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Research Article

Analysis of the Factors that Ensure the Possibility of Developing Economic Relations in the Field of Renewable Energy Between Ukraine and Turkey

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ABSTRACT

Successful international economic activity in a particular technological sector is important for the further development of mutually beneficial socio-economic relations between neighboring countries. In order to implement the basic principles of this activity, it is necessary to determine the current level of cooperation between Turkey and Ukraine and the dynamics of its development, as well as to identify key factors influencing the development of cooperation in the field of renewable energy. The reasons for this study are the importance of ensuring effective cooperation between the two countries in the field of renewable energy, which requires an integrated approach. General scientific methods were used, the main of which are: system analysis – for determining the components of the system of foreign economic relations of Ukraine and Turkey in the direction of developing renewable energy; taxonomic analysis – for identifying factors influencing economic relations and determining their numerical value of the resulting indicator. The conducted study allowed us to evaluate the level of current developments in the direction of forging a strategic partnership and to explore the impact of stimulating and destimulating factors on the potential opportunities of both countries.

Keywords: Economic relations, renewable energy, cooperation between Ukraine and Turkey, strategic partnership

1. Introduction

The strategic partnership between Ukraine and Turkey is mutually beneficial for both countries, as today these two neighboring countries have favorable foreign political, geographical and economic preconditions for development and cooperation. The process of developing the main provisions of the Free Trade Agreement between Ukraine and Turkey is continuing. Thus, in January 2020, another round of negotiations on the Free Trade Agreement between Ukraine and Turkey took place in Ankara. According to the approved Export Strategy of Ukraine ("Roadmap" of Strategic Trade Development) for 2017-2021, Turkey belongs to the main countries the markets of which are of great importance to Ukrainian producers and they have considerable potential for export of products to those markets ("On approval of the Export Strategy of Ukraine ("Road Map" of Strategic Trade Development) for 2017-2021"). With this in mind, actions and strategic programmes of the development of further cooperation are planned by 2021. Therefore, in accordance with the Report on carrying out the plan of actions and measures to implement the Export Strategy of Ukraine for 2018, an educational event Export Talks concerning the market of Turkey was conducted and other measures to enhance cooperation were organized ("Report on the Implementation of the Plan of Tasks and Measures for the Implementation of Ukraine's Export Strategy", 2019).

Cooperation in the field of energy engineering is one of the main areas of bilateral collaboration. Both countries have similar interests in the field of energy engineering such as the need for diversification of energy supply sources, security of energy resources supply, more active use of the country's own transit potential, exploration and production of the country's own resources, among others. The Central and Southern gas corridors, which are important for the transportation of energy resources to Europe, pass through the territory of Ukraine and Turkey. During recent meetings, the parties agreed to cooperate in the construction of underground gas storage facilities, nuclear energy, alternative energy sources, energy-saving technologies and more.

Given Objective 7 i.e. «Affordable and Clean Energy» of the 2030 Global Sustainable Development Goals approved at the UN Sustainable Development Summit, it is crucial for the world to support renewable energy. For example, the goals at global level by 2030 include increasing the share of renewable energy in the global energy balance, activating international cooperation to facilitate access to green energy research and technology, including renewable energy. This is a favorable condition for the development of relations between Turkey and Ukraine in the field of renewable energy. For instance, increasing the ratio of local and renewable energy in the Turkish energy mix is one of Turkey's main goals according to Turkey's energy profile and strategy ("Turkey's energy profile and strategy", 2019). In Ukraine, the development of renewable energy is one of the priority tasks in accordance with the adopted Energy Strategy of Ukraine for the period up to 2035 «Security, energy efficiency, competitiveness» ("Energy Strategy of Ukraine until 2035", 2017).

In addition to the components of the Goal 7 strategic partnership, the deepening of economic relations in the field of renewable energy will also contribute to the achievement of Goal 8 "Decent work and economic growth" and Goal 17 "Partnerships for the goals".

This study will help us to identify and comprehensively analyze the factors ensuring the possibility of cooperation in the field of renewable energy. After all, successful international economic activity and scientific and technical cooperation in a particular field, especially, in a particular technological sector, is important for the further development of international cooperation between neighboring countries. In order to ensure a high level of international relations, it is advisable to assess the current level of cooperation between Turkey and Ukraine, as well as to deter-

mine the prospects for its development. Particular attention is paid to the identification of key factors influencing the development of cooperation in the field of renewable energy.

2. Literature Review

Many scientists have devoted their work to the study of directions and factors of the development of foreign economic activity, cooperation and development of economic relations. Our research focuses on analyzing the work of scientists in the context of initiating and developing joint projects and studying international relations between Turkey and Ukraine. We agree with Gaber (Gaber, 2016) that due to Russian aggression against Ukraine and sanctions against Turkey, military conflicts in the Middle East, failure to preserve economic partnership with Libya or Syria and thus losing foreign markets in the mentioned region, both countries have begun to look for alternative ways to restore economy and trade. In view of this, it is vital to boost Ukrainian and Turkish cooperation as well as diversify energy sources and transportation routes as it is a crucial factor in energy and national security of both countries.

We also agree with the results of the study Turgut (Turgut & Ayşegül, 2018), that if Ukraine and Turkey establish solid economic and political relations with each other and other countries belonging to the Black Sea region on the basis of an inclusive and egalitarian approach, it could cause the regionalization of the Wider Black Sea.

In the context of the application of economic methods of analyzing international relations and economic development, the approach proposed by Voitko (Voitko & Grinko, 2017) defines levels of sustainable development potential and determines the positions of Ukraine and other countries in the peer-groups, based on individual macroeconomic indicators that give the possibility to investigate the country's potential in the limits of the chosen peer-group and propose recommendations for increasing economic potential in order to achieve sustainable development.

It is important to apply a factor approach to the analysis of foreign economic relations, which is employed in the studies of scientists (Kim, Lim, & Park, 2009), that are based on certain statistics. Today, in the rapidly changing market conditions, the application of the factor approach in the analysis of foreign economic relations and the identification of stimulating factors allows generalized objective market trends to be identified. We agree with the statements (Ilyash, Doroshkevych, & Dacenko, 2019) that non-formalized analysis based on a factor approach is an important basis for assessing the current state and establishing trends in the development of foreign trade relations of the country.

