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NATURE-BASED ECONOMICS AND RENEWABLE ENERGY INVESTMENTS: INVESTOR RISK AND BENEFIT ASSESSMENT

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ABSTRACT

The transition to renewable energy is recognised as a catalyst for achieving carbon neutrality by 2050. Such a transition requires significant investments in renewable energy projects, as well as investments in research and development in this area. Increased sector financing can be achieved through effective government policies that reduce the risks of attracting private capital. The article aims to study the main trends in renewable energy investment and identify key risks and benefits in renewable energy markets. The methodology is based on a mixed design, including general scientific methods of analysing and synthesising scientific publications and analysing global investment indicators by type of renewable energy, country, region, and technology. Results. After 2020, there will be a significant increase in investment in the renewable energy sector, which is twice as high as the financing of fossil energy sources. In 2024, investments in the clean energy sector were dominated by investments in renewable energy, energy efficiency, and grid and storage development. This trend is due to the decline in prices for solar power plants and the rise in prices for traditional energy resources. Regionally, there is a significant imbalance in investment flows, with the highest volumes recorded in China, the US, and the EU. In the EU, investments in offshore wind sources prevail, which is explained by the lower weighted average cost of capital for investments after tax. In addition, government incentive policies promote the development of the renewable energy market. In particular, in Germany, the support policy provides for a reduction in fixed tariffs to reduce the costs of technology producers to reduce them. France has introduced preferential tariffs for wind energy. The practical value of the study lies in a detailed analysis of investment trends in the renewable energy sector in different regions and countries.

Keywords: green investment, renewable energy, renewable energy sources, investment risks, profitability.

INTRODUCTION

Between 2015 and 2024, investments in renewable energy more than doubled. Thus, in 2023, the volume of investments in clean energy technologies and infrastructure reached USD 2 trillion (IEA, 2024a). This dynamic is due to the need for significant investments to create an energy system in line with the requirements of the Paris Agreement (Egli, 2020), which requires developed and developing countries to reduce carbon emissions through renewable energy policy measures (Polzin et al., 2019). At the same time, the volume of investments depends on the risks and benefits investors receive when financing the relevant sector. Among the most common risks are various restrictions, barriers related to government regulation, price risks, and profitability of renewable energy projects. Therefore, there are differences in the investment of green projects in different countries. According to the data, developing countries and countries with emerging markets outside of China account for only 15% of such investments. The article aims to study the main trends in investing in renewable energy and identify the key risks and benefits of these markets.

Literature Review

In general, the scientific literature focuses on studying renewable energy investments in Asian countries, including India and China, as well as in some European countries. This is because these regions have the highest volumes of green investment. The level of risks and rewards depends on the policy of promoting investments in renewable energy, prices for technologies and equipment, their availability for the markets of different countries, and the country's geopolitical situation (Sotnyk et al., 2023).

Egli (2020) found reduced investment risks for solar and wind investments in Italy, the UK and Germany during 2009–2017. The main risks include prices, technologies, resources, policies and restrictions. It should be noted that effective renewable energy support policies positively impact decision-making indicators such as investment risk and profitability. In particular, instruments such as feed-in tariffs, auctions, and renewable energy portfolio standards are most effective in reducing the investment risks of projects (Polzin et al., 2019). Reduced investment risks are associated with policy stability, increased technology reliability at lower costs, data availability, and improved assessment tools (Egli, 2020). Similar conclusions about the positive impact of government policy on the renewable energy market and foreign investment are made by Majid and Kumar (2020). At the same time, the lack of clear regulatory rules can constrain private investment.

Taghizadeh-Hesary and Yoshino (2020) also note the reduction in the cost of renewable energy technologies in Asian countries. In contrast, Majid and Kumar (2020) note the high cost of imported equipment in this area in India compared to domestic technology prices, resulting in high costs of renewable energy production.

In addition, Taghizadeh-Hesary and Yoshino (2020) identify the following types of barriers (restrictions) as the primary investment risks: lower rate of return and higher investment risk due to the uncertainty of renewable energy tariffs compared to traditional types of energy.

As a result, there is a problem with the availability of private project financing. As a result, investments in green projects are declining (Zhang et al., 2022a). A lower rate of return on investment as one of the risks is also noted by Capellán-Pérez et al. (2019).

