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Clean Energy in the EAEU in the Context of Sustainable Development: Compliance and Prospects

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ABSTRACT

Clean energy today is in the focus of attention of the global community. The development of this field is vitally important for preserving natural heritage and reducing budget expenditures. The case of the EAEU is very interesting for research, since its member countries rely on conventional energy sources from Russia and Kazakhstan, which are cheaper than the production of clean energy. The authors examined the legislative framework of the EAEU countries and compared it with the 2030 Agenda for Sustainable Development, identifying their similarity. The authors introduced a method for assessing integration tightness, which allowed to divide the EAEU countries into two groups according to the extent of their integration in the EAEU. The other important finding based on a statistical analysis of the countries' cooperation in the field of clean energy is that the EAEU takes nearly no actions in this direction, therefore, clean energy is not important enough in the EAEU. Another result of the statistical study is the fact that none of the EAEU countries, except Armenia, will achieve the 2030 Agenda's goals in the field of clean energy. The authors developed the Index of green potential usage and proposed clean energy development strategy for the EAEU.

Keywords: Clean Energy, EAEU, 2030 Agenda, Sustainable Development, Energy Market

JEL Classifications: Q01, Q40, F55

1. INTRODUCTION

The EAEU countries produce and consume a significant amount of energy. All member countries of the Union aim to create a modern and sustainable economy, including the energy sector. At the same time, Russia has huge reserves of conventional energy resources – oil and gas, in addition, all the EAEU countries have inherited powerful nuclear energy facilities from the USSR. In this regard, it is necessary to assess the economic and environmental aspects of the EAEU's transition to a greener energy in accordance with the Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development (also the 2030 Agenda) (UN, 2015) and national sustainable energy development programs of the EAEU countries.

The importance of the issue lies above simple economic estimates and results. The constant increase in consumer energy prices in

these countries (CEIC, 2020a, 2020b, 2020c; OECD. Stat, 2020; GlobalPetrolPrices.com, 2019) and the necessity to preserve the vast natural wealth of the EAEU countries require the most balanced development strategy of the energy sector, which will lead to improved economic and social aspects of the energy sector functioning in the EAEU.

We focus on the motivation for achieving SDGs and national development goals, and analyze the future of clean energy in the EAEU in the context of achieving these goals. Key findings include the proof of the negative impact of cheap energy resources on clean energy development and insufficient attention to clean energy in the EAEU countries, as well as recommendations on clean energy development based on transfer of best practices of clean energy development in the EAEU from Armenia to other countries.

2. LITERATURE REVIEW

The literature on the EAEU and its energy market is abundant. Zemskova (2018) gives a thorough analysis of energy markets in the EAEU and provides recommendations for the EU based on the transfer of the EAEU successes in this field; nevertheless, the author focuses on a legislative aspect of the issue, and the clean energy development is not sufficiently covered.

Pastukhova and Westphal (2016) consider the EAEU energy market in connection with the EU energy market. Perskaya (2020) gives interesting comparison of clean energy markets in the EAEU and Scandinavia, but the focus of the article is the comparison of energy markets.

Other literature is devoted to a technical assessment of the possibility of clean energy generation in the EAEU and a common electricity market. Gibadullin and Pulyaeva (2019) identify the main problems in this field, but give recommendations only with respect to the legal aspect. Balas et al. (2018) focus on the cooperation in the field of green energy between the EU and the EAEU and provide a deep analysis of the current situation in this field. Vinokurov et al. (2016) focus on a more global context. The research by Movkebayeva and Bimagambetova (2019) is of interest and importance, although it lacks statistical analysis.

All the above contributed greatly to our research. However, we decided to concentrate on plans for a greener future at the global (UN, 2017) and national levels (UNDP-RTF, 2017; Adilet, 2009).

3. METHODOLOGY

Due to differences in social, economic and geographical conditions, we cannot analyze the EAEU countries as a whole, since the reasons and consequences of implementing green energy in these countries are different, as well as their needs. In the article, we use three basic terms: “clean energy”, “green energy” and “renewable energy”. The first two are synonymous and include solar, wind, hydro and biomass energy. In the case of hydropower, the term “small hydro” is used when there are no hydropower plants generating more than 100 MW in the country. Renewable energy includes, in addition to the mentioned energy sources, tidal energy and more exotic energy sources.

