International economic relations

UDC 620.92(4)

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FEATURES OF THE FUNCTIONING THE ALTERNATIVE ENERGY MARKET WITHIN EUROPEAN COUNTRIES
ОСОБЛИВОСТІ ФУНКЦІОНУВАННЯ РИНКУ АЛЬТЕРНАТИВНОЇ ЕНЕРГЕТИКИ У МЕЖАХ КРАЇН ЄВРОПИ

Summary. *The purpose of the scientific research is to study the growth potential of alternative energy in European countries and to determine the prospects of Ukraine's development vectors.*

The policy of greening in European countries was considered, the main directions, methods and level of efficiency of the functioning of facilities using alternative energy were determined.

Econometric equations were developed: the first equation characterizes the influence of factors related to the European concept of greening the economy, namely, the driving forces for the growth of energy consumption from alternative sources are the reduction of emissions and natural gas consumption;

the second equation, based on econometric modeling, consists in the study of the dependence of alternative consumption in the selected countries on GDP, the unemployment rate and the price of natural gas (currently and for the two previous years).

The main problems and reasons for the introduction of green energy in Europe have been identified. Ways of introducing alternative energy in Ukraine have been determined, taking into account the current situation and the state of war.

The results of the conducted research on the formation and implementation of environmental policy in the conditions of increasing need for economic and energy security of European countries will help the government of Ukraine to implement the policy of greening, taking into account the experience and results of the studied countries.

The obtained data can be used in their research by other governmental and non-governmental organizations and institutions.

Key words: *alternative energy, renewable energy sources, energy system, traditional sources, GDP, natural gas, carbon dioxide, unemployment rate.*

Анотація. *Метою наукового дослідження є вивчити потенціал зростання альтернативної енергетики в Європі країн та визначити перспективи векторів розвитку України.*

В статті розглянуто політику екологізації в країнах Європи, визначено основні напрямки, методи та рівень ефективності функціонування потужностей з використанням альтернативної енергетики.

Розроблено економетричні рівняння: перше рівняння характеризує вплив чинників пов'язаних з Європейською концепцією екологізації економіки, а саме рушійними силами зростання споживання енергії з альтернативних джерел є зменшення викидів та споживання природного

газу; друге рівняння на основі економетричного моделювання, полягає в дослідженні залежності споживання альтернативної в обраних країнах від ВВП, рівня безробіття та ціни на природний газ (поточного та за два попередніх роки).

Визначено напрями розвитку альтернативної енергетики у досліджуваних країн: Великобританії. Данії, Швеції, Німеччини, Фінляндії, Ісландії.

Проаналізовано напрямок України в енергетичній сфері до воєнного стануа основні шляхи до енергетичної безпеки України в умовах війни та можливі напрямки втілення еокологічної політики після закінчення війни.

Ключові слова: *альтернативна енергетика, відновлювальні джерела енергії, енергетична система, традиційні джерела, ВВП, природний газ, діоксид вуглецю, рівень безробіття.*

Statment of the problem. The provision of energy resources is one of the key problems of modernity. The functioning of the economic system is impossible without it use of energy resources. To date, the most in demand energy sources are natural gas and oil. Oil (its heavy fractions (fuel oil)) is widely used as fuel. However, there are two main reasons that deny a hundred percent prospect of this species The first, and it is obvious, oil cannot be included in the series ecologically clean sources of energy. The second is oil reserves (including reserves which remain unexplored) are quite limited. Gas is also widely distributed throughout the world. Its reserves are sufficient large but, like crude oil, limited.

According to scientists, these resources, under the condition of active use, will be enough for only 50 years. In addition, they have a destructive effect on the environment, the consequences of which we have already seen today.

Consequently, the current issue for all European countries, in particular for Ukraine, is the prospects for the development of the energy system based on

the use of renewable energy sources, whereas, according to energy monitoring data, such sources cause less damage to the environment and have great prospects in the near future.

So, all over the world, in Europe in particular, the number of institutions that produce energy from renewable sources and investors who understand that alternative energy is the future is increasing every year.

The most developed European countries, such as Iceland, Sweden, Finland, Latvia, Great Britain, produce 40 percent or more of energy from alternative sources. Such a trend is understandable and predictable, because if earlier people thought only about the damage to the environment, the exhaustion of traditional energy sources, now alternative energy has a strategic importance for energy security and national independence of the country in the global political and economic systems.

During a full-scale war, Europe is speeding up the process of transition to alternative energy, therefore, in the near future, non-traditional energy has prospects to completely force out traditional energy.

Key words: alternative energy, renewable energy sources, energy system, traditional sources, Gross domestic product, natural gas, carbon dioxide, unemployment rate.

Analysis of recent research and publications. Forms of development of the energy sphere, substantiation of cyclicality in attention was given to energy in the works of V.L. Nekrasova, V.V. Bushueva, V.A. Kalamanov. The statistical basis of the study is the Organization's databases of economic cooperation and development, International Energy agencies, Theoretical and methodological foundations and current issues of energy security of Ukraine were reflected in the works of well-known Ukrainians scientists: V. Barannik, Z. Varnaliya, A. Galchynsky, V. Heits, M. Zemlany, M. Kovalka, L. Krivorutskyi, V. Lira, R. Podoltsia, Yu. Rudenko, V. Saprykina, B. Groaning.

Formulation purpose of article (problem). The purpose of the article is to study the growth potential of alternative energy in European countries and to determine the prospects of development vectors for Ukraine.

The main material. The EU reached 22,1% of gross final energy consumption from renewable sources in 2020, which is about 2 percentage points higher than planned. This goal is distributed among the EU member states with national action plans designed to determine the path of development of renewable energy in each of the member states [1; 2].

Among the leaders in the development of renewable energy sources: Sweden (60%) had the highest share among EU member states in 2020, ahead of Finland (44%) and Latvia (42%). At the opposite end of the scale, the lowest share of renewable energy sources was registered in Malta (11%), followed by Luxembourg (12%) and Belgium (13%) [3; 4].

Among EU member states more than 70% of electricity consumed in 2020 was produced from renewable sources in Austria (78.2%) and Sweden (74.5%). Electricity consumption from renewable sources was also high in Denmark (65.3%), Portugal (58%) and Latvia (53.4%), accounting for more than half of electricity consumption. At the other end of the scale, the share of electricity from renewable sources was 15% or less in Malta (9.5%), Hungary (11.9%), Cyprus (12.0%), Luxembourg (13.9%) and the Czech Republic (14 .8%). Norway and Iceland (EFTA countries) produced more electricity from renewable sources than they consumed in 2020, so the share exceeds 100% [5; 3; 6].

