The Effects of the Management of Natural Energy Resources in the European Union

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Abstract:

This paper is devoted to the study of the impact of the management of natural energy resources on sustainable development and green growth. The object of the study is the process of management of natural energy resources.

An indicator of adjusted net savings was used to estimate sustainable development. The performed comparative analysis of the adjusted net savings without subtraction and subtraction of the costs of extracting energy natural resources as a result of the synthesis shows a significant difference. It is on average for 2012-2016 is 4% of gross national income for the whole world. When subtracting production costs, the adjusted net savings will be much smaller and this fact must be taken into account.

In order to simultaneously take into account the economic situation of the country, the depletion of energy resources, their consumption, and the consequence of consumption, relevant indicators are proposed, as well as a special index for estimating the changes over time. The results of the study show that most countries in the European Union have positive adjusted energy and carbon efficiency, since they are higher than global measures. In addition, the relationship between carbon efficiency and energy efficiency in these countries is still very close. The analysis of changes in time as a result of synthesis also showed positive results, according to which the adjusted energy efficiency in most countries of the European Union is growing. According to the high growth rates of this indicator, some countries have a good opportunity to make significant progress in green growth, although this may require expensive investments.

Keywords: sustainable development; green growth; adjusted net savings; depletion of natural capital; energy productivity; carbon productivity; natural resources

JEL Classification: Q01, Q35, Q43.

Introduction

The United Nations Conference on Environment and Development in Rio de Janeiro in 1992, through the adoption of the Joint Declaration, launched the implementation of sustainable development. After that, scientists from all over the world began to work on the development of these ideas, which created a whole branch of science. There were lots of issues during the course of study and the question was how to adequately determine if economic development was sustainable. To solve this problem, a large number of criteria and indicators have been developed that are constantly being improved. Among them there are many indicators for assessing the results of management of energy natural resources that have served to characterize green growth. Some of the criteria and indicators have ceased to be used, and many of them have been aggregated into other indicators to facilitate the analysis of development. However, since the 1992 conference, many issues were still not solved, and one of them was the problem of a qualitative and simple assessment of the sustainability of the development and green growth of countries. In this issue, taking into account the effects of the depletion and consumption of energy natural resources takes an important place.

1. Literature Review

At the moment, there are already enough works devoted to the study of the impact of the management of energy natural resources on sustainable development and the green growth of different countries. This impact is reflected in the approaches to developing macroeconomic assessment systems for sustainable development and the progress of green growth. Among the first scientists involved in the study of sustainable development and national wealth using indicators are Pearce and Atkinson [15]. Further, the development of research in this direction was carried out thanks to such scholars as Dixon, et al. [5], Hamilton and Clemens [9], etc.

The study of green growth began after the development of a base for assessing sustainable development. Researchers such as Ekins [6] were among the first to start exploring the progress of green growth on the path to sustainable development. Then the study was developed by Bolt, Matete and Clemens [2], Ekins, Simon, Deutsch, Folke and De Groot [7], Janicke [10], Lorek and Spangenberg [12], Lyulyuv and Shvindina [13], etc. The relationship between sustainable development and tourism was considered by Kovalov, et al. [11]. The effects of energy resource management have been studied in the works of such scientists as Geller, Harrington, Rosenfeld, Tanishima and Unander [8], Dimitropoulos [4], Steinberger and Krausmann [16], Wang and Wei [17], etc. The problems of comparing the effects of energy consumption of natural resources were studied by Beinhocker, et al. [1], Wang, Xian, Wei and Huang [18], etc.

Published literature reviews led to the conclusion that the scientists who developed the study provided an opportunity for further improvement of the tools of macroeconomic evaluation of the progress of green growth on the path to sustainable development of different countries. Therefore, it is possible to assess in more detail the effects of consumption and depletion of natural resources and their comparison with economic indicators of many countries.

The purpose of the paper is to determine the impact of investments in the extraction of energy resources on indicators of sustainable development, as well as in the study of the effects of management of energy resources in the EU, Ukraine and the World in general, on the basis of calculation of the relevant indicators of efficiency and compilation of country ratings by these indicators.

