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Sustainable Energy Development: Global Trends, Challenges and the Role of ESG Reporting

Evstafieva E.M. [a], Guryev K.V. [b], Khakhonova N.N. [c], Mikhailenko R.G. [d] And Kirkach Yu.N. [e]

Rostov State University of Economics (RINH), 69 Bolshaya Sadovaya Street, Rostov-on-Don, Russian Federation
2982232@mail.ru, gurev.kirill.v@gmail.com, N_khakhonova@bk.ru, mihrus@rambler.ru, kirkach-ulya@mail.ru

Keywords : sustainable energy development; renewable energy sources; energy transition; ESG indicators; sustainability reporting.

Abstract: The article is devoted to the consideration of theoretical and practical aspects of sustainable energy development in the context of global environmental and economic challenges. The paper analyzes key international trends in the field of renewable energy, reducing carbon intensity and technological transformation, based on data from the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA) and the United Nations (UN). The authors emphasize that sustainable energy development is not only an environmental necessity, but also a strategic opportunity for economic modernization. Particular attention is paid to the importance of non-financial reporting on sustainable development, including ESG indicators (environmental, social and governance aspects) of energy companies. The results of the study are of interest to researchers, government agencies and corporate structures working on energy transformation issues.

[a] https://orcid.org/0000-0001-7414-4080
[b] https://orcid.org/0000-0002-4588-7341
[c] https :// orcid . org /0000-0003-3327-4561
[d] https :// orcid . org /0000-0003-1720-6331
[e] https://orcid.org/0000-0002-6655-102X

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1 INTRODUCTION

Sustainable energy development is a key area in the implementation of the global sustainable development agenda approved by the UN in 2015. Modern challenges, including climate change, depletion of natural resources, environmental pollution and growth in global energy consumption, require a transition from the traditional model of energy production to an environmentally safe, economically efficient and socially oriented system.

Sustainable development is a process “that ensures that the needs of the present generation are met without compromising the ability of future generations to meet their own needs.”

Keskin , A.İ., Dincer , B., & Dincer , C. point out that: “Over the past four decades, the business world has seen a significant increase in attention to environmental, social and sustainability issues. Companies are forced to incorporate sustainability into their strategies to respond to increasing pressure from all stakeholders and to protect their market shares.”

The transition to sustainable energy systems is not only an environmental necessity, but also a strategic economic imperative. It involves the development of green and low-carbon technologies, infrastructure modernization, energy balance diversification, increased energy efficiency, and the active involvement of stakeholders in the transformation of the energy sector.

One of the most important tools in ensuring transparency and accountability of energy companies in the context of sustainable development is the formation of non-financial reporting. In particular, the disclosure of ESG indicators (environmental, social and governance), which allow an objective assessment of the impact of companies' activities on the environment, society and the corporate governance system, is of particular importance. The availability of such reports helps to increase the investment attractiveness of companies, reduce climate risks and build trust with society and partners.

Thus, sustainable energy development is impossible without the implementation of a comprehensive approach combining technological innovations, government support, international cooperation and transparent reporting mechanisms. The purpose of this article is to analyze modern trends in sustainable energy development, consider key technological and management approaches, and assess the prospects, barriers and role of non-financial reporting in the energy transition, including the specifics of forming ESG-oriented strategies in Russian conditions.

2 MATERIALS AND METHODS

The study is based on:

- analysis of reports and statistical databases of IEA, IRENA, UN, World Bank;
- studying Russian strategies and programs: the Energy Strategy of the Russian Federation until 2035, the low-carbon development strategy until 2050, the national project “Ecology”;
- comparison of international and Russian indicators of sustainable development;
- systems and comparative approaches.

Data visualization methods were also used to present global and Russian trends.

3 RESULTS AND DISCUSSION

The global energy agenda is being transformed by climate challenges, technological innovations and stakeholder demands. The world is moving steadily towards decarbonization of the energy sector .

Sustainable energy development contributes to:

- reduction of greenhouse gas emissions and pollution;
- protection of biodiversity and ecosystems;
- creation of "green" jobs;
- increasing energy availability, especially in remote areas.

According to IRENA and IEA, more than 80% of new electricity generation capacity in 2023 will come from renewable energy sources (RES) , primarily solar and wind energy. The reduction in the cost of RES technologies makes them increasingly competitive. The active implementation of energy storage and digital demand/supply management platforms ensures the sustainability and flexibility of energy systems, especially in conditions of a high share of RES.