For a more detailed analysis of the direction of alternative energy in European countries the authors took 7 leading countries in the development and implementation of alternative energy, in which the percentage of alternative energy consumption from the total level of energy consumption is 17 and above: Denmark, Finland, Germany, Sweden, Great Britain, Iceland [7].

For analysis, the authors developed and tested two equations. The first equation characterizes the influence of factors related to the European concept of greening the economy, the driving forces of the growth of energy consumption from alternative sources are the reduction of emissions and the consumption of natural gas. This equation is built on the basis of econometric modeling for each individual country, its general form is as follows:

$$\text{alter\_con\_} = b_0 + b_1 CO_2 + b_2 gas\_con\_ + b_3 CO_2(-1) + b_4 CO_3(-2) + b_5 gas\_con\_(-1) + b_6 gas\_con\_(-2) \quad (1),$$

where t – corresponds to each time period; alter_con_ – consumption of alternative energy; CO_(2) – emissions of carbon dioxide; gas_con_ – consumption of natural gas

The interdependence between carbon emissions, gas consumption and alternative energy in the implementation of the greening policy is obvious, but the study uses a two-year reaction lag to demonstrate the existence of the strategy of this policy, because the energy market is very dynamic, taking a larger lag is not very appropriate. The hypothesis of the equation is the existence of a greening policy strategy by demonstrating an inverse relationship between the dependent and non-dependent variables. The results of the study are presented in table 1.

Table 1

Summary table of the interdependence of alternative energy consumption from CO 2 emissions and natural gas consumption in the studied countries according to econometric modeling (based on the first equation)

The name of the country	CO2 emissions	CO2 emissions for the previous year	CO2 emissions for the 2 previous year	Gas consumption	Gas consumption for the previous year	Gas consumption for the 2 previous year
Sweden	-	-	-	-	-	-
Great Britain	-	-0,2129 (-4,36**)	-0,2263 (-5,85**)	-0,6165 (-5,03 **)	-	-
Denmark	-	0,0796 (2,62*)	0,0807 (2,40*)	-	-	- 6,24 (-2,66*)

Finland	-	-	-	-	-	-
Germany	-	-	-	-	-	-

Source: developed by the author (general research results are presented in Add. B)

The t-test is presented in parentheses and the significance of the obtained results is conditionally indicated: the hypothesis can be rejected at the level of statistical significance with a 1% margin of error (*** - 1% (very significant coefficient), **- 5% of error (a significant coefficient), *- 10 % of error (small coefficient)).

The second equation, based on econometric modeling, consists in the study of the dependence of alternative consumption in the selected countries on GDP, the unemployment rate and the price of natural gas (currently and for the two previous years) has the following form:

$$\text{alten\_con} = \alpha_0 + \alpha_1 \text{GDP} + \alpha_3 \text{UNEMP} + \alpha_4 \text{gas\_price} + \alpha_5 \text{gas\_price}(-1) + \alpha_6 \text{gas\_price} \qquad (2),$$

where t – corresponds to each time period; alter_con_ - consumption of alternative energy; GDP – Gross Domestic Product; UNEP - unemployment rate; gas_price - gas price.

GDP_t – GDP of the current year, UNEP_t – unemployment rate of the current year, gas_price_t – gas price of the current year, gas_price_(t-1) – gas price of the past year, gas_price_(t-2) – gas price for two previous years

The influence of GDP, gas prices on the volume of consumption of alternative energy indicates the economic factors of the use of alternative energy, with the aim of increasing economic well-being at the macro and micro levels, that is, if the consumption of alternative energy depends on GDP and inversely depends on gas prices for the previous year and two previous years, and at the same time, the hypothesis put forward in the first equation was not confirmed - the country's use of renewable energy is due exclusively to the decrease in the price of the energy component in the national economy and the reduction of the lack of energy resources for economic growth - this statement was confirmed for Sweden on the basis of research (see table 2.). If there is interdependence between unemployment and the consumption of alternative

energy, the population (households) tends to save due to the use of alternative energy, example of Great Britain (tabl. 2).

Table 2

Summary table of interdependence of alternative energy consumption with GDP, unemployment rate, gas prices over two years in the studied countries according to econometric modeling (based on the second equation)

The name of the country	GDP	Unemployment rate	Gas prices	Gas prices for the previous year	Gas prices for the 2 previous year	Gas consumption for the 2 previous year
Sweden	0,0870 (2.89*)	-	-	-0,0537 (3,72**)	-0,0146 (2,40*)	0,0870 (2.89*)
Great Britain	-	-0,2083 (-5,90***)	-	-	-	-
Denmark	-	-	-	-	-	-
Finland	-	-	0,0783 (3,56**)	-0,0369 (-2,71*)	-	-
Germany	-	-	-	-	-	-

Source: developed by the author (general research results are presented in Add. B)

The t-test is presented in parentheses and the significance of the obtained results is conditionally indicated: the hypothesis can be rejected at the level of statistical significance with a 1% of error (*** - 1% (very significant coefficient), **- 5% of error (a significant coefficient), *- 10 % error (small coefficient)).

Ukraine has sufficient potential in the field of alternative sources of energy. The total capacity of renewable energy sources in Ukraine was 8,516 MW in 2020, which is in 8.8 times more than in 2014 - 967 MW.

Since 2015 solar power plants have had the largest capacities. In 2020 they amounted to 6094 MW, namely 71.5% of the total number of capacities. The increase in solar power plants was 14.5 MW. The second place as of 2020 are wind power plants, the power of which is in 5 times smaller than solar power plants - 1314 MW. Regarding the capacities of MHPs and the use of biogas, the trends are slightly more negative, respectively 117 MW and 103 MW for 2019 [8; 9].

Similar to the econometric modeling that was carried out in the first subsection for European countries, the scientific work tested Ukraine's indicators and developed key conclusions.

During the testing of the indicators of Ukraine according to the first equation (1), the author revealed multicollinearity, namely, the correlation index of CO2 emissions and natural gas consumption is very high (0.99) (Add. D) which indicates a very small share of alternative energy in the country's energy system, to confirm this conclusion, a percentage was calculated the share of alternative energy in total energy consumption (see Fig. 1).

Multicollinearity is the presence of close linear dependence or strong correlation between explanatory variables, which can distort the results of the study and be the basis for non-objective conclusions.

