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Nuclear Energy in Turkey: Quo Vadis?

S. DUYGU SEVER-MEHMETOĞLU

PhD Candidate in Political Science and International Relations, Koç University

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GRF convened the following group of distinguished members to evaluate and guide Duygu Sever-Mehmetoğlu's paper:

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GLOBAL RELATIONS FORUM

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Duygu Sever-Mehmetoğlu is a PhD Candidate at Koç University. She is a former Visiting Researcher at IFRI (Institut Français des Relations Internationales), Center for Energy in Paris. She worked as a Project Assistant in EU Horizon 2020 Project: FEUTURE (The Future of EU-Turkey Relations: Mapping Dynamics and Testing Scenarios) for Energy and Climate Drivers. She has received her bachelor's and master's degrees in International Relations at Bilkent University with full scholarship. Her research areas include energy politics, sustainable development, policy learning, foreign policy and global environmental governance. Duygu's PhD dissertation titled as "Domestic and Global Context of Energy Preferences: Explaining Choices for the Nuclear Option", focuses on pushing and constraining factors for a country's decision to engage in nuclear energy generation. Along with her academic activities and international publications, she has also been an active member of platforms including Global Network for The Chicago Forum on Global Cities, Women in Energy by Bosphorus Energy Club and Likeminds: German-Turkish Junior Expert Initiative (by Robert Bosch Stiftung, European Academy of Berlin and Istanbul Policy Center). Recently, she has been working as a mentor, lecturer and consultant for Hamad Bin Khalifa University in Qatar for the promotion of sustainable development goals, global citizenship and youth engagement into sustainable development.

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Abstract

The promotion of nuclear energy centers on decreasing energy dependence, meeting increasing energy demand, adjusting electricity prices, and decreasing emissions. On the other hand, critics highlight the environmental risks, waste management problems, low public acceptance, and risk of nuclear accidents. In spite of the heated global debates over clashing arguments on these different issues, nuclear energy remains a strategic interest for Turkey.

Given that the discussion of nuclear energy in Turkey is very limited, this research aims to offer an objective overview of the major dynamics related to nuclear energy and Turkey's nuclear energy policy. The article makes no claims about whether or not Turkey should engage in nuclear energy generation. Rather, it touches upon major issues that drive the current status of nuclear in the overall world energy mix and evaluates the strengths, weaknesses, threats, and opportunities for the Turkish case.

1. Introduction

Today, states are trapped in energy-related dilemmas at both national and global levels. Their decisions for the composition of their energy mixes are the outcomes of the interplay between sustainability, competitiveness, and continuity of supply. Among the components of energy mixes, nuclear energy gets a special focus given its relation to nuclear proliferation and tragic accidents, as well as heated street demonstrations.

As concerns for climate change and the search for alternative energy solutions rise to the top of global and domestic energy agendas, many experts have started to question whether a nuclear renaissance is on the way.[1] While discussion of this possibility gained pace, an earthquake with a magnitude of 9.0 followed by a tsunami hit the Tohoku region of Japan on March 11, 2011, severely damaging not only the Fukushima power plant but also nuclear technology designers' hopes of having achieved a maximum level of nuclear safety: the event has been deemed a "beyond-design basis" accident.[2] The Fukushima accident has become a critical juncture in the nuclear energy sector, prompting states to reconsider and revise their nuclear energy policies. Some countries, like Spain and Switzerland, have demonstrated their reluctance to continue with nuclear while others, such as China, Russia, and India, have continued to expand their existing nuclear energy capacity. One of the most striking responses came from Germany, which decisively eliminated the possibility of new reactors and announced on May 30, 2011 that existing reactors would be phased out gradually.[3] Despite growing skepticism towards nuclear energy following the accident, other countries have continued to pursue their strategy to diversify their energy mixes with nuclear, Turkey being one of them.

This research aims to provide an objective overview of the major dynamics governing nuclear energy decisions, as well as Turkey's nuclear energy policy. The article does not discuss whether or not Turkey should engage in nuclear energy generation. It rather calls into focus the major issues that drive the current status of nuclear in the overall world energy mix and analyzes the strengths, weaknesses, threats, and opportunities for the Turkish case.

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[1] Adam N. Stulberg and Matthew Fuhrmann eds., *The Nuclear Renaissance and International Security* (California: Stanford University Press, 2013); Bernard Gourley and Adam Stulberg, "Nuclear Energy Development: Assessing Aspirant Countries," *Bulletin of the Atomic Scientists*, 65/6, (2009), 20-28.

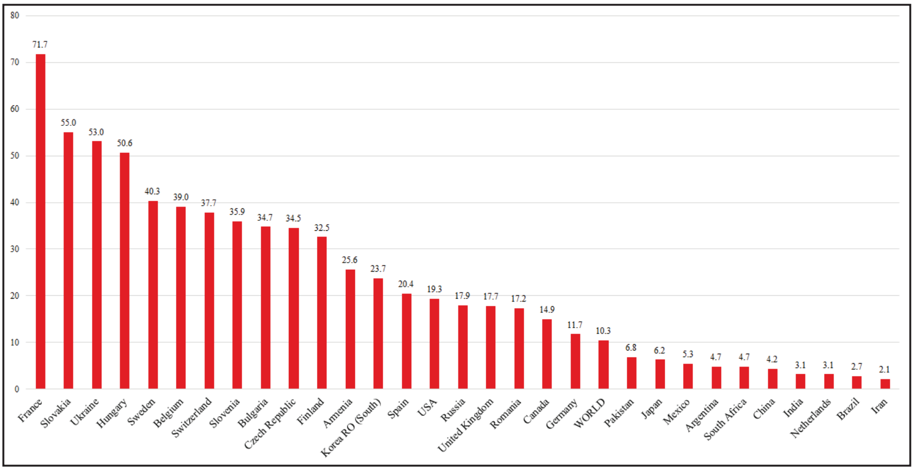
[2] Steve Thomas, "What will the Fukushima disaster change?" Energy Policy, 45 (2012): 12-17.

[3] The Guardian, "Germany to shut all nuclear reactors," May 30, 2011, http://www.theguardian.com/world/2011/may/30/germany-to-shut-nuclear-reactors

2. Nuclear Energy: Current Status in the World and in Turkey

Since the 1970s, especially following the oil crises of 1974 and 1979, there has been a rising trend in global nuclear energy production, even in the aftermath of Chernobyl.[4] Between 1990 and 2010, world nuclear energy capacity increased by 17.75% and related electricity production rose by 40%.[5] Today, nuclear corresponds to 10.2% of the world energy mix for electricity generation, which makes it the second-largest source of low-carbon electricity after hydropower (16.3%).[6] Thirty countries produce nuclear energy, and 12 currently non-nuclear states have revealed their interest in nuclear energy generation. At present, 442 reactors in total are operable, 54 are under construction, 109 are on order or planned, and 330 new reactors are proposed as of January 2020.[7]

Figure 1: The Share of Nuclear Energy in Electricity Production by Country (%), 2018



Data Source: WNA 2020 (Prepared by the Author)

Turkey's quest to become a country with nuclear in its energy mix has a very long history. It dates back to 1956, when its Atomic Energy Commission, which was later replaced by the Turkish Atomic Energy Authority (TAEK), was established.[8] Beginning in the 1970s, several plans for the construction of nuclear power

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[4] The disaster took place on April 26, 1986 at the Chernobyl nuclear power plant in Ukraine, then part of the former Soviet Union.

[5] WNA (World Nuclear Association), *Nuclear Power in the World Today*, 2016, http://www.world-nuclear.org/info/Current-and-Future-Generation/Nuclear-Power-in-the-World- Today.

[6] IEA, *Electricity Information 2019* (2019).

[7] WNA, *World Nuclear Power Reactors & Uranium Requirements*, 2019, http://www.world-nuclear.org/information-library/facts-and-figures/world-nuclear-power-reactors-and-uranium-requireme.aspx

[8] MENR (Ministry of Energy and Natural Resources), *Nükleer Güç Santralleri ve Türkiye* (2014). http://www.enerji.gov.tr/yayinlar_raporlar/Nukleer_Guc_Santralleri_ve_Turkiye.pdf

plants were put forward,[9] yet they were not realized. This changed in July 2010 with the intergovernmental agreement between Turkey and Russia for the construction of the Akkuyu Nuclear Power Plant in southern Turkey. In line with the agreement, Akkuyu is to be constructed based on a Build-Own-Operate (BOO) System, with ROSATOM, Russia's state owned nuclear power company, as the responsible firm.

In parallel with the Akkuyu project, preparatory work for a second plant in Sinop had also been taking place since February 2008. In May 2013, a proposal from a Japanese-French consortium led by Mitsubishi Heavy Industries (MHI), Areva, Itochu, and Engie was accepted to build the reactors in Sinop. Following this decision, Turkey signed another intergovernmental agreement with Japan to cooperate for the development of nuclear power plants and nuclear industry in Turkey. The initial target year for the first reactor at Sinop, which would be an Atmea 1,[10] was 2023. Nevertheless, this date was not realistic, given the pace of the project. How the restructuring of Areva (i.e., Orano and Framatome)[11] would be reflected in the business plan for the construction of the plant became a major question mark, together with financial constraints and uncertainties regarding liabilities. The project's fate became even more dubious when President Erdoğan stated in Japan on June 27, 2019 that Turkey is not at the desired point on the Sinop Nuclear Power Plant project and that the latest feasibility study and cost analysis are not compatible with the initial agreement, in terms of both costs and project calendar. Therefore, recently, the process with Japan was stopped. Still, Turkey is keeping the possibility of a nuclear power plant (NPP) in Sinop open, as declared by Energy and Natural Resources Minister Fatih Dönmez on September 28, 2019: "We will resume the nuclear project in Sinop; however, we don't know yet what country or which technology that will be with."[12]

The following table summarizes the basics regarding the Akkuyu and Sinop Nuclear Power Projects.

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[9] Feda Öner, "Energy Status and Peaceful Usage of Nuclear Energy in Turkey", *Energy Sources* 6 (2011): 314-319; Behiye Akçay, "The Case of Nuclear Energy in Turkey: From Chernobyl to Akkuyu Nuclear Power Plant." *Energy Sources* 4 (2009): 347-355.

[10] ATMEA1 is a type of reactor designed with the combination of French (EDF) and Japanese (MHI) technologies in one medium-powered pressurized water (PWR) reactor, with the aim of developing a safer and more reliable system.

[11] Due to financial problems, Areva was restructured in 2017. The outcome was the establishment of Framatome (owned by EDF -75.5%-, Mitsubishi Heavy Industries -19.5%-, Assystem -5%-) which designs, manufactures, and installs NPPs, and Orano, which is a player in nuclear fuel cycle products and services, from mining to dismantling, conversion, enrichment, recycling, logistics, and engineering.