We have classified the EAEU countries by the integration tightness into two groups – tightly integrated and weakly integrated. The basis for this classification is the participation or non-participation of the country in the Customs Union (the predecessor of the

EAEU), the number of its joint borders with other EAEU countries and its share in intra-EAEU mutual trade (Table 1).

The classification in Table 1 shows that the core of integration is the countries of the former Customs Union.

The forecast for the first group of countries is made using the Gretl tools, namely, the forecast is based on the ARIMA model with exogenous variables of the annual oil price (data from Knoema [2020]) and time series.

We propose to analyze the effectiveness of the transition to green energy by introducing the Index of green potential usage (IGPU), which reflects the effectiveness of measures taken to implement green technologies, by comparing the potential and the actual implementation of clean energy technologies using Equation 1:

$$IGPU = \sum_{i=1}^n \frac{AG}{PG}^n \quad (1)$$

where n is the number of clean energy sources (for the data in the article $n = 4$: solar, wind, small hydro, biomass), AG – actual clean energy generation in MW, PG – potential clean energy generation in the country in MW.

Based on the obtained results, we give recommendations for the EAEU countries and the Eurasian Economic Commission on a better and more efficient development of green energy, taking into account the best practices of the EAEU countries.

4. RESULTS

4.1. A brief overview of the legal framework of green energy transformation in the EAEU

The main documents governing the creation of a better and more sustainable energy development direction in the EAEU are: a) at the global level, the 2030 Agenda for the period up to 2030, b) at the regional level, the Treaty on the Eurasian Economic Union, c) at the national level, strategies for the development of national markets and cooperation in the field of sustainable energy, for example, the Regulatory Framework to Promote Energy Efficiency in Countries of the Eurasian Economic Union (also Regulatory Framework) developed by the UNDP in cooperation with Russia. The last level also refers to the EAEU policy, so it is very important to take into account the fact that the EAEU countries have their own vision of future cooperation in the energy sector.

Table 1: Integration tightness (developed by the authors)

Country	Member of customs union	Number of borders	Length of borders (km)	Share in intra-EAEU mutual trade (% , 2019)	Overall score	Group of tightness
Russia	1	2	2 (8,085)	4 (64.7)	9	1
Kazakhstan	1	2	2 (8,103)	2 (10)	7	1
Belarus	1	1	1 (1239)	3 (23.1)	6	1
Armenia	0	0	0 (0)	1 (1.1)	1	2
Kyrgyz Republic	0	1	1 (1257)	1 (1.1)	4	2

Source: Developed by the authors, trade statistics from (Eurasian Economic Commission, 2019b)

The 2030 Agenda describes the development of green energy in the 7th goal, but its achievement indicators are inadequate: six energy efficiency indicators look uninformative, especially given the fact that most EAEU countries depend on a single energy supplier – Russia; the only the exception is Armenia, which can diversify its energy trade by turning to Azerbaijani and Iranian oil (Trading Economics, 2020; Avetian, 2019). Therefore, energy efficiency and the implementation of the SDGs in the EAEU depends on one country that does not have serious motivation for this, since it has an extensive resource base, which is cheap enough to exploit.

The regional level is also not sufficiently specified. The creation of a common energy market, declared in Section XX of Treaty on the EAEU, is an undefined term; furthermore, recent steps in its creation allow us to conclude that the EAEU's common energy market refers firstly to electric energy, meaning the construction, modernization and connection of the EAEU countries' electric grids, the creation of oil and gas common markets is mentioned, but not in focus; while the document has little or no significance for promoting greener energy, except for potentially less transmission losses between the EAEU countries (as follows from (Eurasian Economic Commission, 2019a)).

The most promising document is the Regulatory Framework, which addresses specific issues of sustainable development of the energy market in the EAEU through the prism of the development of the energy market in Russia. However, since it relies on the methodology proposed in the 2030 Agenda, it has the same problems, namely: declarative goals, such as doubling energy efficiency, which are based on six indicators of the 7th SDG, lack of medium-term control points (the main goals are based on the current situation and prospects by the end of the program), and the lack of financial resources for the implementation of the Regulatory Framework. The last follows from the fact that the energy transformation in Russia requires the same or higher financial efficiency of energy production, which, in turn, requires significant financing. As a result, the green energy transformation

in Russia is not legally developed to the necessary extent. The same refers to other EAEU countries. In general, national clean energy development strategies are either incorporated into energy laws or exist as proposals from non-governmental organizations to national governments. The figures presented in these documents, like the proposed measures, are very similar to those given in the 2030 Agenda, therefore, these documents can be analyzed in parallel. Armenia and the Kyrgyz Republic are less involved in the energy market of the EAEU and do not have sufficient resources to independently begin the green energy transformation.

