



# Green Trend in Global Energy Development: Tendencies and Opportunities

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## ABSTRACT

The actualization of global environmental problems necessitates transformational changes in the global energy sector. The intensification of global trends toward decarbonization leads to alteration in the energy sector. The sustainable development of the renewable energy sector is driven by the greening of global development and will be long-term in nature due to a progressive reduction in its cost and the achievement of stable energy efficiency indicators. The intensive growth of the renewable energy sector is primarily supported by government financial support as part of sustainable development strategies. Various forms of state support for projects for the development of alternative energy sources are used in achieving targets for the potential of renewable energy sources at the national level. Its role gradually decreases as the degree of maturity of alternative energy is reached. Further development of energy policies at the national level will take place in the increased use of market support instruments.

**Keywords:** Global Energy, Sustainable Development, Renewable Energy Sources, Green Economy, Decarbonization, Energy Policy

**JEL Classifications:** O13, P28, Q42, Q56

## 1. INTRODUCTION

Currently, climate change issues act as one of the main trends predetermining global economic development for the coming decade (Brechet et al., 2016; Carattini et al., 2019; Chan et al., 2018; Barrett, 2020; Chen et al., 2018).

The environmental trend is about meeting people's current needs without compromising the next generations and the planet's ecosystem, and is supported by the need to implement the 2030 Sustainable Development Goals, which are integrated through the various dimensions of sustainable development: social (Goals 1-5, 10), environmental (Goals 6, 13-15), economic (Goals 7-9, 12) and institutional (Goals 11, 16, 17), and the Paris Agreement on Climate (Sustainable Development Goals, 2015; The Paris Agreement, 2015).

Sustainable development goals that reflect its economic dimensions include: (7) "Ensuring access to affordable, reliable,

sustainable and modern energy sources for all," (8) "Promoting sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all," (9) "Building strong infrastructure, promoting inclusive and sustainable industrialization and innovation," (12) "Ensuring sustainable consumption and production patterns." The need to implement these targets is due to the need to reduce inequality in the global economy and transition to socio-economic development, taking into account environmental constraints (Mochalova, 2020; Anderson et al., 2017; Boehringer et al., 2014; Du et al., 2020; Ivanitsky and Petrenko, 2020).

## 2. LITERATURE REVIEW

The large-scale development of the global economy and industrial revolutions has harmed all environmental elements, both in terms of depletion of the natural resource potential of the planet and in

various pollution (Meckling and Allan, 2020; Anser et al., 2020a; Cibulka and Giljum, 2020; Anser et al., 2020b).

The need to reduce the effects of climate change and increase the decarbonization of the world's economies by reducing air emissions, greening production, and expanding the use of alternative energy sources is taken into account by most countries. The transformation of the global energy sector plays a special role in achieving these goals (Xie et al., 2020; Lorente et al., 2020; Ravetti et al., 2020).

The article examines the peculiarities of the development of the global energy sector. The study is based on extensive scientific literature that allows comparisons, providing relevant examples, and extrapolating ideas and results. The objective is to study the features and identify opportunities for global energy development in the green trend.

### 3. DATA AND ESTIMATION TECHNIQUES

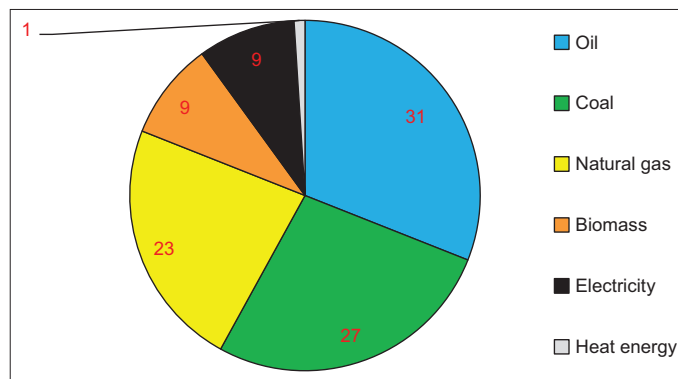
The study methodology was based on methods for calculating the dynamics of indicators characterizing global energy data and comparative analysis. Specific Enerdata on primary energy and electricity production; CO<sub>2</sub> emissions from fuel combustion and their intensity; the share of renewable energy in electricity production; the share of wind and solar energy in electricity production; specific International Energy Agency data on global CO<sub>2</sub> emissions; installed capacity in electricity generation; specific Bloomberg data on clean energy investment, according to the implementation of the dynamics of indicators in 2009-2019 were used to achieve the objectives and assess the results.

