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Energy Economic Resilience under Sanctions in Russia: Policies and Lessons for Iran

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Highlights

- Western sanctions have significantly impacted Russia's energy sector, reducing foreign investment and access to traditional export markets.
- Despite maintaining oil and gas exports, Russia struggles to reduce its reliance on fossil fuels and control carbon emissions.
- Key lessons for Iran include diversifying export markets, boosting renewable energy, and reducing economic dependence on fossil fuels to enhance energy security under sanctions.

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Abstract

Iran, as an oil-dependent economy, has faced strict energy sanctions from the Western bloc, prompting the country to adopt policies aimed at enhancing its energy-economic resilience. Given the similarities in economic structure, this paper explores the concept of energy-economic resilience in Russia under sanctions. Following Russia's special military operations in Ukraine, successive Western sanctions were imposed, primarily targeting its energy sector and global exports. This study aims to identify the key components affected by these sanctions by examining Russia's energy security within a structured framework. The findings indicate that while the sanctions have negatively impacted Russia's energy security and inflicted economic damage, Russia has demonstrated sectoral resilience. This has been achieved through strategic policies such as diversifying oil and gas export destinations and strengthening energy transportation infrastructure via new investments and projects. Despite these successes, Russia remains highly dependent on fossil fuel extraction and exports, with limited progress in increasing the share of renewable energy—a persistent and major weakness.

Keywords: Energy security, Russian federation, Western sanctions, Ukraine crisis, Four A's framework.

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1. Introduction

Rising global concerns over climate change have underscored the urgency of reducing reliance on carbon-based energy and transitioning to a green economy, making energy-economic resilience a critical concept in economic literature. During the Sustainable Development Summit on March 21, 2022, UN Secretary-General Antonio Guterres described the global dependence on fossil fuels as "madness" (United Nations, 2022). A report by S&P Global emphasizes this paradox; despite

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unprecedented growth in renewable energy consumption following the COVID-19 pandemic, 80% of the world's energy still relies on fossil fuels, highlighting the necessity for all countries to pursue energy flexibility (Perkins & Edwardes-Evans, 2023). For decades, Russia's fuel and energy complex accounted for over 60% of its total exports, but the global energy market has undergone rapid changes since 2022 (Central dispatch office of the fuel and energy complex, 2024). A 2024 report on the Russian oil, gas, and coal industry categorizes the new sanctions from Europe and the United States as follows (Infoline, 2024): Following the start of Russia's military operations in Ukraine, the UK announced a ban on Russian oil shipping services effective December 5, 2022, unless the oil was purchased at or below a price cap set by Western nations. On December 1, 2022, the United States and the European Union set this price cap at $60 per barrel, effective December 5, with bimonthly adjustments planned to keep it at least 5% below the export price of Urals crude. In response, the President of the Russian Federation signed Federal Budget Law No. 443-FZ on November 21, 2022, increasing the tax burden on the gas and oil industries for 2023–2025 (Russian Federation, 2022).

Multilateral economic sanctions against Russia, which intensified after the 2014 Ukraine crisis, peaked in 2022 after Russia recognized the independence of the Luhansk (LPR) and Donetsk People's Republics (DPR) and launched its military operation. According to the Chamber of Commerce and Industry of the Russian Federation, these sanctions were designed to disrupt Russia's production chains and financial stability (Chamber of Commerce and Industry of the Russian Federation, 2022). Despite these efforts to isolate Russia economically, it remains the world's largest oil exporter. As shown in Figure 1, while exports to the European Union, the United States, the United Kingdom, and OECD countries in Asia fell significantly to 4.3 million barrels per day—dropping below pre-war levels—exports to India, China, and Turkey increased substantially. For instance, EU oil imports from Russia fell from 3.3 million bpd in 2021 to 0.6 million bpd in 2023. In contrast, India's imports rose from 0.1 million bpd in 2021 to 1.9 million bpd in 2023. The import share of some countries, such as the UK and OECD nations in Asia, fell to zero in 2023.

