



Strategic Thinking in Resource Diversification: Assessing the Value of Nuclear Energy in Turkey

Nurettin Altundeđer^{1*}

¹*Governance and Technology for Sustainability, University of Twente, Building Ravelijn,
Drienerloaan 5, 7522 NB Enschede, Netherlands.*

Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/AJEBA/2020/v14i130184

Editor(s):

(1) Dr. Fang Xiang, International Business School, University of International and Business Economics, China.

Reviewers:

(1) Hussin Jose Hejase, Al Maaref University, Lebanon.

(2) Imam Mukhlis, Universitas Negeri Malang, Indonesia.

(3) P. A. Murad, USA.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/54625>

Policy Article

Received 06 December 2019

Accepted 11 February 2020

Published 18 February 2020

ABSTRACT

Turkey is an energy dependent country with more than 75 percent of its energy being imported from foreign countries. The level of dependency is increasing every year because of the rising energy needs and the lack of national production. Among all forms of energy, increase in demand for electricity is the highest. At a time that some countries are announcing their decision to phase out nuclear power plants (NPPs) in favor of renewable energy sources, Turkey appears to be determined to proceed with its decision to acquire nuclear technology despite safety concerns. A country that has seen domestic opposition towards nuclear energy has already made significant progress towards acquiring one. This article uses a policy analysis framework to assess the value of nuclear energy in Turkey from an energy security perspective. It argues that energy security for Turkey can be dealt with thoroughly when the problem of resource diversification is addressed from a comprehensive perspective. Pros and cons of having NPPs in Turkey will be analyzed through energy security parameters vis-a-vis the urgent need for resource diversification.

Keywords: Nuclear energy; energy security; Turkey; diversification of resources; energy dependence.

*Corresponding author: E-mail: n.altundeger@utwente.nl;

1. INTRODUCTION

Resource diversification has been and still is one of the most important aspects of energy security, a concept that has become an issue of high politics in international and domestic politics. As Winston Churchill put it: "safety and certainty in oil, lie in variety and variety alone." The concept of energy security has gone through stages of evolution since then to include many other factors but the core of the issue still remains the same when it comes to access to the energy sources that the countries rely on. A successful energy policy now encompasses the play on domestic, regional and international factors, thus making it one of the most complex issues for the governments. The dynamic nature of energy politics and diplomacy is the reason that the governments are forced to pay constant attention to make sure that they are able to provide the energy needed at an affordable price without any interruption. This is also true for Turkey, a country located in the middle of the most energy rich regions in the world but lacking any considerable reserves of its own. Turkey is among the countries that are expected to require more energy in the coming decades because of economic growth and population increase [1]. In a world where economic development depends heavily on stable supply of energy, Turkish governments are finding themselves under immense pressure to meet the ever-growing demand [2].

The latest numbers from Turkey's Ministry of Energy indicate that more than 99 percent of the natural gas used in Turkey is imported with only 0.7 percent of it produced locally [3]. The level of dependency is alarming from an energy security perspective [4] where more than 30 percent of dependency is considered too high in the literature [1]. What makes this picture even more dramatic is the fact that more than half of the natural gas (52 percent) that Turkey buys comes from only one supplier: Russia. 2018 figures show that Turkey imports 15.61 percent of its demand from Iran and 14,95 percent comes from Azerbaijan [5]. Despite the fact that the demand for energy fluctuates by years, depending mostly on the economic factors, Turkey's demand for energy is expected to increase at about 140 percent of its current consumption by 2020. A growth that should have been met long before. In this case economic growth and rising demands alongside with lack of planning are to blame. Lower energy demand in 2013 and 2014 is caused by the slowdown in economic growth,

which is also the case for other countries [6]. An average five percent increase in energy demand in general and a two percent more in electricity is an enough reason to force Turkish governments to scramble for sustainable energy policies. Energy imports are one of the reasons for the country's huge budget deficit. In 2018 Turkey paid almost \$43 billion US dollars for energy imports, comparatively less than the previous figures which have reached up to 60-billion-dollar range. Turkey is now looking for ways to achieve energy conservation and efficiency in production. As a major player in the region, a member of G20 and a signatory to the Kyoto Protocol, Turkey have been struggling to find alternative sources of energy to better address the growing energy needs. In order to meet the demand, Turkish government wants to move forward with policies that will make it easy for Turkey to achieve an energy policy customized for its own needs.