In addition to the above-mentioned risks, geopolitical risk is considered one factor that negatively affects investment. Environmental taxes have a less negative impact on investments in renewable energy sources (Abbas et al., 2023).

To reduce the risks associated with financing, Taghizadeh-Hesary and Yoshino (2019) propose schemes for guaranteeing green loans and refunding part of taxes. The study by Yang et al. (2019) found a positive impact of government subsidies for renewable energy investments on the development of Chinese enterprises in this area in 2007–2016. At the same time, tax benefits are the main factor influencing investment.

According to Jin et al. (2022), carbon taxation policies, higher taxes on fossil fuels, and energy tax incentives can increase the renewable energy market. Zhang et al. (2022a) note the importance of promoting a carbon trading market in the Group of Twenty (G-20) countries. Zhang et al. (2022b) also propose the creation of a carbon trading market to increase green finance.

In summary, researchers' studies highlight trends in investment risks in the renewable energy sector and explain in detail the reasons for their occurrence.

MATERIAL AND METHOD

Methodology

The study is based on a mixed design, including general scientific methods of analysis and synthesis of scientific publications to identify key factors favourable to investing in renewable energy. The method of statistical analysis of global investment indicators by type of renewable energy, country, region, and technology in 2015–2024 was used to identify the main investment trends. The source base of the study included data and reports from the IEA (2024a; 2024b; 2024c; 2024d) and the International Renewable Energy Agency (2024) to assess investments by EU member states. For a more detailed characterisation of the effectiveness of the policy to stimulate investment in sustainable energy, the Regulatory Indicators for Sustainable Energy (2024) for Germany and France were used. These countries are characterised by the EU's most significant funding for renewable energy.

RESULTS AND DISCUSSION

For the first time in 2024, global energy investment exceeded USD 3 trillion, of which USD 2 trillion was in the clean energy technologies and infrastructure sector. Since 2020, there has been a significant increase in investment in clean energy. Spending on renewable energy, grids, and storage in this sector exceeds the total spending on oil, gas, and coal.

Overall, investments in clean energy increased from USD 1125 billion in 2015 to USD 2003 billion in 2024. For comparison, investments in fossil fuels amounted to USD 1374 billion in 2015 and USD 1116 billion in 2024. The structure of investments in the clean energy sector is dominated by investments in renewable energy ($771 billion in 2024), energy efficiency ($669 billion in 2024), and grid and storage ($452 billion in 2024). In 2023, $80 billion was invested in nuclear and other clean energy and $31 billion in low-emission fuels (Figure 1).

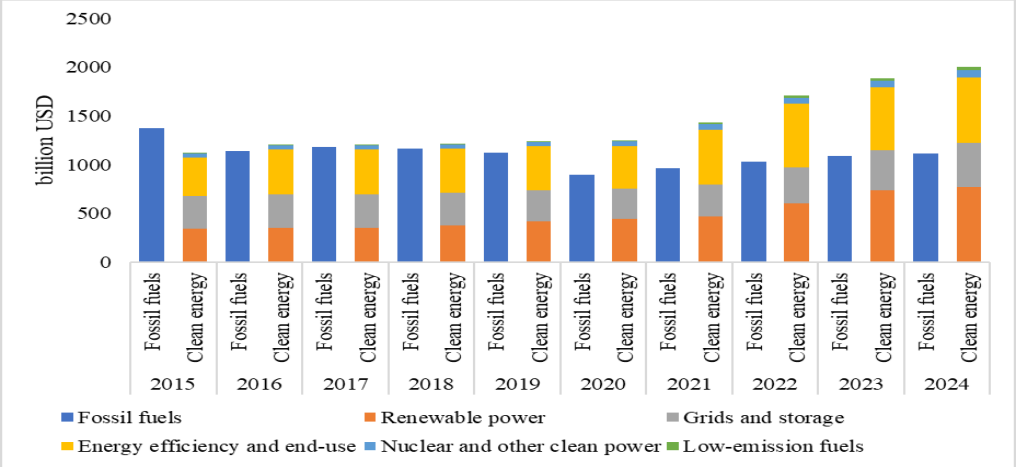

Figure 1. Dynamics of global investments in fossil fuels and clean energy in 2015–2024, USD billion.
Source: IEA (2024b)

Given the end of the period of cheap lending and the overall rise in energy prices, certain types of investment are being curbed, mainly due to higher financing costs. Over the past 2022–2024, the cost of solar panels has fallen by 30%, and prices for minerals and metals important for the energy transition have fallen sharply.

