

challenges. However, the risk that national governments fail to effectively conduct a policy of prevention and adaptation to global climate change remains high.

Key words: globalization, global challenges, global trends, global climate change.

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Phenomenon of Estonian «Shale Revolution»

The article presents the role of the "shale revolution" in Estonia which significantly increases the energy security of the country. The purpose of this paper is to show how significant are the changes triggered by generating energy from oil shale in Estonia. The benefits gained from oil shale since a hundred years have been considerably enhanced by technical progress. As a result of introduced innovations Estonia is able to practically fully satisfy its oil and electricity needs by processing shale. The article also outlines actions undertaken to tackle the problem of harmful emissions arising while generating electricity from shale. Further aspect analyzed in the paper is the impact of oil shale industry in Estonia on the relations with other countries, with Russia in particular.

Key words: Phenomenon, Estonia, «shale revolution», energy security.

Introduction. Among the countries that have imported Russian energy resources for years Estonia has a special position. This country utilizes own oil shale resources and as a result it gained energy independence being no longer forced to acquire raw materials from Russia. The deposits in Estonia are so rich that in the foreseeable future it will be a safe country in terms of oil supplies. There is not only an economic but also a political aspect of this issue.

The “shale revolution” in Estonia and its results are an important experience for many countries in the region. Some of the former "Eastern bloc" countries have sought to extract raw materials from shale but only

Estonia was that significantly successful. Furthermore, Estonia has generated electricity from oil shale for years which is an important benefit for this country. It has hundred years of experience in exploiting its shale resources.

The purpose of this paper is to show how important is the transformation triggered by energy generation from shale in Estonia. It may be assumed that in the future Estonia will remain a country satisfying its oil and electricity needs from own resources. Further, the ways how to tackle the problem of harmful emissions arising during energy production from shale will be described. It is also important to highlight the role of shale energy for relations between Estonia and other countries.

Importance of oil shale for security of Estonia.

Estonia is one of the few countries formed after the collapse of the USSR which is not dependent on external oil supplies. The country became the world leader in the extraction of kerogen shale resulting in its oil independence. The first oil shale mine was opened in 1916, but a large-scale mining began in the independent Estonia. Oil shale has started to be mined in this part of Europe because Russia, immersed in an economic war crisis, needed a new source of energy. Initially, the raw material was locally used for heating purposes, and then it began to replace the shortage of coal in power plants, boilers and industrial furnaces [11]. In 1924, an oil shale-fired power plant was opened in Estonia, and seven years later, a plant extracting shale oil. The state-owned company Eesti Energia, which is the largest in Estonia, generates electricity in oil shale-fired power plants [10], and with the “Enefit” technology it is possible to produce oil from oil shale (Paul Nikolai Kogerman contributed greatly to the development of shale oil research) [9, p. 549 and next].

The ability to mine own resources has turned out to be revolutionary for Estonian energy security. The country uses oil shale to produce oil and generate electricity. Shale oil is locked inside rock and can be extracted by drilling down and injecting high-pressure water, sand and chemicals. The oil released from kerogen shale is also known as shale oil [3]. This is another energy revolution triggered by technical development, initiated in the USA. What is important, the ash remaining after the oil separation process does not contain organic waste, is safe for

the environment and can be used in the construction industry, for cement production in particular (oil shale-fired power plant in Israel produced cat litter from the large part of oil shale ash and sold in Europe) [12]. It is essential that the shale oil extracted in Estonia is used to generate electricity [20]. Even in the first decade of the 21st century, it seemed that Estonia would not be able to diversify its supply of natural gas [18, p. 208] (although between 1950 and 1960 coke from the crude oil was used to produce urban gas) [6, p. 9], however oil shale made Estonia independent on Russian gas.