One of the biggest debates in Turkey is the use of nuclear energy to meet the growing energy demand in the country. Starting with the 1970s, Turkey has pursued a nuclear energy policy that has constantly failed for a variety of reasons, leaving Turkey outside of the countries that belong to nuclear club. With the signing of the Akkuyu Nuclear Power Plant Agreement in May 2010 between Turkey and Russia, Turkey's quest for nuclear energy became a closer reality than ever. However, the issue of nuclear energy has never been free of controversy. Proponents and opponents in Turkey have been debating constantly when most of the developed countries have already been using nuclear energy for more than 60 years. The first nuclear power reactor was established on June 26, 1954, at Obninsk, Russia, the nuclear power plant APS-1 with a net electrical output of 5 MW was connected to the power grid, the world's first nuclear power plant that generated electricity for commercial use [7]. Currently, there are 31 countries having nuclear energy for commercial use, with more than 450 NPPs (Nuclear Power Plants) are in operation and 60 more are under construction [8]. Three quarters of the NPPs are located in 14 of the G20 countries which of the remaining five members, Indonesia, Italy, Turkey and Saudi Arabia are exploring options to use nuclear reactors for the first time [9]. Nuclear energy is responsible for about 11 percent of the global electricity generation. At a time that the environmental concerns are on the rise due to the challenges posed by global climate changes, the NPPs present a special opportunity for the

world community to reduce carbon emissions, also an issue strictly emphasized in the Kyoto Protocol that was signed in 1997 and took effect in 2005.

Other than the challenges posed by meeting the total energy needs, Turkey's real problem with energy security lies in resource diversification and reducing dependency on few suppliers. The urgency was also recognized by the Turkish Parliament's Foreign Affairs Commission Report which cites the urgent need for additional energy supplies to diversify energy resources to reduce dependency on foreign imports [10]. This study deals with the issue of nuclear energy for Turkey as a way of improving conditions for energy security through energy diversification. The paper sets out to assess the added value of nuclear energy as a solution to meet the increasing demands. It also seeks to answer the question of whether the adoption of nuclear energy in Turkey will help to resolve or lessen the problem of overdependence to Russian and Iranian gas as an energy source. The nuclear energy is a promising initiative for Turkey that has a potential to serve the benefits expected but the real problem of energy independence and energy security go far beyond the establishment of nuclear reactors. A solution to Turkey's energy dependence will require a larger and comprehensive approach that will also require investing in other energy sources. The urgency of implementing new and efficient policies can be expressed simply by stating the fact that in year 2018, Turkey as a country of great potential and a member of G20 imported electricity from its neighbors, including Bulgaria [11].

2. THE TURKISH QUEST FOR NUCLEAR ENERGY

Turkey is among the many countries pursuing nuclear technology for energy purposes. The history of Turkey's nuclear quest goes back to the 1970s with the Turkish governments of the period planning to build a 300-Megawatt nuclear reactor in Akkuyu, Mersin. In fact, the history of Turkish desire to acquire nuclear technology goes back to 1955, when Turkey signed an agreement with the USA to cooperate on the 'peaceful uses of nuclear energy' which was followed by the establishment of Turkish Atomic Energy Commission (TAEK) the next year. The same project was also pursued by the government of Turgut Özal in 1983 with no avail. The pessimistic environment created by the Chernobyl accident and its huge psychological

impact on the Turkish people was to blame for the lack of any initiative regarding nuclear energy. In many of these instances the Turkish governments' policy to reduce financial risks and avoid investing huge sums of money contributed to the failure of these projects [12]. Despite its benefits, NPPs' initial cost is considerably high. Securing the funds needed to build an NPP is an important part of transferring the technology. In addition to the financial difficulties, it is worth noting that there is an ever-growing opposition to the proliferation of nuclear technology along with the introduction of very strict regimes controlling its transfer to the third parties [13]. Turkish attempts to acquire nuclear technology for energy purposes has long suffered both from financial troubles and policies as well as the reluctance of the states with nuclear technology to facilitate the process [14]. If history is any guide, countries that are determined to acquire nuclear technology for any purpose will be able to achieve their goal despite any kind of opposition and/or pressure from other countries. In the Turkish case however, the failure to transfer nuclear technology has a lot to do with domestic politics than the international opposition. Absence of a strong political will should be stated as an important factor in Turkey's failure to obtain nuclear technology along with the nature of domestic politics where the governments can come and go within four to five years while an average time needed for an NPP to be successfully built and then to start producing energy is about five to seven years. Therefore, transfer of nuclear technology for peaceful purposes must be a national policy pursued by each government taking control in the country to avoid interruptions. However in Turkey, a long lasting national energy planning with a solid nuclear power policy did not become possible due to weak coalition governments and/or governments leaving office after losing in early elections. Especially after 2010, the rise of AKP as a strong and long-lasting party in government has changed the political landscape in Turkey. This in turn made it easy for the nuclear power projects to be realized as long as the party is in power and its leader favored it as a desirable policy.

With the construction of Akkuyu Nuclear Power Plant well underway (as of 2020), the latest attempt however seems to be the most promising one. After series of unsuccessful attempts over the years, the Turkish government signed an agreement with Russia on May 12, 2010 to build four separate NPPs, Russia undertaking almost

all financial responsibilities. According to the agreement, Russia is to build, own and operate the plant and eventually decommission them after 60 years of operation. The total capacity of the NPPs are planned to be 4800 MWe with each costing around \$5 billion. The agreement was ratified by the parliaments of both Russia and Turkey the same year and the preparations to build the four NPPs are well underway. The Turkish government has guaranteed to buy 70 percent of the first two and 30 percent of the third and fourth reactor's electricity for 15 years at a fixed rate of 12.35 cents/ kWh. If all goes as planned the first nuclear plant should go in operation in 2023.