In order to conduct a multifactor analysis of opportunities for the development of economic relations in the field of renewable energy between Ukraine and Turkey, it is advisable to use the method of taxonomy. This method is widely used by scientists for various purposes- for example, for conducting an analysis at the enterprise level (Sergiienko et al., 2020), for doing research at the level of the regional and national economy (Ilyash, 2012) or carrying out research on international relations (Dvulit et al., 2020).

It should be noted that in the direction of developing renewable energy, there are separate studies by scientists from Turkey and Ukraine. For instance, in their article, Cetin and Vardar (Çetin & Vardar, 2014) analyzed the features of the development of various renewable energy sources in Turkey and identified the most promising ones. In the study by Sabuncu et al. (Turkey's Renewable Energy Sector from a Global Perspective, 2012) much attention is paid to renewable energy support policies. The model proposed in the study by Deina is of great interest, as it shows the dependence of the consumption of fuel and energy resources in Ukraine on other factors (Deina, 2017).

At the same time, the results of our critical analysis of scientific information sources on the subject indicate that the issues of a comprehensive factor analysis of the development of cooperation between Ukraine and Turkey specifically in the field of renewable energy, which would take into account the factors of economic, political and sectoral influences, remain unresolved. Therefore, our article is devoted to tackling these issues.

3. The Structure of the Foreign Trade Turnover between Turkey and Ukraine

In 2019, the commodity structure of exports of goods from Ukraine to Turkey included 17 commodity items. In terms of value, the largest export to Turkey was 82.218 million US dollars, where base metals and articles made of them accounted for more than 78% of the sum. More than 8% of the structure of exported products to Turkey belongs to chemical products and products of related industries, more than 7% to wood and wood products, and more than 3% to land vehicles, aircraft, and waterborne vehicles (Fig. 1).

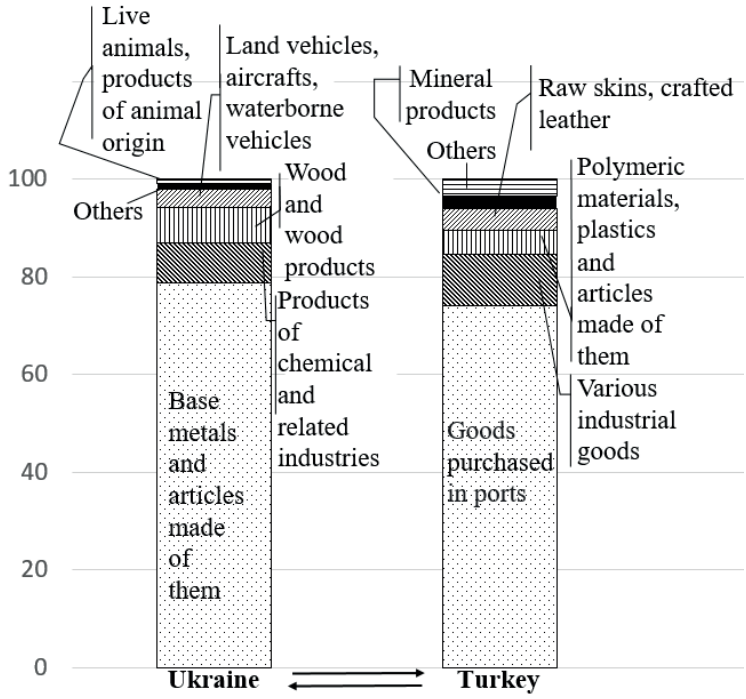

Figure 1. Mass fractions of major product groups in mutual foreign trade turnover of Turkey and Ukraine in 2019, %

Source: designed by the authors on the basis of data ("State Statistics Service of Ukraine", 2020)

The maximum volume in the structure of exports of goods from Turkey to Ukraine belongs to goods purchased in ports and it amounted to 21.568 million US dollars in 2019, which is 74%. Next in the list, there are various industrial goods – more than 10%, polymeric materials, plastics and articles made of them, raw skins, crafted leather – more than 4% for each category.

In general, exports of goods to Turkey increased by 11.3% compared to 2018, and imports of goods to Ukraine from Turkey increased by 37.4%. This indicates positive dynamics in trade for both countries.

Fig. 2 shows the dynamics of the geographical structure of exports of goods from Ukraine to ten countries (excluding the Russian Federation) with the highest value of this indicator. From 2009 to 2015, Turkey was ranked second after the Russian Federation in terms of exports of products from Ukraine. For example, from 2009 to 2013, there was a 79% increase in exports to Turkey – from 2,126 million USD up to 3,805 million USD. From 2013 to 2016, there was a 46% decline in exports from Ukraine to Turkey.

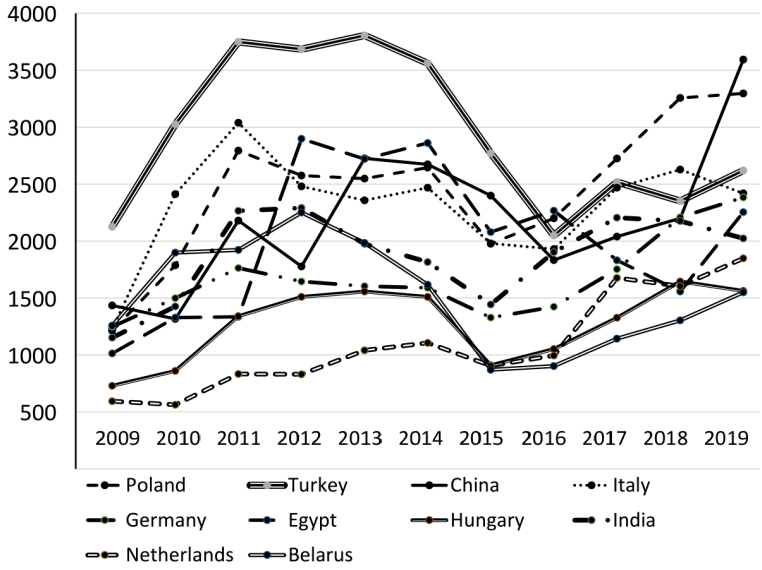

Figure 2. Dynamics of the export of goods from Ukraine for 2009-2019, million US dollars
Source: designed by the authors on the basis of data ("State Statistics Service of Ukraine", 2020)

In January-December 2019, the commodity structure of exports to Turkey included 17 commodity items. In terms of value, the largest export indicator accounted for more than 84% of base metals and their products. More than 8% of the exported products belong to chemical and related industries; land vehicles, aircrafts, waterborne vehicles constitute more than 3% in the structure of the exported products to Turkey.