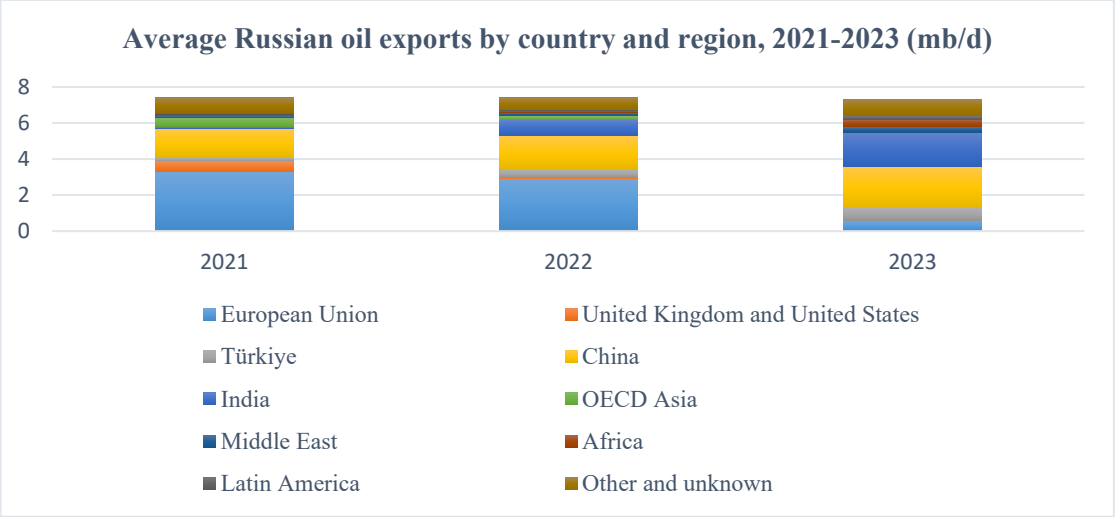


Figure 1

Russia's average oil exports by country and region during 2021–2023 (Categorized by the authors based on data from International Energy Agency data (2025))

Iran and Russia, as two of the world's most sanctioned states, share significant historical, economic, and political commonalities, particularly as energy powers resisting Western influence. Yet, they also exhibit profound differences in governance, military strategy, and geopolitical positioning. While Russia asserts itself as a global nuclear power and energy exporter, Iran's focus is predominantly

regional, driven by a distinct ideological agenda. Despite these differences, both nations engage in strategic cooperation in energy markets, defense agreements, and regional conflicts, making their relationship a pivotal factor in global geopolitics. Iran has faced extensive economic sanctions since the 1979 Islamic Revolution, which have profoundly impacted its economy and society (Salehi-Isfahani, 2020). Similarly, as noted by Vaganova (2019) and Rasoulinezhad & Eksi (2024), sanctions against Russia predate the 1917 revolution and have intensified over the past century. Currently, due to the Ukraine crisis, Russia is confronting the most severe sanctions in its modern history, both in terms of economic scope and the number of participating countries. Given their similar economic structures and the severity of the sanctions, Iran and Russia have adopted distinct policy frameworks to mitigate economic pressure: a resistance economy in Iran and an anti-sanction economy in Russia.

Table 1

Similarities and general differences between Iran and Russia (Classified by the authors)

Dimensions	Iran	Russia
	Socio-Economic	
Economy type	Mixed economy; oil-dependent	Mixed economy; resource-rich, but more diversified
GDP (nominal)	~$400 billion (approx.)	~$1.7 trillion (approx.)
Main exports	Oil, gas, petrochemicals, and agricultural products	Oil, gas, metals, arms, and agricultural products
Sanctions	Heavy Western sanctions limit trade and growth	Sanctions due to Ukraine war, but still trades globally
Income levels	Lower-middle income; high inequality	Middle income; moderate inequality
Industrial base	Limited due to sanctions; growing self-reliance	Stronger manufacturing and defense industry
Technology	Developing tech sector, reliant on imports	Advanced in areas like AI, cyber, and military tech
Population	~89 million	~144 million
Demographics	Young population; declining birth rates	Aging population; declining birth rates
Unemployment	~10–12%	~3–5%
	Geopolitical	
Alliances	Close to Russia, China, Syria, Hezbollah	CSTO, BRICS, close ties with China, Iran, India
Global standing	Regional power; influence in the Middle East	Major power; global ambitions
Relations with West	Hostile; no diplomatic ties with U.S.	Hostile; sanctions after Ukraine invasion
Key conflicts	Proxy wars (Syria, Yemen, Iraq, and Lebanon)	Ukraine war, tensions with NATO
Energy influence	Major OPEC producer; limited exports due to sanctions	Top energy supplier to Europe, China, and India
	Military	
Defense budget	~$10–15 billion	~$80–100 billion
Military size	~600,000 active personnel	~1 million active personnel
Nuclear capabilities	No official nukes, but developing capabilities	Large nuclear arsenal (largest in the world)
Weapons industry	Strong domestic arms production	One of the world's top arms exporters

Dimensions	Iran	Russia
Cyber warfare	Developing cyber capabilities	Advanced cyber capabilities
Military alliances	No formal alliances, but ties with Russia and China	CSTO, informal cooperation with China and Iran

As illustrated in Table 2, both Iran and Russia experienced fluctuations in oil production between 2013 and 2023. Iran's production increased from 3,609 thousand barrels per day in 2013 to 4,662 thousand barrels per day in 2023, while Russia's production also fluctuated, rising from 10,807 thousand barrels per day to 11,075 thousand barrels per day over the same period. Both countries also faced high consumer price inflation, with Iran recording a peak of 44.58% in 2023 and Russia reaching its high of 7.9% in 2022. Economic growth trends varied significantly due to differing government policies. For instance, in 2016, Iran's economy grew by 8.8% compared to Russia's 0.2% growth. Conversely, in 2015, Iran's economy contracted by 1.4%, while Russia's declined by 2.0%. Furthermore, Foreign Direct Investment (FDI) inflows differed considerably; Iran attracted minimal investment at just 0.04% of its GDP in 2013, whereas Russia secured 3.02%. However, following the Ukraine crisis, Russia's attractiveness to foreign investors declined significantly. Finally, the volume of trade also differed, with Russian exports experiencing much more severe fluctuations than Iran's throughout the 2013–2023 period.