### 4. EMPIRICAL RESULTS

As one of the most important industries supporting the planet population, energy is a crucial object of national and international environmental regulation norms. The expansion of the development needs of countries and markets is driven by large-scale growth rates that directly impact the environment. At the same time, in the total structure of global primary energy production, the predominant role belongs to traditional sources (Figure 1).<sup>1</sup>

Since 2019, there has been a reduction in the expected growth in primary energy production (+1.5%) due to the global economy's slowdown. Some structural changes should also be attributed to the peculiarities of the current period: a reduction in crude oil production (0.7%), an increase in gas production (+4%), and electricity production (+1%).<sup>2</sup> Among the leading countries in energy production are the United States and China, which have significantly increased their crude oil and coal production. Besides, energy production increased in Russia, Brazil, South Africa, and Turkey. The decline in energy production was observed in

**Figure 1:** Global primary energy production by type in 2019 (%)



Source: Global primary energy production. <https://yearbook.enerdata.ru/total-energy/world-energy-production.html>

Europe (Germany, Poland, Norway, the Netherlands), Iran, and Saudi Arabia.

In the current period, there was also a slowdown in the growth of power generation (+1% in 2019) due to global trends in economic development. At the same time, there was a decrease in the share of coal-fired power plants (-3.5%), with an increase in the share of natural gas (+3.2%), nuclear fuel (3.6%), solar and wind energy (+4.7%, and +12%, respectively). The electric power industry developed in the United States, Germany, France, Japan, South Korea, and several other countries within the current trends.<sup>3</sup>

The activities of energy companies impact the planet's climate due to the substances emitted into the atmosphere and the build-up of the greenhouse effect (up to 70% of greenhouse gases)<sup>4</sup> (Figure 2). Consequently, increasing energy efficiency, expanding the use of renewable energy sources, and reducing the negative impact of traditional fuel use on the environment are key items on the international climate agenda for global energy.

It is essential to note the entrenched trend of reducing the intensity of CO<sub>2</sub> emissions due to the following key factors: reducing specific energy consumption and the "carbon ratio" (primarily in power generation by reducing coal consumption). The most considerable reduction in the intensity of emissions was observed in the EU countries (Poland, Germany, Spain), South Korea, the United States, Japan, China, India, and several others. The increase in the intensity of CO<sub>2</sub> emissions and their increase was noted in Russia, South Africa, and Iran<sup>5</sup> (Maji, 2019; Ambec et al., 2019; Matak and Krajacic, 2020).

At the end of 2019, the global economy had a minimal reduction in CO<sub>2</sub> emissions from fuel combustion (0.2%), driven by reductions in energy consumption per capita (2.1%) and CO<sub>2</sub> emissions from electricity generation (3.2%) due to coal substitution with gas and

