Geopolitics of Energy®

Volume 41, Issue 4
April 2019
ISSN: 0273-1371

Inside this Issue...

Geopolitics of Energy was founded by the late Melvin A. Conant of Washington, DC in 1979.
Since 1993, it has been published under the auspices of the Canadian Energy Research Institute.

CERI
CANADIAN ENERGY RESEARCH INSTITUTE

Western Sanctions: The Impact on Russia's Oil and Gas Sector

Monika Kochajdova

Introduction

The USSR was the largest producer of oil and natural gas in the world by the early 1980s surpassing the United States and Saudi Arabia with production from the giant fields in western Siberia. The "new Russia" remains the world leader in crude oil production and is currently second in natural gas production.[1] Russia's economic growth is driven by energy exports, given its high oil and natural gas production. Russia was, in 2018, the world's top exporter of natural gas and the second largest exporter of crude oil.[2] These facts illustrate the major role played by oil, gas and the rest of the energy sector in the new Russian economy.

Russia and Europe are interdependent in terms of energy. Europe is dependent on Russia as a source of supply for both oil and natural gas. About 60% of Russia's crude oil exports in 2017 went to European countries, particularly the Netherlands, Germany, Poland, and Belarus. More than 75% of natural gas imports to European countries in the Organization for Economic Cooperation and Development (OECD) in 2017 also came from Russia.[3] Russia is dependent on Europe as a market for its oil and natural gas and the revenues those exports generate.

The Russian economy experienced two major shocks in 2014. The first shock was the sharp decline in oil prices during the third and fourth quarter of 2014. The second shock was the economic sanctions resulting from geopolitical tensions. Since March 2014, Western countries have been gradually introducing restrictive measures against Russia. These measures were taken in response to the unlawful annexation of the Crimea and the deliberate destabilization of Ukraine. Western allies impose various types of restrictive measures; among others, economic sanctions targeted at trade with Russia in specific economic sectors. As a part of those restrictions from the Western alliance, Russia has had limited access to certain sensitive technologies and services that can be used for exploration and oil exploration.[4]

The basic question motivating our research is: "How do Western sanctions affect Russia's energy sector"? Expert opinions are divided. One group argues that sanctions don't have any effect on the Russian energy industry. Another group states that sanctions even stimulate import substitution and technological development. We also hear supporters of the idea that the sanctions will have catastrophic consequences due to the sector's extreme dependence on foreign financing and technology.

According to our research, Western sanctions might have negative impacts on:

- Russia's ability to develop long-term oil projects
- the stability of the Russian national economy
- Russia's future production of gas and oil due to lack of technological capabilities
- Russia's export profits
- the development of export pipeline infrastructure
- foreign investment in Russia

Western Sanctions: The Impact on Russia's Oil and Gas Sector

Sanctions targeting economic sectors are common practice. They are mostly oriented on the suppression of a country's future growth and development. According to Gress, sanctions also aim to decrease the economic connections between the affected countries. Their goal is to change the target economy's political decisions.[5] In the case of Western sanctions targeting Russian oil production, the sanctions were designed so their effect is not immediately noticeable. The main reason for this was to avoid a global economic downturn caused by a decline in Russian oil production. Also, to avoid an energy crisis in Europe, the sanctions haven't targeted the current natural gas productions of Russia.

The main long-run goal is to observe that the country falls into stagnation and loses all impulses for intensive growth. Over the past 4 years, when sanctions are in effect, neither

destabilization nor price shocks have been caused. However, in the future, they are capable of jeopardizing Russia's production of gas and oil. The sanctions could gradually crowd Russia out of external markets and thereby narrow its chances for receiving export profits.

Export of goods and services generated nearly 30% of Russia's GDP in 2017.[6] Losing such a significant income to the state budget could undermine the stability of its national economy. This scenario can also seriously slow the development of export pipeline infrastructure, where Russia plays an important role.

The Countering America's Adversaries Through Sanctions Act (CAATSA), which was signed by US President Donald Trump in August 2017,[7] expands the application of the sanctions to export pipelines. It is thereby causing problems for the Russian gas sector, as well. After consultations with European partners, the US president can impose sanctions blocking any operation worth more than 5 million dollars a year that provides equipment and services for the construction of new gas pipelines and the maintenance of old ones in case the pipelines threaten US national interests.

The Act also contains the commitment to introduce restrictions on individuals investing over 250 million dollars in Russian energy projects and on entities delivering goods, services, capital or technologies with the aim of supporting Russian oil projects.[8] However, the document has not specified the notion of "energy project". As a result, it will be possible to consider them in a much broader way as well as it enables the imposition of restrictions on such investments as the production of solar panels or geological exploration of hydrocarbons. In addition, the Act provides for the introduction of penalties for entities that would violate the sanctions regime as well as calls for coordinating US sanctions with restrictions imposed by the European Union.

