

## Trust In Scientists and Experts on Nuclear Issues

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### ABSTRACT

Scientific knowledge is an extremely important factor for general public to form an opinion on important issues, but also for policy makers in decision making process. Two factors affect scientific knowledge reaching the target: means of knowledge transfer and trust in scientific sources. Trust in science can be rated either based on trust in scientific methods and principles or based on trust in scientific institutions. Since belief in scientific principles and methods is generally high, the main focus of this manuscript is the latter one placed in the framework of nuclear issues. Particular attention is placed on utilization of nuclear energy for electricity generation and management of radioactive waste. Croatian case study is used to examine invoked topics. The analysis is based on the results of the national public opinion survey on nuclear energy and radioactive waste management carried out in 2016, and extensive observation of media coverage and public appearance of politicians and experts on the topics of interest. Preliminary findings indicate that the declarative level of trust in science in Croatia is generally high, in respect to the nuclear topics. However, the actions of targeted parties do not follow scientific recommendations. To further examine observed contradictions, the Croatian situation is placed in a wider European context.

**Keywords:** *trust in scientific knowledge, public opinion, policy makers, social media*

### 1 INTRODUCTION

Science and technology play an important role in modern society. They are the essential tools for innovations which should lead to improvements of goods and services beneficiary for society in general. Science should also act as an advisory tool for policymakers, and a tool for improving the public understanding of socially relevant issues [1]. The final result of the interaction among science, policymakers, and public, all together often referred to as stakeholders, is some kind of the society development strategy, i.e. policy, which defines the path the society will follow towards better future. If one tries to graphically describe that interaction it might look like the scheme depicted in Figure 1.

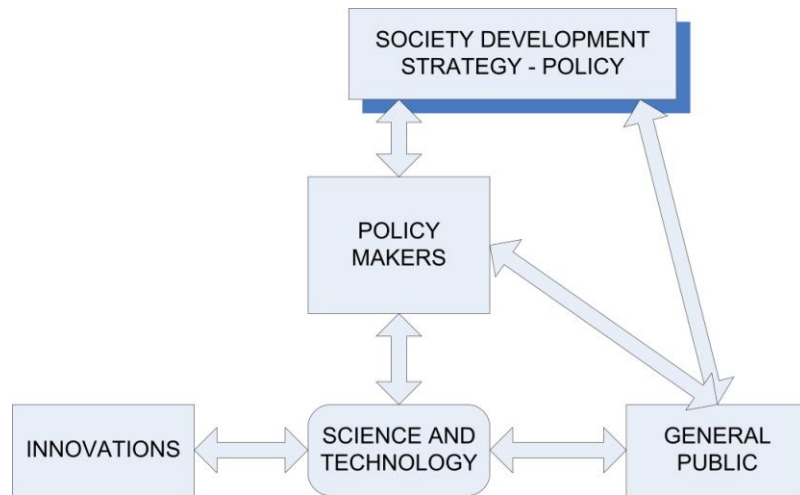


Figure 1: Interaction among stakeholders leading to society development strategy

There are individual scientists and experts, or representatives of scientific communities, participating in advisory bodies to policy makers. The policy makers may also directly contact scientists asking for their opinion, which they may or may not accept. However, scientific and expert community do not have a direction link to the policy creation. Apart for having similar possibilities, general public can influence policy makers through means of public actions and protests, which can result in a rather significant pressure especially in the pre-election period. Even more, the public has direct link to policy creation, for example through referendums [2]. Therefore, it can be concluded that public opinion plays a decisive role in policy creation. Figure 1 also indicates that scientific and expert community has an indirect link to policy makers and policy creation through public. The issue that arises is whether nuclear community can gain the trust of the public and shift the scale towards pro-nuclear?

Before proceeding, let us answer some basic questions related to the subject:

