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**Makale Başlığı / Title**

Public attitudes toward nuclear power plants in Turkey

Türkiye'de nükleer güç santrallerine karşı halkın tutumları

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Abstract

Due to the increasing energy need, countries are required to their usage of energy sources for sustaining developments. options to meet the sustainable energy is the use of nuclear plants (NPPs). However, building and using NPPs present a great challenge to policy makers of the countries: acceptance technology by the citizens. Turkey is one of the countries establish NPPs and adjust their policy in this regard. The cour NPP is already under construction in Mersin, and the second w established in Sinop. A survey to evaluate public acceptance was given to 838 individuals from different cities of Tur participants were interviewed between January and March 2018. The endorsement and opposition rates were deter as 42.3% and 31.1%, respectively. The margin of error at 95 found to be 3.3%. Measuring the participants' knowledge o was also aimed. It has been asked to respondents express i basic knowledge of NPPs. 72% of the participants stated i know the basics of NPPs. To extract the actual rate, thi questions regarding NPPs have been asked, and only 24.5 participants answered 2 or 3 questions correctly. The res further compared with previous surveys for Turkey an countries.

Keywords: Public acceptance, Sinop NPP, nuclear energy poli Turkey

Öz

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Anahtar kelimeler: Toplumsal kabul, Sinop NGS, Türkiye'c

1 Introduction

Energy need of countries is continuously increasing with increases of population and aspirations on technology and developments. For sustainable energy technologies and assessments, the countries require energy production using the available limited resources. In this regard, nuclear energy is an alternative and sustainable energy source particularly preferred by developing and developed countries. Despite its various advantages [1], nuclear power carries crucial doubts and rising costs [2], and it is a fact that public opinion on energy sources are crucial to determine energy policy of countries. This fact has been proved in the past: Switzerland voted to phase out nuclear power in a 2011 referendum and the votes paved the way for them to have any plans to build more nuclear power plants (NPP). Although there are many key parameters effective on public attitude to nuclear energy, majority of the studies carried out in different countries regarding public opinion revealed that the oppositions are mainly due to the risk of nuclear

accidents[4]-[11]. Germany can be presented as a good example of this fact. Due to the Japan's Fukushima nuclear disaster, the opposition to and doubts on NPPs in Germany were highly increased as it was in all over world. Just 3 months after the Fukushima catastrophe, Chancellor Angela Merkel's government declared that all NPPs in Germany would be shut down by 2022. Another example could be Italy to highlight the impact of nuclear accidents on public attitudes. Although Italian government was strongly supporting re establishing nuclear power after the Fukushima accident, the country had to completely abandon it as a result of a public referendum. On the other hand, some countries, such as Czech Republic and Turkey, plan to adjust their energy programs including nuclear energy in order to satisfy their energy need and security by reducing the usage of imported fossil energy sources, regardless accident risk and other drawbacks of NPPs. Turkey is one of the countries that use imported fossil energy sources and has faced reality that it cannot be indefinitely on combustion of fossil fuels for sustainable energy. The policymakers of the country have been making

investments on renewable energy sources and having plans for establishing nuclear power plants since early 90s. Many attempts to build several NPPs in Turkey failed mainly due to economic circumstances of the country. Therefore, to ensure effective and timely investment in nuclear energy, the governments have to mobilize the extensive funds available. Finally, in 2009, Russia and Turkey had an agreement to establish a NPP at Akkuyu in Mersin, Turkey. The construction of Akkuyu NPP has begun in April 2018, and it is expected to start generating electricity by 2023. The Sinop NPP is planned to be second nuclear power plant in Turkey, located at Sinop in northern Turkey. Both NPP aims to reduce the dependence on imported energy sources and meet the sustainable energy. Besides the delays due to the financial conditions, there are many studies reporting health effects and psychological consequences of Chernobyl accident for Turkey [15]. Therefore, the government has to deal with nuclear disaster stress on public. The Turkish authorities are aware that NPP will be a key feature to reach the aim of economic and industrial developments and Turkish Ministry of Energy and Natural Resources [16] reported that the need on electricity for the targeted economic and industrial developments by 2023 will not be satisfied even if whole solar, wind, hydroelectric, biomass and geothermal potential of Turkey are utilized.