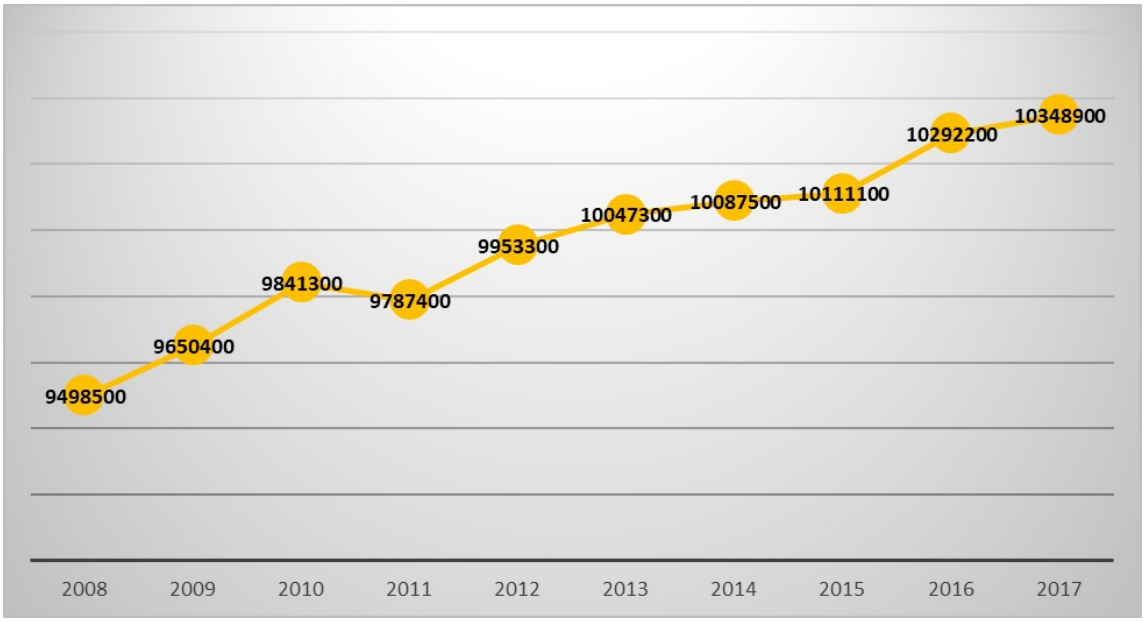
Russia´s agreement to cooperate with OPEC and support its oil price policy as well as cooperation with Turkey[9] on the new gas pipeline project have helped Russia to mitigate some of the negative impacts of sanctions. Finishing of the gas pipeline project Nord Stream 2 would also be beneficial, but the possibility of imposing sanctions on Western oil and gas companies involved in Nord Stream from the US site makes launching Nord Stream 2 in the nearest future even more difficult.

According to CAATSA, only energy projects initiated after August 2017 shall be sanctioned and that is why Nord Stream 2 should be excluded from this legislation. However, basic contracts and agreements for Nord Strem 2 signed prior to August 2017, but additional agreements, e.g., for new loans or investments, negotiated after that period would be subject to sanctions. Russia's conflictual relationship with Ukraine is also an obstacle for gas transit to Europe. To further increase export volumes, Russia must either solve the difficult situation with Nord Stream 2 or increase gas transit through Ukraine, which is for political reasons currently not predicted.

The Russian energy sector has adapted to the sanctions regime. Thanks to external factors (e.g., the devaluation of the ruble), Russia avoided a production decrease and experienced record growth. Figure 1 shows Russia's oil production growth since 2008. Oil production in Russia is hitting records and the production growth in 2017 was its highest in recent years, even though Russia agreed with OPEC to cut production.[10]

Regarding gas production, despite political tensions, Russia's gas exports to Europe, according to Gazprom, reached a record high in 2018. Despite the fact that the EU wants to diversify its supply sources and reduce its dependence on Russia, Gazprom, Russia's monopoly on exports through gas pipelines, covers about one-third of European gas consumption.[11]