[12] Daily Sabah, "Energy Minister: Gas prices unlikely to change in near future". September 28, 2019, https://www.dailysabah.com/energy/2019/09/28/energy-minister-gas-prices-unlikely-to-change-in-near-future

Table 1: Akkuyu and Sinop Nuclear Power Projects

	Akkuyu Nuclear Power Project	Sinop Nuclear Power Project
Approximate Cost	$20 billion	$20 billion<?
Type of Reactor	VVER-1200 (AES-2006)	ATMEA-1
Number of Units	4 Units (1200 MW*4)	4 Units (1200 MW*4)
Service Life	60 years	60 years
Electricity Price	12.30 cents	10.83 cents

Although there have been no official developments yet, some state representatives have pointed to İğneada, on the Black Sea coast of Turkish Thrace, as a potential location for the third power plant to be constructed.

In August 2016, when the Agreement for Cooperation in Peaceful Uses of Nuclear Energy was signed, China and Turkey became nuclear partners and opened up the possibility that Turkey's third nuclear power plant could be built by China. The agreement covered partnership in site studies, design, construction, commissioning, and operation of power plants, as well as joint efforts for nuclear safety, environmental safety, and human resources development.[13] Nevertheless, major details of the third nuclear power plant remain subject to confirmation.

The previous Energy Strategy Document, approved in May 2009, had set the goal of 5% share for nuclear in the country's overall energy production.[14] While the most recent Strategic Plan for energy refrained from setting a goal in terms of percentages, on August 2017, Berat Albayrak, then Minister for Energy and Natural Resources, declared that nuclear in Turkey would represent 10% of the installed power capacity by 2030.[15] Accordingly, Turkey's first nuclear power reactor in Akkuyu is expected to become operational in 2023.

3. Major Factors Influencing Nuclear Energy Policy

Strategies for promoting nuclear energy center on decreasing energy dependence, meeting increasing energy consumption, adjusting electricity prices, and decreasing emissions. On the other hand, critics highlight the environmental risks, waste management problems, low public acceptance, and risk of nuclear accidents. In line with these advantages and risks, some major issues emerge that should be addressed in the analysis of the decision to adopt nuclear energy production. The following sections focus on these factors, first by scanning global perspectives and then by discussing the situation in Turkey for each case.

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[13] Republic of Turkey Prime Ministry, *The Agreement Between the Government of the Republic of Turkey and the Government of the People's Republic of China for Cooperation in the Peaceful Uses of Nuclear Energy* (2016).

[14] MENR, *Nükleer Santraller ve Ülkemizde Kurulacak Nükleer Santrale İlişkin Bilgiler* (2014). http://www.enerji.gov.tr/yayinlar_raporlar/Nukleer_Santraller_ve_Ulkemizde_Kurulacak_Nukleer_Santrale_Iliskin_Bilgiler.pdf

[15] Daily Sabah, "Turkey to expand capacity to meet energy needs with 3 nuclear power plants in action". August 10, 2017, https://www.dailysabah.com/energy/2017/08/11/turkey-to-expand-capacity-to-meet-energy-needs-with-3-nuclear-power-plants-in-action-1502395900

Table 2: SWOT Analysis of Nuclear Energy

STRENGTHS	WEAKNESSES
• Low carbon emission • Resource diversification • Efficiency • High capacity factors/ energy density • Reliable base-load electricity • Small waste volume	• High level waste management • Safety requirements • Financial burden of constructing a nuclear power plant • Low public acceptance • Reminiscent memories of Three Miles Island (1979), Chernobyl (1986) and Fukushima (2011) • Imported uranium supplies
OPPORTUNITIES	**THREATS**
• An option for the fight against climate change • Legal as well as practical arrangements for radioactive waste storage • Developing indigenous expertize • New/safer technologies • Advanced reactor designs • Policies responsive towards public concerns	• Radioactive leakage • Nuclear accidents • Human factor • Lack of transparency • Terrorism • Nuclear proliferation • Long term storage of nuclear waste • Lack of safety culture

NUCLEAR ENERGY

3.1. Energy Security and Nuclear Energy

"The future is electrifying" according to the energy outlook of the IEA, which expects electricity to be the "rising force" potentially making up 40% of the rise in world's final consumption by 2040.[16] Overall, global energy consumption is expected to increase by 18% by 2030 and 39% by 2050.[17] Consequently, uninterrupted availability of energy supplies and the decrease of dependency on uncertain foreign suppliers remain as two major components of energy security. In this context, nuclear energy is considered an important tool for resource diversification. Nuclear is not only depicted as a reliable baseload resource for electricity but also a high-density energy resource. The heat values (used to measure a fuel's energy density), of major resources reveal the difference: crude oil 42-47 MJ/kg, natural gas 42-55 MJ/kg, black coal 23.9 MJ/kg, lignite 17.4 MJ/kg, and nuclear 3900 GJ/kg.[18] Accordingly, we need 163,179 kg of black coal or 224,137 kg of lignite to produce the same energy as 1 kg of enriched uranium.

On the other hand, the promotion of nuclear energy as an effective resource to cope with dependence on exported energy resources inherits another trap that resource-poor countries should be cautious about: fuel and technology dependence on foreign suppliers. The security of uranium supplies and continuous flow of know-how need to be ensured through carefully designed long-term intergovernmental agreements. The world's largest uranium reserves are located in Australia (30%), Kazakhstan (14%), Russia (8%), Canada (8%),

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[16] IEA, *World Energy Outlook 2017* (2017).

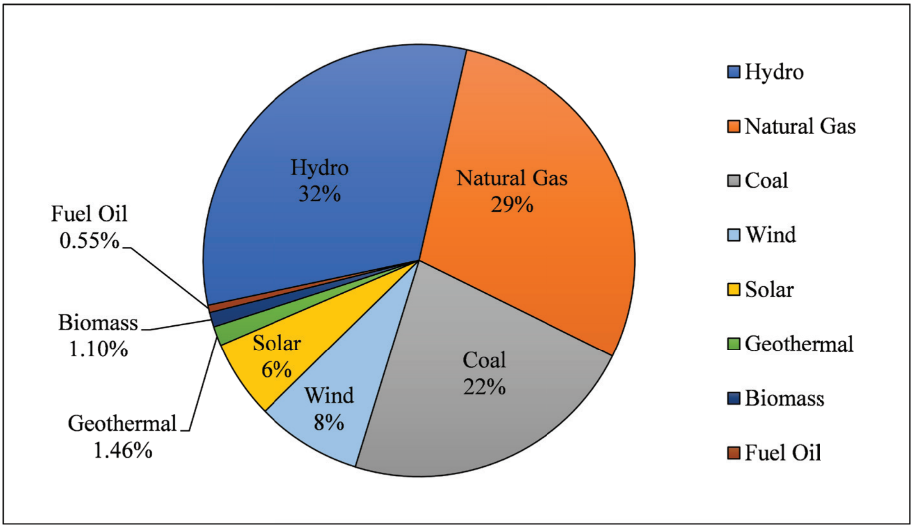
[17] IAEA, *Energy, Electricity and Nuclear Power Estimates for the Period up to 2050* (2017).

[18] WNA, *Heat Values of Various Fuels*, 2018, https://www.world-nuclear.org/information-library/facts-and-figures/heat-values-of-various-fuels.aspx

Namibia (7%), and Niger (5%).[19] In the case of a nuclear expansion, especially from Asia, how the relations and trade among these uranium suppliers will develop and whether the magnitude of uranium trade/dependence will be large enough to influence these relations remain to be seen in the coming decades.

In the case of Turkey, efficient, secure, timely, and environmentally friendly management of energy and mining resources is the fundamental energy security strategy, as the 2015-2019 Strategic Plan clearly reveals.[20] The diversification of energy resources, exporters, and transit routes, and effective consumption of domestic resources by 2023 are major targets of this strategy. Currently, Turkey's installed power capacity (88,550 MW) is dominated by coal, natural gas, and hydro (Figure 2).

Figure 2: Turkey's Installed Capacity by Resource Type, 2019



Data Source: TEIAS 2019 (Prepared by the Author)

The 2015-2019 Strategic Plan sets targets for energy efficiency, nuclear energy,[21] renewable resources (30% by 2023), and clean coal technologies. Accordingly, nuclear energy is considered an important baseload resource to meet increasing electricity demand and ensure energy supply security.[22] It is important to note

[19] The production ranking among these countries is slightly different than their reserve shares. The share of these countries in the world uranium supply is as follows: Kazakhstan 40.5%, Canada 13%, Australia 12%, Namibia 10.3 % and Niger 5.4%, Russia 5.4%. Source: OECD, NEA & IAEA, *Uranium 2018: Resources, Production and Demand,* 2018; WNA, *World Uranium Mining Production*, 2017, http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/mining-of-uranium/world-uranium-mining-production.aspx; WNA, *Uranium Production Figures, 2009-2018*, 2019, https://www.world-nuclear.org/information-library/facts-and-figures/uranium-production-figures.aspx

[20] MENR, *The Republic of Turkey Ministry of Energy and Natural Resources Strategic Plan 2015-2019*, (2015), 19, http://sp.enerji.gov.tr/sp-2015-2019.html

[21] By the time the Strategic Plan was prepared, the target for nuclear was to reach 5% by 2020.

[22] MENR, *The Strategic Plan 2015-2019*, 17, 40.

that there is a strong emphasis by the Turkish authorities on the necessity of nuclear energy. To this end, nuclear energy's potential advantages for Turkey are often highlighted. To illustrate, in a comparison of nuclear with renewable resources, the official nuclear report from the Ministry of Energy and Natural Resources indicates that to produce the same amount of electricity that Akkuyu nuclear power plant will be producing, the country would need an area of 600 km2 for wind tribunes (70% of Yalova's surface) or 2400 km2 for hydro (as big as Düzce).[23]

The first major argument for Turkey's decision to build NPPs concerns the premise that its growing economy will have growing electricity needs, which must be supplied by a diversified energy mix dominated by *national* resources, nuclear energy being one of them. As Minister of Foreign Affairs Mevlüt Çavuşoğlu stated, "Turkey is one of the fastest growing energy markets in the world. Economic growth, rising per capita income, positive demographic trends, and rapid urbanization have been the main drivers. Energy demand in Turkey is estimated to increase by 6% a year through 2023."[24]

The counter-argument to this view comes from the Union of Chambers of Turkish Engineers and Architects (TMMOB), underlining that Turkey does not need any NPPs to cover its electricity consumption as its installed capacity and under-construction electricity generation facilities are enough to meet the projected demand, if used efficiently.[25] Their suggestion is that the surplus in installed power has also led to a surplus in production: according to the analysis, considering that electricity consumption in 2017 is 295 billion kWh, production capacity can meet demand easily. The analysis also reports that the existing electricity production plant capacity utilization is just 40%.[26]

Both lines of argument can be meaningful only with reference to actual calculations concerning Turkey's current profile and future energy demand. In 2018, total electricity generation in Turkey was 300,717 GWh, 67.7% of which was produced by fossil fuels and 32.3% was produced by renewables. Net consumption for the same year was 247.5 TWh.[27] According to the projections of the Ministry of Energy and Natural Resources (MENR), the annual average electricity demand growth rate for the first 10-year period (2019-2028) is 3.6%, 4.2%, and 4.8% for low, base, and high growth scenarios, respectively. For the second 10-year period (2029-2039), the rate is calculated as 2.4% for the low scenario, 2.8% for base, and 3.3% for high.[28]

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[23] MENR, *Türkiye'nin Nükleer Santral Projeleri: Soru-Cevap*. (Nükleer Enerji Proje Uygulama Dairesi Yayın Serisi, January 11, 2016).

