A COMPARATIVE STUDY OF PUBLIC BELIEFS ABOUT FIVE ENERGY SYSTEMS

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RR-80-15
April 1980

INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
Laxenburg, Austria

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SUMMARY

Public acceptance is becoming an increasingly important constraint to be taken into account by those responsible for technological policies. Acceptance by the public will depend on their relevant attitudes toward a given technology, and these attitudes will be a function of beliefs about the attributes and probable consequences of the technology in question. This study explores belief systems with respect to five energy sources: nuclear, coal, oil, hydro, and solar. The method used permits comparisons of attitudes and also of the underlying belief dimensions which characterize each energy source.

Two hundred and twenty-four members of the Austrian public took part in this questionnaire survey; the sample was stratified by age, education, sex, and geographical location (Vienna, provincial capital, and rural).

An overall measure of attitude toward each energy source showed that only in the case of nuclear energy was the sample polarized to any degree. For the fossil fuels there was a large measure of moderate favorability, and for the renewable sources virtually everyone expressed a highly favorable attitude.

The major part of the research was concerned not with the overall attitudes of the public but rather with their belief systems, that is with their perceptions of the qualities and attributes of each energy source. A set of 39 attributes of energy sources was used. These attributes were associated in propositional form with each of the five energy sources (e.g., the use of oil leads to water pollution) and the respondents rated their degree of belief/disbelief in each statement.

The data were simplified using factor analysis. Five underlying dimensions of belief were identified as common to all the energy sources. These dimensions were concerned with: future-oriented and political risks; economic benefits; environmental risks; psychological and physical risks; and future technological development. The attributes most clearly identified with each of these dimensions were used, for each energy source, to construct the profiles of beliefs held by the sample as a whole.

The Austrian sample as a whole believed that environmental risks were

associated with oil, coal, and nuclear energy, in that order; they believed that all the sources except coal provided approximately the same, moderate level of economic benefit; and that only nuclear energy and solar energy would lead to technological development. The sample believed that only nuclear energy would lead to psychological and physical risks; and they believed strongly that, with the single exception of nuclear energy, none of the sources would lead to indirect (future-oriented and political) risks.

Since nuclear energy was the only case where the attitude measures showed groups in the public both in favor of (PRO) and against (CON) the energy source, belief profiles were constructed for two subgroups – those most and least favorable toward the use of nuclear energy. When these belief profiles were examined it was clear that treating the sample as a whole masked important information. First, the two groups had very different belief systems about nuclear energy; and second, the two groups had similar perceptions of hydro, solar energy, and coal, although their beliefs about oil were slightly different.

The sample as a whole (even those most favorable toward nuclear energy) preferred the use of hydro and solar energy. This is because both PRO and CON groups saw these two energy sources as less of a threat than nuclear energy on all risk-related dimensions. The PRO group perceived nuclear energy as the source most likely to lead to economic benefits and future technological developments; the lower ratings given to the fossil fuels by this group were primarily due to beliefs that these sources would provide only small economic benefits while leading to appreciable environmental risks. However, the CON group viewed nuclear energy as only marginally more likely than the fossil fuels to lead to economic and technological benefits but as an appreciably greater threat on the risk-related dimensions.

PREFACE

The risks associated with alternative energy systems, and public perceptions of these risks, have become important constraints in the selection of energy strategies. This Research Report presents results of an application of an attitude-measurement methodology which explores the beliefs held by the public with respect to five alternative energy sources. Emphasis is given to a differential analysis of the belief systems of those subgroups most in favor of (PRO) and most against (CON) the use of nuclear energy. Results specific to public attitudes toward the use of nuclear energy have been published (Otway and Fishbein 1977) and an earlier pilot study on this same topic was reported (Otway and Fishbein 1976). An analysis of the determinants of voting behavior in a public referendum on nuclear energy has also been presented (Bowman *et al.* 1978).

This report is based on work of the Joint IAEA/IIASA Risk Assessment Project, and thus it represents a collaboration between the International Atomic Energy Agency and the Energy Systems Program at the International Institute for Applied Systems Analysis.

CONTENTS

1 INTRODUCTION

Public acceptance is becoming an increasingly important constraint to be considered by those responsible for technological policies. In order to formulate policy wisely it is necessary to understand the underlying determinants, i.e., belief systems, of acceptance or opposition by public groups; in our research we have used the attitude concept for this purpose. The particular approach adopted, in addition to providing an overall estimate of attitude, permits a detailed examination of underlying beliefs. It thus provides a method for exploring systematic differences in belief systems between groups of particular social, political, or professional significance.

The first report in this series (Otway and Fishbein 1976) was a pilot study of the beliefs and attitudes held by a group of energy experts with respect to nuclear energy. This was followed by a similar analysis for a heterogeneous sample of the Austrian public (Otway and Fishbein 1977).[1] The present report describes results of the latter study which extend the exploration of belief systems to include five energy sources: nuclear, coal, oil, hydro, and solar. The beliefs about these five sources held by the entire Austrian sample are described, and a comparison is made between the beliefs held about all energy systems by those subgroups shown to be most in favor of (PRO) and those most against (CON) the use of nuclear energy.

2 METHODOLOGICAL APPROACH

The attitude model used in our studies of the determinants of public acceptance of energy systems has been described in some detail in the reports cited earlier. Therefore we will simply summarize the main points which are relevant to the procedures and analyses discussed in this report.

