The Prospective Position of Nuclear Power in Turkish Energy Policy

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Abstract *Energy security is one of the key challenges confronting the nations all around the globe. Diversification of imports in terms of sources, route, resources and technologies has been an important policy tool to advance energy security further. Geographically located in close proximity to fossil fuel rich regions, Turkey has connected itself to producer countries via several pipelines with the aim of becoming a transit hub. At the same time, however, Turkey became increasingly dependent to foreign imports, reaching 70 per cent. As a result, Turkey moved towards nuclear energy and signed a deal with Russia to build its first nuclear power plant. The recent global advances in nuclear power generation enhanced the importance of nuclear power in bridging the energy gap in Turkey. Nuclear energy is currently enjoying enormous interest internationally, and particularly in Turkey, due to a combination of factors such as increasing fuel prices, diminishing resources of the fossil fuels, and environmental problems. On the other hand, by signing a deal with Russia, which already provides a significant amount of Turkey's imported energy, creates dangers of over-dependence on its neighbor. Moreover, there is a greater awareness of safety problems related to nuclear power plants after the recent incident in Japan, together with environmental concerns related to nuclear waste management, potentially threatening human security. Therefore, this article analyses Turkey's nuclear energy interests and discusses in detail the advantages and disadvantages of enhancing the role of nuclear power for Turkey's energy needs.*

Keywords: *Nuclear Power, Energy Policy, Turkey*

Introduction

Turkey is a rapidly developing country and currently the world's 16th biggest economy, with its $735 billion GDP level (World Bank 2012). However, Turkey's energy consumption is actually low compared to the size of its young and ever more urbanizing population. In addition, its energy use per capita is 1.44 ton of oil equivalent (toe), which is also low compared to other G-20 countries, such as US with 7.23 toe, Japan with 3.88 toe, Germany with 4.05 toe, Saudi Arabia with 5.88 toe , and Argentina with 1.88 toe, as shown in figure 1. Turkey's energy use per capita is only higher than Brazil with 1.24 toe, Indonesia with 0.85 toe and India with 0,58 toe.

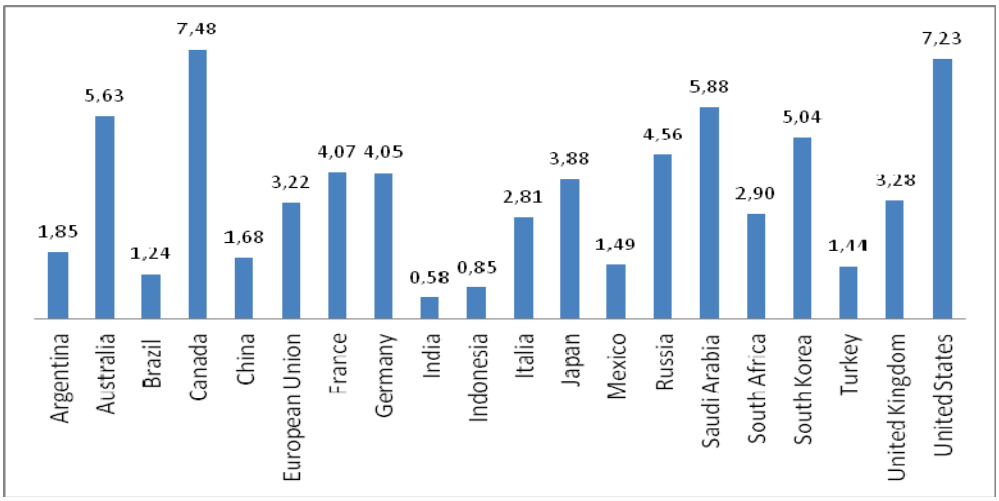

Figure 1. Energy use per capita in G-20 countries
Source: World Bank Statistics (2012a)

Turkey's low energy consumption and rapid economic growth have a positive correlation. This means that in the short to mid-term, Turkish energy demands will increase in accordance with its rapid economic growth.

