

# Nuclear Waste Risk Perceptions and Attitudes in Siting a Final Repository for Spent Nuclear Fuel<sup>1</sup>

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## 1. Introduction

The siting of spent nuclear fuel (SNF) is a highly controversial issue in most countries. So far, Finland [6; 9] and Sweden have been exceptions; for reviews see Sjöberg [13; 15]. The corporation responsible for finding a site and building a repository for SNF in Sweden, SKB, managed to find two promising host communities in 2001: Östhammar and Oskarshamn, two small communities on the Baltic coast which both are hosting nuclear industry<sup>2</sup>. They had been the subjects of pilot studies pointing to a need for an in-depth site investigation, here called phase 2. This phase involves geological studies of the bedrock in chosen localities, and also follow-up studies of the social and psychological consequences of the siting process. The present paper reports some of the results from such a study, carried out in 2005, in Oskarshamn and Östhammar. Comparison data from 2001 will also be presented.

The background of this work is described at the SKB web site in the following way:

“Three factors determine the choice of site. The rock must satisfy stringent requirements. The industrial facility should be built on a site where the environmental impact is as little as possible. The land must be easily accessible with good transportation possibilities. The municipality and its inhabitants must also be positively inclined towards the final repository.”<sup>3</sup>

The major dependent variable in the present work is *the stated intention to vote in a possible future local referendum regarding the siting of an SNF repository*<sup>4</sup>. Such a direct approach was deemed to be preferable to a more indirect attitude measure for two reasons.

First, the level of response to an attitude question is seldom possible to interpret *per se*, and requires other data before a conclusion can be drawn as to its meaning. It is therefore necessary to compare voting intention with a traditional attitude measure used in many Swedish studies carried out by the SOM Institute of the University of Göteborg [5]. The present data set was analyzed in order to describe the relationship between attitude and policy

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<sup>1</sup>. Work support by the Swedish Nuclear Fuel and Waste Management Co (SKB), in its Social Science Research Program. See [www.skb.se](http://www.skb.se).

<sup>2</sup>. Oskarshamn has a nuclear power plant and also a facility for the temporary storing of SNF. Östhammar has a power plant as well, and a facility for the final storing of low and middle-level radioactive waste.

<sup>3</sup>. [http://www.skb.se/templates/SKBPage\\_8733.aspx](http://www.skb.se/templates/SKBPage_8733.aspx), retrieved Feb. 15, 2006.

<sup>4</sup>. At the present (February, 2006) no decision has been made to hold such referenda but they have been carried out in two previous cases, see Drottz-Sjöberg [2; 3].

intention [14]. It was found that a sizable fraction of those who stated that they had a negative attitude (SOM type of format for attitude measurement) still stated that they would vote pro a repository. A majority of those who chose the neutral response option on the attitude question also stated they would vote pro. Hence, the attitude question underestimated the proportion who said they would vote pro. This was so in spite of a high correlation between the two questions (0.82).

Second, the most powerful predictor of political decisions, such as voting, is that of intention specified as concretely as possible. This is not only the best predictor; it is also in most cases a very powerful predictor [1]. Of course, this does not mean that “the buck stops here”; there is always much left to explain when it comes to attitudes [16].

*Perceived risk* has traditionally been held to be an important determinant of policy attitudes [4]. This approach has been called the Psychometric Model and it has a number of serious weaknesses [11]. It involves measuring perceived risk on a large number of dimensions; for the purposes of the present paper it was considered to be too complex (in addition to other aspects which require their own analysis). Instead, the simple approach to perceived risk taken here involved using data on *rated over-all risk of nuclear waste*, both to the respondents’ own person (personal risk) and the risk to others (general risk). Such ratings have been used in many studies and their properties are well known [12]. The first hypothesis of the study is that policy attitude is partly explained by perceived risk.

*Trust* has been extensively discussed in the risk perception attitude, but almost always in terms of social trust. In earlier work I found that social trust was a less potent explanatory variable than epistemological trust, or trust in the pertinent scientific knowledge behind waste management [10]. I therefore test a second hypothesis in the present study, stating that trust in science is an important factor in accounting for policy attitude. Both kinds of trust are measured here by attitude items which are combined to form indices.

Finally, policy attitude should be related to *attitude to the proposed facility per se*. Attitude has been implicated as important to the acceptance of waste management facilities [7; 8]. As mentioned above, these two variables are not identical, not by any means. For example, one could plan to vote in favor of a repository in spite of having doubts as to its utility for the community – possibly because of a belief that the siting process otherwise would become a very difficult national issue. The reverse kind of thinking is also possible, of course. Attitude is measured here by a combined score based on a number of items measuring beliefs about the utility of a repository. The third hypothesis to be tested is that of an explanatory effect of attitude on policy intention.