First, attitude is defined as an overall feeling of favorableness toward an object, where "object" refers to any discriminable aspect of the individual's world. Attitude can be measured either directly, using the semantic differential technique of Osgood *et al.* (1957), or indirectly by considering the responses to a set of belief or opinion items about the attitude object. Second, the model used specifies the relation between beliefs and overall attitude, as follows:

> Each belief is treated as a subjective probability judgment that the attitude object is associated with a given characteristic or attribute. The evaluation of each attribute is then weighted by the probability of the association (i.e., the belief strengths). Thus, according to the model, attitude is approximated by the pairwise products of belief strength X evaluation summed over a set of suitable beliefs.[2]

Strictly, if one wishes to relate beliefs (or observed differences in beliefs between groups) to attitude in a deterministic sense, it is necessary to use only salient beliefs. These are the beliefs which are within the span of attention of each individual when the attitude is measured. In most practical situations, however, a set of modal salient beliefs is used, i.e., those beliefs occurring most frequently in the sample.

In this study a set of modal beliefs about the attributes of energy sources was chosen on the basis of interviews with members of the general public, the data collected in previous research, and a literature survey. The complete set of 39 attributes (see Table 3) spans the most commonly perceived, possible consequences of using coal, oil, hydro, solar, and nuclear energy. Since the

initial concern was with perceptions of nuclear energy, some of the items are specific to this particular source. It follows that, as a set, the 39 belief items cannot be interpreted as "salient" (using Fishbein's terminology) for each and every energy source. Therefore it would be incorrect to make generalizations about the contributions of these beliefs to attitudes toward all energy sources. This report therefore focuses on *strength of belief* data, that is, on the public's beliefs and perceptions of the energy sources, without any necessary implication for the determination of specific attitudes. There is one exception to this: in the case of nuclear energy the same set of 39 attributes has been successfully used in the same attitude model to explore the public acceptance of nuclear energy (Otway *et al.* 1978). The purpose of the present paper is to examine how attributes, already shown in the earlier study to contribute to attitudes toward nuclear energy, are perceived by the public in relation to other energy sources. Particular attention is given to contrasting perceptions of coal, oil, hydro, and solar energy held by those subgroups of the general public who are most in favor of (PRO) and most against (CON) the use of nuclear energy.

3 METHOD

SAMPLE

Sampling of the general public was not intended to be representative of the Austrian population but was a stratified sample controlling for geographic location (Vienna, provincial capital, and rural), sex, age, and education. The total number of usable interviews was 224* and the breakdown of this total across the demographic categories is shown in Table 1.

QUESTIONNAIRE

Apart from demographic information the questionnaire measured the following three factors: overall attitude toward each energy system, attitudes toward each of the 39 attributes (attribute evaluation), and belief strengths.

Overall Attitude toward Each Energy System

This was measured using the semantic differential technique of Osgood *et al.* (1957), i.e., the rating of each attitude object on a series of 7-point scales (+3 to −3) with the end-points labeled with adjective pairs such as good/bad, harmful/beneficial. In keeping with Osgood's procedure, a factor analysis of the responses to these scales, for all five energy sources, was used to identify adjective pairs which most clearly represented the evaluative dimension, which is the dimension that Osgood has equated with attitude. Five adjective pairs were validated in this way and used in the remaining analyses: good/bad, harmful/beneficial, harmonious/controversial, acceptable/unacceptable, moral/immoral. The measure of overall attitude was a sum of the ratings on these five scales giving a range of +15 to −15.

*However, in a small number of cases, respondents did not *completely* fill in the questionnaire: it will therefore be noticed that the sample size for particular sections is sometimes less than 224.

TABLE 1 Demographic breakdown of the Austrian public sample ($N = 224$).

		Vienna ($N = 121$)		Provincial capital ($N = 51$)		Rural area ($N = 52$)		
Education level	Age	Male ($N = 81$)	Female ($N = 40$)	Male ($N = 29$)	Female ($N = 22$)	Male ($N = 31$)	Female ($N = 21$)	ΣN
Grade school	18–34	6	3	2	1	1	5	18
($N = 45$)	35–50	4	1	3	3	2	3	16
	51–65	2	2	1	1	4	1	11
Trade school	18–34	11	14	5	7	8	4	49
($N = 80$)	35–50	3	2	3	6	2	1	17
	51–65	6	2	2	1	2	1	14
High school/university	18–34	30	9	8	1	7	4	59
($N = 99$)	35–50	12	3	4	1	3	1	24
	51–65	7	4	1	1	2	1	16

Attitudes toward Each of the 39 Attributes (Attribute Evaluations)

These were measured in a similar fashion but using only a single 7-point scale (+3 to −3) labeled with the adjective pair good/bad. Each attribute was presented without reference to any specific energy source. For example,

Increasing the prestige of my nation

GOOD :–:–:–:–:–:–:–: BAD

Belief Strengths

These were measured by relating the 39 attributes to each energy source in turn and asking the subject to indicate his judgment of the truth of the statement. A 7-point scale (+3 to −3) was used and the end points were labeled likely/unlikely. For example,

The use of coal leads to air pollution

LIKELY :–:–:–:–:–:–:–: UNLIKELY

It should be noted that although belief strength has been construed as a subjective probability, the way it is scaled (in keeping with most of Fishbein's own work) avoids certain strict requirements of probability measures. The beliefs are *not* treated as a partitioned event space where the probabilities would sum to 1, and further, by using the bipolar scale (+3 to −3) it is possible to encompass levels of probability that the energy source *is* or *is not* associated with the attribute in question.

4 RESULTS

Although the primary concern of this report is the comparison of beliefs about using different energy sources, it is worthwhile to consider first the overall feelings, or attitudes, toward the different sources of energy generation.