2. Methodology

Adjusted Net Savings (ANS) are often used as a macroeconomic indicator of sustainable development assessment. The Adjusted Net Savings Indicator is developed by the World Bank. It's essence is connected to the new tendencies in the assessment of the wealth. Adjusted net savings characterize the accumulation of national savings after due consideration of depletion of natural resources and damage from environmental pollution. The basis for their calculation includes standard indicators of national accounting. In general, the formula for adjusted net savings is given by Bolt, Matete and Clemens [2]. Calculation is done by Eq. (1).

$$ANS = \frac{GNS - D_h + CSE - \sum R_{n,i} - CD}{GNI}, \qquad (1)$$

where ANS – adjusted net saving rate; GNS – gross national saving; D_h – depreciation of produced capital; CSE – current (non-fixed-capital) expenditure on education; $R_{n,i}$ – rent from depletion of natural capital i; CD – damages from carbon dioxide emissions; GNI – gross national income at market prices.

Adjusted net savings are calculated and published by the World Bank each year for more than 200 countries in the world. The World Bank has included in the indicator of adjusted net savings the depletion of mineral, forest and energy natural resources. Depletion of energy natural resources takes into account coal, crude oil and natural gas.

In general, the depletion of natural resources is considered as the difference between the value in world prices of a certain amount of extracted natural resources and the cost of their production, that is, the cost of extraction, receipt, restoration, depreciation, etc. We propose to consider the depletion of mineral and energy natural resources also in the form of their value in world prices, without deducting expenses for their extraction and all related expenses. Such a proposal is explained by the fact that mineral and energy natural resources are classified as non-recoverable and the cost of their extraction is not essentially investment in the future. Investment in mining can be considered as missed, as an alternative could be an investment, for example, in the development of alternative energy. The extraction of such natural resources leads to a reduction in national wealth. Therefore, it is appropriate to analyze the values of adjusted net savings for the case of calculating the depletion of natural resources also according to our proposal.

To assess the progress of the country in green growth towards sustainable development can be through various indicators, the main ones of which are presented by OECD [14]. According to this, as a rule to assess the management of energy resources are used the energy productivity of the economy, the total final energy consumption by sector and the share of renewables in total primary energy supply and in electricity generation. In addition to these, there are streaming data in the form of absolute values, which are used both for the calculation of the listed indicators, and as independent indicators. In order to simultaneously take into account the economic result, depletion of energy resources and their consumption, we have developed an additional indicator that characterizes energy efficiency, based on the features of sustainable development assessment.

The essence of the developed indicator is the specific value of the adjusted result of the economic activity of the country per unit of energy consumed for this resource. The indicator is adjusted by subtracting depletion of energy natural resources, since green growth can't occur due to the extraction of non-renewable natural resources. The calculation is made for three main types of energy natural resources: coal, oil, natural gas. We think that this approach can help to make better management decisions regarding the management of natural resources.

This indicator of the economic result per unit of consumption of natural resources, adjusted by subtracting the value appraisal of their depletion in the region for the year, is calculated by Eq. (2).

$$ER = (GNI - ED)/EC, \tag{2}$$

where *ER* – indicator of the adjusted economic result per unit of consumed energy resources of the country, USD per ton oil equivalent; *GNI* – gross national income at market prices, USD; *ED* – cost estimation of the energy resources depletion of the country without deducting expenses for their extraction, USD; *EC* – quantity of energy consumed by the country, ton oil equivalent.

In order to evaluate the efficiency of the country's green growth from the standpoint of energy consumption, we propose to calculate the developed consolidated dynamic indicator of the country's development efficiency based on the adjusted economic result for energy consumption, that is, a special index. The positive direction of the dynamics of this index is growth. The criterion of efficiency is the index value greater than one. Consolidated dynamic indices are calculated on the basis of chain relative increments of indicators ER by Eq. (3).

$$I_{ER} = \sqrt[N-1]{\prod_{n=1}^{N-1}\left[\frac{ER_{\{n+1\}}}{ER_{\{n\}}\left(1+ir_{\{n+1\}}\right)}\right]}, \tag{3}$$

where I_{ER} – consolidated dynamic index of the country's green growth efficiency based on the adjusted economic result for energy consumption; *ir* – inflation rate; *N* – the number of years for which the analysis is carried out; *n* – the designation of the number of the year.