Figure 1: Russian Crude Oil Production



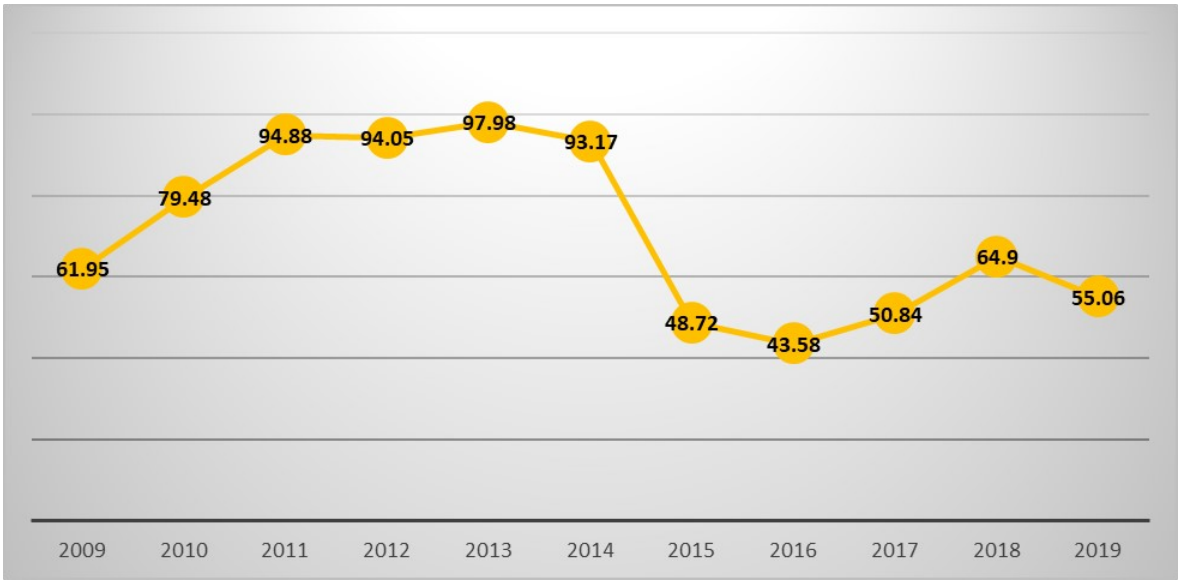
Source: CEIC

The impact of current sanctions depends on the level of geopolitical tension. Unclear wording allows for significant flexibility in interpretation and application. If the geopolitical situation worsens, it is possible to intensify the restrictions. That could mean stricter interpretation or active application to specific projects, in particular, those that require skills of international oil companies. Sanctions were intended to delay Russia's ability to develop long-term oil projects, such as offshore oil exploration and development in the north, deepwater oil development and projects to exploit shale oil deposits. A more consistent application of financial and technological restrictions can have a negative impact on the Russian energy sector. Some equipment needed for oil extraction or processing is subject to control by regulators.

To maintain competitiveness, it is necessary to innovate. Under the current measures, if access by Russia to such technologies is restricted, problems can occur. Russia's existing fleet is old and requires replacement. This is where the possibility for Russian technological development and self-sufficiency arises and where the sanction's positive impact can be seen. Over a few years, a country could launch its own production system and establish relations with new foreign partners. On the other hand, in the last several years while sanctions were in effect, there has not been any demonstrated increase in Russian research. Also, it is important to consider that some delayed projects may have been as a result of them being too expensive given current oil prices. This fact might be from the a Russian point of view considered as a positive aspect.

Figure 2 displays the development of average crude oil price. Oil prices dropped below $50 per barrel in 2015 and moved down to less than $30 per barrel in 2016. The situation got better in 2017 when the oil price increased to $60 per barrel and continued to grow over the course of 2018. At the end of 2018, the price dropped again to $45 per barrel and started to grow slowly at the beginning of 2019.[12]

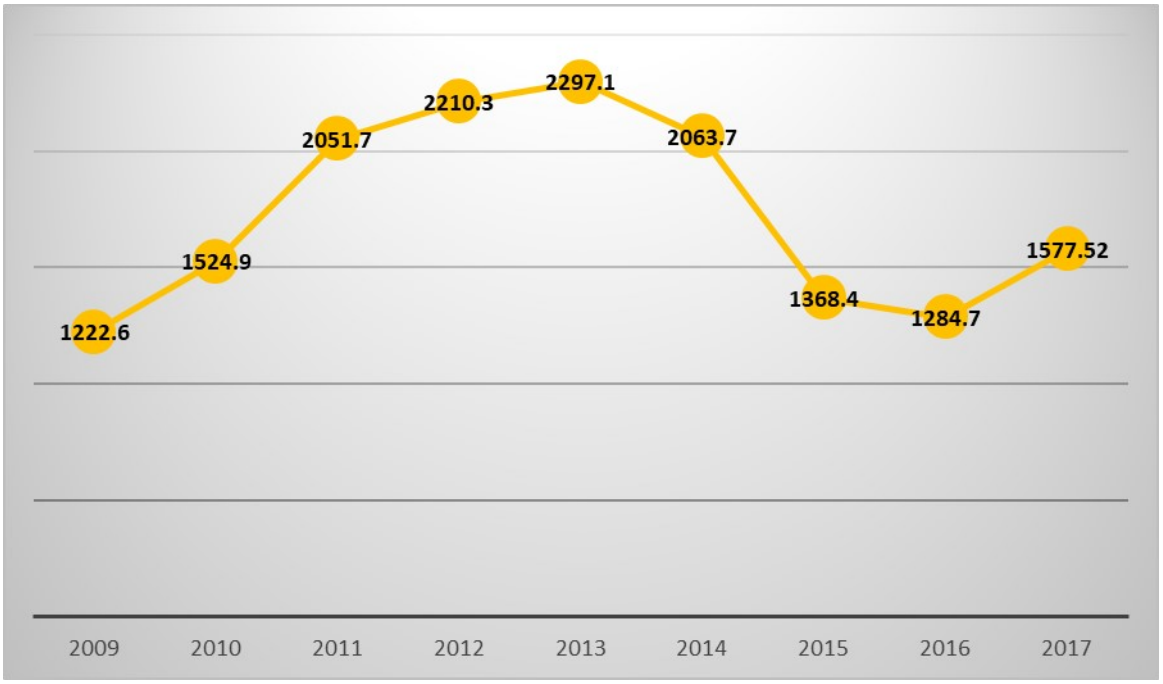
Figure 2: Average Crude Oil Price Development



Source: Macrotrends

The development of Russian nominal GDP can be seen in Figure 3. Since 2013, GDP in Russia has been decreasing, the worst downward movement happened during 2015. At the end of 2016, GDP in Russia started to grow slowly. We can argue that the development of Russian GDP correlates with the development of oil price. Sanctions made the financing of energy projects more difficult and negatively impacted the equity value of Russian energy firms. Though, in terms of GDP, lower oil prices affected the Russian economy much more than sanctions.