"The four-unit, 4800 MWe plant is part of Erdogan's '2023 Vision' marking 100 years since the founding of modern Turkey and is intended to reduce the country's dependence on energy imports. The first unit is scheduled to start operations that year, with the other three units following by 2025. The plant is expected to meet about 10% of Turkey's electricity needs" [15].

Turkey had also a plan to build another nuclear power plant in the city of Sinop on the Black Sea coast. In May 2013, Turkey had accepted an offer from an international consortium led by Japan's Mitsubishi in cooperation with various French-Turkish companies to build four Atmea1 type reactors, third generation pressurized water reactor, with a total capacity of 4480 MWe. Then the Turkish Prime Minister Recep Tayyip Erdoğan and Japanese Prime Minister Shinzo Abe signed the agreement on May 3, 2013. The project was initially expected to cost around \$22 billion. 30 percent of the funds necessary to build and operate the reactors was agreed to be provided by the governments of Turkey and Japan, of which 49 percent would be the responsibility of the Turkish government. The agreement was ratified by the Turkish Parliament at the end of March, 2015 and approved by the Turkish President on April 1, 2015. At the time, the construction was planned to start in 2017 and the first reactor was expected to go operational by 2023. However latest reports indicate that the construction of nuclear power plants in Sinop may not be realized. During his visit to Japan in June 2019, Erdogan confirmed that the Sinop nuclear power plant project came to a halt because of new cost estimates. According to feasibility report by the Mitsubishi company, the projected costs have doubled to 40bn range [16].

There are also plans for a third NPP in Turkey but the decision on the projected site and the details have not been yet made public. In a speech given at The Turkey-Slovakia Business Forum, President Recep Tayyip Erdoğan reiterated Turkey's need for stable energy supply and indicated that other than the two existing projects, there might be another one in the coming days. Focusing on the necessity to diversify energy sources, Erdoğan expressed Turkey's desire to meet its energy needs without harming the environment but utilizing the country's potential resources in an efficient way.

3. NUCLEAR POWER AND THE TURKISH ENERGY LANDSCAPE

Turkey is among the fastest developing countries with a growing economy and population, leaving the country with an increasing demand for energy. However, Turkey's present and forecasted power generation capacity falls way behind the amount required of a growing demand. Electricity is a secondary source of energy and its production and security are directly related to the primary energy sources such as, natural gas, coal, hydro power, renewables and nuclear energy. According to a report by Turkish energy ministry, electricity consumption in Turkey is on the rise with an average three to five percent increase in demand every year [17]. Official estimates indicate that by 2023, Turkey will need 60 percent more electricity than what it needs today. To meet that demand, Turkey is currently relying primarily on natural gas, coal, hydro power and renewables. The share of natural gas however has long been on the rise topping the list in Turkey on electricity generation up until 2018. The decline in the use of natural gas is related to the increase in the use of coal in electricity generation. It is worth noting that more than 21 percent of the coal is also important. In that regard the decline in the use of natural gas does not provide additional value in terms of reliance on other countries. The increase in the use of coal to produce electricity however creates more environmental problems than the use of natural gas. The latest numbers indicate that 31 percent of the electricity produced in Turkey came from natural gas, 37 percent from coal, 21 percent from hydraulic and the rest came from renewables and other sources (See Table 1, [5]).

A country importing 99 percent of its natural gas supply from its neighbors, Turkey's reliance on imported natural gas and coal in electricity

Table 1. Turkey electricity generation by source

Year	Total (GWh)	Natural gas	Coal (%)	Liquid fuels	Hydro	Renewable Energy and wastes*
2010	211.208	46,5	26,1	1,0	24,5	1,9
2011	229.395	45,4	28,8	0,4	22,8	2,6
2012	239.497	43,6	28,4	0,7	24,2	3,1
2013	240.154	43,8	26,6	0,7	24,7	4,2
2014	251.963	47,9	30,2	0,9	16,1	4,9
2015	261.783	37,9	29,1	0,9	25,6	6,5
2016	274.408	32,5	33,7	0,7	24,5	8,6
2017	297.278	37,2	32,8	0,4	19,6	10,0
2018	303,313	30,9	37,4	0,3	20,3	11,1

*Includes geothermal, biomass, biogas, solar and wind energy; Source: TEİAŞ (Turkish Electricity Transmission Corporation) [18] & EPDK (Turkish Energy Market Regulatory Authority). Data set for 2018 comes from EPDK

generation creates a security problem that needs urgent attention. The current state of Turkey's energy sources does not look sustainable since the amount of consumption is constantly increasing at a rate higher than its production. Among the alternatives to diversify energy sources, nuclear power seems to be one of the most plausible options when it comes to its efficiency and stability in electricity generation. Therefore, one might argue that the quest for nuclear energy for Turkey has become a necessity rather than a choice. A country importing 75 percent of its energy needs will have to be aggressive in search for better options to provide energy security. The debate on the establishment of NPPs in Turkey could also be seen from this perspective compared to the ecological challenges that it presents. As indicated above, current energy regime is unsustainable in the long run considering the fact that Turkey lacks the required resources to produce its own energy.