[24] Mevlüt Çavuşoğlu, "Interview of H.E. Mr. Mevlüt Çavuşoğlu to WirtschaftsForum – Nah- und Mittelost (EconomicForum – Near- and Middle East) Magazine", May 2018.

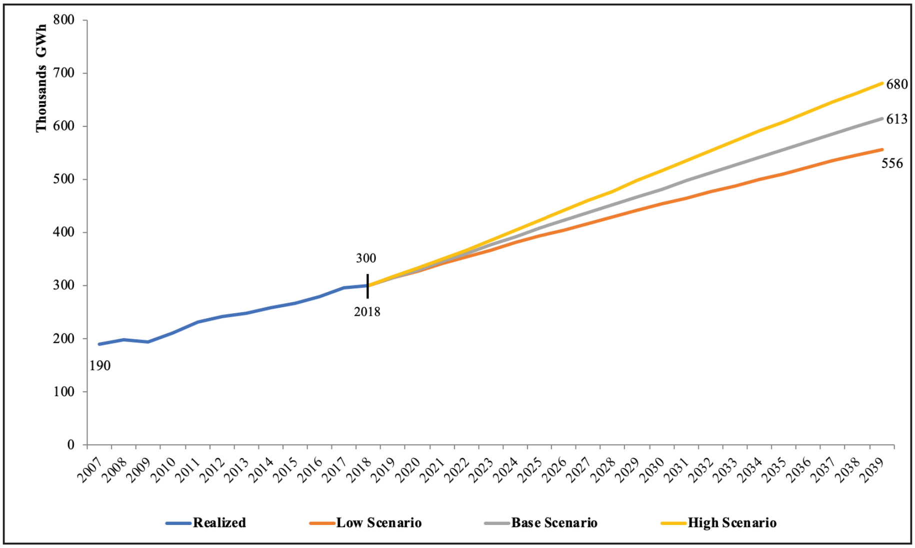
[25] TMMOB, *Türkiye'nin Enerji Görünümü* (2018).

[26] Bülent Damar, "Türkiye'de İzlenen Elektrik Enerjisi Politikalarının Değerlendirilmesi" in *Türkiye'nin Enerji Görünümü*, (Makina Mühendisleri Odası: Ankara, 2018), 121.

[27] TMMOB. *Türkiye'nin Enerji Görünümü* (2019).

[28] TEIAS, *10 Yıllık Talep Tahminleri Raporu 2019-2028* (2019), 52.

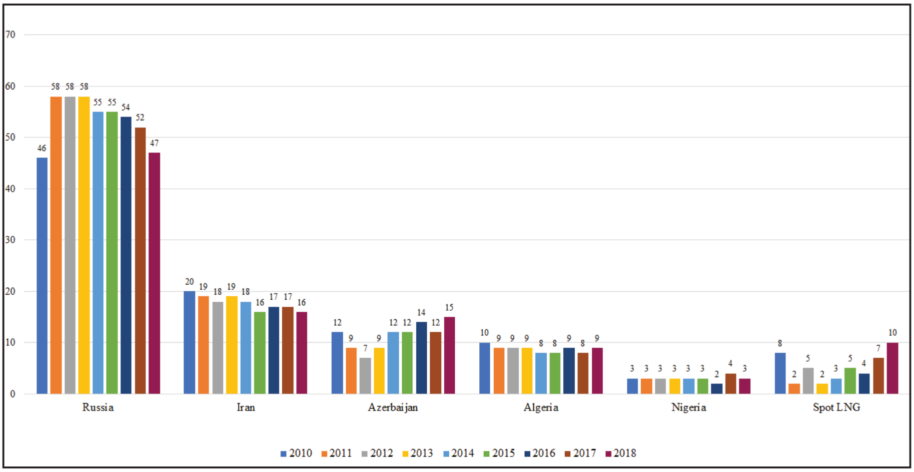
Figure 3: Turkey's Electricity Demand Projections Until 2039, by MENR



Data Source: TEIAS 2019 (Prepared by the Author)

The second argument concerns the necessity of creating alternatives to imported oil and gas by diversifying the country's energy mix through domestic resources,[29] in order to effectively manage its vulnerable reliance on Russian and Iranian imports. Turkey imports 98.8% of its total demand for natural gas and, as Figure 4 represents, 47% of this dependence is on Russian gas.[30]

Figure 4: Turkey's Natural Gas Imports by Country, 2010-2018 (%)



Data Source: EPDK (Prepared by the Author)

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29 MENR, *The Strategic Plan 2015-2019*, 17, 40.

30 EPDK, *2018 Natural Gas Sector Report* (2019).

The search for alternative energy supplies is a legitimate concern that lies at the heart of Turkey's vulnerability in energy security. However, this factor complicates the analysis of Turkey's nuclear energy strategy, since the goal of diversifying away from imported natural gas supplies (i.e., from Russia) through domestic, national resources seems to be incompatible with the deal for Akkuyu. The deal gives 51% of the project company[31] established for the plant's implementation, operation, and ownership to the Russian Party, i.e., Rosatom, through Article 5.4 of the intergovernmental agreement between Turkey and Russia.

3.2. Climate Change, Environment, and Nuclear Energy

Increasing the share of low-carbon energy resources in the energy mix is a crucial step towards limiting greenhouse gas emissions. Compared to conventional fossil fuels, low-carbon nuclear power is a promising tool in the fight against climate change, while also contributing to the energy supply required to meet rising energy demand. In the European Union, for instance, efforts to combat climate change have been a critical component of the discussion about nuclear energy.[32] Some official EU reports have stressed the necessity of nuclear in addressing climate change and ensuring the EU's energy security.[33] The Commission has advised that in the case of decreasing the share of nuclear in Europe, other "supplementary low-carbon energy sources for electricity production" would be necessary since "otherwise the objective of cutting GHG emissions and improving security of energy supply will not be met."[34]

There are, however, differing views regarding the argument that nuclear energy is an essential player in resource diversification and the fight against climate change. A strong criticism facing this argument is the claim that nuclear energy has a misleading image as a clean resource, and that its proponents are abusing the cause of climate change for nuclear propaganda by representing the emissions from NPPs as lower than they really are. Indeed, technological and physical differences between reactors as well as different lifecycle definitions can result in differing data on the amount of carbon emissions for electricity generation from nuclear energy. Still, mean lifecycle emissions for nuclear

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[31] The exact details of Article 5 from the agreement are as follows: "Article 5.2: The Project Company shall be owner of the NPP, including the electricity generated by it. Article 5.3: The Project Company shall be established in the form of a joint stock company under the laws and regulations of Turkish Republic with the shares in the Project Company being initially 100% owned directly or indirectly by the companies authorized by the Russian Party. Article 5.4: The cumulative shares of the Russian Authorized Organizations in the Project Company shall not be less than 51% at any time."

[32] IEA, *Energy Policies Review: The European Union 2008* (OECD Publications, 2008), https://www.oecd-ilibrary.org/energy/iea-energy-policies-review-the-european-union-2008_9789264043381-en; Thomas "What Will the Fukushima Disaster Change", 16; Dagmar Kıyar and Bettina Wittneben, "Nuclear Energy in the European Union After Fukushima: Political and Economic Considerations", *Dice Report 3* (2012), 10; Ben Bradford, "The Nuclear Landscape", *Nature 483* (2012), 152.

[33] IEA 2008, 10.

[34] European Commission, *An Energy Policy for Europe* (2007). http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=URISERV%3Al27067

(ranging from 11 to 122 gCO2/kWh[35]) are considerably lower than the mean emissions for natural gas (443 gCO2/kWh), oil (778 gCO2/kWh), and coal (1,050 gCO2/kWh).[36] Warner and Heath suggest that median life cycle GHG emissions for nuclear could be as low as 9 to 110 gCO2/kWh by 2050, which accounts for only a fraction of traditional fossil sources and which is comparable to renewable technologies.[37]

While accepting that nuclear power is a potential solution to climate change, some scholars such as Busby[38] suggest that it is unlikely that nuclear energy can meet its potential to play a major role in reducing global greenhouse gas emissions due to political and technical obstacles for the construction of new nuclear plants. Calculations reveal that to keep CO2 emissions constant, 1,000 new nuclear reactors would have to be built by 2050, meaning that each year 28 new reactors would have to become operational, for 34 years.[39] Given that only 34 reactors were completed between 2003 and 2013,[40] nuclear energy strategy has to be accompanied by complementary resources and policies. This would further require flexibility for the NPPs with the capability to perform large and frequent load follow operations.

Official Turkish documents reveal that nuclear energy is perceived more as a source of diversification of the energy portfolio than as a tool for the fight against climate change on Turkey's part. While Turkey acknowledges the need to decrease carbon emissions in its overall energy strategy, only a limited number of official reports[41] refer to the low-carbon nature of nuclear energy. As a striking example, the Republic of Turkey Climate Change Action Plan 2011-2023 states the purpose of increasing the share of clean energy in energy production and use, sets the objective to "ensure that the share of renewable energy in electricity production is increased," and declares the target of reducing GHG emissions by using clean coal technologies and energy efficiency measures.[42] There is not a single reference to nuclear energy in this action plan, despite the fact that nuclear energy can eventually contribute to a low-carbon energy mix for Turkey.

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[35] The variations in mean lifecycle emissions for nuclear arise from different operationalizations of the lifecycle. While some calculations consider only the operation phase, others include frontend, construction, operation, backend, and decommissioning phases into their lifecycle definition.

[36] Benjamin K Sovacool, "Valuing the Greenhouse Gas Emissions From Nuclear Power: A critical survey," *Energy Policy* 36 (2008): 2950-2963.

[37] Ethan S. Warner and Garvin A. Heath, "Life Cycle Greenhouse Gas Emissions of Nuclear Electricity Generation Systematic Review and Harmonization," *Journal of Industrial Ecology* 16, no. S1 (2012).

[38] Joshua William Busby, "Vaunted hopes: climate change and the unlikely nuclear renaissance" in *The Nuclear Renaissance and International Security,* Adam N. Stulberg and Matthew Fuhrmann eds. (California: Stanford University Press, 2013), 125-149.

[39] Ümit Şahin. "Nükleer Enerji Türkiye İçin de Çözüm Değil, İklim Değişikliğine Karşı da" in *Nükleer Enerji Çözüm Değil*, Helen Caldicott eds. (İstanbul: Yeni İnsan Yayınevi, 2014), 33.