In addition to the problem of depletion of energy natural resources, carbon dioxide (CO2) emissions also occur after burning. Various indicators are used to assess the effectiveness of the economy in terms of CO2 emissions. Among them are production-based CO2 productivity and demand-based CO2 productivity, proposed by OECD [14]. Stream data is also used for these purposes in the form of absolute values. In order to consider simultaneously the economic result, damages from carbon dioxide emissions and the amount of emissions, we have developed an additional indicator that characterizes the carbon efficiency of the economy, based on the features of sustainable development assessment.

The essence of the developed indicator lies in the specific magnitude of the result of the country's economic activity per unit of CO2 emissions. The result of economic activity is adjusted by damages from carbon dioxide emissions, since the damage from environmental pollution leads to economic losses. Carbon dioxide damage is estimated at 20 USD per ton of carbon dioxide (World Bank [23]).

The indicator of the economic result per carbon dioxide emissions, adjusted by subtraction of damages from carbon dioxide emissions in a year, is calculated by Eq. (4).

$$EE = (GNI - CD)/CE, \tag{4}$$

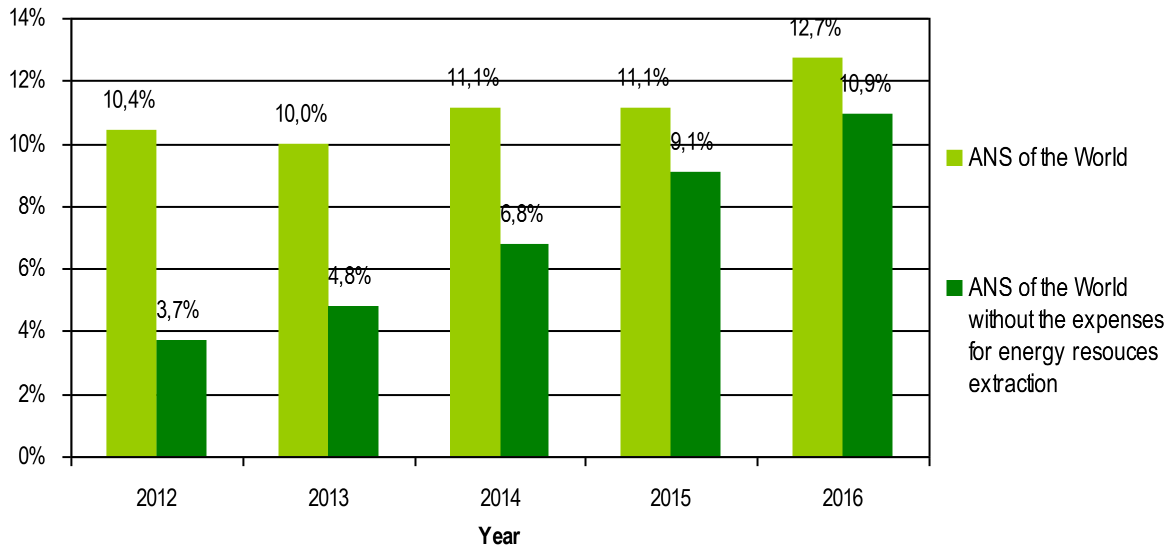
where *EE* – indicator of adjusted economic result per carbon dioxide emissions, USD per metric ton; *GNI* – gross national income at market prices, USD; *CD* – damages from carbon dioxide emissions, USD; *CE* – carbon dioxide emissions, metric ton.

Such methods are justified by the risks borne by carbon dioxide emissions from the consumption of energy resources, which is the main cause of the greenhouse effect.

3. Case studies

The processes of mineral and energy resource depletion have a significant difference. The difference lies in the fact that energy natural resources are consumed in the world on a much larger scale than mineral ones. Therefore, they are depleted more strongly.