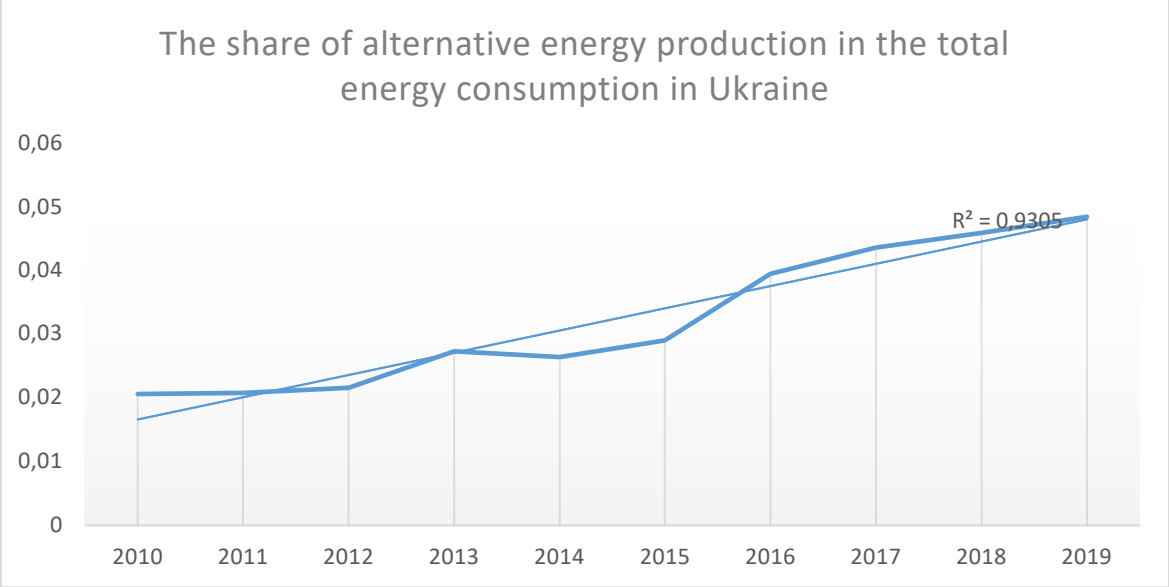

Fig. 1. The share of alternative energy production in the total energy consumption in Ukraine

Source: author's development based on statistical data (Add. A)

A positive, but with a low growth rate, trend of increasing the share of alternative energy in the total consumption of energy resources was also observed, as evidenced by the R2 level of the slope of the trend line (0.93).

Scientifically important and empirically confirmed are the results obtained by the author during econometric modeling of the dependence of alternative energy consumption in Ukraine on key economic indicators, such as GDP, the unemployment rate, natural gas prices (current and with the calculation of the reaction lag) in accordance with equation 2, the results of which are taked off in tabl. 3.

Table 3

Summary table of the interdependence of alternative energy consumption with GDP, the unemployment rate, and gas prices over two years in Ukraine according to econometric modeling (based on the second equation)

The name of the country	GDP	Unemployment rate	Gas prices	Gas prices for the previous year	Gas prices for the 2 previous year	Gas consumption for the 2 previous year
Ukraine	0,002 (4,28***)	0.0614 (0,023***)	0.0134 (3,14**)	-	-0,008 (2,46*)	Україна

Source: developed by the author (the general results of the study are presented in Add. D)

The t-test is presented in parentheses and the significance of the obtained results is conditionally indicated: the hypothesis can be rejected at the level of statistical significance with a 1% margin of error (*** - 1% (very significant coefficient), **- 5% of error (a significant coefficient), *- 10 % of error (low coefficient))

Despite the fact that the coefficients are still significantly small, but significant, it can be argued that the number of business entities (both legal entities and individuals) that increase the use of renewable energy is increasing (this is evidenced by the direct dependence of the increase in the consumption of alternative energy of energy from GDP and the unemployment rate), as in Finland and Sweden, the natural gas and alternative energy markets are competitive, although objectively they are not interchangeable, as the rate of replacement of traditional sources of energy by renewable energy in Ukraine is still very low.

According to the authors, the development vector of the energy market of Ukraine, with the growth of production and consumption of renewable energy sources, is economically correct and liberal, but it needs certain mechanisms that would speed up this process.

Considering the unstable political and economic situation of the country on the world stage, the development of this direction will provide an opportunity to be less dependent on price fluctuations for this energy resource, which is currently widely used in Ukraine.

It is worth noting that Ukraine decided to join the Energy Community in 2010, which was a clear sign of its intention to become part of the European energy market and build a competitive market with strong relationships with all its neighbors. At the same time, it was a commitment to carry out fundamental reforms in the energy sector, revising the inherited Soviet model of energy markets [10; 11].

Against the background of the invasion of the Russian Federation, Ukraine switched to the European energy system in order to receive uninterrupted electricity to ensure the functioning of vital infrastructures [12].

It was scientifically important in the work to test using developed econometric equations the use of alternative energy in Iceland, because this is a country that has completely abandoned the consumption of natural gas, having developed and implemented a state energy system with use large share of alternative sources use. However, in the course of the research, it was found that equations 1 and 2 cannot be objectively applied for Iceland, due to a critically high index of multicollinearity of the dependent variables (about 0.99).

Such a situation once again explains the effective implementation of the energy strategy, which is based on alternative sources (see Fig. 2.) and which, according to the author, is already a closed integrated system, rationally implemented by the state policy of Iceland.

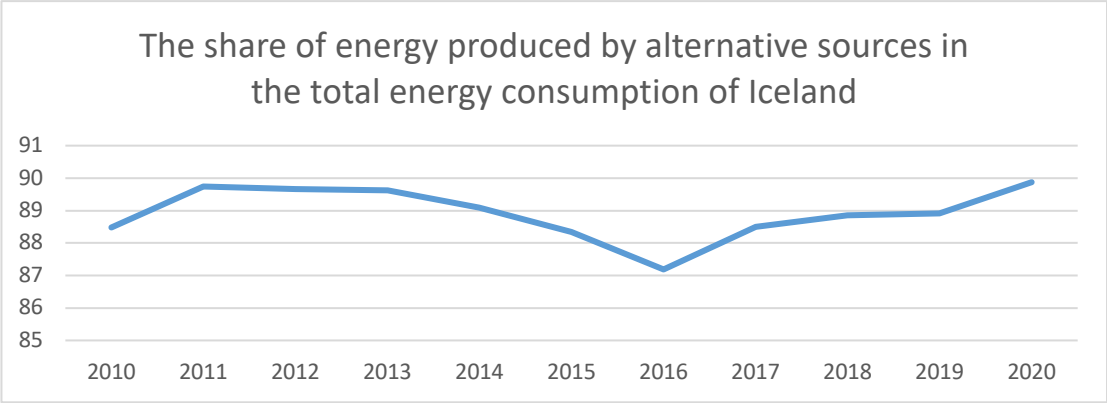

Fig. 2. The share of energy produced by alternative sources in the total energy consumption of Iceland

Source: author's development based on statistical data (Add. A)