At the same time, Turkey exported to Ukraine goods worth 2354.7 million US dollars, which is 37.4% more than in 2018. This indicates positive dynamics in trade for both countries.

4. A Strategic Partnership in the Field of Renewable Energy

Today, Turkey is one of Ukraine's strategic partners. The website of the Embassy of Ukraine in the Republic of Turkey (Embassy of Ukraine in the Republic of Turkish, 2020) states that in general the number of valid documents of the contractual legal framework is 142. The key political documents include the Agreement on Friendship and Cooperation between Ukraine and the

Republic of Turkey (04.05.1992), The Joint Declaration on Establishment of High-Level Strategic Council between Ukraine and the Republic of Turkey (25.01.2011). Within the framework of effective economic cooperation, the following agreements may be mentioned: the Agreement between the Cabinet of Ministers of Ukraine and the Government of the Republic of Turkey on technical and financial cooperation, the Agreement between the Cabinet of Ministers of Ukraine and the Government of the Republic of Turkey on cooperation in the field of science and technology, the Agreement on cooperation in the sphere of development between the Government of Ukraine and the Government of the Republic of Turkey and others. The aforementioned agreements define a favorable basis for cooperation in various spheres of economic activity.

As within the scope of this study we are interested in the analysis of cooperation in the field of renewable energy, we can distinguish the following. The ways of cooperation between Ukraine and Turkey in the field of renewable energy were discussed in 2016 within the framework of the meeting of Ukrainian-Turkish representatives of the State Agency for Energy Efficiency and Energy Saving ("Ukraine and Turkey see prospects for mutually beneficial cooperation in renewable energy", 2017). Primarily, it is bilateral cooperation to exchange experience in the development of renewable energy and to promote the implementation of renewable and alternative energy projects with the participation of Turkish investments.

Turkey is in the top ten leading countries in terms of the introduction of renewable energy. ELIN Renewable Energy Systems, EkoSolar, Güriş Enerji, Zorlu Enerji, and Aksa Energy are among the most powerful Turkish companies in the field of green energy. Furthermore, the Turkish company EMSOLT is developing its projects in Ukraine. For instance, it has already developed and ensured commissioning of Solar Power Plants with a total installed capacity of 60 MW in various regions of Turkey. Moreover, their Ukraine Project pipeline has so far reached a total capacity of 160.7 MW, they have already started the construction for 25 MW and 85.7 MW of which is ready to be built while the remaining 50 MW is under development. Thus, a solar power plant, Luginy, operates in Zhytomyr (Ukraine) with a capacity of 14 MW Solar Power Plant ("EMSOLT Investments", 2020).

Among Ukraine's ongoing solar power plant projects of EMSOLT there are the following: «Mykhailivka» with a capacity of 11 MW (Khmelnytskyi region), Dnipro 1 with a capacity of 4.3 MW, Dnipro II with a capacity of 8.4 MW, Dnipro III with a capacity of 24 MW, Dnipro IV with a capacity of 8.4 MW, Dnipro V with a capacity of 8.4 MW – the city of Dnipro; Ignatpil I with a capacity of 9 MW, Ignatpil II with a capacity of 6 MW, Korosten with a capacity of 75 MW, Malyn I with a capacity of 9.5 MW, Malyn II with a capacity of 6 MW, Bilokorovychi with a capacity of 10 MW, Aria with a capacity of 35 MW – the city of Zhytomyr.

In 2019, the total capacity of all renewable energy sources in Turkey exceeded the same figure in Ukraine by almost 6 times. For comparing the indicators of total renewable energy (MW) in the dynamics, we present the data from Ukraine and Turkey from 2009 to 2018 in Fig. 3. Over 9 years, Turkey increased its renewable energy capacity by 171%, while in Ukraine it grew by just over 60%.

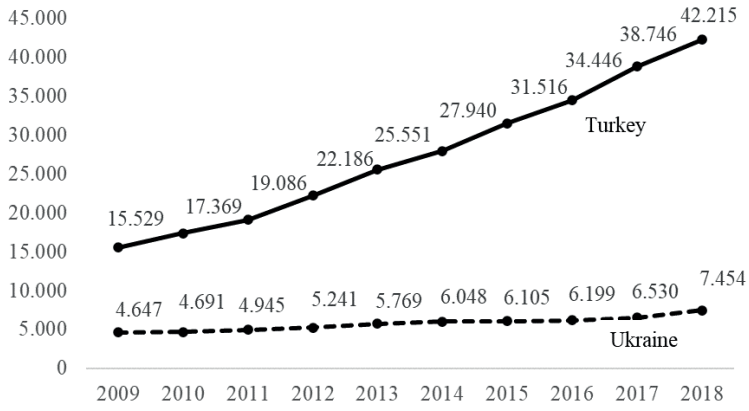

Figure 3. The capacity data of total renewable energy in Turkey and Ukraine, MW
Source: designed by the authors on the basis of data ("Renewable energy statistics ", 2019)

In the study, we did not take into account the indicators of hydropower; we considered only solar and wind energy. It should be noted that the actual wind power capacity in Turkey in 2018 was 7,005 MW, which is 11 times more than in Ukraine - 621 MW. The narrower gap is between the identified capacity of solar power – 5,064 MW in Turkey and 2,003 MW in Ukraine – which amounts to 2.5 times. The growth rates of these capacities in Ukraine and Turkey were compared (Fig. 4), which made it possible to compare the percentage increase of capacity in Ukraine and Turkey in the chain series of dynamics.

