A COMPARATIVE STUDY OF PUBLIC BELIEFS ABOUT FIVE ENERGY SYSTEMS

Kerry Thomas
Dagmar Maurer
Martin Fishbein
Harry J. Otway
Ron Hinkle
David Simpson

January 1979
WP-79-5

INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
A-2361 Laxenburg, Austria

Harry J. Otway is Head, Technology Assessment Sector, Joint Research Centre, Commission of the European Communities, I-21020 Ispra (VA), Italy. This work was performed during his association with IIASA.

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 working paper 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 sub-groups most "PRO" and "CON" the use of nuclear energy. Results specific to public attitudes toward the use of nuclear energy have been published as RM-77-54; and an earlier pilot study on this same topic was reported in RM-76-80. The determinants of voting behaviour in a public referendum on nuclear energy were analyzed in RM-78-8.

ABSTRACT

Public perceptions (n = 244) of five alternative energy sources (nuclear, coal, oil, hydro, and solar) were examined using an attitude model based upon the underlying beliefs held about the attitude object (e.g., each energy system); the focus was on the differing perceptions of sub-groups (n = 50) most PRO and CON the use of nuclear energy.

Both PRO and CON groups preferred hydro and solar energy to the other energy sources; but the PRO Nuclear Group preferred nuclear energy to the fossil fuels while, for the CON Nuclear Group, nuclear energy was the least preferred system. Of the theoretically possible significant contributors to near-term Austrian electricity supply which were considered in this study (i.e., nuclear, coal, oil), the PRO Nuclear Group saw oil as the alternative to nuclear energy while the CON Nuclear Group preferred coal to oil as the non-nuclear alternative.

Factor analysis found that five, relatively independent belief dimensions characterise public thinking about energy systems: beliefs about future-oriented and political risks; economic benefits; environmental risks; psychological/physical risks; and future technology development. Analysis of the belief systems suggested that both PRO and CON Nuclear Groups preferred hydro and solar energy because these systems were perceived as being the least threatening on all risk-related dimensions. The PRO group saw nuclear energy as the system most likely to lead to economic benefits and future technological developments; their low ratings of fossil fuels were primarily due to beliefs that the fossil fuels could provide only marginal economic benefits while leading to appreciable environmental risks. In contrast, the CON group viewed nuclear energy as only marginally more likely to provide economic and technological benefits than the fossil fuels, but as an appreciably greater threat on the risk-related dimensions.

INTRODUCTION

Public acceptance is becoming an increasingly important constraint to be considered by those responsible for technological policies. In order to wisely formulate policy 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 working paper reports 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 sub-groups shown to be most in favour and most against the use of nuclear energy.

METHODOLOGICAL APPROACH

The attitude model we have used in our studies of the determinants of public acceptance of energy systems has been set out in some detail in the reports cited above. Therefore we will simply summarise the main points which are relevant to the procedures and analyses discussed in this paper.

First, attitude is defined as an overall feeling of favourableness 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, Suci and Tannenbaum (1957), or indirectly by considering the responses to a set of belief or opinion items about the attitude object. Second, the model we use specified the relation between beliefs and overall attitude:

[1/] A related study of the beliefs underlying voting behaviour in a nuclear energy referendum in the USA has also been published in this series (Bowman, Fishbein, Otway and Thomas, 1978).

Each belief is treated as a subjective probability judgement[2/] 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[3/].

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 the attributes were chosen following open-ended interviews with members of the general public, from previous research and from a literature survey. Although the complete set of 39 attributes used (see Otway and Fishbein, 1977) is applicable to different energy sources, and covers possible consequences of using these energy sources, many of the items are specific to nuclear energy since this was our primary concern. Therefore, the 39 attributes do not include all modal salient beliefs about all energy sources. The purpose of this paper is to examine how those attributes which are known to contribute to attitudes toward nuclear energy are perceived by the public in relation to other energy sources. Particular attention is given to the beliefs held by those members of the public who are most pro and most con the use of nuclear energy.

