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Energy Productivity of Resources and Transformation of the Economic Development System

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ABSTRACT

As is known, the basis of the economic development system is natural resources, especially energy resources, with the help of which energy is produced for the production of materials and various products. The energy efficiency of natural resources is usually determined by the energy productivity of the resources used. With the increasing demand for the consumption of energy resources as energy sources, there is a need and demand for assessing their energy productivity or potential. At the same time, discussions continue on the effectiveness of a particular economic development system. Most often, we are talking about the transition and use of the "green economy" system, which involves the use of renewable energy sources with the expectation that they will create a minimum amount of emissions into the atmosphere. While the physical or hydrogen economy, also based on the main goal of environmental protection and economic development, assumes the use of traditional natural fuel resources, which, depending on the need and the level ("value") of the materials and products produced, taking into account the energy productivity of resources, are divided into primary and secondary resources. For each technology that uses different resources, there are many methods that can be used to analyze their energy potential or energy productivity.

Keywords: green economy, physical economy, primary resources, secondary resources, energy potential of resources

INTRODUCTION

So much has been written about the transition to a green economy that many people think that this is the real path that all countries in the world should take at the present time. But is this really so? One of the features of such a wide range of publications on the green economy is the broad involvement of politics, or rather politicians, in the process of decision-making and the development of proposals in economic development and economic management. In other words, economic science is "going through" a stage when not economists, but politicians have begun to determine the content of economic research, "cleverly" combining almost all issues of modern economic development into the "content of green economics." The green economy is not a system, not a path, but another opportunity to change the perception of the economy and society as a whole of the problem of subordination of the main components of economic development and environmental protection. The level of subordination of the named main components of such a system depends to a large extent on the level of economic achievements of a particular country. Therefore, proposals to "involve" all countries of the world on the path of "green economy", even taking into account the "certain impact" of the economies of the countries of the world on the state of the climate, should be perceived as important, but still as a proposal made in recent years. It is important to consider the following: not all countries in the world are "ready" to transition to a "green economy", which depends on the level and dynamics of economic development of most developing and poor countries in the world. Moreover, it is much more important not only to take into account emissions from the use of carbon-based resources, but also to motivate and coordinate the efforts of countries around the world to develop and implement technologies to "clean up such emissions." Humanity and international institutions cannot completely cancel and abandon the use of carbon raw materials for the economic development of most countries, but they can and should support the efforts of countries to develop, use and widely use "clean up" technologies for emissions [1, 2021].

The use of the concept of a physical or hydrogen economy system is an opportunity for a broader use of the concept of a circular economy system, in terms of the repeated use of natural resources, when these resources are considered as differentiated groups of sources for the production of various materials and products, depending on the state of the resources. In this case, natural resources can be classified in terms of their primary and secondary use. The differences between such resources are in the energy efficiency of such resources, which can and should be used for the production of various products. Moreover, such differentiation of resources will allow a different approach to the production of one or another product from the point of view of rationality and profitability of

the resources used. Primary resources should not be used for the production of some materials and products. In this case, secondary resources may be the most suitable, depending on the nature and importance of the materials or products being produced. Thus, the purpose of the study is to assess the energy potential of the resources used for comparability and targeted analysis.

Materials and Methods

Natural resources used to produce various materials and products can be considered from different points of view. In our case, the content of the resources used will be considered from their energy component. As is known, in the open press about the use of energy resources, the conversation most often concerns hydrocarbon resources (coal, oil, gas, peat, oil shale). At the same time, the most powerful sources of energy among the existing and used resources should be recognized as the sun and water.

However, unfortunately, I will note right away that despite such a statement, humanity still uses a limited number of the named types of energy. To a certain extent, this is apparently due to the fact that the potential of such resources cannot always and everywhere be used directly, which is largely due to certain limitations in the technology of their use. Moreover, in most cases, the level and volume of use of these resources is much lower than coal, oil and gas, which are considered traditional and main "pests" of the environment. I believe this is due to the fact that the named resources cannot always be used "directly", but indirectly, with the help of certain technologies, which, unfortunately, have also not been developed to their logical conclusion. It should be noted that in this regard, the process of determining and calculating the prospective use of energy resources is known as potential analysis, although there is still no single definition of the term potential analysis for its differentiated use in the future. This is a future-oriented process based on possible, but not yet used potential.