1. ***What is the aim of science?*** There are a number of different definitions of the term “aim of science”. A rather comprehensive one is given by Sloman [3] who writes that “Science is a complex network of different interlocking activities with multiple practical and theoretical aims and a great variety of methods.”. Sloman continues by dividing the aim into three categories: (1) to extend man’s knowledge and understanding of the form and contents of the universe (factual aims), (2) to extend man’s control over the universe, and to use this to improve the world (technological or practical aims), and (3) to discover how things ought to be, what sorts of things are good or bad and how best to further the purposes of nature or God (normative aims).
2. ***What is the aim of scientific communication to public?*** In a variety of definitions the one standing out is that scientific communication should provoke AEIOU (Awareness Enjoyment Interest Opinion Understanding) response from the participant [4]. This vowel idealisation can be broadened with a couple of consonants like CP (Change of Position) or GS (Gaining Support). For a nuclear community who believes in positive aspects of nuclear energy peaceful application, and who is faced with strong, often unreasonable opposition, that consonant annex is realistic in terms of scientific communication.
3. ***What are the means of scientific communication to public?*** In general, means of communication can be verbal, written or a hybrid of two previous types. The first type can be supported by experimental equipment, the latter one with figures or graphs embedded in the text. Over the years, means of communication evolved from newspapers, radio, telegraph, telephone, television, internet, e-mail, text messaging to social media. On the other hand, direct social contact remained a constant over the years. Some of the methods are easier to use in context of scientific communication to

public (e.g. television), some harder (e.g. telephone). Some methods require more active participation of the listeners, e.g. public forum where the participants have to physically attend an organized event at the specified location and time. On the other hand, social media can be accessed at any time, from anywhere. There is also a difference in the size of the population reached by different methods.

4. ***What is trust in science?*** Trust in science can be defined as willingness to rely on science and scientists despite having limited understanding of science and the risk of not fully understanding the presented scientific evidence, i.e. getting to the “bottom of things”. Individuals’ trust in science is based on expectation that scientists make epistemically warranted claims as well as that science provides benefits for society [5].

The main objective of the work presented in this manuscript was to analyse the trust of Croatian public in nuclear scientists and experts. However, to fully grasp the trust issue, means of scientific communication to the public had to be analysed as well, resulting in following tasks:

- to analyse the means of communication used by Croatian general public in obtaining information on every day events and cross reference it with individual’s self assessment on the level of information regarding safety of nuclear power plants,
- to analyse the most trustworthy sources of information for Croatian general public in respect to the issues of nuclear energy and radioactive waste management and cross reference it with the means of communication,
- to put Croatian general public positions in EU context.

The above listed analyses are based on the results of the national public opinion survey on nuclear energy and radioactive waste management carried out in 2016 and public opinion survey carried out in 2018 on student population. The survey 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 SURVEY METHODOLOGY

Detailed description of the methodology used for national public opinion survey on nuclear energy and radioactive waste management carried out in 2016 is available in [6] and [7], including explanations for survey questionnaire preparation and sample size selection. Therefore, in this manuscript only the key factors are stated:

- sampling type: stratified sampling based on national census covering residents of 15 years of age and older,
- sample size: 2002 participants, 955 males and 1047 females,
- maximum margin of error (MOE) for overall group is 2.18%, for males 3.16%, and for females 3.01%,
- number of questions: 15 on nuclear energy, and 3 on radioactive waste management; many of them having sub questions,
- interview type: face-to-face.

Public opinion survey carried out in 2018 on student population covered 981 students from 10 faculties of the University of Zagreb and Zagreb University of Applied Sciences. Altogether 459 male students and 522 female students participated in the polling. Due to smaller sample size, compared to national survey, the MOE slightly increased to maximum of 3.1% for overall student group and 4.6% for each gender. Although the number of questions was reduced when compared to national survey, those used were the same, enabling comparison of results.

### 3 RESULTS OF SURVEY ANALYSES

In this manuscript we focus on the question related to information pathways, trustworthy sources and participants' self assessment on their level of information.

#### 3.1 Information pathways

The participants were asked to select the means of information that they mostly used to obtain information on daily events. Multiple selection of possible information pathways was enabled with the following media offered to choose from: *Television*, *Radio*, *Internet*, *Local newspapers*, *National/international daily newspapers*, *Weekly magazines*, *Expert publications*, and *Something else*. Three top choices, regarding of participants' gender, were *Television* (overall 79.92%, males 77.17%, and females 82.43%), *Internet* (overall 61.04%, males 65.65%, and females 56.83%), and *Radio* (overall 38.46%, males 39.37%, and females 37.63%). Overall results are depicted in Figure 2.