Table 2

The trend of some macroeconomic variables of Iran and Russia during from 2013 to 2023 (Categorized by the authors based on data from energy institute, Statista, and world bank data)

Year		Oil production (thousand barrels daily)	Economic growth rate	Inflation of consumer prices	The inflow of FDI (net inflows as a share of GDP)	Export (billion dollars)
2013	Iran	3609	–1.5	36.60	0.04	90.77
	Russia	10807	1.8	2.7	3.02	521.84
2014	Iran	3714	5	16.61	0.01	95.16
	Russia	10927	0.7	2.4	1.07	496.81
2015	Iran	3853	–1.4	12.48	0.03	70.28
	Russia	11087	–2	1.4	0.50	341.42
2016	Iran	4578	8.8	7.25	0.02	72.9
	Russia	11342	0.2	1.6	2.55	281.71
2017	Iran	4939	2.8	8.04	0.02	92.76
	Russia	11374	1.8	2.3	1.81	352.94
2018	Iran	4720	–1.8	18.01	0.02	103.42
	Russia	11562	2.8	2.4	0.53	443.91
2019	Iran	3510	–3.1	39.91	0.03	65.72
	Russia	11679	2.2	2.2	1.89	419.72
2020	Iran	3230	3.3	30.59	0.03	46.92
	Russia	10666	–2.7	1.9	0.63	333.53
2021	Iran	3766	4.7	43.39	0.02	71.65
	Russia	11000	5.9	3.5	2.19	494.35
2022	Iran	3945	3.8	43.49	0.03	97.85

Year		Oil production (thousand barrels daily)	Economic growth rate	Inflation of consumer prices	The inflow of FDI (net inflows as a share of GDP)	Export (billion dollars)
2023	Russia	11202	–1.2	7.9	–1.76	592.06
	Iran	4662	5	44.58	0.02	91.19
	Russia	11075	3.6	5.6	–0.50	423.92

Given their vast oil and gas reserves and high economic reliance on energy exports, energy resilience is crucial for both Iran and Russia. The flexibility of their energy systems is key to mitigating the impact of economic shocks and enhancing adaptability. This research's primary objective is to examine Russia's energy security and resilience under sanctions to provide valuable, strategic insights for Iran's energy policies. The study's innovation lies in its application of the Four As framework to analyze Russia's energy security, identifying key strengths and weaknesses to inform Iran's strategic energy planning. The paper is structured as follows: Section 2 outlines the theoretical framework, Section 3 details the methodology, and Section 4 presents the analysis of Russia's energy security. Section 5 discusses the findings relevant to Iran, with conclusions and policy recommendations presented in Section 6.

2. Theoretical framework

The concept of energy security, as defined by researchers like Yergin (2006) and Chester (2010), emerged from the 1973 OPEC oil embargo, which triggered a prolonged global energy crisis. This event compelled nations to implement strategic measures to bolster their energy security. According to Gitelman et al. (2023), the crisis prompted three critical decisions: 1) the establishment of the International Energy Agency (IEA) to coordinate policies among major consuming nations; 2) the creation of strategic energy reserves to ensure the availability of essential energy carriers; and 3) the introduction of strict energy efficiency regulations across industrial, commercial, and residential sectors. The IEA later formalized the concept, defining energy security as "the assurance that energy is continuously available in the required quantity and quality at an affordable price under given economic conditions" (World Energy Council, 1992, p.1). Similarly, the United Nations describes it as "the continuous availability of energy in varied forms, in sufficient quantities, and at reasonable prices" (United Nations, n.d.).

The evolution of energy security frameworks can be categorized into distinct historical phases. Trachuk (2010) classifies these as: the **Pre-1973 Era**, when oil dominated industrialized economies; the **Post-1973 Oil Crisis**, which spurred supply security policies in the West; the *1980s–1990s*, when environmental concerns became integral; and the *21st Century*, with new approaches incorporating global markets, technology, and the renewable transition. Complementing this, Strojny et al. (2023) categorize contemporary research into three approaches: the *Supply Security Approach*, focusing on stable supply chains; the *Quantitative Assessment Approach*, using statistical indicators; and the *Systemic Approach*, which examines energy security within a broader geopolitical and environmental context.

A historical review confirms that energy has been fundamental to socio-economic development since the Industrial Revolution, when coal supplanted biomass as the primary source. Fouquet (2008) notes that a significant rise in the real price of wood between 1650 and 1740 accelerated this transition. By the early 19th century, most industries had shifted to fossil fuels, and the rapid increase in coal consumption sparked early concerns about resource depletion. Energy security became critically

important in the early 20th century, particularly for military operations. Yergin (1991) highlights that a 1916 fuel crisis in Britain led the government to introduce rationing, develop a national oil strategy, and prioritize energy in economic planning. The 1973–1974 OPEC embargo, enacted against supporters of Israel, further cemented energy security's importance, leading to greater diversification of energy sources and long-term policies to reduce dependency on single suppliers.