Summing up, the paper will do the following:

- Describe the time trends between 2001 and 2005 in terms of policy intention, perceived risk, trust and attitude
- Analyze the relationships between policy attitude – the major dependent variable – and the explanatory variables of perceived risk, trust and attitude.
- Determine whether policy attitude variation across time, municipalities and genders can be accounted for by variation in perceived risk, trust and attitude.

## **2. Method**

### **2.1 Respondents**

Random samples of 2000 persons living in Östhammar and Oskarshamn were approached with a mailed questionnaire. After two reminders, 888 had returned filled out questionnaires, yielding a total response rate of 50 percent, taking into account that some persons had moved without giving a forwarding address to the post office, and that some were unable to answer due to illness or old age. The data collection in 2001 was described elsewhere; the response rate was about 10 percentage points lower [13]. The total number of respondents analyzed in the present paper was 2167.

A problem of the 2005 sample was a certain under-representation of female respondents. This finding is quite unusual and so far we have no good explanation for it. However, all pertinent analyses in the present paper will be carried out for male and female respondents separately. Also, as we shall see, present findings show relatively weak effects of demographic variables which suggests that bias due to selective drop-out from the samples is small or modest<sup>5</sup>.

### **2.2 Questionnaire**

The following data were used for the analyses presented here:

- Intention to vote in a future local referendum about siting a repository, 5 steps from “surely pro” to “surely con”
- Perceived nuclear waste risk, personal and general. Risks were rated on 8 step scales from “non-existent risk” to “very large risk”
- Social trust, measured by three questions regarding experts, industry (represented by SKB), and the Nuclear Power Inspectorate and the Radiation Protection Institute. Alpha=0.77.
- Epistemic trust, measured by three questions, in abbreviated form: “How well does science know about risks of spent nuclear fuel”?, “Do you consider the technical and scientific questions regarding spent nuclear fuel to be solved?”, and “Science does not provide any definitive answers as to the way of managing spent nuclear fuel in a safe manner”. Alpha=0.70.
- Attitude to a local nuclear waste repository, a 7 step Likert scale from “very strongly positive” to “very strongly negative”. 11 items, alpha=0.93.

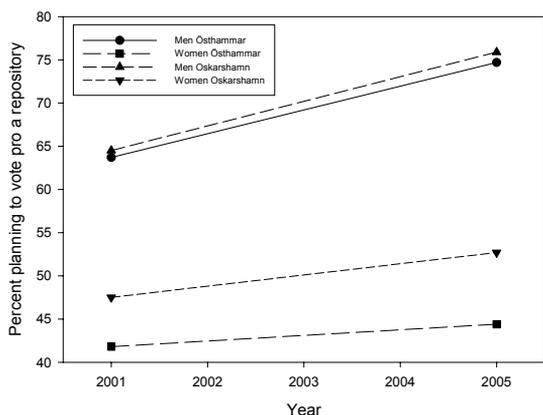
## **3. Results**

### **3.1 Variation in over-all levels of attitudes and risk perceptions**

The percentage of respondents who stated that they would vote in favor of a repository increased from 2001 to 2005 about 10 percent among male respondents, 5 among female respondents, see Fig. 1. The figure also shows a difference between the two municipalities, but only for female respondents.

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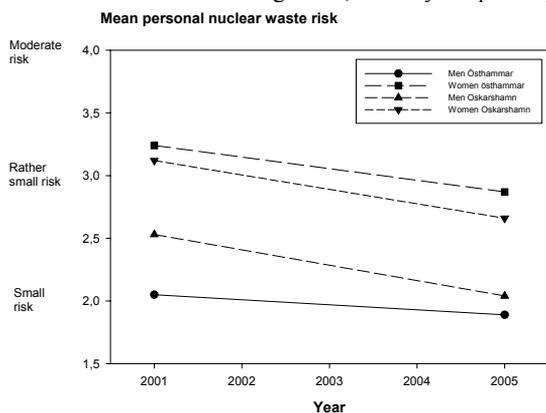
<sup>5</sup>. The typical bias in studies such as the present one is that too many respondents have an above average level of education. However, level of education is seldom strongly related to perceived risk and related variables.



