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RUSSIAN RARE EARTH INDUSTRY: HIGH RESERVE, LOW PRODUCTION?

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INTRODUCTION

The global shift towards alternative energy sources is gradually transforming the global energy sector. Researchers are devoting their efforts to suggesting new resources and materials required to facilitate the transition process and low-carbon development. Rare Earth Elements (REEs) has emerged as the most promising mineral for boosting the modern economy, making them as a critical and strategic "vitamin of modern society." Rare Earth Metals (REMs) are part of Mendeleev's Periodic Table Group III (B). Their global consumption is increasing with the growing adoption of green energy. These REMs can help achieve Sustainable Development Goals (SDG) or Agenda 2030. However their extraction and processing can harm the soil and ecosystem, hence, their environmental benefit is up for discussion.[1] Rare earth metals, rare earth elements, and rare earth oxides are three terms that are used interchangeably but have different market significance and prices. The market for rare earth metals is growing at rapid rates in comparison to other base metals such as nickel, copper, iron, etc. Due to global economic

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1. A.E. Cherepovitsyn and Victoria Solovyova, "Prospects for the Development of the Russian Rare-Earth Metal Industry in View of the Global Energy Transition—A Review", *Journal of Energies* MDPI, vol.15, 387: 2022, pp. 1-24.

The world is witnessing a rise in demand for rare earth elements, primarily due to two factors: the global movement toward a "green energy transition" and the important role these elements play in the economy, strategy, and national security of a country.

growth and technological cycles, the global production and consumption of rare earth metals have increased by a factor of 27, and will reach 135,000 tonnes per year by 2020. China's geopolitics around these elements has increased global concern, especially with its tough message of "go and find your own rare earth metals" to high-import countries.[2]

The world is witnessing a rise in demand for rare earth elements, primarily due to two factors: the global movement toward a "green energy transition" and the important role these elements play in the economy, strategy, and national security of a country. In the case of Russia, the focus of this article, its economy seems to suffer from the 'oil curse' notion despite the country's production of hydrocarbons and high reserves of rare earth elements, and this has been one of the driving forces behind Russia's decision to prioritise its rare earth industry. Russia's transformation to green energy has increased the significance of revitalising and expanding the country's rare earth sector. However, it is challenging for Russia to diversify its energy mix when one type of energy resource (hydrocarbon) dominates the market, an ailment termed the "Dutch Disease." But it is crucial to analyse the potential and options for Russia to diversify its resource market strength by making better use of its reserve potential.

Using the correlation between green transition and rare earth metals as an example, this article seeks to investigate the potential of such a correlation to help Russia's economy and green energy goals. The aim is to analyse why Russia has a low production capacity of rare earth elements, despite having a high reserves and suggest ways for Russia to advance its production capacity by exploiting its mining strength. The article is divided into four sections.

2. Ia. V. Kryukov, N. lu. Samsonov, and V.A. Latsenko, "The Russian Rare Earth Industry: Should China's Experience be Adopted", *Journal of Problems of Economic Transition*, vol. 62, (1-2), 2020, pp. 95-107.

The first section explains the mineral resource dominance of Russia and how its geopolitics impacts the global supply chain. The second section explores the critical mineral capacity of Russia and the trends witnessed by the rare earth industry in Russia. The third section explains the factors responsible for the low development of rare earth production industry in Russia, which has limited production capacity of rare earth metals despite having a reserve. The fourth section examines Russia's Rare Earth Elements (REEs) trade equation with major players such as China, the United States, Australia, and Japan. The fifth section speculates on Russia's ability to take over the rare earth supply chain and alter the supply chain equations.

Russia has put a lot of work into developing and building pipelines both inside its borders and across Europe because natural gas is so crucial to its economy.

I. RUSSIA'S STRATEGIC USE OF ITS RESOURCES

When it comes to natural gas, Russia is a major player in the global energy market. Conventional energy supplies have come primarily from the Middle East and Russia. In this group, Saudi Arabia has the biggest proven crude oil reserves, while Russia ranks second in natural gas production and third in oil production. Both countries have the same oil-making capacity. Due to falling oil prices and the United States' transition from an oil-importing to an oil-exporting nation, the global oil supply and demand balance has been disrupted. There have been problems and intense rivalry ever since, with both countries feeling the effects of shifting geopolitical discourses around the world.

Russia has put a lot of work into developing and building pipelines both inside its borders and across Europe because natural gas is so crucial to its economy. Many of the natural gas pipelines that were constructed when Russia was still part of the Soviet Union passed through former Soviet states like Ukraine and Belarus. The first evidence of Russia's aim for energy dominance in Europe was shown when gas pipeline explosions disrupted

gas supplies in Georgia in 2006. In order to control the flow of natural gas into the area and obtain access to Iran, Russia lobbied the pro-Western government of Georgia to sell it its pipeline. Despite the fact that the Georgia incident did not work out in Russia's favour—Georgia blamed Russia for the explosions, while Russia blamed insurgents; and Georgia ultimately did not sell the pipeline to Russia—Russia places a great deal of importance on the movement and control of natural gas in pursuing its interests. Russia took the same approach in 2014 when it cut off Ukraine's access to natural gas because of Ukraine's failure to pay its obligations to Gazprom, the energy firm owned by Russia. It was extended further into the Russian invasion of Ukraine in 2015 and subsequent seizure of Crimea, which demonstrated the willingness of Russia to use its gas exports as a tool to further its objectives, along with military intervention, cyber attacks, and disinformation campaigns.[3]

Supply Chain Disruption Caused by Russia-Ukraine War

The tensions between Russia and Ukraine go back to the disintegration of the Soviet Union. Russia has always been concerned about the proximity of close relations between republics in the former Soviet Union and Western organisations such as the European Union (EU) and North Atlantic Treaty Organisation (NATO). Despite having proclaimed its independence from the Soviet Union, Ukraine was unable to establish a stable political system in recent years and alternated between Russia and the West. Ukraine and Russia continued to experience multiple crises due to issues over the Black Sea fleet, access to energy sources, and the rapprochement between Ukraine and the West. They even followed a distinctive approach during the Orange Revolution and the Yushchenko period. In 2014, the deepening relations of Ukraine with the EU and NATO disturbed Russia and even resulted in its intervention in Ukraine. The situation aggravated when Russia annexed Crimea and occupied Eastern Ukraine. In March 2014, Crimea declared its independence from Ukraine and joined Russia following a referendum and

3. Xu Hua, "The International Energy Trade Pattern Reshaping, Competition and Energy Revolution", Asia Conference on Geological Research and Environmental Technology, IOP Publishing, 2021, 632: 032022.