ATTITUDES TOWARD FIVE ENERGY SOURCES

Examination of the attitude scores in the total sample (as measured by the semantic differential) yielded the three distinct types of frequency distribution shown (smoothed) in Figure 1. The distributions were virtually the same for the two fossil fuels, as were those for hydro and solar energy; however, the distribution for nuclear energy was quite different. In the case of fossil fuels there were very few negative attitudes and few highly positive; most respondents were moderately favorable. For hydro and solar energy there were virtually no negative attitudes; the most frequent response was highly favorable. Attitudes toward nuclear energy centered in the middle of the scale but with clusters of highly negative and highly positive attitudes at both ends. It was only in the case of nuclear energy that attitudes were sufficiently polarized to warrant differential analyses of underlying beliefs for "PRO" and "CON" groups.

As in the earlier study, two subgroups were formed from the total sample by selecting the 50 respondents most favorable to the use of nuclear energy (PRO group) and the 50 most against its use (CON group). Differences in attitude held by the PRO and CON groups toward the remaining four energy sources were examined by analysis of variance (ANOVA).

The mean values of attitude for each group with respect to energy sources are shown in Table 2. In general, the PRO nuclear group was more favorable toward the non-nuclear energy sources (mean = 10.6) than was the CON nuclear group (mean = 7.9). There was a main effect of energy source on attitude scores, i.e., significant differences in attitudes toward the different sources were observed. For the total sample, respondents were generally more favorable toward

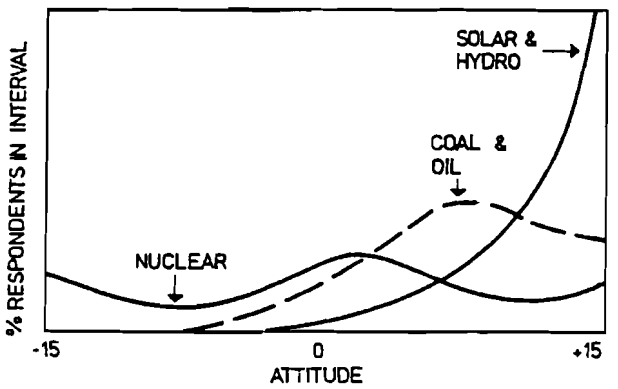

FIGURE 1 Smoothed frequency distribution of attitudes toward energy sources.

hydro (10.7) and solar energy (10.5) than they were toward coal (6.1) and oil (5.4); they were least favorable toward nuclear energy (0.4).

There was also a significant interaction effect which, in this case, indicated that those PRO and CON nuclear energy had similar attitudes toward hydro and solar energy, but differed in their attitudes toward each of the two fossil fuels. The largest difference between the PRO and CON nuclear groups (apart from their attitude to nuclear energy) was their attitude toward oil as a source of energy, the PRO group being significantly more favorable toward its use. When comparisons were made (within the PRO and CON groups) between attitudes toward each possible pair of the four non-nuclear energy sources, those PRO nuclear energy had significantly different attitudes toward all pairs except solar/hydro and coal/oil. The CON group had different attitudes toward all possible pairs except solar/hydro.

To summarize briefly, the PRO nuclear group was more favorable to hydro and solar energy than to coal and oil. Their attitudes toward nuclear energy did not differ appreciably from their attitudes toward oil, and their attitudes toward both nuclear and oil were significantly less favorable than those toward hydro and solar and somewhat more favorable than those toward coal. In contrast, the CON nuclear group was strongly negative toward nuclear energy but had positive attitudes toward the other energy sources; they were most favorable toward hydro and solar, moderately favorable toward coal, and significantly less favorable toward oil.

UNDERLYING COMMON DIMENSIONS OF BELIEF ABOUT ENERGY SOURCES

In the earlier report on beliefs and attitudes of the public toward the use of nuclear energy (Otway and Fishbein 1977) it was found, using factor analysis of belief-strength scores, that the 39 beliefs about nuclear energy clustered on

TABLE 2A Mean values of attitudes of those PRO and CON nuclear energy toward five energy sources.

	Energy source					
Group	Nuclear	Solar	Hydro	Coal	Oil	All[a]
PRO ($N = 50$)	(10.2)	12.2	12.3	8.3	9.7	10.6
CON ($N = 50$)	(−10.1)	11.1	11.2	6.2	3.1	7.9
	**	NS	NS	*	**	**
Total sample ($N = 218$)	(0.4)	10.5	10.7	6.1	5.4	8.2

*Difference between groups significant, $p < 0.05$.
**Difference between groups significant, $p < 0.01$.
NS, difference between groups not significant.
[a]All refers to all energy sources *except* nuclear.

TABLE 2B Summary of analysis of variance of attitude toward five energy sources held by those PRO and CON the use of nuclear energy.

Main effects	
PRO/CON (A)	$p < 0.001$
Energy sources (B)	$p < 0.001$
Interaction	
$A \times B$	$p < 0.001$

four factors.[3] These dimensions underlying perceptions of nuclear energy were named psychological risk, economic/technical benefits, sociopolitical risk, and environmental/physical risk. The reduction of the belief set to four major dimensions, in practical terms, facilitated comparisons between those who were PRO and CON nuclear energy. In order to identify commonalities in perceptions of the five energy sources it again seemed reasonable to reduce the set of 39 items to a smaller set of underlying dimensions by using factor analysis. In this case Tucker's (1966) extension of the factor-analytic procedure to three-dimensional matrices ($n \times m \times q$, where n subjects responded to m belief statements about q energy sources) were used.[4] The three modes in this analysis were thus

- The source mode, five energy sources
- The belief mode, 39 attributes of energy sources
- The subject mode, 224 members of the Austrian public

The findings are reported briefly for each of the three modes in turn, followed by a detailed analysis of the belief mode.

Energy Source Mode

The three-mode factor analysis identified three source factors, one for nuclear energy, one for the fossil fuels, and one for hydro and solar energy. This finding is consistent with the frequency distributions of attitude scores which showed one pattern for the fossil fuels, another for hydro and solar energy, and a different distribution for nuclear energy.