Solar energy or solar radiation energy is currently used with the help of solar cookers, which have a number of disadvantages. They relate not only to the problems of distributing solar panels that receive and convert solar radiation into energy, but also to the safe and long-term use of such structures that cannot, for example, function actively on cloudy days and at night. As for water energy, in addition to traditional hydroelectric power plants, which cannot be built anywhere, but also the enormous energy potential of sea waves and tides, which humanity, unfortunately, uses very limitedly, the experience and achievements in using water as an energy source are also very limited, i.e. also not widely distributed.

Here we return again to the issue of the need to develop technologies for the use of various types of traditional resources as energy sources for production. The use of various types of natural resources for the production of materials and products using energy obtained from the resources used requires that they be classified as primary and secondary resources. This is not a new approach, but in this case, we are talking about their differentiated use within the framework of the circular economy model.

It is clear that primary resources have greater energy potential in comparison with secondary resources, since the latter have already “spent” the available energy on the production of materials or products (heat, etc.). In this regard, let us turn to the data presented in Table 1. As we can see, renewable resources, which include the sun, wind, water and, to a certain extent, geothermal heat, do not have significant energy potential. On the contrary, a secondary resource, to which biomass can rightfully be attributed, has enormous potential, compared to the previous ones, both in theoretical and practical terms, exceeding the energy productivity of water and geothermal heat by almost 10 times.

Table 1. Current use, technical and theoretical potential of renewable energy sources [3, 2000].

Resource type	Current Consumption, PWh/a	Current Potential, PWh/a	Theoretical Potential, PWh/a
Sun	0.02778	>43.50	1.08·106
Wind	0.03333	177.78	1.66·103
Geotherm	0.17	1.39·103	38.89·103
Water	02.50	13.89	40.83
Biomass	13.89	>76,67	805.56
Total	15.56	>2.11·103	>40.00·106

In comparison with the above, in general, hydrocarbon resources, which mainly consist of coal, oil and natural gas, are highly flammable and, when burned, release carbon dioxide, water and heat, which determines their significant potential as a highly efficient energy source. In general, hydrocarbon resources have enormous, both technical and theoretical energy potential. On the other hand, if we turn to the reserves of these resources, their volumes, especially coal reserves on our planet (2, 2023), are quite sufficient to ensure stable economic development of almost all countries in the world. However, these resources appear to be the main pollutants and an assessment of their energy productivity leads to the conclusion that their widespread use may be limited due to various environmental problems.

Increasing the efficiency of use and transition to more environmentally friendly types of energy can help reduce the negative impact of emissions from the use of these resources.

Despite the obvious, practically unlimited potential of their energy productivity, the absence or weak development of technologies for cleaning emissions from the use of hydrocarbon resources is assessed as a source of their negative impact on the environment. On the other hand, in recent years, there has been a growing "popularity" of fossil fuel energy, which is caused by uncertainty about the political support for the transition from fossil fuels to clean energy. All of this ultimately has an "alarming effect" and, to a certain extent, suppresses the energy market. Support for measures to reduce fossil fuels is also under pressure in some European markets.

The process of decarbonization and green economy is characterized by significant pessimism. Companies that supported clean energy production are facing enormous problems and capital outflow, which is moving into the sphere of fossil energy sources. In the current conditions, there is a sharp drop in the energy transition index, which is estimated by experts as very significant in the global clean energy market.