[40] Ibid.

[41] Such as MENR 2017.

[42] Ministry of Environment and Urbanization. *Climate Change Action Plan 2011-2023* (2012), 29-32. http://www.csb.gov.tr/db/iklim/editordosya/IDEP_ENG.pdf.

Regarding the issue's environmental dimension, in addition to the risk of an environmental disaster in the case of a nuclear accident,[43] it is worth mentioning that many experts in Turkey have raised their concerns about the execution of the Environmental Impact Assessment (EIA) for the Akkuyu project: they highlighted problems with matters such as the preparation of the report and its evaluation by incompetent reviewers, and questioned whether the project fulfills all its requirements.[44] The case was even taken to court, but rejected with the ruling that there is no violation of the law in the EIA decision (numbered 3688) taken on 01/12/2014 by the General Directorate of Environmental Impact Assessment, Permission and Control.

3.3. Public Opinion and Nuclear Energy

Positive or negative public opinion is an important component of decision-making on nuclear energy generation. Historically, nuclear energy has grown in parallel with an anti-nuclear movement among the public, especially since the 1980s. Due to the risk of accidents which can result in radioactive leakages that endanger the environment and human lives, nuclear energy has faced strong opposition from the public. The opposition has manifested as street protests, campaigns, and human chains all over the world, which in certain cases have resulted in violent conflicts between the public and state authorities.

Certain countries have reviewed their energy policies in line with public opinion.[45] The case of Italy is a relevant example: in 2011, plans for nuclear power generation were rejected by a popular referendum in which more than 94% of voters opposed the government's plans for nuclear energy. Back then, Prime Minister Silvio Berlusconi interpreted the results as "a will on the part of citizens to participate in decisions about our future that cannot be ignored."[46] The German phase-out decision is also closely associated with the long-standing anti-nuclear movement amongst the public, which urged policy-makers to respond to the will of the people after decades of struggle.

Since the Fukushima disaster, public mistrust toward nuclear has increased. This has required policymakers to be responsive to public demands, questions, and policy requirements, through inclusive and transparent processes. The consolidation of nuclear energy policy, an effective nuclear safety regime, and independent regulatory authority also necessitates a transparent and responsive relationship with the public, including making information available and easy to access.

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[43] For further information regarding the radiation dose limits, please see ICRP (International Commission on Radiological Protection) Publication 103 on radiological protection, available at: http://www.icrp.org/publication.asp?id=ICRP%20Publication%20103

[44] TMMOB, *Türkiye'nin Enerji Görünümü,* 307.

[45] Masatsugu Hayashi, and Larry Hughes, "The Fukushima Nuclear Accident and Its Effects on Global Energy Security", *Energy Policy* (2012), http://www.sciencedirect.com/science/article/pii/S0301421512010282.

[46] BBC, "Italy nuclear: Berlusconi accepts referendum blow", 2011, http://www.bbc.com/news/worldeurope13741105.

For the case of Turkey, different public opinion surveys reveal that approximately 60% of Turkish citizens are against nuclear energy.[47] Moreover, policymakers' relations with the local civil society, especially in Sinop and Mersin where the nuclear power plants are being built, remain problematic.

3.4. Economy and Nuclear Energy

The Global Market

Is nuclear energy an economically viable option? What is going on in the nuclear energy market? These are very interesting questions to ask, yet they are also difficult to answer, since the answers are not based solely on market dynamics, as will be discussed in the following sections. However, before coming to that, providing an overview of the current nuclear energy market offers fertile ground for further analysis.

To begin with, nuclear power is a capital-intensive resource, and the long timeframe for construction of related facilities means that it is prone to unexpected delays and expenses. Thirty-three of the nuclear power units under construction are already reported to be behind schedule by several years (those in China included), and out of 16 units scheduled for startup in 2017, only a quarter were connected to the grid.[48]

When heightened safety requirements, deployment of new generation technologies, delays, and increased construction costs are combined with global financial uncertainties[49] and efforts to decrease electricity demand in line with sustainability policies, distributing all of these risks while investing in NPPs emerges as a vital challenge for the nuclear industry. Although nuclear trade groups expect the civil nuclear industry to generate around $740 billion in sales of equipment and services in the coming decade,[50] problems and miscalculations related to design, construction, and additional safety measures as well as regulatory hurdles challenge the industry, leaving companies with billions in cost overruns. The bankruptcy of Westinghouse in March 2017 is a relevant case, where the construction of two NPPs (one in Georgia and another in South Carolina) resulted in an estimate of $13 billion in cost overruns.[51] Additionally, the world's operating nuclear reactor fleet is aging: over 60% of existing units have been operating for 31 or more years, including 18.5%

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[47] Greenpeace, "Türkiye'nin %64'ü nükleere hayır diyor," April 29, 2011, http://www.greenpeace.org/turkey/tr/news/turkiyenin-yuzde-64u-nukleere-hayir-diyor-290411/; Pınar Ertör Akyazı, Fikret Adaman, Begüm Özkaynak, Ünal Zenginobuz, "Citizens' preferences on nuclear and renewable energy sources: Evidence from Turkey." *Energy Policy* 47 (2012): 309–320.

[48] Schneider et al, *The World Nuclear Industry Status Report 2018*, (Paris, London, A Mycle Schneider Consulting Project, 2018), 3.

[49] IAEA, *Energy, Electricity and Nuclear.*

[50] International Trade Administration, *2017 Civil Nuclear Energy Top Markets Report* (2017).

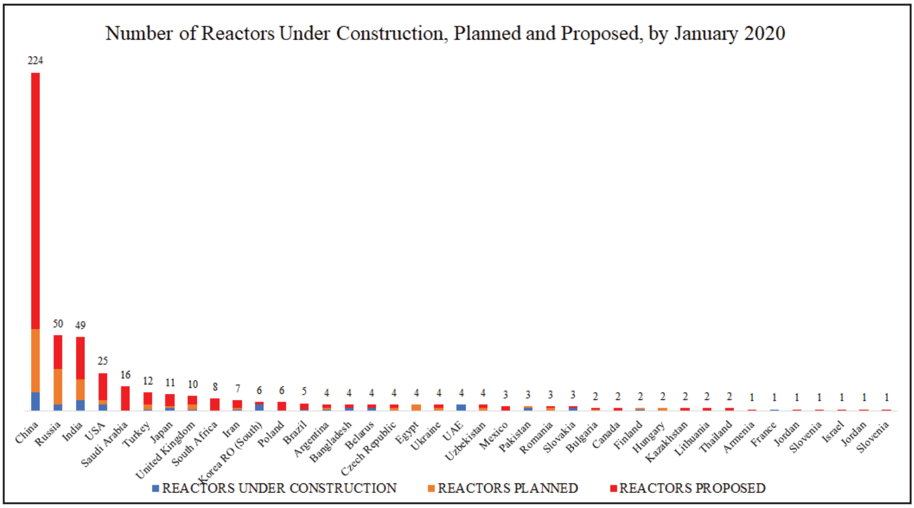
[51] Tom Hals and Emily Flitter, "How two cutting edge U.S. nuclear projects bankrupted Westinghouse," Reuters. May 2, 2017. https://www.reuters.com/article/us-toshiba-accounting-westinghouse-nucle-idUSKBN17Y0CQ

reaching 41 years or more.[52] In those cases, life-extension and decomposition costs emerge as other capital-intensive investment areas.

Overall, compared to the global installed capacity added for renewables, especially for wind and solar, new nuclear generation capacity remains very limited. Trends in the European Union,[53] for instance, display a declining role of nuclear: between 1997 and 2017, wind energy produced an additional 355 TWh and solar 120 TWh, while nuclear power generation declined by 91 TWh.[54]

With the lack of investment due to private companies' unwillingness to take on the financial risk of building an NPP which might never enter operation, high uncertainty on the future political context, and low public support, nuclear energy's popularity has been decreasing in Western economies. Combined with developing countries' increasing interest in NPPs, this trend changes the geography of nuclear energy. The distribution of reactors that are being built, planned, or proposed offers important clues about the countries which will potentially dominate nuclear energy generation in the future (Figure 5). The decrease of nuclear energy's share in Western markets is accompanied by a large growth especially in China, which is expected to overtake the United States and the European Union before 2030.[55]

Figure 5: Future Nuclear Reactors, By Country



Data Source: WNA 2020 (Prepared by the Author)

[52] Schneider et al, *The World Nuclear Industry Status Report*.

[53] The EU's energy production by fuel (2017) is as follows: Nuclear 27.7%, Solid Fossil Fuels 16.4%, Renewables & Biofuels 29.8%, Natural Gas 13.6%, Oil Products 9.8%, Waste 1.9%. (Source: European Commission, *EU Energy in Figures*, 2019).

[54] Schneider et al, *The World Nuclear Industry Status Report*, 22.

[55] IEA, *World Energy Outlook*.

The Middle East is also considered a key region for the deployment of future NPPs, with growing interest coming from Saudi Arabia and the UAE. Developing countries' interest in NPPs clearly triggers a global competition among manufacturers from Russia, China, South Korea, France, and the US.[56] As striking proof, representatives from US nuclear energy developers, including Westinghouse Electric and General Electric, had a meeting with President Donald Trump on February 2019 asking for support in winning contracts to build power plants in the Middle East and elsewhere overseas, and in becoming part of this global competition. As the US domestic nuclear fleet ages and motivations to establish new plants decreases, the industry members consider the export of technology a method of sustaining their national know-how and experience on nuclear power.[57]

The Cost Factor

For nuclear energy, differing regulatory requirements, technical capacities and financial conditions lead to a wide range of overnight costs. Overnight costs include the direct construction and pre-construction costs of the owner (such as site licensing and the environmental testing), indirect costs such as engineering and administrative costs, and contingency costs. The initial investment costs also vary in line with reactor designs, country-specific project constraints (such as working rules, safety requirements, and regulations) and economic conditions (such as labor costs).[58]

To provide some perspective regarding the cost of nuclear energy in comparison to other energy resources, we make use of *levelized costs of generating electricity* (LCOE). LCOE is based on a levelized average lifetime[59] cost approach which represents the costs at the plant level and does not reflect the costs for transmission and distribution. Table 3 illustrates the findings of the analysis conducted by the International Energy Agency and the Nuclear Energy Agency. The table represents the overnight costs and net capacity across resources.

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[56] Research and Markets, *Global Nuclear Power Market, Forecast to 2030* (2018).

[57] Bloomberg, "CEOs Ask Trump to Help Them Sell Nuclear Power Plants Abroad", February 12, 2019.

[58] IEA and NEA, *Projected Costs of Generating Electricity.* 2015.

[59] Expected lifetimes used as the default value for each technology are as follows: wind and solar plants, 25 years; natural gas-fired CCGTs, 30 years; coal-fired power and geothermal plants, 40 years; nuclear power plants, 60 years; and hydropower, 80 years. Source: IEA and NEA, 2015, p. 30.