As expressed and well discussed in Reference [17], there are two faces of nuclear energy, the face of immense promise and the face of peril, and, the public acceptance is dependent on which face comes to the forefront. Turkish government has already taken many steps to overcome the high rate of opposition to nuclear power plants. The nuclear energy policy of the country started in mid 1950s: Turkish Atomic Agency was established in 1956. Meanwhile, the government decided to open nuclear energy education programs at public colleges to promote the nuclear energy and have qualified personnel in the field. Department of nuclear engineering at Hacettepe University has begun teaching activities in 1977 and second and third nuclear energy programs have started at Sinop University in 2015 and Sivas Cumhuriyet University in 2017 respectively. In addition, starting from 2015, the government has been sending Turkish students to study nuclear energy abroad and gain NPP experience in Russia. Even, some of the nuclear engineers sent to Russia have already turned back to the country in December 2017 by completing their studies successfully. All these efforts are well advertised by the government in press and the government is trying to convey the information to the public as much as possible. In addition, in 2017, right before starting the construction of Akkuyu NPP, UNESCO awarded scientist Prof. Bilge Demirköz and Nobel laureate Prof. Aziz Sancar, Turkish scientists starred in a public ad to promote Turkey's first nuclear power plant, Akkuyu. Also, the government agencies and the nuclear energy companies in Turkey are visiting Turkish universities to give public lectures and opening stands in the city centers for briefings. Based on our literature search, there are only two comprehensive studies regarding public opinions to the NPPs in Turkey. The first one [4] was conducted in 2007, and the second survey [5] was made between June 2014 and June 2015. Both of the studies indicated that opposition to nuclear energy was strong. The rates of opposition to NPPs were found 62.5% and 70.2% for 2007 and 2014 surveys, respectively. In addition to the comprehensive studies, there are some studies deserved to be mentioned. These were conducted by Greenpeace [8], BBC [9] and KONDA [20] in

2011, 2011 and 2018 respectively. The opposition rates reported by Greenpeace (56.4%) BBC (41%) and KONDA (68.2%) are significantly higher than our findings. In this study, the public perception of nuclear energy will be updated based on the survey performed in the first quarter of 2018 and the results are compared with previous studies. Our study is the first study after Turkish government's intense efforts to promote nuclear energy and indicates impacts of all efforts. It reflects a clear difference between 2007 and 2018 survey results. This difference could be improved by highlighting the advances from old generation to new generation nuclear power plants such as crucial advantages in economics, reliability and safety, and sustainability. Since public acceptance depends on important social indicators such as age, fear, education level, perception and knowledge, the opinions and knowledge of respondents were further analyzed and discussed using basic questions regarding NPPs. The rates of that citizens find nuclear energy risky are determined based on three different age groups and three different education levels. These rates are compared with other 19 countries. Since public investment and management have been dominating the development in Turkish energy, the public acceptance and attitude to the energy sources are vital.

## 2 Materials and methods

Researchers have suggested various methodologies to evaluate the public attitude to nuclear energy, some can be found in Ref [21]-[24]. However, big data analysis and online survey methods are not good options for Turkey since the internet usage is only 42% level, and most of the users are located in the west of the country. Since we are aiming to reach respondents from each side of the country, we chose to use face-to-face method despite the fact that this methodology requires significant time to process. The survey aims to indicate the knowledge and thoughts of Turkish people about nuclear power plants. 838 people above 15 years of age and from different education levels and different cities of Turkey were interviewed to face-to-face between January 2018 and March 2018. 513 of the respondents were male and while 325 of them were female. Participants from Sinop, Antalya, Bingöl, Bilecik, İzmir, Manisa, Mardin, and Samsun were randomly selected. The selection of these cities is motivated to have inputs from all regions of the country. Besides, Sinop will be home of the second NPP constructed in Turkey. In addition, Samsun has a great potential of hydroelectric power, İzmir and Manisa have the high proportion of renewable energy sources and geothermal power plants, and Antalya is the city that receives the maximum solar radiation in Turkey. Also, Antalya is considered as the center of tourism, which motivates the survey question. Table 1 gives the demographic information about the respondents. In the survey, the questions were prepared to measure participants' opinions and knowledge. Answers to questions were divided into three categories (Yes, No, Undecided). First, we tried to understand the participants' thoughts on NPPs. The questions on Table 2 were asked to understand what they are thinking of. Public acceptance of nuclear energy can be defined as willingness to have NPPs or nuclear energy technologies; therefore, it is better to determine the endorsement rates of NPPs and nuclear waste separately.

