



Energy security and nuclear power in Turkey for sustainable development

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Abstract

Climate change and energy security is one of the most important issues facing the world today. Nuclear power can make an important contribution to reducing greenhouse gas emissions while delivering energy in the increasingly large quantities needed for global socioeconomic development. Nuclear power plants produce virtually no greenhouse gas emissions or air pollutants during their operation and only very low emissions over their entire life cycle. Turkey, with an increasing demand and consumption for electricity, is in need of finding a sustainable source for electricity production. The country has a huge current account deficit most of which results from its energy imports. Plans for nuclear power construction are a key aspect of the country's aim for sustainable economic growth. In Turkey building up a nuclear power plant has always been a hot topic for discussion at least for 40 years. Turkish government unfortunately, until the year 2013 had never achieved to finalize nuclear power plant projects due to economic reasons. In this paper we will examine the pros and cons of having nuclear power plants in Turkey mostly in terms of economic aspects considering economic and social costs as well as economic gains. In addition we will look at Turkey's nuclear energy policies. We will also mention about environmental effects debates of the nuclear power plant in the country.

Keywords: Nuclear energy; energy security; benefits nuclear power in Turkey

1. Introduction

During the years 2001 to 2010 economic growth averaged 1.3 % in the EU-27 and reached 1.1 % in the Euro-Zone, whereas Turkey recorded an average economic growth of 4 % [1] in the same period, which was associated with an increase in the demand for electricity [2]. In the 1980s and 1990s, the energy-mix was depending mainly on thermal generation, but has undergone with the increase in hydro generation by the Southeastern Anatolia Project a steady development and significant increase in capacity [3]. Nevertheless, Turkey's energy sector remained dependent on imports, since over 70 % of domestic energy consumption had to be imported in 2010 [4]. Turkey had intended the use of nuclear energy for quite some time, but has undertaken consistent steps only since 2004 [5]. Finally, after the determined and ambitious actions by the government, the likelihood further substantiated in 2012 that Turkey will have its first nuclear power plant in the near future [6]. Status and prospects in the areas of energy economics and energy legislation as well as in

nuclear and radiation protection regulation including safety requirements for commercial nuclear power plants justify this assessment [7]. However, there is still a consolidation of the nuclear legislative and regulation system needed [8].

Energy is indispensable for development [9]. Enormous increases in energy supply are required to lift 2.4 billion people out of energy poverty [10]. Without a paradigm shift in the global approach to energy, however, GHG emissions will increase even further. Meeting the soaring global energy demand will require primary energy of the order of 16 Million tons of oil equivalent (Mtoe) in 2035 as shown in Table 1 [6]. In the absence of sweeping policy interventions, this would lead to an increase in energy related CO₂ emissions of 40% in 2030 and of 100% in 2050 relative to 2007. The double challenge over the next 10–20 years will be to keep promoting economic development by providing safe, reliable and affordable energy while significantly reducing

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GHG emissions [6-10].

Table 1. World primary energy demand by fuel (Mtoe)

	2013	2020	2035
Coal	3 973	3 966	3 934
Oil	4 235	4 346	4 662
Gas	2 880	3 132	3 748
Nuclear	646	968	1 273
Hydropower	320	376	476
Biomass and waste	1 366	1 501	1 957
Other renewables	159	268	699
Total	13 579	14 556	16 748

Nuclear power belongs to the range of energy sources and technologies available today could help meet the climate–energy challenge [11, 12]. GHG emissions from nuclear power plants (NPPs) are negligible and nuclear power, together with hydropower and wind based electricity, is among the lowest CO₂ emitters when emissions over the entire life cycle are considered [13]. In the electricity sector, nuclear power has been assessed as having the largest potential (1.88 Gt CO₂-equivalent) to mitigate GHG emissions at the lowest cost: 50% of the potential at negative costs due to co-benefits from reduced air pollution, the other 50% at less than \$20/t CO₂-eq [14]. Nuclear energy could account for about 15% of the total GHG reduction in power generation in 2050 [11-15].

