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Advantages and Disadvantages of Nuclear Energy in Turkey: Public Perception

E. Akyuz

Postgraduate Researcher, the University of Leeds, Leeds, England
(Corresponding Author's E-mail: emrahylsy@hotmail.com)

ABSTRACT

Turkey intends to build three nuclear power stations in the Akkuyu, Sinop and Igneada regions to meet its increasing energy demands. This policy, however, is still a highly controversial topic in Turkey as nuclear energy has both advantages and disadvantages. The related literature on this topic is divided into two groups; supporters claim that nuclear energy may decrease Turkey's energy dependency on other countries, as it already imports approximately 70% of its total energy demand. In contrast, opponents argue that nuclear energy poses serious risks to the environment, which in turn can affect human health and lives. This discussion is, however, held mainly by decision makers, NGOs, the media and scholars. The related literature shows that we know little about how the civil populace perceive the pros and cons of NPPs. In order to fill in this gap, this research aims to explore citizens' perceptions of the advantages and disadvantages of NPPs through semi-structured interviews with people local to the Akkuyu, Sinop and Igneada regions. It concludes that people are well informed about pros and cons of NPPs. They raise three main advantages including cheap electricity, low carbon dioxide and reliability, and two disadvantages, including issues of nuclear waste and the risk of accident.

Keywords: Energy policy, nuclear energy, renewable energy, the environment and Turkey.

INTRODUCTION

Nuclear energy is one of the most important energy sources worldwide, providing about 11% of the world's electricity, and 21% of electricity in OECD countries with over 380,000 megawatt thermal (MWe) total capacity (Kaplan et al., 2017). There are about 440 commercial nuclear power reactors operating in 31 countries, with approximately 65 more reactors under construction (Ozcan et al., 2016; Akyuz, 2016). Turkey is one of these countries, constructing nuclear power plants (NPPs) in order to meet its increasing energy demand due to its rapidly growing economy and population. The country intends to build two NPPs in Sinop and Mersin, and has plans to build one more NPP in Igneada (Coskun and Tanriover, 2016), though the latter is still under discussion.

Turkey's nuclear energy policy, however, is still a controversial topic as NPPs have both advantages and disadvantages that are perceived in diverse ways due to the different values which shapes people's understandings of NPPs. While supporters claim that NPPs are cheap, reliable and environmental friendly energy sources, opponents argue NPPs are costly, non-renewable and eco-unfriendly. The literature shows that this discussion is mainly held by only politicians, NGOs, scholars and the media, and although there are many studies considering the pros and cons of NPPs we, however, still have little information about the true public perception of NPPs. As citizen are at the centre of the risks and benefits related to NPPs, the question

becomes one of what the public opinion about the advantages and disadvantages of NPPs actually is, an issue which is still not clear in the literature to date.

In order to fill this gap in the literature, this research aims to explore how the public perceives of pros and cons of NPPs in the Akkuyu, Sinop and Igneada regions by investigating the following research questions: (1) what are the advantages of NPPs that residents living near planned NPPs know/support?; and (2), what are the disadvantages of NPPs that residents living near NPPs know/support? By doing so, this research aims to explain public perception of the pros and cons of the NPPs planned in the Akkuyu, Sinop and Igneada regions, which in turn may help decision makers to develop a nuclear energy policy that properly reflects people's concerns and priorities.

This paper consists of two main sections. The main purpose of first of these is to introduce the related literature on nuclear energy policy of Turkey, and the advantages and disadvantages of NPPs. The second part aims to explore how the public perceives the pros and cons of NPPs through semi-structured interviews with people local to the Akkuyu, Sinop and Igneada regions. This study concludes that people indicated three main advantages, including cheap electricity, low carbon dioxide and reliability, and two disadvantages, including issues of nuclear waste and risk of accident; these viewpoints indicate that public is, in fact, very well informed about NPPs.

