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## RENEWABLE ENERGY SOURCES IMPACT ON ECONOMIC GROWTH: INTERNATIONAL PRACTICES

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Energy is an indispensable source of power for economic development. Mainstream research has concluded that energy can be divided into two types: renewable and non-renewable. Research analyzing the impact of non-renewable energy on economic development is very comprehensive. Researchers dispute the association between expanding the usage of renewable energy sources and stimulating the economy. They investigated the connection between economic growth and energy use in developing countries. The paper assesses the impact of the energy transition to renewable energy sources driving the economic growth of countries. It has been established that positive transformations in economies can be seen both developed and emerging economies. It has been proved that economic growth, once the national energy becomes autonomous (examples of Iceland, Uruguay), ensures the economy protection from external fluctuations in energy prices and guarantees electricity generation at prices lower than those set for the energy produced from fossil sources. The paper shows that freedom from additional financial burden for businesses is a critical precondition for the stable development of the economy during the energy transition period. It is indicated in the paper that if the state cannot carry out such a transition on its own, there are good reasons to engage large businesses and other participants in this process on favourable contractual terms. It has been found that such actions will promote increased investments in the development of renewable power generation in the country. The paper studies the main opportunities for economic growth resulting from the energy transition, including price advantages for power generation (prices for electricity produced using alternative sources are cheaper than those for electricity produced from fossil sources), driving the entrepreneurial activity, as well as the possibility of exporting energy produced from renewable source. The scientific novelty of our research is in the development of the question of the energy impact transition on the economic growth of countries with different financial, economic and energy potential, through the establishment of specific characteristics of this process, which can contribute to the modeling of its implementation at the level of other states, including Ukraine.

**Keywords:** energy transition, renewable power generation, economic growth, fossil energy resources, wind energy, solar energy, hydropower, geothermal energy.

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**Introduction and formulation of the problem**

Energy security is the basis for the smooth functioning of the economy of any country, and it became particularly pressing in the first decades of the XXI century, when it became obvious that the world’s reserves of fossil resources used for the production of electricity, fuel, and heat energy were exhausted. Accordingly, each country faced the need at the international level to ensure an effective energy transition to alternative, so-called renewable energy resources. Moreover, the issue of a rapid transition to renewable energy is conditioned by the need to protect the climate from harmful CO2 emissions in the production of electricity and fuels from traditional sources, and in the use thereof [4].

The development of the economy requires proper supply of energy resources, while in modern markets, businesses can independently choose energy suppliers or, with an appropriate potential, generate it independently. An important aspect of the energy transition to renewable energy is to determine its impact on economic growth. Given the urgency of this issue, the chosen topic is relevant.

**Analysis and research of publications**

The issue of the energy transition to renewable energy sources is covered in the research papers by: L. Neik, A. Sherp, J. Jewell [4], F. Zhao, V. Bai, K. Liu, Z. Liu [7], F. Z. AINU, M. Ali, M. Sadiq [1], E. Tverionaitė, A. D. Sebursdottir, R. Olafsdottir, C. M. Hall [6], C. K. Correa, M. Uriona-Maldonado, C. R. Vaz [2] etc. Despite the availability of certain scientific researches, there is a need to define the problem in the context of a comprehensive study.

**Purpose of the article**

The purpose of the paper is to substantiate the relation between the impact of renewable energy

sources on economic growth in terms of the specifics of best international practices. To achieve this goal, a number of tasks have been set, in particular: to determine the level of dependency of changes in the economic development of countries on the effect of renewable energy implementation; to characterize the features of the impact under study.

**Presentation of the main material**

The study of the energy transition impact on the economic development involves assessing parametric indicators and defining the specific features of this impact.

Let us conduct a study of the fact of dependency of this category.

To do it, we need to choose the countries the practices of which will be studied in the context of ensuring the renewable energy introduction. These are, in particular, the countries that demonstrate global leadership in this field or have declared favourable prospects in this area (Table). Among those Germany, China and Morocco can be named. In addition to determining the level of use of renewable energy as part of the total amount of energy resources used, the GDP dynamics for these countries will be determined.