Nuclear energy can contribute to resolving other energy supply concerns, and it has non-climatic environmental benefits [16]. Significant increases in fossil fuel prices in recent years, fears of their sustained high levels in the future and concerns about the reliability of supply sources in politically unstable regions are fundamental considerations in present day energy strategies. Nuclear power can help alleviate these concerns because ample uranium resources are available from reliable sources spread all over the world and the cost of uranium is only a small fraction of the total cost of nuclear electricity [17]. Nuclear power can also help reduce local and regional air pollution. Among the power generation technologies, it has one of the lowest external costs — costs in terms of damage to human health and the environment which are not accounted for in the price

of electricity [15-22].

With the continuous increase in Turkey's demand for energy, initiatives to build a nuclear power plant were given a new boost in the past decade. Following the failure of a new tender process in 2008 the investment model was changed to a Build Own Operate (BOO) scheme [9]. An agreement was reached with Russia in 2010 and the “Agreement between the Governments of the Republic of Turkey and of the Russian Federation for Cooperation on the Establishment and Operation of a Nuclear Power Plant at Akkuyu in the Republic of Turkey”, signed in May 2010, was ratified by the Parliaments of both countries [11]. The nuclear power plant consisting of four reactors with a total capacity of 4800 MWe will be built at Akkuyu. In accordance with the agreement, the technology and financing for the project will be supplied by the Russian side. In return the Turkish side gave a fixed price purchasing guarantee for a share the electricity produced by the Akkuyu plant. The plant is expected to start generating power by 2019 [10-14].

These concrete steps towards a transition to nuclear power brings underlines the need for reviewing the country's nuclear policies. This study does not aim to support or oppose nuclear energy. As a matter of fact, there are differences of opinion among the authors contributing to this study about the expediency of nuclear energy for Turkey. This study focuses on the principal aspects of nuclear power for energy security and sustainable development in Turkey.

2. Nuclear power for sustainable electricity generation

2.1. Introduction

Since the second half of the 20th century, providing energy from reliable sources has become the most important issue of energy world [16]. Especially, the emerging oil crisis occurred in the beginning of 1970s accelerated these initiatives and is coming to

the forefront of nuclear energy as a reliable source [12]. Consequently till the second half of the 1980s many nuclear reactors were installed and put into operation [13]. However by the end of 1980s demand for nuclear energy decreased and during 1990s this

demand became stable. Despite the mentioned reason for nuclear accidents Three Mile Island and Chernobyl, the main factor was the recession in the world economy and penetration of natural gas to the energy generation market. Just in being the 21st century, new energy generation projects that considered the global climate changes, have become important [17]. Within this framework together with nuclear energy, renewable energy sources have become important and the starting of generating of energy efficiently from these sources has been initiated. However, due to the dependency of renewables on meteorological conditions, the energy generation could not be provided efficiently from these sources. At this point, nuclear energy maintains its importance as a sustainable energy providing energy in 7 days and 24 hours [12-17].

In the world, Turkey has been the second largest economy after China for having the highest rate of increase in electricity demand (6-7% increase rate annually) and the country should add nuclear energy to its energy mix. Our policies and strategies are formed via taking our country's realities into consideration [12]. Turkish government's basic policies can be summarized as the following [10-14]:

- Making the energy accessible for the consumers in terms of cost, time and quantity,
- Decreasing the import dependency,

- Providing diversification of source, route and technology,
- Providing the maximum use of domestic sources,
- Increasing the energy efficiency,.

As a consequence of high economic development and increasing wealth, it is observed that Turkey's demand in all fields of energy sector increases rapidly [10]. The share of renewable energy sources for electricity generation will be at least 30% by 2030 [18]. On the other hand, nuclear energy has great importance for Turkey in terms of reducing the dependency on imported energy sources and its relevant share on the current account deficit of Turkey whereas import of primary energy sources amounts to approximately 10% of current account deficit of Turkey [18-22].