Belief Mode

It will be recalled that the earlier report, based on the Austrian public's beliefs about nuclear energy, showed that four underlying dimensions could account for the intercorrelations amongst the 39 beliefs (i.e., psychological risks, economic/technical benefits, sociopolitical implications, and environmental/physical risk). When three-mode factor analysis was used to identify commonalities amongst perceptions of all five energy sources, the best solution changed slightly and five factors emerged.

The factor structure for beliefs about all energy sources differed from that for nuclear energy alone primarily in that, when the five sources were considered together, the economic/technical benefits factor separated into two factors: an *Economic Benefits* factor, and a future-oriented *Technology Development* factor. In addition, the psychological risk factor associated with nuclear energy included physical risks when all five sources were considered (*Psychological and Physical Risk* factor). The sociopolitical factor associated with nuclear energy became a more general, future-oriented, and political factor which is now called *Future and Political (or Indirect) Risk*. The fifth dimension remained an *Environmental Risk* factor. The five attributes most closely associated with each of these five factors are listed in Table 3.

Subject Mode

Three subject factors were found. Subject Factor I was related to the subjects' strength of agreement with the modal view of the energy sources. Those high on Factor I tended to respond in the same direction (be it positive or negative) as the sample mean, but more extremely; those low on Factor I also tended to respond in the same direction, but less extremely than the sample mean. Thus, in the context of substantial agreement as to the direction of relationships between the energy sources and various attributes, the subjects' strength of belief was a function of their Factor I scores. This factor may be simply a response style, or a tendency to use the ends of the response scale. However, supplementary analyses of Factor I scores, as a function of demographic variables, suggest

TABLE 3 The belief dimensions and most characteristic belief items identified by three-mode factor analysis.

Belief dimension	Belief item
Economic benefit	Good economic value
	Increased standard of living
	Increased employment
	The industrial way of life
	Increasing Austrian economic development
Environmental risk	Air pollution
	Water pollution
	Production of noxious waste
	Making Austria dependent on other countries
	Exhausting our natural resources
Indirect risk (Future-oriented and political)	Changes in man's genetic make-up
	Increasing rate of mortality
	(not) A technology I can understand
	Formation of extremist groups
	A police state
Technological development	New forms of industrial development
	New methods in medical treatment
	Dependency on small groups of experts
	Technical spin-offs
	(not) Exhausting natural resources
Psychological and physical risk	Accidents which affect large numbers of people
	Exposure to risk which I cannot control
	Rigorous physical security measures
	Hazards caused by human failure
	Hazards caused by material failure
Belief items not strongly identified with the five belief dimensions	Exposure to risk without my consent
	A threat to mankind
	Risky
	Delayed effect on health
	Increases my nation's prestige
	Reduces the need to conserve energy
	Satisfies the energy need in the decades ahead
	Decreases dependence on fossil fuels
	Increases the extent of consumer orientation
	Diffusion of knowledge about construction of weapons
	Transporting dangerous substances
	Destructive misuse of technology by terrorists
	Gives political power to big industrial enterprises
	Increases occupational accidents
	Long-term modification of the climate

that this tendency to make more extreme responses may be interpreted as greater confidence, and may, in fact, reflect greater knowledge. Specifically, individuals' scores on this factor were positively related to age and education, and to prestige as based on measures of socioeconomic status and occupation. Further, males scored significantly higher on this factor than did females. The extent to which an individual was identified with this "confidence" factor did not correlate significantly with attitude toward nuclear energy ($r = 0.02$), but correlated positively with attitudes toward hydro ($r = 0.40$) and solar energy ($r = 0.43$). The correlations with attitudes toward the fossil fuels were also significant but low ($r = 0.29$ and 0.27, for coal and oil, respectively).

Subject Factor II was more obviously a response style mode; those scoring high on this factor were invariably closer to the "unlikely" or negative side of the scale, regardless of the content of the item or the implication of the scaling response. Scores on this factor were not significantly correlated with attitudes toward any of the five energy sources. Of the demographic variables, only age showed a significant relationship with Factor II scores. The 24–34 age group had high scores on Factor II while the scores of all other groups (under 24, 35–50, and over 50) were low. Thus, age group 24–34 had a tendency to see all relationships between energy sources and attributes as relatively less likely. This finding for some of the younger participants could be interpreted as a general "negativism," or it could indicate that the attributes used in this survey were less relevant for the 24–34 age group than for the rest of the sample.

Subject Factor III appeared to be a "true" content dimension. Those subjects who had low scores on Factor III shared three common viewpoints:

- They perceived all five energy sources as economically viable, a perception not shared by the modal view (note that the group as a whole, for example, saw coal as an uneconomic prospect)
- They saw nuclear energy as generally "better" than the modal perception, being, for example, more likely to be economically sound and to lead to technological (spin-off) developments
- They perceived oil as somewhat better on all counts than the modal view, being, for example, less likely to lead to indirect risks and more likely to lead to technological spin-offs

This summary of the viewpoint of those individuals who scored low on Factor III (diametrically opposing views were held by those with high scores on Factor III) shows that this subject factor represents an underlying dimension which primarily relates to beliefs about nuclear energy. Consistent with this explanation it was found that Factor III scores correlated with the semantic differential measure of attitude toward nuclear energy ($r = -0.59$). Factor III scores also correlated with attitudes toward the fossil fuels ($r = -0.42$ and -0.23, for oil and coal, respectively). Of the demographic variables, only age showed a significant relationship to Factor III scores. The 24–34 age group had

high scores on Factor III, the 35–50 group was relatively neutral, and the scores of the "under 24" and "over 50" groups were low.

