The Rise of Rosatom & Russia's Nuclear Revival

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Abstract

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Russia's Rosatom State Corporation has become a major player in the global nuclear energy industry precisely at a time when many former leaders in nuclear power, such as Westinghouse and Orano (Areva), are experiencing difficulties. This study explores the trajectory Rosatom has taken since its formation, its current projects, and future potential. This necessitates an overview of Russian nuclear power's lengthy history from its inception in the Soviet period to the present day, as well as an overview of the current situation of Rosatom's competitors. In particular, I focus on the Build-Own-Operate model of nuclear power plant construction which is currently being pioneered at the Akkuyu Nuclear Power Plant in Southern Turkey. Through a case study of the existing Turkish-Russian energy relationship, I address a series of concerns from energy security to economic rationale from the perspectives of both Russia and the host country. I hypothesize that Build-Own-Operate will revolutionize the industry going forward and give Rosatom a further advantage over its competitors in the years to come.

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INTRODUCTION

Russia has throughout its history experienced the paradox of being both a global leader and lagging behind its competitors. This is true of most if not all industries inherited from the Soviet Union, and Russian nuclear energy was no exception. The Soviet Union bequeathed upon the Russian Federation a nuclear industry that was crumbling, yet this very industry has experienced a renaissance while others, including oil and natural gas, have fallen further behind. In *Lonely Ideas: Can Russia Compete,* Loren Graham outlines, sector by sector, the reasons why throughout the centuries Russia has been both remarkably technologically innovative, yet also unable to sustain its inventiveness and become globally competitive. He argues cycles of rapid development followed by periods of stagnation have marked Russian history since at least the rule of Peter the Great.[1] A recurrent characteristic of Russian technological development which he cites is the use of technology for ideological or presentation purposes, which often minimized, if not completely eliminated the benefits they would have given the country had they been put to more practical use. In no other era in Russian history was this more evident than in the Soviet Union, whether it was "[packing] cosmonauts in a small sphere so tightly that they were arranged around each other like pretzels" so that the Soviet Union could launch three men into space at once before the US could launch two,[2] or the 2,000-mile BAM (Baikal-Amur Mainline) Railway, an "economic blunder of massive proportions" that runs from Novokuznetsk in South-Western Siberia to the shores of the Pacific Ocean in the East, took half a million workers decades to build, and yet is barely used today.[3] Graham also identifies seven barriers that hold back Russia's

[1] Loren Graham, *Lonely Ideas: Can Russia Compete?* Kindle ed., The MIT Press, 2013, p. 110.
[2] Ibid.
[3] Ibid., p. 54.

modernization, including social, political, legal, and educational factors. Interestingly, Dmitry Medvedev identified similar barriers in his 2009 article, "Go Russia!" – "an inefficient economy, semi-Soviet social sphere, fragile democracy, negative demographic trends, and an unstable Caucasus," as well as the "persistent social ills" of "centuries of economic backwardness," "centuries of corruption," and widespread paternalistic attitudes. Most importantly, however, Medvedev returns again and again to the problem of overdependence on exports of raw materials and the need to develop Russia's technological and intellectual resources. Nuclear energy is among the five strategic vectors to which Medvedev assigns top priority for increasing Russia's competitiveness and overcoming its reliance on fossil fuels[4]. In *Lonely Ideas*, Graham identifies nuclear technology, along with space and software technology as "exceptions," or fields in which Russia has managed to become "a powerful world competitor."[5] As this study examines, nuclear energy has played a major role and had a complicated history in both Soviet and present-day Russia, and has indeed emerged as an "exception," a Russian industry that has been able to rise to global prominence.

The reasons for nuclear energy's importance in present-day Russia are not only historical, but also pragmatic. Medvedev's speech came just after global oil prices plummeted, bringing the end of record-high revenues from Russian oil exports. It also coincided with the onset of the Great Recession. Investors, well aware of the Russian economy's dependence on oil revenues, lost their confidence in the country's economic growth and stopped lending to Russian firms and institutions, bringing its banking system to the brink of collapse.[6] This was a wakeup call for

[4] "Dimitry Medvedev's Article, Go Russia!," *President of Russia,* September 10, 2009, Accessed March 3, 2018, http://en.kremlin.ru/events/president/news/5413.
[5] Loren Graham, *Lonely Ideas: Can Russia Compete?*, Kindle ed., ch. 10.
[6] Chris Miller, *Putinomics: Power and Money in Resurgent Russia*, Kindle ed., The University of North Carolina Press, 2018, Ch. 7.

Russian leaders who, despite a decade of unprecedented prosperity, had not forgotten the stagnation and collapse of the Soviet Union and the ensuing economic and social turmoil of the 1990s.

Around this time, it was also becoming increasingly difficult to ignore the substantial technological advances that were taking place elsewhere, particularly hydraulic fracturing, which allowed the United States to surpass Russia as the world's largest producer of natural gas within the space of a few short years. This meant that despite its vast reserves of conventional resources, Russia, which lacked these advanced extraction technologies, was suddenly at a disadvantage. According to a 2015 assessment of 46 countries conducted by the US Energy Information Administration (EIA), at least 419 billion barrels of shale oil and 7,576 trillion cubic feet of shale gas resources are available for extraction worldwide.[7] At the time of publication, commercial production of these resources occurred in only four countries,[8] but it was expected that these techniques would be more widely adopted in the future.[9] New developments are easing gas exports in the form of Liquified Natural Gas (LNG). Floating Storage and Regasification Units, or FSRUs, are enabling both the export and consumption of natural gas without the need for expensive infrastructure and pipelines.[10] It goes without saying that these developments pose a major threat to the Russian Federation's natural gas export prospects, especially if China becomes a major regional competitor. Another global drop in energy prices in 2015 exacerbated the situation for Russian oil and gas. In its height in 2008 Gazprom was the world's third most

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[7] "Four countries added to global shale oil and natural gas resource assessment," *EIA,* December 14, 2015, Accessed April 21, 2018, https://www.eia.gov/todayinenergy/detail.php?id=24132.
[8] These countries were the United States, Canada, China, and Argentina.
[9] Meghan L. O'Sullivan, *Windfall: How the New Energy Abundance Upends Global Politics and Strengthens America's Power,* Kindle ed., p. 73.
[10] Ibid., pp. 73-74.

valuable company after Exxon Mobile and PetroChina.[11] By 2017, however, it had lost over three quarters of its value.[12] This loss can be attributed to political, as well as economic factors.[13] The root cause, however, is the state of the industry and the underlying system inherited from the Soviet Union.

The above examples have illustrated how the Russian oil and natural gas industries are beset with difficulties nearly three decades after the collapse of the Soviet Union. However, the Russian nuclear industry, which faced a crisis late in the Soviet period with Chernobyl, has been able to overcome its Soviet legacy and rise to a level of global competitiveness uncharacteristic of many other Russian industrial sectors. This section examines the rise of the Russian nuclear industry, beginning with its roots in the Soviet Union and tracing it to the present day. It includes an overview of the Rosatom State Corporation and its current projects, as well as a survey of the global industry and Rosatom's competitors. The aim is to highlight Rosatom's advantages in comparison with competing international firms, as well as the ways in which Russia's unique experience in the Soviet period has contributed to its competitiveness today.

Among Rosatom's advantages are its flexible offerings, particularly the Build-Own-Operate (BOO) model of Nuclear Power Plant (NPP) construction.[14] The first such plant is currently under construction in Akkuyu, Turkey. Turkey is an interesting case because it is not only a developing country with growing energy needs, but it is also heavily reliant on Russian natural gas imports. A detailed analysis of the project from both the Russian and Turkish perspectives will help provide insight into what both sides have to gain from the construction of this plant,

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[11] Justin Burke, "How Russian energy giant Gazprom lost $300 bn," *The Guardian*, August 7, 2015, Accessed March 10, 2018, https://www.theguardian.com/world/2015/aug/07/gazprom-oil-company-share-price-collapse.
[12] Chris Miller, *Putinomics: Power and Money in Resurgent Russia*, Kindle ed., Ch. 3.
[13] Ibid.
[14] The BOO model is discussed in detail in Part II.

and the implications this has for global NPP construction. Therefore, Part Two includes an in-depth case study of the Akkuyu plant and Turkish-Russian energy relations. Approaching the issue from these perspectives helps to highlight nuclear power's sustained importance and likely growth in the 21st century. It will thus be made clear that Russia's renewed emphasis on nuclear is no coincidence and will likely bring great benefit in the future, especially as its Western competitors suffer decline.