4. THE NEED FOR RESOURCE DIVERSIFICATION

An important aspect of energy security is its affordability but access to those resources is far more important than the price that a country is willing to pay for. The cost of power outages and interruptions in the supply of main energy sources are way more punishing than the above-average or high-cost energy production. The cost of a power outage in the industry is too high to take the risk. It is estimated that a single second interruption in industrial production in large scale manufacturing establishments will result in a financial loss at about 171.000 US dollars [19]. Turkey is no stranger to power outages but its cost to the Turkish economy mostly goes unnoticed. As an example, the blackout on April

2, 2015 might have cost the country a staggering \$600-800 million, excluding the human suffering and a loss of prestige among the world community [20]. The reasons behind the blackouts in Turkey may vary, but seasonal droughts and unexpected interruptions in the supply of natural gas can easily result in power outages throughout the country.

The power outages and interruptions in the supply of main energy sources can only be resolved through diversification of energy resources. In the event of an interruption, the government and the companies providing electricity should be able to work in between alternative and yet stable sources of power to distribute electricity across the grid and avoid costly blackouts.

Another reason that makes it necessary for Turkey to look for alternative sources for electricity generation is the fact that Turkey continues to buy electricity from its neighbors despite burning an increasing amount of natural gas in electricity production which is also imported. This alone should be sufficient to show the dismal state of reliance and overdependence in electricity generation on other countries. In 2018 Turkey have imported 2.4 GWh of electricity 9 percent lower than 2017 but reliance on foreign supplies continues.

Current state of electricity production and available resources reveals series security issues stemming from lack of alternatives and overreliance on a single source of energy to meet the demands. Energy policies concerning resource diversification must be customized according to the needs and the available resources. Making generalizations and disproportionate comparisons will neither

produce positive outcomes nor contribute to the solution of the problem at hand. Each country will have to weigh its options according to its needs, resources and capabilities. Nuclear energy in Turkey should also be taken into consideration from this perspective to see if the benefits of having NPPs would outweigh the costs. The next section examines the benefits and costs of establishing NPPs in Turkey vis-à-vis the urgent need for accessing alternative energy sources.

5. NUCLEAR ENERGY IN TURKEY: PROS AND CONS

The supporters of nuclear energy present it as an efficient, cheap, environmentally friendly and most of all a sustainable source of power that can make huge difference on the supply side of the equation. The opponents however focus on the dangers posed by nuclear facilities in the event of an accident or a meltdown that can be triggered by natural disasters or technical failures. The memories of Chernobyl and a relatively recent incident in Japan Fukushima continue to influence the minds of the people. For a country that had no experience with nuclear power, the negative perception can be understandable [21].

However, the decision to use nuclear power should be based on the realities and necessities rather than perceptions. Perceptions do change by time and yet they can be manipulated. A serious decision like having NPPs will have to be based on sound and reliable data about their contribution to Turkey's energy production. Any decision to build NPPs will also have to be aggressive about safety requirements as accepted by international standards.

Economically speaking, any increase in national electricity production will have positive impact on Turkey's current budget deficit. The Turkish energy imports amount to almost \$42 billion in 2018, 15 percent higher than 2017. The numbers used to be around \$60bn range when the prices were higher. The amount of money spent for energy imports are another contributing factor for the high account deficit numbers in Turkey. Turkish account deficit was \$76.8bn in 2017 and \$55bn in 2018 [22]. The projected growth in energy demand will not make the future budget balance any better if Turkey does not initiate a mechanism to reduce its energy dependency. Despite its initial costs, the NPPs have an average of 60 years of lifetime that can compensate for the large sums of funds spent

within 10-15 years. Once the costs are offset, the nuclear energy will relatively be cheaper than any other energy source compared. The fuel used to fire up the nuclear reactor is highly efficient and unit price per kWh of energy generated is lower than other sources of energy used to generate electricity. For example, one kg of enriched uranium can produce 45.000 kWh of electricity while this can only be obtained through burning 10 tons of oil or 14 tons of coal. "With a complete combustion or fission, approx. 8 kWh of heat can be generated from 1 kg of coal, approx. 12 kWh from 1 kg of mineral oil and around 24,000,000 kWh from 1 kg of uranium-235. Related to one kilogram, uranium-235 contains two to three million times the energy equivalent of oil or coal" [23]. Other than the efficiency of nuclear fuels, we can also cite its stability as an important advantage compared to fossil fuels. The nuclear fuel used in the reactors amount to one fourth of the total production cost while it can run around 80-90 percent of the costs per kWh in fossil fuels. The low fuel costs render nuclear energy much more stable when price of fossil fuels fluctuate and makes it an attractive choice for the governments. The stability of nuclear energy production is also related to the easy access to the fuel sources required to produce the energy, compared to the delicate political and security environment that oil and natural gas have to pass through. The attack on Saudi Arabia's oil facility in September 14, 2019 caused worldwide concerns and resulted in massive spikes in global oil prices. The prices rose as much as 14 percent until Saudi Arabia could restore its oil production [24].