1 Global primary energy production. <https://yearbook.enerdata.ru/total-energy/world-energy-production.html>

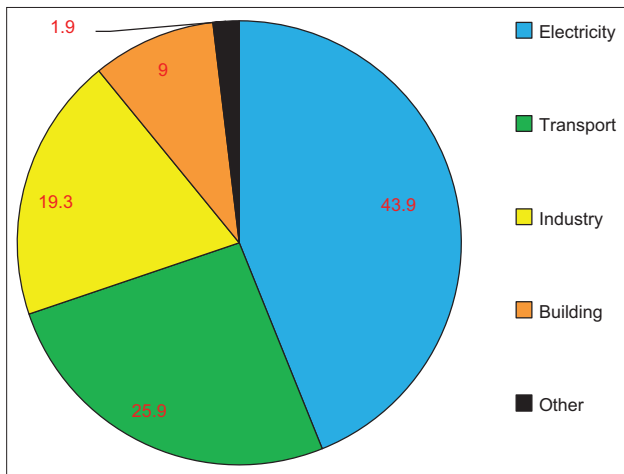
2 Global primary energy production. <https://yearbook.enerdata.ru/total-energy/world-energy-production.html>

3 The production of electricity. <https://yearbook.enerdata.ru/electricity/world-electricity-production-statistics.html>

4 Global CO<sub>2</sub> emissions by sector, 2018. <https://www.iea.org/reports/co2-emissions-from-fuel-combustion-overview>

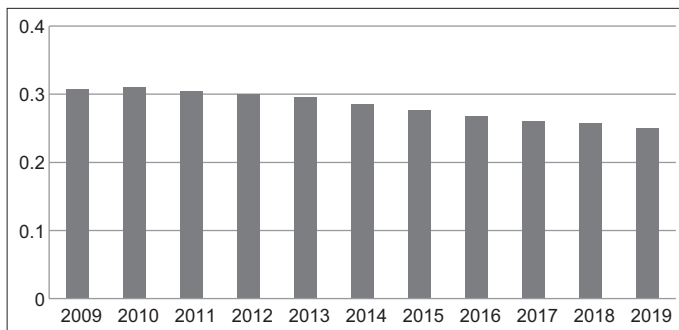
5 CO<sub>2</sub> emission intensity. <https://yearbook.enerdata.ru/co2-fuel-combustion/world-co2-intensity.html>

**Figure 2:** Global CO<sub>2</sub> emissions by sector in 2018 (%)



Source: Global CO<sub>2</sub> emissions by sector, 2018. [https://www.iea.org/reports/CO<sub>2</sub>-emissions-from-fuel-combustion-overview](https://www.iea.org/reports/CO2-emissions-from-fuel-combustion-overview)

**Figure 3:** CO<sub>2</sub> emission intensity in 2009-2019 (kco2/\$2015p)



Source: CO<sub>2</sub> emission intensity. [https://yearbook.enerdata.ru/co2-fuel-combustion/world-CO<sub>2</sub>-intensity.html](https://yearbook.enerdata.ru/co2-fuel-combustion/world-CO2-intensity.html)

an increasing share of renewable energy in the global energy mix. The leading countries in reducing emissions include the United States, Germany, Poland, the United Kingdom, Spain, and Turkey. In the countries that produce coal and hydrocarbons, the growth of CO<sub>2</sub> emissions continued (Russia, Australia, Iran, South Africa, Algeria)<sup>6</sup> (Figure 4).

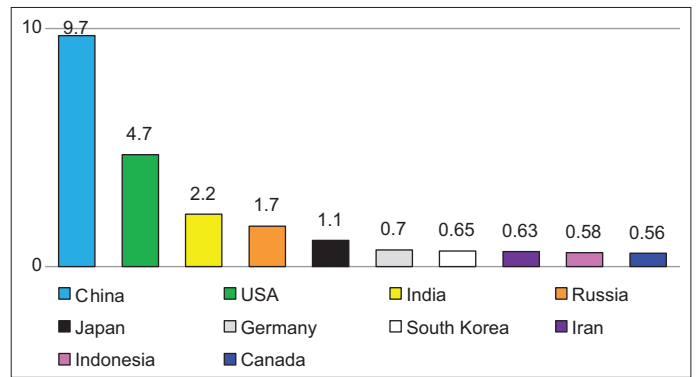
It is important to note some deformations of the established structure of the global energy system due to the intensification of decarbonization of the world economy.