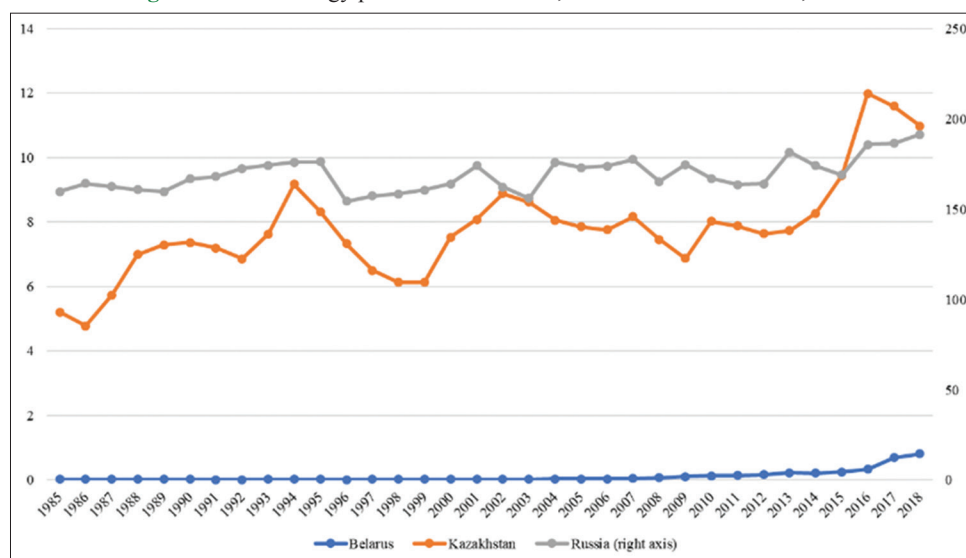
4.2. Econometric and Statistical Estimation of Clean Energy Production in the EAEU

Despite the lack of legal framework for the development of green energy in the EAEU, the countries of the Union try to diversify energy production and consumption, partly due to the need for lower dependence on Russian energy resources (as in the case of Belarus), partly due to the high potential for green energy production in their territories (for example, Kazakhstan). Green energy production by these countries is shown in Figure 1.

Figure 1 demonstrates the uneven dynamics of clean energy production; none of the countries significantly improved their clean energy production after the collapse of the USSR. In this regard, we should note that most of the facilities that are used in the EAEU to generate green energy are the Soviet legacy and their condition is not satisfactory, and the technological base is outdated and, therefore, the cost of their use is higher than in countries, which upgraded clean energy production infrastructure. At the same time, centralization of facilities, characteristic of a planned economy (Mau, 2012; Harrison, 2005), allows to create a distribution system easier than in European countries and the EU as a whole.

Based on data on green energy production, we developed a forecast model for Belarus, Kazakhstan and Russia, aggregating their green energy potential. The basis for this assumption is that Belarus and

Figure 1: Clean energy production in Russia, Belarus and Kazakhstan, TWh



Source: developed by the authors, based on (Ritchie and Roser, 2020)

Russia have several joint projects in the energy sector, especially in the field of oil refining. This leads to a close interconnection of their energy systems. In addition, Belarus cannot rely heavily on the cheapest source of green energy, hydropower, due to the lack of significant rivers. The two countries have close trade relations and, despite temporary misunderstandings on political and economic issues (Shraibman, 2019), have the same development path.

Kazakhstan is the leading EAEU economy in the field of clean energy and has significant potential for the development of solar energy (Terehovics et al., 2017; Karataev and Clark, 2014). At the same time, the country's economy needs foreign direct investment (FDI) for rapid development, so Kazakhstan turns to either China or Russia for FDI. The financial situation in China is much better than in Russia and its green energy technologies are cheaper, therefore, Kazakhstan relies on Chinese investments and innovations, but adheres to the EAEU development course, since it has ambitions to become a leading country in Central Asia and in this respect competes with China. As a result, Kazakhstan is in need of the EAEU and is deeply interested in developing its energy potential (Guliyev and Mekhdiiev, 2017).

The above allows to group these three countries together. The exclusion of Armenia and the Kyrgyz Republic is explained in Methodology.