Figure 3: Development of Russian GDP



Source: Trading Economics

Despite the restrictions, Russia has the potential to continue increasing extraction volumes until 2020.[13] One of the activities typical for the Russian economy is building up financial reserves. When the oil prices are high, Russia's economy performs better. This leads to building up financial reserves when times are good to avoid an economic downturn when times are bad. Those financial reserves built up before the year 2014 also helped Russia to reverse the negative impact of imposed sanctions by supporting investments in the energy sector or lowered oil export duties. Therefore, in the short term, the impact of the sanctions on Russian production in the energy sector will be almost none. On the other hand, future prosperity might not be that bright. Russia might face oil and gas extraction declines. The main explanation for lowered extraction volumes might be the lack of technological capabilities, which are needed for intensifying production at existing oil and gas fields.

We assume that in the long term (considered until 2030) it will be difficult for Russia to increase or maintain its oil extraction and gas production volumes. Sanctions may have negatively impacted Russia's oil industry as it heavily depends on technical equipment imported to Russia from the West. As a result of the ban on the export of some Western technologies, European producers have lost US$3 billion annually. For Russian producers, this means the necessity of developing their own technologies.[14] The solution could be in developing existing traditional oil wells using methods for intensifying production (e.g., hydraulic fracturing) and by developing non-traditional oil reserves on land (Western Siberia) or offshore (including the Arctic shelf).

Sanctions and lower oil prices have reduced foreign investment in Russia, especially in Arctic offshore and shale projects. Reduced foreign investment have made financing projects more difficult. As we already mentioned above, sanctions limit access to foreign technology and Russian companies lack native technology and equipment to develop unconventional and offshore reserves. That's why we believe that maintaining current production volumes is impossible and that, in the long term, the negative impact of sanctions on this sector will be seen.

The Carnegie Moscow Centre calculates that, by 2030, without import substitution measures, the reduction in production could reach 55 million tons (10 percent of current levels).[15] The gas export situation could also be worse. There is no assumed growth in demand on the European market. That's why it is unlikely that Russia will be able to increase gas transit to Europe in the future. On the other hand, the Chinese and the post-Soviet market are the new possibilities for Russian gas export.

It should not be forgotten that the reason for imposing sanctions against Russian energy companies was the attempt to weaken their position on the European market. Our research indicates a high likelihood that Russia will face the consequences described above. Even the restrictions not directly related to Russian oil and gas, due to their broad spectrum, may affect aspects of the Russian energy sector.

Conclusion

It is not expected that Western restrictions, imposed on Russia by the Western countries after the annexation of Crimea, would cause problems for the state's economy in the present years. Russia's oil and gas companies have adapted to the Western sanctions. Russia is currently managing all available resources. The existing infrastructure is currently maximally exploited. Hydrocarbon production has been growing in Russia. The deposits might even allow the country to increase its extraction by the end of 2020.[16] However, we expect that the problems could escalate in later years due to long-term unavailability of Western technologies. Russia cannot pay attention to the sustainability of economic growth while struggling not to lose production. Crowding Russia out of external markets would narrow its export profits and therefore also undermine the stability of its national economy. Without international financing, it is difficult for Russia to stay competitive. Blocking technological cooperation will result in long-term problems with maintaining current extraction levels. It may prevent Russia from

developing its transport infrastructure and long-term oil projects. As a result, the country may lose its outlets because the sector is highly dependent on foreign finance and technology. These are the reasons why this issue will certainly remain one of the main themes of negotiation between Russia and Western countries. In this respect, the most urgent problem is the Nord Stream 2 pipeline project.

We can assume that sanctions have an accumulating effect. The longer time passes, the more visible the negative consequences, such as the potential lack of technologies or foreign financing, will be. In the long term, sanctions could jeopardize Russia's oil and gas production levels as well as the development of pipeline infrastructure. By limiting the country's export volumes and crowding the country out of foreign markets, the stability of the Russian economy might be undermined.

About the Author

Ing. Monika Kochajdová is a Ph.D. student, Department of International Economic Relations, Faculty of International Relations at the University of Economics, Slovak Republic. She can be reached at monika.kochajdova@euba.sk.

Endnotes

[1] Central Intelligence Agency, (2018): Russia. [Online]. [05.02.2019]. Available on the Internet: https://www.cia.gov/library/publications/resources/the-world-factbook/geos/rs.html

[2] Focus Economy, (2018): Russia Economic Outlook. [Online]. [05.02.2019]. Available on the Internet: https://www.focus-economics.com/countries/russia

[3] U.S. Energy Information Administration, (2017): Russia exports most of its crude oil production, mainly to Europe. [Online]. [05.02.2019]. Available on the Internet: https://www.eia.gov/todayinenergy/detail.php?id=33732

[4] European Council, (2018): EU restrictive measures in response to the crisis in Ukraine. [Online]. [05.02.2019]. Available on the Internet: https://www.consilium.europa.eu/en/policies/sanctions/ukraine-crisis/