**Figure 1. Voting intentions in 2001 and 2005.**

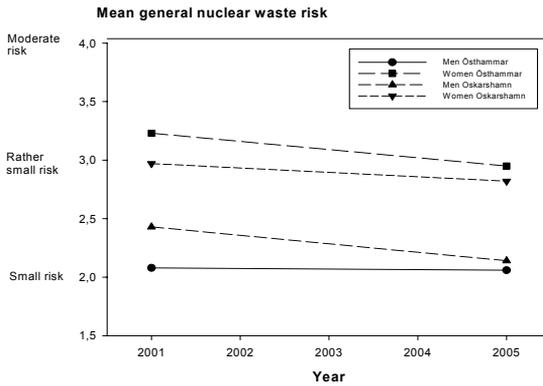
Differences between genders, years and municipalities were all statistically significant<sup>6</sup>, and so was the gender \* year interaction.

Figs. 2 and 3 display the changes in perceived risk of nuclear waste. This judgment dimension referred to nuclear waste in general, not only a repository.



**Figure 2. Mean personal nuclear waste risk.**

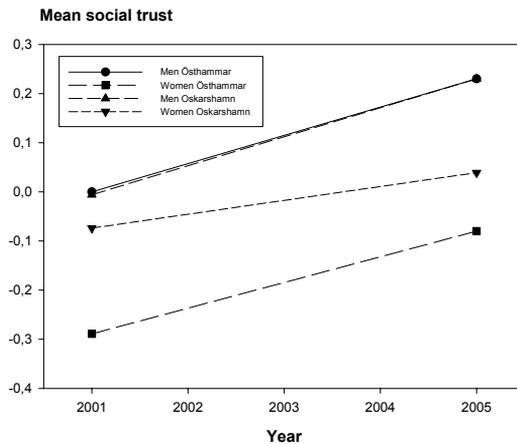
<sup>6</sup> . Most details regarding *F* ratios and *p* values are not reported in this paper. Note, however, that the very large sample size makes even small differences likely to be statistically significant. The effect sizes, as depicted in the graphs, are much more informative. To avoid tedious repetitions in the text, I use the term “significant” to denote “statistically significant” when that term is called for, strictly speaking.



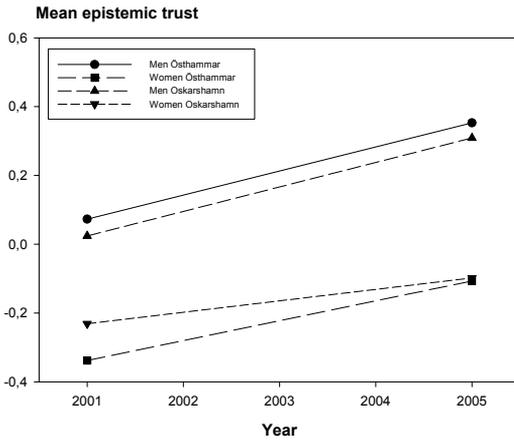
**Figure 3. Mean general nuclear waste risk.**

Figs. 2 and 3 show that there was a change towards small perceived risk, both personal general, albeit of moderate size. Women perceived risk to be larger than men did, a common finding with regards to perceived risk of many kinds. Year and gender, as well as the gender \* municipality differences were significant for both personal and general risk. The gender difference was larger in Östhammar than in Oskarshamn.

Trust was analyzed both in terms of social and epistemic aspects. The results are given in Figs. 4 and 5. It should be noted that trust was measured by means of Likert-type attitude statements and that the mean level therefore cannot be interpreted in a straightforward manner. For this reason, both trust dimensions were standardized to mean=0 and standard deviation=1 before proceeding with the comparative analyses.



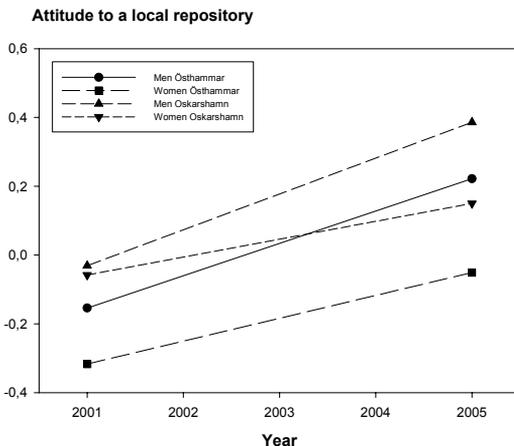
**Figure 4. Mean social trust (standardized values).**



**Figure 5. Mean epistemic trust (standardized values),**

It is seen in Fig. 4 that men had a higher level of social trust than women did. Both genders showed a positive change of moderate size between 2001 and 2005. There was a similar trend for epistemic trust. For social trust, the effects of year and gender and municipality were all significant, but none of the interactions. For epistemic trust, only gender and year effects were significant.