Therefore, for the study of Iceland, equations 3 and 4 were developed in the work to indicate the interdependence of the volume of alternative energy produced on the level of GDP, total consumption and the level of unemployment:

$$\log(\text{prod\_alt}) = b_1 \text{Trend}_t + b_2 \log(\text{cons})_t + b_3 \log(\text{GDP})_t + b_4 \log(\text{GDP})_{t-1} + + e_{it} \quad (3),$$

$$\log(\text{prod\_alt}) = b_1 \text{Trend}_t + b_2 \log(\text{cons})_t + b_3 \log(\text{un})_t + b_4 \log(\text{un})_{t-1} + e_{it} \quad (4),$$

where t corresponds to each time period; Trend – trend line; prod_alt – alternative energy production, cons – energy consumption in Iceland; GDP – Gross Domestic Product; un – unemployment rate; e_{it} – is the research error

The results confirmed the hypothesis (Add. B) - the amount of energy production from alternative sources is not affected by the level of unemployment and GDP, there is a logical dependence between the total consumption and the production of alternative energy, and therefore it is possible to draw a conclusion - the energy system of Iceland is a nationwide concept of a carbon-neutral economy. the priority of which is the complete

rejection of traditional sources of energy in the future, despite possible economic losses.

Insights from this study and perspectives further research in this direction. Despite the fact that the whole Europe is implementing alternative energy and greening policies to reduce the consumption of exhaustible resources and the production of harmful substances that cause greenhouse gas emissions into the air, there are countries that are also guided by economic factors, such as: the level of GDP, unemployment rate, prices of gas. All this is an unconditional process that helps the country avoid economic imbalances caused by various factors, for example, fluctuations in the prices of gas and other fossil resources.

The results of the conducted multifactorial study are as follows:

- The UK follows a greening policy strategy and systematically reduces natural gas consumption and carbon emissions, while actively involving the public and households.
- In Denmark, there is a direct relationship between CO2 emissions for the current and previous year and the consumption of alternative energy and an inverse relationship with gas consumption two years before the current one, taking into account the low significance of the coefficients, - the country is trying to replace natural gas with alternative sources in a long-term strategy, but the growth their consumption is due to the growth of energy consumption in general.
- For Sweden and Finland, one of the most important factors is gas prices, which demonstrates the cyclicality of the economy and the partial competition of renewable energy with natural gas based on economic and price factors.
- For Germany, alternative energy is a key element of energy security, political independence and stability in the international arena.
- Iceland is a country that has completely abandoned consumption natural gas, having developed and implemented a state power system with the

large share of the use of alternative sources. The volume of energy production by alternative sources is not affected by the level of unemployment and GDP, there is a dependence between the total consumption and the production of alternative sources, therefore, the energy system of Iceland is a national concept of a carbon-neutral economy, the priority of which is the complete rejection of traditional energy sources in the future, despite the possible economic losses.

- Until 2020, there was a trend of increasing numbers in Ukraine economic entities (both legal entities and individuals) that increased the use of alternative energy (this is evidenced by the direct dependence of the growth of alternative energy consumption on GDP and the unemployment rate), despite the very low rate of substitution of renewable energy for traditional sources of energy, Ukraine understands the economic efficiency of such energy for the development of the national economy and security. Considering the unstable political and economic situation of the country on the world stage, the development of this direction will provide an opportunity to be less dependent on price fluctuations for this energy resource, which is currently widely used in Ukraine.

After victory, the main tasks will be:

1. Restore destroyed facilities.
2. Attract investors and technical assistance.
3. Focus on the experience of partner countries.
4. Find new promising ways and resources for greening the economy.

And the next steps will be as follows:

- the use of the "gas to power – power to gas" system will make it possible to export the produced energy to European countries;
- increasing the capacity of alternative energy facilities, in particular, one of the promising directions in the near future should be the construction of hydroelectric power plants. The further development of hydropower requires the reconstruction and technical improvement of hydropower units;

- activation of the use of biogas, since it can be used as a fuel, energy is produced from it, which can be used for decentralized energy supply;
- implementation of a stable policy that can be predicted to stimulate the development of the construction of SPPs and WPPs;
- construction and introduction of 5 GW of renewable energy capacity (with the exception of large-capacity hydroelectric power stations);
- investment stimulation of relevant state programs on renewable energy, including popularization within regional, national and global markets.

In addition, the European government has developed a strategy for increasing energy security, which aims to reduce the import of traditional resources from the Russian Federation.

The consequences of a quick and not gradual restriction of imports may be:

1. In the coming months, the prices of energy carriers such as oil, gas and coal will be high, which negatively affects the price of electricity.
2. Doubling up energy efficiency and investing in renewable energy sources (by insulating buildings, installing heat pumps, or installing solar panels on roofs).
3. Solving social problems with the help of transfers (starting from handouts to households and set ceiling prices for gas and electricity to lower tax rates).
4. Support for significant investments in low-carbon technology. The European Green Deal already supports the development of new climate-neutral technologies such as green hydrogen, biochemicals or decarbonized materials

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Addition A

Main indicators of economic research

Denmark	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
GDP	321.995	344.003	327.149	343.584	352.994	302.673	311.988	329.866	352.058	347.176	339.626
Energy consumption	0,82	0,78	0,72	0,75	0,72	0,70	0,71	0,70	0,70	0,68	0,59
Alternative energy consumption	0,12	0,14	0,15	0,16	0,17	0,18	0,18	0,21	0,20	0,22	0,21
Gas consumption	0,19	0,16	0,15	0,14	0,12	0,12	0,12	0,12	0,11	0,10	0,08
Increase in %	0,4	0,4	0,4	0,4	0,5	0,7	0,8	0,6	0,5	0,4	0,3
Finland											
GDP	248.262	273.925	256.849	270.065	273.042	232.582	239.150	252.867	274.210	269.654	267.856
Energy consumption	1,30	1,22	1,18	1,19	1,15	1,14	1,16	1,13	1,16	1,13	1,10
Alternative energy consumption	0,11	0,12	0,12	0,13	0,14	0,14	0,14	0,17	0,18	0,19	0,19
Gas consumption	0,15	0,13	0,12	0,11	0,10	0,08	0,07	0,07	0,08	0,07	0,07
Increase in %	0,5	0,5	0,5	0,5	0,4	0,3	0,3	0,2	0,1	0,1	0,2
Germany											
GDP	3,423.466	3,761.142	3,545.946	3,753.687	3,904.921	3,383.091	3,496.606	3,664.511	3,951.340	3,863.344	3,780.553
Energy consumption	13,70	13,20	13,37	13,74	13,16	13,40	13,62	13,78	13,44	13,05	12,11
Alternative energy consumption	0,90	1,11	1,25	1,30	1,43	1,66	1,64	1,88	1,97	2,10	2,21
Gas consumption	3,17	2,91	2,92	3,06	2,66	2,77	3,06	3,16	3,09	3,19	3,12
Increase in %	-0,2	-1,9	0,2	0,3	0,4	0,9	0,8	0,4	0,3	0,2	0,2
Sweden											
GDP	3,573.581	3,727.905	3,743.086	3,822.671	3,992.730	4,260.470	4,415.031	4,625.094	4,828.306	5,020.803	4,951.553
Energy consumption	2,16	2,13	2,26	2,12	2,11	2,17	2,14	2,21	2,16	2,24	2,20
Alternative energy consumption	0,17	0,19	0,21	0,22	0,24	0,29	0,30	0,33	0,32	0,36	0,41
Gas consumption	0,06	0,04	0,04	0,04	0,03	0,03	0,04	0,03	0,04	0,04	0,04
Increase in %	0,9	0,8	0,7	0,8	1	1,1	1,3	1,3	1,2	1	0,7
United Kingdom											
GDP	2,481.58	2,659.88	2,704.02	2,783.25	3,056.52	2,932.78	2,693.25	2,662.48	2,857.32	2,830.81	2,707.74
Energy consumption	8,92	8,43	8,53	8,48	7,99	8,08	7,99	7,96	7,95	7,73	6,89
Alternative energy consumption	0,26	0,32	0,37	0,49	0,59	0,74	0,74	0,88	0,99	1,09	1,20