Figure 2 shows the forecast results and the general trend of changes in clean energy production in the first group of the EAEU countries.

The coefficient for the oil price is two times higher than for the time, both are positive, therefore the investment model in green energy in the three EAEU countries is a transfer of oil revenue. The higher the price of oil, the greater the production of alternative energy. Russia produces and exports oil and gas, and oil and gas revenues are transferred to develop the green energy sector. The transfer of these revenues may be considered international, since the three countries have strong ties in the oil and gas sphere: for example, Belarus is one of the processors of Russian oil (Mekhdiiev et al., 2018); Russia and Kazakhstan agreed on the joint use of oil and gas pipelines. Kazakhstan is the second largest oil exporter in the EAEU; it exports 88% of its production (Embassy of the

Kingdom of the Netherlands in Kazakhstan, 2019). As a result, a significant part of the country's revenues is generated by oil and gas companies.

This explains the transfer investment model — excess oil and gas revenues are invested in clean energy. The high constant in the model is explained by the countries' high path dependency.

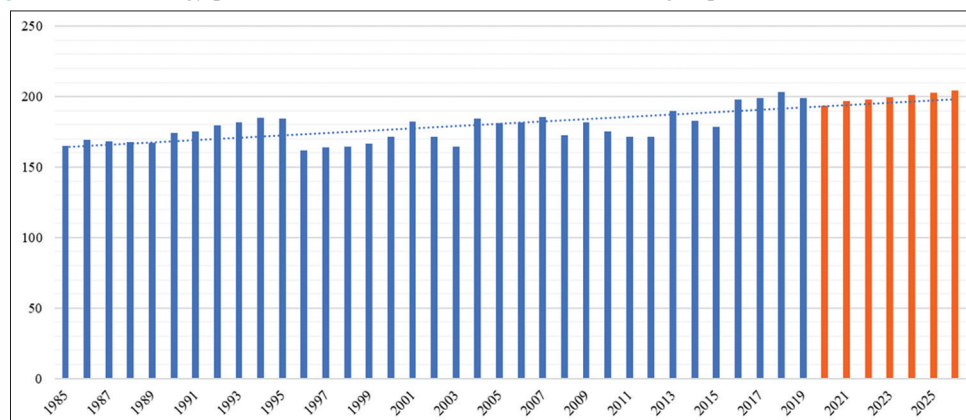
The second group of the EAEU countries mainly depends on support from international institutions in the field of clean energy, since most of the clean energy they produce is hydropower, which is costly. In addition, Armenia began developing other sources of clean energy, but their share is small (less than 0.5% in the production of clean energy). Figure 3 shows the dynamics of clean energy production in these countries.

The growth trends in clean energy in the studied countries are unstable and significantly depend on FDI; the lag in the production of green energy in the crisis and post-crisis period (2008–2012) indicates higher costs for clean energy and the lack of investment in the field. As a result, the EAEU countries have two different models of investments in green energy development: the transfer investment model and the foreign investment model. The latter is a model in which the clean energy field mainly depends on foreign direct investment and foreign aid, since the conditions in the local market are not favorable, and the national economy cannot provide enough resources for the development of this field.

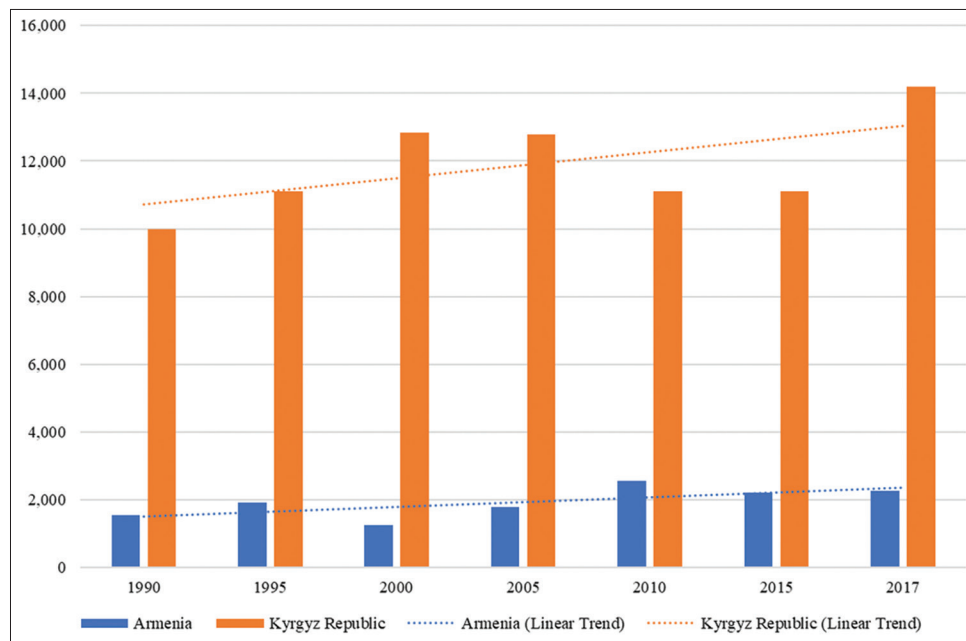
4.3. Clean Energy Production in EAEU and the Sustainable Development of its Member Countries