Fig. 1 shows the growth in the share of renewable energy sources (RES) in global energy production by year from 2010 to 2023.

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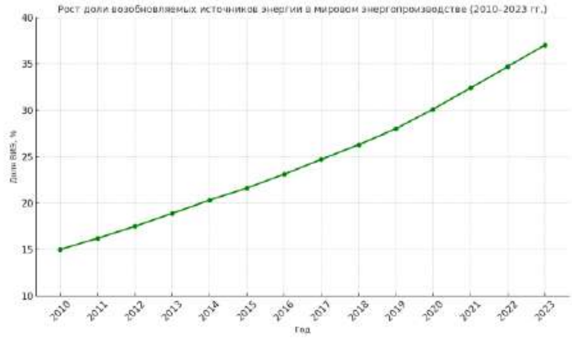

Figure 1: Growth in the share of renewable energy sources worldwide (2010–2023) .

The graph clearly demonstrates the steady and accelerating trend towards increasing use of green energy at the global level.

"Green" and "blue" hydrogen are considered as a promising direction for replacing fossil fuels in industry, transport and energy. EU countries, Japan, South Korea and the UAE plan to switch to hydrogen strategies in the 2030-2050 period. Sustainable and climate financing mechanisms are currently being actively developed: "green" bonds, transition bonds , sustainable funds. Banks and investors are increasingly focusing on climate risks.

The Russian energy sector has significant potential for sustainable development and a unique energy structure, characterized by a high level of resource security and a significant share of low-carbon generation (hydroelectric power plants and nuclear power plants). Coal- and gas-fired thermal power plants predominate in the energy balance of the Russian Federation. However, a significant share of hydroelectric power plants and nuclear generation allows maintaining a relatively low carbon footprint in electricity production. Despite the great potential of solar, wind and bioenergy, their share in the energy balance does not yet exceed 1.5–2%. At the same time, programs for the localization and subsidization of renewable energy sources (RES DPM) have been launched.

Russia's energy profile can be described by the following indicators:

- high proportion of fossil fuels (coal, oil, gas) - about 85%;
- low share of renewable energy sources in the structure of electricity - less than 1% (excluding hydroelectric power plants);
- strong position in nuclear energy (≈20% of electricity generation);
- rich potential for wind energy in the southern regions and solar energy in Siberia and the Far East.

Fig. 2 shows the share of renewable energy sources in electricity production in Russia for the period from 2010 to 2023.

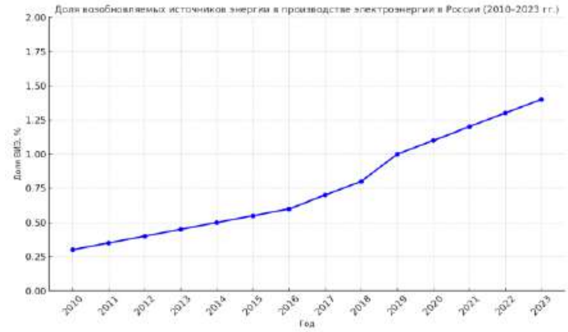

Figure 2: Growth in the share of renewable energy sources in Russia (2010 – 2023).

The graph shows the share of renewable energy sources in electricity production in Russia for the period from 2010 to 2023. It is clear that there is growth, but it is very moderate compared to global dynamics. At the same time, the pace of implementation of renewable energy sources and ESG practices is still lagging behind the global ones. This emphasizes the need for government support and activation of policies in the field of sustainable energy.

As part of the Low-Carbon Development Strategy until 2050, Russia has committed to reducing emissions and increasing energy efficiency . The main goals of the Russian Federation in developing sustainable energy are presented in Table 1.

Table 1 : Russia's key goals in sustainable energy.

Indicator	Goal (year)
Energy intensity of GDP (decrease)	-50% (2035)
Share of renewable energy sources in the energy balance	≥4% (2035)
Export of "green" hydrogen	2 million tons (2035), 20 million tons (2050)
Share of low-carbon generation	45% by 2050
Carbon neutrality of the economy	by 2060

However, the practical implementation of these goals in the Russian Federation requires a legislative framework, project support and financial incentives.

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Modern energy development is determined by a number of global trends aimed at achieving sustainable development goals, decarbonization and increasing the efficiency of energy systems.

Table 2 presents the main indicators of sustainable energy development (according to IEA and IRENA, 2023).

Table 2: Key sustainable energy indicators (IEA and IRENA, 2023).