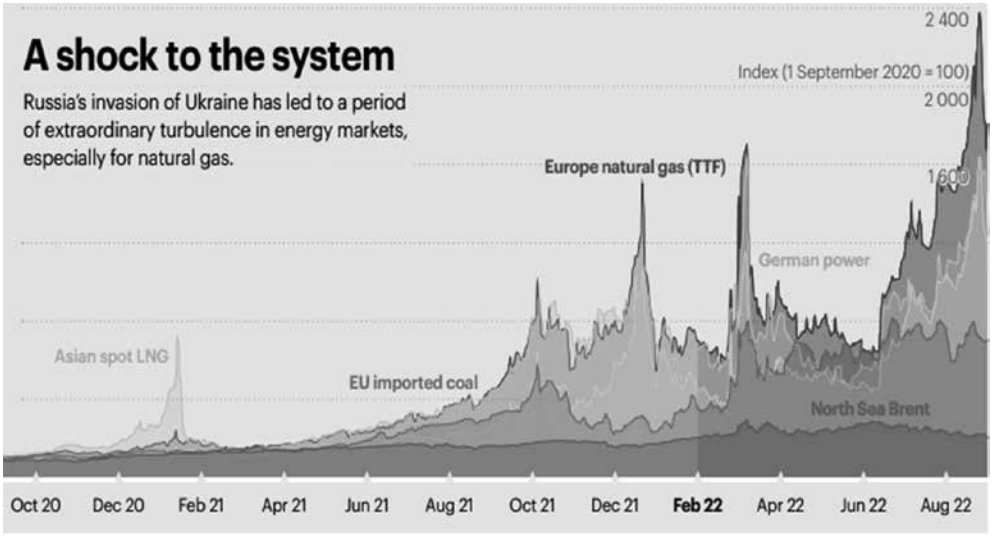
using the right of "self-determination." In February 2022, the tensions were triggered again with the growing possibility of Ukraine joining NATO, which caused Russian President Vladimir Putin to launch a military operation in the region, although Putin clarified his intention of only protecting the rights and self-determination of predominantly Russian-speaking people in the Donbas region, who have faced humiliation and genocide for more than eight years by the Kyiv regime. Experts have suggested factors like NATO-Ukraine rapprochement, energy security, a threat to Russian nationalism, and the significance of Crimea and the Black Sea fleet as additional reasons for the intervention.[4]

In addition to the geopolitical instability and humanitarian crisis, the Russia-Ukraine War has led to a sharp slowdown in the global economy, causing a rise in inflation, debt, and poverty globally. It has also impacted the commodity price, supply chain, and financial market (see Fig 1) through sanctions as reported by the Organisation of Economic Cooperation and Development (OECD), World Trade Organisation (WTO), World Bank, United Nations (UN), International Monetary Fund (IMF), UN Conference on Trade and Development (UNCTAD). Considering that 11 percent of the world's oil and 19 percent of its natural gas come from Russia, energy costs have increased dangerously, which has particularly affected Europe. However, the export embargo has also affected the Russian economy as several countries have imposed a wide range of financial sanctions on the banking sector of Russia and restricted its access to global financial markets and the System for Worldwide Interbank Financial Telecommunication (SWIFT) network.[5] The current Russian export ban to Europe will allow the European market to become less dependent on Russia, benefit from reduced price dividends, and gain a greater economic development buffer. The United States will stand to gain the most. The US enjoys the benefits

4. Salvador Ortega, "Addressing Russia's Energy Dominance in Europe", John Hopkins Capstone Project, May 2021, at https://jscholarship.library.jhu.edu/bitstream/handle/1774.2/62932/Ortega-Capstone%20Project-2020.pdf?sequence=1&isAllowed=y. Accessed on December 10, 2022.
5. Ebru Orhan, "The Effects of the Russia-Ukraine War on Global Trade", *Journal of International Trade (Logistics and Law)*, vol. 8(1), 2022, pp. 141-146.

of energy independence and tightly regulates the oil futures market and energy pricing through energy financial instruments.[6]

Fig 1: Disruptions Caused by Russia-Ukraine War



Source: Ewan Thompson, "6 Ways Russia's Invasion of Ukraine has Reshaped the Energy World", World Economic Forum, November 8, 2022, at https://www.weforum.org/agenda/2022/11/russia-ukraine-invasion-global-energy-crisis/. Accessed on March 25, 2023.

Disruption of Critical Mineral Supply Chain

The Russia-Ukraine conflict has brought the conflict over critical minerals back since the decade-long US policy focus on critical minerals began with the 2010 Chinese embargo on rare exports to Japan, triggered by territorial disputes in the East China Sea. Russia is a rich geography of high-tech metals such as beryllium, cadmium, germanium, indium, lithium, niobium, rhenium, tantalum, and rare earth elements.

6. Ibid.

Nickel

Russia was the third-largest nickel producer in the world in 2021, producing 10 per cent of the world's supply, behind Indonesia and the Philippines. Following the escalation of the Russia-Ukraine crisis, nickel prices spiked by more than 100 percent in the first two weeks. Nornickel produced 236,000 kilotons (kt) of nickel in 2020, making it Russia's largest nickel producer. The nickel market, which was already seriously deficient, was prompted by the prospect of supply disruption due to the sanctions, despite the fact that Russia is a big provider.[7]

Aluminum

Russia's RusAI is one of the world's largest aluminium producers, accounting for 6 per cent of the global supply. The US sanctions against RusAI have not prevented it from serving as a key supplier in a field experiencing rapid growth. Following the revelation that it was a major client of the Russian metal behemoth for its European operations, Tesla was among many foreign corporations that faced wrath from the public. No new direct limitations have been imposed on RusAI as a result of the Ukraine crisis, but Australia has announced it will stop selling bauxite and alumina to Russian customers, which might leave RusAI short of a crucial raw material.

Titanium

Titanium sponge is essential in the aerospace and defence industries, and Russia is the world's third-largest manufacturer of it. Despite Boeing's March 7, 2022, announcement that it will no longer purchase titanium from Russia, Airbus, Boeing's European competitor, continues to rely on Russian supply.

Palladium

This is a crucial component of the semiconductor and automobile industries, and Russia supplies over 37 per cent of the world's supply, making it one

7. Ibid.

Russia, facing continued sanctions, must innovate and modernise its energy sector to make more efficient use of its resources and reduce prices across the entire value chain. Russia's energy transition plans have increased the visibility of the rare earth industry.

of the most critical minerals affected by the conflict in Ukraine. As is the case with Russian palladium, one of the most important geopolitical aspects of strategic minerals is that alternatives are often found in markets that are just as tough.[8]

Rare Earth Elements

Nearly all of Russia's confirmed economic REE reserves are located in complicated deposits. Nearly 60 per cent of the raw materials used in the chemical industry comes from apatite-nepheline ore mined from the currently active Khibiny deposits and apatite-carbonatite metasomatic ore mined from the potential Seligdar deposit in the Sakha Republic. The remainder of the deposits can be found in the weathered mantles of rare metal carbonatites and in the complex loparite ore found at Lovozero. Russia, facing continued sanctions, must innovate and modernise its energy sector to make more efficient use of its resources and reduce prices across the entire value chain. Russia's energy transition plans have increased the visibility of the rare earth industry. Russia faces a strategic choice in the light of the current geopolitical discourse and its effects on energy trading and supply chain: either it attempts the risky transition to carbon-free technologies, which would go beyond its priority industry, or, instead, it focusses on maximising the advantages of the hydrocarbon industry. With the help of research and development, new technologies, and the development of artificial intelligence, Russia's large firms are well-equipped to enter new markets and make use of renewable energy sources.[9]

8. Dr. Robert Johnston, "Supply of Critical Minerals Amid the Russia-Ukraine War and Possible Sanctions", Centre on Global Energy Policy, April 19, 2022, Columbia, SIPA, at https://www.energypolicy.columbia.edu/sites/default/files/file-uploads/CriticalMinerals_CGEP_Commentary_041522.pdf. Accessed on December 10, 2022.
9. Ibid.

