectric power, which have been in use for decades, should be studied for comparative purposes.

Sixth, the authors have conducted a series of surveys of public risk beliefs, preferences, and values associated with electrical energy sources, facility siting, nuclear energy and waste management, and related issues. For example, the current survey was also used to examine public knowledge of energy-related issues[53] and the concept of using DOE sites for energy research parks.[54] Although these papers and others in the literature are revealing, for us, they confirm an ongoing need to continue to ask good research questions to understand more about the intricate web tying together public risk beliefs, values, and preferences in the energy-environmental realm.

Given these limitations, how important are the findings reported in this article for public policy? In one respect they are important because they show that one or two simple messages that attempt to persuade the public to change its preferences for or against specific energy sources are unlikely to succeed, especially if the public has a negative image of the source.[55–57] As such, the results are important for interest groups that support and oppose these energy sources. These energy players can craft messages to reach the populations of interest with the knowledge of which risk beliefs are most important to each group.

Any broader importance that may be attached to these observations implies two challenges. One is to determine how many different subpopulations exist around the subject of energy preferences. For example, a recent study divided the U.S. population into six groups with regard to risk beliefs about global climate change.[58] Climate change is one component of an energy policy, and we believe

that it is important to develop typologies of energy preferences. Given sufficient resources and time, we have no doubt that researchers will determine how many of these groups exist and how to most effectively communicate choices to them.

Yet, whether there are six or two dozen groups has limited public policy value without an official comprehensive policy to communicate. The United States and its states have created policies for some components of the energy system, but not for many others, and have not adequately connected the parts that exist. The United States needs a clear and comprehensive energy strategy that addresses the energy life cycle beginning with securing the energy and transporting it, then to producing and transmitting the energy, and managing the wastes. Without a comprehensive strategy, we envision, for example, public agreement with an expansion of nuclear power but serious opposition to waste management and transport; public support for expansion of solar and wind sources but not for transmission lines; public opposition to siting liquefied natural gas terminals and exploring U.S. natural gas resources without understanding the consequences; and many other inconsistent preferences. Our call for a coherent plan that is communicated is a challenge to national and state governments and interest groups that have been reactive, created piecemeal and inconsistent policies, and have allowed the public to be left with bits and pieces of information, often contradictory, rather than a comprehensive energy policy framework that makes sense, even if parts of it are personally painful.

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