NENE
International Conference
Nuclear Energy for New Europe

Correlation Between Public Acceptance of Nuclear Technology and Trust in Scientists – Case Study Croatia

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ABSTRACT

Public acceptance and support for nuclear technology is one of the key issues affecting potential introduction of nuclear option into energy development strategy and countries' energy mix. There are many factors influencing formation of public opinion on technology matters. One of them is trust in scientists advocating or opposing particular technology. Long term research of public opinion on nuclear issues in Croatia was recently enriched by the new survey conducted during 2023 and carried out on more than 2000 participants. The survey was partially devoted to the question on trust in scientists and scientific, as well as, expert organizations. Preliminary analysis of the survey results indicate that Croatian public trust in scientists is high with observed positive correlation between trust and acceptance of nuclear technology. Scientific engagement in Covid pandemic management raised some controversies and affected relationship between public and scientific community. To explore possible effects in the field of nuclear technology, results of the current survey on trust in scientists are compared to the results of the pre-Covid survey conducted in 2016.

1 INTRODUCTION

Although generally recognized as a reliable and low-carbon source of electricity, nuclear technology often faces difficulties in public understanding and acceptance with benefits being outweighed by potential risks, radioactive waste management, and high initial costs. In addition, pursuing a nuclear programme is a long term political and economic commitment, placing heavy burden on entire society [1]. All of the above are potential obstacles to public understanding and acceptance of nuclear technology, which are the crucial elements for the success of any nuclear programme [2]. It the past, so-called DAD approach (Decide, Announce, Defend) was mostly used for nuclear programme activities [3]. However, it proved to backfire. Absence of communication, information sharing, dialogue and consulting resulted in public opinion formation based not on facts but rather on lack of facts, jeopardizing nuclear project development. For some time, it is evident that early participation of all groups or individuals who feel physically or emotionally affected by nuclear programme activities is crucial for the success of nuclear programme. This is the definition of a stakeholder.

International Atomic Energy Agency (IAEA) identifies a number of stakeholders (media, universities, local community, industry, employees, workers' unions, suppliers, government,

non-governmental organizations, international community, and scientific community) whose mutual engagement is crucial for a nuclear programme to succeed [1]. IAEA also emphasises the need for flexibility, thus enabling incorporation of a priori unidentified stakeholders into the process. Although not explicitly stated, general public is also a stakeholder, probably the most important one. One of the key principles of stakeholder engagement is building mutual trust. Nuclear programme is highly technological and heavily dependent on scientific knowledge. Therefore, particularly interesting is the perception of trust that the scientific community induces in public and potential correlation between public trust in science and public acceptance of nuclear technology. This correlation may be greatly influenced by recent COVID pandemic [4].

Countries with ongoing and active nuclear programmes are likely to have well established stakeholders' dialogue, and as such more resilient to perturbations in relationship between science and public coming from other areas. But, for countries starting their nuclear programmes and still building their stakeholder net, such perturbations might cause great disturbance.

Therefore, it is the aim of this paper to analyse T2AN (the correlation between the trust of public in nuclear scientists and acceptance of nuclear technology), case study Croatia. In addition, T2AN is analysed before and after the COVID pandemic. The analysis is based on data from public opinion surveys carried out in 2016 and 2023. The surveys' methodology is described in Section 2. Survey results are presented in Section 3, followed by discussion in Section 4 and the conclusion in Section 5 also briefly addressing possibilities for future research.

2 SURVEYS' METHODOLOGY

Both public opinion surveys, the one from 2016, as well as the one from 2023, were carried out on the national level. However, there are differences in methodological approach to these surveys which are summarized in Table 1.

Table 1: Main characteristics of 2016 and 2023 public opinion surveys

Category	**2016 survey**	**2023 survey**
Participant's age	15+	15+
Sampling type	Stratified sampling based on national census	Random sampling
Interview type	Face-to-face	Online form
Total number of participants	2002	2159
Female participants	1047	1078
Male participants	955	1081
Maximum margin of error (MOE) for 95% confidence level	Approximately 2.2% for total, 3.2% for males, and 3.0% for females	Approximately 2.1% for total, 3.0% for males, and 3.0% for females

Crucial differences between the surveys are the sampling type and interview type. Stratified sampling backed by face-to-face interviews in 2016 survey allow generalization of results on the entire Croatian population. Random sampling and online interview type in 2023 survey favour younger population more accustomed to Internet. Also, in 2023 survey concentration of participants in more developed Croatian counties has been observed. Therefore, generalization of 2023 results to entire population is not recommended and comparison to 2016 results must be taken cautiously. To enable deeper understanding of the

trends, special attention is given to younger population (age 15 – 24) whose population in both surveys is adequate.