Estonian sedimentary rocks contain kerogen that can be transformed under certain conditions into bitumen, which in turn can release crude oil or natural gas [13, p.17-18]. The resources of kerogen in the world, called "immature oil", are three times larger than of conventional oil. Over the years, Estonia sought to extract shale oil but this proved to be too costly and expensive. USA have adapted methods of shale gas mining in order to extract oil from shale. This has stimulated development of the Estonian oil industry, changing the position of this country [10] (there is a noteworthy joint US – Estonian program of oil shale research) [21, p. 65-79].

Among the Member States of the European Union, Estonia is mostly advanced in the exploitation of shale oil. The generous subsidy from the government budget for the Estonian energy raised concerns from the European Commission, as it violated the principle of free market and free competition [17]. Although already in 2005 over 90% of power production in Estonia constituted oil shale based power, by 2015 it should decrease to 68% in line with the power section development strategy adopted by the Estonian Parliament in 2006 [6, p. 15]. National production of power from oil shale in Estonia represents almost 84% of the world production [4]. The Estonian oil shale deposit constitutes just 17% of all deposits in the EU and in the first decade of the 21st century the oil shale energy sector accounted for 4% of Estonian GDP [6, p. IV]. The reserves of oil shale in Estonia are one of the largest in the world - about 16.3 billion barrels. In 2016, oil shale mining in Estonia reached 13.4 million tonnes, and the existing resources should suffice for about 100 years of further exploitation. By 2020, Eesti Energia intends to produce about 500 thousand tonnes of oil

and fuel from oil shale per year, with about 90% of this production going to export [1].

Conditions of the “shale revolution”

The energy policy adopted by Prime Minister Andrus Ansip, the head of government in 2005-2014, represented a negative attitude towards the import of electricity from Russia. This was the main difference between Estonian energy strategy and the strategies of its neighbors - Latvia, Lithuania and Finland that import most of their energy from Russia. As a result of its activity in 2013 Estonia accounted for 70% of the world's oil shale mining, burned in two large power plants. In 2011, Estonia started discussions on the membership in the International Energy Agency (IEA), hoping that it would help the country to ensure energy security. The solidarity of the IEA members is particularly essential as there is a mechanism of fuel assistance in crisis situations [19].

Critics emphasize that the process of shale oil extraction is energy-intensive and increases high carbon dioxide emissions what will be more detailed described in further part of the article. In January 2011, Enefit, a company owned by Eesti Energia, signed a nearly one billion euros contract with Alstom, a French company, leader in power generation equipment and services, to design and build two 300 MW units for oil shale-fueled power plant that comply with the EU Large Combustion Plants Directive by substantially reducing emissions. Other countries learn from experience of Estonia. Estonia signed an agreement on shale oil extraction and construction of a oil shale fired power plant in Jordan that has some of the world's largest deposits of such rocks. Marocco also shows interest in Estonian shale oil technology. In March 2011 Enefit signed an agreement to acquire all shares in the US company, Oil Shale Exploration Company, that owns large oil shale deposit in the US state of Utah [10]. It is worth mentioning that this deposit may contain up to 2,6 billion barrels of recoverable oil [3].

The largest deposits of oil shale in Estonia are available on the Baltic Sea coast. However, to get to the deposit, it is necessary to remove the top layer, which is very capital-intensive. The deposits are located in an area of about 2.7 thousand km² in a single 2.5 - 3 meters thick layer and at a depth of up to 100 meters around Kohtla-Järve, a mining town near the Gulf of Finland developed in the USSR. It consists of six

administrative districts, directly related to one of the mining or energy units [17].