II. CRITICAL MINERALS AND RARE EARTH INDUSTRY IN RUSSIA

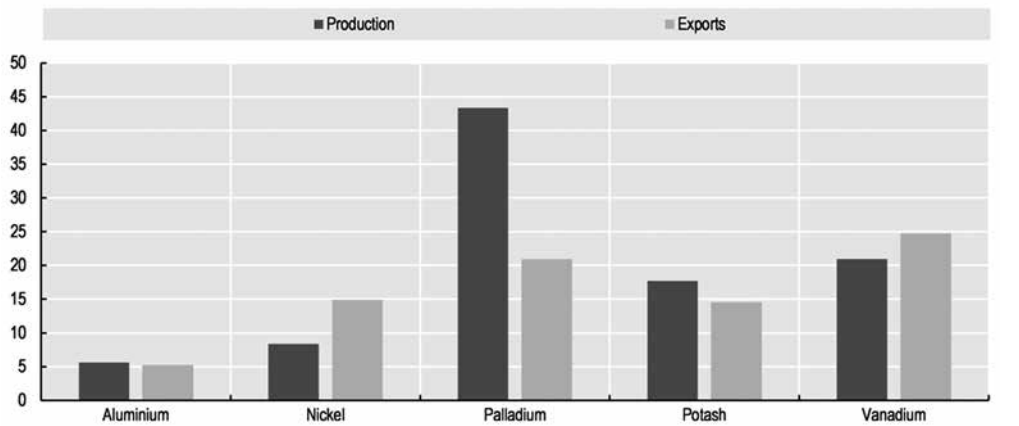
According to an official decree of the Russian government, the strategic elements are oil, natural gas, ferrous metals (manganese, chromium, titanium), non-ferrous metals (copper, nickel, cobalt, lead, molybdenum, tungsten, tin, antimony), rare exotic metals (zirconium, tantalum, niobium, beryllium, yttrium, scandium, lithium), and rare earth elements (lithium, yttrium, scandium-Sc. The United States Geological Survey (USGS) mineral commodities summary has confirmed Russia's high production and export capacity of key critical minerals (see Fig 2). REEs are responsible for the stable oxides, halides, and sulphides. They have relative abundance in nature from 0.003 per cent for lanthanum to 0.0008 per cent for thulium and lutetium. REEs always coexist with one another in REE richer minerals due to their chemical resemblance, making separation difficult. The primary sources of REEs include bastnaesite, monazite, loparite, and ion-absorbing ores. There are only a few mineable REE resources in the world. The Chinese bastnaesite deposits hold the majority (48 per cent) of the world's recoverable REE reserves. Monazite deposits can be found in Australia, Brazil, India, Malaysia, South Africa, Sri Lanka, Thailand, and the United States. These countries also have significant REE reserves. The remaining reserves are found in liquid uranium production wastes, xenotime, ion-absorbing ores, loparite, phosphorite, apatite, secondary monazite, eudialyte, and cheralite.[10]

According to USGS data, Russia has the third-largest rare earth mineral reserves in the world (tied with Brazil), with 21 million tonnes.[11] However, according to President Putin, Russia actually comes in first or second place because of two factors: (a) Russia rates its reserves differently than the US, whose Geological Survey produces the most recent global data; and (b) Russia's vast, uncharted, and, unexplored territory, which may contain

10. Yury Daneykin, et. al., "Energy Transition to Renewable Energy Sources and Its Consequences for Russia", Proceedings of the International Scientific and Practical Conference Strategy of Development of Regional Ecosystems "Education-Science-Industry" (ISPCR 2021), Advances in Economics, Business and Management Research, vol. 208, 2022.
11. N. S. Bortnikov, et. al., "Mineral Resources of High-tech Metals in Russia: State of the Art and Outlook", *Geology of Ore Deposits*, vol. 58(2), 2016, pp. 83-103.

more reserves. In terms of rare earth production worldwide, the US and Australia are significant after China. These two are the second- and third-largest producers worldwide, with a production capacity of about 20,000 million tonnes per year. The output in the US is 15,000 tonnes per year, while Russia only contributes 2 per cent of global production.[12]

Fig 2: Russia's Share Global Production and Export of Key Critical Minerals



Source: OECD, "The Supply of Critical Raw Materials Endangered by Russia's War on Ukraine", August 4, 2022, at https://www.oecd.org/ukraine-hub/policy-responses/the-supply-of-critical-raw-materials-endangered-by-russia-s-war-on-ukraine-e01ac7be/. Accessed on March 25, 2023.

Russia imports 90 per cent of its rare earth materials from China. In order to ensure that supplies don't run out, the Russian government has been promoting the growth of the sector since 2013. Due to their use in military gear, Putin referred to the metals as "critical to Russia's defence capabilities" in 2016. Even so, 80 per cent of Russia's consumption is driven by the petrochemicals industry. The Russian State Duma, the nation's Lower House and stand-in for Parliament, has approved a law that lowers the tax

12. USGS Mineral Commodity Summaries 2022, "Rare Earths", at https://pubs.usgs.gov/periodicals/mcs2022/mcs2022-rare-earths.pdf. Accessed on December 22, 2022.

rate on rare earth extraction to 4.8 per cent from the prior 8 per cent, which got final approval by President Putin in 2019. This reflected the Russian government's keen interest in rare earth elements. Moreover, the Russian government has so far allotted 4.3 billion roubles, or roughly $63 million, for the research and development of rare earth mining and exploration. By 2016, 40 of these initiatives had been completed. There is currently only one plant in Russia that can separate concentrates into different metals, which is the Veliky Novgorod plant, operated by potash producer PJSC Acron. It produces cerium, lanthanum, and neodymium, with an annual production capacity of more than 200 tonnes of rare earth oxides. However, the lack of proper separation, refinement, and processing technology is unquestionably the main point of contention for Russia.[13]

Rare Earth Industry in the Former USSR

In the early 1930s, the Soviet Union began to develop a rare earth element industry, which grew in importance for the production of various metals used in lamps and other ignition devices. The advancement in Russia was a result of the efforts of Professor I.N. Zaozerskii, who organised a laboratory of rare earth elements in the State Research and Design Institute of the Rare Earth Industry, also called the Giredmet Institute in Moscow. His efforts inspired other scientists to work for the advancement of the rare earth industry in Russia, notably P.I. Protserov, V.A. Ryabkov, G.A. Ter-Shmaonov, and others. In the post-War years, the focus of the Giredmet Institute changed, and it organised the All-Union Scientific Research Institute of Chemical Technologies (VNIIKhT) in 1951. The activities and efforts of the Girdement Institute and VNIIKhT helped Russia become the third leading source of high-purity rare earth production in the 1980s. The production capacity even reached more than 8,500 tonnes by the 1990s in Russia.[14]

13. Mining World Russia, "How is Russia Developing Rare Earth Metals?", at https://miningworld.ru/en/media/news/2020/march/3/how-is-russia-developing-rare-earth-metals. Accessed on December 25, 2022.
14. Ibid.