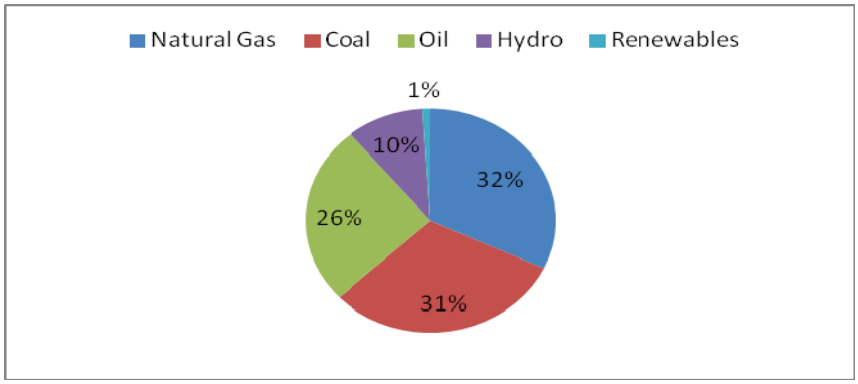

Figure 2. Turkey's Gross Final Energy Consumption by Fuel Type (2010)
Source: Turkish Ministry of Energy and Natural resources (2012), BP Statistical Review of World Energy (2011)

Turkey's energy profile is mainly composed of fossil fuels, namely oil, natural gas and coal, with a share of 89 per cent in overall gross final inland energy consumption (TMENR 2011), displayed in figure 2. Even though the level of investment in renewable energy sector has been increasing rapidly in the last decade, and as a result the installed capacity of renewables has increased, however, the share of fossil fuels in overall energy consumption has not decreased with the increasing levels of energy consumption experienced due to its rapid economic growth.

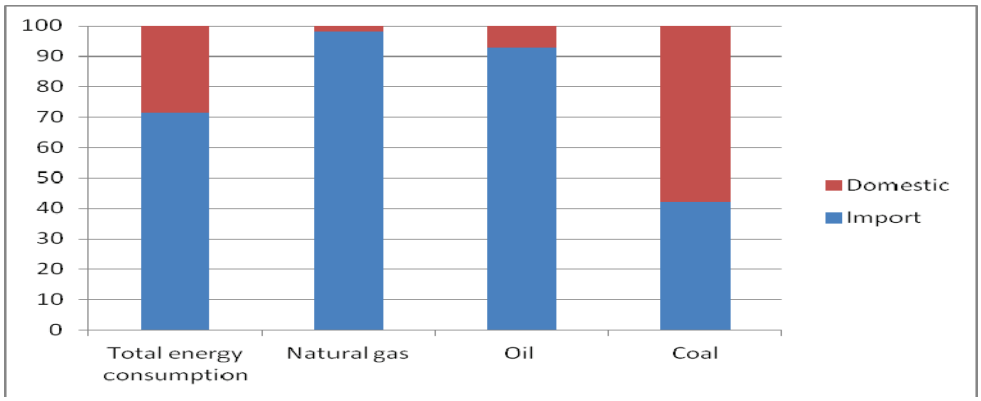

Figure 3. Energy Import dependency rates by fuel type (2010)
Source: Turkish Ministry of Energy and Natural Resources (2012), BP Statistical Review of World Energy (2011)

In parallel with Turkey's increasing energy consumption, Turkey's import dependency on energy resources has been increasing due to limited levels of fossil fuel reserves. According to the Ministry of Energy and Natural Resources, Turkey imports almost 72 per cent of its energy needs from other sources. Turkey imports 98 per cent of its natural gas, 93 per cent of oil and 42 per cent of its coal consumption, as shown in figure 3.

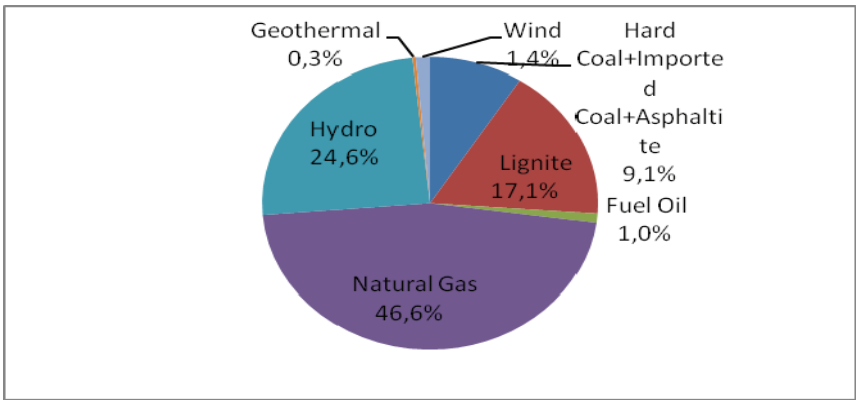

Figure 4. Turkey's Electricity Generation by Fuel Type (2010)
Source: Turkish Electricity Transmission Company (2010)

This profile is even more dramatic in regard to electricity generation by fuel type in Turkey. According to the Turkish Electricity Transmission Company, natural gas has a share of almost 47 per cent in Turkish electricity generation. Together with the imported coal, more than 55 per cent of Turkish electricity generation is based on imported resources. This profile demonstrates a cause for concern both for its economy and energy security.
Accordingly, energy security remains a priority. Therefore, the securities of supply and diversification in terms of energy security have become primary objectives in Turkish energy policy. However, Turkey's key problem is its increasing dependence on energy imports as mentioned.