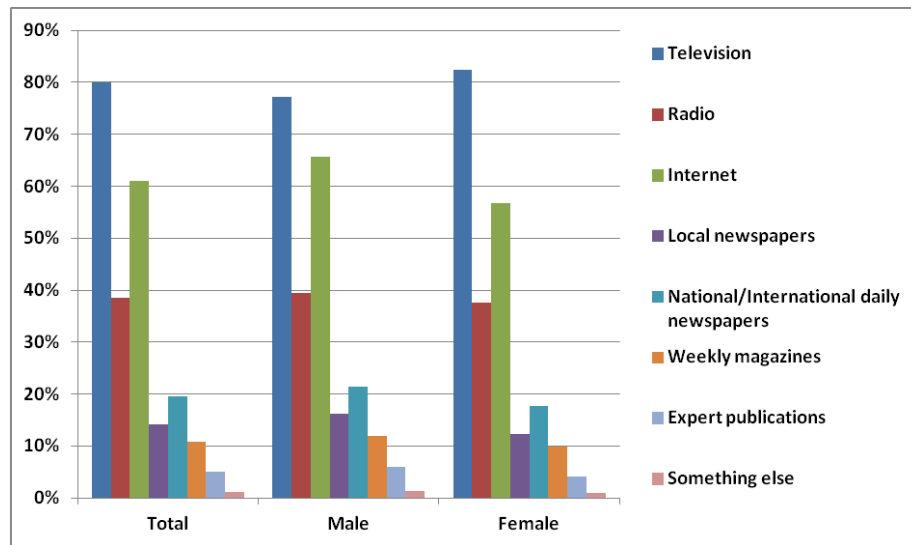


Figure 2: Main information pathways for general public

As expected, the student population is much fonder of *Internet* with *Television* being the second choice as the information pathway (Figure 3)

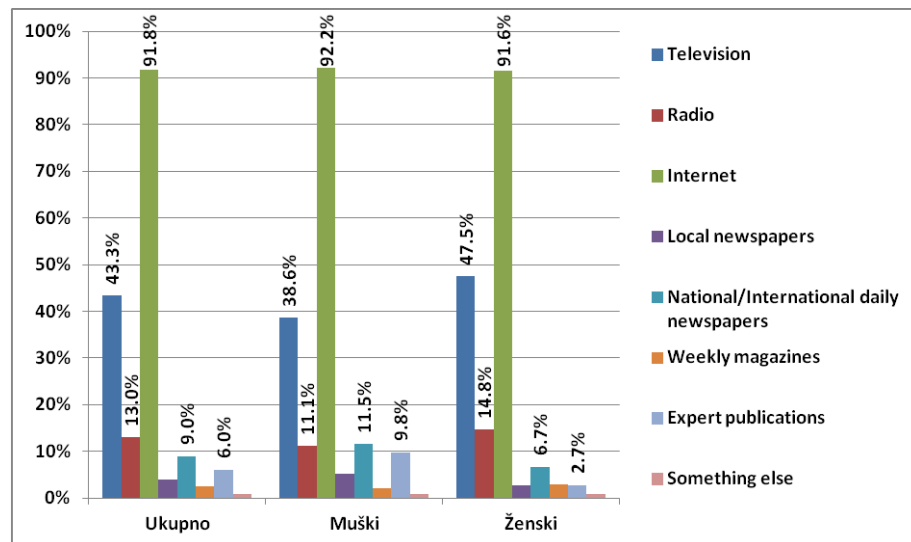


Figure 3: Main information pathways for student population

### 3.2 Trustworthy sources of information

Survey participants were asked to select the most trustworthy sources of information on nuclear energy and radioactive waste. Once again, multiple selection was enabled with the following sources offered to choose from: *Croatian government*, *National regulatory body (SORNS)*<sup>1</sup>, *NPP operator*, *EU*, *Scientists*, *Non-governmental organizations (NGO)*, *IAEA*, *Journalists*, *Private contacts*, *Nobody*, and *Something else*. Four most trustworthy sources of information, regardless of participants' gender, were *Scientists* (overall 63.59%, males 64.29%, and females 62.94%), *IAEA* (overall 45.90%, males 45.13%, and females 46.61%), and *SORNS* (overall 42.11%, males 43.66%, and females 40.69%), closely followed by *NGO* (overall 37.96%, males 35.08%, and females 40.59%). Overall results are depicted in Figure 4.

