Problems and prospects of green energy

Larisa Kapustina, Mushfig Agababayev, and Andrei Drevalev

Ural State University of Economics, Ekaterinburg, Russia

Abstract. The article considers problems in green energy development focusing on wind and solar power, identifies the effects of the production and use of electric vehicles. The authors analyze global value chains in green energy and highlight China's dominant role in extraction and processing of raw materials, as well as production of wind turbines, solar panels and lithium-ion batteries. The green energy sector faces several challenges, including underdeveloped infrastructure for clean energy transmission, high costs and large area requirements of wind and photovoltaic power stations as well as the environmental impact of raw materials extraction and equipment disposal.

The global energy transition brings losses to fossil fuel-producing countries and traditional vehicles manufacturers. Cost intensive green energy projects are not available to many developing countries. The green energy prospects depend on technological advancements in renewable energy storage and transmission, as well as recycling of lithium-ion batteries and wind turbines. The authors propose promoting blue and green hydrogen production during the transition period to create a compromise for the interests of key stakeholders in the global green energy value chain.

Taking into account the identified problems, transition to green energy as the dominant energy system can take from 30 to 60 years.

1 Introduction

The relevance of the study is associated with the need to slow down global warming and climate change caused by the greenhouse effect due to carbon dioxide emission into the atmosphere. In this regard, an international goal to achieve carbon neutrality by 2050 has been set at the intergovernmental level. Wind and solar energy as well as the production of electric vehicles have been developing rapidly in recent decades. Worldwide, capital expenditure on wind and solar assets grew from $357 billion in 2021 to $490 billion in 2022. As a result, the share of renewable energy sources in global electricity consumption reached almost 30% in 2022. It is forecasted to increase to 40% by 2050, which will lead to a reduction in coal and oil consumption. At the same time, the prospects for achieving the sustainable development goals are linked to solving a number of problems caused by the fourth energy transition in the global economy.

Scientific and technological progress in the production, storage and delivery of environmentally friendly energy to consumers is getting the primary role. However,
Coordination of the efforts of many countries is required for the technological breakthrough in the field of green energy. In this regard, it may be useful to study global value creation chains in the process of production and consumption of renewable energy in order to identify problems and solve them with a joint effort at the intergovernmental level.

The study aims to identify problems in the global green energy development and to determine the prospects for solving them based on the analysis of value chains in the process of production and use of clean energy.

2 Problems of green energy development

Carbon dioxide emissions into the atmosphere have increased by more than 60% over the past three decades [1]. Resolving the conflict between economic growth and reducing CO2 emissions is vital for sustainable development, with international trade allowing greenhouse gas emissions to be redistributed between countries. The most important problem is the high cost of clean, environmentally friendly energy and green technologies. Companies among the pioneers of green energy have been noted to go bankrupt. The green energy infrastructure is still underdeveloped. High-income countries benefit from projects implementing renewable energy sources to a greater extent. The richest 10 per cent of the global population accounts for 48 per cent of total emissions. Governments and companies in developed countries need to make efforts to interest their potential business partners from developing countries in sustainable development and green energy [2].

Another problem is that the interests of fossil fuel producers hinder the development of national industrial policies aimed at the introduction of green energy and the use of renewable energy sources [3]. It should also be taken into account that traditional producers of automobiles are reluctant to lose and abandon their core competencies in the internal combustion engine technology [4]. At the same time, compared to traditional cars, the increase in production and sales of electric vehicles in the last decade is associated with a reduction in their prices. However, this trend does not completely solve environmental problems.

Economic growth often comes into conflict with environmental preservation, resulting in different interests of countries of varying income levels regarding the global energy transition. Industrial companies engaged in production of equipment for green energy at the same time contribute to air, water and soil pollution as a result of their production activities.