2.2. Nuclear energy for electricity generation

Electricity demand in the world is projected to increase by 1,2% per year on average and 35% in total between 2013 and 2035 [4]. Turkey's electricity generation demand is projected to increase by 5,4% per year on average and double in total between 2015 and 2035 according to the three projections as shown in Figure 1 [3]. In this situation, it is necessary to supply this electricity demand in the following years, Turkey needs to increase the electrical power generation capacity by adding different energy sources for electricity mix [4, 7, 8, 10].

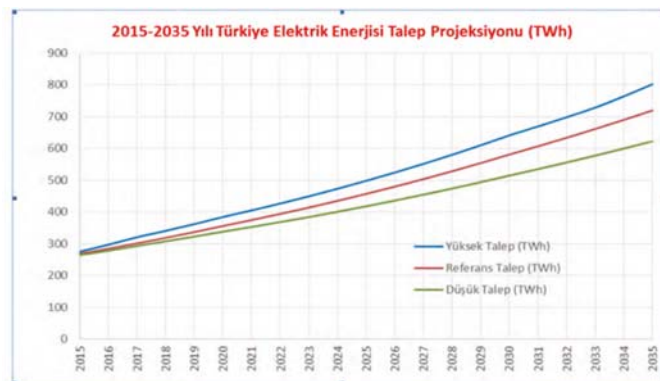


Figure 1. Turkey's electricity demand projections.

These sources should be ready available to use continuously eco-friendly and cheap not depending on meteorological and environmental conditions and be reliable for efficient electricity generation. Nuclear energy fulfills all of these requirements and has a vital role for gaining reliable and sustainable electricity. The other reasons why nuclear energy is preferred world-wide and in our country for electricity generation are following [4, 7, 10, 11, 13]:

- The continuous availability of nuclear power plant (NPP) is considered one of the primary benefits. Otherwise, the generated electricity depends on the right meteorological conditions in renewable energy sources power plants and the quality and composition of coal in coal fired plants and the quantity of reserves in fuel and natural gas power plants. Nuclear power plants do not require

specific locations in order to generate large amounts of power.

- While considering nuclear fuel cycle, NPPs is the eco-friendly option for greenhouse gas emissions to the environment (see Figure 2 and 3). There are no released gases while NPP operated just as in released by combustion of fossil fuels like CO, CO₂, SO₂ and NO_x gases. Nuclear energy stations do not emit criteria pollutants or greenhouse gases when they generate electricity. Because of this, nuclear energy has an inevitable role in reducing the greenhouse gas emissions caused to the climate change. Nowadays, the emitted greenhouse gases amount is reduced approximately by 17 % annually due to the electricity generated in NPPs. If the fossil fuel power plants are used instead of NPPs, the emitted carbon gas amount would be 1.2 billion tons.
- However, by providing electricity generated in NPPs it is prevented that 2.3 billion tons of CO₂, 42 million tons of SO₂, 9 million tons of NO_x gases and 210 million tons of ashes do not emitted. In such a case, if nuclear power plants preferred to fossil fuel power plants in generating of electricity the amount of carbon dioxide emission is reduced and in the long term the best solution for the global warming.
- The amount of energy produced from 1 kilogram uranium with fission is equivalent to energy generated by burning 3000 tons of lignite (according to calorific values) or 2 million cubic meters of fuel. Due to the reason of generating of high amount of electricity from less amount of uranium means at the same time the lesser waste produced from NPPs than its in the fossil

fuel power plants. For example, being the nuclear energy share in electricity consumption so high (75 %) for France where a family composed four persons produced a nuclear waste a golf ball in size for whole life. The waste is dispersed or buried at concentrations considered not harmful. While the resulting impact can be small, the cumulative waste over many years from a large number of waste producing activities can easily overburden the natural environment, locally as well as globally. As nuclear fuel is deposited properly at the plant site, the energy is produced in a reliable manner.