The development of renewable energy sources takes place within the framework of the positive global trend that has formed since the early 2000s and has fixed the share of renewable energy in the global energy balance at about 27%<sup>7</sup>, despite the small share of alternative energy sources in global consumption of primary energy.

6 CO<sub>2</sub> emissions from fuel combustion. [Electronic source] <https://yearbook.enerdata.ru/co2-fuel-combustion/CO2-emissions-data-from-fuel-combustion.html> (Date accessed: 01.12.2020)

7 Share of renewable energy sources in electricity production. <https://yearbook.enerdata.ru/renewables/renewable-in-electricity-production-share.html>

**Figure 4:** Top ten countries in terms of CO<sub>2</sub> emissions into the atmosphere in 2019 (MtCO<sub>2</sub>)



Source: CO<sub>2</sub> emissions from fuel combustion. [Electronic source] [https://yearbook.enerdata.ru/co2-fuel-combustion/CO<sub>2</sub>-emissions-data-from-fuel-combustion.html](https://yearbook.enerdata.ru/co2-fuel-combustion/CO2-emissions-data-from-fuel-combustion.html) (Date accessed: 01.12.2020)

The current growth rate is mainly due to the increasing importance of renewable energy sources globally, which is reflected in the high positive dynamics of the volume of investment and commissioned capacity, outstripping the “traditional” electric power industry. Currently, the renewable energy industry provides a cheaper way to generate electricity. The goal of European countries to achieve 100% climate neutrality by 2050 involves raising funds in the amount of up to 2% of GDP to develop a green economy, the key factor of which is renewable energy. In a number of countries, green generation provides more than 80% of the electricity generated (Figure 5) (Sepehr et al., 2019; Awan et al., 2020).

China, India, Turkey, Russia, Iran, and Nigeria show the most pronounced positive electricity generation dynamics from renewable energy sources. In 2019, the increase in the installed capacity of renewable energy sources amounted to more than 200 GW<sup>8</sup> (Figure 6).

The largest share, over 47%, in the total installed capacity of renewable energy sources belongs to hydropower, which scientists consider to be one of the most environmentally friendly structures for generating electricity. The share of the solar-wind power generation sector amounted to 8.5%.<sup>9</sup>

The magnitude of the changes taking place is mostly supported by the positive dynamics of investment activity in the sector in question. Thus in the first half of 2020, despite the effects of the COVID-19 pandemic, the increase in investment in new renewable energy capacity was 5%<sup>10</sup> (Figure 7). At the end of 2019, the total financing for clean energy investments was \$333.6 billion. The largest share in the total funding structure belongs to the Asia-Pacific region countries and is over 49%.

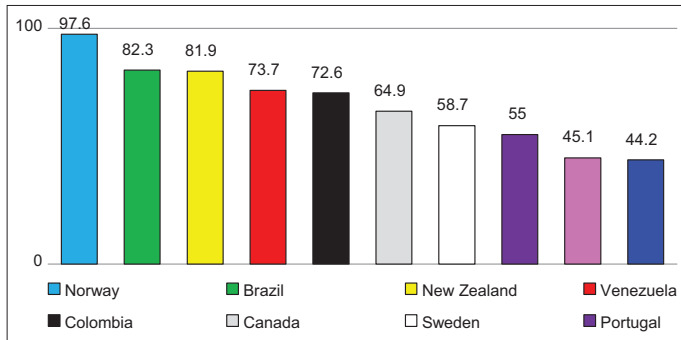
The largest investors in renewable energy are China (\$100.8 billion), the United States (\$71.9 billion), and the EU (\$63.8 billion).