The provisions of the UN Sustainable Development Goals (SDGs) stipulate that achieving 50% renewable power generation is the greatest possible goal for the countries carrying out the energy transition [5]. This benchmark is specified within the framework of the UN SDGs7. Analysing the data in Table 1, it can be stated that at the end of 2022, three countries reached a certain extremely high limit, in particular: Iceland (an increase from 88.7% in 2020 to 88.92% in 2022), Uruguay (an increase from 60.5% in 2020 to 63.35% in 2022), Costa Rica (an increase from 50.4% in 2020 to 50.5%

**The level of renewable energy implementation within the total use of energy resources and GDP of countries**

Item No.	Country	% of renewable energy in the total energy resources utilisation			GDP, billion USD		
		2020	2021	2022	2020	2021	2022
1	Iceland	88.7	90.14	88.92	21.7	25.6	27.7
2	Uruguay	60.5	62	63.35	53.7	59.29	71.16
3	Costa Rica	50.4	50.46	50.5	62.16	64.28	68.5
4	Norway	47.1	54.59	47.59	362.2	482.18	504.7
5	New Zealand	41.8	41.84	40.39	211.7	250	256.75
6	Sweden	40	40	40.07	547.05	635.66	603.92
7	Denmark	33.2	36.93	35.81	355.22	398.3	386.72
8	Germany	14.1	14.63	15.02	3.890	4.260	4.328
9	China	8.9	9.2	9.67	14.690	17.730	18.208
10	Morocco	8.8	9.2	9.42	121.35	142.87	145.15

Source: [3;5;8]

in 2022). We note that Norway is approaching this goal (a rise from 47.1% in 2020 to 47.59% in 2022). High values were also attained by such countries as: New Zealand, Sweden (within 40%); Denmark (an increase from 33.2% in 2020 to 35.81% in 2022).

Germany is distinguished by a stable growth of this indicator (from 14.1% in 2020, 14.63% in 2021, 15.02% in 2022). It has been found that the government of O. Scholz, during the first days of office suggested the largest reform of energy policy in the last decade. Namely, according to program estimations, by 2030 Germany will transfer to 80% use of renewable energy, and by 2035 – to 100% [8].

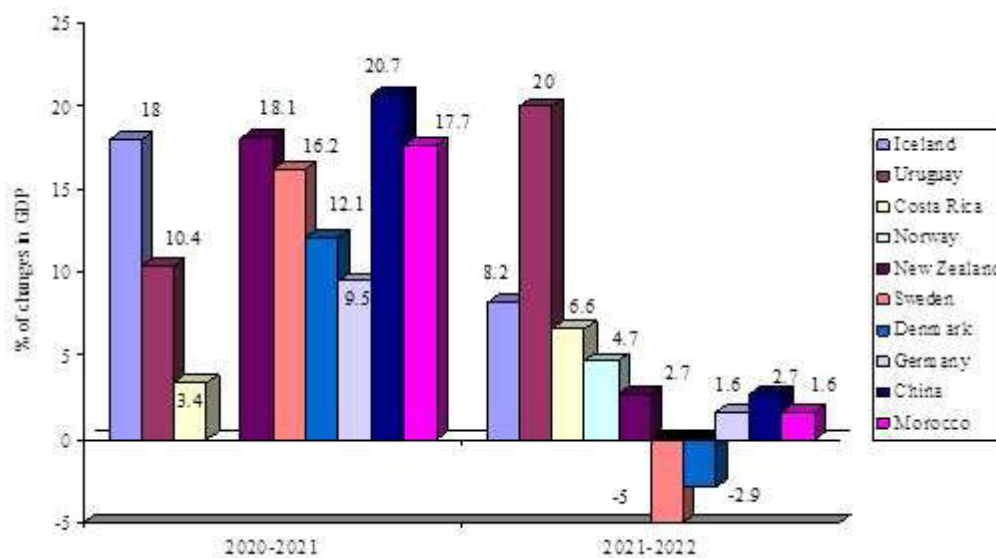
With regard to China, we can also note a certain increase in the level of energy transition (in 2020, this figure was 8.9%, in 2021 – 9.2%, in 2022 – 9.67%). The country is accountable for the world's largest amount of CO<sub>2</sub> emissions into the atmosphere, which is due to the scale of development of energy-intensive enterprises, the large population, whose daily living activities create a great burden on the energy system and the environment. At the same time, at the state level, it is declared that by 2025 the country will reach 1/3 of the production of energy resources from renewable sources (solar and wind energy). Analysis of scientific and statistical data (F. Zhao, V. Bai, K. Liu, Z. Liu [7]) allows us to note that the reserves of renewable energy in China are quite abundant. Wind energy and photovoltaic (solar) energy have the greatest potential for development. It is expected that soon they will outpace hydropower and will become the main source