In 2005 about 14.8 Mt of oil shale was mined in Estonia, the industrial complex employed 7500 people – about 1% of national employment – and accounted for 4% of Estonian GDP. Estonia uses oil shale to produce electricity satisfying demand in the country which is unique in the world [6, p. 15]. In the first quarter of 2013 the average household in Estonia payed 0.0994 euros per kilowatt hour of electricity, while 0.11 euros in Finland, 0.113 euros in Lithuania, 0.114 euros in Latvia and 0.116 euros in Poland. The price differences in favor of Estonia are even bigger for industrial consumers [19]. Eesti Energia is focused on producing high quality products, aiming at the extraction of oil shale-based gasoline [5]. The Enefit 280 oil plant which started to operate in 2015 is able to produce annually approximately 315,000 tons of oil and fuels, mainly heavy fuel oil and gasoline, consuming at the same time about 2.5 million tons of oil shale. Additionally, the plant produces hydrogen rich retort gas (about 75 million m³ per year) and electricity (about 280 GWh per year). The Enefit company has also two older units, called Enefit140 producing various shale oil fractions. At least 90% of oil and liquid fuels are being exported and an efficient production of shale oil is possible even with a price of \$ 40 per barrel [1].

Problem around emissions

The major issue of the oil shale industry are the hazardous emissions arising while generating electricity from shale. When shale is burned, more harmful substances are being produced than in the case of coal, and there is a higher Carbon dioxide emission than during the combustion process of many other minerals. What's more, the oil shale industry uses vast amounts of potable water. Estonia had a surplus of emission allowances, as the calculations were based on state of the industry in 1990, when the country was still a part of the USSR, and had a heavy industry with high emissions. Within 20 years 2/3 of those plants ceased to exist, and the allowances were acquired by Japan, Spain and Switzerland among others [19]. Even though initially the representatives of the shale industry did not intend to reduce their turnover, they later showed interest in the problem. There was a risk that from 2015 on the oldest Estonian power plants will no longer meet increasingly stringent environmental regulations of the European Union,

while the construction of new power plants and the acquisition of pollution allowances will prove to be unprofitable [16]. As the Estonian authorities and business supported the oil shale industry there was a fear that investments in other energy technologies will lose importance.

The Directive 2008/3/EC of the European Parliament and of the Council of 15 January 2008 focuses on the importance of Estonian oil shale and the impact of its use on the environment. During the EU accession negotiations already Estonia referred to the specific features of its electricity sector in order to request a transitional period for application of Directive 96/92/EC of The European Parliament and of the Council of 19 December 1996 concerning common rules for the internal market in electricity. In result, Estonia was granted a transitional period until 31 December 2008 for the application of Article 19(2) of Directive 96/92/EC, relating to the gradual opening of the market. Moreover, declaration annexed to the Final Act to the 2003 Treaty of Accession acknowledged that the specific situation relating to the restructuring of the oil shale sector in Estonia was going to require particular efforts until the end of 2012. Thus, it appeared necessary to grant a further derogation for the period 2009 to 2012 to guarantee security of investments in generating plants and security of supply in Estonia while allowing the serious environmental problems created by those plants to be resolved [4].

Estonia produces twice as much carbon dioxide as other EU countries (per kilowatthour), and in result it needs additional pollution allowances (Estonia's emissions are also higher than in Ukraine and Russia). However, CO₂ is not the only by-product of shale energy - the other are the aforementioned ash produced during shale combustion. When a tone of oil shale is burned 450 kg of ash is produced. Estonia extracts 17m tones of oil shale annually, using most of which to fuel its power plants, and in result the country has to dispose 7 m tones of ash per year (near Narva the ash has been piled to create heaps, some of them have been planted) [16]. The company Eesti Energia has been piloting a new generation of shale oil power plants. Cogeneration of oil, gas and power all at once can halve CO₂ emissions. Another noteworthy project is a combined oil shale and biomass power plant of Esti Energia in Narva, near the Russian border, which is being built by Alstom and is designed to meet future stringent EU emission targets. Together with Finland's

Outotec, Eesti Energia is testing different kinds of oil shale around the world, to adjust its technology to local conditions and prepare for export [3]. Significant financial assets have been invested to reduce emissions in oil shale-fired power plants of Eesti Energia (for example, in 2012 sulfur dioxide emission treatment technology was installed in Narva power plant for 110 million euros) [19].