8 Installed capacity trends. <https://www.irena.org/>

9 Share of wind and solar energy in electricity production. <https://yearbook.enerdata.ru/renewables/wind-solar-share-electricity-production.html>

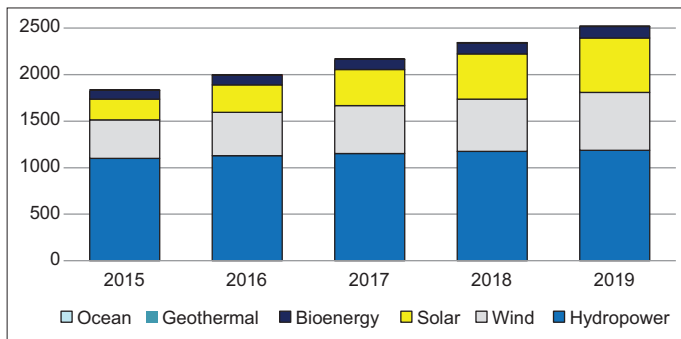
10 Clean Energy Investment Trends, 1H2020. <https://data.bloomberglp.com/professional/sites/24/BNEF-Clean-Energy-Investment-Trends-1H-2020.pdf>

**Figure 5:** Top ten countries in terms of the share of renewable energy sources in electricity production in 2019 (%)



Source: Share of renewable energy sources in electricity production. <https://yearbook.enerdata.ru/renewables/renewable-in-electricity-production-share.html>

**Figure 6:** Installed capacity of renewable energy sources in the world in 2015-2019 (GW)



Source: Installed capacity trends. <https://www.irena.org/>

The largest share of funds goes to the sector of solar and wind generation. Thus, the financing of wind energy in the first half of 2020 amounted to \$35 billion, which is 319% more than in the whole of 2019<sup>11</sup> (Bistline and Young, 2019).

Another of the systemic shifts in the energy sector can be considered a slowdown in primary energy consumption (1.3% in 2019). Simultaneously, the growth itself was driven by the renewable energy sector and natural gas, which contributed more than 70% to the growth. The largest energy suppliers were China, India, and Indonesia. The most noticeable decline was observed in the United States and Germany (Singh et al., 2019; Zhu et al., 2019).

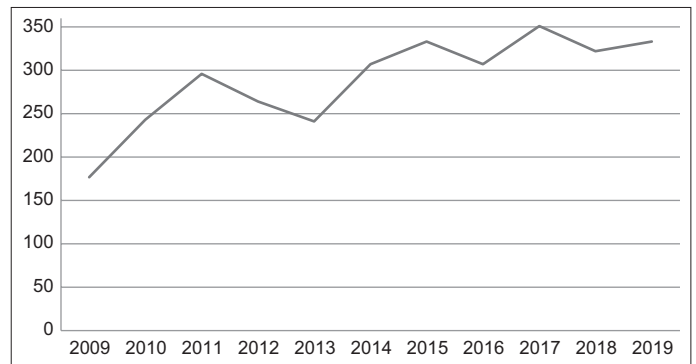
In general, the structure of power generation by country has been entrenched for a long time, and the key leaders are China, the United States, India, Russia, Japan, and several others<sup>12</sup> (Figure 8).

The intensification of global trends toward decarbonization leads to alteration in the energy sector. By 2050, the combined share of

11 Clean Energy Investment Trends, 1H2020. <https://data.bloomberglp.com/professional/sites/24/BNEF-Clean-Energy-Investment-Trends-1H-2020.pdf>