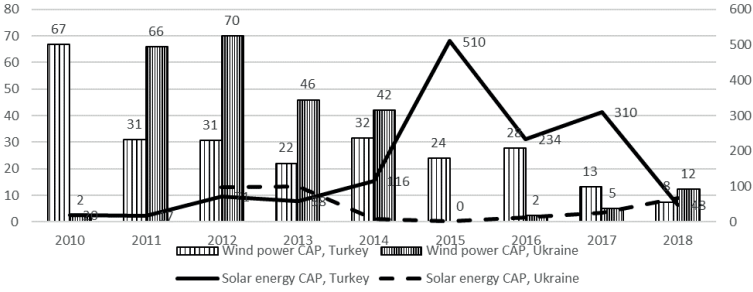

Figure 4. The growth rate of wind and solar power in Turkey and Ukraine, %
Source: designed by the authors on the basis of data ("Renewable energy statistics", 2019)

Thus, the highest growth rate of wind energy in Turkey was in 2010, and from 2016 to 2018, there was a decline in the introduction of new capacity. At the same time, in Ukraine there was a relatively faster growth rate of capacity with a maximum indicator of 70% in 2012, then from 2012 to 2015 there was a decline to zero. From 2016 to 2018, an increase at a slow pace was observed. In terms of solar power capacity, in Turkey the highest rate was 510% in 2015 and there are still different growth rates. From 2016 to 2018, the highest indicator was 310% in 2017 and then there

was a decline of up to 48% in 2018. At the same time, the highest growth rate in Ukraine in 2013 was 101%, followed by a fall from 2014 to 2018 to 9% in 2014. Furthermore, from 2014 to 2018, there was a gradual growth at a slow pace.

5. The Infrastructure for Electric Transport as a Possible Area for Developing Cooperation

In our opinion, one of the most important factors that contributes to the development of renewable energy is an increase in the number of electric vehicles because it is advisable to use wind and solar energy to charge electric motors and the effectiveness of this has been explored and proven in our past studies (Budko, Voitko, & Trofymenko, 2018; Budko, Kudria, Voitko, & Trofymenko, 2019).

Therefore, in the context of this study, we consider it expedient to analyze the dynamics of using electric vehicles in the world, including Turkey and Ukraine.

Nowadays electric mobility is developing at a rapid pace. The global electric car fleet exceeded 5.1 million in 2018, up by 2 million since 2017, almost doubling the unprecedented amount of new registrations in 2017 (IEA, "Global EV Outlook 2019 – Analysis").

The People's Republic of China (hereafter "China") is still the world's largest electric car market, which sold almost 1.1 million electric cars in 2018. The Chinese electric car market with 2.3 million units accounted for nearly half of the global electric car stock. Europe produced 1.2 million electric cars and was the second after China, while the United States was responsible for 1.1 million cars on the road by the end of 2018. In terms of electric car market share, Norway remained the global leader, as its market share was 46% due to its new electric car sales in 2018. The share of Norway is twice as high as the share of the second-largest country Iceland (17%) and six times as high as the third-highest share of Sweden (8%).

Chinese Taipei has announced a ban on the sale of fossil fuel-burning two- and four-wheel vehicles as part of an action plan to curb air pollution and promote renewable energy (Taiwan Today, 2017).

In 2019, Turkey presented the first electric car of its own production. Turkey's Automobile Joint Venture Group Inc., created under the auspices of the Ministry of Industry and Technology, is developing the first domestically produced car within a planned series of five models. ("TOGG to present Turkey's first domestically made electric vehicle", 2019). This indicates the increased demand for electric vehicles in the country. At the same time, it is essential to provide the right infrastructure for this type of transport, which will include RES-based charging stations.

In 2017, 77 full EVs and 4,451 hybrid vehicles were registered in Turkey – a total of 4,528 vehicles. In 2016, only 44 EVs and 950 hybrid vehicles were registered. Due to the tax incentives offered by the government in 2017, the registered number of EVs (especially hybrids) has quadrupled.

In February 2020, Ukrainians purchased and registered 663 electric cars ("Association of Automobile Manufacturers of Ukraine", 2020). In 2019, 7700 electric cars were registered in Ukraine, in 2018 – 5,539 electric cars. In the fourth quarter of 2019, electric vehicle registrations were 5% less than in the previous quarter ("Automobile Employers Federation", 2020).

According to the report "Global EV Outlook 2019", policies and market frameworks should guarantee that electric mobility have a major role in improving the flexibility of power systems. Due to the fact that electric mobility provides flexibility services, it can increase the ability to integrate variable renewable energy into the production mix and cut the costs connected with adapting power systems to increase electric vehicle consumption. To meet the demand in the electricity market, aggregators do not have to face high transaction costs (including not only fees

but also other regulatory, administrative or contractual obstacles) to be able to pool large amounts of small loads (IEA, "Global EV Outlook 2019 – Analysis").

Policies are essential in order for electric mobility to have a positive influence. The use of electric vehicles for providing flexible services is a characteristic that has the appropriate implications for improving the ability to integrate renewable energy into the mix for electricity generation and for cutting the costs related to adapting the grid to increased electric vehicle consumption. The renewal of the European directive on general rules for the internal market in electricity, endorsed by the European Parliament in March 2019 as part of the Clean Energy Package for All Europeans, is a major benchmark in this respect.

GHG emissions: Growing electric mobility combined with a progressive rise in generating low carbon electricity can lead to a considerable reduction in GHG emissions from road transport that are associated with ICE vehicles. Furthermore, electric vehicles can have an expanded role due to their use in ensuring flexible services of the power grid and the integration of different renewable energy sources for generating electricity (IEA, "Global EV Outlook 2019 – Analysis").

For the development of EVI activities, the IEA secretariat co-operates with the IEA Technology Collaboration Programmes on Advanced Fuel Cells (AFC) and Hybrid and Electric Vehicle Technologies and Programmes (HEV). Other partners include: Argonne National Laboratory (ANL); C40; ClimateWorks Australia; ClimateWorks Foundation; Electrification Coalition; European Association for Electromobility (AVERE); Forum for Reforms Entrepreneurship and Sustainability (FORES) in Sweden; Global Environment Facility (GEF); GreenTechMalaysia; International Council for Clean Transportation (ICCT), which hosts the secretariat of the International Zero-Emission Vehicle Alliance); International Electrotechnical Commission (IEC); International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE); International Renewable Energy Agency (IRENA); Hewlett Foundation; King Mongkut's University of Technology Thonburi (Thailand); Lawrence Berkeley National Laboratory (LBNL); Mission 2020; Natural Resources Defence Council (NRDC); National Renewable Energy Laboratory (NREL) of the United States; Nordic Energy Research (NER); Partnership on Sustainable Low Carbon Transport (SloCaT); REN21; Rocky Mountain Institute (RMI); Swedish Energy Agency; The Climate Group; United Nations (UN) Environment (UN Environment); UN Human Settlements Programme (UN Habitat); UN Industrial Development Organization (UNIDO); World Resources Institute (WRI) and Urban Foresight.