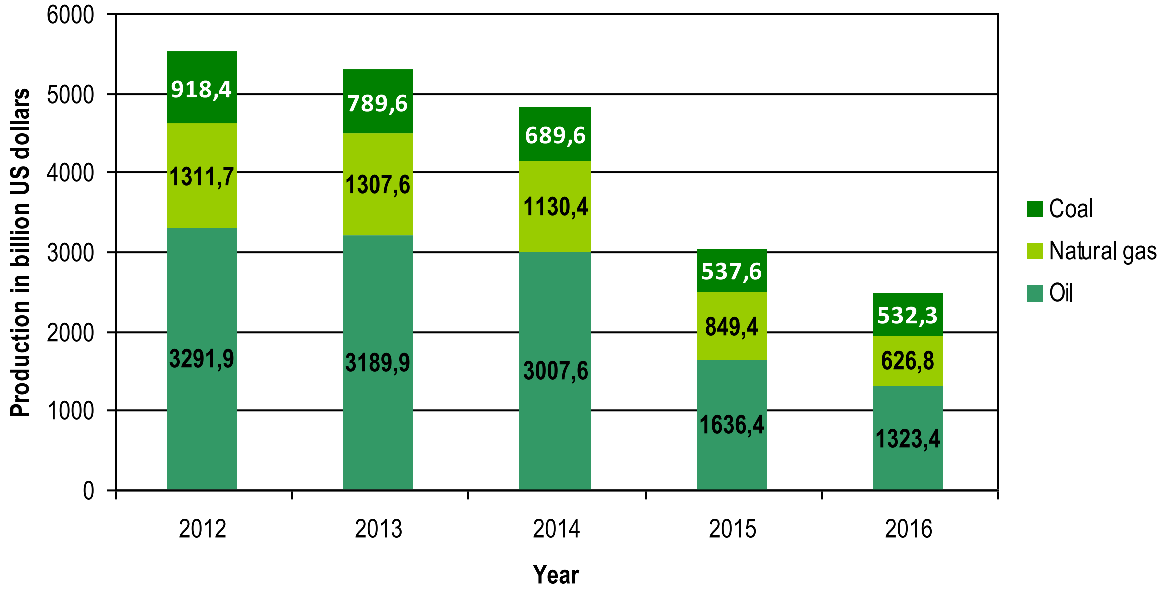
It should be noted that energy consumption is the basis of any economy. The nature and efficiency of the country's energy consumption, as well as its change over time, determine the country's sustainable development and show that it has green growth. Therefore, when analyzing the values of adjusted net savings, the main interest is the depletion of energy resources. We have made an analysis of adjusted net savings for the case of calculating depletion of energy resources without subtracting the expenses for their extraction and related costs (Figure 1).



Source: Calculated and constructed by the authors based at data from World Bank [19], [20], [21], [22], [23] and BP [3]

Figure 1 - Adjusted net savings of the World

Figure 1 shows that subtracting the expenses for energy resources extraction leads to significantly lower values of adjusted net savings. The average for this period is less than 4% of the *GNI*. This means that the wealth of nations is less saved and is lost more. It is noteworthy that the more distant the year in the past, the less adjusted net savings excluding the expenses for energy resources extraction. This is due to the fact that we made a calculation of the corresponding average annual prices for energy natural resources. A significant drop in prices affected the growth of the second variant of adjusted net savings. The value of the extracted natural resources around the world is shown in Figure 2. This cost is the result of the multiplication of the produced amount of coal, oil and natural gas by their respective average annual price. This is exactly reducing the adjusted net savings to significantly lower values, since it is adjusted energy depletion.



Source: Calculated and constructed by the authors based at data from World Bank [19], [20], [21], [22], [23] and BP [3]

Figure 2 - The cost of energy natural resources extracted throughout the world (adjusted energy depletion)

Adjusted energy depletion is the depletion of energy natural resources, taking into account all the expenses of their extraction. The cost of the total amount of extracted natural energy resources decreased each year that cause the growth of adjusted net saving of the World without taking into account the expenses of production. As it was mentioned, this is mostly due to a significant drop in world prices for oil, natural gas and coal.

Comparative analysis of the graphs in Figures 1 and 2 shows the conclusion that calculating adjusted net savings with subtracting the expenses for energy resources extraction gives a completely different idea of savings. This fact needs to be taken into account and it is undesirable to ignore. Therefore, we suggest when calculating and analyzing adjusted net savings to consider also the results without taking into account the expenses for energy resources extraction. This will allow conducting more qualitative analysis of the sustainability of development and assessing the progress of green growth.