According to the data on investment in the global energy sector, there is a significant imbalance in investment flows and investments. In particular, there are significantly lower volumes of financing for the sector in developing countries and emerging markets compared to China. In China, fossil fuel investments totalled USD 197 billion in 2019 and USD 185 billion in 2024. In contrast, Chinese investments in clean energy are estimated at USD 372 billion and USD 659 billion, respectively. For comparison, in the United States, fossil fuel investments totalled $228

billion in 2019 and $197 billion in 2024. At the same time, financing for the US clean energy sector is much lower, with values of $190 billion in 2019 and $300 billion in 2024. The situation in the EU is different, as investments in fossil fuels are significantly lower than in China and the US, amounting to USD 29 billion in 2019 and USD 36 billion in 2024, respectively. Investments in clean energy in the EU exceed those in the US, amounting to USD 226 billion in 2019 and USD 410 billion in 2024 (Figure 2).

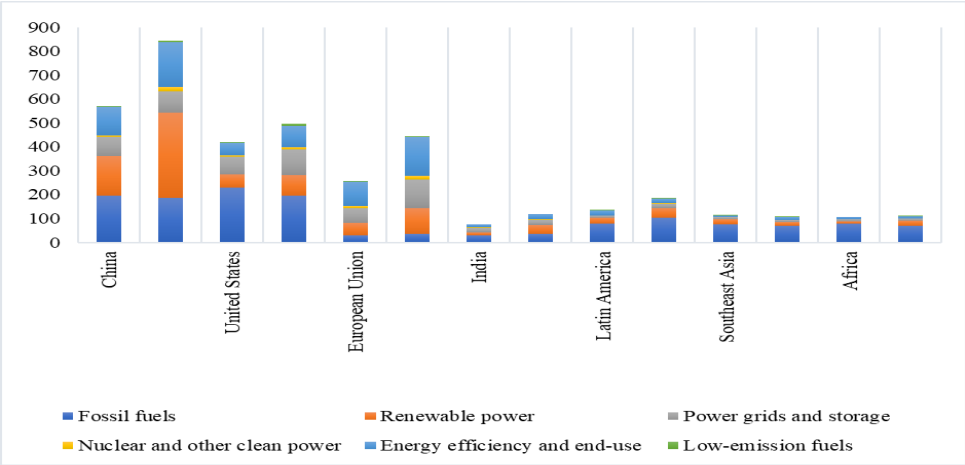

Figure 2. Clean energy investments by country and region in 2019 and 2024, USD billion
Source: IEA (2024c)

At the same time, the growth of investments in renewable energy in India, Brazil, certain Southeast Asian countries and Africa is associated with political measures, effective public procurement management, and improved grid infrastructure. In 2024, India's investments in clean energy totalled USD 81 billion, including USD 37 billion in renewable energy, USD 19 billion in power grids and storage, and USD 20 billion in energy efficiency.

Such differences and imbalances in renewable energy investment in developing countries are related to the problems of servicing the high level of public debt in these countries. Accordingly, the potential for state financing of renewable energy sources, the level of availability of clean energy and the ability to meet demand are reduced.

Different EU countries show differentiation in investments in different sources of renewable energy. For example, in Belgium, public investment in solar photovoltaic networks amounted to USD 60.03 million, and in Italy – USD 177.83 million in 2022. In contrast, Croatia made $70.32 million in public investments in onshore wind energy sources in 2022. Denmark and Finland invested $206.98 million and $65.05 million in offshore wind in 2021. Estonia invested $10.91 million in solar PV in 2020 and $78.09 million in onshore wind in 2022. France has one of the highest funding volumes for offshore wind energy sources, which amounted to $544.52 million in 2020, $413.96 million in 2021, and $181.23 million in 2022. Significant investments in offshore wind energy sources were recorded in Germany, namely $ 183.49 million in 2021 and $ 679.6 million in 2022 (The International Renewable Energy Agency, 2024).

The different weighted average after-tax cost of capital for renewable energy projects explains the predominance of public investment in offshore wind. According to Steffen (2020), the cost of capital is higher for solar PV projects. At the same time, the cost of capital is lower for onshore wind and offshore wind projects. On average, developing countries have a significantly higher cost of capital for such projects than industrialised countries (Steffen, 2020).