It should also be noted that such companies founded by Ukrainians as GreenWay Otomobil Hizmetleri and GreenWay Enerji are based in Turkey and engaged in electric transport i.e. selling electric vehicles and developing the needed infrastructure in Turkey.

Today, cooperation between Turkey and Ukraine is developing in the direction of increasing this market. For example, the Turkish mobile operator TurkCell Group is planning to invest in the creation of a Ukrainian electric car, as stated at the Turkcell Technology Summit 2019 in Istanbul.

TurkCell Group is investing in the development of the first Ukrainian electric car. This will happen no earlier than 2022. Five companies are participating in the financing of the production: four Turkish and one Ukrainian. The pledged amount of money needed to manufacture a Turkish electric car is 3 billion US dollars (EspresoTV, 2019).

Other factors that need to be regarded today as an impetus for the development of cooperation between the Republic of Turkey and Ukraine are political instability and military conflicts. These factors require collaboration in order to combat them and ensure sustainable development of countries. In addition, it is important to work together to refine the mechanisms of cooperation,

sign a free trade area agreement and define the legal bases for the interaction of investors, producers and consumers.

It is worth mentioning that from the beginning of 2020 new rules of the game for the participants of the RES market have come into force. For instance, those, which are regulated by the Law of Ukraine «On Amendments to Certain Laws of Ukraine on Ensuring Competitive Conditions for Electricity Production from Alternative Energy Sources», dated April 25, 2019, № 2712-VIII, the Law of Ukraine «On Alternative Energy Sources» as amended in August 09, 2019, № 555-IV, the Resolution of the National Energy and Utilities Regulatory Commission "On Approval of Legal Acts Governing the Activities of the Guaranteed Buyer and Purchase of Electricity Under the Feed-in Tariff", as of 26.04.2019, number 641, which approves the Order of Purchase of Electricity Under the Feed-in Tariff and a new Template of Power Purchase Agreement under the feed-in tariff. These changes are aimed at transforming the existing system of state support for renewable energy sources (RES), which is based on a green tariff, on a new model in the form of auctions for distributing support quotas for new producers of alternative energy. The main advantage of the auction system over the "green" tariff is the creation of conditions for competition between the RES market participants, which should ensure a balance of interests in the market, as well as a longer period of guaranteed purchase of electricity by the state from producers at the auction price that is determined before the start of the power plant construction. As a whole, this will promote the interests of Turkish investors.

6. Methodology

In the process of conducting this study, the main prerequisites for the development of economic relations between Ukraine and Turkey in the field of renewable energy and the factors of their provision were identified. This necessitated making a comprehensive assessment of various factors influencing the development of Ukrainian-Turkish relations and identifying the relevant stages of the study.

In the first stage of the study, the structure of foreign trade turnover between Turkey and Ukraine was analyzed, the dynamics of exports of goods from Ukraine to Turkey was examined and the place of Turkey in terms of the share of exports from total exports from Ukraine was defined.

In the second stage, the main factors of strategic partnership between the countries in the field of renewable energy were studied, namely: the main documents of the legal framework were identified, the growth rates of wind and solar energy capacity of Turkey and Ukraine were compared, and the existing projects which have interaction of both countries were identified. In addition, we separately identified trends in the electric vehicle market in Turkey and Ukraine as a driver of the infrastructure growth for electric vehicles, and hence for renewable energy.

In the third stage, a set of factors that determine the provision of economic relations in the field of renewable energy was analyzed. A group of indicators was selected and a taxonomic indicator of opportunities for the development of economic relations in the field of renewable energy for the period from 2012 to 2018 was determined separately for each country under study.

We would like to mention that a taxonomic method is often used to compare objects with a large number of indicators. The methodology of taxonomic analysis described by the Polish scientist Plyuta (1980) in his work "Comparative multidimensional analysis in economic research: methods of taxonomy and factor analysis" was used in our study. Our research is also based on the recommendations concerning taxonomic method procedures proposed by O. Ilyash (Ilyash, 2012).

It should be noted that 11 indicators were chosen to determine a taxonomic indicator; some of them indicate the development of the economy, some show the political component, some – the field of renewable energy. These indicators allow the opportunity for cooperation to be comprehensively assessed. In addition, they are generally accepted in their field, which justifies the feasibility of their use in economic research. The values of these indicators were determined separately for Turkey and Ukraine. These indicators have a slight correlation between themselves, which shows their low level of interdependence, and this will not distort the final result of the study. A detailed description of the indicators is given below.

Thus, we included the following of these indicators, which we marked as Xi:

X_1 - GDP per capita, PPP is gross domestic product converted to international dollars using purchasing power parity rates and divided by total population. According to our study, this indicator shows the development of the national economy, and thus contributes to its ability to develop various projects in the field of renewable energy.

X_2 - Consumption of Primary energy. The value of this indicator was taken from the BP Statistical Review of World Energy ("BP Statistical Review", 2019). We want to note that in this review, primary energy comprises commercially-traded fuels, including modern renewables used to generate electricity.

X_3 - Renewables consumption. This indicator is based on gross generation from renewable sources including wind, geothermal, solar, biomass and waste, and not accounting for cross-border electricity supply. It was converted on the basis of thermal equivalence assuming 38% conversion efficiency in a thermal power station. The source of information for the values of this indicator was also the BP Statistical Review of World Energy.

X_4 - Export of goods. Exports are goods and services made domestically and purchased by foreigners. This indicator shows the economic development of the country and its foreign trade capacity. The indicator is important to consider when studying the opportunities for economic relations.

X_5 - Ease of doing business score is an indicator calculated according to the methodology of the World Bank ("Doing Business", 2019). A high ease of doing business ranking means the regulatory environment is more conducive to the starting and operation of a local firm. The rankings are determined by sorting the aggregate scores on 10 topics, each consisting of several indicators, giving equal weight to each topic. Consequently, it determines the country's ability to launch joint projects for the development of renewable energy.

X_6 - The Corruption Impact Index was determined by us according to the formula: 100 - Corruption Perceptions Index in order to take this index as a destimulator. The Corruption Perceptions Index ("Corruption Perception Index", 2018) is an annual ranking of countries of the world compiled by Transparency International. The minimum score (0 points) means that corruption actually replaces the state, the maximum (100 points) indicates that corruption is almost absent in society. Since it was more convenient for us to use reverse values within the applied technique, we determined the reverse index.

X_7 - Inflation, GDP deflator (annual %).