[5] GRESS, M., (2018): ECONOMIC SANCTIONS AND THEIR EFFECTIVENESS IN CONFLICTS. [Online]. In: Medzinárodné vzťahy 2018: Aktuálne otázky svetovej ekonomiky a politiky, vol. XIX, p.204. 2018. [02.04.2019]. Available on the Internet: https://fmv.euba.sk/www_write/files/veda-vyskum/konferencia-smolenice/2018/Smolenice_2018.pdf

[6] Central Intelligence Agency, (2018): Russia. [Online]. [05.02.2019]. Available on the Internet: https://www.cia.gov/library/publications/resources/the-world-factbook/geos/rs.html

[7] U.S. Department of the Treasury, (2017): Resource Center; Financial sanctions. [Online]. [12.02.2019]. Available on the Internet: https://www.treasury.gov/resource-center/sanctions/Programs/Pages/caatsa.aspx

[8] Warsaw institute, (2018): New U.S. Sanctions against Russia's Energy Sector. [Online]. 19.08.2018. [19.02.2019]. Available on the Internet: https://warsawinstitute.org/new-u-s-sanctions-russias-energy-sector/?fbclid=IwAR1wJ_E4wblTvLsNQ2D08NARGwBegyA3MsPs4vNg2q9Jdxrs6k1-OxWRtz8

[9] TurkStream, (2018): Info. [Online]. [12.03.2019]. Available on the Internet: http://turkstream.info/project/

[10] CNBC, (2018): OPEC and allies agree to cut oil production by 1.2 million barrels per day. [Online]. 07.12.2018. [12.03.2019]. Available on the Internet: https://www.cnbc.com/2018/12/07/opec-meeting-saudi-arabia-and-russia-look-to-impose-production-cuts.html

[11] Energy Market Price, (2018): Russia's gas exports to Europe reach record high. [Online]. 31.12.2018. [06.03.2019]. Available on the Internet: https://www.energymarketprice.com/energy-news/russia%E2%80%99s-gas-exports-to-europe-reach-record-high

[12] Macrotrends, (2018): Crude Oil Prices - 70 Year Historical Chart. [Online]. 2018. [10.03.2019]. Available on the Internet: https://www.macrotrends.net/1369/crude-oil-price-history-chart

[13] Mitrova, T., (2018): Western Sanctions on Russia's Oil and Gas Sector: A Damage Assessment. *In: Carnegie Moscow Center.* [Online]. 25.07.2018. [12.02.2019]. Available on the Internet: https://carnegie.ru/commentary/76909?fbclid=IwAR2hwzMefgLzpTGSplM0R3ayI9Y29Fgf9xrgmd3X8cY95pKso9U_i9u3wIl

[14] Bačišin, V., Voronkova, M., (2017): Sankcie pomohli ruskej ekonomike. *In: Pravda.* [Online]. 01.06.2017. [05.02.2019]. Available on the Internet: https://nazory.pravda.sk/analyzy-a-postrehy/clanok/431098-sankcie-pomohli-ruskej-ekonomike/

[15] Mitrova, T., (2018): Western Sanctions on Russia's Oil and Gas Sector: A Damage Assessment. *In: Carnegie Moscow Center.* [Online]. 25.07.2018. [12.02.2019]. Available on the Internet: https://carnegie.ru/commentary/76909?fbclid=IwAR2hwzMefgLzpTGSplM0R3ayI9Y29Fgf9xrgmd3X8cY95pKso9U_i9u3wiI

[16] Biznes Alert, (2018): Western sanctions: Little impact to Russia's oil and gas sector. [Online]. 02.08.2018. [19.02.2019]. Available on the Internet: http://biznesalert.com/russia-sanctions-oil-gas/?fbclid=IwAR2KrUjC55apsqiWmvyDGEcwQKBGQqtHGllsJgdtrz53nFbtVJ3TZg2-_fQ