Gas consumption	3,55	2,95	2,77	2,75	2,52	2,59	2,90	2,83	2,86	2,78	2,61
Increase in %	0,8	0,8	0,7	0,7	0,7	0,8	0,8	0,7	0,6	0,6	0,6
Ukraine											
GDP	136,01	163,16	175,71	179,57	130,57	90,49	93,31	112,11	130,92	154	155,3
Energy consumption	5,1	5,27	5,17	4,89	4,33	3,59	3,75	3,49	3,62	3,42	3,31
Alternative energy consumption			0,01	0,01	0,02	0,02	0,02	0,02	0,02	0,05	0,09
Gas consumption	1,96	2,02	1,87	1,72	1,45	1,15	1,13	1,09	1,1	1,02	1,06
Unemployment rate in %	8,8	8,6	8,1	7,7	9,7	9,5	9,7	9,9	9,1	8,6	9,9
The price of gas in UAH. per cubic meter	0,725	0,725	0,725	0,725	1,09	7,19	6,88	6,88	6,96	8,55	4,3
Emissions of CO2 tons per capita	6,75	7,15	7,01	6,79	5,89	4,94	4,97	4,5	4,71	4,49	4,34
Increase in %	-0,39	-0,04	-0,32	-0,18	-0,38	-5,5	-0,39	-0,41	-0,47	-0,55	-0,59

Iceland	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
General consumption	226 698	242 547	236 756	246 877	246 000	234 224	221 306	232 800	255 736	251 760	247 812
Alternative energy consumption	200 585	217 676	212 300	221 240	219 163	206 895	192 949	206 017	227 231	223 857	222 718

Source: [3; 13; 14].

Addition B

B.1.

Correlation of energy consumption obtained from alternative sources with natural gas consumption and CO2 emissions in Sweden

	ALTER__CON	CO2	GAS_CONS_
ALTER_	1.000000	-0.826799	-0.384692
CO2	-0.826799	1.000000	0.697894
GAS_C	-0.384692	0.697894	1.000000

Source: author's development based on statistical data presented in Add. A

An econometric model of the dependence of alternative energy consumption on the volume of natural gas consumption and the strategy to reduce CO2 emissions for the previous two-year period in Sweden

Dependent Variable: ALTER__CON
Method: Least Squares
Date: 01/27/22 Time: 15:13
Sample (adjusted): 2012 2020
Included observations: 9 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CO2	0.116148	0.149055	0.779230	0.5174
GAS_CONS_	4.813761	2.300041	2.092903	0.1714
CO2(-1)	0.082775	0.135443	0.611144	0.6033
CO2(-2)	-0.306670	0.111281	-2.755814	0.1103
GAS_CONS_(-1)	4.361023	2.259605	1.929994	0.1934
GAS_CONS_(-2)	3.632263	2.460253	1.476378	0.2779
C	0.373042	0.503096	0.741492	0.5356

R-squared	0.958239	Mean dependent var	0.297778
Adjusted R-squared	0.832955	S.D. dependent var	0.066291
S.E. of regression	0.027094	Akaike info criterion	-4.327550
Sum squared resid	0.001468	Schwarz criterion	-4.174153
Log likelihood	26.47398	Hannan-Quinn criter.	-4.658580
F-statistic	7.648543	Durbin-Watson stat	2.192481
Prob(F-statistic)	0.120125		

Source: author's development based on statistical data presented in Add. A

B.2.

Correlation of energy consumption obtained from alternative sources with the price of natural gas, GDP and the level of unemployment in Sweden

	ALTER__CON	GAS_PRICE	GDP	UNEMPL
ALTER_	1.000000	-0.532240	0.968080	-0.496132
GAS_PR	-0.532240	1.000000	-0.473681	-0.237339
GDP	0.968080	-0.473681	1.000000	-0.644687
UNEMPL	-0.496132	-0.237339	-0.644687	1.000000

Source: author's development based on statistical data presented in Add. A

An econometric model of the dependence of alternative energy consumption on natural gas prices for the previous two-year period, GDP and the unemployment rate in Sweden

Dependent Variable: ALTER__CON
Method: Least Squares
Date: 01/27/22 Time: 14:08
Sample (adjusted): 2012 2020
Included observations: 9 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GAS_PRICE	-0.006550	0.013537	-0.483879	0.6616
GDP	0.087092	0.030105	2.892892	0.0629
UNEMPL	0.008647	0.013033	0.663486	0.5545
GAS_PRICE(-1)	-0.053734	0.014427	-3.724550	0.0337
GAS_PRICE(-2)	0.014688	0.006100	2.407985	0.0952
C	0.378717	0.400957	0.944533	0.4146

R-squared	0.994434	Mean dependent var	0.297778
Adjusted R-squared	0.985157	S.D. dependent var	0.066291
S.E. of regression	0.008076	Akaike info criterion	-6.565054
Sum squared resid	0.000196	Schwarz criterion	-6.433571
Log likelihood	35.54274	Hannan-Quinn criter.	-6.848794
F-statistic	107.1961	Durbin-Watson stat	2.265355

Source: author's development based on statistical data presented in Add. A

B.3.