X_8 - Total renewable energy capacity is the whole energy capacity of all sources that do not deplete or can be replenished within a human's lifetime in the country.

X_9 - Wind and solar energy capacity shows the available capacity of the studied countries in the priority areas of renewable energy, which were also selected by us during the study.

X_{10} - External long-term debt stocks is debt owed to non-residents repayable in currency, goods, or services. Total external debt is the sum of public, publicly guaranteed, and private nonguaranteed long-term debt, use of IMF credit, and short-term debt. Thus, this indicator negatively affects the financial capacity of the country and its investment attractiveness, which, taken together, has a negative impact on the possibility of economic relations in the field of renewable energy.

X_{11} - Fragile States Index is an index designed to assess the inability of the authorities to control the integrity of the territory, as well as the demographic, political and economic situation in the country. Of course, an increase in this indicator has a negative influence on the opportunities for international cooperation and the development of renewable energy.

These indicators became the basis for the construction of a taxonomic index according to Plyuta's methodology, which, together with the first and second stages of our research, allowed us to comprehensively analyze opportunities for economic relations in the field of renewable energy of the countries under study and provide recommendations for further cooperation.

A detailed procedure for calculating the taxonomic indicator of the possibility of developing economic relations in the field of renewable energy for Ukraine and Turkey is described below. According to the methodology, a matrix of initial data was first formed to study the possibility of developing cooperation in the field of renewable energy. The initial data included 11 indicators, which are described above. The next step was to standardize the values of the matrix of the studied indicators. This is necessary to reduce the values of the indicators with different units of measurement to dimensionless quantities. The following formula was used to standardize the values:

$$Z_{rei} = \frac{X_{rei}}{\overline{X}re} \qquad (1)$$

where: X_{rei} is the value of the i-th indicator, which affects the development of cooperation in the field of renewable energy; $\overline{X}_{re}$ is the average value for each indicator for 7 studied years.

Further, the standardized indicators of the possibility of developing cooperation in the field of renewable energy between Turkey and Ukraine were transformed into a matrix of 11×7 (rows of the matrix correspond to the factors of influence and columns show years - j) separately for both countries, receiving a total of two matrices. The matrices are presented in table 2.

Next, in accordance with this methodology, among the proposed indicators we identified (positive impact) stimulators and (negative impact) destimulators on the potential for cooperation in the field of renewable energy for both countries.

The division of indicators into stimulators and destimulators is the basis for constructing a vector standard. The coordinates of this vector were calculated by the formula:

$$\begin{cases} Z_{0rei} = \max Zreij \text{ (stimulator)} \\ Z_{0rei} = \min Zreij \text{ (destimulator)} \end{cases} \qquad (2)$$

where: Z_{reij} is a standardized value of the *i*-th indicator in the *j*-th year; Z_{0rei} is a standardized value of the *i*-th indicator in the standard.

In this case, The vector-standard has the following form:

$$Z_{0rei} = (+;\ +;\ +;\ +;\ +;\ +;\ -\ ;\ -;\ +;\ -;\ -), \qquad (3)$$

That is, the indicators $X_1 X_2 X_3 X_4 X_5 X_6$ are stimulators (+), $X_7 X_8 X_9 X_{10} X_{11}$ are destimulators (-).

The next step in implementing the methodology was to form a matrix of distances, which later helped to determine the opportunity for cooperation in the field of renewable energy in each year under study. The element of the matrix F_{reij} is a multidimensional Euclidean distance (quasi-distance) between individual observations and the vector standard for each individual indicator of the possibility of developing cooperation in the field of renewable energy, which was determined by the formula:

$$F_{reij} = (Z_{reij} - Z_{0rei})^2 \qquad (4)$$

The matrix is as follows:

$$F_{re} = \begin{vmatrix} F_{re11} & F_{re12} & \dots & F_{re1j} \\ F_{re21} & F_{re22} & \dots & F_{re2j} \\ F_{rei1} & F_{rei2} & \dots & F_{reij} \end{vmatrix} \qquad (5)$$

Thus, in each year under study, an integrated taxonomic indicator of the level of the possibility for developing cooperation in the field of renewable energy was determined in the following sequence:

1) the distance vector was determined: $F_{rei0} = (F_{re10}, F_{re20} \dots F_{ren0})$, which is the basis for calculating the taxonomic index, according to the formula:

$$F_{rei0} = \sqrt{\sum_{i=1}^{n} \left(z_{reij} - z_{0rei}\right)^2} \qquad (6)$$

2) the arithmetic mean of the distances between the standardized indicators in the *i*-th period and in the standard was calculated:

$$\overline{F_{re0}} = \frac{\sum_{i=1}^{n} F_{rei0}}{n} \qquad (7)$$

3) the mean square deviation of the standard point was defined:

$$\sigma_0 = \sqrt{\frac{\sum_{i}^{n} (F_{rei0} - \overline{F_{re0}})^2}{n}} \qquad (8)$$

4) the quality indicator of the functioning object under study in the *j*-th period was calculated:

$$F_{re0} = \overline{F_{re0}} + 2\sigma_0 \qquad (9)$$

5) the integrated taxonomic indicator of the possibility of cooperation in the field of renewable energy was calculated:

$$IT_{re} = 1 - \frac{F_{rei0}}{Fre0} \qquad (10)$$

7. Taxonomic Analysis of the Potential for the Development of Cooperation in the Field of Renewable Energy

Within the study of opportunities for cooperation and economic relations in the field of renewable energy between Turkey and Ukraine, it is advisable to conduct a comprehensive (multifactor) analysis of the potential for cooperation in the field of renewable energy. As the partnership between Turkey and Ukraine is bilateral, the same set of factors was analyzed separately for Turkey and Ukraine. This is important for comparing the potential of both countries in order to achieve common goals in the future. Thus, the method of taxonomy was the basis for a comprehensive analysis of the potential for the development of cooperation in the field of renewable energy.

To analyze the potential for cooperation in the field of renewable energy, we selected such indicators as: GDP per capita (PPP), Consumption of Primary energy, Renewables consumption, Exports of goods from the country, Ease of doing business score, The Corruption Impact Index (100-Corruption Perceptions Index), Inflation, Total renewable energy capacity, External long-term debt stocks, Fragile States Index. Among these indicators, there are both stimulators and destimulators of the development of the economy and the field of renewable energy. Economic indicators from this list characterize the country's economic growth and its investment attractiveness.