Rare earth deposits in Russia, Kazakhstan, and Kyrgyzstan were used to make hard magnetic materials in the former USSR. These deposits were found on the land of these three countries. Russia had ten explored deposits, but only three were being used: the Kirghiz Mining and Metallurgical Integrated Plant (MMIP) in Kazakhstan, the Prikaspiysk MMIP near the Caspian Sea, and the Lovozerskoye Mining and Processing Plant (MPP) (in Russia). The JSC "Solikamsk Magnesium Plant" (SMP) was set up to make loparite, a raw material, and the rare earth compound titanate-niobate-tantalate. So, the processing plant started to give out a lot of chlorides, carbonates, rare earth oxides, niobium, tantalum, and titanium.[15] The Tomtor deposits have unique natural concentrations that involve the presence of up to 1 kg of scandium, 0.8 kg of europium, 0.2 kg of terbium, 1.5 kg of dysprosium, 6 kg of praseodymium, and more than 20 kg of neodymium in one tonne of the ore.[16] (see Table 1)

Table 1: Major Rare Earth Deposits/Plants in USSR

Deposits/Plants	Location	Available Ores/ Rare Earth	Mining Capacity
During USSR			
Loparite Kol'skii peninsula	Murmansk, Russia	Cerium	70-80%
SMZ Solikamsk	Kirgizia, Kyrgyzstan	Xenomite, Yttrosyn-chysite	5%
Bone Detritus	West Kazakhstan		15-20%
Plant of Nonferrous Metals	Moscow	Yttrium	-

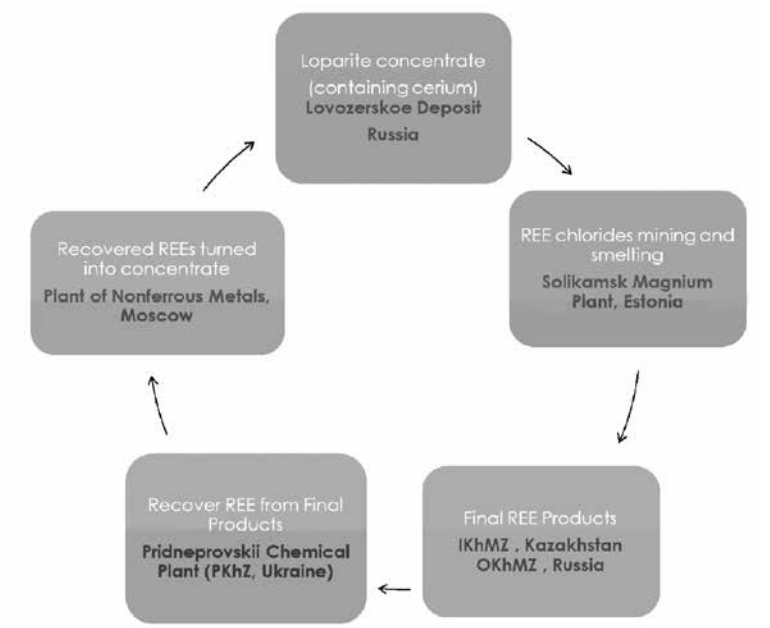
Source: A.A. Gasanov, "Certain Tendencies in the Rare-Earth-Element World Market and Prospects of Russia", *Russian Journal of Non-Ferrous Metals*, vol. 59, 5, 2020, pp. 502-511.

In the Soviet Union, obtaining, purifying, and using rare earths followed a standard procedure (see Fig 3). The Silmet Plant in Sillamae, Estonia,

15. A.A. Gasanov, "Certain Tendencies in the Rare-Earth-Element World Market and Prospects of Russia", *Russian Journal of Non-Ferrous Metals*, vol. 59(5), 2018, pp. 502-511.
16. YU.A. Vereschagin, N.V. Kudrevatykh, M.A. Malygin and T.N. Emelina, "Rare-Earth Magnets in Russia: Raw Materials, Processing, Properties Control and Output Issues", Proceedings of 19th International Workshop on Rare Earth Permanent Magnets and Their Applications, 2018, pp. 23-32.

and the Solikamsk Magnesium Plant refined loparite concentrate mined from the Lovozerskoe deposit of rare earth elements. Products were then manufactured at the Pyshma Pilot Chemical and Metallurgical Plant and the Irtysh Chemical and Metallurgical Plant (IKhMZ, Kazakhstan) (OKhMZ Giredmet, Russia). The Prikaspiisk GMK (Mining and Smelting Combine) supplied melovoe raw materials to Dneprodzerzhinsk, and, subsequently, the Pridneprovskii Chemical Plant (PKhZ, Ukraine) separated cerium REEs from the combination (for the petrochemical industry). The yttrium rare earth element concentrate was also sent from there to the Moscow Nonferrous Metals Processing Plant (MZP).[17]

Fig 3: Cycle of Rare Earth Industry in the former USSR



Source: N. Yu. Samsonov, et al., "Possibilities of Russian Hi-Tech Rare Earth Products to Meet Industrial Needs of BRICS Countries", *African Journal of Science, Technology, Innovation and Development*, 2020, http://dx.doi.org/10.1080/20421338.2017.1327922.

17. Ibid.

III. RARE EARTH INDUSTRY IN RUSSIA POST DISINTEGRATION

With the disintegration of the Soviet Union, Russia lost the required extraction technology despite having high reserves. Russian rare earth export capacity also experienced an 'up-down-up again-down again' process,[18] and went through five major periods, with growth and declining trends (see Table 2).

Table 2: Russia's Rare Earth Export Capacity (2006-20)

Period	Export Value (in USD)	Export Capacity Status
I (2006-2009)	32.28 million	Moderate Growth
II (2009-2011)	89.81 million	High Growth
III (2011-2016)	19.3 million	Major Decline
IV (2016-2019)	60 million	High Growth
V (2019-2020)	51.04 million	Moderate Decline

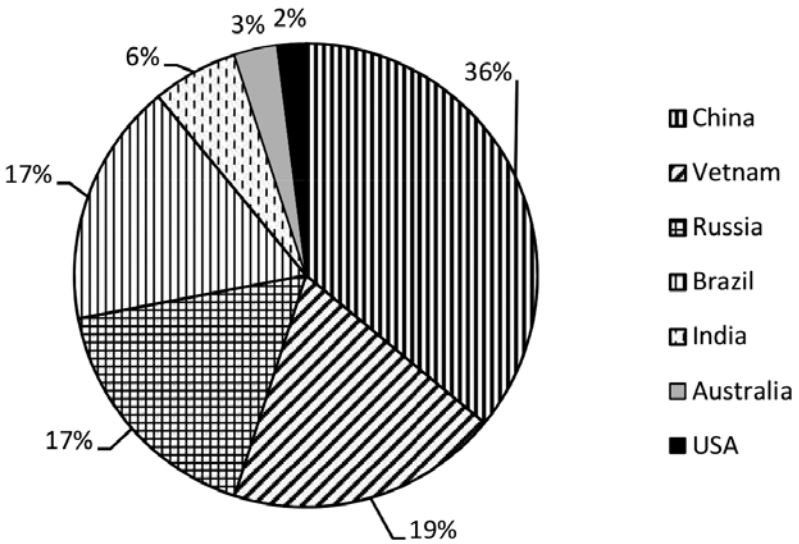
Source: Qing Guo, Zishan Mai, "A Comparative Study on the Export Competitiveness of Rare Earth Products from China, the United States, Russia and India", *Journal of Sustainability*, vol. 14, 12358, 2022, pp. 1-31.

Though it has the third-largest REM reserves in the world today, Russia has only the third-lowest REM production capacity and consumption (see Figs 4, 5, and 6). The Russian REM market is poorly understood and not studied systematically. Although they have reserves, REMs are not treated with the same prominence by countries that rely heavily on imports, such as Europe, Japan, and South Korea. Low acceptance of new resources, low adaptation to mineral deposit replenishment, less established institutional and economic systems, and a lack of production capacity required for high-value products all contribute to Russia's low-profile rare earth business.

18. Ibid.

Russia has the fourth-largest reserve of REMs, although it has only the Lovozero deposit from which to extract those elements. In reality, Russia possesses the necessary technologies but has not been using them to launch any new initiative.[19] This promise is not being realised, however, due to a number of factors, including a lack of reliable quantitative data on incidental vital elements in ores and concentrates at many Russian deposits, technological challenges with crucial metal recovery, and low production profitability.