Development of Nuclear Energy Policy of Turkey

As of August 2017, there were 31 countries with a total of 447 nuclear reactors worldwide, which between them produce about 17% of the world's electricity with an installed net capacity of approximately 392 gigawatt (GW) (Elliott, 2016). Nuclear power capacity worldwide is increasing steadily, with 59 nuclear reactors currently under construction in 16 countries (Ozcan et al., 2016). Turkey is one of these countries, currently constructing two NPPs in the Akkuyu and Sinop regions and with plans to build a third in Igneada (Coskun and Tanriover, 2016). The previous Turkish Energy Minister, Taner Yildiz, claims that the commissioning of the Akkuyu and Sinop nuclear power plants will reduce the natural gas bill by $7.2 billion per year (Jewell and Ates, 2015). It is estimated that the share of nuclear energy, in terms of total energy consumption, is intended to be 8–10% in 2020, and 20% by 2030 (Aras, 2013). The Akkuyu and Sinop reactors would replace a little under 10% of the total electrical generation capacity (Jewell and Ates, 2015).

Although Turkey has only begun to construct NPPs over the last decade, its nuclear energy policy goes back to the 1950s (Jewell and Ates, 2015); Turkey has no NPPs, but it has had a nuclear energy program for more than 60 years. The country's interest in nuclear energy started in the 1950s when the Turkish Atomic Energy Commission (TAEC) was established in 1956 in Ankara to oversee the peaceful use of atomic energy (Jewell and Ates, 2015). First construction begun on a 1 MW research reactor at the Çekmece Nuclear Research and Training Centre (ÇNAEM) in 1959, and which started operation in 1962 (Oner, 2011). The country established its second nuclear research centre at the Ankara Nuclear Research and Training Centre (ANRTC) in 1969 (Ozcan et al., 2016). It issued a new nuclear tender for the construction of a nuclear reactor at the Akkuyu and Sinop sites but cancelled it in 1988 due to financial difficulties (Erdogdu, 2007). Similarly, Turkey announced another tender for the

construction of a nuclear power plant at Akkuyu in 1996. The post-modern coup IN 1997 and a massive earthquake in 1999 slowed the country's tender process, which ended in 2001 because of a further financial crisis (Akcay, 2009; Ozacan et al., 2016).

Turkey announced a new nuclear tender in 2008, and made an agreement with Russia for the construction of four nuclear power plants in 2010 with VVER-1200 reactors with a total capacity of 4.800 MW in the Mersin province, located on the southern coast of Turkey. It is expected that construction for the first plant will start at Akkuyu in 2018 and that this plant will come online in 2020. The Akkuyu NPP will be built, owned and operated by a Russian subsidiary of Rosatom, which is a state-owned nuclear company. It is estimated that the project will ultimately cost $20 billion and will employ about 10,000 people. The life cycle of the nuclear plant is rated as being approximately 60 years (Aras, 2013; Aghayev and Aktas, 2017; Heffron and Hatinoglu, 2014; Melikoglu, 2016).

Figure 1. Planned Nuclear Power Reactors at Akkuyu (World Nuclear Association, 2017)

	Type	MWe gross	Start construction	Start operation
Akkuyu 1	VVER-1200	1200	2018	2023
Akkuyu 2	VVER-1200	1200	2019	2023
Akkuyu 3	VVER-1200	1200	2020	2024
Akkuyu 4	VVER-1200	1200	2021	2025

An intergovernmental agreement on nuclear power plant construction and cooperation for the Sinop Nuclear Power Plant on the Black Sea coast, which is the second Turkish nuclear power plant project, was signed with Japan in 2013. The consortium for the Sinop NPPs includes Japan's Mitsubishi and Itochu, France's GDF Suez and Areva, and EUAS from Turkey, the latter of which owned only 49% of the share. It is estimated that this 5000-5600 MWe water nuclear reactor with a combined capacity of about 4.5 GW will cost approximately $22-25 billion, of which 70% will be debt financed. The project still remains on of a feasibility study, though site preparation is already underway. The construction of the second NPP, however, will start in 2017 once an environmental impact assessment (EIA) has been conducted and approved. It is expected that the first unit at the Sinop plant will be active by 2023, and the fourth unit will enter service by 2028 (Gunay and Iseri, 2017; Kok and Benli, 2017; Melikoglu, 2016).