To allow for an international perspective, some of the questions in the conducted survey were taken from Turkey's efforts to promote nuclear energy can help publication regarding public acceptance of nuclear energy governments to adjust their policies. [25]. Their face-to-face choice matches to our methodology.

The publication includes results from Argentina, Australia, Cameroon, Canada, China, France, Germany, Hungary, India, Indonesia, Japan, Jordan, South Korea, Mexico, Morocco, Russia, Saudi Arabia, UK, and USA. The study is missing Turkey, and the authors are asking respondents to express how much they know the nuclear energy to determine the participant's knowledge. An important feature of this survey is that it is not only asking whether the participants know nuclear energy but also asking some basic questions to measure their knowledge of participants. The question in the survey is "How much do you know about nuclear energy?" and the results are shown in Figure 1. Figure 1 shows the number of participants who found respondents. Then, to evaluate how many of the participants really know the basics of the NPP questions on Table 3. The participants were given to the participants. If the respondent answers more questions correctly, we categorized the participants into three groups: "I don't know", "I know a little", and "I know a lot". The maximum rate of thinking nuclear power plants risky is 46% in the 15-25 age group, while the minimum rate is 18.5% in the 45+ age group. On the other hand, the rate of people considering NPPs risky decreases with increase of education level. The comparison of these results with the reference [25] given in Table 4. It should be certainly noted here that compared results are from a paper published in 2014 while our results belong to 2018.

### 3 Results and discussions

Table 1: Demographic information about respondents.

|           |                 | Number of responden | %    |
|-----------|-----------------|---------------------|------|
| Gender    | Female          | 325                 | 38.8 |
|           | Male            | 513                 | 61.2 |
| Age       | 15-25           | 387                 | 46.2 |
|           | 26-44           | 296                 | 35.3 |
|           | 45+             | 155                 | 18.5 |
| Education | High school     | 463                 | 55.2 |
|           | College         | 338                 | 40.3 |
|           | Graduate school | 37                  | 4.5  |
| Residence | Sinop           | 116                 | 13.8 |
|           | Antalya         | 127                 | 15.1 |
|           | Bingol          | 77                  | 9.2  |
|           | Bilecik         | 108                 | 12.9 |
|           | Izmir           | 100                 | 11.9 |
|           | Manisa          | 99                  | 11.8 |
|           | Mardin          | 104                 | 12.4 |
|           | Samsun          | 107                 | 12.8 |

Table 2: Questionnaire sheet to determine the participants' opinions.

|   | Yes | No | Undecided |
|---|-----|----|-----------|
| Q1: Do you support NPPs in Turkey?  |     |    |           |
| Q2: Should Turkey have own nuclear weapon?  |     |    |           |
| Q3: Do you think NPPs are risky?  |     |    |           |
| Q4: Do you think Turkey has enough qualified personnel to operate one or more NPPs? |     |    |           |
| Q5: Do you concern about a NPP explosion?   |     |    |           |
| Q6: Do you have negative thoughts about NPPs due to the accidents happened?         |     |    |           |
| Q7: Would you visit Sinop NPP to understand how it works if there were public?      |     |    |           |
| Q8: Do you think NPPs affect tourism negatively?                                    |     |    |           |

Table 3 Questionnaire sheet to determine the participants' knowledge.