The consumption of fossil fuels poses a big problem for society, since the environmental pollution that occurs as a result of burning occurs almost everywhere. Important consequences of the extraction and transportation of energy resources should also be added to this. Therefore, the reduction in the rate of depletion and consumption of energy natural resources as a result of the introduction of energy-efficient technologies and renewable energy makes it possible to achieve significant progress in green growth towards sustainable development.

It is necessary to evaluate the effects of the management of energy natural resources to describe the progress in green growth nowadays. For this purpose, the values of the *ER* indicators for the European Union countries, which are the largest consumers or producers of energy natural resources, as well as for Ukraine and the whole world for the last five years, have been calculated for 2012-2016 years. The results are presented in Table 1, in which the countries are ranked by the average *ER* indicator in five years in descending order.

Table 1 - Ranking of countries by the average value of the indicator *ER*, 2012-2016

Rank	Country	*ER* in thousand USD per ton oil equivalent					
		2012	2013	2014	2015	2016	2012-2016 (average)
1	Sweden	26,6	28,6	30,6	34,8	33,7	30,9
2	Denmark	22,9	23,1	24,8	27,3	26,2	24,9
3	France	21,2	21,4	23,3	23,8	23,1	22,6
4	Austria	16,6	17,1	17,8	18,5	17,7	17,5
5	Finland	15,6	15,5	16,3	18,2	17,9	16,7
6	Italy	15,2	16,4	17,2	17,1	16,5	16,5

7	United Kingdom	13,1	13,4	15,1	17,0	18,2	15,4
8	Ireland	14,7	14,6	14,7	15,5	15,9	15,1
9-10	Germany	13,4	13,4	14,3	14,9	14,7	14,1
	Spain	13,4	14,8	14,6	14,0	13,9	14,1
11	Portugal	13,0	12,7	12,5	11,7	11,9	12,4
12	Greece	11,1	11,0	11,0	10,7	10,9	10,9
13	Belgium	10,6	10,6	11,0	10,9	10,9	10,8
14	Netherlands	9,4	9,7	10,2	10,9	10,8	10,2
15	Slovakia	7,9	7,3	8,8	8,8	8,6	8,3
16	Lithuania	6,8	7,6	8,5	8,8	8,9	8,1
17	Hungary	7,6	7,9	7,7	7,7	7,6	7,7
18	Romania	5,6	6,8	6,8	7,3	7,6	6,8
19	Czech Republic	5,5	5,9	6,0	6,1	5,9	5,9
20	Poland	5,0	5,0	5,4	5,7	5,6	5,3
21	Bulgaria	3,3	3,9	3,7	3,8	4,1	3,8
22	Ukraine	1,2	1,4	1,9	2,8	2,3	1,9
-	World	5,2	5,5	6,0	6,5	6,7	6,0

Source: Calculated by the authors based at data from World Bank [19], [20], [21], [22], [23] and BP [3]

The results obtained in Table 1 show that the European Union countries have good results of *ER* indicators, as in most countries they exceed the values of *ER* indicators for the whole world taken as a reference base. Especially Sweden should be highlighted, the average *ER* in which for five years exceeds the *ER* for the entire world almost five times and is 30900 USD per ton oil equivalent. Denmark and France also should be mentioned, whose values of these indicators are above 20. The three countries mentioned above have a high *GNI* value per unit of consumed energy natural resource. In addition, in these countries there is practically no energy depletion due to the extraction of energy natural resources. In some other countries, the *ER* indicator decreases due to such production. The largest coal producers are Bulgaria, the Czech Republic, Germany, Greece, Poland, Romania, Ukraine. The largest producers of natural gas are the Netherlands, the United Kingdom, Ukraine. The largest producer of oil is the United Kingdom. In all these countries, large shares in the *GNI* account for the production of these energy natural resources, but in countries with large economies, such as Germany, the Netherlands, the United Kingdom, this is less affected by the *ER* indicator. The production of energy natural resources affects the decrease in the *ER* indicator more significantly in such countries as Bulgaria, the Czech Republic, Greece, Poland, Romania, Ukraine, which is reflected in their ranking in Table 1.

Let's analyze the situation in dynamics. This should show us whether the countries are moving in the direction of improving the value of the *ER* indicator. For the analysis, we apply the proposed consolidated dynamic index of the country's green growth efficiency based on the adjusted economic result for energy consumption I_{ER}. Calculation of indicator values has also been made over the past five years, i.e. for 2012-2016 years. A positive indicator value over five years will be the average value that is greater than 1. The calculation results are shown in Table 2.