Figure 2. Planned Nuclear Power Reactors at Sinop (World Nuclear Association, 2017)

	Type	MWe gross	Start construction	Start operation
Sinop 1	Atmea1	1150	2017	2023
Sinop 2	Atmea1	1150	2018	2024
Sinop 3	Atmea1	1150	-	By 2030
Sinop 4	Atmea1	1150	-	By 2030

Turkey plans to build a third nuclear power plant. The Turkish Energy Atomic Authority (TAEK) has identified Igneada, which is 12 km from the Bulgarian border in the Eastern Thrace region, virtually on the Black Sea coast, as a third NPP site (Kurt, 2014). The project was confirmed in October 2015, but is still under negotiation with several companies, including Chinese companies and the U.S.-based Westinghouse to develop and construct a four-unit nuclear power plant. It is estimated that the NPP at Igneada will be active by 2030 (Gunay and Iseri, 2017).

Figure 3. Planned Nuclear Power Reactors at Igneada (World Nuclear Association, 2017)

	Type	MWe gross	Start construction	Start operation
Igneada 1	AP1000	1250	-	By 2030
Igneada 2	AP1000	1250	-	By 2030
Igneada 3	CAP1400	1400	-	By 2030
igneada 4	CAP1400	1400	-	By 2030

Advantages and Disadvantages of NPPS In Turkey

As summarized above, Turkey's nuclear energy policy is not new but rather is a very heated ongoing debate by politicians, decision makers, NGOs, activists and, particularly, the academic world, as it has both advantages and disadvantages which can be perceived in diverse ways depending on people's values. It is not interesting that the related literature is divided into two main groups; while supporters claim that NPPs are carbon free, cheap and reliable energy sources, opponents disagree, claiming that nuclear energy is costly, risky and eco-unfriendly energy in comparison with renewable energy sources such as solar and wind power.

Supporters raise some of the advantages of NPPs. The first of these is that it is argued NPPs will reduce Turkey's heavy dependence on oil and natural gas imports (Kurt, 2014; Aras, 2013; Kok and Benli, 2017), which in turn will enhance the security of energy supplies and ultimately the security of the nation (Erdogdu, 2007). Since 1960, electricity consumption in Turkey has grown on average by 9% per year, as compared to 7% for the world as a whole (Jewell and Ates, 2015). Turkey had a total installed electricity-generating capacity of 41.8 GW in 2008, a 78% increase on the same for 1998 (Kurt, 2014). Turkey, however, meets nearly 70% of its energy demands through imports (Akyuz, 2015). For this reason, Oner (2011) states that Turkey needs NPPs to meet the increasing energy demand of its own domestic sources. Secondly, fossil fuels are significant sources of the greenhouse gas emissions which cause climate change and global warming (Talinli et al., 2010). There are, however, no such gases released in the nuclear power-generated electricity (Sirin, 2010). NPPs are one of the few energy production methods that emit virtually no air-polluting or greenhouse gases (Erdogdu, 2007). As Turkey is facing environmental problems due to increasing CO2 emissions, NPPs could indeed represent a serious option by which to combat environmental issues such as climate change (Aras, 2013). Thirdly, supporters note that NPPs are a sustainable energy source. This is particularly true when compared with renewable energy, which is directly affected by meteorological conditions. Renewable sources are, as a nature of their design, dependent on meteorological conditions, such as the absence of sufficient sun, wind, and water sources, which affect their effectiveness (Coskun and Tanriover, 2016). It seems true that nuclear energy is a sustainable

energy source in that it provides energy 7 days a week, 24 hours a day. Fourthly, NPPs are relatively cheap to run. They have low operation costs. Aras (2013) states that NPPs are particularly cost-competitive compared with fossil fuel for electricity generation, which means electricity could well become cheaper in Turkey thanks to NPPs. Fifthly, NPPs have long operational lifespans. While reactors were made to last only 40 years in the 1960s, as a result of the technological development in the nuclear industry over the time, the lifespans of NPPs have been reliably extended to 80 years (Ozcan et al., 2016).