References

1. Bačišin, V., Voronkova, M., (2017): Sankcie pomohli ruskej ekonomike. *In: Pravda.* [Online]. 01.06.2017. [05.02.2019]. Available on the Internet: https://nazory.pravda.sk/analyzy-a-postrehy/clanok/431098-sankcie-pomohli-ruskej-ekonomike/
2. Biznes Alert, (2018): Western sanctions: Little impact to Russia's oil and gas sector. [Online]. 02.08.2018. [19.02.2019]. Available on the Internet: http://biznesalert.com/russia-sanctions-oil-gas/?fbclid=IwAR2KrUjC55apsqiWmvyDGEcwQKBGQqtHGllsJgdtrz53nFbtVJ3TZg2-_fQ
3. CARTER, B.E. (1987): International Economic Sanctions: Improving the Haphazard U.S. Legal Regime. [online]. In: California Law Review, 1987, vol. LV, n. 4. [Quoted 14. 03. 2019.] Available on the internet: https://scholarship.law.georgetown.edu/cgi/viewcontent.cgi?article=2598&context=facpub
4. Central Intelligence Agency, (2018): Russia. [Online]. [05.02.2019]. Available on the Internet: https://www.cia.gov/library/publications/resources/the-world-factbook/geos/rs.html
5. Central Intelligence Agency, (2018): Russia. [Online]. [05.02.2019]. Available on the Internet: https://www.cia.gov/library/publications/resources/the-world-factbook/geos/rs.html
6. CNBC, (2018): OPEC and allies agree to cut oil production by 1.2 million barrels per day. [Online]. 07.12.2018. [12.03.2019]. Available on the Internet: https://www.cnbc.com/2018/12/07/opec-meeting-saudi-arabia-and-russia-look-to-impose-production-cuts.html
7. Energy Market Price, (2018): Russia's gas exports to Europe reach record high. [Online]. 31.12.2018. [06.03.2019]. Available on the Internet: https://www.energymarketprice.com/energy-news/russia%E2%80%99s-gas-exports-to-europe-reach-record-high
8. European Council, (2018): EU restrictive measures in response to the crisis in Ukraine. [Online]. [05.02.2019]. Available on the Internet: https://www.consilium.europa.eu/en/policies/sanctions/ukraine-crisis/
9. Focus Economy, (2018): Russia Economic Outlook. [Online]. [05.02.2019]. Available on the Internet: https://www.focus-economics.com/countries/russia
10. GRESS, M., (2018): ECONOMIC SANCTIONS AND THEIR EFFECTIVENESS IN CONFLICTS. [Online]. In: Medzinárodné vzťahy 2018: Aktuálne otázky svetovej ekonomiky a politiky, vol. XIX, p.204. 2018. [02.04.2019]. Available on the Internet: https://fmv.euba.sk/www_write/files/veda-vyskum/konferencia-smolenice/2018/Smolenice_2018.pdf
11. Macrotrends, (2018): Crude Oil Prices - 70 Year Historical Chart. [Online]. 2018. [10.03.2019]. Available on the Internet: https://www.macrotrends.net/1369/crude-oil-price-history-chart
12. Mitrova, T., (2018): Western Sanctions on Russia's Oil and Gas Sector: a Damage Assessment. *In: Carnegie Moscow Center.* [Online]. 25.07.2018. [12.02.2019]. Available on the Internet: https://carnegie.ru/commentary/76909?fbclid=IwAR2hwzMefgLzpTGSplM0R3ayI9Y29Fgf9xrgmd3X8cY95pKso9U_i9u3wiI
13. ROSSIGNOL, M. (1993): Sanctions: The economic weapon in the New world order. [online]. In: Political and Social Affairs Division, 1993. [Quoted 15. 03. 2019.] Available on the internet: http://publications.gc.ca/Collection-R/LoPBdP/BP/bp346-e.htm
14. TurkStream, (2018): Info. [Online]. [12.03.2019]. Available on the Internet: http://turkstream.info/project/
15. U.S. Department of the Treasury, (2017): Resource Center; Financial sanctions. [Online]. [12.02.2019]. Available on the Internet: https://www.treasury.gov/resource-center/sanctions/Programs/Pages/caatsa.aspx
16. U.S. Energy Information Administration, (2017): Russia exports most of its crude oil production, mainly to Europe. [Online]. [05.02.2019]. Available on the Internet: https://www.eia.gov/todayinenergy/detail.php?id=33732
17. WALLENSTEEN, P. (2016): Characteristics of economic sanctions. [online]. In: Sage Publications, Ltd., 26.7.2016. [Quoted 17. 03. 2019.] Available on the internet: http://www.jstor.org/stable/423276
18. Warsaw institute, (2018): New U.S. Sanctions against Russia's Energy Sector. [Online]. 19.08.2018. [19.02.2019]. Available on the Internet: https://warsawinstitute.org/new-u-s-sanctions-russias-energy-sector/?fbclid=IwAR1wJ_E4wblTvLsNQ2D08NARGwBegyA3MsPs4vNg2q9Jdxrs6k1-OxWRtz8

Development of the Russian Energy System Resilience: Towards a More Secure Future

Vadim I. Loktionov and Elena A. Loktionova

The Russian government faces new challenges in ensuring the development of the national energy system due to the growing geopolitical tensions, leading to the introduction of financial, economic and technological sanctions against Russian energy companies. As a result, the Russian government and the Russian energy companies need to develop the national energy industry in terms of restrictions on access to international capital markets, restrictions on the supply of energy equipment, restrictions on the implementation of large-scale energy projects, etc. Under such conditions, it is necessary for Russia to increase the national energy system resilience to ensure long-term energy security and maintain the growth in economic well-being.

The energy system is a complex dynamic system. Its development is determined by both internal processes in the system as well as exogenous factors, including the management decisions made by independent actors (domestic companies, international companies, governments). The development of internal trends in the energy system, due to the logic of technical and economic processes, may lead to an increase in its adaptive properties. For example, such a trend could be the emergence of new competing suppliers of energy resources in a liberalized energy market, which would increase the adaptability of the system as a whole. However, to ensure the stable growth of the national energy system resilience by increasing its efficiency through scientific, technological and social development, management of the system should be carried out by well-thought-out and scientifically sound energy policy aimed directly at the country's energy security by increasing the adaptive properties of the national energy system.

Measures, raising the level of the national energy system resilience, can be divided according to the stages in the adaptation process, which include the occurrence of a stressful event, the system’s response to a stressful event, accompanied by a drop in the efficiency of its functioning, the development of adaptation measures and their implementation, and the return of the system to pre-crisis levels of its efficiency. Development and implementation of a set of economic and technical measures to increase the Russian energy system resilience reduce the time required for the system to fully restore its efficiency after a stress event along with the costs of adaptation. The measures can be grouped into the following blocks:

1. Measures aimed at reducing the likelihood of the occurrence of stressful events.
2. Measures aimed at reducing the power of their effect on the energy system.
3. Measures aimed at reducing the time required for a system to fully restore its efficiency.