The concept of energy security gained renewed prominence following a socio-economic paradigm shift beginning in the 2000s, as analyzed by scholars such as Goldthau (2010), Smil (2017), Perkins (2017), and Tertzakian & Hollihan (2009). Since 2005, efforts have been made to expand the concept beyond its traditional focus on resource availability and cost to include environmental acceptability and supply reliability. These four dimensions are encapsulated in the "Four A's" of energy security, a framework introduced by Chester (2010) and first outlined in a 2007 Asia Pacific Energy Research Center (APERC) report. The framework consists of: (1) **Availability** – the physical existence of energy reserves; (2) **Affordability** – economic accessibility and reasonable pricing; (3) **Accessibility** – the physical and infrastructural means to reach energy sources; and (4) **Acceptability** – the environmental sustainability of energy use. The first two dimensions are rooted in the classical 20th-century approach, while the latter two reflect 21st-century concerns like fuel poverty and climate change (Cherp & Jewell, 2014, p. 416).

Sanctions significantly impact energy security by disrupting trade, limiting technology transfer, reducing foreign investment, and undermining economic stability. These impacts can be analyzed through the four A's framework:

1. **Disruption of Availability:** Sanctions can directly limit a country's ability to extract, produce, and export energy. For instance, sanctions against Iran reduced its crude oil exports from 2.5 million barrels per day in 2011 to less than 500,000 in 2019 (Salehi-Isfahani, 2019).
2. **Reduced Affordability:** Sanctions create market uncertainties that lead to price volatility. The G7 and EU price cap on Russian oil in December 2022, for example, forced significant discounts on Russian crude, reducing government revenues (Yermakov, 2024).
3. **Restricted Accessibility:** Sanctions can hinder the development and maintenance of energy infrastructure. The disruption to the Nord Stream pipelines led to a 39% decline in Russia's pipeline gas exports to Europe in 2022 (Semikashev & Gaivoronskaya, 2023).
4. **Impaired Acceptability:** Sanctions can hinder the green transition by limiting access to clean technology and increasing reliance on carbon-intensive fuels. Iran's renewable sector development has been slowed by sanctions, and the Ukraine conflict led to an estimated 175 million tons of additional CO_2 emissions due to increased fossil fuel use (Hunder, 2024).

3. Materials and methods

This research employs an analytical-interpretive methodology, utilizing the Four As framework to examine Russia's energy security before and after the imposition of sanctions in 2014 and 2022. The study relies on data from international energy agencies, government reports, and academic literature. As outlined in Figure 2, key indicators are used to assess each dimension of the framework: **Availability** is measured through Russia's oil, gas, and coal production; **Accessibility** is evaluated via the capacity and development of energy transport infrastructure, such as oil and gas pipelines; **Affordability** is assessed based on fluctuations in domestic and international oil and gas prices; and **Acceptability** is analyzed through metrics for renewable energy adoption and CO_2 emissions. The methodology

integrates both qualitative and quantitative analysis, combining statistical evaluation with policy assessment.

4. Findings

4.1. Availability

The sanctions imposed on Russia following the 2014 Ukraine crisis were relatively limited compared to the comprehensive sanctions introduced in 2022, which directly targeted the nation's energy sector. For instance, on March 17, 2014, the United States imposed sanctions on senior Russian officials in response to the annexation of Crimea, a move later joined by the European Union, Japan, and Australia. These early sanctions can be categorized into four key areas (Economic sanctions against Russia, 2017, pp. 9–10): the **Oil Sector**, including technology export bans; the **Gas Industry**, involving project suspensions; the **Financial Sector**, encompassing asset freezes and credit restrictions; and **Other Sectors**, such as arms embargoes. While the share of oil and gas revenues in the Russian federal budget fell by 2% in 2016 compared to 2015, it remained high at 41.4% (RIA Novosti, 2013). The 2022 sanctions, however, have had a more profound and negative impact on Russia's economic and energy structure, creating significant challenges for its oil revenues.