NPPs are, however, not without controversy. Opponents note a number of their significant disadvantages. Firstly, Jewell and Ates (2015) raises the human resource challenge that Turkey does not have sufficient operators and regulators to properly oversee implementation and safe operation. Turkey lacks the human resources to effectively regulate nuclear safety and manage large-scale NPPs (Gunay and Iseri, 2017). Indeed, NPP projects require competent and well-trained human resources (Sirin, 2010) as they represent a highly sophisticated technology. Secondly, opponents claim that nuclear energy is a costly energy source. It requires large investment costs. NPPs are much more expensive than conventional electric generation technologies; it is not incidental that Turkey's previous NPPs have been cancelled due to economic reasons. Thirdly, NPPs have an associated potential risk of accident which pose threat to people and the environment (Ertor-akyazi et al., 2015). The world has witnessed 33 nuclear accidents and incidents to date (Akyuz, 2015). Security concerns have been raised in particular since the disastrous accident at Chernobyl in 1986, which still today poses risks to the environment and human health (Kok and Benli, 2017). It is known that NPPs are particularly vulnerable to natural events such as tsunami and earthquake; for instance, the Akkuyu site is near an active Mediterranean earthquake zone, which increases people's concern in this regard (Akcay, 2009). Fourthly, as Sirin (2010) states, the main issue in relation to NPPs is waste management. NPPs create toxic, long-lived radioactive waste but the nuclear industry still has no effective solution to the treatment and disposal of such waste. Nuclear waste can remain hazardous for hundreds of thousands of years. In other words, it poses an unacceptable risk to people and the environment. Additionally, disposal of waste in these plants is a costly process. Nuclear waste issues cost around £2.5 billion a year (Ozcan et al., 2016). Another criticism is that NPPs are considered the first step to developing nuclear bombs, which threaten worldwide peace. It is a fact that civil nuclear power plants can produce plutonium for military uses but Turkey has signed and approved the Non-Proliferation Treaty (Akcay, 2009).

MATERIALS AND METHODS

The empirical research involved a qualitative case study approach. This method is used extensively in various disciplines within the social sciences such as sociology, administrative science, political sciences and environmental studies (Gomm, 2009). The qualitative case study methodology provides tools for researchers to study complex phenomena within a real-life context, especially when the boundaries between the phenomenon and the context are not immediately evident (Eckstein, 2000). Three cases have been chosen for the collection of data. They include the Akkuyu, Sinop and Igneada regions, which are places where Turkey plans to build NPPs. There are, however, many ways to collect data for case study research which include interview, observation, surveys, questionnaires, and so on. Primary data has been collected through individual interviews. This research has applied the semi-structured interview method to achieve its research objectives.

Interviews were chosen as the primary method of data collection because they allow the researcher to collect more detail than is possible through surveys or questionnaires (Pfefferbaum et al., 2013:311). As McNamara (1999) states, interviews are particularly useful in elucidating the 'story' behind a participant's experiences, opinions, thoughts, and feelings. The interview method is an ideal way of discovering the public's experiences of, and thoughts about, NPPs in the area in which they live. The sampling universe for interview included all people living in the Akkuyu, Sinop and Igneada regions where the NPPs will be built. There is no 'ideal' number by which to ensure reliable interview data in the literature, but 90 people participated in interviews which were undertaken between 2014-2017. The sampling size relied on the concept of 'saturation', or the point at which no new information or themes are observed in the data. The random sampling (RS) method was used to select participants in interviews as it is one of the most common and straightforward probability samples by which one can guarantee a representative sample in quantitative social science research in particular, and in scientific research generally (Marshall, 1996). Lastly, all data has been analysed through the thematic analysis method.

Figure 4. Characteristics of Participants in the Interview

Characteristics		**%**	Characteristics		**%**
Gender	Male	53	**Age**	18-25	15
	Female	47		25-35	20
				35-45	26
				45-55	15
				55-65	10
				65 and older	14
Employment Status	Full time	20	**Level of Education**	Postgraduate	10
	Part-time	10		Bachelor Degree	53
	Unemployed	08		High School	16
	House wives	20		Elementary and	11
	Student	14		Secondary	
	Retired	10		School	
	Student	12		Others	10
	Retired	06			

RESULTS AND DISCUSSION

The thematic analysis of the interview data gave rise to two main themes. Accounts of the corresponding five sub-themes, each of which is illustrated by direct quotes from the transcripts, are given below. A thematic map, consisting of the two main themes and five sub-themes, is presented in Figure 5.