- It is economically feasible only when waste volumes are small and arise under easily controlled conditions. It is underlined in an example, the NPPs having a installed capacity of 1000 MW_e produces 30 tons of waste annually. But, the same sized capacity fossil fuel power plant produces 2 billion tons of petroleum waste or coal waste. This figure indicated that it means nearly 67000 times much more waste.
- The share of nuclear fuel in operating cost is around 30 % while this is 77 % for coal power plants and 90 % for natural gas power plants. Directly, the fluctuations in nuclear fuel prices is less impressed the cost of electricity production in nuclear power plants. When the fuel prices doubled, the effect of that cost increase the total operating cost in 66 % in natural gas power plant and in 31 % in thermal power plant and this makes LCOE for fossil fueled thermal power plants vulnerable to fluctuations in fuel prices and environmental emission constraints.

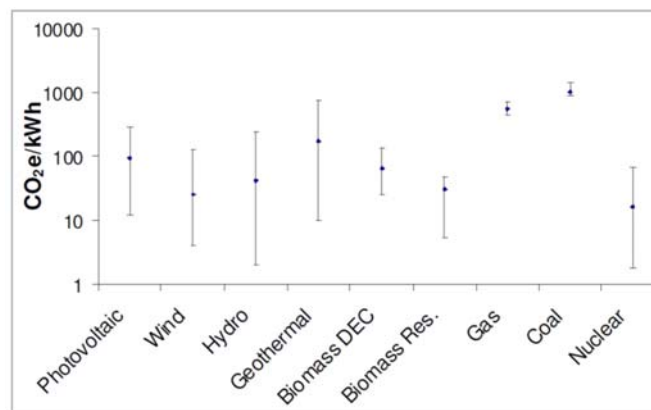


Figure 2. CO₂ emissions from electricity generation technologies (gram CO₂ / kWh electricity generated).

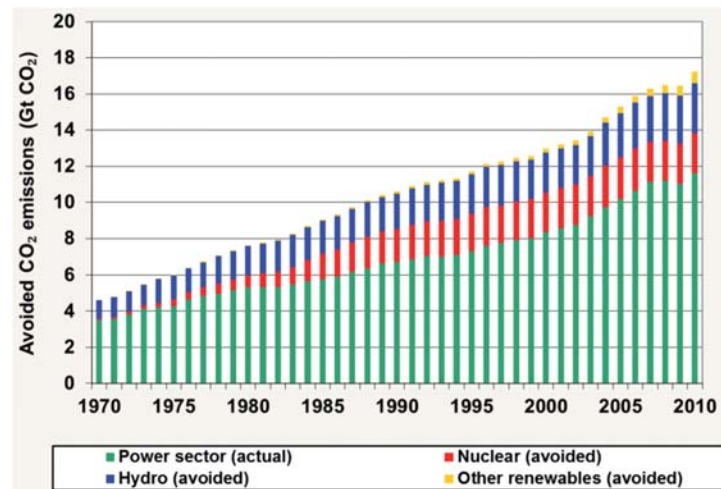


Figure 3. Global CO₂ emissions from the electricity sector and emissions avoided by using three low carbon generation technologies.

3. Process and technology

3.1. Present energy situation

Turkey has very limited reserves of natural gas, oil and coal [1]. It means that Turkey is considered energy imported country [2]. So, the MENR outlines with regard to its mission to ensure efficient, effective safe and environment-sensitive use of energy and natural resources in a way that reduces external dependency of our country, and makes the greatest contribution to our country's welfare the following general facts and expectations: Secure energy supply remains essential also for our country. In this context, significant progress has been made recently in legal and technical terms which include restructuring our energy market on a competitive transparent basis, identifying and utilizing our domestic and renewable resource potentials, making nuclear energy a part of electricity production, and making use of energy efficiency and new energy technologies. Turkey's energy policy principally aims at: Making energy available for the consumers in terms of cost, time and amount, exploiting public and private facilities within the framework of free market practices, discouraging import dependency, securing a strong position for our country in regional and global trade of energy, ensuring the availability of diversified resources, routes and technologies, ensuring maximum use of renewable resources, increasing energy efficiency, minimizing negative environmental impact while producing and using energy and natural resources [1-4].