Survey conducted in 2016 was oriented towards nuclear energy and radioactive waste management, while 2023 survey covered a wide range of new emerging technologies, including nuclear. In the proceeding analysis we focus only on the areas that fall into the scope of the current manuscript.

3 RESULTS OF SURVEYS' ANALYSIS

In 2016 survey the participants had to answer all questions. That obligation was not imposed in 2023 survey. As a result, some participants occasionally skipped questions. On average, less than 1% skipped the questions that are analysed in this manuscript, which, in our opinion, does not influence the conclusions. Statistical analysis is performed based on recorded number of answers.

3.1 Acceptance of nuclear technology

The participants- acceptance of nuclear technology can be assessed be analysing the answers to a number og questions asked in both surveys. In the most direct one the participants were asked to express their general position towards nuclear technology by selecting one out of five offered answers: "Strongly support", "Partially support", "Neutral", "Partially oppose", and "Strongly oppose". The comparison of the 2016 and 2023 surveys' results is depicted in Figure 1.

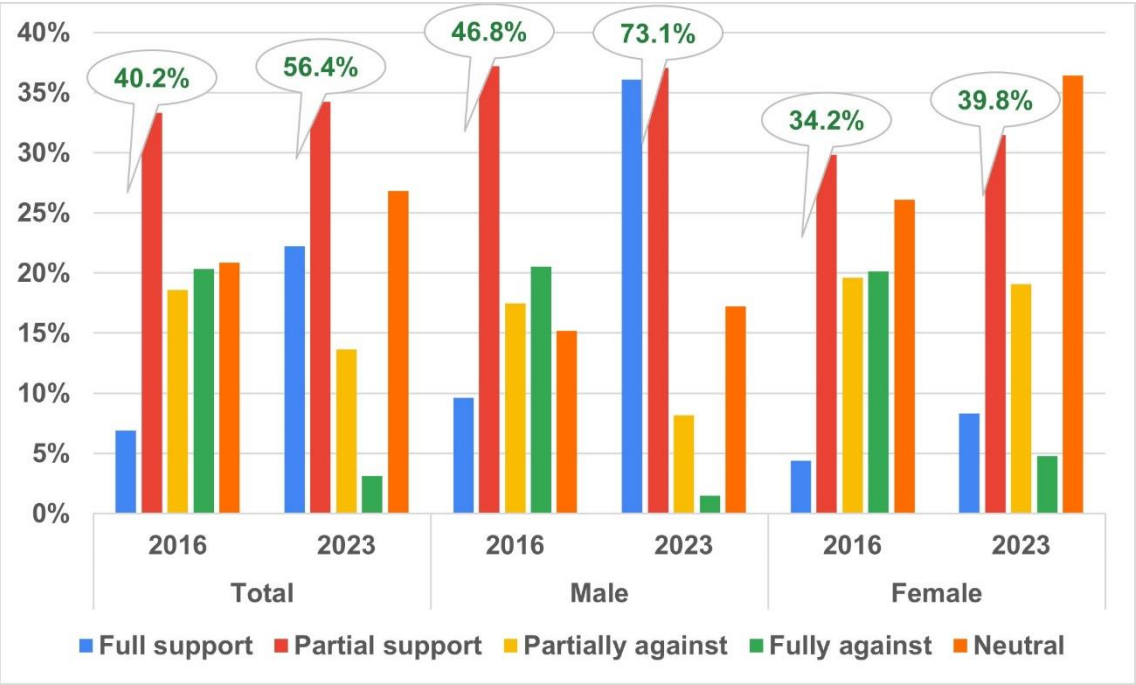

Figure 1: Comparison of participants' general position towards nuclear technology for 2016 and 2023 survey – entire population of participants (highlighted percentages are the sum of "Full support" and "Partial support").

3.2 Trust in scientists

In both surveys there was a similar question asking participants to select three most trustworthy sources of information regarding nuclear technology. Ten possible sources were offered: Government, National regulatory body, Operator, EU bodies/agencies, Scientists, Non-governmental organizations, IAEA, Journalists, Private contacts, and Nobody. The results of surveys' analysis are given in Table 2.