There is no consensus in scientific literature on the impact that enterprises from developing countries involved in global value chains have on the dynamics of energy consumption and emissions of pollutants. Some scientists argue that the environmental impact of developing countries is increasing as they are more actively integrated into the global economy. Since raw materials for green energy are located mainly in developing countries, they are increasing their negative impact on the environment by expanding production. Others believe that these countries can reduce greenhouse gas emissions of the expanding industrial production by adopting environmentally friendly technologies of green energy from developed countries. In particular, integration of Chinese companies into global value chains has led to the adoption of management practices from developed countries and elements of sustainability-oriented business models which resulted in the growth of green innovation [5]. Globalization facilitates the transfer of environmentally friendly technologies to developing countries promoting green energy. Participation in the global value chain encourages companies to invest in green technologies and reduce environmental pollution [5].
In order to achieve carbon neutrality by 2050 and provide electricity to the increased fleet of electric cars, six times more natural resources will be required than the currently consumed amount. Table 1 presents global value chains in green energy.

Table 1. The global value chain in green energy

<table>
<thead>
<tr>
<th>Renewable energy sources</th>
<th>Extraction of raw materials</th>
<th>Processing of raw materials</th>
<th>Components</th>
<th>Assembly</th>
</tr>
</thead>
</table>

The shift to renewable energy brings about an increase in the extraction of many mineral resources and higher energy costs, as well as soil degradation, and environmental pollution. The deposits of many minerals and rare earth elements are distributed less evenly around the globe than oil, gas and coal, which leads to their increased supply from a limited number of countries. China’s position in the field of green energy is regarded as the strongest. It accounts for 66% of global production of lithium-ion batteries, which are used in electric vehicles and other electronic equipment; 89% crystalline and amorphous Si cells and wafer; 56% nacelles and blades used in renewable energy production. Thus, PRC secures a monopoly in raw material extraction and processing for the production of renewable energy. New opportunities for economic development and geopolitical influence arise for countries producing uranium, lithium, cobalt, copper, and rare earth elements.
Africa and Latin America show their potential in the development of green value chains. Therefore, when implementing a strategy for decarbonizing the global economy, it is crucial to find solutions that could balance the interests of different groups of countries. Blockchain technology can provide a secure platform for tracking the production and consumption of renewable energy and thus enable transparent energy trading [8].

Each type of renewable energy has its drawbacks. Wind energy is associated with the following problems: environmental pollution in the process of blades disposal, soil corrosion, high equipment cost, large land allocation requirements for wind stations, weather dependence of electricity generation, inability to store energy, remoteness from energy consumers and the resulting need to construct additional power lines, and finally disruption of bird migration. As concluded from Table 1, in the field of wind energy, China accounts for 54% of the raw materials extraction, 41% of the primary processing of raw materials and 56% of the world production of wind turbine components. Consequently, the environmentally harmful production in the value chain is located in developing countries, while the production of wind farms is predominantly concentrated in the European Union - 58%.

As for developing countries, in order to install wind power plants, they have to buy turbines from developed countries, as well as China, which accounts for 23% of world production (Table 1).

Solar energy faces the following challenges: environmental pollution during silicon extraction and solar panel disposal, high equipment costs, large area of solar stations, dependence on sunny weather, lack of energy storage technologies, and economic inefficiency in countries with cold climate. China possesses the world’s biggest production capacities for the raw materials extraction and processing, as well production of solar panels and stations.

The electric vehicles industry deals with the following issues in the scope of manufacturing and disposal of products: environmental pollution during lithium mining and lithium-ion batteries recycling, high energy costs for the production of an electric vehicle. The market can also be characterized as concentrated with China accounting for 32% of the global primary production of raw materials for electric cars and 66% of the global production of lithium-ion batteries (Table 1).

It should be noted that despite these challenges, the prospects for green energy are promising.

3 Prospects for green energy

- accelerated development of infrastructure for the renewable energy production and transmission;
- integration of digital technologies in the energy sector;
- global transition to green energy is forecasted to occur within 40-50 years, with constantly increasing demand for solar and wind energy, as well as for natural gas as more environmentally friendly source of energy compared to coal and oil [9].