Similarly, since 2000, our country has been the second largest economy after China for having the highest rate of increase in electricity and gas demand [1]. Projections by our Ministry show that this trend will continue in the medium run [2]. In 2013, total primary energy consumption of our country was realized as 120.3 million tons oil equivalent (Mtoe) while production was at 31.2 Mtoe as given in Table 2 [2]. Of total energy supply, natural gas comes first (32 %) which is followed up by oil (29.9 %), coal (29.5 %), and renewables including hydraulic sources (8.6 %) [2]. Based on the reference scenario, our primary energy consumption is expected to increase by 4 % annually by 2020 [4]. The latter is in harmony with the estimated rates of economic growth in Turkey of about 3 to 4 % by 2016 [1-4].

With regard to electricity and nuclear energy, the MENR declares [3]: Our electricity generation is expected by 2020 to reach 500 TWh with an annual increase of around 8 % according to the higher demand scenario, or 406 TWh with an annual increase of 6.1 % according to the lower demand scenario. In 2013, our installed power has now reached 64,126 MW after the deployment of a new power plant of 3,479 MW. In 2014, our electricity generation came from three main sources: natural gas by 47.6 %, coal by 29.3 %, hydroelectric by 18.5 %, liquid fuels by 3.1 %, and renewable resources by 1.5 % [1-4].

Table 2. Turkey's energy production and consumption in 2013 (Mtoe)

Energy source	Production	Consumption
Hard coal	990	17 692
Lignite	13 973	13 182
Oil	2 485	33 896
Natural gas	443	37 628
Hydropower	5 110	5 110
Geothermal (electric)	1 173	1 173
Geothermal (heat)	1 463	1 463
Animal & plant wastes	1 666	1 666
Wood	2 707	2 707
Wind	650	650
Solar	795	795
Total	31 944	120 290

3.2. Nuclear power in Turkey

Nuclear power has always been some part of Turkey's future plans so far in the history [7]. Current government also has been using future nuclear power projects as a strong card for the elections as well [1]. Nuclear energy in Turkey has been presented by the government as cheap, sustainable, and environmentally friendly and is seen by many as a powerful way to diversify the country's energy portfolio while at the same time reducing energy dependence. The Energy Ministry emphasizes nuclear power's relatively low cost and high sustainability as the main reasons for pursuing the project. Former energy Minister Hilmi Guler stressed that nuclear technology would be beneficial to development, would provide a threshold for attaining high-tech products, and would contribute to Turkey's prestige [1, 4, 7, 17].

For a variety of reasons, including public opposition, high capital cost and financing difficulties, and insufficient governance and management capacity on the part of the state agencies, Turkey has not been able to build its first nuclear plant yet [7]. At the same time, Turkey is closer to its first nuclear facility that the country has been pursuing since the 1970s. The official goal is 5% nuclear by 2020 [14]. Given that renewables are still costlier than conventional technologies and intermittent, and have low capacity factors, nuclear offers another option for Turkey to diversify its energy portfolio with an emissions-free technology. Perhaps, the biggest concern is the lack of an independent nuclear regulator and a safety culture in state institutions that is commensurate with the risks inherent in nuclear operations. A five-page nuclear law is not sufficient to instill confidence that Turkey is institutionally ready to build and operate a nuclear facility, and manage radioactive waste properly [11, 14].

Proponents of nuclear power have made several

arguments to support their cause. They argue that nuclear energy would not only fulfill Turkey's future energy demands and prevent a shortage, but would also facilitate rapid development in other sectors [4]. As Turkey's dependence on natural gas increased, nuclear energy proponents drew attention to the increasing demand for electricity and the growing dependence that kept energy costs high, turned the trade balance to Turkey's disadvantage, and constrained its diplomatic negotiating power [7]. They also argue that because the government has ratified the Kyoto Protocol, fossil fuels are not a good option for Turkey to address its energy needs, and that renewable resources are insufficient to make up the gap. In addition, proponents regard a nuclear energy program as a matter of prestige. Overall, they argue that nuclear energy will have beneficial economic, political, and security aspects, as well as be conducive to environmental protection and development goals [4, 7, 10, 17].