|  |                     |                |
|--|---------------------|----------------|
| Q10: Which power plant generates more electricity when equal amount of fuel is used?   |                     |                |
| Hydroelectric Power Plant  | Thermal Power Plant | Nuclear Power  |
| Q11: What is the smoke coming out from the towers of nuclear plant?  |                     |                |
| Radiation  | Water vapor         | Carbon dioxide |
| Q12: An amount of water used for cooling is discharged back into the water source. Does the dis have any radiation waste or fission product? |                     |                |
| Yes  | No                  | No Idea        |

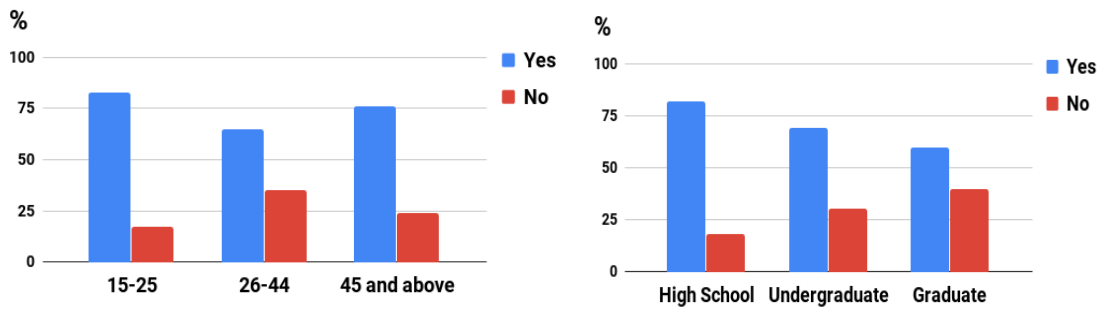


Figure 1: Age vs. risky (left) and education vs. risky (right) diagrams.

Table 4: Descriptive statistics. The results of Argentina (ARG), Australia (AUS), Cameroon (CMR), Canada (CAN), China (CHN), France (FRA), Germany (GER), Hungary (HUN), India (IND), Indonesia (IDN), Japan (JPN), Jordan (JOR), South Korea (KOR), Mexico (MEX), Morocco (MAR), Russia (RUS), Saudi Arabia (SAU), the UK (GBR), and the US (USA) are taken from [21] 2014.

|        | Respondents | Acceptance |        | Knowledge |      | Risk  |           |
|--------|-------------|------------|--------|-----------|------|-------|-----------|
|        |             | Endorse    | Oppose | Yes       | No   | Risky | not risky |
| ARG    | 1000        | 13.9       | 22.9   | 21.6      | 52.0 | 51.2  | 19.3      |
| AUS    | 1020        | 35.2       | 22.9   | 18.0      | 51.6 | 53.9  | 36.6      |
| CMR    | 1900        | 21.5       | 27.6   | 16.9      | 44.6 | 42.2  | 25.5      |
| CAN    | 1012        | 34.8       | 20.9   | 13.1      | 62.6 | 50.7  | 35.3      |
| CHN    | 1800        | 61.2       | 7.4    | 52.6      | 18.3 | 50.1  | 39.3      |
| FRA    | 1002        | 24.9       | 16.3   | 9.7       | 64.3 | 57.4  | 32.1      |
| GER    | 1002        | 23.8       | 26.6   | 20.5      | 54.9 | 59.3  | 33.5      |
| HUN    | 1008        | 19.3       | 19.1   | 30.0      | 34.9 | 49.7  | 34.5      |
| IND    | 1000        | 37.3       | 19.6   | 33.6      | 24.0 | 40.7  | 32.0      |
| IDN    | 1000        | 33.0       | 27.6   | 29.1      | 27.4 | 61.9  | 23.4      |
| JPN    | 1003        | 20.7       | 14.6   | 52.0      | 13.0 | 79.5  | 15.6      |
| JOR    | 800         | 36.5       | 39.5   | 32.9      | 42.1 | 52.3  | 38.1      |
| KOR    | 1000        | 51.1       | 12.0   | 63.6      | 7.6  | 56.9  | 37.4      |
| MEX    | 1000        | 33.0       | 23.0   | 34.7      | 20.5 | 59.5  | 25.0      |
| MAR    | 1038        | 10.0       | 38.0   | 12.5      | 1.2  | 42.8  | 7.0       |
| RUS    | 1003        | 21.0       | 19.9   | 17.4      | 47.3 | 63.5  | 21.1      |
| SAU    | 1200        | 16.1       | 35.9   | 48.6      | 20.1 | 42.7  | 30.8      |
| GBR    | 1011        | 33.0       | 22.2   | 13.2      | 58.7 | 54.7  | 35.5      |
| USA    | 1004        | 45.8       | 13.7   | 23.5      | 50.8 | 56.3  | 28.7      |
| Total  | 20803       | 30.7       | 22.2   | 29.2      | 36.0 | 53.2  | 29.1      |
| Turkey | 838         | 42.3       | 31.1   | 72        | 24.2 | 61.2  | 19.3      |