In summary, the interpretation of the three-mode factor analysis is straightforward for the energy mode and the belief mode: the sample of the Austrian public perceived nuclear energy differently from other sources, but perceived the two fossil options as similar, and also hydro and solar energy as similar. For the belief mode five factors emerged: psychological/physical risk, economic benefits, technological development, future/political risk, and environmental risk. These dimensions represent the basic considerations that are taken into account in judging the different energy systems. The findings for the subject mode are more difficult to interpret since the "types" which emerged could not be definitively identified by demographic variables (i.e., they were not clearly specified social groups).

The analysis of the subject mode indicated that there were three sorts of considerations that influenced respondents' judgments about the attributes of the five energy systems

- A "confidence" factor where (on many items) the sample is in general agreement that a given energy source has (or does not have) a particular attribute, but some people tend to be more confident (or extreme) than others (Factor I)
- An influence of response style whereby some people tended to use the "unlikely" side of any scale (Factor II)
- A "true" content dimension that reflects differences in beliefs about the different energy systems (Factor III)

This latter content dimension is notable in that it does tend to distinguish between those who are PRO (low scores on Factor III) and CON (high scores on Factor III) nuclear energy. That is, the viewpoint of those individuals scoring low on Factor III was similar to that of the original PRO nuclear group used in our earlier reports.[5] Further examination showed that 56% of the PRO group was present amongst the 50 lowest scores on Factor III, and 52% of the CON group was present amongst the 50 highest Factor III scores. Despite this overlap it is not reasonable to assume that the two groups correspond sufficiently to generalize *a priori* from the Factor III findings to a PRO–CON analysis. However, analysis of variance of beliefs about the five energy sources, based on these two alternative groupings (either low/high scores on Factor III or the original PRO–CON nuclear groups), showed very similar results. While it is of some interest to examine the different belief systems of subjects low and high on Factor III, it must be recalled that respondents' final judgments are influenced not only by their position on Factor III, but also by their positions on Factors I and II. Therefore, in keeping with the earlier reports and with the basic social question underlying the research, the remainder of this report will primarily consider the beliefs of those public groups who were most in favor (PRO) and most against (CON) the use of nuclear energy.

PUBLIC BELIEFS ABOUT FIVE ENERGY SOURCES

The five dimensions underlying perception of the energy options, obtained from the three-mode factor analysis, were used first to examine the beliefs of the Austrian public sample as a whole, and then to compare the belief systems of those PRO and CON nuclear energy. The five belief items most closely identified with each belief dimension were summed to give an index of belief strength ($\Sigma_{i=1}^{5} b_i$) for each energy source in turn. The mean values of $\Sigma_{i=1}^{5} b_i$ for each of the five belief dimensions and each of the five energy sources are shown in bar diagram form in Figure 2 (total sample, $N = 211$). It can be seen that, overall, the public have very different perceptions of the five energy systems. These differences can best be seen by considering each of the five belief dimensions separately.

Indirect Risk

Although the public (on average) believed that none of the five energy sources would lead to future-oriented and political risks (such as a "change in man's genetic makeup" or "a police state"), they were significantly less certain of this vis-à-vis nuclear power than for any other energy source. They were also somewhat less certain that the use of oil would avoid such indirect risks in comparison with coal, hydro, or solar energy.

Economic Benefit

With the exception of coal, the public believed that all energy sources would lead to economic benefits (e.g., "an increased standard of living," or "increased employment"). They believed that oil was the energy source most likely to lead to these benefits, although not significantly more so than hydro or nuclear energy; but all of these three were seen as more likely to lead to economic benefits than was solar energy.

Environmental Risk

Here, on average, the public saw significant differences amongst all the energy sources. They believed that the fossil fuels and nuclear energy would lead to environmental risks (such as air and water pollution) whereas hydro and solar energy would not. The order from most to least risky in environmental terms was: oil, coal, nuclear, hydro, solar; thus the fossil fuels were seen as posing a greater environmental threat than nuclear energy.

Psychological/Physical Risk

Only the use of nuclear energy was perceived as leading to psychological and physical risks (e.g., "accidents affecting large numbers of people," or "exposure

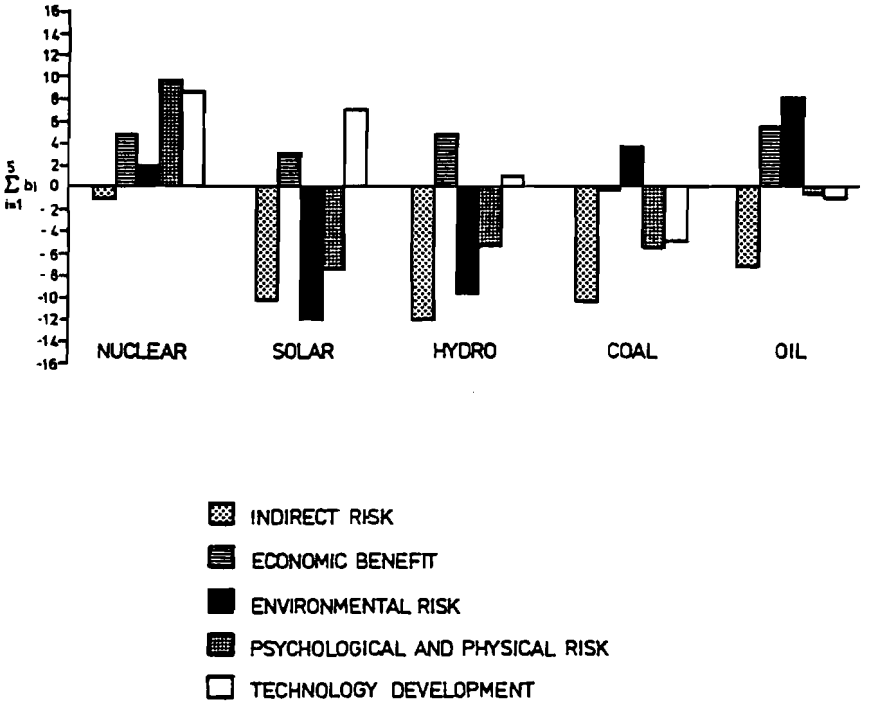

FIGURE 2 Public beliefs about five energy sources (N = 211) held by the total public sample.

to risk without personal control"). Solar energy was seen as least risky in this respect, and the public were uncertain with regard to oil.