Correlation of energy consumption from alternative sources with natural gas consumption and CO2 emissions in Great Britain

	ALTER__CON	CO2	GAS_CONS_
ALTER_	1.000000	-0.271577	-0.114044
CO2	-0.271577	1.000000	0.484439
GAS_C	-0.114044	0.484439	1.000000

Source: author's development based on statistical data presented in Add. A

An econometric model of the dependence of alternative energy consumption on natural gas consumption and CO2 emission reduction strategies for the previous two-year period in Great Britain

Dependent Variable: ALTER__CON
Method: Least Squares
Date: 01/27/22 Time: 15:22
Sample (adjusted): 2012 2020
Included observations: 9 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CO2	0.129330	0.074159	1.743945	0.2233
GAS_CONS_	-0.616573	0.122359	-5.039047	0.0372
CO2(-1)	-0.272924	0.062474	-4.368634	0.0486
CO2(-2)	-0.226341	0.038639	-5.857901	0.0279
GAS_CONS_(-1)	-0.055750	0.072791	-0.765898	0.5238
GAS_CONS_(-2)	-0.109119	0.052151	-2.092365	0.1715
C	5.428662	0.540646	10.04107	0.0098

R-squared	0.998680	Mean dependent var	0.787778
Adjusted R-squared	0.994721	S.D. dependent var	0.277839
S.E. of regression	0.020186	Akaike info criterion	-4.916134
Sum squared resid	0.000815	Schwarz criterion	-4.762738
Log likelihood	29.12261	Hannan-Quinn criter.	-5.247164
F-statistic	252.2507	Durbin-Watson stat	2.477152
Prob(F-statistic)	0.003954		

Source: author's development based on statistical data presented in Add. A

B.4.

Correlation of consumption of energy obtained from alternative sources with the price of natural gas, GDP and the level of unemployment in Great Britain

	ALTER__CON	GAS_PRICE	GDP	UNEMPL
ALTER_	1.000000	-0.200713	-0.051721	-0.075194
GAS_PR	-0.200713	1.000000	0.828488	-0.123158
GDP	-0.051721	0.828488	1.000000	-0.332762
UNEMPL	-0.075194	-0.123158	-0.332762	1.000000

Source: author's development based on statistical data presented in Add. A

An econometric model of the dependence of alternative energy consumption on natural gas prices over the previous two-year period, GDP and unemployment in Great Britain

Dependent Variable: ALTER__CON
Method: Least Squares
Date: 01/27/22 Time: 17:10
Sample (adjusted): 2012 2020
Included observations: 9 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GAS_PRICE	0.137914	0.190970	0.722176	0.5224
GDP	-0.571079	0.582056	-0.981140	0.3989
UNEMPL	-0.208317	0.035305	-5.900456	0.0097
GAS_PRICE(-1)	-0.058406	0.143411	-0.407260	0.7111
GAS_PRICE(-2)	-0.089276	0.101782	-0.877128	0.4450
C	3.532151	1.185312	2.979934	0.0586

R-squared	0.938902	Mean dependent var	0.787778
Adjusted R-squared	0.837072	S.D. dependent var	0.277839
S.E. of regression	0.112148	Akaike info criterion	-1.303276
Sum squared resid	0.037731	Schwarz criterion	-1.171793
Log likelihood	11.86474	Hannan-Quinn criter.	-1.587016
F-statistic	9.220279	Durbin-Watson stat	2.003871
Prob(F-statistic)	0.048488		

Source: author's development based on statistical data presented in Add. A

B.5.

Correlation of energy consumption obtained from alternative sources with natural gas consumption and CO2 emissions in Denmark

	ALTER_CONS	CO2	GAS_CONS
ALTER_	1.000000	-0.935699	-0.925619
CO2	-0.935699	1.000000	0.979964
GAS_C	-0.925619	0.979964	1.000000

Source: author's development based on statistical data presented in Add. A

An econometric model of the dependence of alternative energy consumption on natural gas consumption and CO2 emission reduction strategies for the previous two-year period in Denmark

Dependent Variable: ALTER_CONS
Method: Least Squares
Date: 01/27/22 Time: 17:24
Sample (adjusted): 2012 2020
Included observations: 9 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CO2	-0.075045	0.060726	-1.235788	0.3045
GAS_CONS	0.270271	2.000230	0.135120	0.9011
CO2(-1)	0.079662	0.030315	2.627777	0.0785
CO2(-2)	0.080760	0.033653	2.399770	0.0959
GAS_CONS(-1)	3.049993	3.230266	0.944192	0.4147
GAS_CONS(-2)	-6.240891	2.342394	-2.664321	0.0761

R-squared	0.541618	Mean dependent var	0.186667
Adjusted R-squared	-0.222351	S.D. dependent var	0.024495
S.E. of regression	0.027082	Akaike info criterion	-4.145206
Sum squared resid	0.002200	Schwarz criterion	-4.013723
Log likelihood	24.65343	Hannan-Quinn criter.	-4.428946
Durbin-Watson stat	2.252083		

Source: author's development based on statistical data presented in Add. A

B.6.

Correlation of energy consumption obtained from alternative sources with the price of natural gas, GDP and the unemployment rate in Denmark

	ALTER_CONS	GAS_PRICE	GDP	UNEMPL
ALTER_	1.000000	-0.817385	0.201941	-0.899193
GAS_PR	-0.817385	1.000000	-0.118320	0.732230
GDP	0.201941	-0.118320	1.000000	-0.058284
UNEMPL	-0.899193	0.732230	-0.058284	1.000000

Source: author's development based on statistical data presented in Add. A

An econometric model of the dependence of alternative energy consumption on natural gas prices for the previous two-year period, GDP and the unemployment rate in Denmark

Dependent Variable: ALTER_CONS
Method: Least Squares
Date: 01/27/22 Time: 17:26
Sample (adjusted): 2012 2020
Included observations: 9 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GAS_PRICE	-0.001780	0.008701	-0.204618	0.8510
GDP	0.028005	0.025132	1.114317	0.3464
UNEMPL	-0.015624	0.008397	-1.860723	0.1597
GAS_PRICE(-1)	-0.013881	0.009451	-1.468797	0.2382
GAS_PRICE(-2)	0.002145	0.012394	0.173078	0.8736
C	0.286252	0.123331	2.320996	0.1030

R-squared	0.917446	Mean dependent var	0.186667
Adjusted R-squared	0.779857	S.D. dependent var	0.024495
S.E. of regression	0.011493	Akaike info criterion	-5.859459
Sum squared resid	0.000396	Schwarz criterion	-5.727976
Log likelihood	32.36756	Hannan-Quinn criter.	-6.143199
F-statistic	6.667989	Durbin-Watson stat	3.128179
Prob(F-statistic)	0.074640		

Source: author's development based on statistical data presented in Add. A

B.7.