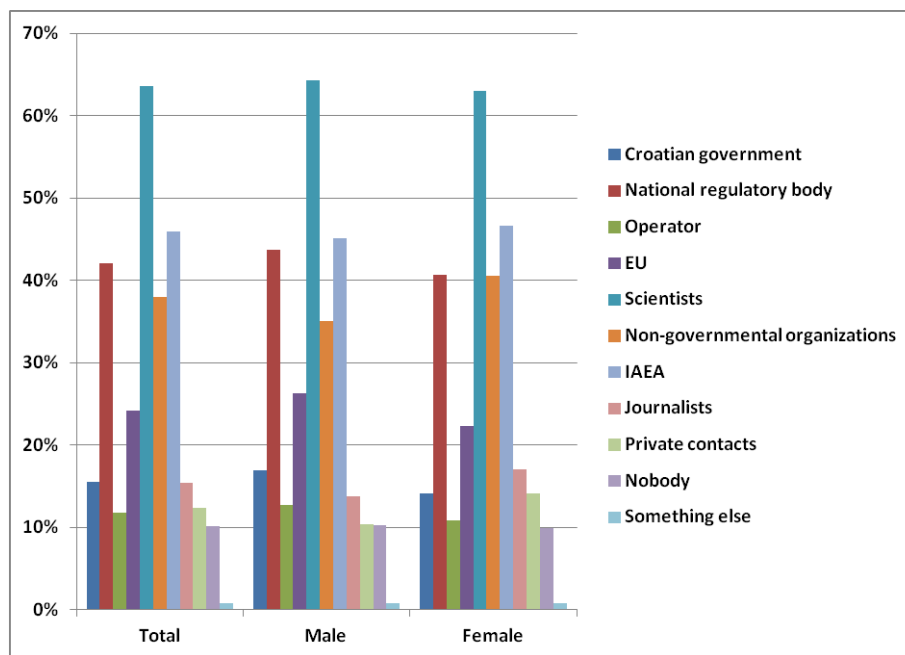


Figure 4: Trustworthy sources of information for general population

It is interesting to notice that *Croatian government* and *Journalists* earned the trust of only one out of six participants from general population (approximately 15.5%).

Student body is even more sceptical towards *Croatian government* and *Journalists* with only 3% of participants trusting them. On the other hand, trust to *Scientists* and *IAEA* drastically increases in student population to 85.5% and 69.8%, respectively. Similar question has been asked in the Eurobarometer 2010 survey “Europeans and nuclear safety” [8]. Comparison of all surveys' results is depicted in Figure 5. Due to the seven years gap among the surveys the comparison has to be taken with caution. However, it is interesting to observe position of Croatian participants in the EU context. In Croatian national survey, as well as in the Eurobarometer survey, data for the participants 15 – 24 years of age are available and are also given in Figure 5. Younger participants express stronger trust to scientists. In Croatia it is especially emphasized for those attending university.

<sup>1</sup> In 2016, when both surveys were carried out, Croatia had an independent nuclear regulatory body, State Office for Radiological and Nuclear Safety (SORNS). As of January 1st 2019, the SORNS has been closed and its responsibilities have been transferred to Ministry of Interior, Directorate of Civil Protection, Sector for Radiological and Nuclear Safety.

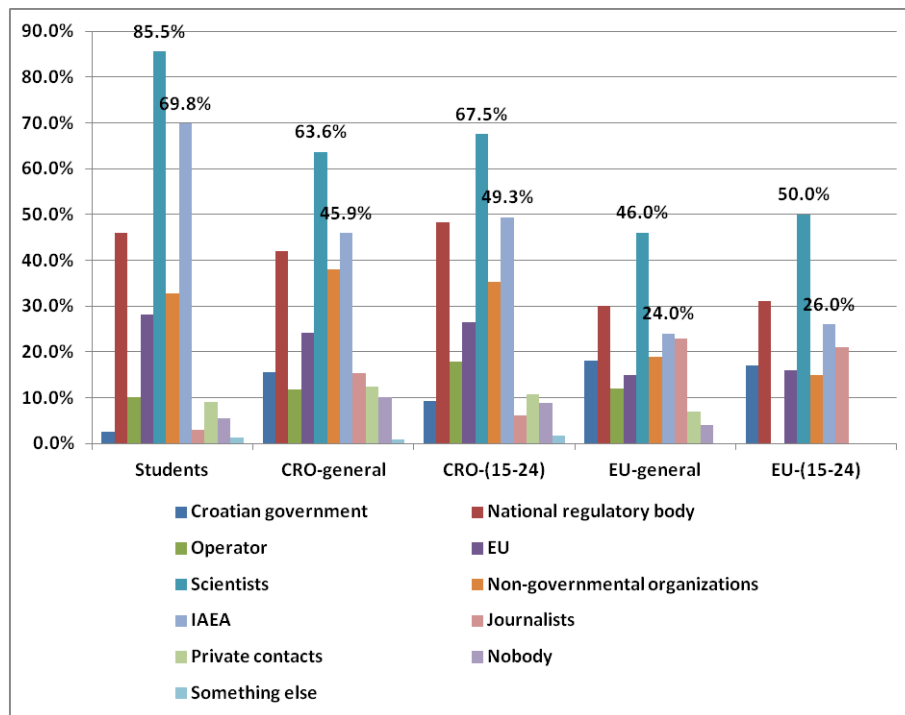


Figure 5: Trustworthy sources of information – comparison of Croatian general public, student population, and EU population