The growth in public investment in renewable energy is also explained by the introduction of political and economic incentives and the growing role of technological innovation in the green transition. Thus, according to Khan et al. (2022), Germany is a leader in innovation spending, investing heavily in developing renewable energy sources. The country's renewable energy support policy provides for reducing fixed tariffs to influence the costs of technology producers to reduce them. The stability of the country's legal environment has facilitated public and private investment in solar, wind and bioenergy since the 1990s. Financial and policy support measures have facilitated private investment in renewable energy (Khan et al., 2022). According to Jin et al. (2022), Germany has seen an increase in innovation in the energy sector, and increased investment in clean energy and energy efficiency research and development has positively impacted the utilisation of installed capacity.

In France, as part of its renewable energy support policy, incentives have been introduced to support citizen participation projects in green financing. In 2015, financial support was introduced for €1 to €3 per MWh, subject to compliance with the financing thresholds. As a result, 36% of projects in all renewable energy sectors received such support, and 70% of projects for installing ground-mounted solar PV power plants. To meet EU requirements, the French government has also introduced a feed-in tariff mechanism to support renewable energy development (Sebi & Vernay, 2020). In contrast, Feurtey et al. (2015) argue that French feed-in tariffs for wind energy are inefficient regarding installed capacity due to high costs.

According to the five-indicator assessment of sustainable energy regulation, Germany is among the top five countries in terms of policy impact on the sector in 2023. Thus, Germany has high scores for sector governance, the impact on developing renewable energy sources, including heating and cooling, and market rules. In contrast, the assessment of the regulation of the renewable energy sub-sector in the transport sector is average. By comparison, France scores somewhat lower in all dimensions except governance (Figure 3).

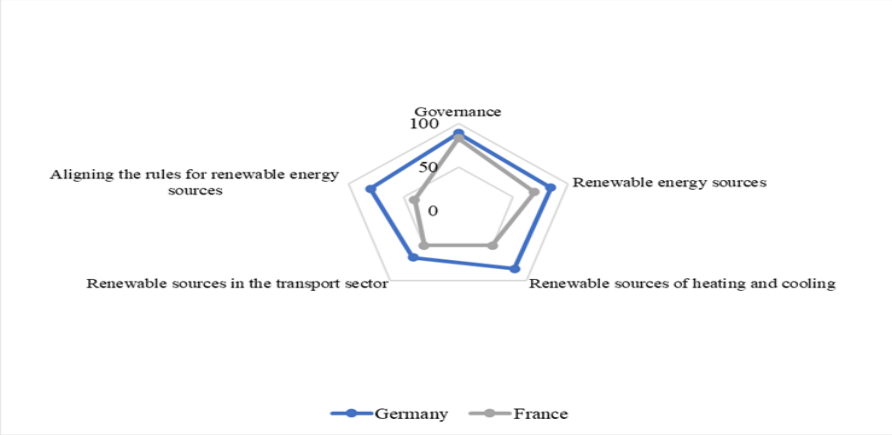

Figure 3. Sustainable Energy Sector Regulatory Assessment by Five Indicators in Germany and France in 2023.
Source: compiled by the author based on Regulatory Indicators for Sustainable Energy (2024).

It should be noted that since 2020, trends in various types of investment have been changing in favour of solar energy. According to the IEA (2024d), the energy sector's investments in solar photovoltaic technologies amounted to USD 503 billion, significantly higher than other generation sources, estimated at USD 426 billion in 2024 (Figure 4). Investment growth slowed in 2024 due to falling prices for photovoltaic modules. Solar energy sources and technologies are crucial to transforming the energy sector.

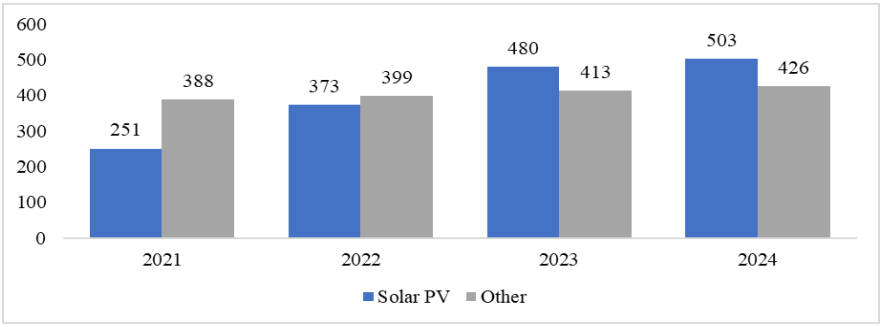

Figure 4. Global energy sector investment by type in 2021-2024.
Source: IEA (2024d).