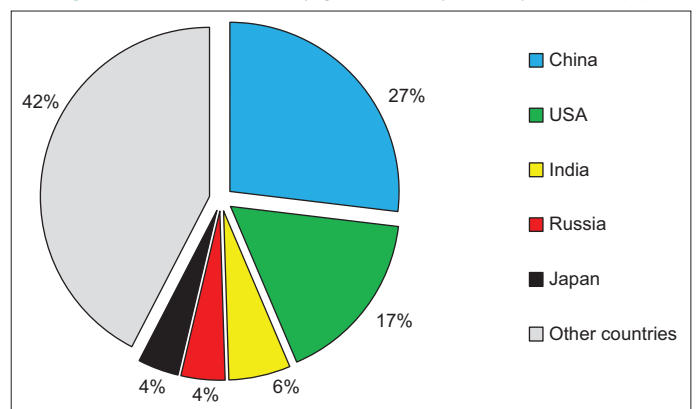
12 The production of electricity. <https://yearbook.enerdata.ru/electricity/world-electricity-production-statistics.html>

**Figure 7:** Investments in clean energy in 2009-2019 (\$bn)



Source: CleanEnergy Investment Trends, 1H2020. <https://data.bloomberglp.com/professional/sites/24/BNEF-Clean-Energy-Investment-Trends-1H-2020.pdf>

**Figure 8:** Global electricity generation by country in 2019 (%)



Source: The production of electricity. <https://yearbook.enerdata.ru/electricity/world-electricity-production-statistics.html>

renewable energy sources could amount to more than 55% of the world's total electricity production. These trends will only intensify due to countries' obligations to decarbonize their economies and require the implementation of measures that reduce adverse environmental impacts and stimulate innovation to achieve the necessary level of energy efficiency (Barroco and Herrera, 2019; Walton et al., 2020; Milovidov, 2019).

The current period has seen many stimulating trends that consolidate renewable energy development in the global energy sector. The critical factor that ensures high rates of alternative energy development is the comparability of renewable energy costs with traditional energy.<sup>13</sup> The renewable energy sector has also seen an increase in the productivity of this type of energy (CF – capacity factor) through the introduction of new technologies that provide increased energy efficiency. In this regard, there has been a massive expansion of demand for the development of the alternative energy sector, underpinned by the need to meet the expanding decarbonization needs of economies and markets and ensuring its further integration into the global energy system.

13 Lazard's levelized cost of energy analysis – version 14.0. <https://www.lazard.com/media/451419/lazards-levelized-cost-of-energy-version-14.0.pdf>

The development of the renewable energy sector solves the problems of providing consumers with environmentally friendly, reliable, and cheap energy sources and provides ample opportunities for the use of various energy supply options (da Silva et al., 2020).

The needs of the population of states to improve the quality of life and sustainable development require new solutions in the transformation of the energy sector to reduce environmental pollution, economic growth, uninterrupted power grids, etc. Country and city development strategies suggest increased importance of alternative energy in connection with the need to address energy efficiency and the development of renewable municipal energy, both within and outside the centralized grid. Emerging markets and corporations play a special role in shaping the demand for renewable energy sources. The collaboration of these sectors in solving their problems provides a robust, innovative development, leading to a reduction in the cost of such energy and an expansion of energy supply options.

The intensive growth of renewable energy over the past decade has primarily been driven by the use of a wide range of government support mechanisms that help decarbonize national economies and mitigate the effects of climate change (Hortay and Rozner, 2019).

Many states are planning to implement measures to expand the installed capacity of renewable energy sources. For example, in the EU, the National Energy and Climate Plans call for doubling them in France by 2028 and expanding them by 200GW in Germany.<sup>14</sup> China plans to provide renewable electricity generation at 50% of its total production by 2030.

The scaling up of the share of renewables in the world's energy systems is relatively recent and has been supported primarily by government energy policies to provide broad financial support to the alternative energy sector to offset the negative profitability in the early stages of development.

State support is realized through investment grants, promotional loans, tax incentives, and other preferences. Along with this, the most common tool is direct support for electricity prices.<sup>15</sup>

The price support schemes are as follows. Under the first one, renewable energy generators are given a feed-in-tariff for a long-term period (15–20 years) under an agreement with the regulator to buy renewable energy for sale at a pre-fixed price, regardless of market fluctuations. Alternatively, price-based public support can be activated to enhance market integration through feed-in-premiums provided over the market price of electricity.