of renewable energy. In terms of geographical distribution, there is a huge regional imbalance in the use of renewable energy sources in the country. It has been established that Western China with its huge renewable resources is the main centre of their production, however Eastern China accounts for most of the energy consumption (mainly non-renewable sources are used).

Morocco, like China, shows a slight but steady increase in the use of renewable energy (from 8.8% in 2020, 9.2% in 2021, to 9.42% in 2022) (Table). According to the findings of the study (F. Z. Ainu, M. Ali, M. Sadiq [1]), Morocco is an energy deficit country that needs almost 94% of energy imports to power up its growing economy. Due to the rapid growth of Morocco's population, energy consumption is estimated to increase significantly, which will intensify the pressure on the energy system. The issues related to resource scarcity, fluctuating energy prices and environmental concerns have made energy security a top priority. Thus, in 2009, the Moroccan government created and proclaimed the National Energy Strategy (NES), aimed at reaching 42% of renewable generation by 2020, which was updated to 52% by 2050. In fact, in 2020, the declared figures were not achieved, however steps were taken to accelerate the energy transition.

Figure shows variations in GDP of these countries for 2020–2022.

Analysis of statistical data (Figure) illustrate that most of the countries under study show GDP growth. This applies both to the countries with a high level of energy transition and those with its



Dynamics of changes in the GDP of the countries for 2020-2022

Source: [3]

stable, but insignificant increase.

It has been established that the most positive changes were achieved in Iceland (GDP growth in 2020-2021 by 18%, in 2021-2022 – by 8.2%), Uruguay (an increase in 2020-2021 by 10.4%, in 2021-2022 – by 20%). Some states showed significant upgrade in 2020-2021, particularly, Norway (33.1%), New Zealand (18.1%), Sweden (16.2%), Denmark (12.1%), China (20.7%).

It is necessary to note the specific features of the impact of the energy transition on economic growth in individual countries studied above.

Researchers (E. Tverionaitė, A. D. Sebursdottir, R. Olafsdottir, C. M. Hall [6]) state that Iceland is one of the leading countries producing electricity from renewable sources per capita. As the analytical data show, almost 100% of the electricity produced in the country in 2020 was received from renewable sources, with 68.8% coming from hydropower and 31.2% from geothermal energy [6]. More than 80% of all energy consumed in Iceland's main economy sectors, the housing and utilities sector, is renewable energy. The country's dependence on renewable energy sources is likely to increase even further in the future. This is confirmed by the fact that Iceland's Climate Action Plan suggests solving the problem of a low percent of renewable energy in the transport sector by promoting the purchase and use of electric vehicles and other vehicles running on emission-free energy. Iceland has been using hydro and geothermal energy for several decades, and numerous wind farm proposals were considered in 2022. The specified characteristics of renewable energy introduction into the business activities illustrated that business in the process of energy transition had no financial burden due to the commissioning of new facilities (geothermal and hydroelectric power plants) that produce electricity. The transition to a nearly autonomous supply of energy resources has become the key to the smooth operation of businesses, increasing income from the activities of service companies (tourism, hotel and restaurant business). Given the fact that electricity generated from renewable energy sources had a lower cost, while overall production of exported products increased. In general, these transformations in the energy market led to the stabilization of the country's economy.

It is worth noting the positive transformations in the economic development of Uruguay associated with the effects of the energy transition. Analysis of scientific materials (K. K. Correa, M. Uriona-

Maldonado, K. R. Vaz [2]) showed that within 20 years, Uruguay has transformed from a country dependent on hydro and thermal energy into one of the world leaders in the wind power industry, including a huge excess of capacity, which allows exporting energy to neighbouring countries. Due to the stable export of electricity produced by wind turbines, the country ensures GDP growth, which allows securing the state of economy even during the global energy and financial crisis.