[2/] A simplified measure of subjective probability is used which avoids the strict requirements of probability measures: (a) the beliefs are not treated as a partitioned event space where probabilities would sum to 1; (b) by using a bi-polar (+3 to -3) scale it is possible to encompass levels of probability that the attitude object <u>is</u> or <u>is not</u> associated with the attribute in question.

[3/] The particular attitude model used in this series of reports is that developed by Fishbein and his associates (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.

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 I.

Questionnaire

The responses on which this report is based were collected at the same time as the responses to questions about nuclear energy. Attribute evaluations were measured without reference to any specific energy source (e.g., 'increase the prestige of my nation') using a 7-point scale where the end points were labelled good/bad. The belief strength measures, relating the set of attributes to each energy source in turn, were made on 7-point likely/unlikely scales. In addition, overall attitude toward each energy source was independently measured using the semantic differential technique of Osgood et al. (1957).

RESULTS

Although the primary concern of this report is the comparison of beliefs about using different energy sources, it is worthwhile to first consider 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 [4]) yielded the three distinct types of frequency distribution shown (smoothed) in Figure 1. The distributions were virtually the same for the two fossil fuels and again for hydro and solar energy; 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 favourable. For hydro-power and solar energy there were virtually no negative attitudes; the most frequent response was highly favourable. Attitudes toward nuclear energy

---

[4] In keeping with Osgood's definition of attitude only adjective pairs which (for all five sources) had high loadings on the evaluative dimension were used. To identify these items factor analysis of semantic differential scores was carried out for all sources combined. The five pairs retained were: harmful/beneficial; good/bad; harmonious/controversial; acceptable/unacceptable; and moral/immoral; giving a range of possible attitude scores of -15 to +15.

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 polarised to warrant differential analyses of underlying beliefs for 'PRO' and 'CON' groups.

As in the earlier study, two sub-groups were formed from the total sample by selecting the 50 respondents most favourable to the use of nuclear energy (PRO group) and the 50 most negative (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)[5/].

[5/] ANOVA is a statistical technique for examining the significance of effects in a factorial experiment, i.e., an experiment where the possible effects of more than one experimental (independent) variable are tested simultaneously. This type of experimental design enables the investigator to evaluate not only the overall effects of each experimental variable but also the interactions between them. In a factorial design the experimental variables or factors are tested by examining different levels of each factor. In the present study, for example, the effects of 2 factors on attitude scores were examined. The factor were: (1) energy source (with 4 levels, e.g., coal corresponds to one level) and (2) group membership (2 levels, PRO and CON the use of nuclear energy). This design can be represented as a 4 x 2 matrix where each cell is a combination of one level of one factor with one level of another factor. ANOVA decomposes the total variance in the dependent measure in a way which permits testing of the statistical significance of main effects (i.e., the effect of one factor, over all its levels, when all factors are combined) and interactions between these effects (i.e., where one factor has a differential impact on different levels of another factor). ANOVA does not examine specific combinations of levels of factors (i.e., cells in the matrix) but provided that interaction effects are shown to be significant then differences in mean values of the dependent variables in cells of the matrix which are of particular interest can be tested a posteriori.

The statistical significance of the effect of a factor (A) depends on the ratio of variance in the dependent measure which can be attributed to A and the variance which is treated as error. The variance attributed to A is the portion of total variance in the dependent measure due to variation between different levels of A (other factors combined); and the error is the portion of variance in the dependent measure due to variation within each level of A. Since error is derived from variation within levels of a factor it is important to differentiate between instances where these effects of levels are measured on different (and randomly assigned) individuals or on the same people by repeated measures. Clearly, in the second case, underlying consistencies in response can be expected and have to be taken into account. This can be done by analysis of variance. It should be noted that repeated measures were used in this study, i.e., each individual responded to beliefs about five energy sources.