Another mechanism for allocating support involves the following administrative procedures established at the state level or

competitive bidding procedures. Renewable energy auctions allow forming a competitive price based on creating a high level of competition among renewable energy generators, whose demand for support exceeds the volume of the auction.

Large-scale government support for renewable energy development in the previous period allowed reducing the cost of renewable energy projects, primarily in the solar-wind power generation circuit, and integrating it more deeply into power systems. Increasing the renewable energy sector's degree of maturity entails adjusting the approaches to its support by states and requires further expansion of market-based regulatory instruments.<sup>16</sup>

Renewable energy quotas obligations based on tradeable green certificates (TGCs) are another tool for supporting the renewable energy sector. This scheme involves establishing renewable energy targets, expressed in the share of renewable energy sources in the final electricity consumption or the volume of electricity produced. Within the framework of the current legislation, participants in this market are obliged to buy and issue green electricity certificates, the number of which corresponds to the quota obligations of renewable energy sources multiplied by the volume of electricity supplied annually. This form of support provides renewable energy generators with an additional income source in the form of a supplement to the wholesale price. Green certificates allow determining a competitive price through the interaction of supply and demand for TGCs.

Thus, the development of the renewable energy sector ensures a reduction in the amount of state support and an increase in the use of market-based regulatory instruments. Thus, power purchase agreements are concluded between the producer and the consumer and act as a long-term bilateral agreement, within the framework of which the volume and price of supplies are determined. This form of interaction between market participants is becoming increasingly popular for large companies seeking to decarbonize.

The rapidly developing RES auctions (2005–6 countries; 2020 – over 100 countries) are expected to be central to energy policy within the renewable energy sector, providing countries with an expansion of renewable energy capacity, a reduction in the price of alternative energy, and the development of innovative technologies in the sector.

Thus, the large-scale growth of the renewable energy sector is mostly due to many stimulating factors and increasing demand and is supplemented by government financial support. In the current period, various forms of state support for renewable energy projects are used to achieve targets for the potential of renewable energy sources at the national level. Its role gradually decreases as the degree of maturity of alternative energy is reached. As part of the development of national energy policies, it is expected to expand market support tools, such as renewable energy auctions.

14 National energy and climate plans (NECPs). [https://ec.europa.eu/energy/topics/energy-strategy/national-energy-climate-plans\\_en](https://ec.europa.eu/energy/topics/energy-strategy/national-energy-climate-plans_en)

15 Renewables Auctions and the Energy Transition. <https://www.enerdata.net/publications/executive-briefing/renewables-auctions-world-energy-transition.html>

16 European Commission Guidelines on State aid for environmental protection and energy 2014-2020. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52014XC0628%2801%29>

## 5. CONCLUDING REMARKS

The actualization of global environmental problems, enshrined in international agreements, necessitates a transformational change in the global energy sector. Sustainable development of the renewable energy sector is driven by the green trend of global development and will be long-term.

The intensification of global trends toward decarbonization leads to alteration in the energy sector. By 2050, the combined share of renewable energy sources could amount to more than 55% of the world's total electricity production. These trends will be exacerbated by countries' obligations to decarbonize their economies and require the implementation of measures that reduce negative environmental impacts and stimulate innovation to achieve the necessary level of energy efficiency.

The scaling up of demand for clean energy is due to the progressive reduction of its cost and the achievement of stable energy supply indicators. Sustainable demand for the renewable energy segment is driven by the needs of countries and markets to implement a sustainable development strategy in the context of a green trend.

The intensive growth of the renewable energy sector is primarily supplemented by government financial support. In the current period, various forms of state support for renewable energy projects are used to achieve targets for the potential of renewable energy sources at the national level. Its role gradually decreases as the degree of maturity of alternative energy is reached. As part of the development of national energy policies, market-based support tools, such as renewable energy auctions, are expected to increase.

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