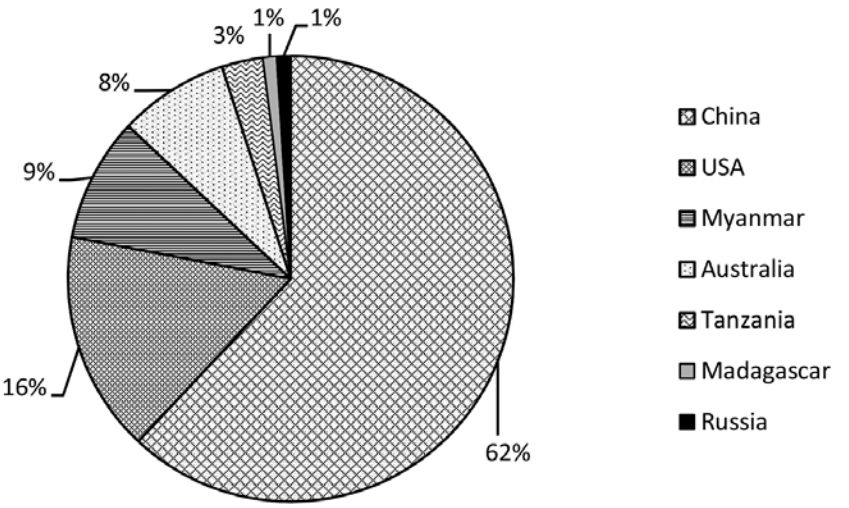
Fig 4: Russia's Share of Global Rare Earth Reserves



Source: USGS Mineral Commodity Summaries 2022- Rare Earths- https://pubs.usgs.gov/periodicals/mcs2022/mcs2022-rare-earths.pdf

19. Qing Guo and Zishan Mai, "A Comparative Study on the Export Competitiveness of Rare Earth Products from China, the United States, Russia and India", *Journal of Sustainability*, vol. 14, 12358, 2022, pp. 1-31.

Fig 5: Russia's Share of Global Rare Earth Production



Source: USGS Mineral Commodity Summaries 2022- Rare Earths- https://pubs.usgs.gov/periodicals/mcs2022/mcs2022-rare-earths.pdf

Fig 6: Rare Earth Potential of Russia and other Major Powers

	Ore production	Ore concentrate	Oxide production	Production of pure metals	Production of neodymium magnets
China	x	8*	11	7	9
Australia	x	1			
India	x	1			
Russia	x	1	1		
Europe		1	2	2	1
Japan				5	5

* - number of companies per country

Source: Ia.V. Kryukov, et. al., "The Russian Rare Earth Industry: Should China's Experiences be Adopted?", *Journal of Problems of Economic Transition*, vol. 62, 1-2, 2020, pp. 95-107.

The REE Development State Programme says that Russia must stop relying on imports and instead develop its own production. The Ministry of Industry and Trade estimates that REE demand in the Russian Federation ranged from a small increase of 5–7 kt to a large increase of 13 kt by 2020. The complex rare metal resources on the Kola Peninsula have been mined recently, and the results have been good. The Lovozero Mining and Concentrating Company is another major player. The amount of REEs that Russia uses is expected to rise from 2 kt now to 20 kt by 2032. If the Olenii Ruchei deposit in the Khibiny Mountains and the Katu Gin, Tomtor, and Chuktukon deposits are all put to use, Russia may be able to meet its expected REE demand. Scandium (Sc) is one of the most expensive rare earth metals, and Russia has more than enough of it in its certified economic reserves (1.3 kt) to meet all current and future demand. To carry out the ARMZ Uranium Holding's (Moscow) Sc mining strategy, the Lermontovo Metallurgical Plant (6 t/yr) will work with the Dalur and Khiagda mining and concentrating combines. With this project, the needs of the Russian economy will be met, and exports will be safe. Scandium is a rare earth metal that is being mined by ARMZ Uranium Holding. It will soon be processed at the Lermontovo Metallurgical Plant, which has a capacity of 6 tonnes per year. With this project, the needs of the Russian economy can be met, and exports may be assured. The Kola Peninsula has a lot of potential because a cutting-edge method is used to get REE oxides out of an apatite concentration. It will not only meet the needs of Russia but also about half of the needs of the rest of the world. The problem of where to find the most important metals will be solved by a complex use of Russia's local technology reserves.[20]

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20. Ibid.

Rare Earth Processing Technology in Russia

V.I. Kuzmin of the Institute of Chemistry and Chemical Technology SB RAS in Krasnoyarsk came up with a new research and industrial technology at the beginning of the 2000s. This technology is now being used to mine the tomtor deposit at the Blizzard site. During the processing stage, the technology helps turn more than 75 per cent of tomtor ores into marketable products, such as carbonates of rare earth elements, individual oxides, and high-purity products (pure REMs, including heavy and expensive lanthanides). A new pyrometallurgical technology called "Liquation Melting" was created by the Joint Institute for High Temperatures in Moscow and the "Lanthanum" company in the Novosibirsk region. It also makes it possible to get phosphate-saline alloys with rare earths (slag) and alloys with niobium that are easy to separate and much cheaper than the standard alkaline hydrometallurgical method (up to 25-30 per cent).[21]

Ongoing Rare Earth Projects in Russia

In charge of the greatest proposed expansion is the TriArk Mining Co., is a company jointly owned by the industrial behemoth Rostec and business billionaire Alexander Nesis. The Tomtor deposit, which TriArk is now developing, has the potential to increase annual production by 14,000 tonnes of ferroniobium and 16,000 tonnes of rare earth metal oxides. The Rostec spokesperson Andjey Krasutsky predicted that by 2023, Tomtor would account for 10 per cent of global production. ZAO Technoinvest Alliance, in which steel pipe manufacturer ChelPipe PJSC has a stake, is developing a second, smaller rare earth project. Tantalum, niobium, and rare earth metal oxides will be extracted from the Zashikhinskoye deposit in the Irkutsk region. Pipes will be constructed using some of these materials. The project's ultimate aim is to treat 1,000,000 tonnes of ore annually. According to TASS, the regional authorities have predicted that the facility wouldn't begin operations until 2023.[22]

21. N. S. Bortnikov, et. al., "Mineral Resources of High-tech Metals in Russia: State of the Art and Outlook", *Geology of Ore Deposits*, vol. 58(2), 2018, pp. 83-103.
22. Ibid.

Russia is facing a slew of challenges in terms of deposit development and production. The processing technique is the primary issue. Russia is currently working on a number of different projects. In terms of prospective completion, George Voloshin, who heads the Paris branch of the consultancy Aperio Intelligence, cites Tomtorskoye in the northern Sakha Republic and the Zashikhinskoye deposit in the Irkutsk Oblast as the most promising. Rostec Corp., a state-owned technology conglomerate, signed a US$1 billion deal in 2013 to develop Tomtorskoye in collaboration with Polymetal International PLC founder Alexander Nesis's ICT Group, but progress has been slow and long-term financing remains uncertain. TriArk Mining LLC is in charge of the project, which aims to produce 16,000 tonnes of rare earth oxide per year as well as 14,000 tonnes of ferroniobium, an alloy used in high-strength low-alloy steel. Although Zashikhinskoye was notably absent from the Ministry of Natural Resources' most recent report on Russia's mineral resources, the Russian Ministry of Industry and Trade told S&P Global Market Intelligence that developing Tomtorskoye is the only way to sharply increase Russia's extraction of rare earths and production of collective concentrates. In an effort to foster the growth of the sector, Moscow launched a subsidy package in 2013 that was set to conclude in 2020. Its goal was to lessen Russia's dependency on imports by guaranteeing a stable supply of rare earth-bearing concentrates and solving the more difficult issue of extracting the metals on the country's own. The vast bulk of Russia's processed rare earths originate from China, as reported by Voloshin.[23]

Though the metals are most often used in permanent magnets, an essential component of electric vehicles, Putin identified them as crucial to Russia's defence capacity, sophisticated weaponry, and military equipment in 2016.