Political aspects of "shale revolution"

Becoming a European leader in extraction of oil shale from own resources impacts significantly energy security of Estonia, oil security in particular. Its powerful neighbor, the Russian Federation, has clearly lost the ability to exercise both economical and political pressure on this country. The "shale revolution" triggered a break-up with many years of dependence which still exists in a number of other countries, either former Republics of the Soviet Union or countries reliant on the Russian Federation.

In 2007 the company "Russian railways" stopped oil supplies to Estonia. The company's authorities denied that these were economic sanctions, explaining that it was related to the maintenance of the track. However, as the Estonian traders informed, the transport plan for the next month has not been approved, and they were notified that "Russian Railways" did not have the appropriate technological capabilities to unload goods in Estonia. The relations between Estonia and Russia reached a low in 2007 and have been problematic for months as Estonians have decided to move a bronze statue of a Red Army soldier away from the centre of Tallinn despite protests from the Russian authorities [14].

Estonia buys very little oil from Russia, importing, however, oil products, some of which are also re-exported [7, p. 14]. Estonia uses its numerous ports for this purpose [2, p. 24]. Estonia is not a strategic target for Russian companies, nevertheless the Russian authorities exercise economic pressure on this country, yet mainly in relation to gas supplies [15, p. 288]. Estonia has, however, successfully become independent from the largest oil supplier in the region, which, along with ensuring the development of the national power industry, is considered to be a great achievement. Further success is Estonian energy cooperation with many countries in the world, including the United States and the Arab countries.

Conclusion

When considering all presented aspects it can be stated that Estonia will in the foreseeable future remain a country able to meet its own demand for crude oil, generating at the same time enough energy to satisfy its own needs. Estonia can also meet the internal demand for electricity which is a great success.

Estonia has undertaken measures to limit environmental impact of the oil shale industry, and in particular has invested in shale-fired power plants to reduce harmful emissions. Meeting stringent environmental regulations of the European Union proved to be a big challenge but did not prevent further development of the Estonian oil shale energy.

The "shale revolution" has significantly impacted relations between Estonia and Russia. Estonia doesn't need to import Russian oil at the moment (imports only a small amount of it). At the same time, Estonia continues to buy oil products from Russia that are partly re-exported.

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Войчешак Лукаш. Феномен естонської «сланцевої революції».
Йдеться про роль «сланцевої революції» в Естонії, яка суттєво посилює енергетичну безпеку країни. Мета статті – показати важливість змін,

запущених виробництвом енергії від видобутку горючих сланців у Естонії. Вигоди, отримані зі сланцю, упродовж ста років значно підвищуються завдяки технічному прогресу. В результаті запроваджених інновацій Естонія здатна практично повністю задовольнити свої потреби в нафті й електроенергії шляхом переробки сланцю. У статті також описуються дії, вжиті для вирішення проблеми шкідливих викидів, що виникають при генерації електроенергії зі сланцю. Проаналізовано також вплив сланцевої промисловості в Естонії на відносинах з іншими країнами, з Росією, зокрема.

Ключові слова: феномен, Естонія, «сланцева революція», енергетична безпека.

Войчешак Лукаш. Феномен эстонской «сланцевой революции». Речь идет о роли «сланцевой революции» в Эстонии, которая существенно усиливает энергетическую безопасность страны. Цель статьи – показать важность изменений, запущенных производством энергии от добычи горючих сланцев в Эстонии. Выгоды, полученные из сланца, на протяжении ста лет значительно повышаются благодаря техническому прогрессу. В результате введенных инноваций Эстония способна практически полностью удовлетворить свои потребности в нефти и электроэнергии путем переработки сланца. В статье также описываются действия, предпринятые для решения проблемы вредных выбросов, возникающих при генерации электроэнергии из сланца. Проанализировано также влияние сланцевой промышленности в Эстонии на отношениях с другими странами, с Россией, в частности.

Ключевые слова: феномен, Эстония, «сланцевая революция», энергетическая безопасность.

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