government efforts to promote the NPPs work well; however, undecided people are also at high rate. As it is obtained from the face-to-face interviews, most of the participants consider nuclear energy is just another energy option; therefore, the endorsement and decrease the undecided rate, the policy

makers should let residents to know that nuclear energy is not slightly higher than the endorsement of NPPs (42.3%) while just another energy option; it is also a clean energy source and opposition to nuclear weapons was found to be much greater will be beneficial to the environment. Most of the participants in an opposition to NPPs (31.1%). The sharp increase on the in Turkey are not aware of the fact that nuclear energy is a clean energy source. Comparison to other countries from Table 4 explicitly shows that the endorsement rate is higher than or close to the most of the countries having NPP technology at that time, such as USA, France, Japan, Russia, India, and the UK. Table 5 gives the rates of opposing and endorsing NPPs for women and men, separately. Men are found to be more likely to support while women tend to strongly oppose. Another valuable remark here is that 1/3 of the participants did not mind the location of NPPs.

M. Dear in Ref. [26] suggests that the residents living nearer to unwanted facilities tend to more oppose comparing to those living further away. Therefore, besides the gender study, impact of the distance between the location of NPPs and the participant was investigated. Considered cities were chosen different regions of Turkey with different distances to Sinop NPP. The opposition rate was found to be close to each other for the selected cities (except Sinop), which means that participants did not mind the location of NPPs. Although Sinop is the city that will be home of the second NPP in Turkey, the endorsement rate was found to be 52%, the highest value among the selected cities. The opposing and undecided people are 31.0% and 26.6% of the respondents from Sinop, respectively. So, we reported the opposite of the hypothesis assumed in Ref. [26].

In addition to citizens' point of view to NPPs, their desire to owning nuclear weapon was evaluated since the nuclear energy can be used for military purposes as well as peaceful usages. The rates of 45%, 43%, and 12% were determined for the questions 2, 3, and 4 respectively. The numbers are illustrated in Figure 2.

Table 5 Gender vs. opposition to endorsement of NPPs in Turkey.

| Women       |            |           | Men         |            |           |
|-------------|------------|-----------|-------------|------------|-----------|
| Endorsement | Opposition | Undecided | Endorsement | Opposition | Undecided |
| 28.3%       | 37.2%      | 34.5%     | 49.7%       | 27.1%      | 23.2%     |

Table 6 Rates of questions 4, 5, 6, 7, and 8.

|  | Yes   | No    | Undecided |
|--|-------|-------|-----------|
| Q4: Do you think Turkey has enough qualified personnel to operate more than one NPP?     | 26.7% | 50.5% | 22.8%     |
| Q5: Do you concern about a NPP explosion?  | 69.5% | 21.9% | 8.6%      |
| Q6: Do you have negative thoughts about NPPs due to the accidents in the past?           | 69.7% | 23.0% | 7.3%      |
| Q7: Would you visit Sinop NPP to understand how it works if there were public open days? | 37.1% | 51.1% | 11.8%     |
| Q8: Do you think NPPs affect tourism negatively?   | 51.7% | 30.2% | 18.1%     |