Opponents in Turkey, on the other hand, perceive nuclear power as dangerous and disadvantageous [7]. They argue that nuclear energy is costly and that nuclear energy plants threaten human life and the environment because of the risk of radioactivity related accidents, the unresolved waste disposal issue, and the threat of proliferation [17]. They do not believe that Turkey is facing a dire future energy shortage, and maintain that the contribution of nuclear power could well be substituted for by a combination of local and renewable resources and energy efficiency measures such as upgrading existing infrastructure [3]. Opponents also question the rationale of the decision to pursue nuclear energy, arguing that political concerns and bureaucratic interests might be at play instead of technical assessments of supply and demand. The opposition includes civil society organizations with an emphasis on the environment. In Table 3, it can see the details

of nuclear energy debate in Turkey [17].

Table 3. Nuclear energy debate in Turkey

Supporters	Dissenters
Nuclear energy is necessary for Turkey: it will meet future demands, decrease energy dependency, and contribute to sustainable development	Projections of a future energy shortage scenario are exaggerated. Nuclear energy is disadvantageous such the costs exceeds benefits
Nuclear energy is urgent because its absence is a threat; without it Turkey will have darkness and dependency.	Nuclear energy is a threat because of radiation accidents could have lethal impacts on humans, tourism, the environment and agriculture.
Nuclear power compares favorably to fossil fuels and renewables	Other alternatives exist: renewables such as solar, wind, hydro, biomass; the efficient use of energy.
Nuclear energy will augment Turkey's power in national security, economic, environmental and social aspects and it will increase its status and prestige.	Decision makers are irrational and immoral: nuclear power plants are dangerous, costly, and threatening: the developed world is giving up on nuclear, but Turkey is pursuing it.
Opposition is irrational, misinformed or collaborating with foreign powers to keep Turkey non-nuclear and weak.	The government is irrational and immoral: it is influenced by the nuclear lobby and pursues bureaucratic interests at the expense of its citizens.
Turkey's security is at risk: Iran's nuclear program is worrisome. The USA and the EU are not reliable. Nuclear technology will create infrastructure for a proliferation option.	Nuclear power plants are gateways to proliferation, which is a serious threat.

Turkish economy has an annual growth rate of 4-6% on the average in the long term. Therefore it has a rising demand for electricity. Turkey has been a dependent country for energy. It imports almost all of its gas and oil. In 2013, Turkey had a current account deficit of 64.9 Billion dollar. Turkey had total energy imports of 55.9 billion dollar which accounts for 22.2% of all country's imports. Therefore, either with starting up with nuclear power projects or finding new alternatives, the country should find ways to reduce energy import bills and its energy import dependent situation [15].

Turkey has had plans for establishing nuclear power generation since 1970 [1]. Today, plans for nuclear power are a key aspect of the country's aim for economic growth [3]. Application has been made for construction and operating licenses for the first plant, at Akkuyu in early 2014 [2, 8]. A renowned Czech research and development and engineering company focused on nuclear technologies has been invited to sign a contract in mid-august 2014. In 2012 Turkey's electricity production was 240 billion kWh gross from 53 GWe of plant. Of this, 105 TWh (44%) came from gas (two thirds of this from Russia, most of the rest from Iran), 68 TWh (28%) from coal, and 58 TWh (24%) from hydro. Net import was 3 TWh. Demand growth is about 8% pa, and in the first half of 2012 consumption was 119.3 billion kWh. Per capita consumption has risen from 800 kWh/yr in 1990 to about 2500 kWh/yr. Demand in 2023 is expected to be 450 billion kWh, implying new investment by then of \$100 billion. Peak demand was

40 GWe in first half of 2013 [4, 7, 17].

Plans for nuclear power are a key aspect of the country's aim for economic growth, and it aims to cut back its vulnerable reliance on Russian and Iranian gas for electricity. The Ministry of Energy and Natural Resources (ETKB) projects 2020 electricity production as possibly 499 TWh in a high scenario of 8% growth, or 406 TWh with a low one with 6.1% growth [3]. Plans are to have 30 GWe of coal-fired capacity by 2023. However, much of the country's coal resources are lignite with low calorific value – less than 12.5 MJ/kg, and a substantial amount (Afsin Ebistan) at less than 5 MJ/kg [3, 12, 22].