Environmentally speaking, nuclear energy production is safer and greener compared to any other fossil fuel, including natural gas which is the least carbon emitter among them [2]. International Energy Agency estimates that the use of nuclear energy might have saved the world more than a 56 gigatonne of carbon dioxide from being released into the air since 1971.

Greenhouse gas emissions of the NPPs are among the lowest of any electricity generation method and on a lifecycle basis. Lifecycle emissions of natural gas generation are 15 times greater than the nuclear and the lifecycle emissions of coal generation are 30 times greater than the nuclear [24]. The data in Table 2 puts nuclear power on par with wind, hydro-electricity and biomass on carbon emissions.

Table 2. Lifecycle greenhouse gas emission intensity (in tons)

Technology	Average carbon dioxide emission / GWh
Lignite	1,054
Coal	888
Oil	733
Natural gas	499
Solar PV	85
Biomass	45
Nuclear	29
Hydroelectric	26
Wind	26

Source: World Nuclear Association 2019 [25]

The choice for renewables however is a difficult one to assess because of the cost associated with acquiring the technology needed and its energy yield compared to Turkey's demand in retrospect to nuclear alternative. This is not to imply that renewables should not be on the table when it comes to energy diversification. From an energy security perspective, investment in renewables should be considered as another goal to diversify rather than a rival to choose in between. Nuclear energy and renewables need not be two competing alternatives in energy diversification but can be two different venues inherently serving the same purposes. As Daniel Yergin explains: "This struggle over fuel choice is not just about meeting today's needs but also about how to meet expected growth in demand and new environmental objectives. Coal, nuclear power and natural gas will all be part of the picture, both in the United States and around the world" [26].

It is also important to mention here that the nuclear technology also serves other benefits along with providing a stable and efficient source of energy. The nuclear technology indicates a level of development and yet is also a source of prestige (See: [27]). The technology used in medicine with tens of thousands of hospitals around the world benefitting from radiotherapy and radioisotopes to treat and diagnose many illnesses. Any country lacking nuclear technology will also have to rely on foreign countries to provide advanced medical equipment that has become an integral part of modern hospitals. The use of nuclear technology is not limited to medical industry. Its applications in other areas also serving great advantages in the production of advanced materials and chemicals as well.

In retrospect, some of the European countries have expressed their decision to phase out

nuclear reactors in the coming years. Germany and Switzerland have shown great interest in renewables and voiced their desire to rely more on green energy in the future (See: [28] and [29]). Their decision came after the Fukushima nuclear accident that has caused a lot of concern worldwide about the safety of the NPPs. However, the number of NPPs are still on the rise in some of the Asian countries like China and South Korea. The same is also true for India and Russia. Even in Europe, France is still the leading country in terms of nuclear energy dependence (72 percent of its electricity) and has shown no sign to reduce its nuclear reactors, currently 58, with another reactor under construction. Other European countries like Belgium, Slovakia, Ukraine, Check Republic and Hungary are getting more than one third of their energy from nuclear reactors. While the government of the Netherlands debating the possibility of a new nuclear plant, Germany is looking to phase its nuclear plants (currently 7 in operation) out by 2022. The difference lies in the difference in the energy landscape in both countries. While Germany can invest heavily in renewable energy to utilize its vast potential, the Dutch government is seeking a new alternative against its diminishing natural gas resources in the Groningen area.

In the light of the current debates, we can conclude that there is no global trend in favor or against nuclear energy production and building new generators. Each country is making its own decisions based on its own needs and capabilities. In that respect, Turkey will also have to make its own decision based on its current demand and future projections since the conditions surrounding Turkey's energy environment are different than the conditions of those other countries. Comparing Germany to Turkey in that regard will be misleading because of the underlying differences in many areas including their energy demand, growth rate, geography, financial resources, level of development and technological capabilities. All things considered, Turkey's decision will have to reflect its own interests based on its own resources and limitations. What Turkey actually needs is an energy policy that transcends the governments. Governments can come and go but the country's energy policy should stay in place without going through major changes. Modifications and adjustments should be accepted as part of the evolutionary nature of energy policies to adapt to the changes that take place outside of its boundaries. Continuity and

flexibility should also be an integral part of the policy to give a clear direction to the governments but overarching goals like energy security, energy independence and diversification should remain on top of every new policy implemented by the coming governments.

Since the dawn of the nuclear technology, the cost of building a nuclear power plant has not come down. The construction of nuclear power plants still is a costly enterprise for the governments. Most of it is related to the advancements made in the safety and efficiency of nuclear technology. Constant improvements are made in the planning and construction of these reactors to achieve maximum safety, to reduce risks and to attain highest level of efficiency in electricity generation. An average nuclear reactor would cost around four to five billion US dollars. A four-unit NPP in Mersin Akkuyu will cost Turkey about 20 billion dollars, a sum that Turkish governments have so far found it very difficult to spare and very risky to undertake. The intergovernmental deal with Russia provides an opportunity in that regard that almost all financial aspects related to the construction and operation of the reactors will be undertaken by the Russian company and guaranteed by the Russian government.