While renewable energy technologies are advancing rapidly, it will still take decades to restructure the global energy system and make clean energy prices competitive with fossil fuels. The green innovation value chain provides a possible framework for determining the prospects for the diffusion of clean technologies through comparisons, in environmental and financial terms, with traditional alternatives at individual points in the chain [10].

The concept of an “impossible triangle” in green energy development reflects the contradictions between three goals: achieving economic growth, ensuring energy security, and benefiting from the global energy transition [11]. The following key trends can be identified in the development of the global energy market:

- accelerated development of infrastructure for the renewable energy production and transmission;
- integration of digital technologies in the energy sector;
increasing sales of equipment and technologies that facilitate the decarbonization of the economy;

- constant progress in technology and cheaper green energy;

- demand for fundamentally new innovative solutions for the green energy;

- achieving carbon neutrality through energy-saving measures and increasing energy efficiency,

- enhancing the price competitiveness of renewable energy;

- search for management strategies and practices that can simultaneously drive profit growth and support sustainable development goals;

- priority development of urban green energy solutions to reduce CO2 emissions.

Hydrogen can potentially become an important segment of the energy market in the future. The use of hydrogen reduces the environmental impact. The advantages of hydrogen energy solutions include the possibility of its long-distance transportation, accumulation and storage capabilities, thus addressing corresponding problems of the wind and solar energy. In this regard, the hydrogen economy is able to provide electricity to large and small consumers and export surpluses to other countries. It is also important that the shift to renewable energy decreases revenues of fossil fuel suppliers. Therefore, hydrogen energy could potentially offer a global transition scenario that balances the interests of exporters and importers of fossil fuels, developed and developing countries. It is considered that gas infrastructure and gas pipelines can be repurposed for hydrogen thus supporting decarbonization of the economy and improving energy supply to a wide range of consumers.

It should be noted that while technological challenges associated with the production and consumption of hydrogen still exist, collaboration among the participants of the value chain could effectively resolve major problems, which will result in lower market price of hydrogen, comparable to fossil fuel prices.

The value chain of hydrogen is presented in Table 2.

<table>
<thead>
<tr>
<th>Energy and feedstock</th>
<th>Hydrogen production</th>
<th>Hydrogen packing</th>
<th>Transportation</th>
<th>Hydrogen unpacking and Storage</th>
<th>End-uses</th>
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<tbody>
<tr>
<td></td>
<td>Green Hydrogen</td>
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<tr>
<td></td>
<td>Blue Hydrogen</td>
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As evident from Table 2, green hydrogen is produced by electrolysis from solar, wind and geothermal energy, while blue hydrogen is derived from biomass, coal, natural gas, and oil. Ammonia, methanol, and hydrogen are transported using appropriate ships and tankers, as well as pipelines. Thus, hydrogen energy is versatile in meeting the energy demand of a wide range of consumers.
An increase in R&D in the field of hydrogen energy is required, in particular to develop fuel cells alongside with the promotion of fuel cell vehicles in the market. Balancing prices of different types of fuel can be achieved through the introduction of a CO2 emissions tax.

4 Conclusion

The primary challenges for green energy are associated with the underdeveloped infrastructure of energy transmission from wind and solar power plants, the need for substantial investments in the construction of renewable energy facilities, new power transmission lines and the development of energy storage technologies, particularly increasing the capacity of lithium batteries and their recycling. From a corporate perspective, green energy is seen as a business with high financial risks. The interests of different countries vary. In particular, least developed countries prioritize economic problems while oil, coal and gas exporters are interested in slowing down the transition to green economy in order to maximize the return on their investments in developing the fossil fuels extraction and processing industries. In this context, the development of hydrogen energy, as a compromise solution for the transition period, could balance the economic and political interests of most countries, providing the most attractive option for all the participants of the global value creation chain. The transition period leading to green energy becoming the dominant energy system can take from 30 to 60 years due to the high degree of uncertainty regarding the pace of improvements in energy efficiency and the time line for developing new production, storage and transmission technologies in the field of renewable energy.

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