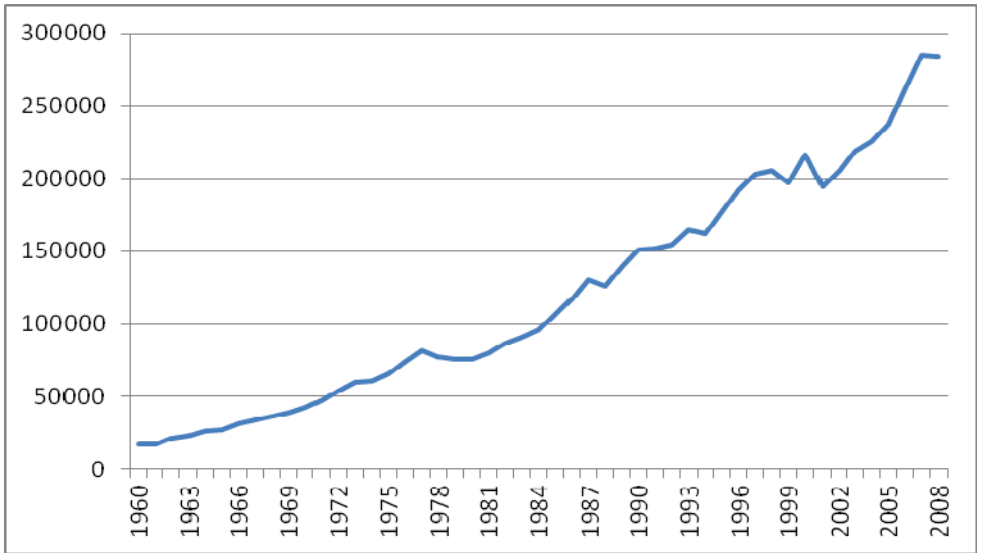

Figure 5. Turkey's CO2 Emissions (kt)
Source: World Bank Statistics (2012b)

In addition, Turkey suffers from increasing carbon emission levels. These have tripled in the last 25 years due to rapid urbanization, mass fossil fuel use and economic growth as demonstrated in figure 5.
Due to increasing energy dependency and carbon emission levels, this study assumes that the inclusion of nuclear power in the Turkish energy profile will have a positive impact over its increasing energy imports and carbon emission levels. Therefore, this article seeks to analyze the impact of the inclusion of nuclear power in the Turkish energy profile.

Security of Supply and Diversification

Security of energy supply has become a priority for energy dependent countries, especially with the increasing energy demand from developing countries such as China and India. Since energy is the one of major input for economic development, the possibility of disruption to energy supply would seriously threaten these economies. In general, security of supply is "a flow of energy supply to meet demand in a manner and at a price level that does not disrupt the course of economy in an environmental sustainable manner."(Chevalier 2006). In other words, security of supply is "the idea of the level of fairly stable prices that customers might be willing and able to pay and this price will have to adjust economic fundamentals including environmental and other reasons". (Helm 2002)
However, the concerns over security of energy supply have been raised due to increasing energy dependency of the economies throughout the world, such as the EU, the US and China. Energy dependency means the degree of imports to meet the energy needs of an economy. It is determined by dividing the share of imports in an economy's gross final energy consumption. As discussed by Cameron & Kempler (2010), in an ideal world, security of supply should not be equated with energy independence since the free and global energy market should guarantee to deliver all the necessary energy resources in a timely manner. However, the geopolitical aims of the energy producer countries undermine this ideal, because energy becomes a tool in foreign policy making.
Since energy independence is impossible for majority of the countries, the main option could be to increase the diversification in the energy supply. Diversification is currently one of the most commonly discussed fundamental issues as regards the energy security concept, and the present work will take the 'diversification' issue as an initial point. As argued, Turkey is challenged by increasing import dependency.