Storage of used nuclear fuel in special (underground) repositories is currently the most popular method since there is no technology to eliminate or reprocess these highly radioactive materials entirely. The growth of the waste produced by the nuclear reactors continues to pose a risk to the environment and the human life provided that the strict security safeguards failed to contain these hazardous materials. Waste management also requires financial calculations since the transportation and the storage of used fuels is a costly business, just like its initial costs and decommissioning of it after decades in operation. However, the costs associated with waste management and decommissioning of the plant is usually resolved through an initiation of a fund collected during the time when the plant is in operation. Large sums of money accrue to these funds that eliminate any possibility of a burden on the society at the end of its lifecycle.

Turkey is an earthquake prone country located on active tectonic fault lines. The history of major earthquakes raises serious concerns about the safety of NPPs in Turkey. People who are opposing to the establishment of nuclear reactors

in the country often cite earthquakes as a reason why Turkey must forgo nuclear energy and look for alternatives (See [30]). But there are ways to minimize risks. For instance, the Akkuyu NPP site is about 150-200 km away from the fault lines and the units are planned to withstand a 9.0 magnitude earthquake on the Richter scale. It is important to mention that any argument made in favor of nuclear energy and establishment of nuclear power plants in Turkey inherently assumes that the government and the construction company prioritize the security and safety of the reactors first and foremost. A thorough investigation should be carried out at each and every step along the way before the government can issue license to proceed to the next step. As a non-nuclear country, Turkey has already made considerable progress in terms of adapting regulations concerning the safety and operation of nuclear establishments and filling the gaps in the legal framework governing the various aspects of nuclear energy and related activities based on to the international standards (See: [31]). Before going back and forth between the nuclear accidents happened in the past and decision to have our own, we need to keep in mind that modern reactors are safer and stronger compared to first generation reactors and the likelihood of a leak or radioactive fallout is smaller [27].

Once operational, nuclear reactors in Akkuyu expected to contribute a total of 48 billion kWh of energy to the grid. This will significantly reduce the use of natural gas to produce electricity and reduce overdependence to natural gas from foreign supplies. The chart depicted in Fig. 1 compares the capacity of nuclear reactors to hydropower plants (HPP) in Turkey. The largest of the hydroelectric terminal Atatürk HPP carries roughly half the capacity of the NPP to be constructed in Akkuyu. Given the numbers, the NPPs offer a great potential to add to Turkey's electricity production.

Considering the fact that Turkish electricity consumption will continue to rise in the future, slower or faster than the expected rate, nuclear energy's role and importance will be crucial in meeting future demands. By the time the NPPs in Akkuyu are completed and became fully operational, Turkey is expected to gain 48 MWe electricity generating capacity. Based on current projections, nuclear reactors will be able to provide about ten percent of the total production in Turkey. The estimate can change based on the domestic production and state of the

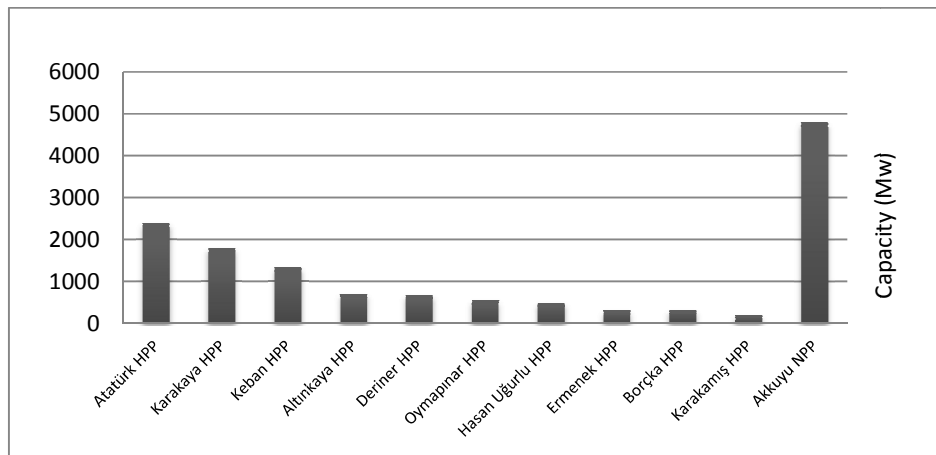


Fig. 1. Comparison of 10 largest hydro power plants in Turkey and Akkuyu NPP

Data Source: DSI (The General Directorate of State Hydraulic Works) [32]

economy and the demand for energy (See [25]). The projected amount will not resolve Turkey's dependence on foreign supplies in electricity generation but will be an important addition to the country's energy landscape in terms of diversification.

6. CONCLUSION

The decisions that are made today will determine Turkey's future in terms of its energy policies and economic development. Nuclear technology represents a reliable and a stable source of energy production and yet it is a source of great prestige and an indication of technological development. For more than 60 years, Turkey sought to acquire nuclear technology for peaceful purposes and currently Turkey has come ever closer to that goal. It is however too early to declare victory since the projects are already at the initial stage. The authorities will have to thread very carefully to avoid any kind of foreseeable and/or unforeseeable development hindering the realization of the projects. The nuclear energy projects in Mersin Akkuyu and Sinop represent a psychological barrier for Turkey to achieve nuclear energy production. The success in these projects will permanently alter the energy landscape for Turkey and consolidate Turkey's base for energy security and energy diversification. Once these projects are complete and successful, it will be a lot easier for Turkey to discuss additional reactors if necessary. On the contrary, a failure in these projects will probably be the end of Turkey's aspiration to have nuclear energy as an alternative source of energy for a long time to come.