Indicator	Meaning (2023)	Forecast for 2030
Share of renewable energy sources in the global energy balance	30%	50–60%
Level of access to electricity	91% of the world's population	>98%
Carbon intensity (CO_2/kWh)	450 g/kWh	<100 g/kWh
Investments in renewable energy sources (billion $/year)	1,700	3,000–4,000

Among the most promising areas of sustainable energy development are:

solar and wind energy are the leaders in terms of growth rates;

green hydrogen - an alternative to carbon-intensive industry;

smart grids - demand management and distributed generation;

Energy accumulation - ensuring stability of energy supply.

These trends shape the strategy of both international and national energy companies, including Russian enterprises.

The most significant trends include the active growth of renewable energy (solar, wind, hydro); the development of energy storage systems and smart grids; the transition to the use of hydrogen in energy and industry; the increasing importance of ESG factors and sustainability reporting; the expansion of "green" financing; ensuring energy justice and energy accessibility. Table 3 presents a comparison of the key trends in sustainable energy development in the world and in Russia.

Table 3: Comparison of global and Russian sustainable energy trends.

Direction	Global trends	Russian peculiarities
RES	Rapid growth in solar and wind energy	Low share in the energy balance, but high potential
Hydrogen energy	Active strategies in the EU, Japan, UAE	Projects in their infancy, export-oriented
Energy saving and efficiency	Large-scale programs, "smart grids"	Energy efficiency levels remain low
ESG and reporting	Mandatory reporting, GRI, TCFD standards	Voluntary reports of large companies, transition to IFRS S1/S2
Financing	The rise of green bonds and investment funds	Development is just beginning, single emissions
Decarbonization goals	Net Strategies Zero by 2050–2060	The goal is to reduce emissions without strict deadlines

Russia, with its powerful energy base, can become an active participant in the global sustainable transition. This requires:

stimulation of the development of renewable energy sources and R&D;

creating a transparent regulatory environment for ESG and green investments;

improving energy efficiency and environmental friendliness of infrastructure;

development of international cooperation on hydrogen, climate and technology.

An important component of sustainable development of the energy sector is the formation of transparent and high-quality non-financial reporting - ESG reporting.

Energy companies, as major emitters of greenhouse gases and key players in the environmental transition, have an increased responsibility to disclose information on the impact of their activities on the environment, society and corporate governance.

Sustainability reports based on international standards (GRI, SASB, TCFD, IFRS S1/S2) allow stakeholders — investors, government, society — to objectively assess a company’s ESG profile, risks and opportunities related to the climate agenda and energy transition. Of particular importance are such indicators as:

volume of CO_2 emissions (Scope 1, 2 and, where possible, Scope 3),

specific energy intensity of production,

the share of "green" generation in the production structure,

the volume of investment in R&D in the field of renewable energy and decarbonization,

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the presence of environmental policies and climate goals,

social initiatives and labor protection programs.

According to a number of authors: "monitoring these indicators can help promote corporate policies and actions to achieve zero carbon emissions." In order to organize this control, not only environmental reporting has been actively developed, but also reporting of a new format - ESG reporting, which discloses information on the impact of their activities on the environment, social sphere and corporate governance in general, which helps investors and other stakeholders to assess the sustainability of the company's business. The need to form and present these reports is reflected in the works of Boiral , O. , Serpeninova , Y., Lehenchuk , S., Zdyrko , N., Zakharov , D., & Podolianchuk , O., Odintsova, T.M. and other authors.

The development of sustainability reporting not only increases transparency and responsibility of business, but is also a tool for integrating sustainable development goals (SDGs) into corporate strategy, including SDG 7 (affordable and clean energy), SDG 13 (climate action) and SDG 12 (responsible consumption and production).

In 2013, the Global Reporting Initiative (GRI) published the G4 Sustainability Reporting Guidelines, which aim to outline the general principles for preparing ERM; its fourth edition is currently in effect.

That same year, WikiRate was created : ".. a technology platform that promotes organizational transparency through communication and advocacy of SDG reporting." Posting ESG reports on this platform makes them more accessible to users.

Research by Yadav , P. L.; Khan, S. H.; Roh , J. J. , conducted back in 2015, on data from major US companies, already highlighted: "the impact of environmental performance on company value for sustainable investments ."

In Russia, as well as throughout the world, more and more energy companies are implementing the practice of preparing ESG reporting (Fig. 3). Thus, PJSC Rosseti , PJSC RusHydro , SC Rosatom , PJSC Inter RAO and others annually publish non-financial reports containing key ESG indicators. This helps to increase their investment attractiveness, including within the framework of "green" and transition financing, and allows taking into account the risks of climate change in strategic planning.