The most effective way to secure the supply in the face of this increasing trend is to diversify energy supplies. Diversification means that while "holding other things constant, the overall risk to energy supplies is smaller if there is a diversified portfolio of suppliers".(Cohen et al. 2011) This means that by diversifying, the states could reduce the risk of supply disruption from particular groups of suppliers. The main of diversification is to decrease the risks of monopolistic approach from one supplier or dependence to one single resource. (Blyth and Lefevre 2004). Accordingly, this paper examines whether the inclusion of nuclear power will serve the Turkish aim of securing supply and increasing the level of diversification.

Nuclear Power in the World

Nuclear power currently has a share of 5.4 per cent in world's gross final energy consumption (BP 2011). However, the share of nuclear power in global electricity generation is much greater than this, at 13.6 per cent, as shown in figure 6.

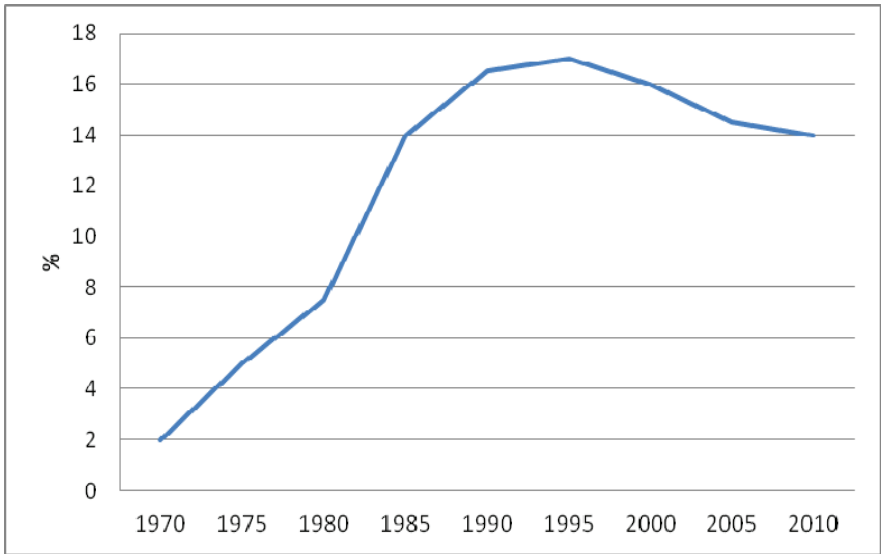

Figure 6. The Share of Nuclear Power in Global Electricity Generation
Source: World Nuclear Association

Currently, there are 435 operable nuclear reactors in 30 countries, with a capacity of 372,158 Mwe electricity, as shown in Table 1. Moreover, there are 250 nuclear reactors for research in 56 countries and 180 nuclear reactors for powering ships and submarines (WNA 2012).

Table 1. World Nuclear Power Reactors

	Nuclear Electricity Generation 2010		Reactors Operable March 2012		Reactors Under Construction March 2012		Reactors Planned March 2012	
Country	BkWh	e%	No	Mwe net	No.	Mwe Gross	No	Mwe Gross
Argentina	6.7	5,9	2	935	1	745	2	773
Armenia	2.3	39,4	1	376	0	0	1	1060
Bangladesh	0	0	0	0	0	0	2	2000
Belarus	0	0	0	0	0	0	2	2000
Belgium	45.7	51,2	7	5943	0	0	0	0
Brazil	13.9	3,1	2	1901	1	1405	0	0
Bulgaria	14.2	33,1	2	1906	0	0	2	1900
Canada	85.5	15,1	17	12044	3	2190	3	3300
China	71	1,8	15	11881	26	27640	51	57480
Czech Republic	26.4	33,2	6	3764	0	0	2	2400
Egypt	0	0	0	0	0	0	1	1000
Finland	21.9	28,4	4	2741	1	1700	0	0