Today, Turkey has plans to build up two nuclear power plants. One is on the north coast of Turkey near a city named Sinop. The other one is planned to be located in the south coast of Turkey near a southern city of Akkuyu. Akkuyu nuclear project has an estimated investment cost about US\$ 20 Billion and it will have four 1200 MWe capacity units. The plant is estimated to be paid off in 15 years. The first plant is planned to be operational in 2018 and the other plants will be active in 2019-2021 [3, 7, 10, 17].

Sinop nuclear project will be accompanied with EUR 1.7 billion nuclear technology center. It will have a capacity of 5600 MWe and is expected to have an overall cost about \$20 billion. Turkey imports much of its energy, including nearly all of its oil and gas, and in 2012 this amounted to more than \$60 billion.

Improving energy efficiency and energy security are high priorities. Considering Turkey's yearly energy bill that is about \$60 billion, the cost of constructing two new nuclear plants is not too high for the country [10].

3.3. Advantages of nuclear power for Turkey

First of all, by building up two new nuclear power plants Turkey will be able to reduce its energy bills considerably. Since it imports most of its oil and gas, nuclear plant project will help to assure the security of electricity supply. Most important environmental positive effect is reduced greenhouse gas emissions. Since nuclear power plant uses uranium reserves, they have high level of potential reserves which will be adequate for all nuclear power plants for at least 150 years more. Nuclear power plants supply very high level of energy compared to the volume of its raw material. For example, whereas 1000 gram coal produces 3 KWh electricity, 1000 gram oil produces 4 KWh energy; 1000 gram uranium produces 50,000 KWh electricity [3].

Nuclear power plants have a little cost of raw material since a very small volume of raw material is used for electricity generation [5]. This makes nuclear energy a very advantageous source compared to fossil fuel utilizing electricity generation [7]. Compared to other electricity generation plants using other sources, nuclear power plants use a small portion of land. In addition, it is possible to recycle nuclear waste. Furthermore, since nuclear power plants are designed for energy production, actually there is not risk of proliferation in these plants. Some other advantages of nuclear power in Turkey from the advocates' point of view are as follows [3, 7, 10, 17, 20]:

- It is a more economical since the price of energy generated from the nuclear energy power plants is much cheaper than the other conventional power plants.
- The damage to the environment is not as bad as what occurs with the fossil-based energy power plants (such as depletion of the ozone layer).
- Cutting trees from the forest for use in burning is an important side effect of the environment.
- Use of nuclear energy power plants will help protect our natural resources, such as industrial raw materials, petroleum, coal, and natural gas.
- It provides a clean energy source.
- The construction of power plants does not need too much space.

- Its construction is cheaper than the hydroelectric power plants.
- It assures a steady production of energy over the year.
- There are fewer waste products compared with other sources.
- The world has a 100 year uranium reserve.
- Fossil energy resources are declining.
- The power plants produce only water vapor.
- Nuclear energy improves nuclear medicine.
- It resolves the electrical energy problems.
- It helps improve the economy

When we talk about economic benefits of nuclear power for Turkey, we should not disregard job opportunities benefits of nuclear sector. The Nuclear Energy Institute (NEI) estimates that private investment in new nuclear power plants has created 14,000 to 15,000 clean energy jobs over the last few years in the US alone. Operation of a nuclear power plant not only generates 400 to 700 permanent jobs, but jobs that pay as much as 36 percent more than average salaries in the area they are located [20-22].

Technical assessment studies indicate that Turkey has large wind, solar, hydro, and geothermal resources, especially relative to its energy needs but the estimates cover a wide range [23]. Hence, a cautious approach to these resource estimates is warranted, especially given the fact that these resources have not been used much with the exception of hydro [1, 2]. According to MENR, the government needs to give price support to renewable electricity generation. This poses a big question for the government. Given that renewables are still costlier than conventional technologies and system operators have to deal with intermittency and low capacity factor, like any rapidly growing country without significant hydrocarbon resources [3, 17].