### 3.3 Correlation between trust and information pathways

When one as a scientist and expert considers the most efficient ways to communicate with the public hoping to convince public and earn public trust, one of the first decisions to be made is the selection of appropriate information pathway. To examine whether a connection between public trust and information pathway exists, the correlation analyses have been performed. The results are depicted in Figure 6 for participants who express trust to particular source and in Figure 7 for participants who do not express trust to particular source. Both analyses have been performed for Croatian general population.

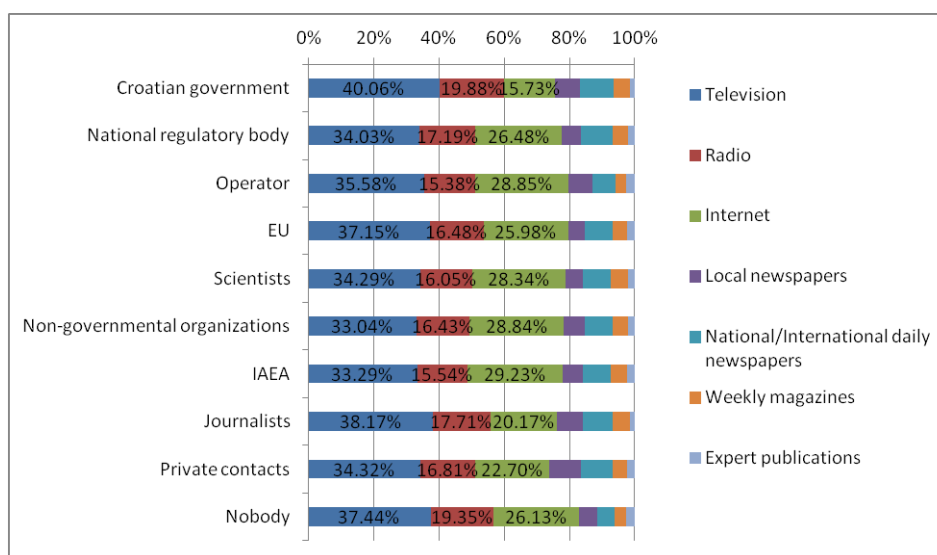


Figure 6: Correlation between trusted sources and information pathways for participants who express TRUST

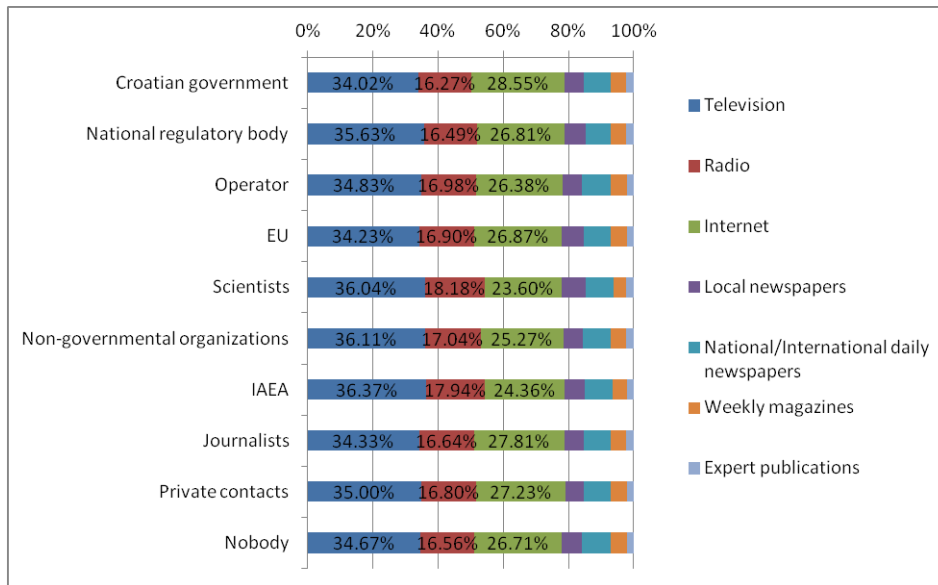


Figure 7: Correlation between trusted sources and information pathways for participants who DO NOT express TRUST