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23. n. 13.

The energy industry relies heavily on energy trading to facilitate production and distribution. The expansion and development of a country's energy market on a worldwide scale affects the growth and functioning of that country's economy; hence, it is subject to economic rules as well.

in 2016. The lower chamber of the Russian legislature, known as the State Duma, voted in favour of a Bill that would drop the tax rate on rare earth extraction from 8 per cent to 4.8 per cent. A 2035 industry development plan is also in the works. In 2013, the Kremlin allocated 4.2 billion roubles for four years of Research and Development (R&D), with 40 R&D initiatives completed by the end of 2016. Despite this, due to a lack of separation plants, Russia exports 95 per cent of the rare earth concentrate it produces, according to the Ministry of Industry and Trade. Putin inaugurated the $50 million plant in Veliky Novgorod in 2016, which produces cerium, lanthanum, and neodymium. It is Russia's only industrial-scale rare earth concentrate separation project. It also produces concentrates of light and medium heavy rare earths. An yearly output of 200 tonnes of rare earth oxide is claimed by the Ministry of Industry and Trade. In June of 2022-23, JSC Uralchem, a fertiliser company, reached a deal with state officials and Moscow-based SkyGrad Innovations to extract rare earth concentrations from phosphogypsum waste dumps, a somewhat radioactive byproduct of apatite production. Additionally, all of Russia's rare earth compounds come from the Perm-based OJSC Solikamsk Magnesium Works. The head of a Russian gold and silver manufacturer, Vitaly Nesis, announced in June that Polymetal International was considering rare earth investments with an emphasis on technology.[24]

24. Ashleigh Cotting, Toby Woodall and Jose Miguel Fidel Javier, "Russia Struggling to Capitalize on Rare Earth Reserves", S&P Global Market Intelligence, July 3, 2019, at https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/russia-struggling-to-capitalize-on-rare-earth-reserves-52525919. Accessed on December 24, 2022.

Table 3: Ongoing Rare Earth Metal Projects in Russia

Deposit/ Company	Rare Earth Products	Annual REEs Production Capacity	Required Investments	Implementation Year
Tomtor Deposit/ IST Group	Niobium	2.4 thousand tonnes	RUB 53 billion	2025-26
Zashikhinskoye Deposit/ Technoinvest Alliance	Ferroniobium, tantalum, zirconium, rare earth metals	240 tonnes of REE oxides	RUB 28 billion	2024-25
Afrikanda Deposit/ SGK Arkmineral LLC	Niobium, tantalum, titanium dioxide, rare earth metals	400 tonnes of mixed REE concentrate	RUB 70 billion	2020-39
Seligdar Deposit	Apatite concentrate, rare earth metals	100 tonnes of REE concentrate	RUB 46 billion	-

Source: A.E. Cherepovitsyn, Victoria Solovyova, "Prospects for the Development of the Russian Rare-Earth Metal Industry in View of the Global Energy Transition—A Review", *Journal of Energies MDPI*, vol. 15, 387, 2022, pp. 1-24, at https://doi.org/10.3390/en15010387.

IV. RARE EARTH TRADE EQUATION OF RUSSIA WITH MAJOR POWERS

The energy industry relies heavily on energy trading to facilitate production and distribution. The expansion and development of a country's energy market on a worldwide scale affects the growth and functioning of that country's economy; hence, it is subject to economic rules as well. In recent

years, countries that produce energy have advocated greater diversification in their exports as a means of achieving financial stability, while countries that consume energy have advocated greater diversification in their import sources as a means of protecting against disruptions in their own energy supply. As a rule, the structure of energy exchange is intricate and involves many different parties. Four distinct trade blocs can be distinguished in the international energy market: the North American bloc (including the United States, Canada, Mexico, Brazil, Venezuela, etc.); the European and Russian blocs; the East Asian and Southeast Asian blocs; and the Australian, Indian, and African blocs.[25] Energy trade is different from regular trade because of its potential to alter the political, economic, and strategic balance of the world. It is impossible to grasp the intricacies of energy commerce and cooperative methods without first appreciating the influence of the geopolitical discourse at higher levels. Russia has played a significant part in this geopolitical discussion as shale oil and gas technologies evolve, causing massive shifts in the global energy sector.[26] There will soon be a moment when a country's opponent is not only a friend, but also a competitive advantage in terms of its involvement in integration communities like the World Trade Organisation, the Brazil, Russia, India, China, South Africa (BRICS) countries, the East Asian Economic Union, and the Association of Southeast Asian Nations (ASEAN). When "everyone is against everyone," friends and adversaries coexist, and each nation must learn to grasp its own trend of non-prescription involvement in international economic interactions, according to the theories of T. Hobbes. This will not only result in the segregation of the most advanced companies in Industry 4.0, but also in the fragmentation of the global economy into separate currency, innovation, and technology zones, as well as a reduction in the reformatting of environmental standards and the resulting emergence of a new wave of population movement.[27]

25. Ibid.
26. Xu Hua, "The International Energy Trade Pattern Reshaping, Competition and Energy Revolution", Asia Conference on Geological Research and Environmental Technology, IOP Publishing, 2021, 632: 032022.
27. Ibid.

Brazil and China are the two BRICS countries with a significant share of the market for rare earth elements. The Araxa carbonatite deposits in Brazil account for 90 per cent of the world's niobium production. Bayan Obo's deposit field meets 90 per cent of China's needs for rare earth elements. There is an infinite supply of the highly molten materials at Tomtor, Russia's niobium-rare earth deposits located in the Arctic zone to the northwest of Yakutia. The state corporation Rosatom (SC Rosatom) has the ability to strengthen Russia's position as a global leader in the rare earth industry by revitalising and expanding the country's REE market. Rosatom, a conglomerate of around 400 businesses and organisations involved in the Russian nuclear industry and nuclear weapons, is currently responsible for nuclear energy policy in Russia. Rosatom has the second-highest uranium deposits and the third-highest uranium production capacity in the world, making it the top producer of nuclear technologies and nuclear power stations. SC Rosatom has the potential to get involved in the REE production chain, providing a significant boost to the Russian economy at a time when resilience is in high demand. SC Rosatom has the ability to establish a reliable technological chain for REM processing and manufacturing.[28]

How China's Experience can Help Russia

In comparison to China's rare earth industry, developed from bottom-up, the Soviet Union had functioned steadily in the rare earth sector. China's experience and techniques can be used by Russia to reorient its REM industry in the following ways:

(a) Encourage participation of small and medium size enterprises in the market of rare earth metal and high-tech production.
(b) Incorporate other countries to diversify the sources in the supply chain.

28. Yury Daneykin, et. al., "Energy Transition to Renewable Energy Sources and Its Consequences for Russia", Proceedings of the International Scientific and Practical Conference Strategy of Development of Regional Ecosystems "Education-Science-Industry" (ISPCR 2021), Advances in Economics, Business and Management Research, vol. 208, 2022.