A political will to support the process and willingness to invest financial resources are necessary to complete the construction of the reactors. As indicated above, the benefits of nuclear energy will not be seen in the short term because of the high investment costs. Financially speaking, it will take years before the nuclear energy becomes a cheap energy source for Turkey. However, it will be a reliable and a stable source of energy for a country that is desperately looking for additional energy sources to meet its growing demands.

The nuclear energy seems to be a good solution for Turkey in terms of diversification but the problem with reliance on foreign countries on energy continues to present challenges for the Turkish government. As long as Turkey continues to import huge amounts of natural gas from Russia for electricity generation and relies on the same country on nuclear projects, the issue of dependence remains problematic. Turkey has to look for other international partners in nuclear energy business to eliminate further dependence on Russia.

The nuclear energy may be the most efficient source of power in terms of the fuel needed to produce electricity but diversification of energy sources requires countries to invest in other sources of energy as well. The arrival of nuclear energy will indeed be a positive contribution to the solution of Turkish energy problems but the real solution to Turkey's growing needs will require the country also to invest in renewables and other sources to achieve a more balanced and diverse energy policy. In the greater energy landscape, the nuclear energy will play an

important role as a new source of energy to complement, rather than to compete with, other energy sources.

Environmentally speaking, the nuclear energy is a better alternative to fossil fuels but the issue of safety should be one of the most important aspects of the nuclear projects. Turkish government has already indicated its resolve to build safe and secure nuclear reactors and it should continue to do so until the completion of the reactors. Any support in this study given to the nuclear energy in Turkey assumes that the reactors meet international safety standards and the parties in these projects make it an issue of utmost importance during both in its construction and its operation in the future.

ACKNOWLEDGEMENT

I am thankful to the Department of Governance and Technology for Sustainability (CSTM) and the University of Twente for providing a welcoming environment to carry out my studies.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Emre İ, Cem Ö. Türkiye'de Sürdürülebilir Enerji Politikaları Kapsamında Nükleer Enerjinin Konumu. İ.Ü. Siyasal Bilgiler Fakültesi Dergisi. 2012;47:161-180. (Turkish)
2. Sevda Y. Enerjiye Dayalı Büyüme, İstanbul, Beta Yayınları; 2013. (Turkish)
3. TPAO. Ham Petrol ve Doğal Gaz Sektör Raporu; 2017. (Turkish)
4. Sözen A, Alp İ, İskender Ü. An evaluation of Turkey's energy dependency. Energy Sources, Part B: Economics, Planning, and Policy. 2014;9(4):398-412.
5. EPDK. Elektrik Piyasası 2018 Yılı Gelişim Raporu; 2018. Ankara T.C. Enerji Piyasası Düzenleme Kurumu Strateji Geliştirme Dairesi Başkanlığı; 2018. (Turkish) Available: <https://www.epdk.org.tr/Detay/DownloadDocument?id=X/fUh6+7kaM=> Accessed: 13 December, 2019
6. Aras E. The necessity of nuclear energy in Turkey: A Comparison with hydropower energy. Energy Sources, Part B: Economics, Planning, and Policy. 2013;8(2):107-114. DOI: <http://10.1080/15567249.2011.633594>
7. European Nuclear Society. Nuclear Power Plants, World-Wide; 2019. Available: <https://www.euronuclear.org/info/encyclopedia/n/nuclear-power-plant-world-wide.htm> Accessed: 7 August, 2019
8. World Nuclear Association. Nuclear Power in the World Today; 2019. Available: <https://www.world-nuclear.org/information-library/current-and-future-generation/nuclear-power-in-the-world-today.aspx> Accessed: 11 September, 2019
9. Jongryn M. Introduction: G20 Middle Powers (MIKTA) and Global Governance. In: Jongryn M. (eds) MIKTA, Middle Powers, and New Dynamics of Global Governance: The G20's Evolving Agenda. Asan-Palgrave Macmillan Series. Palgrave Pivot, New York. 2015;1-12.
10. TBMM. Foreign Affairs Commission Report to Turkish Parliament; 2014. (Turkish) Available: <http://www.tbmm.gov.tr/sirasayi/donem24/yil01/ss673.pdf>
11. Hurriyet Daily news. Türkiye'nin elektrik ithalatı faturası yüzde 58 azaldı. Hurriyet Daily news; June 1, 2019. (Turkish) Available: <http://www.hurriyet.com.tr/ekonomi/turkiyenin-elektrik-ithalati-faturasi-yuzde-58-azaldi-41199949> Accessed: 12 October, 2019
12. Udum Ş. Turkey's nuclear comeback. Nonproliferation Review. 2010;17:365-377.
13. Ülgen S. Turkey and the bomb. Nuclear Policy. Carnegie Endowment for International Peace; 2012. Available: www.jstor.org/stable/resrep13061
14. Thomas L, Joanna K. Turkey and multilateral nuclear approaches in the Middle East. The Nonproliferation Review. 2010;17(3):513-530. DOI: 10.1080/10736700.2010.516999
15. World Nuclear News Report. Basemat of Turkey's Akkuyu 1 completed. March 14, 2019. Available: <http://world-nuclear-news.org/Articles/Basemat-of-Turkeys-Akkuyu-1-completed> Accessed: March 17, 2019
16. BIA News Desk. Erdoğan: Sinop nuclear plant project halted. BIA News Desk. İstanbul. June 27, 2019. Available: <http://bianet.org/english/environment/209842-erdogan-sinop-nuclear-plant-project-halted> Accessed: 4 January, 2020