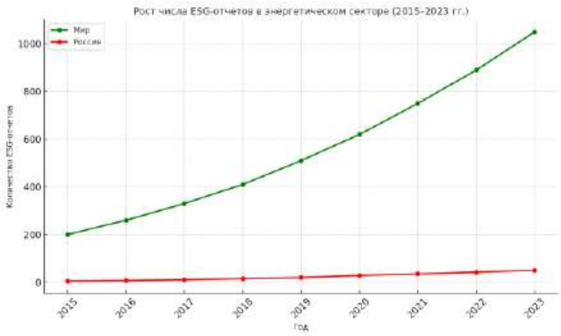

Figure 3: Comparative characteristics of the growth in the number of ESG reports generated in the energy sector of the Russian Federation and foreign countries (2015 – 2023).

The graphs presented in the figure clearly demonstrate a not so rapid growth in the number of ESG reports generated by energy companies, but a positive trend can be traced. Let us consider the practice of generating these reports in the Russian Federation in more detail.

Based on the information provided in the national register of corporate non-financial reports, Russian companies have compiled and published 695 reports in the field of sustainable development since 2003. It is worth noting that the energy sector can be considered one of the leaders in the number of companies that generate non-financial reports. This circumstance is confirmed by the data presented in Figure 4.

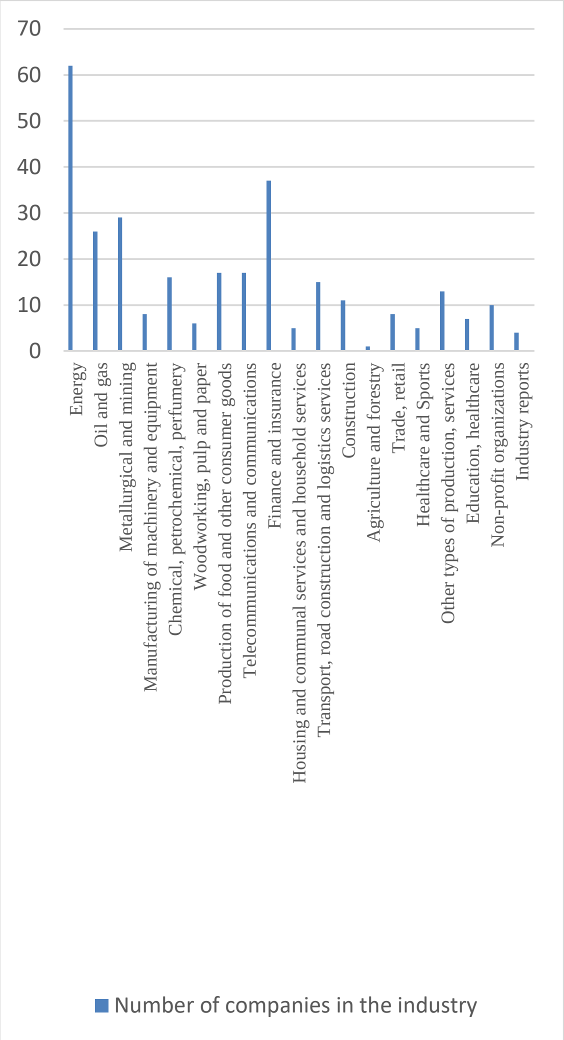

Figure 4: Number of companies producing non-financial reports by industry.

Energy companies publish all kinds of non-financial reporting, but integrated reporting and sustainability reporting enjoy the greatest trust. Given that sustainability reporting is currently regulated at the state level, we believe it is necessary to study the practice of preparing this type of reporting by energy companies.

Since 2006, energy companies have been using sustainability reporting to demonstrate the sustainability of their business. According to the data presented in Figure 5, in recent years, energy companies have begun to generate sustainability reporting more often. We believe that this is due to the fact that the Ministry of Economic Development of the Russian Federation has developed methodological recommendations for this type of reporting, which simplify the process of compilation and improve the comparability of data both by year and among companies in the same industry.

Figure 5: Activity in the formation of ERM by companies in the energy sector by year.