Table 3: Summary Statistics for Different Generating Technologies[60]

Technology	Net capacity (MWe)			
	Min	Mean	Median	Max
Nuclear	535	1 434	1 300	3 300
Coal	605	1 131	772	4 693
Natural gas – CCGT	350	551	475	900
Natural gas – OCGT	50	274	240	565
Offshore wind	2	275	223	833
Solar thermal (CSP)	50	135	146	200
Hydro – large	11	1 093	50	13 050
Geothermal	6.8	62	27	250
Onshore wind	2	38	20	200
Biomass and biogas	0.2	154	10	900
Solar PV – large	1	19.3	2.5	200
Hydro – small	0.4	3.1	2	10
Solar PV – commercial	0.05	0.34	0.22	1
Solar PV – residential	0.003	0.007	0.005	0.02

Technology	Overnight cost (USD/kWe)			
	Min	Mean	Median	Max
Solar thermal (CSP)	3 571	5 964	6 072	8 142
Geothermal	1 493	4 898	5 823	6 625
Hydro – small	1 369	5 127	5 281	9 400
Offshore wind	3 703	4 985	4 998	5 933
Nuclear	1 807	4 249	4 896	6 215
Biomass and biogas	587	4 447	4 060	8 667
Hydro – large	598	3 492	2 493	8 687
Solar PV – residential	1 867	2 379	2 297	3 366
Coal	813	2 080	2 264	3 067
Onshore wind	1 200	1 911	1 804	2 999
Solar PV – commercial	728	1 583	1 696	1 977
Solar PV – large	937	1 555	1 436	2 563
Natural gas – CCGT	627	1 021	1 014	1 289
Natural gas – OCGT	500	708	699	933

Data Source: IEA & NEA, 2015 (Prepared by the author)

The findings of the analysis reveal that nuclear has the highest median for net capacity. On the other hand, the median cost for nuclear is higher than coal, natural gas or onshore wind. Moreover, the analysis also underlines that the cost of renewable technologies has a declining trend for the past five years, and that these technologies are no longer "cost outliers."[61] With regard to technological trends in nuclear energy, the IEA and NEA's analysis suggests that for now, small modular reactors (SMRs), an emerging nuclear technology, are expected to be on par with large nuclear in terms of total electricity generation costs. Nevertheless, the economics of nuclear will be depending on realizing competitive advantages of SMRs that are instrumental in lowering financing costs. This achievement rests on several preconditions that are subject to progress, including but not limited to accelerated deployment of SMR prototypes, increased number of units produced through serial production, optimized supply chains and the learning rates from factory assembly.

On the other hand, lifetime extensions for NPPs already in operation have emerged as an additional factor influencing overall cost. Once accepted by safety authorities, nuclear power plants nearing their initial design lifetimes will be subject to extensive refurbishment and safety upgrade programs, which are more costly than routine maintenance and therefore a major capital investment.[62] It is important to note that all cost calculations are subject to change depending on market-, technology-, and country-specific conditions. As the IEA states, "there is no single technology that can be said to be the cheapest under all circumstances."[63]

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[60] CCGT: Combined Cycle Gas Turbines; OCGT: Open Cycle Gas Turbines; CSP: Concentrated Solar Power.

[61] IEA and NEA, *Projected Costs of Generating Electricity.*

[62] IEA and NEA, *Projected Costs of Generating Electricity*, 159-160.

[63] IEA and NEA, *Projected Costs of Generating Electricity.*

The cost breakdown also reveals that the most vulnerable point in the production chain is the construction and installation work, which make up 61% of capital costs. Table 4 presents the capital costs for nuclear by distinguishing two broad categories: activities and inputs (such as labor, goods, and materials).

Table 4: Breakdown of Capital Costs for Nuclear Energy

Capital Costs			
By Activity		**By labor, goods and materials**	
Construction and installation works	61%	Equipment (steam supply system, mechanical, electrical and generating equipment, instrumentation and control system, software)	48%
Site development and civil works	20%	Labor onsite	25%
Project engineering, procurement and construction management	7%	Construction materials	12%
Design, architecture, engineering and licensing	5%	Project management services	10%
Commissioning and first fuel loading	5%	First fuel load	3%
Transportation	2%	Other services	2%
Total	100%	Total	100%

Data Source: WNA 2016 (Prepared by the author)

As expected, the costs for construction and installation work as well as related equipment constitute the highest share in the capital costs. On the other hand, the cost of fuel in both categories remains minor. This is striking when compared with fuel costs for other resources. For instance, for gas power plants, fuel costs constitute almost 80% of the total cost. Moreover, the prices of coal and natural gas are subject to fluctuating markets. This means that once the initial investment is made, the cost for nuclear energy is relatively stable.[64]

The Cost of Nuclear Energy for Turkey

As highlighted in previous sections, while building a new nuclear power plant, the majority of the costs concern the up-front investment, which is very high and in a way uncertain due to changing construction timeframes that are subject to regulations, licensing processes, and additional safety measures in the post-Fukushima environment. Accordingly, countries have difficulty financing their nuclear programs, most of them failing to launch their projects within targeted timelines.

Turkey seems able to partially overcome the investment challenge, at least for the Akkuyu Power Plant. Akkuyu will be the first NPP in the world built based on the Build-Operate-Own (BOO) model. The agreement delegates to the Russian Party, through the project company, all responsibilities concerning engineering design, obtaining the necessary licenses and permits, financing, construction, commissioning, operation, maintenance, waste management and

[64] Global Relations Forum, *Turkish Energy Strategy in the 21th Century: Weathering Uncertainties and Discontinuities*. Task Force Report (2013), 106.

decommissioning, and the training of Turkish staff. According to Article 5.6 of the Akkuyu Agreement, in case of the project company's failure to meet these requirements, the Russian Party will take on the responsibility to assure the fulfilling of its obligations under the intergovernmental agreement. Some experts consider the agreement a "good deal" and "an opportunity to transfer all major risks to the project company," in particular, "in an era where parties are looking for innovative ways to share risks associated with the construction and operation of nuclear plants."[65] The BOO model transfers the majority of the financial risks and responsibilities to the Russian project company, meaning that Rosatom will need to invest the capital required for the construction and operation of the power plant. This is also believed to protect the Turkish Treasury against the costs of delays.[66]

The matter of why Russia would take on all the financial risks and responsibilities of the project can be partly explained by Russia's approach to promoting nuclear technology, especially in emerging markets. Russia has had a clearly defined strategy to become a global supplier of nuclear plants.[67] In 2014, it was reported that "according to the World Nuclear Association, Moscow is building 37 percent of the new atomic facilities currently under construction worldwide."[68] Still, the Akkuyu project has a political dimension as well, given that the agreement is an intergovernmental one and Rosatom is a state-owned company.

In terms of the cost of nuclear energy for Turkey, the critical discussion crystallizes around electricity prices. In Article 10.5 of the intergovernmental agreement with Russia, TETAŞ (Turkish Electricity Trading and Contracting Company)[69] guarantees to buy 70% of the electricity produced from the first two units and 30% of the electricity produced from the third and fourth units for 15 years, starting from the operation date of each unit, for 12.35 cent/kWh (not including the value-added tax). A similar purchasing guarantee was also made for Sinop in the agreement with Japan: the Appendix to the main text, regarding the Electricity Purchasing Agreement, Article 4.b, fixed the price to 10.83 cent/kWh (not including the value-added tax) for 20 years following the start date for each unit. The Union of Chambers of Turkish Engineers and Architects raises concerns for the decision, highlighting that the price is 78% higher than

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[65] İzak Atiyas, 2016. "The "Build Own Operate" Model in Nuclear Energy: An Analysis with Emphasis on Turkey's Akkuyu Project" in *Managing the Risks of Nuclear Energy: The Turkish Case*. (Istanbul: EDAM Publication, 2016).

[66] Sinan Ülgen, "Turkey and the Bomb." *The Carnegie Papers:* Nuclear Policy, (2012), 21.

[67] Pulitzer Center. "Russia's New Empire: Nuclear Power," October 17, 2013, http://pulitzercenter.org/reporting/asia-europe-russia-empire-nuclear-power- reactor-generator-expo-sale-kremlin; Ian Armstrong, "Russia is creating a global nuclear power empire." *Global Risk Insights*, 2015, http://globalriskinsights. com/2015/10/russia-is-creating-a-global-nuclear-power-empire

[68] CNBC, "The hidden nuclear battle between Russia and US." 2014, http://www.cnbc.com/2014/03/21/nuclear-power-in-the-new-cold-war.html

[69] In 2018, the state-owned wholesale company TETAŞ merged into EÜAŞ (Electricity Generation Company). TETAŞ has ceased to exist and EÜAŞ has taken over the former responsibilities of TETAŞ.

the average electricity price calculated by TETAŞ for its 2013 report.[70] A more recent report also reveals that the current price of electricity for 1 kWh, under state control, is around 4.5 cents, highlighting that the prices of electricity for both Akkuyu and Sinop are already 2.5 to 2.75 times higher than today's market[71]. Moreover, the price of renewables and overall prices of electricity in the world display a decreasing trend while the introduction of new technologies in energy efficiency, storage, and the interconnection of electricity networks open up new opportunities for electricity markets. Therefore, the fixed price in the nuclear deals sets a commitment at a potentially higher-than-market price for the years 2030-2040. [72]

On the other hand, these concerns for the price of electricity should be evaluated keeping in mind that by placing all the financial responsibility on the project company, the BOO agreement for Akkuyu offers Turkey a deal for nuclear energy immune to the investment cost. Accordingly, other experts such as Kumbaroğlu assess that the agreement is "an economically advantageous deal for Turkey provided that safety measures and regulations related to the construction, operation, and maintenance of the reactor, as well as related to waste transport and management activities are all well-defined and provide convincing confidence and reliability regarding the risk of an accident and nuclear leakage."[73]

3.5. Safety and Nuclear Energy

Nuclear safety and security constitute the most important dimensions of nuclear energy, because the cost and impact of nuclear accidents and high-level radioactive leakages for human lives and the environment are beyond calculation. Accordingly, informed, committed, and responsible political engagement to alleviate safety risks is a central element of any national nuclear energy initiative.[74]

A major challenge for nuclear energy relates to the problem of radioactive waste management. How to deal with the radioactive waste is still an important question that the global nuclear industry is working on to improve safe and proven solutions. Mismanagement and improper waste disposal inherit the risk of having devastating effects on the environment and on human lives. What makes the issue more critical is the fact that nuclear waste has to be stored for many years, making it a concern for future generations as well.

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[70] TMMOB, *NKP`den Japonya ile Sinop`ta Nükleer Santral Kurulmasına İlişkin Anlaşmanın Reddedilmesi İçin TBMM`ye Çağrı*. 2015.