Energy production has a significant impact on both the economy and the social sphere of the country. Income tax from energy companies, as shown (Embassy of the Kingdom of the Netherlands in Kazakhstan, 2019; Rosenfeld, 2016), is one of the main sources of financial resources for Russia and Kazakhstan. In addition, the industry generates large social benefits, such as higher than average wages for its employees, high levels of economic activity, extra profit for related industries, high standards of social protection for the people and companies involved, etc. (Stjepcevic and Siksnylyte, 2017).

Figure 2: Clean energy production in 2020–2026: forecast for the first group of the EAEU countries, TWh



Source: Developed by the authors

Figure 3: Dynamics of clean energy production in Armenia and the Kyrgyz Republic, GWh

Source: Developed by the authors, based on (IEA, 2020a, 2020b)

Green energy allows to generate greater benefits to society, taking into account the better environmental standards and the higher level of technological contribution that green energy provides to the economy. All in all, green energy in the countries that do not have a high potential for the conventional energy development is undoubtedly economically and socially beneficial.

Nevertheless, for Russia and Kazakhstan, speaking of the EAEU, green energy is of dubious value. As follows from (IRENA, 2017), green energy in Russia has a high development potential; in addition, hydropower plays a significant role in the country's energy balance. At the same time, due to the vast territories and severe climatic conditions, the use of green energy in the Siberian region is difficult and requires additional financial support from the government. The implementation of small hydropower plants is followed by the difficulties of their connection to the electric grid, and wind and solar power plants are effective in limited areas in the southern regions of the country. Biowaste energy generation is a promising direction for the green energy development, but it is followed by emissions of carbon dioxide into the atmosphere, so its effect from the point of view of ecology and SDGs is lower. The calculation of LCOE of alternative energy sources presented in (IRENA, 2017) allows us to conclude that the total price of alternative energy in Russia is higher than, for example, the total price of energy produced from gas.

The situation for Kazakhstan looks similar: the country's potential in the production of clean energy is high due to large areas and a large number of sunny days per year, but due to the centralization of population density (as in Russia) and the need for additional financing (for example, most of projects reviewed in (Karatayev and Clarke, 2014) were implemented with foreign capital) has several specific points described below. A study of the future renewable energy in Kazakhstan (European Bank for Reconstruction and Development, 2019) provide a basis for the

conclusion that most of the realized potential of renewable energy in Kazakhstan is a legacy of the USSR and needs to be updated and modernized. Another problem for Kazakhstan is the lack of domestic demand. As we have already mentioned, only 20% of the oil produced in Kazakhstan is sold on the national market. The same is the situation with the energy, there is no demand for energy resources in the country.

The situation in Belarus is different. The country does not have significant conventional energy resources, so it has to rely on energy imports (UNECE, 2018). The main exporter of energy to Belarus is Russia, therefore, Belarus has a stronger motivation for the development of alternative energy in its territory, namely, optimization of budget expenditures. The analysis of the prospects and advantages of alternative energy in Belarus by Meerovskaya et al. (2014) shows that the country's potential in generating green energy is insufficient to meet national energy demand. Therefore, it is necessary to turn to other energy sources to reduce the country's dependence on energy imports. In the context of the development of clean energy in the EAEU, this is a very important issue, as it provides a field for cooperation in the transmission of green energy from countries with large amounts of clean energy production to countries such as Belarus, which require more energy for a stable and sustainable economic development. Another option for Belarus is the use of nuclear energy, which can be described as potentially harmful to the environment (due to the consequences of endogenous catastrophes) (International Atomic Energy Agency, 2018).