(c) Simplify the research and development about products and technologies containing REMs.
(d) Prioritise 'what and where to extract' and 'where and how to consume or use' to balance the supply-demand equation.
(e) Join the value-added chains developed by China or Japan.[29]

V. POTENTIAL OF RUSSIA TO DOMINATE REE SUPPLY CHAIN: CONCLUSION

Despite producing hydrocarbons and having a rich store of rare earth elements, the Russian economy appears to be afflicted by the 'oil curse' The switch to green energy had increased the significance of developing and revitalising Russia's rare earth sector. When one type of energy resource dominates the market (oil and gas in Russia's instance), implementing a plan to diversify the energy mix becomes extremely challenging. This disorder is known as the "Dutch Disease".

Herein lies the significance of Russia's energy transformation and the diversification of its reserve-based resource market strength. The Russian Government Regulation No. 449 (2013) encouraged the use of renewables in the wholesale electric power and capacity markets in Russia, and Decree No. 861-r (2013) also aimed to increase the energy efficiency of the electrical energy industry through the use of renewables until 2020. These were the original legal foundations for trading renewable electricity in the wholesale Russian energy market. One of the steps established by the Russian Government Regulation #47 (2015) to encourage biogas, energy biomass, landfill gas, and other renewables on retail power markets defined the energy transition goals of Russia. The Russian Federation introduced the "Strategy for Science and Technology Development" in 2016, which outlined seven priorities, including "the transition to an ecologically friendly and resource-efficient energy economy." This priority focusses on

29. N. Yu. Samsonov, et. al., "Possibilities of Russian Hi-Tech Rare Earth Products to Meet Industrial Needs of BRICS Countries", *African Journal of Science, Technology, Innovation and Development*, vol. 9(5), June 19, 2017, pp. 637-644.

the areas of future research and technology that the Russian government will fund until 2035.[30]

In September 2019, Russia affirmed its commitment to the Paris Agreement (COP21) to establish strategies for a successful transition to a path of low-carbon growth. The Russian government approved the "National Action Plan" for the first phase of climate change adaptation by 2025 in January 2020. As of 2019, it was claimed that Russia has 1.7 Giga Watts (GW) of renewable energy capacity, the majority of which was solar energy. However, Russia has not established any facilities for wind power generation or production of electric vehicles, which hinders its green energy transition. The desire to develop other renewable energy sectors prompted the Russian Federation to implement laws and strategies to aid its transition to green energy. The 'Energy Strategy' to be followed until 2035 was approved in April 2020, implying a resource-innovative path as the optimal way for the transition to a resource-based energy industry, which involves: (a) renewable energy; (b) hybrid and electric vehicles; (c) hydrogen fuel; (d) unmanned vehicles and intelligent transport systems; and (e) electric power. In July 2021, the Russian government approved a 'National Security Strategy' that stressed human capital and the environment as key factors in transforming the country's economy. Russia has also accepted the National S&T Foresight through 2030, the National Energy Strategy through 2030, and the S&T Foresight of Energy Industry Segments through 2035.[31]

Researchers and decision-makers in Russia have been more interested in oil and gas processing (oil and gas to chemicals), using related gas, and building oil and gas pipelines, and have given less emphasis to a potential new energy sector. But now is the time for Russia to prioritise its energy transformation and use its potential reserves to diversify its resource market strength. Under geopolitical discourses, Russia's macroeconomic policy-oriented frameworks

30. Unguru Manuela, et. al., "Russian Trade in Non-Food Raw Materials: Focus on EU-Russia Trade Relations", European Union Commission JRC Technical Report, June 7, 2022, at https://publications.jrc.ec.europa.eu/repository/handle/JRC129611. Accessed on December 27, 2022.
31. Anastasia Lyrchikova and Gleb Stolyarov, "Russia has $1.5 Billion Plan to Dent China's Rare Earth Dominance", Reuters, August 12, 2020, at https://www.reuters.com/article/russia-rareearths-idUSL8N2F73F4. Accessed on December 28, 2022.

Russia plans to invest $1.5 billion in rare earth minerals, which are important for the defence, telecommunications, and renewable energy sectors. Russia wants to be the second-largest producer of rare earth minerals after China by 2030.

recommend and favour two strategies for keeping up with ongoing changes in energy trade: "Technology Adaptation" and "Technology Breakthrough." The approach to technological breakthrough implies a transitional phase in energy usage that requires high costs and a comprehensive innovation system to get fruitful results. The approach to technology adaptation entails large-scale imports of technologies that have advanced in research and strategic priorities. The "Strategy for the Development of the Automotive Industry" in Russia acknowledged that REMs are essential and irreplaceable components for the domestic manufacture of electric vehicles. Adoption of the "Concept for the Development of Electric Transportation" confirmed the development of production facilities for electric vehicles in Russia.[32]

A top government official told Reuters that Russia plans to invest $1.5 billion in rare earth minerals, which are important for the defence, telecommunications, and renewable energy sectors. Russia wants to be the second-largest producer of rare earth minerals after China by 2030. Russia has 12 million tonnes of reserves, which is 10 per cent of the world's total, and its government is willing to support any foreign investment. Alexei Besprozvannykh, who is Russia's deputy minister of industry and trade, said that Russia is offering investors lower mining taxes and cheaper loans as part of a list of 11 projects that aim to raise Russia's share of the world's rare earths production from 1.3 per cent to 10 per cent by 2030. In an interview with Reuters, Besprozvannykh said that China will continue to lead the market, but Russia's goal is to be at least second after China by 2030. The only entity other than China that processes rare earths is an Australian company's plant in Malaysia. The deputy minister said that the 11 projects, which include

32. Liliana Proskuryakova, "Foresight for the 'Energy' Priority of the Russian Science and Technology Strategy", *Energy Strategy Reviews*, vol. 26: 100378.

developing the Tomtor deposit in Russia's Far East, will allow Russia to be almost self-sufficient in rare earth elements by 2025 and to start exporting in 2026. He also said that Russia could make up to 7,000 tonnes of rare earth concentrate per year by 2024.[33] Russia's economy, which is based on petroleum export and is faltering as a result of the global energy shift, may find its solution in the rare earths business. If adequately utilised or prioritised, Russia's vast REM reserves could facilitate a transition to a low-carbon development path. There is a developing correlation between Russia's transition to green development and the need to boost its rare earth sector.[34] In addition, Russia can also lead the world towards less dependence on rare earth for green energy transition with its innovations, for instance, the ZETTA (Zero Emission Terra Transport Asset) model in Russia has created electric vehicles that do not use rare earth metals. It wants, at an estimated cost of 550 thousand roubles, to replace electric motors with non-REM-required wheel motors, which reflects how Russia can reduce the reliance on rare earth metals with its technological innovations.

If adequately utilised or prioritised, Russia's vast REM reserves could facilitate a transition to a low-carbon development path. There is a developing correlation between Russia's transition to green development and the need to boost its rare earth sector.

Overall, the entire research of this paper implies that Russia might be a substantial challenge and consequential participant in the supply chain of rare earth elements, just as it controls the oil, gas, and other resource supply chains. Russia has the reserves, economics, and technical advancements necessary to alter the geopolitical discourse around rare earth elements under China's sway. If the Russian production capacity for rare earth elements is given a higher priority, it can contribute to the improvement of the Russian economy, which has been negatively impacted by the ongoing sanctions;

33. Ia. V. Kryukov, N. lu. Samsonov, and V.A. Latsenko, "The Russian Rare Earth Industry: Should China's Experience be Adopted", *Journal of Problems of Economic Transition*, vol. 62 (1-2), 2020, pp. 95-107.
34. Ibid.

the energy transition goals to adopt renewables; and the establishment of Russia's geoeconomic significance in the supply chain.