[71] TMMOB, *Türkiye'nin Enerji Görünümü*, 305.

[72] Damar, "Türkiye'de İzlenen Elektrik Enerjisi Politikaları".

[73] Gürkan Kumbaroğlu, "The Economics of Nuclear Power in the Turkish Context" (Istanbul: EDAM Publication, 2011).

[74] Global Relations Forum, T*urkish Energy Strategy in the 21th Century: Weathering Uncertainties and Discontinuities*. Task Force Report (2013).

The regulation of nuclear safety falls under the responsibility of national governments. However, given the trans-border effects of the risks, in order to protect the people and the environment from the harmful effects of radiation, a broad international consensus exists on radioactive waste management. The IAEA sets the standards for safety and security principles, with requirements and recommendations for every stage of the nuclear lifecycle.[75] Harmonization of these international standards with the national framework is important. However, the internalization and strict application of the measures are more critical, especially in newcomer countries and new power plants: studies reveal that newly built NPPs are more prone to safety risks due to manufacturing defects, material imperfections, or human error.[76]

In making the decision to build NPPs, Turkey is also taking on the risks associated with nuclear energy: risks of accident-related radiation leakages, radioactive waste and storage problems, potential adverse effects on marine life, the challenge of protecting the nuclear power plant against terrorist attacks, and providing for the safekeeping of highly strategic materials.[77] While Turkey has taken steps regarding the legal framework for regulating these matters, further alignment with international safety and security regime remains a priority.[78] Additionally, the construction of Akkuyu in a region prone to earthquakes is a high risk factor requiring strategic environmental assessments, which were also referred to in the European Parliament resolution of 14 April 2016. Moreover, memories of some politicians' reactions to the radioactive leakage from Chernobyl reaching Turkey back in the late 1980s[79] remain fresh. As a result, a perception that policymakers are downplaying the risks of nuclear power results in major concerns especially among the critics of Turkey's nuclear energy policy.[80] All these components offer room for progress for Turkey, to further develop its oversight mechanisms for monitoring nuclear processes through its independent authority, and to work on its "safety culture," which requires a deeper transformation in risk perception.

In the sphere of safety for Akkuyu, two issues remain open for further discussion and clarification: waste management and third-party liability. According to the agreement, Rosatom is responsible for the management of nuclear waste

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[75] IAEA. *IAEA Safety Standards* (2018).

[76] Benjamin K Sovacool, "Questioning a Nuclear Renaissance". *GPPi Policy Paper* 8 (2010): 8-9.

[77] For a very detailed analysis of these threats please see: EDAM, *Nuclear Security*, and EDAM, *Managing the Risks of Nuclear Energy: The Turkish Case* (2016), http://edam.org.tr/wp-content/uploads/2016/01/edam_managing_nuclear_risks_report.pdf

[78] Global Relations Forum, Turkish Energy Strategy in the 21th Century: *Weathering Uncertainties and Discontinuities*. Task Force Report (2013), 17.

[79] As a response to the claims that radioactive rainfall affected the Black Sea region in northern Turkey, famous for its tea and hazelnut crops as the main source of income, former President Kenan Evren stated that radiation cannot harm us and former Minister for Industry and Trade, Cahit Aral, drank tea in front of the press officially denying any danger of contamination.

[80] Necdet Pamir, *Enerji'nin İktidarı* (Istanbul: Hayykitap, 2016).

(the spent nuclear waste can be shipped back to Russia for reprocessing) and decommissioning of the power station. For every kWh of electricity sold to Turkey, Rosatom will pay 0.15 US cents to two funds, allocated to waste management and decommissioning.[81] Further information begs clarification regarding waste management, transport routes, and safety measures to be taken while transferring the spent fuel to Russia. Similarly, Article 16 of the Akkuyu agreement declares that "the third party civil liability will be determined according to the international agreements to which Turkey is or will be party to and to Turkey's domestic laws and regulations."[82] Currently, there is no insurance limit determined for Akkuyu regarding the cost of a severe nuclear accident.

In general, a critical point in BOO model investments concerns the incentives to decrease costs by reducing quality. A fixed price contract is usually associated with an impetus for the company to decrease the cost to the lowest levels.[83] In the case of an NPP, this incentive would clearly be in contradiction to globally required safety standards, and it would create potential deficits in safety and security. While such a motivation would not be compatible with Russia's efforts to lead the emerging markets in nuclear energy, Turkey still requires solid safety regulation and implementation schemes to supervise both the construction and operation processes.

3.6. Security and Nuclear Energy

In terms of security, NPPs involve several risks, such as unintentional release of radiological material, nuclear terrorism, theft of radiological materials, and insider or outsider attacks targeting the reactor site. Sagan and Bunn highlight that organizational problems can result in loose security, especially in newcomer countries: "All of the cases of theft of nuclear materials where the circumstances of the theft are known were perpetrated either by insiders or with the help of insiders."[84] In such cases, insider threats pose vital challenges for nuclear security systems by providing intelligence on the weaknesses relevant to a potential attack or sabotage. This intelligence can include information on the operation of NPPs, such as work schedules, facility plans, and safety and security precautions. Moreover, the theft of hazardous materials by criminal or terrorist groups also presents risks to national security. Overall, NPPs in a country can be considered attractive targets by terrorist groups aiming to harm the country or access sensitive materials.[85] Countering these threats requires complex security

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[81] Kumbaroğlu, "The Economics of Nuclear Power"; Ülgen "Turkey and the Bomb".

[82] Kumbaroğlu, "The Economics of Nuclear Power"

[83] İzak Atiyas, "Risks, Incentives and Financing Models of Nuclear Power Plants: International Experiences and the Akkuyu Model" (Istanbul: EDAM Publication, 2011).

[84] Matthew Bunn and Scott D. Sagan, *A Worst Practices Guide to Insider Threats: Lessons from Past Mistakes*, (Cambridge: American Academy of Arts and Sciences, 2014).

[85] EDAM, *Nuclear Security: A Turkish Perspective* (2015), http://edam.org.tr/wp-content/uploads/2015/01/edam_nucphysec2015_full.pdf; Mustafa Kibaroglu, "Nuclear Security and Turkey: Dealing with Nuclear Smuggling" in *Nuclear Security: A Turkish Perspective*, (Istanbul: EDAM Publication, 2015).

structures in line with international requirements, which should be carried out according to global best practices to not only cover the physical security of the NPPs but also ensure cybersecurity and prevent human deficiencies that can lead to insider threats.

In line with its specific security circumstances, Turkey needs to carefully design its nuclear security strategy. Turkey's decades-long experience of terror attacks, as well as the turbulent military and political conditions in its close neighborhood, require a very cautious risk assessment, although experts consider a major military attack targeting Turkey's NPPs an unlikely scenario.[86]

Another important dimension of nuclear security concerns nuclear terrorism and smuggling networks that are directly or indirectly responsible for the acquisition of sensitive and hazardous materials. Turkey, which is situated at the crossroads of Europe and Asia, plays a crucial and committed role in preventing nuclear smuggling, especially on routes that involve the Middle East and the Caucasus.[87]

The treatment of these potential threats to nuclear security becomes a special challenge for Akkuyu due to the BOO model, which grants ownership to Rosatom. This brings along the following question: where will the boundaries be drawn regarding responsibilities for security precautions? The BOO model will require close cooperation between Rosatom and Turkish authorities in matters of the allocation of responsibilities, transportation of nuclear material, and cooperation between intelligence services, which will potentially require the sharing of sensitive and secret information.[88]

3.7. Non-Proliferation and Nuclear Energy

The increase in the number of newcomers represents new risks for world security through the expanded amount of nuclear material in the global market and the diffusion of nuclear technologies. Therefore, the implementation of international regulations and control mechanisms are vital for global efforts to control and govern nuclear activities.

The fact that nuclear technology was first used for military purposes inherently gives nuclear energy a critical status: The interlinked nature of nuclear power and nuclear weapons create security concerns in international fora due to their key, common technologies, notably uranium enrichment and plutonium separation by reprocessing capabilities. Supply of nuclear materials, ionizing

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[86] Sinan Ülgen, "Introduction" in *Nuclear Security: A Turkish Perspective*, (Istanbul: EDAM Publication, 2015).

[87] Ülgen, "Introduction", 78.

[88] Doruk Ergun and Can Kasapoğlu, "Physical Security of Turkey's Prospective Nuclear Infrastructure: Outlook and Challenges" in *Managing the Risks of Nuclear Energy*: The Turkish Case, (Istanbul: EDAM Publication, 2016); Ahmet K. Han, Mitat Çelikpala and Doruk Ergun, "Assessing Turkey's Capacity to Effectively Secure Its Nuclear Infrastructure: The Case for Transparency and an Integrated Approach" in *Nuclear Security: A Turkish Perspective*, (Istanbul: EDAM Publication, 2015).

radiation and related security challenges for the safety of nuclear materials against theft and sabotage[89] connect civilian nuclear power with nuclear proliferation and terrorism risks.[90] With increasing access to nuclear technology, the number of suppliers, and growing global trade ties,[91] the control of this dual use has become even more important.

With its three pillars (nuclear nonproliferation, nuclear disarmament, and peaceful use of nuclear energy) the Nuclear Nonproliferation Treaty (NPT) remains the key cornerstone of the global nonproliferation regime,[92] with the aim of promoting cooperation in the peaceful uses of nuclear energy while preventing the spread of nuclear weapons.[93] The NPT is a kind of "bargain," where "non-nuclear states give up their rights to nuclear weapons in exchange for access to nuclear technology and the commitment that eventually no state will possess nuclear weapons."[94] Countries' right to "develop research, production and use of nuclear energy for peaceful purposes" is protected as an "inalienable right" by Article IV of the NPT.[95] However, due to the nature and historical roots nuclear energy, as well as the NPT regime, all nuclear activities in the scope of "peaceful use of nuclear energy" automatically become an international issue, and become subject to rules and regulations under International Atomic Energy Agency (IAEA) safeguards.[96] This requires all nuclear energy-producing countries that are parties to the safeguard agreements to be ready for inspection of their nuclear facilities by the IAEA and to report their planned nuclear activities.[97]

In recent decades, there has been an increasing interest, especially by developing countries, in accessing nuclear technology and including nuclear energy in their energy portfolios. This has heightened the worries of long-standing nuclear

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[89] Mustafa Kibaroglu, and Baris Caglar, "Nuclear Energy Development and Proliferation Concerns in the Middle East." *ORIENT* I. (2008).

[90] Steven E. Miller, and Scott D. Sagan, "Nuclear power without nuclear proliferation?" in *The Global Nuclear Future*. The American Academy of Arts & Sciences: Dædalus, Vol.1. (2009).

[91] Sinan Ülgen, "The Security Dimension of Turkey's Nuclear Program: Nuclear Diplomacy and Non-Proliferation Policies" in *The Turkish Model for Transition to Nuclear Power* (Istanbul: EDAM Publication, 2011), 137-180.