France	410.1	74,1	58	63130	1	1720	1	1720
Germany	133	28,4	9	1200	0	0	0	0
Hungary	14.7	42,1	4	1880	0	0	0	0
India	20.5	2,9	20	4385	7	5300	16	14300
Indonesia	0	0	0	0	0	0	2	2000
Iran	0	0	1	915	0	0	2	2000
Japan	280.3	29,2	51	44642	2	2756	10	13772
Jordan	0	0	0	0	0	0	1	1000
Kazakhstan	0	0	0	0	0	0	2	600
South Korea	141.9	32,2	23	20787	3	3800	6	8400
Lithuania	0	0	0	0	0	0	1	1350
Mexico	5.6	3,6	2	1600	0	0	0	0
Netherlands	3.75	3,4	1	485	0	0	0	0
Pakistan	2.6	2,6	3	725	1	340	1	340
Poland	0	0	0	0	0	0	6	6000
Romania	10.7	19,5	2	1310	0	0	2	1310
Russia	159.4	17,1	33	24164	10	9160	17	200000
Slovakia	13.5	51,8	4	1816	2	880	0	0
Slovenia	5.4	37,3	1	696	0	0	0	0
South Africa	12.9	5,2	2	1800	0	0	0	0
Spain	59.3	20,1	8	7448	0	0	0	0
Sweden	55.7	38,1	10	9399	0	0	0	0
Switzerland	25.3	38	5	3252	0	0	0	0
Turkey	0	0	0	0	0	0	4	4800
Ukraine	83.95	48,1	15	13168	0	0	2	1900
UAE	0	0	0	0	0	0	4	5600
UK	56.9	15,7	17	10528	0	0	4	6680
USA	807.1	19,6	104	101607	1	1218	11	13260
Vietnam	0	0	0	0	0	0	4	4000
World	**2630**	**13,8**	**435**	**372158**	**61**	**61554**	**162**	**180945**

Source: World Nuclear Association (2012)

As shown in Table 1, there are more than 100 nuclear power plants situated in the US, and more than 200 in Europe. According to World Nuclear Association (2012), there are 61 nuclear power plants under construction, representing 16.5 per cent of the current installed capacity, and 162 nuclear power plants projected, representing to 48.5 per cent of current installed capacity.

Energy Technology	**t CO2eq/GWh**
Lignite	1062-1372
Coal	757-1085
Oil	657-866
Natural Gas	398-499
Solar PV	13-104
Hydroelectric	4-120
Biomass	15-49
Wind	7-15
Nuclear	3-20

Source: World Energy Council (2004)

As displayed in table 1, the world's leading energy consumer countries, such as US, Germany, France, Canada, Japan and Sweden, are all using nuclear power to diversify their energy supply and enhance their level of energy security. The primary contribution of nuclear power to energy security is to decrease the energy import dependency, as discussed. In

addition, nuclear power is an environment-friendly source, as it generates a much lower level of carbon emissions compared to other sources, shown in table 2.
Therefore, implementing or increasing the share of nuclear power will both contribute to energy security and lowering the carbon emission levels of any country. The main drawback of this source of power is the problems of waste management and possible accidents as these could have an enormous hazardous impact on the environment. However, to date only 3 major accidents have occurred, namely Three Mile Island (1979), Chernobyl (1986) (IAEA 2007) and Fukushima (2011) (IAEA 2012). However, in spite of the small number, their impact was enormous.

History of Nuclear Power in Turkey

The first discussion on implementing nuclear power in Turkey took place in 1955 and as a result Turkey signed the Atoms for Peace agreement. The first Nuclear Research Center was established in Istanbul Technical University in 1956, and in parallel, Turkish Atomic Energy Authority (TAEK) was also established in the same year. The main objectives of TAEK are to conduct academic research on nuclear energy, and implement and develop non-military nuclear technologies (TAEK 2012).

Table 3. The Development of Nuclear Research Reactors

Time Period	Reactor Type
1962-1977	1 MWth TR1
1979-1982	250 KWth Triga Mark II
1982-	5 MWth TR2

Source: Turkish Atomic Energy Agency (2012)

Three nuclear research reactors have been established in Turkey, starting from 1962, as shown in table 3. These were mainly used to produce isotopes and do experiments, especially for the health sector.
The first attempt to build nuclear power plant in Turkey was in 1965. The first plan was to build a Pressurized Heavy Water Reactor (PHWR) with 400 Mwe capacity (AEK 1965). However, this was never realized due to the political and economic problems that emerged in Turkey in early 1970s. The second attempt was first planned in 1972, when Akkuyu, Mersin was licensed for nuclear power plant in 1976. The plan was to build a boiling water reactor (BWR), but this project was similarly abandoned due to lack of finance for the proposed company (Adalioglu et al. 1978). In 1980s, there were other attempts to build nuclear power plants not only in Akkuyu [PHWR and Pressurized Water Reactor (PWR)], Mersin but also in Sinop (BWR). However, none of these were ever realized because of various regulative, economic and political problems. The most recent attempt was in 1997 when the Turkish government invited bids to build a nuclear power plants. However, this project too remained unrealized due to the same obstacles that existed throughout the decades.