PART I: THE RISE OF ROSATOM & RUSSIA'S NUCLEAR REVIVAL

A. Nuclear Energy in the Soviet Union:

As Lenin famously said, "communism equals Soviet power plus electrification of the entire country." Development of technology and the fantastical, futuristic benefits it would bring to the people occupied a central role in the concept of building a communist utopia ever since the early days of the USSR, and the development of nuclear technology further enhanced this vision. As in the West, the Soviet nuclear energy program had its roots in the development of military uses. However, the centralized nature of the Soviet Union along with a desire to outpace the West and a view of nuclear technology as a mass-produced cure-all led to a growth in scope and utilization that was unparalleled anywhere else in the world. In *Red Atom,* Paul Josephson addresses the development and impact of nuclear technology on the Soviet Union and its use as a propaganda tool to further the vision of a socialist utopia. The USSR's peaceful nuclear program had its roots in Stalinism but gained pace following Stalin's death and played a central role in the shift in Soviet foreign policy under Khrushchev in order to "demonstrate the peaceful intentions of the nation" and away from "the inevitability of war with the capitalist countries."[15] It also served to enhance Khrushchev's reputation as a "man of science" and underscore the social changes that were taking place during the "thaw" – a refocus on improving the quality of life for the average citizen, who by that time had endured famine, purges, and the death and destruction of World War II. According to Josephson, "[Khrushchev] believed that the Soviet economic and social system would enable the USSR to take advantage of science as the United States could not – for the benefit of all the people and guided by a strictly materialist methodology."[16] Scientists carried a special prestige in this new policy, as they were seen as the ones who would bestow these benefits on the Soviet population.[17] Nuclear energy was a display of this promise with benefits that could be pointed to as visible proof of Soviet superiority and peaceful intentions both at home and abroad.

Power to the People: The Spread of Nuclear Power in the Soviet Socialist Republics

The father of the Soviet peaceful nuclear program (as well as the Soviet atomic bomb) was Igor Kurchatov. Kurchatov oversaw the construction of the world's first nuclear power plant in Obninsk, Russia[18], as well as research reactors in Ukraine, Uzbekistan, Georgia and Latvia, and other research facilities in Azerbaijan, Belarus, and Moldova before his death in 1960.[19] By the 1980s, there were over 40 nuclear reactors in the Soviet Union alone, plus more in the satellites (East Germany, Czechoslovakia, Poland, Romania, Hungary, North Korea, Bulgaria).[20] As nuclear facilities mushroomed at ever-increasing pace near cities, in far-flung regions of

[15] Paul R. Josephson, *Red Atom: Russia's Nuclear Power Program from Stalin to Today*, New York, W. H. Freeman and Company, 1999, p. 3.
[16] Ibid., 223.
[17] Ibid., 4.
[18] The Obninsk Nuclear Power Plant went critical in 1954, three years before the first NPP in the US.
[19] Ibid., 204.
[20] Ibid., 241, 305-306.

Russia, and throughout the Socialist republics, they brought with them the promise of cheap, "safe" energy and a purported increase in the quality of life, and thus served essential propaganda purposes.[21] The expansion of the Soviet nuclear energy sector which began under Khrushchev continued throughout the Brezhnev and early Gorbachev eras, despite growing signs that the nuclear industry was becoming increasingly unsustainable. According to Josephson, by 1984 "reactors had to be shut down more frequently than planned" for a variety of reasons, such as "underfulfillment of nuclear energy plans," and delays in the construction of new plants. The Chernobyl disaster finally brought the industry to a screeching halt, "[leaving] no doubt about the Potemkin park in which engineers had built their two score power reactors."[22]

Chernobyl and the Downfall

Even before the Chernobyl disaster, cracks in the Soviet nuclear infrastructure were starting to show; problems included frequent accidents, inadequate training, and poor construction and management.[23] These were largely ignored by the authorities, and even if taken seriously, nobody at the time would have accepted that the Lenin Chernobyl Atomic Energy Station, a showcase for the USSR, was at risk. The gargantuan facility consisted of four reactors, with an additional two under construction and plans to expand to a total of ten. The meltdown at Chernobyl marked the beginning of the end of Soviet atomic-powered communism, and perhaps even the USSR itself. It was no longer possible to cover up accidents and sweep the issue of nuclear safety under the rug – everything about the Chernobyl disaster: the conditions leading up to it, the way the disaster and cleanup were handled, and its consequences for the people living in the region and elsewhere, exposed the emptiness of the Soviet nuclear program and its inferiority

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[21] Ibid., 4-5, 11.
[22] Ibid., 46.
[23] Ibid., 253.

in comparison with the West. Against the backdrop of Glasnost, it fueled an anti-nuclear movement which only served to exacerbate the collapse of the Eastern Bloc and the Soviet Union in the following years. [24]

The Chernobyl disaster finally led to the authorities' decision to abandon the heavy reliance on inefficient, outdated and unsafe RBMK[25] reactors, halting construction and beginning to phase out or upgrade those that were in uses.[26] The final chapter of *Red Atom* provides a picture of the state of nuclear energy in the years following the dissolution of the USSR. Josephson paints the picture of a region that has been hit hard by the harsh realities and the consequences of nearly half a century of atomic communism. At the time the book was written, one of the problems with which these newly-formed republics had to grapple was the disposal of nuclear waste, including military-grade waste, which was "an order of magnitude larger than that from the civilian sector."[27] In addition, despite the resolutions following Chernobyl, many RBMK plants remained in operation and accidents were still frequent.[28] Given the economic chaos following the collapse of the USSR and the dearth of alternate fuel sources, shutting down these plants remained unrealistic.[29] Furthermore, scientists lost the privileged status they formerly enjoyed in the Soviet times, many emigrating or changing jobs for lack of pay. Those that remained often lacked the resources to conduct experiments, which further undercut Soviet technological prowess. As will be seen in the coming sections, however, this did not spell the end of the Russian nuclear industry. In fact, Rosatom has been able to draw upon the lessons

[24] Ibid., 244, 260.
[25] "*Reaktor Bolshoy Moshchnosty Kanalny*," or "High-Power Channel Reactor." Most NPPs built during the Soviet period up until the Chernobyl disaster were of this design.
[26] Ibid., 260.
[27] Ibid., 281.
[28] Ibid., 290.
[29] Ibid., 266, 293.

learned from Chernobyl to highlight its plants' advanced safety mechanisms and ease concerns about future accidents.

B. The Russian Nuclear Energy Industry's Transformation

This section addresses the transformations the Russian nuclear energy sector has undergone in the 21st century and how the industry has come back from the brink of total collapse to become one of the world's leaders in nuclear power today. It is clear that in the first decade after the fall of the Soviet Union, the future of the Russian nuclear power industry was uncertain, and there were even signs that collapse was imminent. This is not what happened, however – following the first turbulent post-Soviet decade, the industry began to show signs of recovery. In the 21st century Russian nuclear energy technology has rapidly caught up with, and even surpassed that of the West. This unexpected recovery was due to several factors. By the 1990s, many of the Soviet-era power plants were reaching the end of their life cycles and were in need of an upgrade. Additionally, some RBMK reactors were still awaiting their post-Chernobyl safety modifications. Along with these much-needed improvements, construction of new plants domestically resumed in the late 1990s and early 2000s with power stations in Smolensk and Rostov. This also coincided with the sale of reactors to China, India and Iran.[30] These developments gave indication that the Russian nuclear energy industry was beginning to show signs of life, though heavily supported by state subsidization. As improvements continued to be made, the capacity of domestic power stations increased dramatically during this time, from an overall capacity factor of 60% in 1990 to 81% in 2014. This included 11 Soviet-era RBMK

[30] "Nuclear Power in Russia," *World Nuclear Association,* Updated November 2017, Accessed November 19, 2017, http://www.world-nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-power.aspx.