[92] Şebnem Udum, "The Role of Turkey in the 2015 NPT Review Conference." *EDAM Discussion Paper Series* 2015/1, May 4, (2015).

[93] Kibaroglu and Caglar, "Nuclear Energy Development"

[94] Ülgen, "The Security Dimension".

[95] Article IV of the Treaty on the Nonproliferation of Nuclear Weapons (NPT) states: 1. Nothing in this Treaty shall be interpreted as affecting the inalienable right of all the Parties to the Treaty to develop research, production and use of nuclear energy for peaceful purposes without discrimination and in conformity with Articles I and II of this Treaty. 2. All the Parties to the Treaty undertake to facilitate, and have the right to participate in, the fullest possible exchange of equipment, materials and scientific and technological information for the peaceful uses of nuclear energy. (Source: http://www.un.org/en/conf/npt/2005/npttreaty.html).

[96] Şebnem Udum, "Nuclear Energy and International Relations: Outlook and Challenges for Newcomers." *Perceptions* XXII, no: 2-3 (2017): 57-84.; Ülgen, "The Security Dimension".

[97] Udum, "Nuclear Energy and International Relations".

powers regarding their influence over and control of nuclear technologies, relative to the new block of "newcomers."[98] Nevertheless, concerns over security or potential dual usage of nuclear technologies do not focus solely on the newcomers. The threat of terrorist attacks by international terrorist organizations using nuclear and radiological material or targeting nuclear facilities remains high on the international security agenda going beyond state-level proliferation. [99]

Throughout history, Turkey's efforts to build nuclear power plants has been accompanied by the discussion of Western security analysts about Turkey's intentions on nuclear weapons.[100] In the initial phases of Ankara's efforts to obtain peaceful nuclear power, Western suppliers' fear of a Pakistani connection and allegations of – actual or potential – illicit cooperation with Pakistan, overshadowed Turkey's attempts. These arguments were further sharpened by remarks from a few Turkish politicians who were later criticized as being "irresponsible and reckless."[101]

Contrary to those speculations of the past, Turkey has always demonstrated full commitment to the international nonproliferation regime. It became a member of the IAEA on July 19, 1957, signed the Treaty on the Non-Proliferation of Nuclear Weapons on January 28, 1969, and ratified it on April 17, 1980.[102] The official Turkish position is entirely against the proliferation of weapons of mass destruction (WMDs) and provides full support for non-proliferation initiatives. The country has a very clean record and an outlook in favor of a regional nuclear weapons-free zone, as well as eventual global nuclear disarmament.[103] In addition to the NPT, Turkey is also a signatory of the Comprehensive Test Ban Treaty, the Chemical Weapons Convention, the Biological Weapons Convention, and the Additional Protocol (INFCIRC/540), which expands the IAEA's rights of access to information and nuclear sites in states for a fuller picture of such countries' nuclear programs, plans, nuclear material holdings, and trade.[104]

On the other hand, together with non-proliferation, Turkey is also strongly committed to ensuring the safe, secure, and peaceful utilization of nuclear energy, standing up against any efforts to constrain the exchange of nuclear-sensitive materials in the scope of energy production and countries' rights to the peaceful use of nuclear energy under Article IV of the NPT. In that regard, Turkey's major concern has been the fear that international restrictions on

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[98] Ülgen, "The Security Dimension".

[99] Udum, "Nuclear Energy and International Relations".

[100] Mustafa Kibaroğlu, "Energy or Weapon? Two Faces of Nuclear" *Ortadoğu Analiz* Ekim 5, no: 58, (2013).

[101] Mustafa Kibaroğlu, "Turkey's Quest for Peaceful Nuclear Power." *Nonproliferation Review* Spring-Summer 33-34 (1997): 41.

[102] UN, *Treaty on the Non-Proliferation of Nuclear Weapon*s (2019), http://disarmament.un.org/treaties/t/npt

[103] Ülgen, "The Security Dimension"; Ülgen, "Turkey and the Bomb."

[104] IAEA, *Additional Protocol* (2019), https://www.iaea.org/topics/additional-protocol.

accessing enrichment and reprocessing technologies for nuclear energy will hamper its nuclear energy program and will force nuclear-aspirant countries to be dependent on existing nuclear suppliers, which contradicts the ultimate aim of increased energy independence.[105]

Turkey's interpretation of Article IV and its critical perspective on international efforts to limit nuclear-aspirant countries from accessing enrichment and reprocessing technologies for civilian purposes have created disagreements with some of its Western allies.[106] Nonetheless, protecting its right to peaceful use of nuclear power and its commitment to the IAEA safeguards have remained at the heart of Turkey's nuclear diplomacy. "Disarmament, non-proliferation and arms control are of critical importance for global security and peace. Turkey's ultimate goal is to see a world free of nuclear weapons," Foreign Minister Çavuşoğlu said on February 25, 2019, at the UN's Disarmament Conference held in Geneva, Switzerland.[107] Earlier in 2018, he had also strictly rejected criticisms of Turkey's nuclear energy program, stating, "some people don't know the difference between a nuclear power plant and a nuclear weapon."[108]

As a long-time member of the North Atlantic Treaty Organization (NATO), a party to the Western approach to deterrence, and an EU candidate country, any attempt by Turkey to proliferate would not only be against international law,[109] but also imperil its "international standing, undermine its economic resurgence, and seriously damage its relations with the United States and its other NATO allies."[110] Developing an independent weapons capability by dismissing its non-nuclear diplomacy and NATO security guarantee would have no place in a rational decision making scheme. On the contrary, it would further risk Turkey's security. Consequently, investing intellectual and diplomatic capital in global non-proliferation and security efforts remains a vital requirement for Turkey's nuclear energy strategy.[111]

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[105] Ülgen, "Turkey and the Bomb."

[106] Ülgen, "Turkey and the Bomb."

[107] Hürriyet Daily News, "Turkey wants to see world free of nuclear weapons: FM", February 26, 2019, http://www.hurriyetdailynews.com/turkey-wants-to-see-world-free-of-nuclear-weapons-fm-141486.

[108] TRTWorld, "Turkey against nuclear weapons,not nuclear energy says Turkish FM", April 5, 2018, https://www.trtworld.com/turkey/turkey-against-nuclear-weapons-not-nuclear-energy-says-turkish-fm-16500

[109] Kibaroğlu, "Energy or Weapon?"

[110] Ülgen, "Turkey and the Bomb."

[111] Global Relations Forum, *Turkish Energy Strategy in the 21th Century: Weathering Uncertainties and Discontinuities.* Task Force Report (2013).

3.8. Intertwined Technologies: The Survival of Nuclear Power

Despite multiplying costs, political hurdles, technical challenges of waste management, demands for increased safety measures, and escalating need for government financial concessions and guarantees, there is still strong commitment to nuclear power projects in certain countries.[112] Nuclear energy (though with a limited share in the world energy mix) resists not only all these challenges but also changing market conditions and alternative energy technologies. What sustains nuclear energy seems to be more than its low-carbon nature and reliable electricity supplies.

Some experts emphasize that nuclear weapon states remain the major supporters of nuclear energy and ask whether "military interests serve as one of the drivers for plant-life extension and new-build."[113] To illustrate, in the US, nuclear developers argue that the nation's role as a developer of civilian nuclear power plants is correlated with the country's national security, especially with the naval nuclear propulsion[114] industry.[115] The naval nuclear propulsion industry is instrumental in reinforcing nuclear submarine capabilities, which in turn are considered an important component of the country's global strategic leadership.[116] Similarly, another linkage can be established with nuclear technology for space research. Nuclear propulsion is considered well-suited for space travel and rockets. As a recent example, NASA's Kilopower project aims to develop technologies for an affordable fission nuclear power system to enable long-duration stays on planetary surfaces.[117] In this context, the persistence of support for civil nuclear power is usually associated with the maintenance of national military capabilities other than nuclear weapons, as well as the maintenance and development of technical expertise in other areas, such as space research, which are considered focal points of global prestige and leadership.

The survival of nuclear energy is thus perceived to be vitally linked to national interest from a technological perspective: "Nuclear power and a robust associated supply chain (equipment, services, people) are intimately connected with leadership in global nuclear nonproliferation policy and norms, and with

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[112] Holly Watt, "Hinkley Point: The 'dreadful Deal' behind the World's Most Expensive Power Plant", *The Guardian*, December, 21, 2017, https://www.theguardian.com/news/2017/dec/21/hinkley-point-c-dreadful-deal-behind-worlds-most- expensive-power-plant

[113] Schneider et al. *The World Nuclear Industry Status Report*.

[114] Naval nuclear propulsion uses nuclear reaction as the primary power source for submarines.

[115] Bloomberg, "CEOs Ask Trump to Help Them".

[116] Schneider et al. *The World Nuclear Industry Status Report,* 175.

[117] NASA, *Kilopower*, 2020. https://www.nasa.gov/directorates/spacetech/kilopower

the nation's nuclear security capabilities."[118] Indeed, most discussions of the interconnections between the civil nuclear industry and security or weapons proliferation concentrates on the production of fissile material (especially plutonium and highly-enriched uranium). However, this interconnection includes more than this: industrial interdependencies between civil and military nuclear capabilities also involve nuclear skills, expertise, education, research, design, and engineering.[119] Therefore, skills management and technological progress remain a key motivation in supporting nuclear energy, which can be perceived by states as an indicator of their national position in the global arena.

4. Evaluating Turkey's Nuclear Energy Program

4.1. Strengths

A major strength of a nuclear energy program rests in its contribution to a low-carbon future and a secure energy supply. Overall, in comparison to a projected reliance on fossil fuels, increasing the share of low-carbon resources in its energy mix is of high interest for Turkey. From the supply security dimension, diversification of the energy portfolio would certainly increase Turkey's energy security, especially if it helped mitigate reliance on imported natural gas. In this regard, nuclear can be counted among Turkey's alternative options under the condition of nuclear safety and security principles. In its current format (the BOO model), the Akkuyu deal seems more like an electricity purchase agreement than a "national" option as framed by the official discourse. Nonetheless, the Akkuyu NPP could still increase Turkey's electricity supply capacity.

Since financial hurdles are on the table for Sinop and potentially for the third NPP as well, the Akkuyu deal, which put the economic burden of initial capital investment on a Russian company, has been evaluated as advantageous for Turkey. Setting aside concerns over potential weaknesses and risks arising from this BOO type of agreement, one can conclude that both economic and operational risks rest on Rosatom during the construction phase of the project.