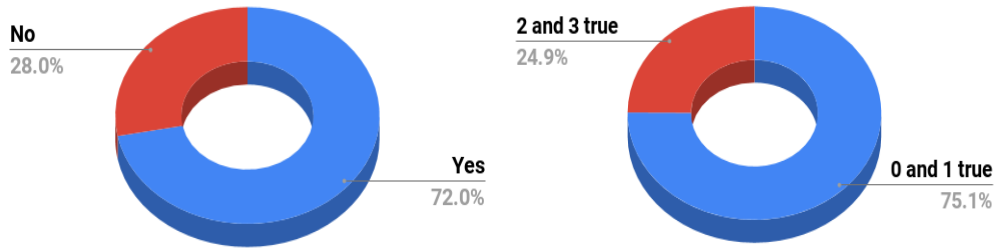


Figure 2 Age vs. risky (left) and education vs. risky (right) diagrams.

#### 4 Conclusion

After 2015, the government made many efforts to promote the nuclear energy in Turkey. Those can be listed as sending students to abroad to study nuclear energy, advertising nuclear energy with Turkish scientists, starting new nuclear engineering programs at public universities, and funding local companies to collaborate with international nuclear energy companies. Especially, when Turkish scientist stars, UNESCO awarded scientist Prof. Bilge Demirköz and Nobel laureate Prof. Aziz Sancar, starred in ads, everyone was talking about nuclear energy. It could be safely stated that the policy followed by Turkish government is successful. In this work, the rate of opposition against NPPs in Turkey was found to be 31.1% while the endorsement was determined as 42.3%. The opposition and endorsement rates of Turkish people were previously reported by P. Ertoğrul et al., M. Özcan, Greenpeace [18], BBC [19] and KONDA [20]. KONDA, a research company in Turkey, conducted a public survey about climate change in March 2018. In KONDA research the opposition rate to nuclear power plant was found to be 68.2% which is significantly higher than our findings. However, the question asked to determine this rate was not a direct question for nuclear energy processes. Which of the two power plants you oppose most? Therefore, we exclude the results of KONDA from the comparison table. Table 7 compares our results with the previous reports. According to the reported numbers, opposition to nuclear energy reaches the highest level in 2014 and 2015, and our study that the endorsement rate of nuclear energy is currently higher than the rate of opposition. Also, it should be noted here that the opposition rate in 2018 was found to be almost half of the opposition rate in 2007. It should be also highlighted here that the endorsement rate of NPPs in Turkey is found to be higher than or equal to many countries that have nuclear energy, such as USA, France, Germany, Japan, Russia, India, and the UK. The policy followed by Turkey could be useful for other countries.

Table 7 Comparison of 2018 results with previous reports.

|                              | Endorsement | Opposition | Undecided | Year         |
|------------------------------|-------------|------------|-----------|--------------|
| Our study                    | 42.3%       | 31.1%      | 26.6%     | 2018         |
| M. Ozcan                     | 18.9%       | 70.2%      | 10.9%     | 2014<br>2015 |
| Greenpeace                   | 31.8%       | 56.4%      | 11.0%     | 2011         |
| BBC                          | -           | 41%        | -         | 2011         |
| P. Ertoğrul<br>Akyazi et al. | 7.2%        | 62.5%      | 30.3%     | 2007         |

In the presented study, it is also found that majority of participants think that they know what nuclear power plant is although the obtained results indicate opposite. The selected questions to measure the respondents' knowledge are very basic questions of NPPs, and they revealed that only 24.9% of the participants answered 2 or 3 questions correctly. Although it is founded that the policy followed by the Turkish government is effective, the residents are lack of nuclear energy knowledge. The majority of the respondents consider the nuclear energy as an alternative energy source to satisfy the energy need for sustaining developments since all efforts made by the government convey this to residents. The policy makers of the country need to tell people that the nuclear energy is not just another energy option, and it is also crucial for the environment. This could reinforce the endorsement rate and prepare a good future of nuclear energy. This rate should let authorities criticize themselves and they should reach to public not only to tell that nuclear energy is a need for economic and industrial developments but also to give them the basics of NPPs and its impact to the environment regardless of whether they support it or not.

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