Input data for both surveyed countries concerning economic relations and cooperation in the field of renewable energy are presented in Table 1.

Table 1: The data for analyzing the possibility of developing cooperation in the field of renewable energy between Turkey and Ukraine

The name of an indicator, X_i	Ukraine							Turkey						
	2012	2013	2014	2015	2016	2017	2018	2012	2013	2014	2015	2016	2017	2018
GDP per capita, PPP, current international, thousand US dollars	8	9	9	8	8	9	9	21	22	24	26	26	28	28
Consumption of primary energy, Million tonnes oil equivalent	123,1	117,3	103,2	85,7	89,8	83,4	84	122,3	121,5	125,4	137,2	144,6	152,7	153,5
Renewables consumption, Million tonnes oil equivalent	0,2	0,3	0,4	0,4	0,4	0,4	0,6	1,7	2,2	2,7	3,7	5,2	6,6	8,5
Export of goods, billion US dollars	68,8	63,3	53,9	38,1	36,4	43,3	47,3	152,5	151,8	157,6	143,8	142,5	157,0	167,9
Wind and solar energy CAP (MW)	620	1110	1333	1355	1481	1753	2624	2273	2779	3671	4753	6585	6938	12069

Ease of doing business score	45,5	49,8	60	62,4	64,2	65,4	68,1	65,7	66,8	68,5	68,8	69,1	69,4	70,9
Inflation, GDP deflator (annual %)	7,8	4,3	15,9	38,9	17,1	22,1	15,4	7,4	6,3	7,4	7,8	8,1	10,9	16,4
Corruption Impact Index (calculated per 100 - Corruption Perceptions Index)	74	75	74	73	71	70	68	51	50	55	58	59	60	59
Total renewable energy, CAP (MW)	5241	5769	6048	6105	6199	6530	7454	22186	25551	27940	31516	34446	38746	42215
External debt stocks, long-term (DOD, current, billion US dollars)	88,0	86,0	104,3	96,2	84,7	81,4	77,0	219,5	236,2	258,4	269,4	293,3	306,0	335,0
Fragile States Index	67,2	65,9	67,2	76,3	75,5	74,1	72,6	76,6	75,9	74,1	74,6	77,3	80,8	82,2

In accordance with the taxonomic method described in the work of Plyuta (Plyuta, 1980), comparative multidimensional analysis in economic research methods of taxonomy and factor analysis, which presented eleven indicators, were standardized. The obtained standardized indicators are given in Table 2.

Table 2: Standardized indicators (indicators) of ensuring the development of economic relations in the field of renewable energy in Ukraine

Indices - indicators	Ukraine							Turkey						
	Z2012	Z2013	Z2014	Z2015	Z2016	Z2017	Z2018	Z2012	Z2013	Z2014	Z2015	Z2016	Z2017	Z2018
X1	0,99	1,01	1,02	0,93	0,97	1,01	1,08	0,83	0,89	0,96	1,03	1,05	1,12	1,13
X2	1,26	1,20	1,05	0,87	0,92	0,85	0,86	0,89	0,89	0,92	1,00	1,06	1,12	1,12
X3	0,52	0,78	1,04	1,04	1,04	1,04	1,56	0,39	0,50	0,62	0,85	1,19	1,51	1,94
X 4	1,37	1,26	1,07	0,76	0,72	0,86	0,94	0,99	0,99	1,03	0,94	0,93	1,02	1,10
X 5	0,42	0,76	0,91	0,92	1,01	1,19	1,79	0,41	0,50	0,66	0,85	1,18	1,24	2,16
X 6	0,77	0,84	1,01	1,05	1,08	1,10	1,15	0,96	0,98	1,00	1,01	1,01	1,01	1,04
X 7	0,45	0,25	0,92	2,24	0,99	1,27	0,89	0,81	0,69	0,81	0,85	0,88	1,19	1,79
X 8	1,03	1,04	1,03	1,01	0,98	0,97	0,94	0,91	0,89	0,98	1,04	1,05	1,07	1,05
X 9	0,85	0,93	0,98	0,99	1,00	1,05	1,20	0,70	0,80	0,88	0,99	1,08	1,22	1,33
X 10	1,00	0,97	1,18	1,09	0,96	0,92	0,87	0,80	0,86	0,94	0,98	1,07	1,12	1,22
X 11	0,94	0,92	0,94	1,07	1,06	1,04	1,02	0,99	0,98	0,96	0,96	1,00	1,04	1,06

Source: calculated by the authors

Next, in accordance with this methodology, among the proposed indicators, we identified stimulators (positive impact) and destimulators (negative impact) on the potential for cooperation in the field of renewable energy for both countries.

The division of indicators into stimulators and destimulators is the basis for constructing a vector standard. The coordinates of this vector were calculated by the formula presented in the methodology section.

The results of the division and the value of the vector standard are presented in Table 3.

Table 3: The division of the studied indicators into stimulators and destimulators

Index (indicator) of the potential for cooperation in the field of renewable energy	Stimulator or destimulator	Value max/min
X1	Stimulator	max
X2	Stimulator	max
X3	Stimulator	max
X4	Stimulator	max
X5	Stimulator	max
X6	Stimulator	max
X7	Destimulator	min
X8	Destimulator	min
X9	Stimulator	max
X10	Destimulator	min
X 11	Destimulator	min

Next, according to the data, we formed vector-standards for the development of cooperation in the field of renewable energy for Ukraine and Turkey:

Z_{0re}Ukraine = (1.08; 1.26; 1.56; 1.37; 3.30; 1.15; 0.25; 0.94; 1.20; 0.87; 0,92),
Z_{0re}Turkey = (1.13; 1.12; 1.94; 1.10; 2.16; 1.04; 0.69; 0.89; 1.33; 0.80; 0,96).

Then, according to the methodology (Plyuta, 1980), we calculated the distances between individual observations (periods) and the vector standard as well as the taxonomic indicator of the possibility of cooperation in the field of renewable energy for the selected years of the study. The results of the calculations are presented in Fig. 5.