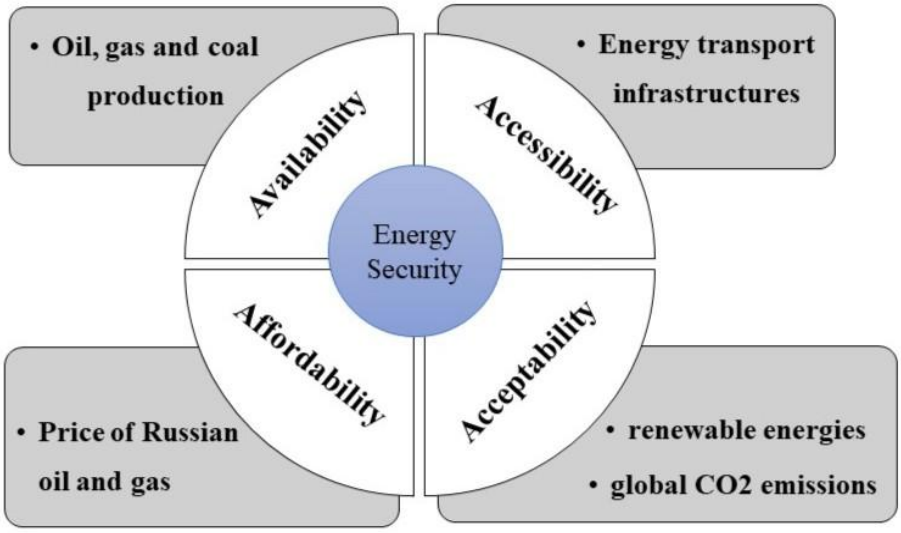


Figure 2

Components of Russia's Energy Security (Categorized by authors based on the framework of four A's)

Availability, the first dimension of Russia's energy security, is analyzed as follows. As shown in Table 3, Russia has maintained substantial oil and gas production levels despite restrictions. Between 2013 and 2018, oil production rose from 532 to 567 million tons. Natural gas production fell from 591 billion cubic meters in 2013 to 548 in 2015 but recovered to 669 by 2018. While coal and nuclear energy production increased from 2013 to 2018, renewable energy production initially declined before recovering by 2018. However, Russia experienced a sharp production decline in 2020 due to the COVID-19 pandemic and again in 2023, as intensified Western sanctions negatively impacted production volumes.

Table 3

The amount of production of different energies in the Russian Federation from 2013 to 2023 (Categorized by the authors based on data from the Statistical Review of World Energy report (2024))

Resource	Oil (million tonne)	Natural gas (billion cubic meters)	Coal (million tonne)	Nuclear energy (Terawatt-hours)	Renewable energy (Exajoules)
2013	532.2	614.5	355.2	172.5	1.78
2014	537.4	591.2	357.5	180.8	1.70
2015	544.6	584.4	372.5	195.5	1.64
2016	558.5	589.3	386.6	196.6	1.79
2017	558.5	635.6	411	203.1	1.79
2018	567.9	669.1	441.3	204.6	1.83
2019	573.4	679	440.7	209	1.87
2020	524.4	638.4	399.8	215.9	2.05
2021	538.8	702.1	434.1	222.4	2.09
2022	548.5	618.4	439	223.7	1.94
2023	541.7	586.4	432.5	217.4	1.97

4.2. Affordability

Energy exports have historically been a major source of revenue for Russia, providing a buffer against external economic shocks. However, after the United States and the European Union imposed trade bans, Russia redirected its crude oil and refined product exports to Asia, frequently offering them at discounted prices. As illustrated in Table 4, the price of Russian Urals crude closely tracked Brent crude prices from 2013 to 2021, typically differing by only a few dollars. This parity demonstrated Russia's ability to ensure energy security for its customers by providing oil at a reasonable market price. This dynamic shifted following the military conflict in Ukraine. In December 2022, the G7, the European Union, and Australia imposed a $60 per barrel price cap on Russian oil. In response, Russia halted supplies to countries enforcing the cap. Consequently, the price gap between Urals and Brent crude widened significantly; by September 20, 2023, Urals crude traded at $16.77 per barrel less than Brent, a disparity that exceeded $20 per barrel for much of the year (Statista, 2024). This discount, coupled with a decline in export volumes from 7,821 to 6,736 thousand barrels per day, underscores how the ongoing Ukraine crisis directly threatens Russia's energy security and oil revenues.

Table 4

Prices of Ural oil, Brent oil, and Russian oil exports from 2013 to 2023 (Categorized by the authors based on data from the Statistical Review of World Energy report (2024) and Yermakov (2024))

Oil price	Price of Urals crude oil blend, $/bbl	Crude oil prices Brent$/bbl2	Oil export (thousand barrels daily)
2013	107.9	108.66	7948
2014	97.6	98.95	7792
2015	51.2	52.39	8434
2016	41.9	43.73	8811
2017	53	54.19	8981
2018	70	71.31	8026

Oil price	Price of Urals crude oil blend, $/bbl	Crude oil prices Brent$/bbl2	Oil export (thousand barrels daily)
2019	63.6	64.21	8090
2020	41.7	41.84	7397
2021	69	70.91	7816
2022	76.1	101.32	7821
2023	63	82.64	6736

Table 5 details Russia's natural gas production, exports, domestic consumption, and the market share of three major companies from 2013 to 2023. The data indicate that 2019 was a peak year, with production reaching 739 billion cubic meters, alongside the highest recorded exports (258.5 billion cubic meters) and domestic consumption (480.5 billion cubic meters). While exports accounted for 57% of revenues in 2019, this share surged to 82% in 2022, driven by unusually high global prices for LNG and pipeline gas. Gazplays a critical role in balancing the Russian gas market; consequently, fluctuations in domestic and foreign demand have directly impacted its output. As a result, Gazprom's share of total production declined from 71% in 2013 to 61% in 2023.