Current Situation of Nuclear Power in Turkey

According to the Turkish Electricity Tranmission Company's (TEIAS) expectations (2009), Turkey's electricity consumption will increase to 370000 GWh in 2019 in a high case scenario, from 200000 Gwh in 2008. Moreover, it is expected that yearly electricity growth rate will be 6.5 per cent until 2020. As mentioned, Turkey has a high level of dependency on imported resources for electricity generation. Therefore, the prospective gap will need to be generated from imported resources, and Turkey's dependency will be even higher than current levels. This could be the single largest threat for the Turkish economy.
Therefore, the Turkish government decided to develop its stagnated nuclear power program in 2006, and invited bids to build a nuclear power plant in Akkuyu, Mersin. However, only one company responded. Accordingly, Turkey shifted its open call process, and started bilateral discussions with Russia on building a nuclear power plant and granted the right to the Russian public Rosatom Company to build nuclear power plant without needing to bid. Turkey and Russia signed an agreement to cooperate on the construction and operation a nuclear power plant in Akkuyu, Mersin on 12 May 2010.(Turkish Official Gazette 2012, No:28240) The Akkuyu Project Company (APC) was established in Ankara by the Russian partner on 13 December 2010. APC has started to investigate the site with the approval of TAEK. (TAEK 2011) The construction is expected to begin in 2013 and to be operable in 2019.

This nuclear power plant will be built, financed, owned and run by a Russian company. The Turkish government has guaranteed to buy 50 per cent of generated electricity for 15 years through Turkish Electricity Trade and Contracting Corporation (TETAS). After the termination of the, Turkish side will receive 20 per cent of the profits from APC for the remaining 45 years. (Turkish Official Gazette 2010, No:27721) Four power reactors which will each have 1200 MWe capacity, with a total of 4800 Mwe, will be built in Akkuyu, Mersin. These reactors will be third generation Russian VVER-1200. (TMENR 2012) However, there has been criticism over the decision to use these reactors, since there are no operating examples in the world. There are currently two nuclear power plants of this type, Leningrad II and Novovoronezh II under construction in Russia. (WNA 2012) However, VVER 1000, the second generation, has been operating in Finland, China, India and Bulgaria. (WNA 2012) It is expected that this power plant will supply 6 per cent of Turkey's electricity demand. (TMNER 2012)

Conclusion

As discussed, the main reasons of installing nuclear power are concerned with energy security and environmental protection. There are advantages and disadvantages, including nuclear power in Turkish energy profile. Nuclear power is not a non-renewable energy source,, but a sustainable one. It is highly reliable and produces large concentrations of energy with no CO^2 emissions. Moreover, it uses a small amount of raw material, uranium, to produce a unit of energy. Also, compared to its production level, it produces small amounts of waste. However, there are also significant disadvantages related to nuclear power. It is highly radioactive, which can threaten human health if not operated securely; accordingly the installation of a plant is potentially dangerous to the surrounding area. Also, there are high waste disposal costs in addition to its major building costs. In Turkish case, these duties belong to the Russian side. Therefore, this study argues that if it is operated securely, it will be a valuable addition to Turkish energy profile.

However, one important factor is that the projected power plant will be built, owned and operated by Russian Rosatom, as mentioned rather than Turkish government. Therefore, this could jeopardize the main aim of decreasing its energy dependence as currently Turkey is already highly dependent on Russia for its oil and natural gas imports. In addition, it should be noted that Turkey will not benefit from the transfer of any know-how or technology.

Overall, nuclear power will be a valuable addition to Turkish energy profile since it will contribute to its aim of increasing its level of energy security by decreasing it energy import dependency. Moreover, it will contribute to Turkey's secondary aim of decreasing its carbon emission levels. Once built, the projected power plant will generate almost 6 per cent of Turkish electricity production. However, the lack of control of the projected power plant could jeopardize Turkish energy security. Nevertheless, it will contribute to the diversification of energy resource, but not the source, Russia, which Turkey is already highly dependent on for its oil and natural gas exports. This study argues that with the right conditions, such as high-quality waste management and operation, nuclear power is a valuable addition to any country's energy profile, and Turkey is no exception.