It should be noted that the increase in the overall efficiency of the Russian energy system due to implementation of the measures on each stage of the adaptation process is not linear (additive), which means that the successful implementation of measures within one stage of the adaptation process can greatly facilitate the implementation of the measures within another stage.

Modern energy systems tend to enhance their complexity due to the emergence and expansion of digital technologies, the growing number of actors on the energy market, the transformation of energy consumers into prosumers, etc. A complex system is a system in which a large number of independent elements and subsystems interact, leading to the emergence of emergent properties. The complexity of the energy system is shaped not only by the number of elements in its structure but also by their technological, organizational and economic diversity along with multiple interconnections between them.

The emergence of new elements of the national energy system can lead either to enhancing its resilience or to increase its vulnerability, since new elements and interactions between them may be exposed to stressors and disrupt the operation of other elements of the system. In this regard, energy policy directed towards the resilience of the Russian energy system, while its complexity

increases due to the digitalization of the energy sector and the appearance of new energy technologies, should consider the following principles for adding new elements and interconnections to the national energy system:

1. A new element should bring redundancy to the system in the form of additional reserve capacity, a throughput increments of intersystem communications, etc.
2. A new element as a technological, economic and self-governing unit must itself possess adaptive properties that will allow it to function effectively in the conditions of stressful events.
3. The emergence of new elements in the energy system should comply with the law of the requisite variety of W.R. Ashby. According to the law, the stability of a system can be achieved by growth in the number of states of its control mechanism. In other words, the more diverse the actions available to the control system, the more disturbances it can compensate. With regard to energy systems, this law means that the emergence of new elements should expand the management tools of energy companies and governments.
4. A new element should reduce the time needed to fulfill structural changes in the energy system as a response to stressful events.
5. A new element should facilitate energy diversification and renewable energy development. Energy diversification improves the long-term resilience of the national energy system due to the enhancement of its flexibility and growth in the number of possible economically and technically efficient responses to stressful events.

Given major transformations taking place in the global energy sector, only those elements which comply with the new paradigm of energy development will increase the energy system resilience. Nowadays, the global energy sector has been undergoing radical changes, the main driver of which are technological innovations that facilitate the transition of energy systems into a fundamentally new stage of development. In recent decades, the following changes have occurred, forcing the revision to the requirements for power generating facilities, network infrastructure and, in general, the organization of the electric power industry and electricity markets:

1. Growth in global electric power demand and changes in its structure. The main drivers of the growth in electricity consumption in the world are global human population growth and human development. According to the IEA, by 2040, the production of electricity will grow from 25,500 TWh to 40,000 TWh.[1] At the same time, the demarcation line between power producers and power consumers is blurred as new technologies and the development of distributed power generation makes prosumers very efficient energy market participants.[2] It will lead to a gradual increase in the share of prosumers in the structure of energy production and consumption. In addition, technological development in other industries increases the requirements for the quality of electricity and the reliability of its supply.
2. Growing global preference for green energy. Electricity production from fossil fuels is a significant source of pollutant emissions and greenhouse gases, which leads to the deterioration of the environment, the decline in the quality of life and the increase in the state expenditures on social security, health care, and environmental measures. As a result, developed and many developing countries are ready to use more expensive, but at the same time, more environmentally-friendly energy, which facilitates enhancing the quality of life. Development and implementation of new energy technologies improve national energy system resilience by creating new complex adaptive structures.
3. Ageing of large power stations. Since the energy systems of most developed countries were actively developed during the second half of the 20th century, most large coal power plants, hydropower plants and nuclear power plants around the world have grown old. For example, according to the US Energy Information Administration (EIA), the average age of US commercial reactors is about 37 years.[3] About 74% of all coal-fired power plants in the US are older than 30 years. Analyzing the average age and technical lifetime of the

operating power plants in Europe, J. Farfan and Ch. Breyer conclude that 48.6% of the gas, 78.3% of the oil, 79.1% of the coal and 81.7% of the nuclear power capacities will be decommissioned by 2030.[4] Though this situation gives opportunity to make a technological shift towards sustainable energy, the national energy systems require substantial investments in maintaining, updating and modernizing its elements.

The traditional power systems evolved with strong government support. In the last few decades, in developed countries, governments have reduced the degree of their intervention in the energy industry due to the liberalization of energy markets. At the same time, banks do not show interest in large-scale energy projects due to the presence of more attractive investment projects. To solve the problem of maintaining, updating and modernizing national energy systems, the transition to the new paradigm of the electric power industry, focused on investments in renewable energy sources, distributed generation, customer services and innovative technologies, needs to be fulfilled.

4. Urbanization. The growth of old and the emergence of new cities leads to the necessity of the development of urban energy systems, which should be reliable in terms of high spatial density of energy use. The key goals of the development of urban energy systems are reducing the costs of connection to an electricity grid, improving energy efficiency, reducing air pollutant emissions, using new methods to accommodate energy facilities in terms of expensive urban lands, etc.