Although renewable energy resources are technically large, only a small percentage of these resources can be expected to be brought online on a commercially viable basis. Thorium is another important source to consider while discussing about nuclear power plants. The amount of the thorium reserves of Turkey are disputed by different sources. Some reports state that Turkey has the second order in thorium reserves in the world with 380,000 tons. However, it was also reported that Turkey is the first country having about 800,000 tons of thorium reserve with a share of 52% in the world. All technical parameters obtained from the studies on use of thorium as nuclear fuel (thorium

fuel cycle) during the last 50 years indicate that in case of developing the technologies based on thorium fuel cycle systems, thorium will probably be a nuclear material much more valuable than uranium in the future [1, 2, 3].

3.4. Disadvantages of nuclear power for Turkey

Nuclear power plants can be constructed in those areas with specific geographical features. Raw material location is not a key factor while selecting the location of the plant. The most important issue to consider here is the closeness of the plant to the cooling water and to the market. Because of this, seaside, riverside or lakeside areas are suitable places for nuclear power plants. When it comes to marketing, closeness to industrial zones is important.

There are also some flaws in Turkey's nuclear energy policy which may be some disadvantages for the country. Turkey does not have a comprehensive nuclear energy plan which covers globally all aspects of nuclear power. The country lacks proper legal framework as well. There are some uncertainties in the role of the government [17]. There are also some problems regarding technology choice and there is not a satisfactory technology transfer plan. In

addition, for the moment there is no precise decommissioning and waste policies for nuclear power plants. In Turkey, public consultation and dispute settlement mechanisms does not exist yet. We can also mention about problems in the participation of domestic industries, problems in training of human resources and problems in project financing [19].

Turkey is a region plagued with a high degree of earthquakes. The Akkuyu site is near an active Mediterranean earthquake zone [3], and there have been 6.2 Richter earthquakes hitting Adana, which is 180 km from the plant site. An earthquake would have been the most likely cause of a catastrophic nuclear accident at Akkuyu. There have been efforts to build a nuclear power plant since 1976 when the first license was issued for the Akkuyu site, which is now condemned by some experts as too seismically active [14]. Public opposition is another disadvantage of nuclear power in Turkey. Almost 90% of Turkish people are against the construction of nuclear power plants in the country. This situation leaves the current government without support for nuclear investments [3, 14, 17].

4. Conclusions

To obtain new and more effective transformation of nuclear energy in collaboration with renewable energy, more research activities must be developed. In this context, a really technical progress in the nuclear industry is considered to be slow compared to other traditional sciences. In consequence, there is a strong need to review the educational requirements for undergraduate and postgraduate studies to provide applied engineering skills required to design, built, and operate nuclear systems and to develop new technologies that ensure energy supply in accordance with a common world standard.

Hydroelectric power is reliable and cheap, but there aren't enough suitable sites to satisfy our energy demands. Wind and solar energy don't provide consistent output, and battery technology would have to improve significantly to solve that problem. Today, renewables are just an expensive supplement to an electricity system based on coal and natural gas. There is one source of carbon emission-free energy that is cheap, reliable, and proven to work on a large scale: nuclear power. It often gets a bad rap because

of perceived safety problems. In reality, it has become a sort of litmus test for societal rationality. People have a hard time estimating some kinds of risks.

The renewable energy resources produce no significant waste and are generally favored by policy incentives, but some of them are plagued by high production costs and low efficiency. On the contrary, the examined nuclear technologies, despite their enhanced safety, reduced costs and minimized waste, still have to face the major issues of weapons proliferation, safety, waste handling and high costs as well as public acceptance, which have been affected by the recent Fukushima accident. Turkey today generates a high percentage of its electricity generation from hydro power plants which can be easily affected by dry seasons. Therefore nuclear power plants not only will be able to provide a sustainable electricity source but also will bring in new nuclear technologies for the country and will enhance the technological know-how of the country.

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