17. Turkish Energy Ministry. Türkiye Elektrik Enerjisi Talep Projeksiyonu Raporu. Turkish Energy Ministry. August 21, 2019. (Turkish)
Available: <https://www.enerji.gov.tr/File/?path=ROOT%2F1%2FDocuments%2FE%2C4%B0GM%20Ana%20Rapor%2FT%2C3%B0Crkiye%20Elektrik%20Enerjisi%20Talep%20Projeksiyonu%20Raporu.pdf>
Accessed: 12 January, 2020
18. Turkish Electricity Transmission Corporation. 2018 Yılı Türkiye Elektrik İletimi Sektör Raporu. Strateji Ve İş Geliştirme Müdürlüğü; May 2019. (Turkish)
Available: <https://webapi.teias.gov.tr/file/44a7faa7-4224-4d1c-903d-8d06ca0c11d3?download>
Accessed: 17 January, 2020
19. Ertuğrul HM. Türkiye’de Elektrik Tüketimi Büyüme İlişkisi: Dinamik Analiz. Enerji, Piyasa ve Düzenleme. 2011;2:49-73. (Turkish)
20. Haberturk. Elektrik kesintisi Türkiye’de üretimi felç etti. February 4, 2015. (Turkish)
Available: <http://www.haberturk.com/ekonomi/ekonomi/haber/1061040-elektrik-kesintisi-turkiyede-uretimi-felc-etti>
Accessed: October 21, 2019
21. Cem IA. Nuclear energy debate in Turkey: Stakeholders, policy alternatives, and governance issues. Energy Policy. 2019;136(2020).
Available: <https://doi.org/10.1016/j.enpol.2019.111041>
22. Turkish Ministry of Trade. Yıllara Göre Dış Ticaret. Turkish Ministry of Trade. July 11, 2019. (Turkish)
Available: <http://risk.gtb.gov.tr/data/572b3a8a1a79f50cd8a22b1a/1-Yillara%20Gore%20Dis%20Ticaret.pdf>
Accessed: 16 October, 2019
23. ENS: European Nuclear Society. Fuel Comparisons; 2018.
Available: <https://www.euronuclear.org/info/encyclopedia/f/fuelcomparison.htm>
Accessed: 2 November, 2019
24. ET Market News. Oil prices settle after turbulent week as Saudi Arabia reassures on output. ET Market News. September 19, 2019.
Available: <https://economictimes.indiatimes.com/markets/commodities/news/oil-prices-settle-after-turbulent-week-as-saudi-arabia-reassures-on-output/articleshow/71194195.cms>
Accessed: November 23
25. World Nuclear Association. Comparison of lifecycle greenhouse gas emissions of various electricity generation sources. Available: http://www.world-nuclear.org/uploadedFiles/org/WNA/Publications/Working_Group_Reports/comparison_of_lifecycle.pdf
Accessed: 24 September, 2019
26. Yergin D. The Quest: Energy, security and the remaking of the modern world. New York: Penguin Books; 2012.
27. İmer S, Dalbudak A. Türkiye’de Nükleer Güç Santrali Kurulması ve Dış Politikaya Etkileri. Akademik Bakış. 2012;5(10):158-170. (Turkish)
28. Annika H. Germany's energy transition: Making it deliver. European Policy Centre. 9 October, 2017.
Available: http://aei.pitt.edu/91830/1/pub_7997_germanyenergytransition.pdf
Accessed: 5 February, 2020
29. Renewables 2019 Global Status Report. Available: https://www.ren21.net/wp-content/uploads/2019/05/gsr_2019_full_report_en.pdf
Accessed: 5 February, 2020
30. Ertör-Akyazı P, Adaman F, Özkaynak B, Zenginobuz Ü. Citizens' Preferences on nuclear and renewable energy sources: Evidence from Turkey. Energy Policy. 2012;47:309-320.
31. Ercan E, Schneider H. Turkish nuclear legislation: Developments for a nuclear newcomer. Nuclear Law Bulletin. 2013;92(2).
32. The general directorate of state hydraulic works. Available: <http://www.dsi.gov.tr/dsi-resmi-istatistikler>
Accessed: April 6, 2019

© 2020 Altundeğer; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
<http://www.sdiarticle4.com/review-history/54625>