reactors which received 15-year extensions after undergoing renovation to increase efficiency and eliminate safety risks.[31]

The consolidation of the nuclear sector in the mid-2000s may have also facilitated its revival: in 2004, the Ministry for Atomic Energy (MINATOM), formed immediately after the USSR's dissolution, was restructured into the massive Federal Agency on Atomic Energy, a.k.a. Rosatom. Although Rosatom had relatively low priority at the time, this began to change with the appointment one year later of Sergei Kiriyenko, who had served a brief tenure as Prime Minister under the Yeltsin administration, to head of the agency[32] Kiriyenko established the goal of restoring the Russian nuclear industry to its Soviet-era glory, when all nuclear-related activities were organized under the colossal (and cryptically named) Ministry of Medium Machine Building, or "Minsredmash." Rosatom received a boost in 2007 when it became the State Atomic Corporation Rosatom after President Putin signed a law bearing the same name.[33] As a state corporation, this also meant that Rosatom's management reports directly to Putin, who also has the power to appoint or fire the head of the corporation at will.[34]

The Russian nuclear industry was given further support under Dimitry Medvedev's presidency. Medvedev's response to the 2008 oil crisis was to attempt to diversify the Russian economy away from heavy reliance on oil and gas and other raw materials toward sectors in which he believed Russia still had an advantage. [35] In his article "Go, Russia!," written shortly after he assumed the presidency in 2009, Medvedev identified five "strategic vectors" for

[31] Ibid.
[32] Alexander Nikitin, "Rosatom State Corporation," *Bellona,* November 26, 2007, Accessed March 3, 2018, http://bellona.org/news/nuclear-issues/nuclear-russia/2007-11-rosatom-state-corporation.
[33] "Federal'nyy zakon ot 01.12.2007 g. No. 317-F3," *Prezident Rossii,* December 5, 2007, Accessed April 21, 2018, http://kremlin.ru/acts/bank/26621.
[34] Alexander Nikitin, "Rosatom State Corporation," *Bellona,* November 26, 2007, Accessed March 3, 2018, http://bellona.org/news/nuclear-issues/nuclear-russia/2007-11-rosatom-state-corporation.
[35] Chris Miller, *Putinomics: Power and Money in Resurgent Russia*, Kindle ed., Ch. 7.

Russia's economic modernization. Among these were alternate energy sources and energy efficiency, information technology, space and satellite infrastructure, medical equipment, and nuclear power, which he deemed necessary to "maintain and raise…to a qualitatively new level."[36] Heavy investment in these vectors and supporting the necessary knowledge base they required would be essential if Russia was to overcome its "humiliating dependence on raw materials" and combat "centuries of economic backwardness, corruption, and paternalistic attitudes."[37] Later that year, Medvedev elaborated on this by identifying three priority objectives to ensure Russia's nuclear primacy: to "substantially optimize pressurized water nuclear reactors" in the short term, to "create a new technology base for producing nuclear energy using a closed fuel cycle based on breeder reactors" in the medium term, and to "develop and apply controlled thermonuclear fusion as the foundation for the energy of the future" in the long term.[38] This led to a federal target program, "Nuclear Power Technologies of a New Generation for 2010 – 2015 and for the Future till 2020,"[39] aimed at developing fast reactors and resulting in a cost reduction of 36% in electricity production from 2011 to 2017.[40] It also led to the creation of the Proryv ("Breakthrough") project, which aims to close the nuclear fuel cycle, increase safety, reduce costs, and develop nuclear power in Russia.[41]

Rosatom controls all of the Russian Federation's nuclear assets, both civilian and military, though sometimes under various subsidiaries (for example, the division known as Atomenergoprom controls the Russian civilian nuclear industry, and is further divided into

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[36] "Dimitry Medvedev's Article, Go Russia!," *President of Russia,* September 10, 2009, Accessed March 3, 2018.
[37] Ibid.
[38] "Sokhranit' lidiruyushchie pozitsii v atomnoy otrasli Rossii pozvolit realizatsiya tryokh printsipial'nykh zadach," *Prezident Rossii,* July 22, 2009, Accessed March 3, 2018, http://kremlin.ru/events/president/news/4885.
[39] "O proyekte," *Rosatom Proryv,* Accessed March 9, 2018, http://proryv2020.ru/o-proekte/.
[40] "Nuclear Power in Russia," *World Nuclear Association,* Updated February 2018, Accessed March 2, 2018, http://www.world-nuclear.org/information-library/country-profiles/countries-o-s/russia-nuclear-power.aspx.
[41] "O proyekte," *Rosatom Proryv,* Accessed March 9, 2018, http://proryv2020.ru/o-proekte/.

Rosenergoatom, which oversees the operation of domestic nuclear power plants.[42] All this makes Rosatom one of the largest corporations in Russia, with functions as wide-ranging as uranium enrichment, nuclear icebreakers, equipment manufacturing, research, medicine, and of course power plant construction. Rosatom has also recently taken on renewable energy projects in addition to nuclear.[43] An increased share for nuclear in Russia's domestic power production figures into the country's energy policy for the coming decades, as this will decrease reliance on its own oil and gas, freeing up these resources for export abroad. The plan is to build a number of new reactors to maintain and improve domestic nuclear power capacity by replacing older plants that are scheduled for retirement.[44]

C. Global Competitors:

This section provides an overview of Rosatom's current and potential global competitors, mainly American, French, South Korean, and Chinese firms. As will be seen, Westinghouse and Orano (Areva), previously two major players in nuclear power, are experiencing a period of turmoil and uncertainty. The deteriorating influence of formerly big Western players provides a window of opportunity for Russian, and potentially Chinese and South Korean firms to become more widespread.

US (Toshiba-Westinghouse)

By the turn of the century, the nuclear energy states of the former Eastern Bloc had become a post-Cold War battleground, as both the US and Russia fiercely competed for influence in the region's nuclear industry. This was an important foreign policy tool for the US,

[42] "Rosenergoatom," *Rosatom*, Accessed March 11, 2018, http://www.rosatom.ru/en/rosatom-group/power-generation/rosenergoatom/.
[43] "O Rosatome," *Rosatom*, Accessed December 9, 2017, http://www.rosatom.ru/about/.
[44] "Nuclear Power in Russia," *World Nuclear Association*, Updated November 2017.

which believed that reducing the newly-independent states' energy dependence on Russia would help prevent their slipping back into its sphere of influence in the future. As a result, many post-communist states were encouraged, if not required, to obtain fuel from Westinghouse. For example, Westinghouse sourced the fuel rods for the Czech Republic's Temelin plant from the early 2000s until 2010, when Czech energy group *České Energetické Závody* (ČEZ) abandoned Westinghouse entirely in preference of Rosatom's nuclear fuel company TVEL. Ironically, the reason given was that the fuel designed by Westinghouse was of inferior quality and rods were prone to leaks and breakage.[45] This is a stark contrast with quarter century earlier when Russian technology was notably inferior in most regards. Unfortunately, Westinghouse's poor reputation caused it to fall out of favor in the Eastern European market. Nevertheless, as recently as April 2016 Westinghouse was still reiterating its key role in diversification in the European energy market.[46] By this time, however, the company was struggling to remain competitive and its plant construction both in the US and abroad was falling years behind schedule and going over budget.[47] One year later, in spring 2017, Westinghouse filed for Chapter 11 bankruptcy. This can at least partly be attributed to the AP1000 pressurized water reactor, Westinghouse's new design which was supposed to be the world's simplest, safest, and economically competitive power plant.[48] It was expected to revolutionize plant construction and make Westinghouse an