The clean energy sector of Armenia is one of the most developed in the EAEU, with a share of 5.4% of renewable energy sources in energy generation (UNDP, 2014a), Armenia becomes the first country in the EAEU to overcome the barrier of 5% of renewable energy in energy generation structure. Nevertheless, Armenia has several significant problems, including a lack of financial resources for the development of the sector and cheaper alternatives, for

example, energy produced from gas. In addition, Armenia's import of hydrocarbons is diversified: it partially imports oil and gas from Russia, and partially from Iran. Therefore, there is no obvious threat to the country's energy security, as in the case with Belarus (Babayan, 2017).

The potential for generating green energy in the Kyrgyz Republic is high, but the lack of financial and economic development potential leads to the exploitation of the USSR's heritage (Botpaev et al., 2011). The main source of renewable energy in the Kyrgyz Republic is hydropower, while the potential for generating solar and wind energy is huge (UNDP, 2014d).

We calculated the Index of green potential usage in accordance with Methodology. The results are presented in Table 2.

The results of Table 2 demonstrate that all countries have high potential for the future development of clean energy, since their natural resources are far from efficient use. Armenia is again a pioneer in the development of green energy in the EAEU. In this respect Russia is the only country with a net energy use efficiency below 0.5%, but due to the high energy consumption this value cannot be called critical, since the amount of green energy generated in the country in absolute numbers is high. At the same time, if the data are examined in the context of achieving the goals established by law, the only country that can reduce carbon dioxide emissions by 25% by 2025. As a result, one of the main points of this article is that the EAEU as a whole does not have sufficient power (political and financial) and sufficient willingness to transfer the economies of its members to clean energy.

5. DISCUSSION

The above analysis and data from (Angelou et al., 2013) allow us to conclude that the creation of a common electricity market for the EAEU countries and the formation of a unified attitude to the development of clean energy in the EAEU countries are vital. At the moment, the declarative nature of the transition to clean energy in the EAEU countries does more harm than good. As a result, the EAEU countries cannot find a single basis for cooperation in creating common energy markets, and the integration of Eurasian countries is losing drivers. To overcome the controversies, we propose to identify the problems for introducing clean energy (technological and economic), then find a regional leader and identify the drivers for promoting clean energy in this country and, finally, transfer these drivers to other EAEU countries, adapting them to other conditions of functioning.

As we mentioned earlier, the key problems of the EAEU countries in the field of clean energy are: (a) underfinancing of green

projects, (b) low technological base, (c) cheapness and abundance of conventional energy resources in Russia and partially in Kazakhstan. The only EAEU country that is likely to achieve SDGs is Armenia, while other countries are unlikely to reach the target indicators in 2025 for both international and national clean energy development programs.

The key factors enabling Armenia to quickly develop on the path of transforming the energy sector are the following:

1. The availability and abundance of green energy sources, namely wind, solar energy and hydropower;
2. Higher population density compared to other EAEU countries (Smith, 2020);
3. Sufficient financial and consultative support for green development by international organizations;
4. The need to preserve nature and historical heritage, since tourism and eco-agriculture are one of the key contributors to the national economy.

Table 3 shows the existence of these factors in other EAEU countries.

We assessed the driving factors in Table 3 comparing statistics from (The World Bank, 2020a, 2020b, 2020c), and the third factor was analyzed based on (Eurasian Economic Commission, 2017).

This analysis allows us to conclude that, due to the lack of drivers, the clean energy development in the EAEU has no chance unless these drivers are created.

Based on four identified driving factors, we propose the following steps to generate support for clean energy development in the EAEU:

- 1.1. Create a legislative document regulating the transmission of electricity in the EAEU and providing for a tax-free regime for energy generated from green sources.
- 1.2. Form a unified approach to the use of green energy resources, since their quantity is also limited – the potential for energy generation from clean sources depends on the geographical location, therefore their regional distribution is uneven. In this regard, a unified approach to their use and ways to develop alternative energy generation in the EAEU will lead to an increase in the efficiency of the sector development and lower costs (including transaction costs) for all parties.
- 1.3. Higher population density is a factor that cannot be changed, but due to the low population density in Siberia, Kamchatka and numerous Kazakhstani territories, the model of energy supply to consumers must be changed to adaptive. Consumers should be able to sell electricity to state companies and other consumers – in order to provide this opportunity, it