Most of the differences are within statistical MOE, apart from participants trusting government. Those who do not trust Croatian government selected *Internet* as the information pathway more often than those who do trust the government (the difference of approximately 13%). Those who trust *Scientists* and *IAEA* are slightly fonder of *Internet* than those who did not select Scientist and IAEA as trustworthy sources, but the difference is just slightly over MOE (4.75% and 4.87%, respectively) leaving it open for further analysis. Initial examination of possible age or gender influence did not reveal any particular tendency.

### 3.4 Level of information on nuclear power plant safety in correlation to trust and information pathways

The survey participants were asked to self assess their level of information on the matter of nuclear power plant safety (Figure 8).

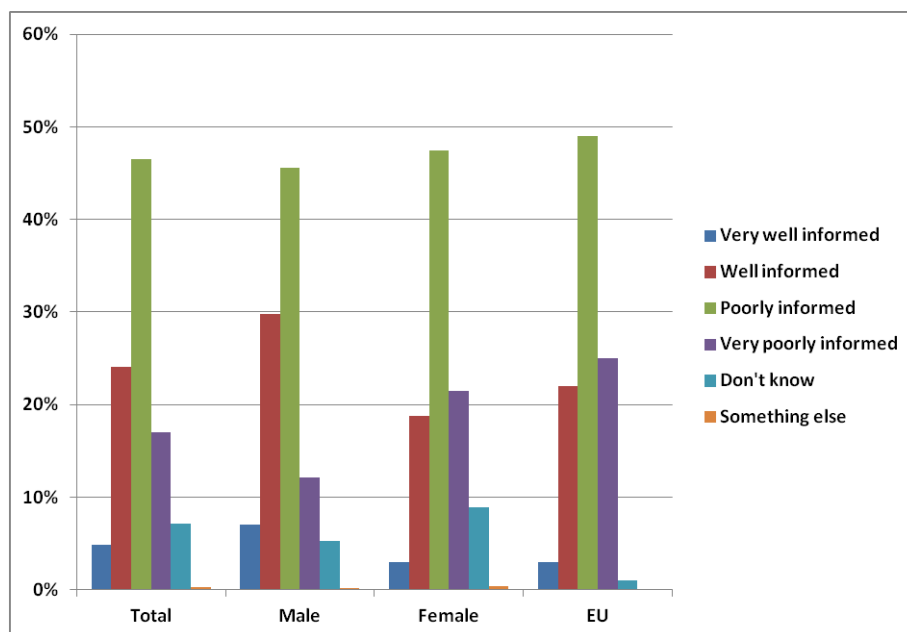


Figure 8: Self assessed level of information on nuclear power plant safety

Most of the participants feel poorly or very poorly informed (46.55% and 17.03%, respectively) on the issues of nuclear power plant safety, while only 28.97% express some level of satisfaction regarding their level of information. The results are very similar to those observed for EU citizens [8].

Correlating level of information with information pathways reveals that participants who feel informed on the subject of nuclear power plant safety are slightly fonder of *Internet*, while those who feel poorly informed are fonder of *Television* (Figure 9).