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[45] Kenneth Rapoza, "How Washington Is Fighting For Russia's Old Europe Energy Market," *Forbes*, May 17, 2016, Accessed November 19, 2017, https://www.forbes.com/sites/kenrapoza/2016/05/17/washingtons-european-energy-security-boondoggle/#6d2dd9cd7b32.
[46] "Westinghouse Expands VVER Fuel Capacity to Meet Growing Demand for Diversification in Europe," *Westinghouse*, April 28, 2016, Accessed December 9, 2017, http://www.westinghousenuclear.com/About/News/View/WESTINGHOUSE-EXPANDS-VVER-FUEL-CAPACITY-TO-MEET-GROWING-DEMAND-FOR-DIVERSIFICATION-IN-EUROPE.
[47] Kenneth Rapoza, "A Bankruptcy That Wrecked Global Prospects of American Nuclear Energy," *Forbes*, April 13, 2017, Accessed November 19, 2017, https://www.forbes.com/sites/kenrapoza/2017/04/13/a-bankruptcy-that-wrecked-global-prospects-of-american-nuclear-energy/#5ac3ea017a1a.
[48] "AP1000 Pressurized Water Reactor," *Westinghouse*, Accessed December 9, 2017, http://www.westinghousenuclear.com/New-Plants/AP1000-PWR.

industry leader, but in 2017 the only one with completion in sight was the Sanmen Nuclear Power Station in China. It will be the first reactor to be opened by Westinghouse in over 20 years[49] – the rest have either been delayed or cancelled. One interesting feature of the AP1000 was that it was designed with cost in mind, and like its Soviet predecessors, features a "modular" design with prefabricated parts in order to lower construction costs. In reality, though, construction proved much more complicated – the decision to aggressively push a new, untested design and manufacturing process led to hurdles which proved insurmountable.[50]

Following its bankruptcy, Westinghouse continued to be an unsustainable burden for Toshiba, which was forced to sell its memory chip business just to recoup its losses.[51] Toshiba ultimately had to cut Westinghouse loose, selling it to the Canadian conglomerate Brookfield Business Partners LP for a meager $4.6 billion.[52] At the time of writing it's unclear what lies ahead for Westinghouse, whose sale was announced in January 2018. While it is highly unlikely that Westinghouse will disappear completely from the scene, it also appears equally unlikely that it will regain its former glory in the near future.

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[49] "Russian nuclear ambition powers building at home and abroad," *Reuters*, July 22, 2013, Accessed December 5, 2017, https://www.reuters.com/article/russia-nuclear-rosatom/russian-nuclear-ambition-powers-building-at-home-and-abroad-idUSL5N0F90YK20130722.
[50] Tom Hals & Emily Flitter, "How two cutting edge U.S. nuclear projects bankrupted Westinghouse," *Reuters*, May 1, 2017, Accessed November 19, 2017, https://www.reuters.com/article/us-toshiba-accounting-westinghouse-nucle/how-two-cutting-edge-u-s-nuclear-projects-bankrupted-westinghouse-idUSKBN17Y0CQ.
[51] "Explainer: Toshiba after the Westinghouse sale," *Reuters*, January 5, 2018, https://www.reuters.com/article/us-westinghouse-m-a-toshiba/explainer-toshiba-after-the-westinghouse-sale-idUSKBN1EU0S3.
[52] Dana Mattioli, et al., "Westinghouse, Once an Industrial Powerhouse, Is on Brink of Sale," *The Wall Street Journal*, January 4, 2018, https://www.wsj.com/articles/brookfield-business-partners-to-acquire-westinghouse-for-4-6-billion-1515075664.

South Korea (KEPCO)

With 24 operational units,[53] nuclear energy provides about one third of South Korea's energy needs.[54] South Korea is also a prominent exporter of nuclear technology under the Nu-Tech 2030 plan, which originally sought to build 80 reactors abroad by 2030, even though this number was greatly reduced to six several years later.[55] KEPCO's most prominent recent project has been its $20 billion contract for the construction of four reactors in the UAE.[56] The role of nuclear in South Korea's energy mix was briefly called into question when president Moon Jae-in vowed to "pave the way for a nuclear-free era," beginning with the retirement of the country's oldest nuclear reactor in 2017.[57] Perhaps because South Korea is one of the few advanced nuclear countries in which the industry appears to be doing well, President Moon recently announced a reversal in his plans to phase out Korean nuclear power.[58] It would evidently be too hard to encourage nuclear plant construction abroad while simultaneously opposing it at home, and the resulting rise in electricity costs from alternate fuel sources would be unpopular with the Korean populace.[59]

China (CGN)

China appears to be Russia's most likely competitor for global nuclear primacy. Faced with increasing pollution and health risks due to its heavy reliance on coal, China has implemented a comprehensive policy to rapidly develop its nuclear infrastructure and aims to

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[53] Mycle Schneider & Antony Froggatt, *The World Nuclear Industry Status Report 2017*, Paris, Mycle Schneider Consulting, 2017, p.145
[54] Daniel Shane, "South Korea does a sudden U-turn on nuclear power," *CNN Money*, October 20, 2017, Accessed March 4, 2018, http://money.cnn.com/2017/10/20/news/economy/south-korea-nuclear-power-moon/index.html.
[55] "Nuclear Power in South Korea," *World Nuclear Association,* Updated December 2017, Accessed March 4, 2018, http://www.world-nuclear.org/information-library/country-profiles/countries-o-s/south-korea.aspx.
[56] Ibid.
[57] Schneider & Froggatt, *The World Nuclear Industry Status Report 2017*, p. 69.
[58] Daniel Shane, "South Korea does a sudden U-turn on nuclear power," *CNN Money,* October 20, 2017.
[59] Ibid.

achieve 10% of its total power generation from nuclear by 2030.[60] With 38 operational NPPs, China has already joined the ranks of countries with the most NPPs in operation, behind the United States, France, and Japan. This reflects a more than tenfold increase since the start of the millennium, and there are currently 20 more under construction.[61] Thanks in large part to a technology transfer agreement with Westinghouse, China has also become self-sufficient with regards to nuclear technology, having developed its own CAP-1400 plants based off Westinghouse's AP-1000 design.[62] Though China eyes self-sufficiency, its nuclear program is characterized by collaboration with other countries. Priority has been given to the development of advanced Generation IV reactors [63] and small modular reactor (SMR) technology, and in 2014 a deal to build floating nuclear plants was signed between China's Atomic Energy Authority and Rosatom.[64]

The Chinese government has also recently shifted its focus to exports with its 'go global' policy and Belt and Road Initiative.[65] China's growing expertise in the field, as well as a reputation for completing plants quickly and within budget,[66] will likely help its future expansion. However, China is still a relatively new player globally and lacks the many years of experience that Russia possesses, and, with the exception of Pakistan, the foreign projects which

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[60] "Nuclear Power in China," *World Nuclear Association*, Updated March 2018, Accessed March 10, 2018, http://www.world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power.aspx.

[61] Laura Gil, "How China has Become the World's Fastest Expanding Nuclear Power Producer," *IAEA*, October 25, 2017, Accessed March 10, 2018, https://www.iaea.org/newscenter/news/how-china-has-become-the-worlds-fastest-expanding-nuclear-power-producer.

[62] Joe McDonald, "China sets sights on new global export: nuclear energy," *Phys.org*, August 24, 2016, Accessed March 10, 2018, https://phys.org/news/2016-08-china-sights-global-export-nuclear.html.

[63] Generation IV refers to advanced nuclear power technology which is currently under development. Most nuclear power plants in operation today are Generation II, while recently-built plants and those which are currently under construction employ Generation III technology. For more information, see Montgomery & Graham., "Seeing the Light: The Case for Nuclear Power in the 21st Century," pp. 89-91.

[64] Scott Montgomery & Thomas Graham Jr., "Seeing the Light: The Case for Nuclear Power in the 21st Century," New York, Cambridge University Press, 2017, p. 264.

[65] "Nuclear Power in China," *World Nuclear Association*, Updated March 2018.

[66] Camila Ruz, "Why does the UK need China to build its nuclear plants," *BBC*, September 25, 2015, Accessed March 10, 2018, http://www.bbc.com/news/magazine-34329617.

it has announced have yet to materialize.[67] Given the speed at which the Chinese nuclear industry is developing, this will likely change in the near future.