The mean values of attitude for each group with respect to energy sources are shown in Table II. In general, the PRO Nuclear Group was more favourable 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 energy sources. For the total sample, respondents were generally more favourable toward hydro (10.7) and solar energy (10.5) than they were toward coal (6.1) and oil (5.4); they were least favourable 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 favourable towards oil. 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 summarise briefly, the PRO Nuclear Group was more favourable to hydro and solear energy than to coal and oil. Their attitudes toward nuclear energy did not differ significantly from their attitudes toward oil. These attitudes were significantly lower than those toward hydro and solar and somewhat more favourable than those toward coal. In constrast, the CON Nuclear Group was strongly negative toward nuclear energy but had positive attitudes toward the other energy sources; they were most favourable toward hydro and solar, moderately favourable toward coal, and significantly less favourable 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 four factors[6/]. These dimensions underlying perceptions of nuclear energy were named: psychological risk, economic/technical benefits, socio-political risk and environmental/physical risk. The reduction of the belief set to four major dimensions, in practical terms, facilitated comparisons

---

[6/] 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).

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 using factor analysis[7]; in this case a more sophisticated factor-analytic technique was used, i.e., Tucker's (1966) extension of the factor analytic to three-dimensional matrices. The three modes in this analysis were the five energy sources (source mode), the 39 attributes (belief mode), and the 224 individuals (subject mode)[8]. The findings are reported briefly for each of the three modes in turn, followed by a detailed analysis of the belief factors.

(a) 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.

---

[7] Factor analysis is a generic term for several linear, parametric statistical methods which identify the minimum number of dimensions required to account for the variance in a larger set of intercorrelated variables. Normally factor analysis is carried out on a data matrix (n x m) where n subjects have each responded to m variables. Underlying factors are derived to summarise relationships among the variables. Each variable is assigned a loading (or weight) which represents its relationship to the factors. Further, subjects' scores on these factors can be calculated that quantify the degree to which each factor is applicable to (or employed by) a given subject. Subsequent analyses attempt to clarify the nature of individual differences by relating these subject scores to other (e.g., demographic) variables or by identifying discrete sub-groups, or clusters, of subjects in the multi-dimensional space determined by the factor scores. This procedure provides a dimensional representation of the two-mode data matrix in terms of the interrelationships amongst the variables (attribute mode) and the interrelationships amongst the subjects (subject mode).

[8] The three-mode factor analysis was based on a three-way decomposition of the raw crossproducts matrix, followed by DAPPFR rotation (Direct Artifical Personal Probability Factor Rotation; Tucker, 1978) method which produces oblique (correlated) factors; the intercorrelations between the factors were, however, low.

(b) 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, socio-political implications, and environmental/physical risk). When 3-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 the economic/technical benefits factor separated into two factors when the five sources were considered together: 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 socio-political 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 III.

(c) 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 that this tendency to make more extreme responses may be interpreted as greater confidence and might, 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 socio-economic 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 attitude 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 attitude 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 was high on Factor II while 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.

Subject Factor III appeared to be a 'true' content dimension. Those subjects who had low scores on Factor III shared three common viewpoints: (1) They perceived all five energy sources as economically viable and more so than the modal view (note that the group as a whole, for example, saw coal as an uneconomic prospect); (b) they saw nuclear energy as generally 'better' than the modal perception, e.g., as more likely to be economically sound and to lead to technological (spin-off) developments; (c) they perceived oil as somewhat better on all counts than the modal view, e.g., as 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 (symmetrically opposing views were held by those high on Factor III) shows that this subject factor represents an underlying dimension which primarily relates to beliefs about nuclear energy. Consistent with this 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 was high on Factor III, the 35 - 50 group was relatively neutral and the under 24 and 'over 50' groups were low.