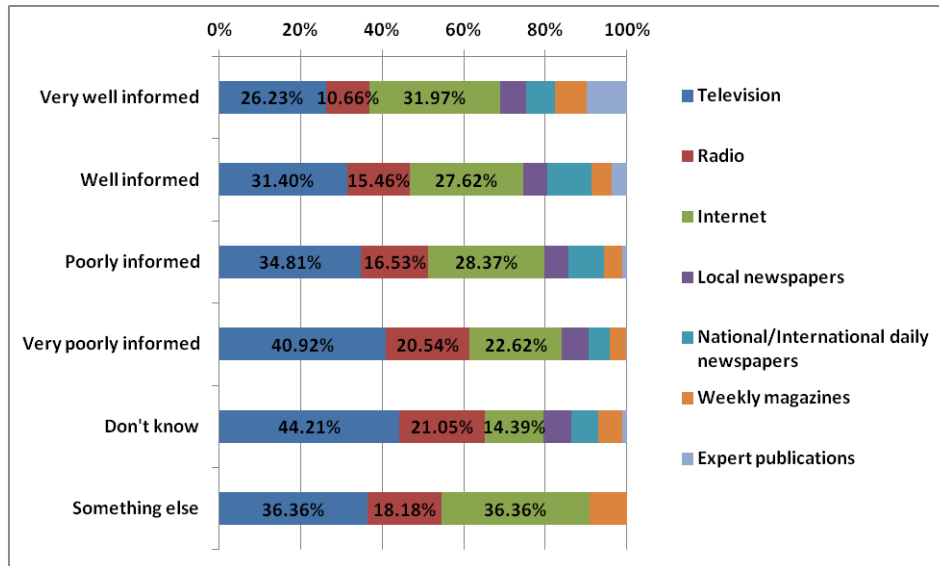


Figure 9: Correlation of level of information and information pathways

Correlating level of information with trustworthy sources of information reveals that participants who feel informed on the subject of nuclear power plant safety expressed more trust to *National regulatory body (SORNS)*, while those who feel poorly informed are more inclined to trust *Government* (Figure 10). Scientists are almost equally trusted by both groups.

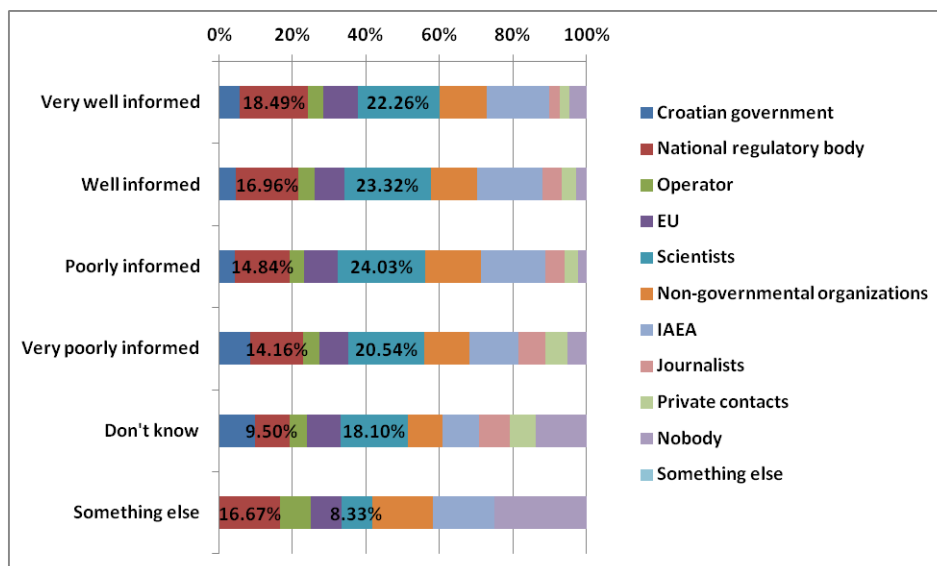


Figure 10: Correlation of level of information and trustworthy sources of information



## 4 DISCUSSION

Based on the results of the Croatian national survey and student survey, on the matter of nuclear energy and radioactive waste, presented in the previous section it is relatively reasonable to conclude that *Scientists* are considered as trustworthy sources of information by majority of participants. Apart from the general term *Scientists*, participants also consider organizations like *SORNS* and *IAEA* as trustworthy. Although not explicitly asked, face-to-face interviews revealed that both of these institutions are conceived as scientific institutions.

However, one has to have in mind that the surveys took place five years ago. In the meantime, *SORNS* has been closed and responsibilities transferred to Croatian Ministry of Interior. The trust to government is very low in Croatian general public, and even lower in student population. It is therefore very dubious whether the Ministry of Interior, Directorate of Civil Protection, Sector for Radiological and Nuclear Safety, would have the same trustworthy level as *SORNS*.

On the global level, last two years placed heavy burden on scientific communication, specifically medical science and epidemiology. After COVID break out, in most of the countries including Croatia, scientific advisory bodies have been established with the task to advice governments. Crisis Headquarter has also been formed in Croatia comprised of scientists and representatives of the government, with the task of managing the pandemic and communication with public. At the beginning, in early 2020, both bodies had high public trust. However, the trust soon began to fade. Scientists had different positions on the COVID virus and measures that had to be taken. Very often those positions were fully opposite. The politicians were also considering economic impacts of anti COVID measures. Public opinion survey (on-line, 395 participants) and media coverage analysis showed that the majority of participants believe that the Headquarters did not communicate transparently or credibly, while media coverage was positive at the beginning of the first infection wave, and negative at the end of the first wave [9].