References

AEK (1965). *Atom Enerjisi Komisyonu ikinci beş yıllık plan ilkeleri*, AEK Seri: D-3, Mart 1965, Ankara.

BP, 2011, BP statistical Review of World Energy, British Petroleum, London.

D. Helm (2002). *Energy Policy: security of supply, sustainability and competition*, Energy Policy, Vol.30, Issue 3, February 2002, pp. 173-184

Gail Cohen et al., (2011). *Measuring Energy Security: Trends in the Diversification of Oil and Natural Gas Supplies*, IMF Working paper, February 2011.

IAEA (2007). IAEA Safety Glossary, *Terminology Used in Nuclear Safety and Radiation Protection (2007 Edition)*, International Atomic Energy Agency, Vienna

IAEA (2012). Fukushima Nuclear Accident Update Log, retrieved from http://www.iaea.org/newscenter/news/tsunamiupdate01.html

J.M. Chevalier (2006). *Security of energy supply for the European Union*, European Review of Energy Markets, Vol.1, Issue 3, November 2006.

R. Cameron and J.H. Keppler (2010). *Security of Energy Supply and the contribution of nuclear energy*, Facts and Opinions, NEA News 2010, No:28.2

TAEK (2011). Akkuyu Nuclear Power Plant, retrieved from http://www.taek.gov.tr/eng/services/206-akkuyu-nuclear-power-plant/789-akkuyu-nuclear-power-plant.html

TAEK (2012). Tarihçe, retrieved from http://www.taek.gov.tr/hakkimizda/tarihce.html

TEIAS (2009), Türkiye Elektrik Enerjisi 10 Yıllık Üretim Kapasite Projeksiyonu (2010-2019), retrieved from http://www.teias.gov.tr/projeksiyon/KAPASITEPROJEKSIYONU2009.pdf

TEIAS (2010). Türkiye Elektrik Üretim-İletim İstatikleri, retrieved from http://www.teias.gov.tr/istatistik2010/%C4%B0statistik%202010.htm

TMENR (2012). 2009 Yılı Genel Enerji Dengesi (Bin Tep) http://www.enerji.gov.tr/index.php?dil=tr&sf=webpages&b=y_istatistik&bn=244&hn=244&id=398

TMENR (2012). Nükleer Santraller ve Ülkemizde Kurulacak Nükleer Santrale İlişkin Bilgiler, retrieved from http://www.enerji.gov.tr/yayinlar_raporlar/Nukleer_Santraller_ve_Ulkemizde_Kurulacak_Nukleer_Santrale_Iliskin_Bilgiler.pdf

Turkish Official Gazzette (2010). Türkiye Cumhuriyeti Hükümeti ile Rusya Fedarasyonu Hükümeti Arasında Türkiye Cumhuriyetinde Akkuyu Sahası'nda Bir Nükleer Güç Santralinin Tesisine ve İşletimine Dair İşbirliğine İlişkin Antlaşma, retrieved from http://www.resmigazete.gov.tr/main.aspx?home=http://www.resmigazete.gov.tr/eskiler/2010/10/20101006.htm&main=http://www.resmigazete.gov.tr/eskiler/2010/10/20101006.htm

Turkish Official Gazzette (2012). Akkuyu Nükleer Güç Santrali Projesi, No:28240, retrieved from http://www.resmigazete.gov.tr/eskiler/2012/03/20120321-11.htm

U. Adalıoğlu et al. (1978). *AEK IV. ve V. plân dönemleri nükleer enerji üretimi makroplan taslağı*, ÇNAEM Rapor No. 191

WEC (2004). *Comparison of energy system using life cycle assessment – special report*. World Energy Council, July, London.

William Blyth and Nicolas Lefevre (2004). *Energy Security and Climate Change Policy Interactions: An Assestment Framework,* IEA Working Paper, December 2004, cited in Gail Cohen et al., *Measuring Energy Security: Trends in the Diversification of Oil and Natural Gas Supplies*, IMF Working paper, February 2011.

WNA (2012). World Nuclear Power Reactors and Uranium Requirements, retrieved from http://www.world-nuclear.org/info/reactors.html

World Bank Statistics (2012a), Data on Energy Use (kt of oil equivalent), retrieved from http://data.worldbank.org/indicator/EG.USE.COMM.KT.OE/countries

World Bank Statistics (2012b), Data on CO2 Emissions (kt), retrieved from http://data.worldbank.org/indicator/EN.ATM.CO2E.KT