Table 5

Natural gas produced and exported by the Russian federation from 2013 to 2023 (Categorized by the authors based on data from Gazprom, Rosstat, and the Ministry of Energy of Russia)

Gas	Gas production (billion cubic meters)	Export (billion cubic meters)	Domestic consumption (billion cubic meters)	Structure of natural gas production by company	
2013	668	196	456.8	Gazprom	71%
				Novatek	9%
				Rosneft	6%
2014	639.2	188.8	458.4	Gazprom	67%
				Novatek	10%
				Rosneft	9%
2015	633.4	185	444.3	Gazprom	64%
				Novatek	11%
				Rosneft	10%
2016	640.2	212.7	456.7	Gazprom	65%
				Novatek	11%
				Rosneft	10%
2017	691.1	220	468	Gazprom	68%
				Novatek	9%
				Rosneft	10%
2018	725.4	248.6	481.9	Gazprom	69%
				Novatek	9%
				Rosneft	9%
2019	737.7	258.5	480.5	Gazprom	68%
				Novatek	10%
				Rosneft	9%
2020	692.9	240.4	464.4	Gazprom	65%
				Novatek	11%
				Rosneft	9%
2021	762.8	245.3	476	Gazprom	68%
				Novatek	11%

Gas	Gas production (billion cubic meters)	Export (billion cubic meters)	Domestic consumption (billion cubic meters)	Structure of natural gas production by company	
2022	673.8	170.6	484	Rosneft	8%
				Gazprom	61%
				Novatek	12%
2023	636.7	175.7	501	Rosneft	10%
				Gazprom	61%
				Novatek	12%
				Rosneft	9%

Russian export gas prices have been influenced by a range of factors, including shifts in the global energy market, domestic and foreign policies, and international sanctions. Between 2018 and 2019, price fluctuations were primarily driven by changes in global demand and the launch of new international liquefied natural gas (LNG) projects. During this period, the price peaked at 28.766 euros/MWh in October 2018 and fell to a low of 11.521 euros/MWh in July 2019. From 2020 to 2022, the COVID-19 crisis and the subsequent decline in global energy demand significantly impacted prices, causing them to drop to 6.744 euros/MWh in August 2020 before rising sharply to 29.729 euros/MWh in January 2022. The military conflict in Ukraine and the ensuing economic sanctions in 2023 led to major disruptions in the gas market. After fluctuating between 22 and 23 euros/MWh from April to September 2022, the price of Russian export gas rose to 28.604 euros/MWh in October 2022 and stabilized at approximately 24 euros/MWh in early 2023.

4.3. Accessibility

The 2022 sanctions significantly impacted Russia's energy transportation infrastructure, a critical dimension of its energy security. While restrictions on maritime oil transport to Europe and the UK were partially offset by rerouting exports to Asian markets, the most severe challenge was the disruption to Russia's gas pipeline network. The Nord Stream 1 and Nord Stream 2 pipelines to Europe were effectively decommissioned, leading to a 39% decline in Russian pipeline gas exports, from 204.4 billion cubic meters (bcm) in 2021 to 124.9 bcm in 2022 (Semikashev and Gaivoronskaya, 2023, p. 30). Supplies through Ukraine's gas transportation system also fell by 55%, from 41.7 bcm in 2021 to 18.7 bcm in 2022 (Semikashev and Gaivoronskaya, 2023). This crisis represents the most immediate threat to Russia's energy security. A major transit contract between Ukraine and Gazprom, which accounts for half of Russia's pipeline gas exports to the EU and provides Kyiv with steady revenue, is set to expire at the end of 2024 (Keliauskaitė & Zachmann, 2024). Ukraine has announced plans to terminate this transit, affecting key pipelines like Brotherhood, Soyuz, and Central Asia, though it has indicated a potential allowance for transit if European buyers agree to withhold payments to Russia until the war's conclusion (Liboreiro, 2024). Consequently, as illustrated in the map below, the potential loss of these vital transit routes through Ukraine poses a fundamental challenge to Russia's long-term gas export strategy.