Technological Development

The public, on average, also saw large differences amongst the energy sources in terms of their likelihood of leading to future technological developments: they were certain that the use of nuclear energy would lead to such developments and that the use of coal would not. They also believed that the use of solar energy would lead to these developments (although statistically less so than nuclear energy), and they were uncertain about oil and hydro in this respect.

DIFFERENTIAL ANALYSIS OF PRO AND CON NUCLEAR GROUPS

While the above results describe the average responses of the total public sample, it is perhaps more meaningful to examine the differing views of the five energy systems which are held by those PRO and CON nuclear energy. These differences were also examined by analysis of variance.[6] As expected, a significant three-way interaction was obtained indicating that, for at least some of the energy sources,

TABLE 4 Mean belief strengths for each belief dimension and energy source held by those PRO and CON the use of nuclear energy.

		Energy source				
Belief dimension	Group	Nuclear	Solar	Hydro	Coal	Oil
Indirect risk	PRO	−6.8	−10.7	−12.2	−10.5	−8.8
(Future-oriented/political)	CON	3.9	−10.5	−12.4	−10.7	−6.6
		**	NS	NS	NS	**
Economic benefits	PRO	7.1	3.9	6.1	1.8	5.5
	CON	0.8	2.6	2.2	−1.6	4.0
		**	NS	**	**	NS
Environmental risk	PRO	−2.7	−11.7	−10.1	3.2	4.7
	CON	5.1	−12.6	−9.9	3.4	9.1
		**	NS	NS	NS	**
Psychological and physical risk	PRO	4.4	−7.6	−6.6	−6.9	−3.5
	CON	12.4	−9.5	−5.9	−5.6	−0.9
		**	NS	NS	NS	*
Technological development	PRO	9.1	5.9	1.7	−5.0	1.3
	CON	6.4	6.5	−1.2	−5.8	−0.8
		*	NS	**	NS	*

*Difference between PRO and CON group significant, $p < 0.05$.
**Difference between PRO and CON group significant, $p < 0.01$.
NS, difference between groups not significant.

those PRO and CON nuclear energy had different beliefs. These differences are given in Table 4 and are summarized in bar diagrams in Figure 3.

It is not surprising that the PRO and CON groups were found to have quite different perceptions of nuclear energy. For the PRO group nuclear energy was believed to lead to economic benefits and technological development, but also to be associated with some degree of psychological and physical hazard. The PRO group did not believe that using nuclear energy would lead to indirect (i.e., future-oriented and political) risks nor, to a lesser degree, to environmental risk. The CON group believed nuclear energy would lead to all three types of risks. They also believed that it would lead to technological developments (but to a lesser degree than did the PRO group), and they did not perceive nuclear energy as leading to economic benefits. The differences between the PRO and CON groups' perceptions of nuclear energy have been discussed in depth in earlier publications (Otway and Fishbein 1977; Otway *et al.* 1978).

Turning to the other energy sources, Table 4 and Figure 1 show that, although those who were PRO and CON nuclear energy did not differ in their beliefs about solar energy, there were significant differences in some of their beliefs about the remaining three energy sources:

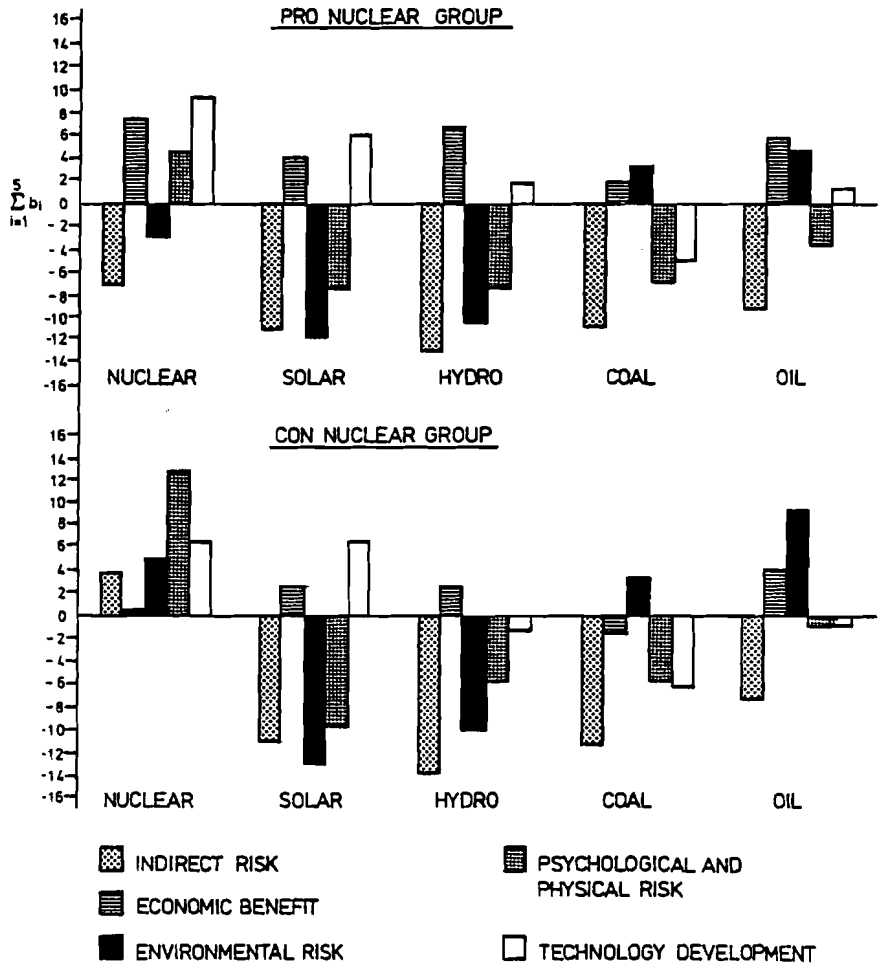

FIGURE 3 Beliefs about five energy sources held by those PRO and CON the use of nuclear energy.

Hydro

On average, people who were PRO or CON nuclear energy believed equally strongly that hydro-power would not lead to any type of risk. They disagreed, however, about the benefits of using these systems. Those who were PRO nuclear energy believed more strongly that their use would lead to economic benefits and technological developments than did the CON nuclear group.

Coal

People who were PRO and CON nuclear energy did not differ in their beliefs about the risks associated with the use of coal, or in their beliefs that using coal

would not lead to technological developments. There was a significant difference between the two groups only with respect to economic benefits: the PRO group believed that coal would lead to some economic benefits while the CON group did not.

Oil

The two groups differed more in their beliefs about the use of oil than about any other source apart from nuclear energy; indeed it was only with respect to economic benefits that there was any agreement at all. Consistent with the previous findings that the PRO group's attitude toward oil was more favorable than that of the CON group, the PRO group saw the use of oil as less risky on all counts, and more likely to lead to technological developments.

These different beliefs about the energy sources resulted in different rankings of these sources by the PRO and CON groups. Table 5 shows the differences in mean belief scores, on each dimension, amongst all possible pairs of energy sources. Differences between the PRO and CON groups were found primarily in three areas: comparisons between nuclear energy and the other energy sources, comparisons between hydro and solar energy, and comparisons between coal and oil. These differences will be discussed separately below.

Nuclear Energy As Compared to the Fossil Fuels

Both those groups PRO and CON nuclear energy believed that this energy source was more likely than the fossil fuels to lead to indirect risks as well as psychological/physical risks. However, with respect to environmental risks, nuclear energy was viewed by the PRO group as being less of a threat than the fossil fuels, and by the CON group as being less risky than oil but about the same as coal. Both groups believed that the use of nuclear energy was significantly more likely to lead to technological developments than was the use of either fossil fuel. In terms of economic benefits nuclear energy was seen by the PRO group as a significantly better prospect than coal but only slightly better than oil. In marked contrast, those opposed to nuclear energy believed that oil was the energy source most likely to lead to economic benefits; they saw little difference in this respect between nuclear energy and coal.

Nuclear Energy As Compared to Hydro and Solar Energy

Both PRO and CON nuclear groups believed that hydro and solar energy posed the least threat on all risk dimensions, and significantly less so than nuclear energy. With respect to benefits, however, the PRO group believed that using nuclear energy was significantly more likely to lead to technological developments than either hydro or solar, and likely to lead to significantly more economic benefits

TABLE 5 Pairwise contrasts of belief strengths about different energy sources held by those PRO and CON the use of nuclear energy.

		Indirect risk			Economic benefit			Environmental risk			Psychological/ physical risk			Technological development		
Nuclear/Solar	PRO	−6.8	−10.7	**	7.1	3.9	*	−2.7	−11.7	**	4.4	−7.6	**	9.1	5.9	**
	CON	3.9	−10.5	**	0.8	2.6	NS	5.1	−12.6	**	12.4	−9.5	**	6.4	6.5	NS
Nuclear/Hydro	PRO	−6.8	−12.2	**	7.1	6.1	NS	−2.7	−10.1	**	4.4	−6.6	**	9.1	1.7	**
	CON	3.9	−12.4	**	0.8	2.2	NS	5.1	−9.9	**	12.4	−5.9	**	6.4	−1.2	**
Nuclear/Coal	PRO	−6.8	−10.5	**	7.1	1.8	**	−2.7	3.2	**	4.4	−6.9	**	9.1	−5.0	**
	CON	3.9	−10.7	**	0.8	−1.6	NS	5.1	3.4	NS	12.4	−5.6	**	6.4	−5.8	**
Nuclear/Oil	PRO	−6.8	−8.8	*	7.1	5.5	NS	−2.7	4.7	**	4.4	−3.5	**	9.1	1.3	**
	CON	3.9	−6.6	**	0.8	4.0	*	5.1	9.1	**	12.4	−0.9	**	6.4	−0.8	**
Solar/Hydro	PRO	−10.7	−12.2	NS	3.9	6.1	NS	−11.7	−10.1	NS	−7.6	−6.6	NS	5.9	1.7	**
	CON	−10.5	−12.4	*	2.6	2.2	NS	−12.6	−9.9	*	−9.5	−5.9	**	6.5	−1.2	**
Solar/Coal	PRO	−10.7	−10.5	NS	3.9	1.8	NS	−11.7	3.2	**	−7.6	−6.9	NS	5.9	−5.0	**
	CON	−10.5	−10.7	NS	2.6	−1.6	**	−12.6	3.4	**	−9.5	−5.6	NS	6.5	−5.8	**
Solar/Oil	PRO	−10.7	−8.8	*	3.9	5.5	NS	−11.7	4.7	**	−7.6	−3.5	**	5.9	1.3	**
	CON	−10.5	−6.6	**	2.6	4.0	NS	−12.6	9.1	**	−9.5	−0.9	**	6.5	−0.8	**
Hydro/Coal	PRO	−12.2	−10.5	*	6.1	1.8	**	−10.1	3.2	**	−6.6	−6.9	NS	1.7	−5.0	**
	CON	−12.4	−10.7	*	2.2	−1.6	**	−9.9	3.4	**	−5.9	−5.6	NS	−1.2	−5.8	**
Hydro/Oil	PRO	−12.2	−8.8	**	6.1	5.5	NS	−10.1	4.7	**	−6.6	−3.5	**	1.7	1.3	NS
	CON	−12.4	−6.6	**	2.2	4.0	NS	−9.9	9.1	**	−5.9	−0.9	**	−1.2	−0.8	NS
Coal/Oil	PRO	−10.5	−8.8	*	1.8	5.5	**	3.2	4.7	NS	−6.9	−3.5	**	−5.0	1.3	**
	CON	−10.7	−6.6	**	−1.6	4.0	**	3.4	9.1	**	−5.6	−0.9	**	−5.8	−0.8	**