France (Orano)

France is another major player in the nuclear power industry. Owing to a government decision following the first oil shock in 1974 and a scarcity of natural fuel resources, the government decided to invest heavily in nuclear power. As a result, nuclear now provides slightly over 75 percent of France's domestic energy needs and has also made France the world's largest net exporter of electric power.[68] However, Areva, the French government-owned energy corporation, was hard hit by both a slump in demand post-Fukushima and a quality-control records falsification scandal in 2016,[69] resulting in total net losses of more than €7 billion from 2014 to 2016. By this time construction of plants in Finland and China, in addition to two in France had already been subjected to multiple delays.[70] All this forced Areva to announce in 2016 its sale to French utility company Électricité de France S.A. (EDF).[71] What remained of Areva was rebranded as "New Areva," or NewCo, a new company focused solely on the nuclear fuel cycle,[72] and was subsequently renamed Orano in early 2018.[73] Unlike Westinghouse, both Areva and EDF are majority-owned by the French government, which means Areva's purchase essentially amounted to a government bailout. While this ensures Orano's continued existence, it is unclear when and if the company will once again become profitable, especially when taking

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[67] "Nuclear Power in China," *World Nuclear Association*, Updated March 2018.
[68] "Nuclear Power in France," *World Nuclear Association*, Updated January 2018, Accessed March 4, 2018, http://www.world-nuclear.org/information-library/country-profiles/countries-a-f/france.aspx.
[69] "Nuclear cracks are beginning to show," *Nuclear Engineering International*, March 21, 2017, Accessed March 2, 2018, http://www.neimagazine.com/features/featurenuclear-cracks-are-beginning-to-show-5768266/.
[70] Schneider & Froggatt, *The World Nuclear Industry Status Report 2017*, pp. 136-137.
[71] "Nuclear cracks are beginning to show," *Nuclear Engineering International*, March 21, 2017.
[72] "Areva outlines restructuring plan," *World Nuclear News*, June 15, 2016, Accessed March 2, 2018. http://www.world-nuclear-news.org/C-Areva-outlines-restructuring-plan-1506164.html.
[73] "New Areva changes name to Orano," *World Nuclear News*, January 23, 2018, Accessed March 2, 2018, http://www.world-nuclear-news.org/C-New-Areva-changes-name-to-Orano-2301185.html.

into account the French government's plans to reduce the share of nuclear energy in domestic power generation to one half by 2025, necessitating the shutdown of one third of its reactors.[74] This *Energy Transition for Green Growth Act*, however, takes for granted the participation of future leaders as well as the development of renewable solar and wind technology to a level of efficiency that has yet to be achieved.[75] A further complication is the difficulty in compensating for the variable electrical output generated by wind and solar power as weather patterns fluctuate. While this is true for any country attempting to introduce renewable energy, it is rendered more problematic in France due to its high reliance on nuclear. Nuclear power plants are typically designed to generate a steady supply of energy over an extended period and thus do not lend themselves to ramped output. In most countries renewable energy replaces other power sources, such as coal, that are more readily adaptable, but in France any significant expansion of renewable energy would make this issue more acute as it would be eating directly into nuclear's share.[76]

Lastly, for a country as dependent on nuclear power as France, the task of phasing out nuclear power may simply be too great. In addition to the political and technical factors outlined above, one must also take into account the human capital invested in the country's far-reaching nuclear energy industry. The decommissioning of nuclear plants in large numbers would necessitate a plan for the large numbers of people formerly employed in the industry. As a result, it is likely that nuclear will at least retain its large domestic role in France for the foreseeable future. With regard to exports, French leaders may reach a conclusion similar to that of South

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[74] Schneider & Froggatt, *The World Nuclear Industry Status Report 2017*, pp. 21, 38, 44
[75] Scott Montgomery & Thomas Graham Jr, *Seeing the Light: The Case for Nuclear Power in the 21st Century*, pp. 258-259.
[76] Craig Morris, "Why France really has to postpone its nuclear reduction," *Energy Transition*, November 20, 2017, https://energytransition.org/2017/11/why-france-really-had-to-postpone-its-nuclear-reduction/.

Korea; that it is difficult to support expansion abroad while opposing it at home. In addition, France has significantly more international expertise than the former.[77] It is unclear whether Orano will be able to fully overcome its current financial difficulties. If it is able to, however, it carries the potential to once again pose major competition to Rosatom.

Part II: Rosatom's International Expansion

A. Current & Planned Projects

Rosatom has achieved major success in the international markets through sales of fuel and power plant construction, and in 2016 its foreign orders totaled $133 billion.[78] There are currently seven post-Soviet Russian-built power plants in operation in Ukraine, Iran, China and India[79] and more under construction or contracted in Bangladesh, Belarus, China, Egypt, Finland, Hungary, India, Iran, and Turkey.[80] The plant in Turkey is unique in that it will be the first to operate under a BOO (Build-Own-Operate) model, discussed in detail in the following section. Foreign plant construction has been incredibly profitable for Rosatom – every ruble spent on foreign nuclear power plants has yielded two rubles in return, and the company expects to be involved in the construction of four to five power plants every year starting in 2020,[81] with orders for at least 80 reactors by 2030.[82] If accurate, this will help the company to be profitable without relying on government support. It was announced that the government would stop subsidizing foreign plant construction in 2020.[83]

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[77] "Nuclear Power in France," World Nuclear Association, Updated January 2018.
[78] "Proekty," *Rosatom*, Accessed April 21, 2018, http://www.rosatom.ru/investor/projects/.
[79] Nuclear Power in Russia, *World Nuclear Association*, Updated November 2017.
[80] "Projects," *Rosatom*, Accessed March 11, 2018, http://www.rosatom.ru/en/investors/projects/.
[81] "Nuclear Power in Russia," *World Nuclear Association*, Updated November 2017.
[82] "Russian nuclear ambition powers building at home and abroad," *Reuters*, July 22, 2013.
[83] "Nuclear Power in Russia," *World Nuclear Association*, Updated November 2017.

Rosatom is on the rise internationally and seems to be well-positioned to benefit from an expected rise in global demand for nuclear power thanks to its range of products, affordability, and flexible options such as BOO. These all give it a unique advantage over its rivals, especially in developing countries. Russia has come a long way since the Soviet days - it has managed to use the legacy of Chernobyl to its benefit by highlighting the experience it has gained from the disaster, its role as the first state to develop nuclear power and its many years of Soviet experience.[84] Rosatom particularly emphasizes that it is the first company to incorporate into its standard design a "core-catcher," a device designed to trap and rapidly cool the molten reactor core in the event of a meltdown. The core-catchers used today have their roots in the Chernobyl crisis, when physicist Leonid Bolshov was called upon to engineer a device to halt the downward flow of the reactor's core. Bolshov became the director of the Nuclear Safety Institute of the Russian Academy of Science, a post which he holds to this day.[85] Adopting the core-catcher as a standard component of all their NPPs has not only helped to dispel doubts about the safety of Russian technology, but also gives Rosatom an advantage over its competitors, some of which have yet to fully incorporate this added safety feature.[86] Recently, top priority has been given to the development of new, safer nuclear plant technology such as fast reactors and a closed fuel cycle.[87] All this means that Rosatom will likely see further growth both within Russia and internationally in the coming years, especially as Western firms continue to struggle. If Rosatom continues to expand and develop its technology, it will be poised to dominate the industry.

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[84] "Russian nuclear ambition powers building at home and abroad," July 22, 2013.
[85] Eve Conant, "To Catch a Falling Core: Lessons of Chernobyl for Russian Nuclear Industry," *Pulitzer Center,* September 18, 2012, https://pulitzercenter.org/reporting/catch-falling-core-lessons-chernobyl-russian-nuclear-industry.
[86] Ibid.
[87] "Nuclear Power in Russia," *World Nuclear Association*, Updated November 2017.

B. Build – Own – Operate: A Revolution in Nuclear Power Plant Construction

This section is devoted to Rosatom's unique BOO (Build-Own-Operate) model, which sets Rosatom apart from its competitors and could potentially revolutionize nuclear power plant construction and ensure Rosatom a competitive advantage in the field. The first plant to be built under this model will be the Akkuyu NPP in Turkey, which is set to be completed in 2023. The choice of Turkey is interesting because Russia and Turkey already have a robust energy relationship, and Turkey is heavily dependent on Russia for natural gas. This raises the question of the implications of constructing a nuclear plant in Turkey. Particularly, will this further entrench Turkey in its dependence on Russia to meet its energy needs? For Russia, the main question is whether the benefits of NPP construction outweigh the risk of less natural gas sales? In the former case, what implications does this have for other countries that might consider the BOO model? It is important to explore these questions because more BOO orders are expected in the future as global demand for nuclear energy continues to grow. This section will include a case study of the Turkish-Russian energy relationship, and overviews of the Akkuyu NPP project and the Build-Own-Operate model and will conclude with a discussion of implications the BOO model will have for the NPP industry worldwide.