One of the possible ways of using hydrocarbon resources is the decision on the need to develop and widely implement technologies for "reducing" harmful emissions from their use into the atmosphere, as well as the use of secondary resources for the production of some products and materials that do not require large expenditures of energy resources. This makes it possible to reduce the profitability of manufactured products and materials, and at the same time, to preserve primary resources and energy costs for their extraction and use, reducing as much as possible the negative impact on the environment. It is no secret that hydrocarbon resources are very important for the development of the modern economy, accounting for more than 80% of global energy consumption [3, 2020], although in fact the role of hydrocarbons in the economy is actually significantly underestimated, since they are used in a wide range of applications beyond their use as an energy source. For example, these resources ensure the production of many derivative materials that play a critical role in the global economy, such as plastics, solvents and lubricants, etc.

Results and Discussions

It has been established that different approaches, strategies and technologies are used in relation to the assessment of the energy potential of natural resources and their consumption, which reduces the possibility of comparability and target analysis. In this regard, let us turn to the data on changes from year to year in energy consumption by sources. Let us turn to the following diagram (Fig. 1). So, global energy consumption is not standing still, it is growing. And in recent years it has grown too fast for renewables and nuclear power to keep up. The chart shows the primary energy consumption in absolute terms for each source. Overall, energy production from fossil fuels – especially coal, oil and gas – continues every year.

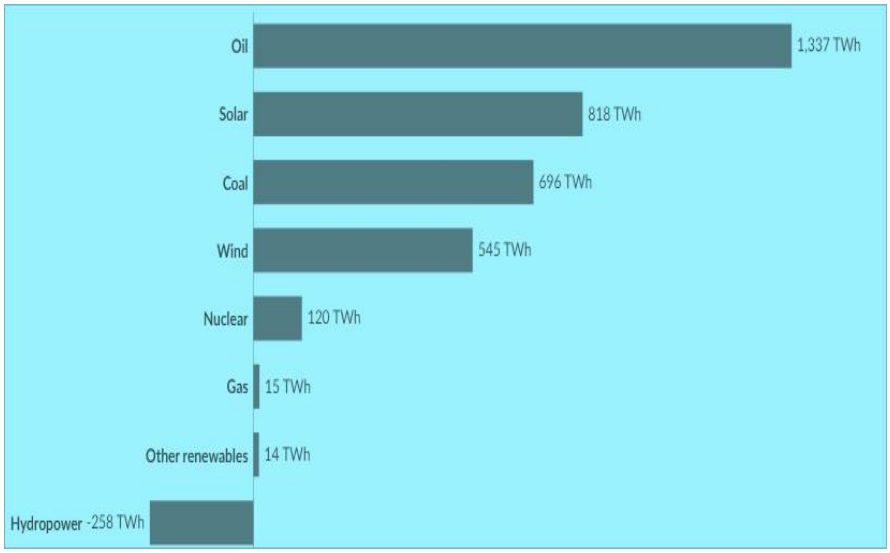

Figure 1. Annual change in primary energy consumption for one year relative to the previous year. (Energy is measured in terawatt-hours) [7, 2024].

At the same time, one can also note a certain growth in low-carbon energy based on renewable energy sources (see Fig.2).