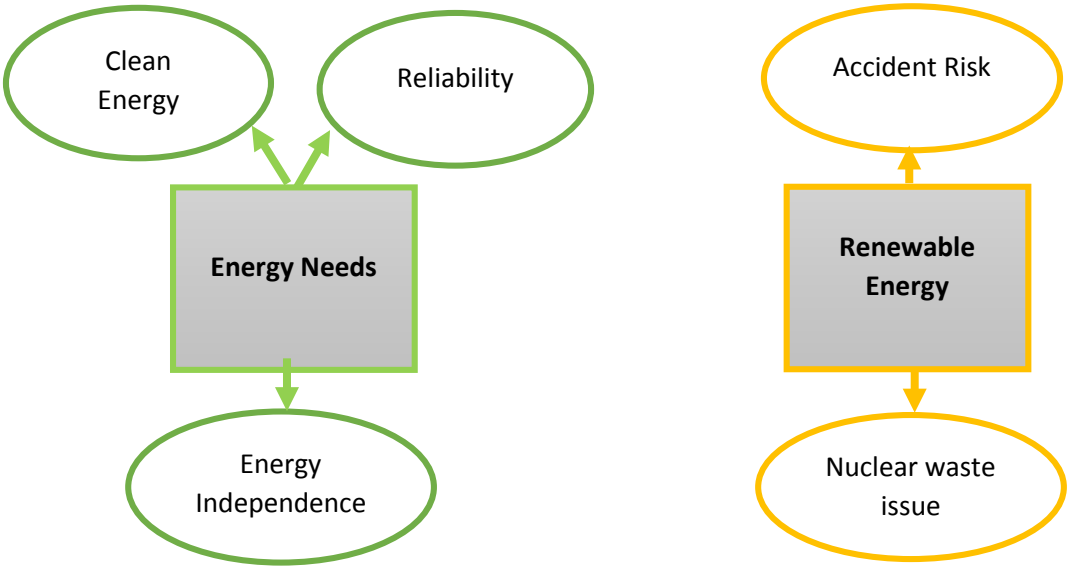
Energy Needs

Energy Independence *(N= 75 quotations assigned to this theme)*

It is well known that Turkey has a heavily dependence on fossil fuels imports. The country meets only about 30% of its total energy demand through its national resources. This is the main concern of the survey participants that consider NPPs to be a solution to Turkish energy dependency. They commonly raise the point that nuclear power plants will mitigate Turkey's energy dependence on oil and natural gas, which will also make a considerable contribution to the Turkish economy through reduced import costs. Accordingly, supporters connect NPPs to energy independence and an improved economy. One of the citizens living near the Akkuyu power station states:

"I pay a lot of money for oil and natural gases because we import them from Russia, Iran and Iraq. Turkey does not have oil and natural gases. In other words, we are dependent on these countries to meet our energy demand. If we build NPPs in our country we will import less oil and natural gases which will improve our economy. Then Turkey will be an independent country as it will meet its energy with its own resources."

Figure 5. Themes Map.



Clean Energy *(N= 64 quotations assigned to this theme)*

This refers to 'carbon-free' energy. Turkey mainly uses fossil fuels to meet its energy demands, which in turn causes serious environmental issues, such as air pollution, due to high emissions of carbon dioxide. It is also stated that the burning of fossil fuels causes climate change and global warming, which also affect Turkey. For this reason, NPPs are regarded as a solution to these environmental problems as they do not emit pollutants or greenhouse gases. Participants, therefore, categorise NPPs as a clean energy source. One stated:

"*I live in Igneada during summer but go to Istanbul to visit my parents in the winter. I know that people use coal and oil a lot and this leads to air pollution in the city. Fossil fuels are very dangerous to our environment and health. I believe that NPPs will mitigate this issue as they do not produce* carbon dioxide"