Correlation of energy consumption obtained from alternative sources with natural gas consumption and CO2 emissions in Finland

	ALTER_ENE	GAS_CONS	CO2
ALTER_	1.000000	-0.828776	-0.840539
GAS_C	-0.828776	1.000000	0.943872
CO2	-0.840539	0.943872	1.000000

Source: author's development based on statistical data presented in Add. A

An econometric model of the dependence of alternative energy consumption on the volume of natural gas consumption and the strategy to reduce CO2 emissions over the previous two-year period in Finland

Dependent Variable: ALTER_ENERGY_CONS_
Method: Least Squares
Date: 01/27/22 Time: 22:17
Sample (adjusted): 2012 2020
Included observations: 9 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CO2	-0.018521	0.007099	-2.609138	0.1208
GAS_CONS	0.972568	0.586112	1.659355	0.2389
CO2(-1)	0.001210	0.009345	0.129453	0.9088
CO2(-2)	0.000411	0.008354	0.049252	0.9652
GAS_CONS(-1)	-0.116953	0.544134	-0.214935	0.8497
GAS_CONS(-2)	-1.021897	0.405682	-2.518961	0.1280
C	0.327436	0.072550	4.513257	0.0458

R-squared	0.978977	Mean dependent var	0.155556
Adjusted R-squared	0.915909	S.D. dependent var	0.026977
S.E. of regression	0.007823	Akaike info criterion	-6.812010
Sum squared resid	0.000122	Schwarz criterion	-6.658613
Log likelihood	37.65405	Hannan-Quinn criter.	-7.143040
F-statistic	15.52243	Durbin-Watson stat	2.004932
Prob(F-statistic)	0.061752		

Source: author's development based on statistical data presented in Add. A

B.8.

Correlation of consumption of energy obtained from alternative sources with the price of natural gas, GDP and the level of unemployment in Finland

	ALTER_ENE	GDP	UNEMPL_	GAS_PRICE
ALTER_	1.000000	0.294085	-0.428748	0.871149
GDP	0.294085	1.000000	-0.699526	0.483618
UNEMP	-0.428748	-0.699526	1.000000	-0.586863
GAS_PR	0.871149	0.483618	-0.586863	1.000000

Source: author's development based on statistical data presented in Add. A

An econometric model of the dependence of alternative energy consumption on natural gas prices for the previous two-year period, GDP and the unemployment rate in Finland

Dependent Variable: ALTER_ENERGY_CONS_
Method: Least Squares
Date: 01/27/22 Time: 22:20
Sample (adjusted): 2012 2020
Included observations: 9 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP	0.000403	0.000388	1.039375	0.3750
UNEMPL_	0.035429	0.017577	2.015716	0.1372
GAS_PRICE	0.078342	0.021985	3.563360	0.0377
GAS_PRICE(-1)	-0.036949	0.013618	-2.713317	0.0730
GAS_PRICE(-2)	-0.009362	0.010437	-0.897064	0.4358
C	-0.769031	0.279082	-2.755573	0.0704

R-squared	0.951918	Mean dependent var	0.155556
Adjusted R-squared	0.871781	S.D. dependent var	0.026977
S.E. of regression	0.009660	Akaike info criterion	-6.206935
Sum squared resid	0.000280	Schwarz criterion	-6.075452
Log likelihood	33.93121	Hannan-Quinn criter.	-6.490675
F-statistic	11.87869	Durbin-Watson stat	2.844797
Prob(F-statistic)	0.034262		

Source: author's development based on statistical data presented in Add. A *B.9.*

Correlation of energy consumption obtained from alternative sources with natural gas consumption and CO2 emissions in Germany

	ALTER_CON	GAS_CONS_	CO2
ALTER_	1.000000	0.243275	-0.854393
GAS_C	0.243275	1.000000	-0.244172
CO2	-0.854393	-0.244172	1.000000

Source: author's development based on statistical data presented in Add. A

An econometric model of the dependence of alternative energy consumption on the volume of natural gas consumption and the strategy to reduce CO2 emissions for the previous two-year period in Germany

Dependent Variable: ALTER_CONS_
Method: Least Squares
Date: 01/27/22 Time: 22:32
Sample (adjusted): 2012 2019
Included observations: 8 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CO2	-0.230651	0.625332	-0.368846	0.7750
GAS_CONS_	-0.371313	1.338885	-0.277330	0.8278
CO2(-1)	-1.218766	1.105252	-1.102704	0.4689
CO2(-2)	0.552074	1.012411	0.545306	0.6822
GAS_CONS_(-1)	0.959494	0.932380	1.029081	0.4909
GAS_CONS_(-2)	-1.212882	0.721528	-1.680990	0.3416
C	12.10563	13.71607	0.882587	0.5397

R-squared	0.963559	Mean dependent var	1.653750
Adjusted R-squared	0.744911	S.D. dependent var	0.313685
S.E. of regression	0.158431	Akaike info criterion	-1.176440
Sum squared resid	0.025100	Schwarz criterion	-1.106929
Log likelihood	11.70576	Hannan-Quinn criter.	-1.645266
F-statistic	4.406903	Durbin-Watson stat	2.813253
Prob(F-statistic)	0.349329		

Source: author's development based on statistical data presented in Add. A

B.10.

Correlation of consumption of energy obtained from alternative sources with the price of natural gas, GDP and the level of unemployment in Germany

	ALTER_CON	GAS_PRICE	GDP	UNEMPL_
ALTER_	1.000000	-0.298705	0.044905	-0.982784
GAS_PR	-0.298705	1.000000	-0.296403	0.352719
GDP	0.044905	-0.296403	1.000000	-0.093753
UNEMP	-0.982784	0.352719	-0.093753	1.000000

Source: author's development based on statistical data presented in Add. A

An econometric model of the dependence of alternative energy consumption on natural gas prices for the previous two-year period, GDP and the unemployment rate in Germany

Dependent Variable: ALTER_CONS_
Method: Least Squares
Date: 01/27/22 Time: 22:35
Sample (adjusted): 2012 2018
Included observations: 7 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GAS_PRICE	0.070513	0.406896	0.173295	0.8908
GDP	-0.039220	0.249009	-0.157505	0.9005
UNEMPL_	-0.145776	0.352770	-0.413231	0.7505
GAS_PRICE(-1)	-0.538674	0.662563	-0.813015	0.5654
GAS_PRICE(-2)	0.562242	0.704860	0.797665	0.5714
C	1.811695	2.242332	0.807951	0.5674

R-squared	0.975854	Mean dependent var	1.590000
Adjusted R-squared	0.855125	S.D. dependent var	0.277248
S.E. of regression	0.105528	Akaike info criterion	-1.891312
Sum squared resid	0.011136	Schwarz criterion	-1.937674
Log likelihood	12.61959	Hannan-Quinn criter.	-2.464346
F-statistic	8.082980	Durbin-Watson stat	2.836174
Prob(F-statistic)	0.260624		

Source: author's development based on statistical data presented in Add. A

Addition C

C.1.