*Difference in mean values significant, $p < 0.05$.
**Difference in mean values significant, $p < 0.01$.
NS, difference in mean values not significant.

than solar energy but about the same as hydro. The CON group did not distinguish amongst these three energy sources with respect to economic benefits, although they did believe that both solar and nuclear energy were significantly more likely to lead to technological developments than was hydro.

Hydro As Compared to Solar Energy

The PRO nuclear group only distinguished between hydro and solar energy with respect to the question of future technological developments, solar energy being rated significantly more positive. The CON group viewed these two energy sources as being significantly different on all but the economic benefits dimension. That is, the CON group believed that solar energy was less likely to lead to environmental risk and psychological/physical risk but more likely to lead to indirect risks and technological developments.

Coal As Compared to Oil

Both groups believed that oil was more likely to lead to economic benefits and future technological developments than was coal, and that oil was also more of an indirect risk and psychological/physical risk. However, while those who were PRO nuclear energy believed that coal and oil posed equal environmental threats, those in the CON group believed oil to be significantly worse in this respect than coal.

5 CONCLUSIONS

This report has described an analysis of the Austrian public's beliefs about five energy options, and their overall attitude to each energy source. Attitudes were shown to be polarized only in the case of nuclear energy; and, regardless of their position on nuclear energy, the members of the public who participated in the survey were most favorable toward the renewable sources hydro and solar energy. The public sample *as a whole* was least favorable to nuclear energy. Those who were PRO nuclear energy, like the rest of the sample, were most favorable toward hydro and solar energy, but they were least favorable toward the fossil fuels; their attitudes toward nuclear energy were thus intermediate (on average) between their views on the renewable and the fossil sources. Given this widespread preference for hydro and solar energy it is worth emphasizing that in Austria, as elsewhere, suitable large-scale solar systems are not commercially available. Further, the attitudes toward hydro-power probably reflect favorable experience with this source, whose potential in Austria has already been developed to an extent where additional projects could not make a significant contribution to national electricity needs. Of the options studied here, only coal, oil, and nuclear energy are viable possibilities for appreciable near-term increases in Austrian electricity-generation capacity.

Austria's first nuclear power plant, a 730-MWe facility at Zwentendorf near Vienna, has been completed; however, due to adverse public reaction, and as a result of a referendum (November 1978) in which the Austrian electorate decided against the use of nuclear energy, this plant will not become operational. During the construction of the Zwentendorf plant the Austrian government sponsored a public information campaign (in late 1976 and early 1977) intended to open up debate on energy options to the general public, and the publicity given to articulate pressure groups dramatically polarized opinions with respect to the intended nuclear energy program; the resulting controversy led directly to the public referendum (Hirsch 1977).

Although the findings described here are for only a small sample of the

Austrian public, the in-depth analysis of beliefs about the different energy options can make some contribution to understanding the Austrian dilemma. This report focuses on beliefs which are relevant to a *comparison* of energy systems, but, in view of the existing controversy, also explores the perceptions of those individuals shown to be PRO or CON nuclear energy in an attempt to define the crucial differences.

NOTES

1. A related study of the beliefs underlying voting behavior in a nuclear energy referendum in the USA has also been published in this series (Bowman *et al.*, 1978).
2. The particular attitude model used in this series of reports is that developed by Fishbein and his co-workers (see Fishbein and Ajzen 1975). The way in which evaluations and belief strengths are combined to estimate attitude can be stated formally:

$$A_o \approx \sum_i^n b_i e_i$$

where

A_o = the attitude toward the object o
b_i = the strength of the belief which links the attitude object to attribute i
e_i = the evaluation of attribute i
n = the number of salient beliefs, i.e., those currently within the span of attention

3. The method used was principle components analysis of the correlation matrix followed by Varimax rotation. This technique produces underlying dimensions which do not correlate with each other (orthogonal factors).
4. The three-mode factor analysis was based on a three-way decomposition of the raw crossproducts matrix, followed by DAPPFR rotation (Direct Artificial Personal Probability Factor Rotation; R.L. Tucker, Personal Communication 1978), a method which produces oblique (correlated) factors; the intercorrelations between the factors were, however, low.
5. The 50 individuals with highest scores on the semantic differential measure of attitude toward nuclear energy.
6. This ANOVA was 2 X 5 X 5: group membership (PRO/CON) X belief dimension (5 belief dimensions derived from the factor analysis) X energy sources (nuclear energy, coal, oil, hydro-power, solar energy).

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