In summary, the interpretation of the 3-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 hydro and solar energy as similar. For the belief mode five factors emerged: psychological/physical risk; economic benefits; technology 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' judgements about the attributes of the five energy systems: (1) an influence of response style whereby some people tended to use the 'unlikely' side of any scale (Factor II); (2) 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); and (3) a 'true' content dimension that reflects differences in beliefs about the different energy systems. This latter content dimension is noteable in that it does tend to distinguish between those who are PRO (low on Factor III) and CON (high 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[9]. 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 generalise 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 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 judgements 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 paper will primarily consider the beliefs of those public groups who were most in favour (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 3-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 $\left(\sum_{i=1}^{5} b_i\right)$ for each energy source in turn. The mean values of $\left(\sum_{i=1}^{5} b_i\right)$ for each of the five belief

---

[9] The 50 individuals with highest scores on the semantic differential measure of attitude toward nuclear energy.

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-a-vis nuclear power than 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 Benefits. With the exception of coal, the public believed that all energy sources would lead to economic benefits (e.g., 'an increased standard of living', 'increased employment'). They believed that the use of oil was the energy source most likely to lead to these benefits, although not significantly more so than hydro and nuclear energy; but all of these three were seen as more likely to lead to economic benefits than 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', 'exposure to risk without personal control'). Solar energy was seen as least risky in this respect, and the public were uncertain with regard to oil.

Technology 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 which those PRO and CON nuclear

energy have of the five energy systems. These differences were also examined by analysis of variance[10]. As expected, a significant 3-way interaction was obtained indicating that, for at least some of the energy sources, those PRO and CON nuclear energy had different beliefs. These differences are given in Table IV and are summarised in bar graphs 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 technology 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 it would lead to technology 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 PRO and CON groups' perceptions of nuclear energy have been discussed in depth in earlier publications (Otway and Fishbein, 1977; Otway, Maurer and Thomas, 1978).

Turning to the other energy sources, Table IV and Figure 3 show that, although those 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:

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 PRO nuclear energy believed more strongly that their use would lead to economic benefits and technological developments than did the CON Nuclear Group.

Coal. Those 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.

---

[10] This analysis of variance can be represented as a 2 x 5 x 5 matrix; the three factors are: (1) group membership (2 levels PRO/CON); (2) belief dimensions (5 levels corresponding to the 5 factors); and (3) energy sources (5 levels, one for each source).

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 favourable 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 V 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 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 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 significant more likely to lead to technological developments than either hydro or solar and to lead to significantly more economic benefits 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 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.

SUMMARY AND CONCLUSIONS

This paper has examined public perceptions of five alternative energy sources; the focus was on the differing views of those members of the public who were PRO and CON the use of nuclear energy.

The public as a whole were more favourable toward the use of the renewable sources of hydro and solar energy than toward the use of fossil fuels. They were least favourable to the use of nuclear energy. When sub-groups PRO and CON the use of nuclear energy were examined separately, it was found that this same ordering was maintained for the CON group; however, the PRO Nuclear Group viewed the use of nuclear energy somewhat less favourably than the use of hydro and solar energy, but more favourably than the use of the fossil fuels[11].

---

[11] The potential hydro-electric capacity in Austria has been developed to an extent where additional projects could not make a significant contribution to national electricity needs. As large-scale solar systems are not yet commercially available, of the five energy sources considered in this study, only coal, oil or nuclear energy are possibilities for appreciable near-term increases in Austrian electricity-generation capacity. At the time of writing, construction has been completed on Austria's first nuclear power plant, a 730 MWe facility located near Zwentendorf; at the end of 1977 the total Austrian generating capacity was about 11.500 MWe. A public referendum is scheduled for 5 November, 1978, to determine if the Zwentendorf plant will be allowed to go into operation.

Five relatively independent belief dimensions were found to characterise public thinking about all five energy systems: beliefs about future-oriented social/political (indirect) risks; economic benefits; environmental risks; psychological/physical risks; and future technological developments. Differential analysis of the belief systems of the PRO and CON Nuclear Groups provided insights into the bases for their energy systems preferences; of special relevance to the Austrian energy situation are preferences amongst coal, oil, and nuclear systems.