Energy digitalization. In recent years, the national energy systems with other industries have undergone significant changes. Many new digital technologies have been implemented in energy, which has helped keep the transmission grid stable, cut costs by improving energy efficiency, prosumers appear as new energy market actors, etc. Energy digitalization can change the energy market structure; this is why it is important to take into consideration the process while developing the national energy system resilience.

Despite the development of new technologies, Russia faces the problem of the growing inefficiency of its energy sector (increase in operating costs due to the deterioration in the energy infrastructure of the Russian energy system, undeveloped innovation infrastructure, old and inefficient energy equipment, etc.), which has led to rapid growth in electricity prices. An additional factor that leads to the growing inefficiency of the Russian electricity sector is the low technological level of thermal power plants, which constitute 68% of the generating capacities of the country. The situation is further complicated by the lack of interest in the Russian energy companies in the increase of their efficiency.

High electricity prices and the significant limitations in choosing an electricity supplier makes consumers develop their own generation. This, in turn, causes an additional decrease in the efficiency of the existing market due to the relative decline in supply volumes and an increase in unit generation costs. As a result, the more actively consumers move away from the centralized electricity supply system, the higher electricity prices are to remaining customers and the more difficult it is for government to develop the Russian energy system resilience.

The energy industry based on traditional technologies of power generation could not significantly improve its efficiency and meet consumers' demand for reliable electricity supply without structural changes. That is why the Russian government should take into consideration the undergoing changes in the global energy industry and the outlined principles of the complex systems development to reform the Russian energy industry and to develop the Russian energy system resilience. The energy policy aimed at solving the problems of ensuring the country's energy security by increasing the national energy system resilience should consider the outlined principles. However, when most decisions about the implementation of various energy projects are made at the corporate level, it is a challenge to develop and fulfill a set of measures aimed at increasing the national energy system resilience. The Russian government has to develop a

system of incentives for managers and owners of the Russian energy companies to include the criterion of the resilience of energy facilities (newly created or modernized) in the management decision-making process.

To create favourable conditions for improving the Russian energy system resilience during the process of transition to a new energy paradigm, it is necessary to make the following adjustments to the energy policy of the Russian government:

- to define the rights and obligations of energy prosumers;
- to develop rules for the trading systems operating in the distributed energy markets;
- to promote transmission planning;
- to revise technical standards for the energy facilities;
- to revise the practice of state subsidies in the electric power industry;
- to revise energy taxation;
- to introduce government financial support measures to facilitate renewable energy producers;
- to pay attention to creating a balanced organizational structure that will provide the optimal combination of elements of the new technological paradigm and centralized electricity generation.

New technologies, government support and the new energy market structure will reduce costs of renewable energy development, decrease the need for new capacity and provide greater energy opportunities for more efficient management of existing capacities by controlling the load of distributed energy resources and optimizing the network infrastructure. Technological unpreparedness of the Russian power system to the mass emergence of prosumers connected to the national electric grid, as well as the obsolescence of the technological and production base of power engineering companies, means that intelligent multi-agent control systems, power storage systems, advanced high voltage and high-frequency power electronics, and digital financial technologies should be the central issues for the government support activity towards a more secure future.

About the Authors

Vadim I. Loktionov, Ph.D., is a senior researcher at Melentiev Energy Systems Institute of Siberian Branch of the Russian Academy of Sciences (ESI SB RAS) in Irkutsk, Russia. He can be reached at vadlok@mail.ru. Elena A. Loktionova, Ph.D., is an assistant professor at Baikal State University in Irkutsk, Russia. She can be reached at loktionova_ea@mail.ru.

This article was prepared with the financial support of the Russian Foundation for Basic Research (RFBR) (grant №17-06-00102-a).

Endnotes

[1] https://www.iea.org/weo/

[2] Leal-Arcas R., Lesniewska F., Proedrou F. (2018) Prosumers as New Energy Actors. In: Mpholo M., Steuerwald D., Kukeera T. (eds) Africa-EU Renewable Energy Research and Innovation Symposium 2018 (RERIS 2018). RERIS 2018. Springer Proceedings in Energy. Springer, Cham. DOI: 10.1007/978-3-319-93438-9_12

[3] https://www.eia.gov/tools/faqs/faq.php?id=228&t=21

[4] Farfan J., Breyer Ch. (2017). Aging of European power plant infrastructure as an opportunity to evolve towards sustainability. *International Journal of Hydrogen Energy*, vol. 42, iss. 28, pp. 18081-18091. doi: 10.1016/j.ijhydene.2016.12.138

Publication Date: May 9, 2019

Submit manuscripts and Letters to the Editor to Allan Fogwill at the address below or via email at **mmurphy@ceri.ca**. Manuscripts dealing with energy and geopolitics, generally between 2,000 and 4,000 words in length, will be considered for publication. Unsolicited manuscripts will undergo peer review by members of the editorial board. Available by subscription for $800 (US) per year; $400 (US) for public libraries universities. For Canadian residents—$800 per year; $400 for public libraries and universities—plus 5% GST.

Publisher: Canadian Energy Research Institute, #150, 3512 - 33 Street NW, Calgary, Alberta, Canada T2L 2A6
Telephone: (403) 220-2370; Fax: (403) 290-2251; Email: **mmurphy@ceri.ca**.

CANADIAN ENERGY RESEARCH INSTITUTE