### **Conclusions**

As part of the study, the impact of the energy transition to renewable energy sources on the economic growth of countries has been proved. It has been established that positive transformations in economies can be characteristic of both developed and emerging economies. It can be stated that economic growth, once the national energy autonomy is established (examples of Iceland, Uruguay), ensures the economy protection from external fluctuations in energy prices and guarantees electricity generation at prices lower than those set for energy produced from fossil sources. Freedom from additional financial burden for businesses is a critical precondition for the stable development of the economy during the energy transition period. Accordingly, if the state cannot carry out such a transition on its own, there are good reasons to engage large businesses and other participants in this process on favourable contractual terms. Such actions will promote increased investments in the development of renewable power generation in the country. The paper specifies the main opportunities for economic growth resulting from the energy transition, including price advantages for power generation, driving the entrepreneurial activity, as well as the possibility of exporting energy produced from renewable sources.

The scientific novelty of our research is in the development of the question of the energy impact transition on the economic growth of countries with different financial, economic and energy potential, through the establishment of specific characteristics of this process, which can contribute to the modeling of its implementation at the level of other states, including Ukraine.

The question of forecasting the effect of the introduction of renewable energy, in our opinion, can become a relevant direction of further scientific research. The issue of the estimating effect of the renewable energy introduction can become a topical area of further scientific researches.

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## ВПЛИВ ВІДНОВЛЮВАНИХ ДЖЕРЕЛ ЕНЕРГІЇ НА ЕКОНОМІЧНЕ ЗРОСТАННЯ: ЗАРУБІЖНИЙ ДОСВІД

**Божанова Вікторія, Кононова Олександра, Доду-Савка Кароліна, Доду-Гугея Ларіса, Чернишева Олена**

Енергія є незамінним джерелом потужності для економічного розвитку. Основні дослідження дійшли висновку, що енергію можна розділити на два види: відновлювану та невідновлювану. Наукові роботи, що аналізують вплив невідновлюваної енергії на економічний розвиток, є дуже всеосяжними. Існує достатньо досліджень, де науковці мають розбіжності у поглядах на зв'язок між розширенням використання відновлюваних джерел енергії та стимулюванням економіки. Вони досліджували зв'язок між економічним зростанням і використанням енергії в країнах, що розвиваються. В статті визначено вплив енергетичного переходу до відновлюваних джерел енергетики на забезпечення економічного зростання країн. Встановлено, що позитивні економічні перетворення можуть бути характерні як для розвинених економік, так і для економік, що розвиваються. Доведено, що економічне зростання у випадках створення національної енергетичної автономності (приклади Ісландії, Уругваю) сприяє захисту економіки від зовнішніх коливань цін на енергоносії, дає гарантії отримувати електроенергію за цінами, дешевше тих, які встановлюються на енергію, вироблену із викопних джерел. Показано, що важливою умовою стабільного розвитку економіки під час енергетичного переходу до відновлюваної енергетики є відсутність додаткового фінансового тягаря для підприємництва. Вказано, що якщо держава не може самостійно реалізувати такий перехід є сенс залучення до вказаного процесу крупного бізнесу, інших учасників на вигідних контрактних умовах. Визначено, що вказане сприятиме росту інвестиційних потоків у розвиток відновлюваної енергетики в країні. Вивчено основні можливості економічного зростання від енергетичного переходу, серед яких, цінні переваги на енергетику (ціни на електроенергію, вироблену завдяки використанню альтернативних джерел дешевше тих, які встановлюються на електроенергію, вироблену із викопних джерел), які сприяють активізації підприємницької діяльності та можливість експорту енергії, виробленої за рахунок відновлюваних джерел. Наукова новизна дослідження полягає в розробці питання впливу енергетичного переходу на економічне зростання країн з різним фінансово-економічним та енергетичним потенціалом через встановлення специфічних характеристик цього процесу, що може сприяти моделюванню його впровадження на рівні інших держав, у тому числі України.

**Ключові слова:** енергетичний перехід, відновлювана енергетика, економічне зростання, викопні енергетичні ресурси, вітрова енергетика, сонячна енергетика, гідроенергія, геотермальна енергія.

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