The group PRO nuclear energy recognised that its use would lead to psychological/physical risks but they did not believe it would lead to future/political (indirect) risks or to environmental risks. They also believed that the use of nuclear energy was more likely to lead to future technological developments and to economic benefits than was any other energy source and that it was less of an environmental threat than the fossil fuels. Of the two fossil fuels, the PRO Nuclear Group preferred oil to coal as an alternative to nuclear energy; they viewed oil as more likely to provide economic benefits than coal, more likely to lead to future technology development and less likely to lead to psychological/physical risks.

The group opposed (CON) to the use of nuclear energy believed that only the nuclear energy option would lead to both future/political (indirect) risks and to psychological/physical risks; they also associated the use of nuclear energy with a considerable degree of environmental risk. Although this group did view nuclear energy as being most likely to lead to future technological developments, they saw only oil as a less viable energy option in economic terms. The CON group preferred coal to oil as the fossil-fuel alternative to nuclear energy. They saw oil as worse than coal on all three risk-related dimensions, but believed oil to be more likely to provide economic benefits and future technological developments.

In summary, the members of the public interviewed in this study tended to be most favourable to the use of hydro and solar energy, regardless of their feelings about the use of nuclear energy. Even those most PRO nuclear energy only preferred this energy system in comparison with the fossil fuels. This is due to the fact that, for both PRO and CON groups, hydro and solar energy were seen as less of a threat than nuclear energy on all risk-related dimensions. The PRO group saw nuclear energy as the system most likely to lead to economic benefits and future technological developments; the lower ratings of the fossil fuels by this group was primarily due to beliefs that these systems 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.

TABLE I

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	
GRADE SCHOOL N = 45	18-34	6	3	2	1	1	5	N = 18
	35-50	4	1	3	3	2	3	N = 16
	51-65	2	2	1	1	4	1	N = 11
TRADE SCHOOL N = 80	18-34	11	14	5	7	8	4	N = 49
	35-50	3	2	3	6	2	1	N = 17
	51-65	6	2	2	1	2	1	N = 14
HIGH SCHOOL UNIVERSITY N = 99	18-34	30	9	8	1	7	4	N = 59
	35-50	12	3	4	1	3	1	N = 24
	51-65	7	4	1	1	2	1	N = 16

TABLE II

A. MEAN VALUES OF ATTITUDE OF THOSE PRO AND CON NUCLEAR ENERGY TOWARD FIVE ENERGY SOURCES

	NUCLEAR	SOLAR	HYDRO	COAL	OIL	ALL+
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 $p < .05$
** difference between groups significant $p < .01$
\+ ALL refers to all energy sources except nulcear

B. SUMMARY OF ANALYSIS OF VARIANCE OF ATTITUDE TOWARDS FIVE ENERGY SOURCES HELD BY THOSE PRO AND CON THE USE OF NUCLEAR ENERGY

MAIN EFFECTS:	PRO/CON (A)	$p < .001$
	ENERGY SOURCES (B)	$p < .001$
INTERACTION:	A x B	$p < .001$

TABLE III

THE BELIEF DIMENSIONS AND MOST CHARACTERISTIC BELIEF ITEMS IDENTIFIED BY 3-MODE FACTOR ANALYSIS

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

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

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

TECHNOLOGY DEVELOPMENT

new forms of industrial development
new methods in medical treatment
dependency on small groups of experts
technical spin-offs
(not) exhausting natural resources

TABLE IV

MEAN BELIEF STRENGTHS FOR EACH BELIEF DIMENSION AND ENERGY SOURCE HELD BY THOSE PRO AND CON THE USE OF NUCLEAR ENERGY

BELIEF DIMENSION		ENERGY SOURCE				
		NUC	SOLAR	HYDRO	COAL	OIL
INDIRECT RISK (Future oriented/ Political)	PRO	-6.8	-10.7	-12.2	-10.5	-8.8
	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	*
TECHNOLOGY 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	*