The Turkish-Russian Energy Relationship

Russian-Turkish energy cooperation has its roots in the late Soviet period but gained pace after the collapse of the Soviet Union. The year 1997 is widely regarded as a turning point, as it marked the signing of an agreement to construct the Blue Stream pipeline which allowed for a direct connection between the two countries via the Black Sea. Completed in 2003, the pipeline is capable of delivering up to 16 billion cubic meters of gas annually.[88] Blue Stream was envisioned as a competitor to the Baku-Tblisi-Ceyhan (BTC) oil pipeline project which was designed to transport crude oil from Azerbaijan, Turkmenistan and Kazakhstan to Europe via Turkey. The BTC pipeline was to be the first stage in the establishment of an East-West Energy Corridor with the ultimate aim of diversifying the European Union's fuel sources, and it was therefore heavily backed by the US and EU. The project was planned to include a gas pipeline in addition to the BTC oil pipeline, which would have decreased Europe's reliance on Russian gas. However, it was decided that the gas pipeline was no longer needed following the completion of Blue Stream and it was cancelled. Therefore, while Russia was unable to prevent the construction of the BTC oil pipeline, thanks to Blue Stream it was able to ensure that it still benefitted from gas sales by preventing the gas pipeline phase of the East-West Energy Corridor from being carried out. In the meantime, while Russia only benefitted from Blue Stream, both projects were to Turkey's advantage, as they both passed through Turkey and contributed to Ankara's vision of Turkey as a regional energy hub,[89] despite the fact that Blue Stream greatly increased Turkey's reliance on Russia for natural gas.

A similar situation played out in 2009, when two new rival projects were proposed – the Nabucco-West[90] and South Stream natural gas pipelines. Backed by the US and EU, Nabucco was planned to transport Azeri gas to EU, while the latter project would originate in Russia. Again, Turkey was to play an important role as a transit point in both projects. Although these

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[88] "Blue Stream," *Gazprom*, Accessed February 17, 2018, http://www.gazprom.com/about/production/projects/pipelines/active/blue-stream/.

[89] Volkan Ediger & Duygu Durmaz, "Energy in Turkey and Russia's Roller-Coaster Relationship," *Insight Turkey*, Updated January 1, 2017, Accessed February 14, 2018, https://www.insightturkey.com/turkey-russia-energy/energy-in-turkey-and-russias-roller-coaster-relationship.

[90] The Nabucco-West Pipeline, also known as the Turkey-Austria gas pipeline, is often simply referred to as the Nabucco Pipeline.

projects were eventually cancelled, both in a sense lived on, as Nabucco took the form of the Trans-Anatolian Natural Gas Pipeline (TANAP) while South Stream was later modified and reintroduced as Turkish Stream, which is planned for completion in 2019.[91] With a total cost of $40 billion and a planned capacity of 63 bcm, Turkish Stream will transport Russian gas under the Black Sea to Turkey, stopping at the Turkish-Greek border.

All this pipeline construction helped bolster Turkish-Russian economic relations in other sectors as well. Over the years, Russia has become Turkey's largest trading partner, and Turkey is Russia's fifth largest trading partner. It has also made Turkey dependent on Russia for more than 65% of its natural gas.[92] However, Turkey also benefits from these projects as they further its ambitions to become an energy hub. In addition, Blue Stream seemed to be the best option at the time, as Turkey was anxious about meeting its growing energy needs and the competing East-West Energy Corridor seemed mired in difficulties.[93] As a result, Ankara was willing to risk more vulnerability to Moscow for the sake of securing its energy supply. Despite its dependence on Russian gas, Turkey has all the while maintained a balancing act between different Russian and EU-backed projects.

While Turkey is a developing country with a growing demand for electricity, its own fuel reserves are poor. According to a 2011 study, Turkey imports 72% of its energy, including 98% of its natural gas and 92% of its petroleum. It is dependent on natural gas for 53% of its total electricity production, 65% of which, as mentioned above, comes from Russia.[94] By allowing

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[91] Ibid.
[92] Nikolas Gvosdev & Christopher Marsh, *Russian Foreign Policy: Interests Vectors & Sectors,* Los Angeles, Sage Publications, 2014, p. 299.
[93] Şaban Kardaş, "Turkey – Russia Energy Relations," *International Journal*, vol. 67, no. 1, p. 88.
[94] Necdet Pamir, "Türkiye ve Dünyada Enerji, Türkiye'nin Enerji Kaynaklar ve Enerji Politikaları," *Metalurji Dergisi*, February 22, 2011, http://www.metalurji.org.tr/dergi/dergi134/d134_73100.pdf, p. 30.

for domestic electricity production, nuclear power would help lower Turkey's energy dependence and its vulnerability to political manipulation and market volatility. However, access to nuclear technology brings with it benefits beyond electricity production. These include various applications in the medical and agricultural fields, as well as a certain level of prestige which accompanies simply having the nuclear power plant. İmer & Dalbudak stress that electricity production should be secondary to these other benefits and that Turkey's primary aim in developing power should be to gain a place among "the "first-class countries," i.e. countries which are able to reap the benefits of nuclear technology.[95] Furthermore, they warn that this will only be possible if Turkey develops the capability to build and maintain a nuclear power plant on its own. Other models, such as Build-Own-Transfer or Build-Own-Operate not only come with lower prestige but fail to decrease Turkey's dependence on foreign powers. They argue that this is exactly what Turkey has done by signing the NPP agreement with Russia, which does not explicitly ensure the transfer of nuclear technology and doesn't make the plant Turkish property. This gives too much control to the Russian side, and further entrenches Turkey's dependence on Russia for energy: "…expecting a foreign company [Russia] to both risk billions of dollars for an extended period just for the sake of a guarantee of electricity purchases, and equip the country in which it's investing with knowledge that could one day be used to compete against it, could only be considered laughable."[96] The next section explores the Akkuyu NPP agreement further, and addresses the concerns raised by İmer & Dalbudak and earlier in the chapter. In addition, it will address whether the BOO model gives Russia too much control over power production. If not, why would Russia want to provide Turkey with technology that will decrease its reliance on

[95] İmer & Dalbudak, "Türkiye'de Nükleer Güç Santrali Kurulması ve Dış Politikaya Olası Etkileri," pp. 158, 164.
[96] Ibid., p. 169.

Russian gas? The answers to these questions will have wider implications for the NPP industry given the projected increase in BOO orders.

The 2010 Akkuyu NPP agreement

Given the history of energy cooperation between Moscow and Ankara, it's no surprise that Rosatom was granted the tender for construction of the Akkuyu Nuclear Power Plant. There are, however, other reasons. First of all, construction of a nuclear plant in Turkey has been in the works for a very long time. The first feasibility study was conducted in 1970, and the Akkuyu site was deemed suitable in 1976. Attempts were made in 1980, 1993, and 1997 but fell through because of financial or other issues. Throughout all this the proposed location has remained the same. Located on Turkey's southern coast, Akkuyu is a particularly suitable location because it is both sparsely populated and close to major urban centers, particularly Adana, Mersin, Konya, and Antalya.[97] The latter is especially important as it is Turkey's ever-expanding tourism hub and home to the country's third-busiest airport.[98] This means that when Turkey revisited the idea in 2006, the task of choosing a location had already been carried out. New headway was made the following year, when Turkey passed its first nuclear power legislation, Law 5710, concerning the Construction and Operation of Nuclear Power Plants and the Sale of Energy (generated by these plants). The law stated that the OECD Paris and Brussels Conventions on third party accident liability would apply, and all subsequent criteria and regulations that were released complied with IAEA safety standards.[99] The Turkish Electricity Trading and Contracting Co. (TETAŞ) began accepting bids in 2008, and an agreement was reached with Russia in 2010 but