Table 2: 2016 and 2023 public opinion surveys' results on three most trustworthy sources of information regarding nuclear technology

	2016			2023		
	Total	**Male**	**Female**	**Total**	**Male**	**Female**
Government	15.48%	16.96%	14.14%	5.69%	6.29%	5.08%
National regulatory body	**42.11%**	**43.66%**	**40.69%**	**41.96%**	**39.06%**	**44.87%**
Operator	11.74%	12.67%	10.89%	12.41%	12.58%	12.23%
EU bodies/agencies	24.23%	26.28%	22.35%	28.76%	33.15%	24.37%
Scientists	**63.59%**	**64.29%**	**62.94%**	**79.04%**	**79.62%**	**78.46%**
Non-governmental organizations	37.96%	35.08%	40.59%	21.05%	23.10%	19.00%
IAEA	**45.90%**	**45.13%**	**46.61%**	**62.59%**	**60.38%**	**64.82%**
Journalists	15.43%	13.72%	17.00%	3.52%	3.38%	3.67%
Private contacts	12.34%	10.37%	14.14%	13.91%	14.55%	13.26%
Nobody	10.89%	11.10%	10.69%	8.13%	8.36%	7.90%

To enable better understanding of the relationship between science and public, survey conducted in 2023 was enriched by several questions related to public perception of scientists. Among others, there was a question asking the participants to express their level of agreement with the statement "We can no longer trust scientists to tell the truth when it comes to controversial topics because they are too dependent on industry funding.". The results are depicted in Figure 2.

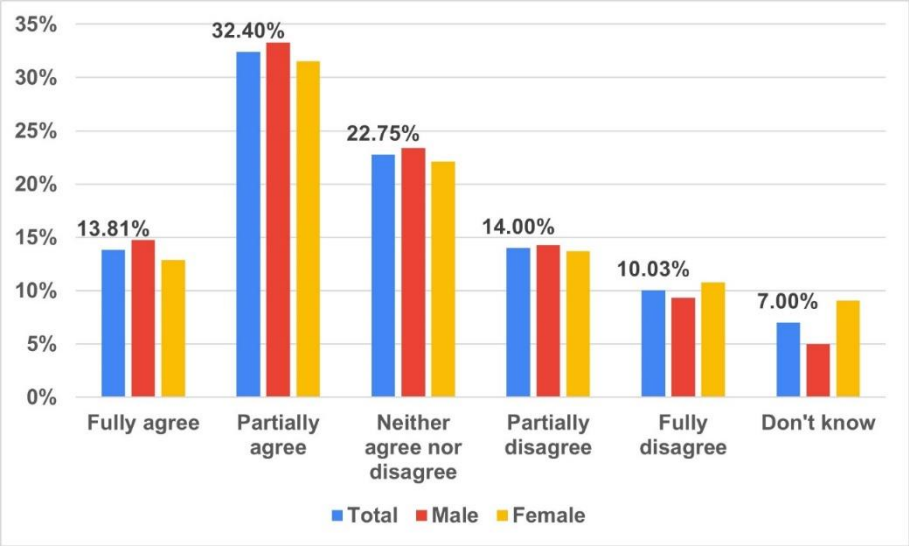

Figure 2: 2023 public opinion survey results – level of agreement with the statement "We can no longer trust scientists to tell the truth when it comes to controversial topics because they are too dependent on industry funding. (highlighted percentages represent position of the overall participant population).

3.3 Correlation between trust and acceptance

To examine relationship between trust in scientists and acceptance (support) of nuclear technology additional cross analysis has been performed to answer following two questions:

1. Do the participants who support nuclear technology trust scientists more than the ones who do not think that scientists are trustworthy?
2. Do the participants who support nuclear technology believe that scientists can be trusted despite industry financing?

Results of the analysis corresponding to the first question are depicted in Figure 3 (2016 survey) and Figure 4 (2023 survey), while Figure 5 depicts the results of the analysis addressing the second question (2023 survey). Y axis on figures 3 and 4 represent the percentage of the participants who selected scientists as trustworthy source of information to overall number of participants expressing certain level of support or opposition for nuclear technology. Y axis of Figure 5 represents the ratio between relative number of participants who do not believe that industry financing influences truthfulness of scientists and those who have the opposite position, also in correspondence to the level of support/opposition towards nuclear technology. For example, 28.1% of participants who partially or fully disagree with the statement that scientists are influenced by industry financing fully support nuclear technology. On the other hand, 20.9% of participants who partially or fully agree with that statement also support nuclear technology. The ratio of these two percentages is 1.34.