Table 2 - Results of calculation of the index I_{ER} , 2012-2016

Country	I_{ER}					Result
	2012-2013	2013-2014	2014-2015	2015-2016	2012-2016 (average)	
Austria	1,015	1,033	1,032	0,937	1,003	+
Belgium	0,985	1,030	0,984	0,980	0,994	-
Bulgaria	1,164	0,942	1,020	1,057	1,043	+
Czech Republic	1,057	1,009	1,009	0,948	1,005	+
Denmark	0,994	1,065	1,093	0,940	1,021	+
Finland	0,979	1,044	1,108	0,964	1,022	+
France	0,995	1,081	1,014	0,951	1,009	+
Germany	0,985	1,059	1,034	0,967	1,011	+
Greece	0,976	0,992	0,966	0,998	0,983	-
Hungary	1,024	0,967	0,993	0,967	0,988	-
Ireland	0,979	0,999	1,047	1,005	1,007	+
Italy	1,063	1,041	0,987	0,945	1,008	+
Lithuania	1,101	1,110	1,028	0,991	1,056	+

Netherlands	1,017	1,044	1,061	0,971	1,022	+
Poland	0,985	1,072	1,048	0,963	1,016	+
Portugal	0,962	0,977	0,929	0,996	0,966	-
Romania	1,196	0,992	1,066	1,020	1,066	+
Slovakia	0,910	1,196	0,993	0,957	1,009	+
Spain	1,088	0,979	0,952	0,973	0,997	-
Sweden	1,059	1,062	1,129	0,949	1,048	+
United Kingdom	1,008	1,118	1,118	1,049	1,072	+
Ukraine	1,149	1,347	1,463	0,805	1,162	+
World	1,042	1,083	1,075	1,010	1,052	+

Source: Calculated by the authors based at data from World Bank [19], [20], [21], [22], [23] and BP [3]

The results show that most of the EU countries and Ukraine have positive growth rates of *ER* values. They have the importance of a consolidated dynamic index of the country's green growth efficiency based on the adjusted economic result for the energy consumption I_{ER} is greater than 1. With the continued growth rates, these countries have a good opportunity to achieve significant green growth progress due to the availability of potential. At the same time, countries that have high *ER* indicator values may need expensive investments.

In Belgium, Greece, Hungary, Portugal and Spain, the value of the I_{ER} indicator is less than 1, which means that the rates of consumption of energy resources are outstripping those of the economies of these countries. It should be also noted that for the whole world, the value of the indicator is greater than 1, which means that the world economy is outstripping growth rates in comparison with the rates of consumption and extraction of energy natural resources.

Particular attention should be paid to Ukraine, where the value of the I_{ER} index is also higher than 1. In this country, there has recently been a decline in economic growth, but the reduction in the consumption and extraction of energy resources has been faster. Intermediate values of the I_{ER} indices generally do not experience significant fluctuations and are very close to the average values. It should also be noted that for the year 2016 as compared to 2015, the values of the I_{ER} indices of most countries are less than 1, which is possibly due to an increase in the rates of consumption of energy natural resources due to a drop in prices for them.

Since carbon dioxide, which is one of the main greenhouse gases, is formed as a result of the consumption of energy resources, this should put some restrictions on countries. Otherwise, all this can lead to a multiple increase in the natural greenhouse effect and, as a result, make temperature changes, as well as other consequences for the Earth, an acute problem. At the moment, the management of CO2 emissions from the consumption of energy resources has become one of the most important aspects of the climate policy of most countries. In order to assess the effects of management, the values of the *EE* indicators for the countries of the European Union, Ukraine and the whole world have been calculated for the last five years, i.e. for 2012-2016 years and are presented in the form of table 3. The initial values used indicators per capita.