Reliability *(N= 45 quotations assigned to this theme)*

Most participants compared nuclear energy to renewable energy. Many use solar power in their homes, and their concern is that solar power would not work effectively during winter. In other words, they are concerned that renewable energy is not reliable as it is dependent on the weather. In contrast, they claim that NPPs can work consistently, even in the winter, and for this reason, participants mainly define NPPs as being reliable energy sources compared with solar or wind power. One participant living in Igneada stated that:

"Turkey has four seasons in a year. In the winter and spring, solar power does not meet our energy needs. We need an alternative energy source to meet our energy demand in the town, which cannot be a renewable energy source. In contrast to solar and wind power, the weather conditions do not affect nuclear energy. We can have energy from NPPs at any time and season."

Renewable Energy

Accident Risk *(N= 82 quotations assigned to this theme)*

Chernobyl is the most well-known nuclear accident, which 90% of participants mentioned when we asked about the disadvantage of NPPs. Particularly, those who live near the Akkuyu NPP are worried about a potential nuclear accident due to the Akkuyu being an earthquake region. It is known that nuclear accidents can cause serious human health problems such as cancer. Security is one of the main concerns citizens have about NPPs. One of participants living near Sinop stated that:

"I find nuclear power plants very risky because if an accident happens we can all die. We have been living in the Black Sea region for more than 50 years. Over the last decade, we have witnessed an increase of cancer rates due to the Chernobyl nuclear accident. We can have similar nuclear accident and I know that if it happens we will die. We should find alternative energy sources to NPPs because of security reasons."

Nuclear Waste *(N= 65 quotations assigned to this theme)*

Participants are greatly concerned about nuclear waste. They have no idea as to how nuclear waste will be safely disposed of, which is one of the main reasons why they are worried about NPPs. They think that nuclear waste will pose a serious risk to both the environment and their health. One participant from the Sinop region stated that:

"The Black Sea has an amazing green region with famous valleys, lakes and forests. Nuclear waste, however, will kill this beauty because of radioactive materials. Why do we contaminate nature with radioactive waste? We can take advantage of what nature gives us such as wind and solar to generate electricity."

CONCLUCIONS

This paper has presented an analysis that aimed to explore public perception of the pros and cons of NPPs in the Akkuyu, Sinop and Igneada regions, concluding that the people who live near potential NPPs raise three main advantages and two disadvantages. The former includes energy independence, a clean environment and continuous reliability; the latter include waste management and potential accident risk due to natural events. This perception clearly shows that citizens are well informed/educated as to the pros and cons of NPPs in Turkey which are also commonly discussed by scholars, NGOs, politicians and decision makers in a similar way.

What is not clear, however, is how people actually weigh the advantages and disadvantages of NPPs. In other words, it is important to understand the public's acceptance of NPPs. Social acceptance of nuclear energy can be measured using two criteria: risk perception (cons) and benefit perception (pros). How the risks and benefits of NPPs is perceived in the public mind answers the question of how acceptable NPPs are considered by society generally. However, the risk and benefit perception of individuals is directly associated with values. The judgement of NPPs is essentially a value judgement as influenced by social, political and economic factors, rather than an objective determination. The perception of the risks and benefits by people who have different values can vary significantly.

As citizens perceive the pros and cons of NPPs in different ways due to their different values, it is important that governments should establish appropriate mechanisms to include the public's concerns and priorities in any associated decision-making process. Participation in environmental decisions is recognised as an environmental human right by various sets of international legislation such as the Rio Declaration and the Aarhus Convention. Principle 10 of the Rio Declaration, for example, states that: "Environmental issues are best handled with the participation of all concerned citizens, at the relevant level."

Public participation in the decision-making process regarding nuclear management is the key to reducing a distorted public perception of risk regarding nuclear energy, and increasing public support. *As* Slovic et al. (2011) states, public participation in nuclear energy issues may make the decision process more democratic, improve the relevance and quality of technical analysis, and increase legitimacy through greater public acceptance of the resulting decisions. For these reasons, Turkey's nuclear energy policy, therefore, should guarantee the mechanisms that encourage public participation in any decision-making process in relation to NPPs.

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