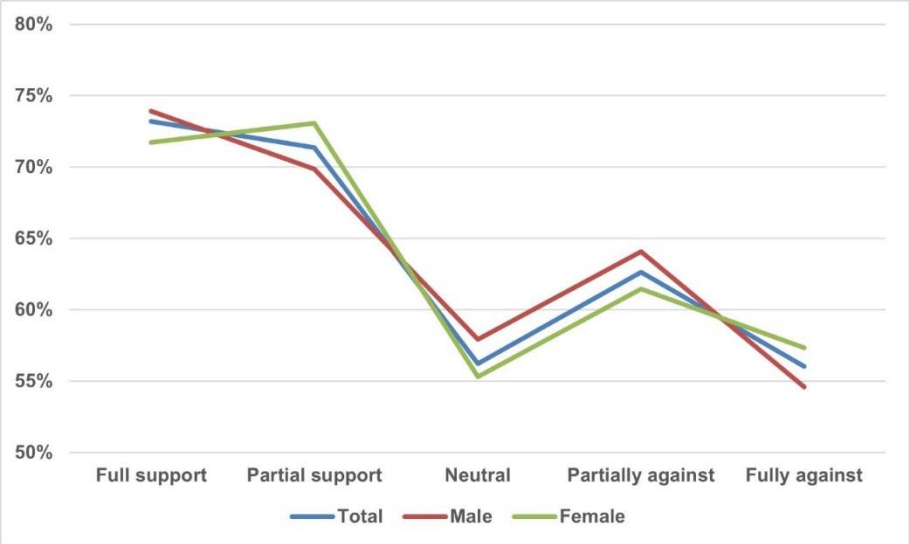

Figure 3: 2016 public opinion survey– percentage of participants who selected scientists as trustworthy source of information to overall number of participants expressing certain level of support or opposition for nuclear technology.

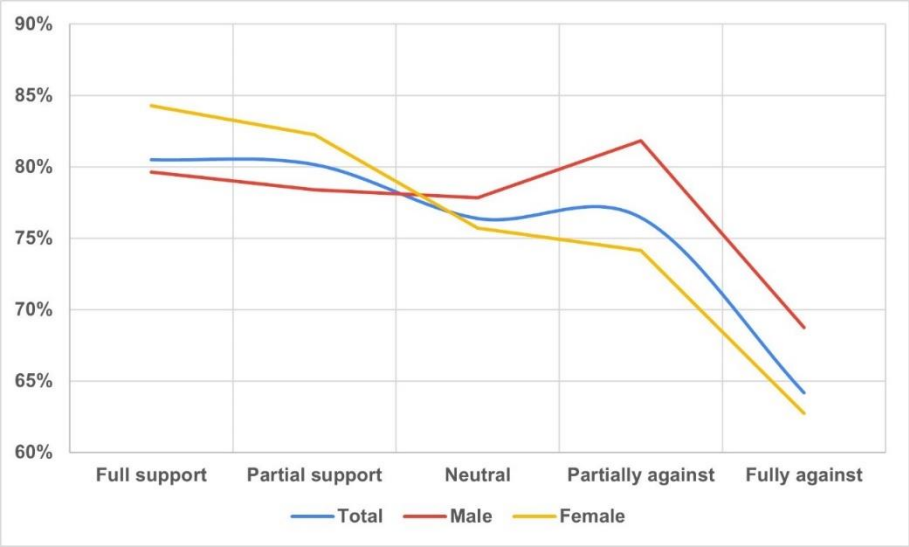

Figure 4: 2023 public opinion survey– percentage of participants who selected scientists as trustworthy source of information to overall number of participants expressing certain level of support or opposition for nuclear technology.