4.2. Weaknesses

Internalization of safety and security principles is one of the most critical concerns for Turkey's nuclear energy program. Each and every person involved in the planning, construction and operation of the NPPs, from suppliers to security personnel, should be fully devoted to nuclear security culture, which prioritizes human lives over everything else. Combined with regulatory and enforcement capacity for nuclear safety, it will take time for Turkey to consolidate its safety

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[118] Energy Futures Initiative, "The US Nuclear Energy Enterprise: A Key National Security Enabler" (2017): 6-7, https://static1.squarespace.com/static/58ec123cb3db2bd94e057628/t/5992f7e0bf629ad8f9d575ec/1502803938248/EFI+Nuclear+Repo rt+FINAL+08.2017.pdf

[119] Andy Stirling and Phil Johnstone, "A global picture of industrial interdependencies between civil and military nuclear infrastructures" *Nuclear Monitor* 868 (October 23, 2018).

culture. On the other hand, given the ambitious operation date targets and the number of reactors to be built until the 2030s, Turkey needs to increase the pace of progress in augmenting its existing capabilities and regulatory structures so as to meet and build on international safety and security standards.

Capacity building should also take place in the sphere of human capital. Turkey needs to evaluate its human resources in nuclear engineering, policy making, and regulations, while investing in its personnel to reach the required human capacity in terms of both numbers and competence.

Problems regarding waste management are not unique to Turkey, as this is one of the most contested aspects of the nuclear industry. However, Turkey's waste management policy should be clear even before its first nuclear reactor begins operation. The management of high-level waste, both physically and legally, stands out as a major weakness of nuclear energy and begs further measures and technologies for the sake of environmental safety and human health. Exclusively for Akkuyu, where the waste will be managed by Russia, the routes, means, and secure transportation of the spent fuel require further clarification.

Another weakness concerns the involvement of the public in policy-making processes. While nuclear energy is by its nature a hot public debate, with such a decisive nuclear energy agenda, Turkey needs to reconsider its public diplomacy. Being transparent and responsive to public concerns, establishing open public platforms, organizing national debates, and providing impartial, scientific, and clear data about the public's burning questions can be the first steps.

There are also certain weaknesses specific to the Akkuyu NPP, the first of which is its fixed electricity price. Some experts consider the deal a successful one, as explained in detail in section 3.4 on the economics of nuclear energy. However, it locks Turkey into a fixed price level for the next couple of decades, in an era when technological innovations in energy resources and systems are rolling out faster than ever. The second issue concerns clearance, intelligence, and security coordination with Russia, which could require the sharing of sensitive information. While this is an area open for improvement, how the coordination and chain of command will be arranged between the operator, Turkey, and Russia requires further analysis. Last but not least, the language barrier remains one of the major weaknesses for Akkuyu, especially in emergency situations or in the event of a nuclear incident/accident, in the worst-case scenario. The procedures for emergencies and for communication with locals without knowledge of Russian or English should be well defined.

It is true that an approximate amount of $20 billion of Russian investment will further deepen the economic ties between Russia and Turkey. As a solution to the high initial investment costs of nuclear, the Russian offer is also a commercially attractive deal. However, the Akkuyu deal increases Turkey's energy-related reliance on Russia. Although so far the geopolitical divergences between the two states have not heavily affected the project, the issue will remain a potential risk as bilateral relations weather turbulent regional dynamics.

4.3. Threats

As with any NPP, several threats to nuclear safety and security are a concern for Turkey as well: unintentional accidents, natural disasters, and damage to nuclear facilities through deliberate attacks may all have catastrophic results in an already turbulent region. Nevertheless, in addition to the usual risks of a nuclear energy program, Turkey's strategy inherits some unique threats. First, as examined in the proliferation section, Turkey's attempts to acquire nuclear energy have always been perceived with doubt and suspicion by other states, despite the country's staunch adherence to the NPT. Turkey's official nuclear agenda clearly targets civilian usage of nuclear. Still, all the processes, policies, and statements from the Turkish side should remain transparent and clear so as not to give way to any misunderstandings or misinterpretations that could escalate into a foreign policy crisis. In line with the developments regarding Iran's nuclear program or the increased interest in nuclear in the Middle East, Turkey's nuclear strategy will also increasingly come under the spotlight. Decision-makers, state representatives, and public figures should remain conscious of the delicate balance between foreign policy, the NPT, and the nuclear energy agenda. They should try to avoid any risk of miscommunication while defending Turkey's legal rights under Article IV.

Second, given that Turkey's increased energy dependence on Russia is intensified with the Akkuyu deal, one can ask whether the Akkuyu NPP might become a foreign policy tool in bilateral relations. While these kinds of partnerships are always vulnerable in the face of potential tensions, it should be noted that Russia is a global supplier in the nuclear energy market, and that within the scope of a rational decision-making mechanism, manipulating such a partnership for political motives should remain an unreasonable option. This is because any attempt to flout global economic, legal, or security principles on the part of Russia could easily jeopardize its marketing efforts. On the other hand, the political character of the agreement could bring pressure from both Ankara and Moscow for speeding up the construction, licensing, inspection, or other regulatory processes. Given that the target of 2023 for operation is already an ambitious one, any attempt to reduce costs or rush the Akkuyu project at the expense of security and safety would constitute a major threat. Likewise, supervision and control of the power plant should remain immune to any political pressure.

4.4. Opportunities

Several opportunities await Turkish companies in the field of nuclear industry. First, the high level of technology and safety requirements in nuclear can spill over into the related production, manufacturing, and transportation sectors, thereby helping to improve industry standards. While the supply of critical components may remain under the control of Rosatom or other project companies for the foreseeable future, domestic production of other materials and equipment can boost local industries. The International Nuclear Power

Plants Summit, organized each year in Istanbul, is remarkable evidence of this spillover, with more Turkish companies participating in the exhibition each year to demonstrate their willingness and capacity to become suppliers for NPPs.

Turkey's decades-long pursuit of nuclear power has also meant a brain drain for nuclear know-how, with experts compelled to look for job opportunities in companies or universities abroad. Turkey's increased efforts in the construction of NPPs, as well as the establishment of an independent regulatory authority, can create new opportunities to invite this human capital back to the country. Moreover, increasing the number of nuclear engineering departments in universities and reinforcing local expertise for regulations, safety measures, NPP management, and public relations through training programs, starting at the university level, could offer Turkey the ability to expand its human capacity. For Turkey, investment in human capital, by educating local experts to design and run nuclear power plants, stands out as a major long-term target. Moreover, establishing a multidisciplinary Nuclear Research & Policy Center, [120] either positioned within a university or structured as an independent research institution, promises great potential for national policy formulation, international policy education and global research partnerships.

Finally, for a country so determined to engage in nuclear energy generation, creating national debate platforms and increasing the opportunities to discuss both the positive and the negative aspects of nuclear energy – together with its economic, social, and environmental dimensions – would create a healthier environment for nuclear policy making.

5. Conclusion

This study has aimed to review major issues in nuclear energy and evaluate Turkey's nuclear energy program with regards to its strengths, weaknesses, threats and opportunities. Given that the discussion of nuclear energy in Turkey is very limited, the purpose of this research is to put forward an objective analysis of the prospects, challenges, and issues that require deeper attention.

Technological innovations such as alternative nuclear fuel cycles, the thorium fuel cycle, light water small modular reactors (SMRs), and advancements via both evolutionary and revolutionary designs do increase the opportunities for the future. Nonetheless, as is the case for domestic nuclear policy, these technical trends have to fall within the framework of strengthened global governance. Although decisions for nuclear energy generation are taken at the national level, the risks of nuclear accidents reach beyond boundaries.

Current deficiencies and windows of opportunity regarding nuclear energy

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[120] The name was originally suggested by the Task Force Report of Global Relations Forum: *Turkish Energy Strategy in the 21th Century: Weathering Uncertainties and Discontinuities* (2013).

reveal several lessons. The shadow of past nuclear accidents put safety culture and improved safety measures at the heart of a sustainable nuclear energy policy. No matter how advanced nuclear technology becomes, cautious standard operation measures need to be internalized by all actors. As an important argument suggests: "What makes nuclear plants safer is experience, not new designs. Human factors swamp design."[121] In that respect, Turkey's cooperation with experienced nuclear powers is crucial.

Overall, despite its vulnerabilities, nuclear energy remains a strategic interest for Turkey. Throughout its history, almost every Five-Year Development Plan of every subsequent government depicted nuclear energy as "the future," a priority, or a "Grand Project" for Turkey.[122] In an era where climate change is a pressing challenge and where energy security is a critical component of realpolitik, no technology should be ruled out from the options. However, this should not imply blindly supporting any specific resource of energy either. On the contrary, each resource and innovation should receive an equal amount of attention and be fairly assessed as a potential option. We must not forget that diversification and increased independence in energy security can only be achieved within a broader roadmap for energy transition which targets not only supplies, but also demand management and efficiency. Thus, Turkey needs to demonstrate the same persistence and determination that it does for nuclear energy for efficiency policies, green systems, and renewables too, including solar, wind and geothermal.

A nuclear master plan for Turkey should amount to more than a prestigious and political project. It should implement a strategic roadmap designed in collaboration with the country's scientists and decision makers. An increase in the use of locally sourced components in upcoming projects and interactive engagement between local experts, the public, and state authorities emerge as necessities. The major message for Turkey would be as follows: rather than rushing to generate the first electricity at Akkuyu as early as 2023, accelerate efforts to build capacity in regulation, human resources, and nuclear safety.

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[121] Michael Shellenberger, "Nuclear Industry Must Change — Or Die", *Environmental Progress Website*, February 17, 2017, http://environmentalprogress.org/big-news/2017/2/16/nuclear-must-change-or-die

[122] S. Duygu Sever, "Turkey's Nuclear Energy Policy in the Context of Environment: A case of Europeanization?", *Turkish Studies,* (2019).

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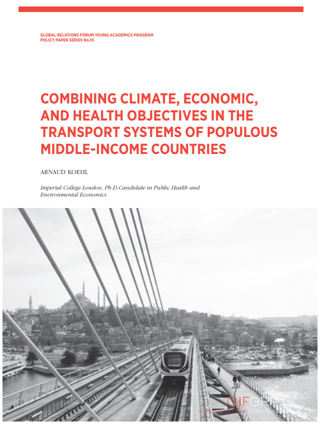

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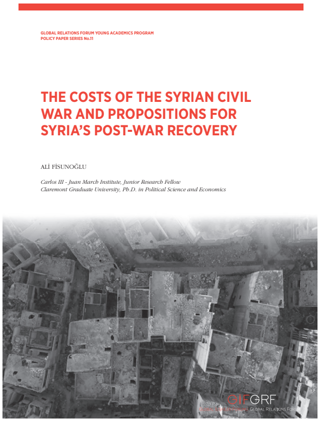

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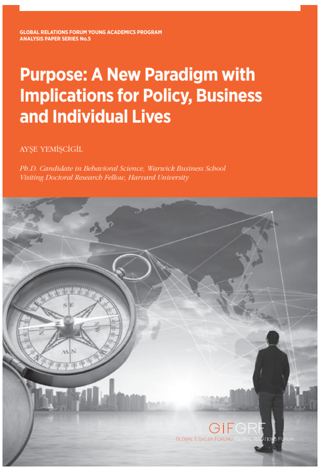

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