The energy return on investment increased between 2013 and 2023. Thus, in 2023, compared to 2013, one dollar of investment in wind and solar photovoltaic installations provided 2.5 times more energy production. Consequently, the profitability of these technologies has also increased. The results of an empirical study by Stucki (2019) show

that 81% of firms in Austria, Germany, and Switzerland have an insignificant or negative return on investment in green energy (energy-efficient technologies, wind or hydroelectric power plants).

In 2015, the ratio of net energy produced to fossil fuel-based energy investments was estimated at around 2:1. By comparison, in 2024, this ratio reached 10:1.

Due to the growing use of wind and solar energy, wholesale prices for these energy sources have fallen in some countries, reaching below zero. This reduces potential revenues for producers on the spot market and points to the need for additional investment in storage.

Despite the slow growth rate of investment in networks and storage, in 2024, their volume increased by 42% compared to 2019, amounting to USD 378 billion, as opposed to USD 266 billion five years ago. New financing policies in the US, China, Europe, and certain parts of Latin America drive this dynamic. The EU, the US, and China developed economies accounted for 81% of investments in networks and storage in 2019 and 84% in 2024. Investment volumes have doubled since 2021 in Latin America, especially in Brazil, Chile, and Colombia.

Despite significant geopolitical risks and challenges, investments in energy efficiency and electrification of buildings and industry have been quite resilient. Thus, China's energy efficiency investments totalled USD 120 billion in 2019 and USD 188 billion in 2024; the US – USD 52 billion and USD 89 billion, respectively, and the EU – USD 103 billion and USD 163 billion, respectively. By the end-use sector, investments in energy-efficient transport prevailed.

Growth in clean energy investment is driven by the need to meet carbon emission reduction targets, energy security, especially in the EU, and strategic factors. New industrial strategies are being implemented in the EU and the US to stimulate clean energy production and strengthen market positions. These policies can provide several localised benefits for investors.

Corporations make most investments in the energy sector, while private enterprises account for a much smaller share of investments, including in the renewable energy sector. There is considerable differentiation between different developing countries. The government or state-owned enterprises make up about 50% of all investments in developing countries. In contrast, in developed economies, this share is only 15%. National oil companies and some state-owned utilities mainly make investments in state-owned enterprises.

CONCLUSION

- In 2020–2024, there was an increase in investment in the renewable energy sector, which is twice as high as fossil fuel financing. In 2024, investments in the clean energy sector were dominated by investments in renewable energy, energy efficiency, grid and storage. These trends are associated with a decline in prices for solar power plants and an increase in prices for traditional energy resources (Jiang et al., 2019). In the regional context, a significant imbalance of investment flows was identified, with the highest volumes recorded in China, the US and the EU, with a total share of 84% in 2024.
- Across EU countries, offshore wind is the preferred source of investment due to its lower weighted average cost of capital after tax. Therefore, the cost of capital for financing solar PV networks was a significant obstacle to investor investment until 2020. In contrast, the increase in the energy return on investment in solar PV installations in 2013–2023 contributed to the growth of their financing in 2021–2023. In addition, government incentive policies promote the development of the renewable energy market. In particular, in Germany, the support policy provides for a reduction in fixed tariffs to reduce the costs of technology manufacturers to reduce them. France has introduced preferential tariffs for wind energy. At the same time, the policy of stimulating the industry under study has limitations, as small firms with low energy costs in Austria, Germany, and Switzerland receive almost no or relatively low returns on investments in green energy. Therefore, the profitability of investments and the price of renewable energy technologies can be key risks for its financing.
- The study's main limitation is the lack of data disaggregated by individual renewable energy projects, which makes it impossible to analyse them in detail when studying the risks and benefits of investment.
- Further research should highlight the effectiveness of state policy in supporting investment in renewable energy in different countries.

Conflict of Interest. The authors declare that they have no conflict of interest.

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