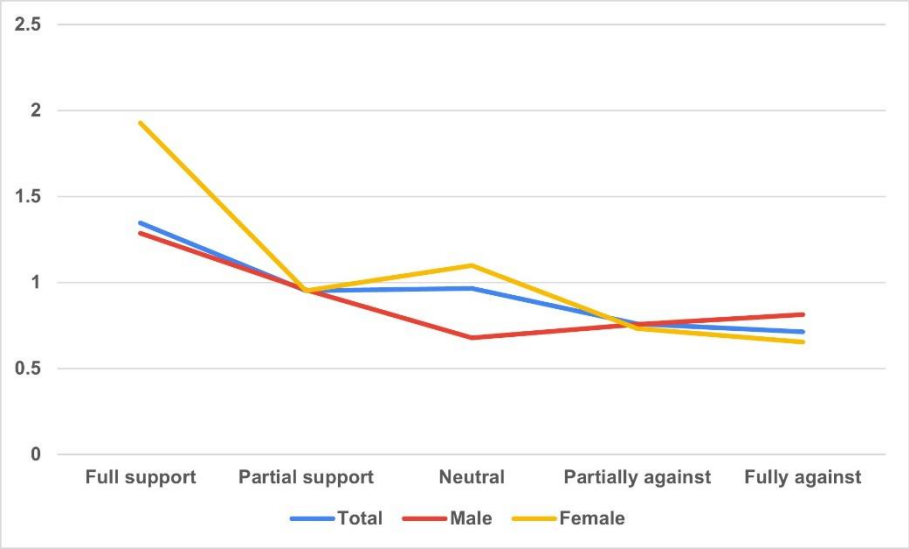

Figure 5: 2023 public opinion survey– ratio between relative number of participants who do not believe (partially or fully) that industry financing influences truthfulness of scientists and those who have the opposite position, in correspondence to the level of support/opposition towards nuclear technology.

4 DISCUSSION

Due to different methodological approach in 2016 and 2023 surveys, direct comparison of the surveys' results is not recommended. However, observed strong increase in support for nuclear (Figure 1) might indicate shift in opinion in overall population. Therefore, further research is needed and justified. It should be noted that additional analysis of the younger participants (age 15-24) of both surveys has also been carried out, since the majority of 2023 survey participants fall into that category. Similar strong shift of opinion towards support for nuclear has been observed.

Based on the results given in Table 2 it is rather evident that public considers scientists to be the most trustworthy source of information regarding nuclear technology. However, almost half of 2023 survey participants expressed certain level of scepticism regarding, in a way, scientists' truthfulness due to dependence on industry financing (Figure 2). It is interesting to notice that compared to 2016 (pre-Covid) in 2023 more participants selected scientists as a trustworthy source of information. There is a difference between structure of two surveys' participants pool so definite conclusion can not be made, but the data suggest that, occasionally questioned scientists' behaviour during Covid pandemic, did not have negative impact on public perception of science.

Apart from a small anomaly observed for female participants in 2016 survey and male participants in 2023 survey, data depicted on Figure 3 (2016 survey) and Figure 4 (2023 survey) indicate it is more likely that those who believe scientists as trustworthy source of information are also more likely to support nuclear technology. Maximum difference (female participants in 2023 survey) of approximately 20% between "Fully support" and "Fully against" nuclear suggest that increase of trust to scientists would not automatically guarantee change of position from being opposed to being supportive to nuclear. But it does open a window for possible pro-nuclear activities.

When comparing 2016 and 2023 data (Figure 3 and Figure 4) it is interesting to notice that there is a small increase of, one might say, scientific influence on participants' position, both positive and negative, towards nuclear technology.

Data depicted on Figure 5 (2023 survey) indicate that participants who believe industry financing has negative influence of truthfulness of scientists are more likely to be against nuclear technology. On the other hand, participants who do not consider truthfulness of scientists to be influenced by industry financing are more likely to support nuclear. That is particularly noticeable for female participants.

5 CONCLUSIONS

For a favourable outcome of nuclear program, successful mutual engagement of all stakeholders is necessary. Of the key elements of that engagement is trust between participants. It was the aim of this manuscript to examine correlation of public trust in scientists and public support, i.e., acceptance of nuclear technology. The analysis has been performed on data obtained in two public opinion surveys carried out in 2016 and 2023. Due to different methodology applied in these two survey, direct comparison or results was not possible, but some general tendencies could be identified.

The data indicate increase of support for nuclear technology in the period 2016 to 2023, as well as increase in trust to scientists compared to other sources of information. However, 2023 survey participants expressed scepticism to truthfulness of scientists influenced by industry financing.

In general, there is a positive correlation between public trust in scientists and public acceptance of nuclear technology since those who believe scientists as trustworthy source of information are more likely to support nuclear technology. There is also a negative correlation between public beliefs of industry financial influence on scientific objectiveness and support for nuclear technology.

It must be noted that presented conclusions are based on preliminary analysis of surveys' results. Short-term future research will be focused on conducting a more detailed analysis of available data, while the long-term future research encompasses new survey methodologically identical to 2016 survey therefore enabling straightforward comparison of results and generalisation to entire Croatian population.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the field work done by interviewers, many of them students of the University of Zagreb, Faculty of Electrical Engineering and Computing.

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