Figure 3

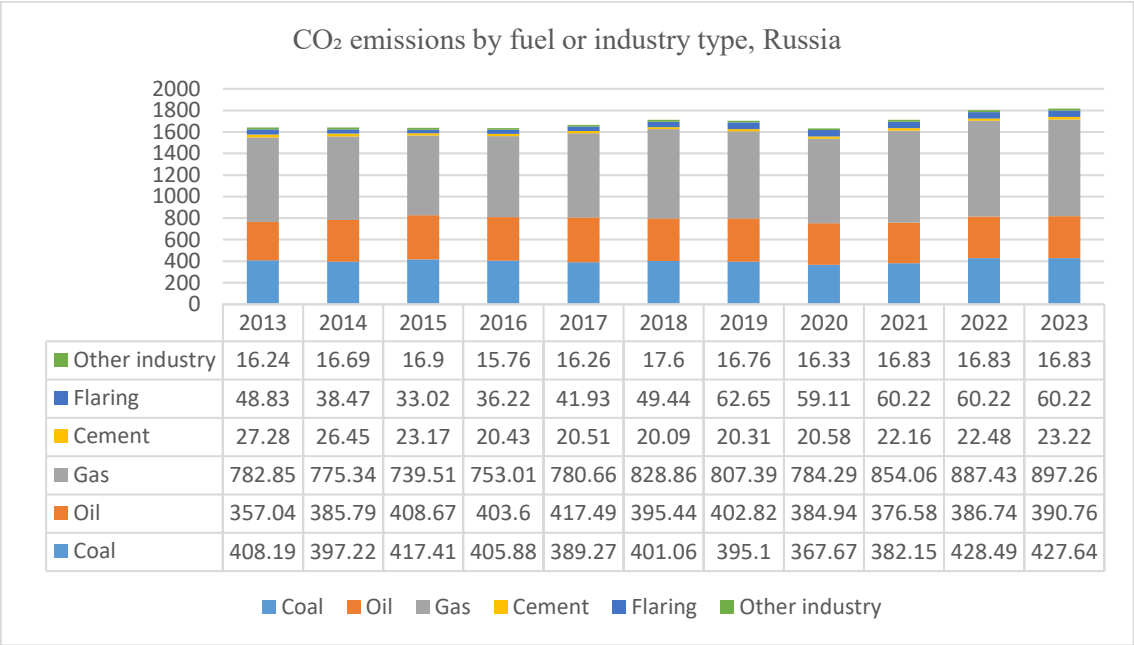
Natural gas pipelines from Russia to Europe (Categorized by authors based on (Hall, 2022))

4.4. Acceptability

The final dimension of energy security, **acceptability**, can be analyzed using variables such as Russia's carbon dioxide emissions from fossil fuels. Figure 4, which categorizes emissions by fuel type and source, shows an increase across all categories except cement between 2013 and 2023. Total CO_2 emissions in Russia rose from 1.64 billion tons in 2013 to 1.82 billion tons in 2023, with the sharpest increase occurring after the 2022 military intervention in Ukraine. A slight decrease was observed only after Russia joined the Paris Agreement in 2019. Given its vast territory, large population, and energy-intensive economy, Russia plays a pivotal role in global efforts to reduce CO_2 emissions and mitigate climate change. A significant driver of the recent increase in harmful emissions is the conflict in Ukraine. A report from Ukraine's Ministry of Environment and international NGOs estimates the war has directly contributed approximately 175 million tons of CO_2 due to military operations, fires, and infrastructure damage (Polish Press Agency SA, 2024). This includes billions of liters of fuel consumed by military vehicles, nearly one million hectares of burned fields and forests, exploded fuel depots, and the vast quantities of steel and cement used for fortifications. Therefore, strengthening energy security is essential for Russia to meet its environmental commitments.

5. Further discussion

To derive relevant insights for Iran, this section applies the Four As framework to analyze Iran's energy security, comparing its situation with Russia's experience under sanctions. Table 6 summarizes the key indicators of Iran's energy security used for this analysis.



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Other industry	16.24	16.69	16.9	15.76	16.26	17.6	16.76	16.33	16.83	16.83	16.83
Flaring	48.83	38.47	33.02	36.22	41.93	49.44	62.65	59.11	60.22	60.22	60.22
Cement	27.28	26.45	23.17	20.43	20.51	20.09	20.31	20.58	22.16	22.48	23.22
Gas	782.85	775.34	739.51	753.01	780.66	828.86	807.39	784.29	854.06	887.43	897.26
Oil	357.04	385.79	408.67	403.6	417.49	395.44	402.82	384.94	376.58	386.74	390.76
Coal	408.19	397.22	417.41	405.88	389.27	401.06	395.1	367.67	382.15	428.49	427.64

Figure 4

CO_2 emissions by type of fuel or industry in Russia (Categorized by authors based on (Roser et al., 2023))

Table 6

Analysis the components of Iran's energy security (Categorized by the authors based on data from Organization of the Petroleum Exporting Countries (2023))

Year	Proven crude oil reserves (Mb)	Proven natural gas reserves (bn s cu m)	Crude oil prices (Iran Light) ($/b)	Value of petroleum exports (m $)	Fossil (CO_2) emissions (tons)
2018	155.600	33.330	69.10	60.519	676.559.840
2019	208.600	33.899	62.74	19.402	664.101.460
2020	208.600	33.988	40.36	7.914	656.798.170
2021	208.600	33.988	67.90	25.526	677.815.330
2022	208.600 (22)	33.988 (76)	96.28 (67)	42.619 (18)	686.415.730

5.1. Analysis of Iran's energy security using the four A's framework

1. Availability

Iran's proven crude oil reserves increased significantly from 155.6 billion barrels in 2018 to 208.6 billion barrels in 2019, remaining stable through 2022. Similarly, its proven natural gas reserves held steady at approximately 34 trillion cubic meters. This indicates a robust and stable long-term supply of both resources, ensuring strong energy availability.