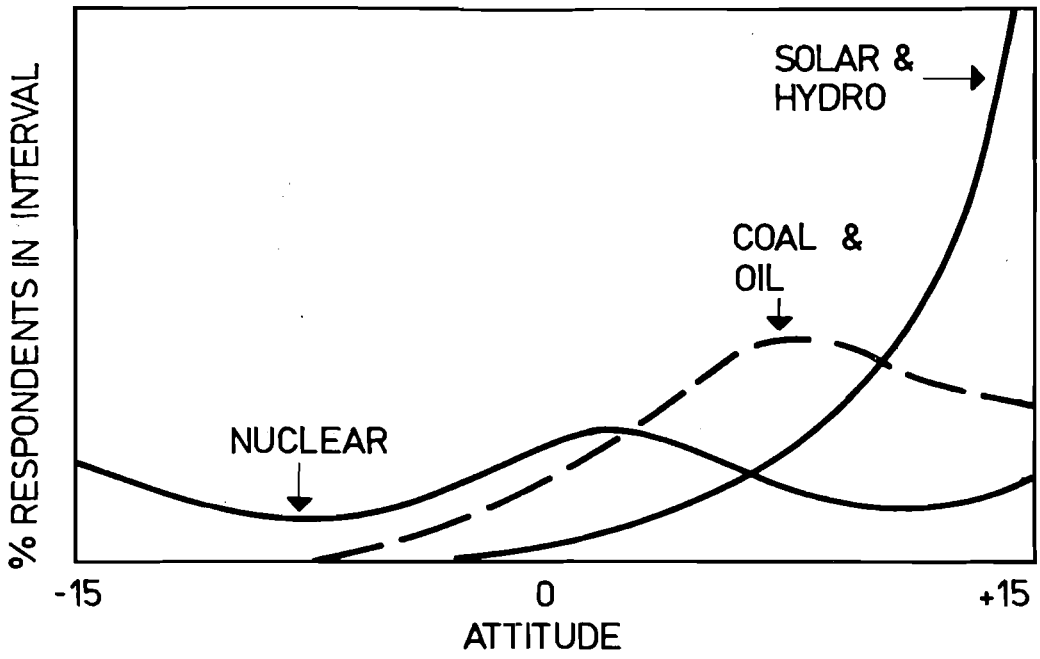
* difference between PRO and CON group significant $p < .05$
** difference between PRO and CON group significant $p < .01$

TABLE V

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			TECHNOLOGY 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 $p < 0.01$