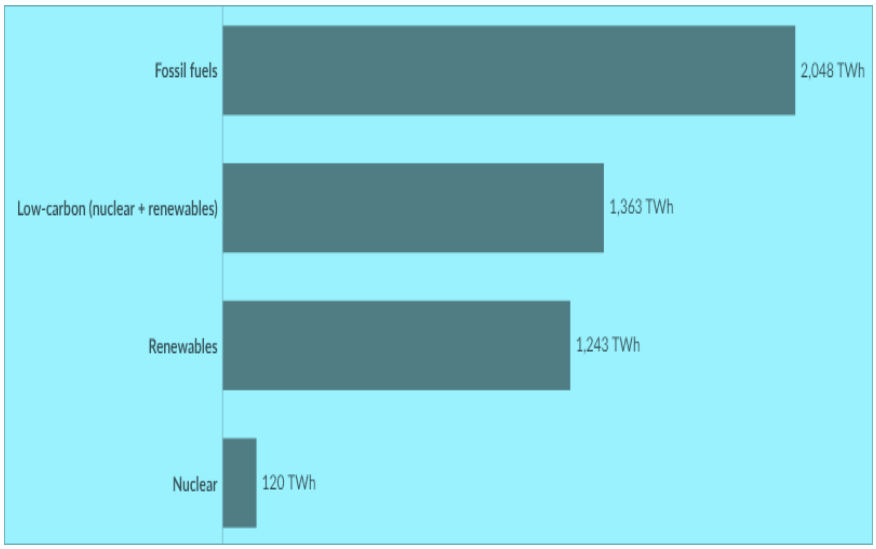

Figure 2. Annual change in primary energy consumption from fossil fuels relative to low-carbon energy, world, 2023. [7, 2024].

As we can see from the diagram, fossil fuels, consisting of coal, oil and gas, are the largest source of energy and consumption, but also of global carbon dioxide (CO^2) emissions. Oil is currently the largest source of energy in the world. It is the dominant source of energy, in particular, for the transport sector. At the same time, there is a rapid consumption of natural gas, which is used as a replacement for coal in the energy balance, although some restrictions on its use are not always justified economically, but are the basis of political decisions. Gas is currently the main supplier of electricity and a key source of heat, especially in developed European countries.

However, against this backdrop, we are still fooling ourselves by looking at this progress through the lens of what proportion of energy used is low-carbon. Part of the reason for this slow progress is that much of the gains in renewables have been offset by the decline of nuclear power. Renewables have grown while nuclear power has declined. This is even more obvious when you look at global electricity production: nuclear power has declined almost as much as renewables have grown. Renewables have grown while nuclear power has declined. This is even more evident when you look at global electricity production: nuclear power has declined almost as much as renewables have grown. Overall, we can see that decarbonization is happening, but not fast enough. To make the necessary progress for the climate, we need its growth not only to meet our new energy needs each year, but also to begin to displace existing fossil fuels from the energy mix much faster (5, 2025).

The solutions to the set tasks require the need to develop new technologies for obtaining energy, which can rightfully be the use of hydrogen. Hydrogen is considered one of the most promising sources of energy for transport, electricity production and even space flights. It is no coincidence that it is called the fuel of the future, since it is characterized by a high level of energy potential and is practically inexhaustible. However, the problem with its use is that it is highly explosive and requires special storage and transportation technologies.

A team of researchers from the GRT Group and the Federal Polytechnic School of Lausanne (EPFL) in Switzerland has developed the world's first formic acid fuel cell, called HYFORM-PEMFC. This innovative fuel cell converts formic acid into electricity, offering a new approach to storing hydrogen and producing energy. A method has been developed in which a process converts formic acid into hydrogen gas, while a second reaction reverses the process and restores pure hydrogen (4, 2012).

The two chemical reactions – hydrogen to formic acid and back to hydrogen – are catalytic: the advantage is that nothing is lost in the conversion, and the process can therefore be used to create sustainable devices, for example to produce electricity at night. This problem was successfully solved by Swiss scientists under the leadership of Professor G. Lourenzu (6, 2018). Another possible application of this technology could be the use of atmospheric CO^2 to synthesize a number of useful chemical products.

In conclusion of the discussion of the problem of assessing the energy potential of the resources used in terms of their energy productivity, I would like to draw attention to the following conclusions regarding the results of the study. The lack of a unified methodology for assessing the energy productivity of resources does not allow for a more detailed assessment of the comparability of the energy potential of various types of resources. Hence, the production of materials and goods does not allow for a clear definition of which resources should be used in the production of certain products. These circumstances underlie the transformation

of the economic system, which should equally take into account the costs of not only production, but also consumption. Such studies are certainly important and require continuation.