Table 3 - Ranking of the EU Countries and Ukraine by the average value of the indicator *EE,* 2012-2016

Rank	Country	*EE* in USD per metric ton					
		2012	2013	2014	2015	2016	2012-2016 (average)
1	Sweden	9433	11293	10001	11000	11175	10580
2	France	7161	7555	7453	7751	8239	7632
3	Denmark	7051	7228	7193	7410	8498	7476
4	Austria	5786	6490	5975	6279	6339	6174
5	United Kingdom	4474	4886	4853	5256	6091	5112
6	Italy	4804	5252	5162	5142	5141	5100
7	Germany	4466	4894	4943	5172	5327	4960
8	Spain	4390	4890	5039	5142	5047	4902
9	Belgium	4658	4764	4462	4614	5348	4769
10	Ireland	4204	4190	4424	4877	5869	4713
11	Netherlands	4605	4801	4354	4622	5115	4699
12	Finland	4468	4756	4031	4225	4729	4442
13	Portugal	4106	3937	4118	4234	4525	4184
14	Latvia	3507	4420	3886	4227	3993	4007
15	Cyprus	3705	3907	3710	3581	3915	3764
16	Luxembourg	3560	3774	3336	3245	3614	3506
17	Malta	3065	3083	3162	3364	3480	3231

18	Lithuania	2538	3396	3121	3366	3404	3165
19	Slovenia	2792	3127	3024	3076	3124	3029
20	Greece	3078	2896	3059	2889	2981	2981
21	Croatia	2601	2743	2850	2835	2684	2743
22	Slovak Republic	2421	2550	2547	2638	2763	2584
23	Hungary	2362	2578	2413	2580	2702	2527
24	Romania	1764	2180	2175	2301	2247	2133
25	Czech Republic	1577	1796	1674	1753	1744	1709
26	Poland	1479	1567	1505	1575	1628	1551
27	Estonia	1043	1262	1171	1268	1338	1216
28	Bulgaria	932	1166	1120	1207	1117	1108
29	Ukraine	409	511	510	580	545	511
-	World	1869	2004	2064	2160	2184	2056

Source: Calculated by the authors based at data from World Bank [19], [20], [21], [22], [23] and BP [3]

The results presented in Table 3 show that almost all the European Union countries have good values of *EE* indicators, as they exceed the values of *EE* indicators for the whole world, taken as a basis for comparison. In addition, the results are generally consistent with the positions that most countries occupy in Table 1. This is due to the fact that *ER* and *EE* indicators are closely interrelated. The first place, as for Table 1, has Sweden with the largest average indicator value of 10580 USD per metric ton, which proves its high level of green growth. Further in the ranking are the same countries as in Table 1. This is France, Denmark, Austria. In these countries, the average values of *EE* exceed the global *EE* by approximately 3 times, which is also a good result. Unfortunately, countries such as the Czech Republic, Poland, Estonia, Bulgaria and Ukraine have average indicators less than the global average, which is not a positive development especially considering the fact that these countries, except for Estonia, close the rating by the average value of the indicator *ER*. These countries need to pay special attention to their green growth.

Indicators *ER* and *EE* are closely interrelated, but not identical. CO2 emissions mainly result from the burning of fossil fuels, but as it replaces alternative energy, the link between energy consumption and CO2 emissions is weakening.

Conclusion

Comparative analysis of adjusted net savings without subtraction and subtracting the expenses for energy resources extraction shows a difference of 4% of gross national income for the World in 2012-2016. Subtracting production expenses significantly reduces the adjusted net savings and this needs to be taken into account. Such an approach may have a continuation for studies in the form of studying missed opportunities. Investments in the production of energy natural resources are not investments in sustainable development and green growth, since they cannot contribute to the resumption of exhaustible resources. From this point of view, extraction expenses can be considered in future studies as missed, since an appropriate alternative could be to invest in the development of alternative energy.

The results of the research on the effects of the management of natural energy resources show that, in the countries of the European Union, adjusted energy and carbon efficiencies are mostly positive, as the values of indicators exceed global values. At the same time, the relationship between carbon efficiency and energy efficiency in the countries surveyed continues to be close. The analysis of the changes in time also showed positive results, according to which the adjusted energy efficiency in most countries of the European Union is growing. Prospects for future research in this area are to analyze the changing nature of the relationship between energy consumption and carbon dioxide emissions. This relationship with the development of the alternative energy sector in the future and the reduction in the consumption of energy resources will be weakened, which is already of research interest. In this regard, the future work is to explore new opportunities to make significant progress in green growth towards sustainable development.

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