Potential of Russia-India REE Ties

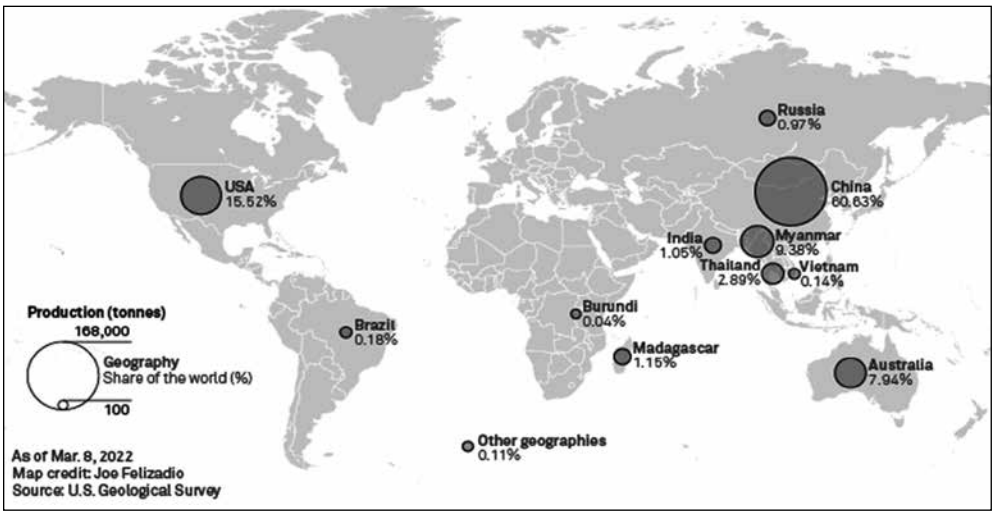
In an era wherein trade is being employed as a strategic weapon, Russia has become India's most dependable energy partner. India and Russia created a Vladivostok–Chennai energy corridor in September 2019 to enhance their energy cooperation. With oil from the Sakhalin oil field, New Delhi is able to continue its energy partnership with Russia. India sees Russia as a 'steady and time-tested partner'. Russia's proportion of India's oil imports rose from 2 per cent in February 2022[35] to 23 per cent in November 2022, displacing Iraq and Saudi Arabia at the top of the list. Additionally, India has spent billions in the Russian oil and gas industry. It acquired a 100 per cent share in Russia's Imperial Energy Corporation, as well as 26 per cent of the Vankorneft oil field in Northern Russia and 29.9 per cent of the Taas-Yuryakh oil field in Siberia.[36]

While Russia is interested in rare earth projects, many of them are still in the planning stages, with a projected launch date remaining several years away. It means Russia will continue to rely on China for finished rare earth products, and ongoing project development implies that Russia's rare earth mine output is not likely to increase any time soon.[37] In this situation, India, with its fifth largest reserve and seventh largest production capacity,[38] can prove to be a viable partner to Russia. India is in the process of achieving its rare earth self-sufficiency through domestic reforms or policies; bilateral

35. "Why Russia Remains India's Top Oil Supplier for 2nd Month in a Row", *The Times of India*, December 14, 2022, at https://timesofindia.indiatimes.com/business/india-business/whatsapp-pay-india-chief-quits-within-months-of-taking-charge/articleshow/96231265.cms. Accessed on March 25, 2023.
36. Joshy M. Paul, "Russia Remains India's Most Dependable Energy Partner", East Asia Forum, January 20, 2023, at https://www.eastasiaforum.org/2023/01/20/russia-remains-indias-most-dependable-energy-partner/#:~:text=India%20has%20also%20invested%20billions,Yuryakh%20oil%20field%20in%20Siberia. Accessed on March 28, 2023.
37. Avery Chen, "Russian Invasion of Ukraine May Drive EU Back to China as Source for Rare Earths", S&P Global Commodity Insights, March 15, 2022, at https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/russian-invasion-of-ukraine-may-drive-eu-back-to-china-as-source-for-rare-earths-69217025. Accessed on March 20, 2023.
38. n. 12.

partnership initiative with countries like the US, Australia, Japan; or through multilateral platforms like the Quadrilateral Security Dialogue (Quad), Supply Chain Resilience Initiative (SCRI), and others.

Fig 7: India and Russia in Global Rare Earth Ranking



Source: Avery Chen, "Russian Invasion of Ukraine May Drive EU Back to China as Source for Rare Earths", S&P Global Commodity Insights, March 15, 2022, at https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/russian-invasion-of-ukraine-may-drive-eu-back-to-china-as-source-for-rare-earths-69217025. Accessed on March 20, 2023.

However, the rising China-Russia energy commerce has been driving their relationship. In the year since Russia invaded Ukraine, Chinese imports of Russian oil, gas, and coal increased by almost 50 per cent, according to official Chinese customs figures. Moscow is boosting its war chest and budget gap with energy supplies to China. In addition, as Russia scrambles to equip its military, China has increased exports of computer chips and other technical products.[39]

39. Mary Hui, "China is Gobbling up Russian Oil, Gas, and Coal", *Quartz*, March 22, 2023, at https://qz.com/china-is-gobbling-up-russian-oil-gas-and-coal-1850250775. Accessed on March 25, 2023.

Nevertheless, it is noteworthy that Russia is attempting to reduce its reliance on China since its announcement to invest $1.5 billion in rare earth minerals, considering their importance to the defence, telecommunications, and renewable energy industries.[40] The collaboration of Russia-India could be driven by a similarity of goals and challenges.

In the case of India, the Indian Rare Earth Limited only works in the upstream part of the rare earth industry, which involves mining monazite and producing rare earth oxides. However, the midstream and downstream capabilities, which involve processing and making finished goods, are not as well developed. As a result, it sells the oxides to companies in other countries and has to import the finished rare earth magnets, most particularly from China.[41] While, for Russia, developing rare earth facilities is riskier than mining for copper or iron ore, according to David Abraham, a senior fellow at the think-tank New America. This is because "making sure that the refining technology is right for the mine is more critical in the rare earth space than it is in other mining sectors." A number of promising fields are located in Eastern Siberia in difficult climatic conditions, which in the current level of maturity of development technologies leads to high capital intensity of projects, according to Dmitry Kasatkin, head of research projects at Deloitte CIS, as quoted by S&P Global Market Intelligence.[42]

In this situation, Russia and India can prove to be partners of mutual gain, if the partnership and unexplored deposits are developed right, and redefine the discourse around the supply chain of rare earth elements, thus, further reducing reliance on China.

40. Lyrchikova, and Stolyarov, n. 31.
41. B. Baskar, "A 'Rare' Opportunity for India", *The Hindu*, January 16, 2022, at https://www.thehindubusinessline.com/opinion/a-rare-opportunity-for-india/article64863510.ece. Accessed on March 25, 2023.
42. Ashleigh Cotting, Toby Woodall and Jose Miguel Fidel Javier, "Russia Struggling to Capitalize on Rare Earth Reserves", S&P Global Market Intelligence, July 3, 2019, at https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/russia-struggling-to-capitalize-on-rare-earth-reserves-52525919. Accessed on March 26, 2023.