In addition to the above, I would like to address the following questions, which, at first glance, may not have a direct connection with the subject of the problem under discussion, but may contribute to the expansion of our ideas and may be useful in developing general concepts about the content of economic science at the current stage of its transformation. Let us begin with the fact that at the heart of almost all existing systems of economic development is the basic idea of production and consumption. In this construction, more attention, and hence the main concepts in the structure of economic development, is always or almost always given to the production stage and much less to consumption. Although, strange as it may seem, it is consumption, not production, that is the visible and invisible reason for the significant volume and scale of production in the use of a huge amount of natural resources.

It is the growth of consumption, as a sign of growth of economic development, that seems to be an indicator of sustainable economic development. However, at present a paradoxical picture is being discovered in the area of consumption: on the one hand, in developed countries the level of consumption significantly exceeds the need and costs of production of everything, including food products, at the same time, as in developing and poor countries there is a deficit of products and materials for sustainable development. For developing and poor countries, which make up the majority of countries on our planet, the implementation of sustainable development goals, in the context of limited use of available natural resources, primarily hydrocarbons, reveals the problem of not only following the principles of sustainable, but also adaptive development. These countries have no other opportunity to organize economic development than the use of hydrocarbon raw materials and, in the absence of emission purification technologies within the framework of the adaptive development strategy, they do not always follow the course of promoting the reduction of emissions of polluting elements into the atmosphere.

Thus, the task of rational use of natural resources, within the framework of economic development of countries are solutions to problems of control over the level and scale of consumption, profitable production taking into account the energy productivity of the resources used. Sustainable development presupposes not only economic growth, but also environmental protection. However, the search for solutions to such a complex problem should not be based on the principle of either economic growth or environmental protection.

Against this background, global climate change is associated not only with the development of greenhouse gases, but also with the cyclicity of climate processes. It is precisely cyclicality as a basis on which other changes in the natural environment are superimposed, including those resulting from anthropogenic activity, that requires comprehensive and detailed research. In this case, the analysis and assessment of energy productivity and energy potential of natural resources in the course of their use should be correlated with the volumes of production of consumer goods and the development of innovative technologies for energy production, economic efficiency and profitability of produced materials and products of production and the reduction of the harmful impact on the environment of both traditional and renewable resources as energy sources.

Conclusion

The energy productivity of a resource is the most important indicator of the energy potential and use of the resource, since the technologies for obtaining energy from a resource depend on a certain type of resource. Energy production technologies are also associated with the technology of "cleaning" emissions from technologically imperfect mechanisms of traditional use of the resource. Naturally, in this case, the most important aspect of using a particular resource to obtain and use energy from the resource is its close relationship with the cost price of the resource. It is these indicators of the energy potential of the resource and its cost in the energy markets that are the most important factors determining the availability and cost price of energy goods and services.

The cost price of hydrocarbon energy is generally lower today than the cost price of production and use of renewable energy sources. This is explained by at least two things: 1) the imperfection of the technology for using renewable resources and 2) the problem of the efficiency (duration) of using renewable resources and the disposal of structures used for such use. It is clear that energy resources do not represent an inherent constraint to meeting the rapidly growing global energy demand as long as adequate investment is made upstream - for exhaustible resources in exploration, production technologies and capacities (mining and development of deposits) and, by analogy, for renewable energy sources in conversion technologies. However, along with this, it is necessary to develop and implement innovative technologies for "cleaning" emissions from the use of hydrocarbon raw materials. Proposals by developed countries to reduce emissions that contribute to the formation of greenhouse gases do not always seem to be effective in comparative terms, since they have a one-sided effect on developed countries, but can create certain difficulties in energy use and economic development for developing and poor countries of the world.

I believe that the time has come to reconsider the concept of energy productivity of various resources for the purpose of energy production and use, taking into account production and consumption within the framework of the transformation of economic development systems. Such an approach within the framework of a physical or hydrogen economy will allow countries to concentrate their efforts not only on the use of both hydrocarbon and renewable energy sources within the framework of innovative technologies for the use and "cleaning" of harmful emissions into the environment, but also to ensure profitability and "reasonable" cost in the production and use of energy.

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