Having studied the sustainable development reports of some energy companies, for example, PJSC Gazprom, the Engineering Division of the State Corporation Rosatom , PJSC Rosseti , the following conclusions can be drawn:

1) the data contained in sustainability reports is often repeated;

2) the information is presented in text and tabular format, and hyperlinks are also used to go to the information portal on the Internet;

3) when preparing a sustainable development report, a large number of regulatory acts and methodological recommendations are used, including Target indicators characterizing the achievement of national development goals of the Russian Federation, national and federal projects (programs), Recommendations of the Bank of Russia on the disclosure by public joint-stock companies of non-financial information related to the activities of such companies, GOST R 71198–2023 Business Reputation Index of Entrepreneurs (EKG Rating), etc.;

4) reports are published late. Thus, as of April 2025, not a single report for 2024 has been published in the Library of Corporate Non-Financial Reports.

Therefore, it can be assumed that the preconditions for developing a Russian sustainability reporting standard are currently being strengthened, which:

1) expand the list of basic indicators reflected in the sustainability report to improve understanding of the company's activities;

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2) regulates the format of data presentation in the report;

3) will become a key regulatory act for the preparation of a sustainable development report;

4) the deadlines for publishing the sustainable development report will be fixed.

An important step towards creating a sustainability reporting standard, according to the authors, is the expansion of the basic indicators in terms of economic, environmental, social and management aspects recommended for disclosure in a sustainability report. We believe that these should include the indicators presented in Table 4.

Table 4: Key indicators recommended for inclusion in the sustainability reporting standard.

Item No.	Economic indicators	Environmental indicators	Social indicators	Management indicators
1.	Earnings per share, RUB/share	Installed capacity, MW	Share of young professionals under 35 years old, %	Number of claims and complaints from customers in the reporting year, pcs.
2.	Amount of dividends paid, million rubles.	Heat output, thousand Gcal	Minimum wage, million rubles	Customer Satisfaction, %
3.	Value of intellectual property objects, million rubles.	Electricity generation, million kW • h	Occupational injury rate	Employee satisfaction, %
4.	Pricing		Occupational disease rate	Information on risk management and identification of key risks of the company
5.			Number of complaints regarding violation of labor legislation, pcs.	Assessment of the technical condition of equipment

We believe that the indicators presented in Table 4 are important for the sustainable development of the company and the industry as a whole. The proposed indicators of the economic aspect contribute to the inflow of investments, improvement of investment attractiveness, increase of trust on the part of users and investors. In the environmental aspect, the indicators are proposed that, in our opinion, will demonstrate the rationality of energy resource consumption, which also contributes to the improvement of the investment attractiveness of the company and its sustainable development. The recommended social indicators are aimed at preventing the shortage of personnel in the energy industry. By disclosing these indicators, the company characterizes the working conditions: what is the minimum wage that young employees without work experience can receive, what impact work activity will have on their health, what age group of employees predominates in production, whether the rights of young specialists are infringed. All these indicators together will help to reveal the prospects of work in production in the energy industry and thereby contribute to the influx of young personnel.

The proposed indicators of the management aspect help to clarify the state of the company's management system: they characterize the satisfaction of employees and consumers with the quality of working conditions and the quality of manufactured products, describe the technical condition of the equipment and demonstrate measures to minimize the company's key risks.

To form indicators for sustainable development reporting, ESG reports, and integrated reporting, it is advisable to implement a risk-oriented accounting system that provides the ability to improve the quality and reliability of information provided within the framework of non-financial reporting.

Risk-based accounting is a methodological approach to accounting and reporting that focuses on identifying, assessing and managing risks that affect an organization’s operations. Its primary goal is to provide reliable information about potential threats and opportunities to help management make informed decisions. The development of risk-based accounting methodologies and techniques for the energy sector is necessary to ensure the stable functioning of the industry, compliance with regulatory requirements and maintaining confidence among investors and the public. This process will help improve planning, reduce risks and increase the overall sustainability of the energy system.

4 CONCLUSION

Ensuring sustainable energy development presupposes, in our opinion, a transition to a management system capable of meeting the needs of the present generation without compromising the future. It requires a transformation not only of technologies, but also of management models, consumer behavior, policies and investments. International and national companies are committed to achieving the goals of Net Zero , in connection with which they implement ESG approaches in management and publish reports on sustainable development. It is proposed to supplement the composition of the basic indicators recommended for reflection in the standard of reporting on sustainable development and the feasibility of forming a risk-oriented accounting system for the purpose of generating information for non-financial reporting is determined. Thus, the article offers a comprehensive approach to the development of energy through the prism of sustainable development and strengthening the role of non-financial reporting. The results obtained will be useful for researchers, government agencies and corporate structures working on energy transformation issues.

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