2. Accessibility

The value of Iran's petroleum exports fluctuated dramatically, falling from $60.519 billion in 2018 to just $7.914 billion in 2020 before recovering to $42.619 billion in 2022. These extreme variations underscore the severe impact of international sanctions and geopolitical tensions on Iran's ability to access global markets.

3. Affordability

The price of Iran's Light crude oil was highly volatile, dropping from $69.10 per barrel in 2018 to a low of $40.36 in 2020, before rising to $96.28 in 2022. This instability reflects broader market uncertainties and directly impacts national revenue and the economic affordability of energy.

4. Acceptability

Iran's CO_2 emissions remained persistently high, with only minor fluctuations from 656.8 million tons in 2020 to 686.4 million tons in 2022. This indicates a continued heavy reliance on fossil fuels and limited progress in transitioning to cleaner energy sources, highlighting a significant challenge in environmental acceptability.

A comparison of Russia's (2013–2023) and Iran's (2018–2022) energy security data reveals similar challenges under sanctions. As summarized in Table 7, both Iran and Russia are leading nations in energy **Availability** due to their vast, stable reserves of oil and gas. However, sanctions have severely constrained **Accessibility**, limiting their export potential, though Russia has been more successful in diversifying markets to Asia. Both face significant **Affordability** challenges due to price and revenue volatility. Furthermore, **Acceptability** remains a shared weakness, with both countries exhibiting high CO_2 emissions and lagging in renewable energy adoption. Given these parallels, Iran can learn from Russia's adaptive strategies to enhance its own energy resilience.

Table 7

Comparing four A's model in Iran and Russia (Categorized by the authors)

Four A's	Iran	Russia
Availability	Large crude oil and natural gas reserves ensure availability.	Abundant oil and gas reserves maintain long-term energy security.
Accessibility	Sanctions restrict export markets and limit infrastructure investments.	Pipeline disruptions and geopolitical tensions limit export routes.
Affordability	Price volatility affects revenue stability.	Oil price caps and trade bans impact revenue streams.
Acceptability	High CO_2 emissions with limited renewable energy adoption.	High CO_2 emissions and slow transition to renewables.

6. Conclusions and policy recommendations

6.1. Concluding remarks

This study analyzed Russia's energy security through the Four As framework, identifying key strategies employed to withstand economic sanctions. The findings indicate that Western sanctions significantly disrupted Russia's energy sector, reducing exports to Europe and restricting access to Western financial and technological resources. Despite these pressures, Russia demonstrated resilience by diversifying its trade to non-Western markets like China and India. However, a critical finding is that while Russia successfully maintained its fossil fuel exports, it has faced significant challenges in increasing the share of renewable energy within its energy mix and in controlling its carbon dioxide emissions. It is also notable that Russia's advanced energy infrastructure, such as the Nord Stream pipelines, and its ongoing development of nuclear and renewable energy, are central to its strategy for diversifying energy sources and enhancing long-term security.

6.2 Policy implications for Iran

The insights from Russia's experience provide valuable lessons for Iran, which faces similar geopolitical and economic constraints. To enhance its energy security under sanctions, Iran should consider the following policy measures:

1. **Diversify Energy Exports:** Expand energy partnerships beyond traditional markets by leveraging trade agreements with China, India, and regional allies. Strengthening regional energy diplomacy will reduce vulnerability to Western sanctions.
2. **Invest in Renewable Energy:** Accelerate the development of solar, wind, and geothermal projects to reduce dependence on fossil fuels and align with global sustainability goals. Expanding domestic clean energy infrastructure enhances long-term resilience and economic diversification.
3. **Strengthen Energy Infrastructure:** Invest in refinery capacity and modernize energy transport networks to better manage supply chain disruptions. Localizing energy technology through domestic innovation and collaboration with non-Western partners will reduce reliance on foreign expertise.
4. **Enhance Economic Resilience:** Reduce the economy's dependence on oil and gas by investing in non-energy sectors such as technology, manufacturing, and the digital economy. Establishing strategic energy reserves and storage facilities will help cushion the economy against external shocks.

By implementing these strategies, Iran can enhance its energy security, mitigate economic risks, and strengthen its position in the global energy landscape.

6.3 Suggested research areas

For future research, it is recommended to explore Iran–Russia energy cooperation, particularly under the framework of the Iranian–Russian Treaty on Comprehensive Strategic Partnership signed in January 2025. This collaboration could have significant implications for bilateral energy security, trade, and technological exchange. Additionally, investigating the role of artificial intelligence (AI) in achieving energy efficiency targets presents a promising research direction. AI-driven solutions for energy optimization, demand forecasting, and grid management could play a crucial role in reducing waste and advancing Iran's sustainable energy development.

Nomenclature

AI	Artificial intelligence
DPR	Donetsk People's Republics
FDI	Foreign direct investment
IEA	International Energy Agency
LNG	Liquefied natural gas

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