Correlation of alternative energy production with unemployment and total energy consumption in Iceland

	PROD_ALT	CONS	UN
PROD_	1.000000	0.991486	-0.024742
CONS	0.991486	1.000000	-0.126799
UN	-0.024742	-0.126799	1.000000

Source: author's development based on statistical data presented in Add. A

An econometric model of the dependence of alternative energy production on current and previous years' unemployment and total energy consumption in Iceland

Dependent Variable: LOG(PROD_ALT)
Method: Least Squares
Date: 05/12/22 Time: 14:55
Sample: 2010 2020
Included observations: 11

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(CONS)	1.141924	0.034394	33.20139	0.0000
LOG(UN)	0.016705	0.097970	0.170511	0.8694
LOG(UN-1)	-0.001489	0.074318	-0.020038	0.9846
C	-1.898613	0.444971	-4.266830	0.0037

R-squared	0.994160	Mean dependent var	12.27110
Adjusted R-squared	0.991658	S.D. dependent var	0.051646
S.E. of regression	0.004717	Akaike info criterion	-7.599917
Sum squared resid	0.000156	Schwarz criterion	-7.455228
Log likelihood	45.79954	Hannan-Quinn criter.	-7.691123
F-statistic	397.2282	Durbin-Watson stat	2.067719
Prob(F-statistic)	0.000000		

Source: author's development based on statistical data presented in Add. A

C.2.

Correlation of alternative energy production with GDP and total energy consumption in Iceland

	PROD_ALT	CONS	GDP
PROD_	1	0.991486258	0.274260607
CONS	0.991486258	1	0.365333192
GDP	0.274260607	0.365333192	1

Source: author's development based on statistical data presented in Add. A

An econometric model of the dependence of alternative energy production on GDP for the current and previous years and total energy consumption in Iceland

Dependent Variable: LOG(PROD_ALT)
Method: Least Squares
Date: 05/12/22 Time: 14:50
Sample: 2010 2020
Included observations: 11

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(CONS)	1.174266	0.040602	28.92155	0.0000
LOG(GDP)	0.070484	1.635408	0.043099	0.9668
LOG(GDP-1)	-0.089113	1.547936	-0.057569	0.9557
C	-2.226646	0.596725	-3.731445	0.0073

R-squared	0.992251	Mean dependent var	12.27110
Adjusted R-squared	0.988930	S.D. dependent var	0.051646
S.E. of regression	0.005434	Akaike info criterion	-7.317063
Sum squared resid	0.000207	Schwarz criterion	-7.172374
Log likelihood	44.24385	Hannan-Quinn criter.	-7.408269
F-statistic	298.7882	Durbin-Watson stat	1.948587
Prob(F-statistic)	0.000000		

Source: author's development based on statistical data presented in Add. A

Addition D

D.1.

Correlation of energy consumption obtained from alternative sources with natural gas consumption and CO2 emissions in Ukraine

	ALTER_CON	CO2	GAS_CONS_
ALTER_	1.000000	-0.587037	-0.526571
CO2	-0.587037	1.000000	0.990293
GAS_C	-0.526571	0.990293	1.000000

Source: author's development based on statistical data presented in Add. A

An econometric model of the dependence of alternative energy consumption on the volume of natural gas consumption and the strategy to reduce CO2 emissions for the previous two-year period in Ukraine

Dependent Variable: ALTER_CONS_
Method: Least Squares
Date: 01/30/22 Time: 09:18
Sample (adjusted): 2012 2020
Included observations: 9 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CO2	-0.125154	0.097585	-1.282513	0.3282
GAS_CONS_	0.290283	0.303643	0.956001	0.4400
CO2(-1)	-0.004394	0.084249	-0.052152	0.9631
CO2(-2)	-0.115049	0.089293	-1.288452	0.3265
GAS_CONS_(-1)	-0.131164	0.304527	-0.430715	0.7087
GAS_CONS_(-2)	0.492790	0.376696	1.308190	0.3209
C	0.460251	0.292813	1.571827	0.2566

R-squared	0.738184	Mean dependent var	0.028889
Adjusted R-squared	-0.047263	S.D. dependent var	0.025712
S.E. of regression	0.026313	Akaike info criterion	-4.386053
Sum squared resid	0.001385	Schwarz criterion	-4.232656
Log likelihood	26.73724	Hannan-Quinn criter.	-4.717083
F-statistic	0.939827	Durbin-Watson stat	1.571030
Prob(F-statistic)	0.597752		

Source: author's development based on statistical data presented in Add. A

D.2.

Correlation of energy consumption obtained from alternative sources with the price of natural gas, GDP and the level of unemployment in Ukraine

	ALTER_CON	GAS_PRICE	GDP	UNEMP
ALTER_	1.000000	0.242592	0.158731	0.370216
GAS_PR	0.242592	1.000000	-0.621889	0.440690
GDP	0.158731	-0.621889	1.000000	-0.743121
UNEMP	0.370216	0.440690	-0.743121	1.000000

Source: author's development based on statistical data presented in Add. A

An econometric model of the dependence of alternative energy consumption on natural gas prices for the previous two-year period, GDP and the unemployment rate in Ukraine

Dependent Variable: ALTER_CONS_
Method: Least Squares
Date: 01/30/22 Time: 09:20
Sample (adjusted): 2012 2020
Included observations: 9 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GAS_PRICE	0.013425	0.004272	3.142289	0.0516
GDP	0.002093	0.000494	4.237098	0.0241
UNEMP	0.061469	0.014357	4.281574	0.0234
GAS_PRICE(-1)	-5.32E-05	0.002572	-0.020687	0.9848
GAS_PRICE(-2)	-0.008293	0.003359	-2.468838	0.0902
C	-0.851731	0.198961	-4.280890	0.0234

R-squared	0.927120	Mean dependent var	0.028889
Adjusted R-squared	0.805654	S.D. dependent var	0.025712
S.E. of regression	0.011335	Akaike info criterion	-5.887105
Sum squared resid	0.000385	Schwarz criterion	-5.755622
Log likelihood	32.49197	Hannan-Quinn criter.	-6.170845
F-statistic	7.632731	Durbin-Watson stat	3.044681
Prob(F-statistic)	0.062478		

Source: author's development based on statistical data presented in Add. A