The final dimension to analyze was that of attitude to a local repository, measured as the mean of responses to 11 items. The results are given in Fig. 5. Effects of gender, year and municipality were all significant but none of the interactions. It is seen that that there was a trend towards a more positive attitude in both municipalities and for both genders, although women were not as positive as men were. There was a more positive attitude in Oskarshamn than in Östhammar.



**Figure 6. Mean attitude to a local SNF repository (standardized values).**

### 3.2 Explaining policy attitude

Perceived risk and trust have been implicated as determinants of policy attitude. In the present study, I included also attitude to the facility in question. A regression analysis was carried out on the pooled data for both years. The results are given in Tables 1 and 2.

| Block of explanatory variables                                 | R square adjusted | R square change | F change | Significance of F change |
|--|-------------------|-----------------|----------|--------------------------|
| Demographics (gender, age and educational level)               | 0.065             | -               | -        | -                        |
| Perceived risk (personal and general) + demographics           | 0.400             | 0.335           | 604.079  | <0.0005                  |
| Trust (social and epistemic) + demographics + perceived risk   | 0.597             | 0.197           | 529,418  | <0.0005                  |
| Attitude to repository + demographics + perceived risk + trust | 0.631             | 0.034           | 199,525  | <0.0005                  |

The table shows that the over-all fit of the full model is quite satisfactory, 63.1 percent explained variance. Experience shows that this level is hard to surpass with behavioral data at the individual level. The table also shows that each block of explanatory variables contributed strongly to the over-all power of the model, albeit demographic factors were relatively weak (also a common finding).

Standardized regression coefficients, their levels of significance and part correlations are given in Table 2. These estimates were obtained from application of the full model.

| Explanatory variable           | Standardized regression coefficient | Significance level | Part correlation |
|--------------------------------|-------------------------------------|--------------------|------------------|
| Gender (1=male, 2=female)      | -0.095                              | <0.0005            | -0.091           |
| Age                            | 0.035                               | 0.013              | 0.032            |
| Educational level              | 0.039                               | 0.006              | 0.036            |
| Personal risk of nuclear waste | -0.164                              | <0.0005            | -0.090           |
| General risk of nuclear waste  | -0.076                              | <0.001             | -0.042           |
| Social trust                   | 0.234                               | <0.0005            | 0.164            |
| Epistemic trust                | 0.245                               | <0.0005            | 0.171            |
| Attitude to local repository   | 0.236                               | <0.0005            | 0.184            |

Table 2 shows that the most important factors in accounting for policy attitude were epistemic trust and attitude to the repository. These two variables also contributed most strongly unique explanatory power. Social trust and risk perceptions were also important.

An analysis of covariance was performed on policy intention, using municipality, gender and year as independent factors. The covariates were perceived risk, trust and attitude – the same variables as used above. The result showed that there was no longer an effect of municipality, but some effect of year. A sizable gender effect remained.

### **Discussion**

Summing up, the following was found:

(1). There was a substantially more positive attitude to a local SNF repository in 2005 than in 2001, after an intervening period of phase 2 site investigation. This was true for men and women, both municipalities and with all the response measures analyzed. Men were more positive than women, and had developed more strongly in the positive direction than women had. The attitude in Oskarshamn was somewhat more positive than in Östhammar.

(2). Policy intention was well accounted for by the explanatory variables used here, close to 64 percent of the variance. The most important explanatory variables were epistemic trust, attitude to the repository and social trust, in that order. The differences among these three variables were small with regard to explanatory power.

(3) Variation in policy attitude across time, municipalities and gender was reduced in an analysis of covariance with risk, trust and attitude as controlling factors. Hence, these factors explain a large fraction of the variation in policy attitude as observed here. Yet, the time trend was not fully explained and gender variability remained to some extent unexplained as well.

The reasons for the development towards more positive attitudes cannot be determined with any certainty at this point. However, it should be mentioned that attitude to nuclear power *per se* became more positive during the studied period, both in the two municipalities and in the nation as a whole. Nuclear power attitude was strongly correlated with policy intention in the present data (0.67). Yet, adding nuclear power attitude to the analysis of covariance model mentioned above did not result in a substantially weaker effect of the time factor (or of gender). This result suggests that whatever factor accounts for the changes observed, beyond the ones measured and investigated here, probably are area specific and possibly connected with the SKB program of information – a question for future research to answer.

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