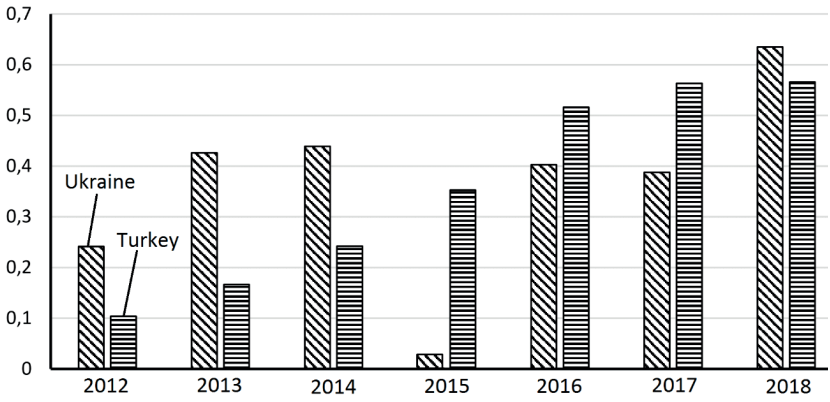

Figure 5. The results of modelling the taxonomic indicator of the possibility of developing economic relations in the field of renewable energy for Ukraine and Turkey
Source: Designed by the authors

The analysis of the values of the taxonomic indicator representing the possibility of developing economic relations in the field of renewable energy shows that in Turkey, there is a gradual stable growth of this indicator during 2012 - 2018. The lower value of this indicator is conditioned by an increase in the values of indicators-destimulators and/or a decrease in the values of indicators-stimulators. In Ukraine, however, there is some inconsistency of the values of the indicator during this period.

First of all, this is due to the transformation processes in the country's environment and the growing importance of destimulators in recent years. Thus, in 2015, the level of the indicator was less than 0.1, which is a critical value. The main cause of this is the large amount of financial, material and human losses of Ukraine as a result of the Russian military aggression and the illegal occupation of the territories of Ukraine. This destabilised the situation in the country as a whole, and inflation reached 38.9%. However, in 2018, the taxonomic indicator of the possibility of developing economic relations in the field of renewable energy for Ukraine was 0.63; for Turkey, it was 0.57. This is positive dynamics in the context of shifts in the field of renewable energy and additional opportunities that can be used. That is why, given Turkey's experience in building a relatively large amount of energy-generating capacity based on wind and solar energy, the growing favorable investment climate of Ukraine and the attraction of human capital from both countries, it is important to initiate and develop joint projects that will help to achieve a synergy effect due to cooperation between both countries.

In our opinion, another factor that can be taken into account, when analyzing the prospects of renewable energy, is the indicator Consumption of Nuclear energy. After all, the development of nuclear energy may slow down the development of renewable energy as an alternative technology. In Ukraine, in 2019, nuclear power plants produced the main share of electricity – more than 53% in the structure of electricity production from various generation sources. Since the same indicators were used to compare the potential, and there is currently no nuclear energy consumption in Turkey, this indicator was not taken into account. However, based on the fact that Turkey's first nuclear power plant, at Akkuyu, commenced construction in 2018, and that one unit of the planned four has a capacity of 1300 MW, we can predict that the maximum annual electricity production by one unit

of the nuclear power plant will be equivalent to 1 million tons of oil. Hence, we can consider this figure in further studies of the taxonomic indicator of opportunities for the development of economic relations in the field of renewable energy. Of course, this assumption can be made in order to obtain an appropriate indicator concerning the nuclear component when calculating the potential with the aim of taking into account the potential of nuclear energy (as a planned output) in the country's development and cooperation between the countries in the area under study.

8. Conclusion

The opportunities of Turkey and Ukraine in the sphere of developing cooperation are considerable. It should be noted that the long-standing cooperation of these countries has laid a basis for the development of the existing fields, which have been analyzed above. The fundamental principles of ensuring the development of economic relations in the field of renewable energy between Ukraine and the Republic of Turkey have already been largely agreed to at the interstate level and legally approved. The identified favorable factors for the development of cooperation in general and in the field of renewable energy make it possible to further develop this field with mutual benefit. Taking into account the growing demand for electric vehicles and clean energy, the infrastructure for electric transport has been identified as a possible area for cooperation in the context of providing charging stations with wind and solar energy. The growth rates of wind and solar power in Turkey and Ukraine have been compared. For instance, the actual wind power capacity in Turkey in 2018 was 7,005 MW, which is 11 times more than in Ukraine – 621 MW. The gap between the indicators of the determined capacity of solar power - 5,064 MW in Turkey and 2,003 MW in Ukraine is only 2.5 times narrower. This indicates that Ukraine should take into account Turkey's experience in the development of renewable energy. The examples of successful cooperation between Ukraine and Turkey in the field of energy, including the construction of solar power plants in Ukraine by the Turkish company EMSOLT, have been given. The conducted analysis confirms the possibility and necessity of promoting cooperation in the field of renewable energy development. Nowadays, for Turkish investors, the new auction systems should be better than the "green" tariff because they help to create conditions for competition between the participants of the RES market, which has to ensure a balance of interests in the market.

In addition, in order to conduct a multifactor analysis of ensuring the possibility of developing economic relations in the field of renewable energy, we used a taxonomic method. Initially, we formed the main indicators that directly or indirectly affect the development of renewable energy, the economy as a whole and the investment attractiveness of the studied countries. After that, taking into account the values of these indicators in the dynamics, the taxonomic indicator was modelled separately in Ukraine and Turkey for 2012 - 2018 and its main trends were analyzed.

To ensure effective cooperation between Turkey and Ukraine in the field of renewable energy, it is important to implement and support the main policy instruments for renewable energy, namely: the introduction of "green" auctions, which ensures transparency of procedures and reduces the price of renewable energy; Public Procurement; the application of various price instruments; providing Quantity instruments, which means market-based instruments that define a specific target or absolute quantity for renewable energy production; the development of new and improvement to the existing Regulations and Standards; the development of joint scientific, training and investment projects in the field of renewable energy between Turkey and Ukraine.

Unlike existing research, the conducted study allowed us to comprehensively assess the potential for cooperation and economic development of the countries in order to initiate its use and

development, to evaluate the level of current developments in the direction of forging a strategic partnership and to explore the impact of stimulators and destimulators on the potential opportunities of both countries. At the same time, the similarity of this study to the existing ones consists in the use of universal methodological tools for the analysis of specific goals of implementing the principles of cooperation.

The advantages of this study are the application of a comprehensive approach to determining the opportunities for cooperation in the field of renewable energy because some indicators show the development of the economy, some indicate the political component, while others indicate the field of renewable energy, which together provide the prerequisites for successful international cooperation in the field of renewable energy.

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