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[97] See Appendix 3.
[98] "Antalya Havalimani," *Hürriyet*, Accessed April 16, 2018, http://www.hurriyet.com.tr/haberleri/antalya-havalimani.
[99] "Nuclear Power in Turkey," *World Nuclear Association*, Updated December 2017, Accessed March 9, 2018, http://www.world-nuclear.org/information-library/country-profiles/countries-t-z/turkey.aspx.

was stalled due to a brief chill in relations between Moscow and Ankara after Turkey downed a Russian fighter jet in November 2015. As a result, construction was delayed until 2018, pushing the launch date from 2019 to 2023.[100]

The First Build-Own-Operate Plant

The $20 billion Akkuyu project will see the construction of four VVER 1200[101] reactors with a total capacity of 4800 MWe. According to the Build-Own-Operate agreement, the Russian party will provide the financing and insurance, engineering-procurement-construction, operation and maintenance, fuel supply, and decommissioning at the end of the plant's 60 to 80-year life cycle.[102] In addition to the allocation of the site, the Turkish party will be in charge of interconnection with the national transmission grid and a power purchase agreement (PPA) for 50% of the electricity. The remaining electricity will be sold by Rosatom on the open market.[103] Though the BOO model will be pioneered in Turkey, an agreement was reached in 2013 to construct a second plant using this model in Jordan. As with Turkey, this will be Jordan's first nuclear power plant.[104] Though there are currently only two confirmed BOO plants, Rosatom plans to have as many as 24 by 2030.[105] Although this figure may be somewhat unrealistic, it shows just how much confidence Rosatom has placed on the model's success.

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[100] Andrew Ward, "Turkey's reconciliation with Putin spurs new power projects," *Financial Times*, June 25, 2017, Accessed February 15, 2018, https://www.ft.com/content/83be5fd4-4ad3-11e7-a3f4-c742b9791d43.

[101] "*Vodo-Vodyanoy Energeticheskiy Reaktor,"* or "*Water-Water Power Reactor*," Rosatom's pressurized water reactor design.

[102] "Deputy General Director of AKKUYU NUCLEAR JSC performed at the International Conference on investments to energy sector of Turkey, *Rosatom,* September 15, 2015, Accessed February 15, 2018, http://www.rosatom.ru/en/press-centre/news/41-deputy-general-director-of-akkuyu-nuclear-jsc-performed-at-the-international-conference-on-investments-to-energy-sector-of-turkey/?sphrase_id=253884.

[103] "The Build-Own-Operate (BOO) approach: Advantages and Challenges," *IAEA*, 2014, Accessed February 17, 2018, https://www.iaea.org/NuclearPower/Downloadable/Meetings/2014/2014-02-04-02-07-TM-INIG/Presentations/35_S7_Turkey_Camas.pdf.

[104] "Nuclear Power in Russia," *World Nuclear Association,* Updated May 2018.

[105] Ibid.

The BOO model has several advantages and disadvantages, depending on the host country's expectations. It is ideal for electricity generation but doesn't provide the level of expertise that a do-it-yourself approach would allow. This also means that it is much less time consuming to establish. The model also simplifies the process by eliminating the need to engage in bidding and secure financing, since everything is included in the package. Russia takes responsibility for building and maintaining the plant and guarantees the host country electricity at a fixed price. In Turkey's case, this is 12.35 cents/kWh for the first 15 years. The presence of such an agreement minimizes the risk of unexpected price increases for Turkey, while ensuring Rosatom a dependable flow of long-term revenue. According to Turkey's Ministry of Energy and Natural Resources, these benefits outweighed the costs of using the BOO approach, and the issue of lack of technology transfer did not appear to be a major influencing factor. [106]

While the agreement outlined that Russia will hold no less than 51% of the Akkuyu NPP's shares, opportunities are still present for the development of local expertise. The remaining 49% is now owned by a Turkish consortium comprised of three of the largest holdings in the country.[107] Numerous Turkish firms also have the opportunity to engage in construction of the plant, and it's expected that up to 40% of construction work will be done by Turkish companies.[108] Lastly, an important part of the BOO agreement is that Russia will train local personnel.[109] Rosatom appears very committed to the development of nuclear expertise in newcomer countries, featuring it as part of its "integrated offer" and stressing the opportunities

[106] "The Build-Own-Operate (BOO) approach: Advantages and Challenges," *IAEA,* 2014.
[107] "Cengiz-Kalyon-Kolin Akkuyu'ya ortak oldu, *Sabah,* June 20, 2017, https://www.sabah.com.tr/ekonomi/2017/06/20/cengiz-kalyon-kolin-akkuyuya-ortak-oldu.
[108] "Akkuyu construction formally starts," *World Nuclear News,* December 12, 2017, http://www.world-nuclear-news.org/NN-Akkuyu-construction-formally-starts-12121701.html.
[109] Yu. A. Sokolov, "Multiple approaches on supporting nuclear program development and contracting of NPPs," *IAEA,* November 14, 2013, https://www.iaea.org/NuclearPower/Downloadable/Meetings/2013/2013-02-11-02-14-TM-INIG/11.sokolov.pdf.

staff will have to learn about all aspects of nuclear plant development.[110] While most of this training takes place in Russia, it seems that ambitious countries would be able to utilize this knowledge at home to aid them in developing a nuclear infrastructure without reliance on Russia. This may be what is happening in Turkey; while Akkuyu will be its first NPP, there are already plans to build two more elsewhere in the country.[111] Rosatom is not involved in these projects, which will be handled by Japanese-French and Chinese-American joint ventures.[112] The contract for the Sinop NPP on the Black Sea coast was awarded to Mitsubishi, owing to the firm's experience constructing plants in earthquake-prone Japan. These will be Atmea1 units, based off Areva's EPR pressurized water reactor design, and the Sinop plant is scheduled to begin operation in 2023, the same year as the plant in Akkuyu.[113] The third plant in İğneada was only recently announced in 2014 and construction is not scheduled to begin until 2019. It will be built using a combination of Westinghouse's AP-1000 and Chinese CAP1400 technology under a comprehensive lifecycle agreement provided by China which is similar to BOO.[114] Viewing the Akkuyu plant as one of many plants to be built in cooperation with other countries seems to minimize the risk that Turkey is becoming more vulnerable to Moscow for its energy needs.

This brings the discussion to the second question; is Russia putting its future oil and gas revenues at risk by helping Turkey develop an alternate fuel source? This seems unlikely for several reasons. Firstly, the Akkuyu NPP will only provide a relatively small portion of Turkey's

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[110] "Rosatom Education and Training Approach for Newcomer Countries," *Rosatom HR Solution,* Accessed March 9, 2018, http://atomhrs.com/static/books/ROSATOM%20EDUCATION%20AND%20TRAINING%20APPROACH%20FOR%20NEWCOMER%20COUNTRIES.%20NPP%20PROJECT.pdf.
[111] See Appendix 2 for locations of proposed NPPs in Turkey.
[112] "Nuclear Power in Turkey," *World Nuclear Association,* Updated December 2017, Accessed March 9, 2018, http://www.world-nuclear.org/information-library/country-profiles/countries-t-z/turkey.aspx.
[113] Ibid.
[114] Ibid.

energy needs, and it will still remain dependent on Russia, especially since these needs will continue to grow. Second, Turkey plans to build at least two additional reactors in the future which will be constructed by other firms. This means that if Rosatom hadn't seized the opportunity, one of its competitors likely would have. In this sense, the fact that Rosatom was able to establish itself first will ultimately help its image while securing an enduring role in Turkey's nuclear energy sector. Finally, Rosatom has much to gain from the Akkuyu plant's completion. Not only will the company have a fixed source of revenue guaranteed for the long term, but it will have proven the BOO model's success. From the Russian perspective, Turkey can be seen as an ideal testing ground for the BOO model, owing to the existing high level of energy cooperation and Turkey's willingness to make the necessary accommodations for the NPP's construction. The successful implementation of a BOO project can open the door for Russia to other opportunities in Turkey's neighbors, including Iran, Jordan, the United Arab Emirates, Saudi Arabia, and Egypt, all of which are exploring or currently developing their own nuclear energy programs.[115] As previously mentioned, Jordan has already agreed to build its first NPP using the BOO model. More revenue from foreign NPPs would help Russia to weather the volatility in the oil and gas markets while also building Russia's image as a flexible provider of cutting-edge nuclear power technology.