SMOOTHED FREQUENCY DISTRIBUTION OF
ATTITUDES TOWARD ENERGY SOURCES

FIGURE I

PUBLIC BELIEFS ABOUT FIVE ENERGY SOURCES (N=211) HELD BY THE TOTAL PUBLIC SAMPLE

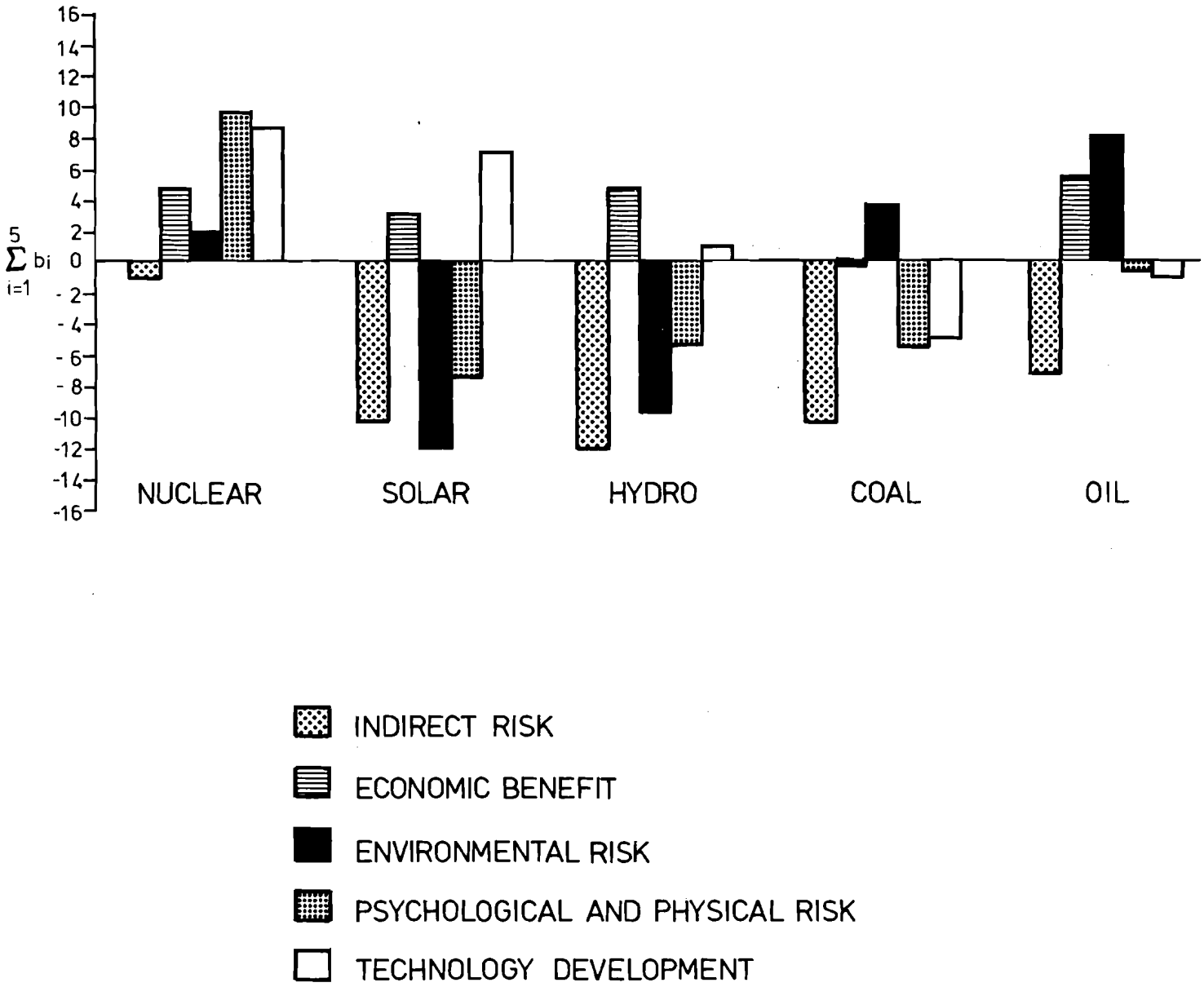


FIGURE II

BELIEFS ABOUT FIVE ENERGY SOURCES HELD BY THOSE PRO AND CON THE USE OF NUCLEAR ENERGY

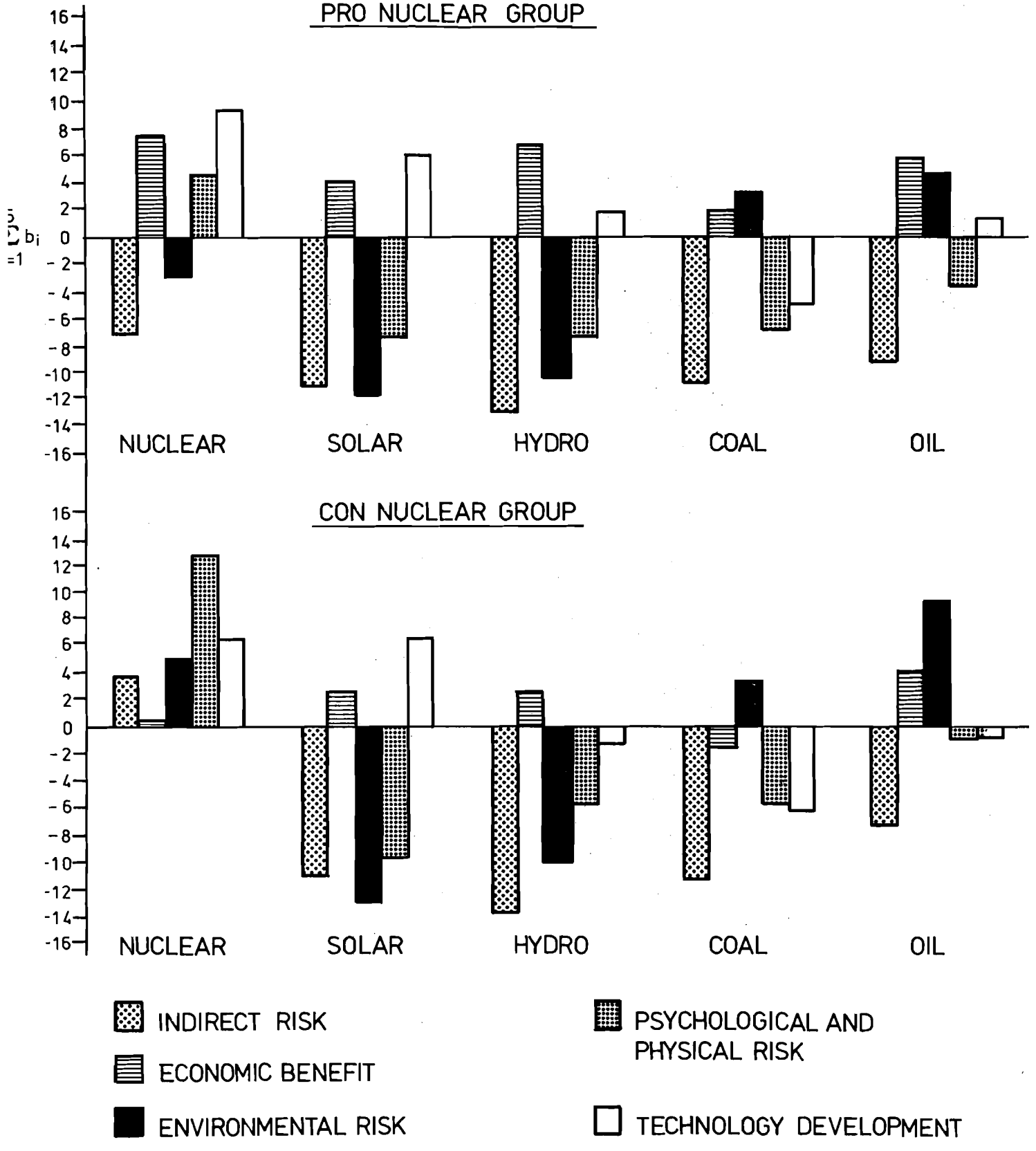


FIGURE III

REFERENCES

Bowman, C.H., M. Fishbein, H.J. Otway, and K. Thomas (1978). *The Prediction of Voting Behaviour in a Nuclear Energy Referendum*. RM-78-8, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Fishbein, M., and I. Ajzen (1975). *Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research*. Addison-Wesley, Reading, Massachusetts.

Osgood, C.E., G.J. Suci, and P.H. Tannenbaum (1957). *The Measurement of Meaning*. Urbana, University of Illinois Press.

Otway, H.J., and M. Fishbein (1976). *The Determinants of Attitude Formation: An Application to Nuclear Power*. RM-76-80, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Otway, H.J., and M. Fishbein (1977). *Public Attitudes and Decision Making*. RM-77-54, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Otway, H.J., D. Maurer, and K. Thomas (1978). Nuclear Power: The Question of Public Acceptance. *Futures*, 10, April, 1978, 109-118.

Tucker, R.L. (1966). Some Mathematical Notes on Three-Mode Factor Analysis. *Psychometrika*, 31, 279-311.

Tucker, R.L. (1978). Personal Communication.