Table 2: Index of green potential usage in the EAEU

Country	Russia	Kazakhstan	Belarus	Armenia	Kyrgyz Republic
Index value (%)	0.2	0.6	1.4	18.3	0.6

Source: Developed by the authors, based on data from (IRENA, 2017; UNDP, 2014a, 2014b, 2014c, 2014d)

Table 3: Comparative analysis of the EAEU countries' drivers (developed by the authors)

	Factor 1	Factor 2	Factor 3	Factor 4
Russia	+	-	-	-
Kazakhstan	+	-	-	-
Belarus	-	+	-	+
Kyrgyz Republic	+	-	+	-

is necessary to change the legal framework, and electricity produced from clean sources by individuals should not be subject to tax (VAT, income tax).

- 1.4. In areas of low population density, clean energy sources should be used with state financial support; the creation of infrastructure for isolated or remote villages should be state financed.
- 1.5. In areas of high population density, compensation fees should be introduced for suppliers using conventional energy sources. These fees should be proportional to the harm from the energy source used: the highest for coal, the lowest for gas. Electricity costs for the population and the corporate sector should be state regulated and estimated in terms of the social responsibility of the state and companies to citizens.
- 1.6. The economy of Russia and Kazakhstan will benefit from a more even distribution of the population; measures should be taken to provide social support for people migrating to areas with low population density.
- 1.7. Most of the newly created development banks, especially the Asian Infrastructure Investment Bank and the New Development Bank of BRICS, set green energy financing goals as key in their financial strategies. Attracting their support to the development of clean energy in the EAEU, especially in Belarus and the Kyrgyz Republic, as countries with higher demand for green energy and lower costs for its implementation, is a significant step towards the creation of clean energy sector in the EAEU.
- 1.8. Creation of a preferential loan mechanism for projects in the field of clean energy within the framework of the Eurasian Development Bank program, which should be aimed at achieving the clean energy use indicators declared in the 2030 Agenda and the 7th SDG. After the EAEU country has achieved this, the loan mechanism ceases to be preferential.
- 1.9. Fast introduction of zero tariffs on trade in technological equipment between the EAEU and Vietnam, Serbia and Iran under free trade agreements.
- 1.10. The development of a joint declaration on the preservation of natural and historical heritage in the EAEU is a vital step towards the formation of unified approaches to ecology and tourism. Both sectors play a very important role in the development of social and cultural partnership between the countries of the Union and will contribute to the beginning of a dialogue in the field of clean energy generation in the framework of environmental cooperation.

The proposed measures will lead to improved cooperation in the EAEU in the field of clean energy generation and will inevitably lead the energy sectors of the EAEU countries to a cleaner and more sustainable use and production of energy, thus contributing to the implementation of the 2030 Agenda and national green development programs.

6. CONCLUSION

At the moment, the situation with the development of clean energy in the EAEU is not encouraging. All countries except Armenia have no prospects of achieving the 2030 Agenda's goals, and their national clean energy development strategies are declarative in

nature. The EAEU as a whole lacks a strategic vision for energy development, especially in the field of green energy and renewable sources.

The EAEU countries are developing unevenly; moreover, their development potential in the field of clean energy is also unevenly distributed. We divided the countries into two groups. The tightly integrated countries rely heavily on energy from Russia, the prospects for clean energy in this group of countries (Russia, Belarus and Kazakhstan) are pale due to the high costs of clean energy implementation. The second group of countries (Armenia and Kyrgyz Republic) are heavily dependent on imported energy, but due to less tight integration, they have better starting conditions for the development of clean energy. Unfortunately, the Kyrgyz Republic does not have the financial and economic potential for the rapid and stable development of green energy, therefore, the most effective results of implementing clean energy are achieved in Armenia.

Conditions, both economic and geographical, in Armenia have a significant impact on its position in the development of clean energy in the EAEU. None of the other EAEU countries has close enough conditions to develop clean energy at the pace of Armenia. The best way to overcome this problem is to stimulate cooperation and financial support for this field within the EAEU, but the lack of financial resources and the need to overcome sanctions leads to difficulties in financing clean energy in the EAEU.

Cooperation with regional development banks and the spread of the EAEU's partnership in trade with other countries will lead to an improvement in this field. However, another important point is the development of technologies in the field of clean energy and the reduction of green energy costs, since the current level of costs allows countries rich in conventional energy resources to use them at lower costs than clean energy sources, even taking into account the negative external effects of conventional energy such as pollution.

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