CONCLUSION

This study has attempted to illuminate the complicated history of Russian nuclear power and how it has shed its Soviet-era legacy to arrive at its current state. While Russia inherited a vast nuclear infrastructure and a great deal of scientific expertise from the Soviet Union, it was

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[115] Scott Montgomery & Thomas Graham Jr, *Seeing the Light: The Case for Nuclear Power in the 21st Century*, p. 267.

the oil crisis in the late 2000's that spurred the refocus on the development and export of nuclear energy technology. Nuclear was correctly identified as one of the few sectors in which Russia held a comparative advantage internationally and was a way to diversify Russia's sources of income away from raw material exports and their associated price fluctuations. Ironically, the Chernobyl disaster may have helped the industry sustain its competitiveness by forcing Russia to develop and implement safety technology which it now uses to market its plants abroad. The refocus on nuclear focus couldn't have come at a better time for Russia, as many of the former big players in nuclear energy are struggling in the wake of Fukushima and a rise in renewable energy and advanced oil and gas extraction techniques. However, the fact remains that nuclear energy is still looked upon as a viable energy option in much of the rest of the world, especially developing nations. Through comparison of Rosatom with its international competitors and in-depth discussion of its new Build-Own-Operate model, it has become clear just what makes Rosatom stand apart from other nuclear energy companies. Though it is difficult to predict with absolute certainty what lies ahead for Rosatom or for the industry as a whole, this multi-angled approach has made clear that Rosatom's future prospects appear bright.

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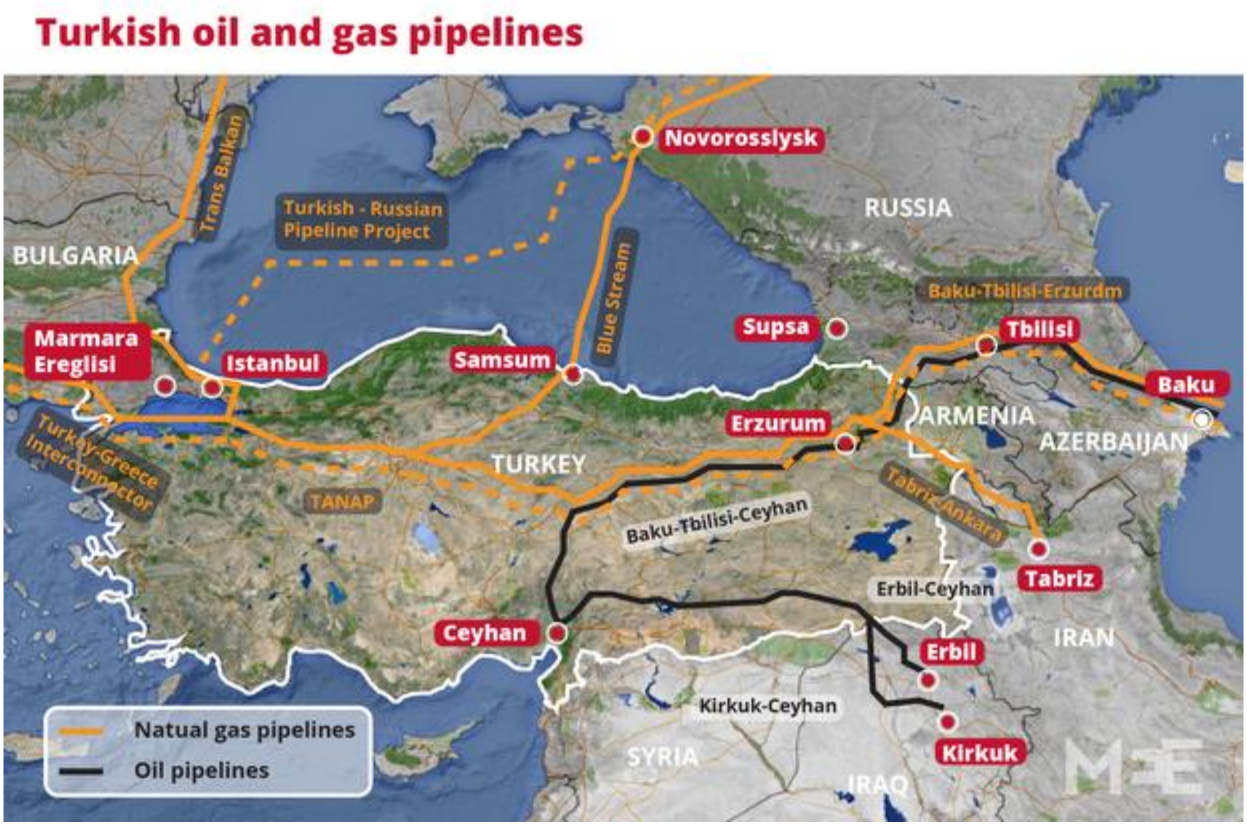
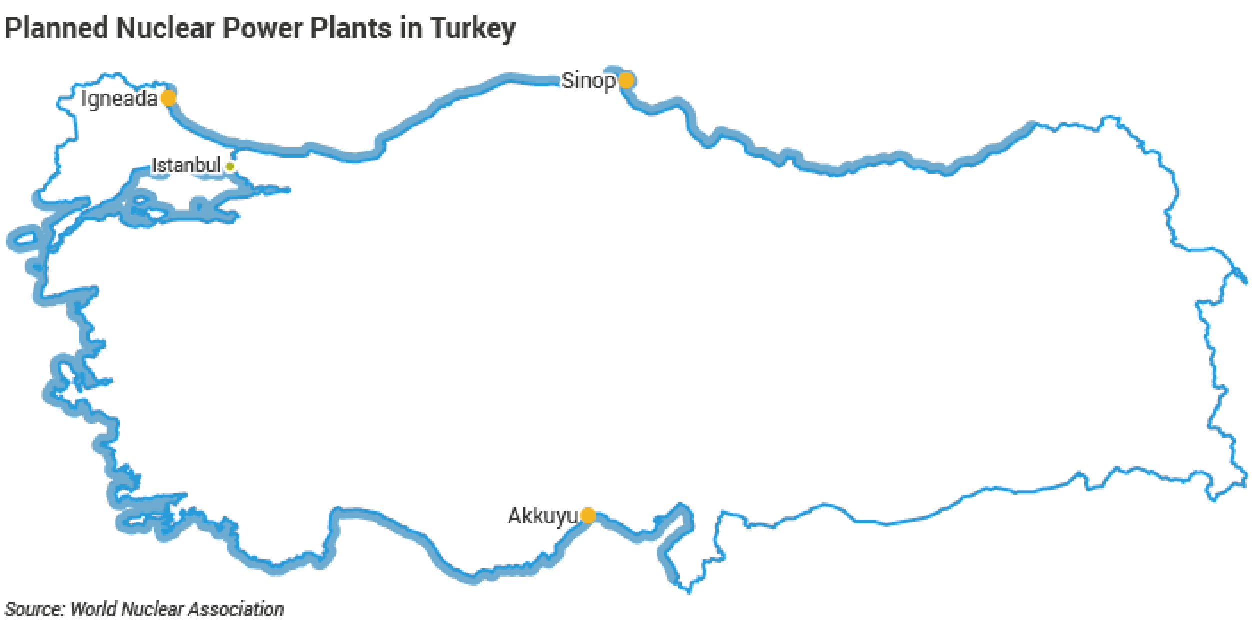
Appendices

Appendix 1: Oil and Gas Pipelines in Turkey. Information courtesy of Middle East Eye.



Appendix 2: Locations of proposed nuclear power plants in Akkuyu, İğneada, and Sinop, Turkey. (Note: Istanbul is indicated for reference purposes and is not the site of a proposed NPP). Information courtesy of World Nuclear Association.



Appendix 3: Locations of the Akkuyu and proposed Sinop NPPs relative to major Turkish cities. Image courtesy of IAEA.