Although those events were not linked to nuclear energy and radioactive waste management, they are rather significant for understanding relationship between science and public. Apart from scientist losing trust, scientific method was also affected. In general, scientific method is a close loop comprised of hypothesis, experiment, data analysis, and conclusion followed by observation and questions raised leading back to hypothesis. Over the process hypothesis and conclusions may change. If scientific communication to public is not clear enough in explaining the process itself and the conclusions change, the public loses trust. Even the clear scientific communication does not guarantee acceptance of facts as the members of the public may form and persist in beliefs characteristic for the group they belong to, a behaviour known as “identity-protective cognition” [10].

It is an open question whether loss of trust in scientists and scientific bodies dealing with COVID affected other areas, including nuclear. But group beliefs are affecting nuclear issues. For example, the necessity for establishing the Croatian central storage facility for low level radioactive waste was communicated to the public on numerous occasions. Initially the communication was slightly mismanaged, but later on became clear and straightforward. Despite the efforts and given facts, public acceptance of the necessity and especially the proposed location are still questioned. One of the arguments presented by the “green groups” is that the storage facility will influence “eco-tourism” and “eco-agriculture” in the area surrounding the facility [6].

Correlation analysis of trust to scientists and information pathways, as well as correlation analysis of trustworthy sources and level of information did not conclusively reveal any particularities. There are some indications that those who trust scientists are slightly fonder of *Internet* as the main source of information. There are also indications that those using *Internet* feel more informed than those using *Television* which is still the most used information pathway for general public. As expected, the student population differs, placing *Internet* as the most important information pathway. Selection of the most suitable information pathway for scientists to communicate with the public, gaining or keeping the trust level, is an open question.

In comparison to other EU countries Croatians express higher trust to scientists and lower trust to government and journalists. The main information pathways for Croatian public are similar to those of other EU member states, although EU citizens were less oriented towards *Radio* and *Internet* than Croatians (*EU Radio* 23% compared to Croatian 39%, and *EU Internet* 27% compared to Croatian 61%) [8]. It has to be noted that EU survey has been carried out in 2010 and *Internet* experienced strong boost in the seven years till Croatian survey took place.

Pro nuclear scientists and experts were actively engaged in public communication over the last couple of decades proclaiming safety of nuclear installations, responsible management of radioactive waste, and necessity of nuclear energy. Regardless of that effort, the full or partial public support to nuclear in Croatia is around 40%, while only 30% believe that benefits of nuclear are greater than risks. Up until autumn 2021 there was no open political support for nuclear. The political change started in October 2021 with Croatia signing the ten EU countries initiative for EU shift to nuclear energy, proclamation of closing the largest Croatian coal fired power plant by 2033, and modest initiatives for consideration of joining Slovenian JEK2 new nuclear build. Public opinion on these governmental manoeuvres is not clear. It is also unclear how the latest energy crisis, initiated by Russian invasion on Ukraine, and uncertainty of energy supply in the future impacts public attitudes towards nuclear energy.

## 5 CONCLUSION

Croatian case study was used to examine trust to scientists and main information pathways regarding nuclear energy and radioactive waste management. The analysis is based on the results of the national public opinion survey on nuclear energy and radioactive waste management carried out in 2016, and student survey carried out in 2017, as well as on the extensive observation of media coverage and public appearance of politicians and experts on the topics of interest. Preliminary findings indicate that the declarative level of trust in science in Croatia is generally high, in respect to the nuclear topics. However, the actions of targeted parties do not follow scientific recommendations.

In comparison to other EU countries Croatians express higher trust to scientists and lower trust to government and journalists. The main information pathways for Croatian public are similar to those of other EU member states with Television being the main one, and followed by Internet and Radio. Due to seven years gap between the surveys the actual numerical data have to be taken with caution.

The events that took place on global level (COVID pandemic) and locally (closing of SORNS) surely affected the Croatian public understanding of science and public trust. The level of that impact on nuclear subjects remains an open question. The same doubt on how public perceives nuclear energy is linked to latest energy crisis and uncertainty of energy supply in the future.

Correlation analysis of trust to scientists and information pathways, as well as correlation analysis of trustworthy sources and level of information did not conclusively reveal any particularities, but rather indicated possible links which might affect the choice of scientists when communicating to public.

The presented research did answer some question regarding public trust, information pathways, and trustworthy sources. However, combination of survey results and global and local events taking place in the last two years opened a series of new questions, which are to be addressed in our future research.

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