Renewable Energy Transition and Sustainable Economic Development

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Abstract

The transition towards renewable energy has become an important component of sustainable economic development. Increasing energy demand, climate change, energy insecurity and the environmental costs of fossil fuels have encouraged countries to expand solar, wind, hydropower, bioenergy and other renewable technologies. This paper examines the contribution of renewable energy transition to sustainable economic development, with particular emphasis on investment, employment, energy security and inclusive growth. The study uses secondary data obtained from original publications of the International Renewable Energy Agency (IRENA), International Energy Agency (IEA) and International Labour Organization (ILO). The analysis shows that global renewable power capacity reached 4,448 GW in 2024, with 585 GW added during the year, representing 92.5% of total global power-capacity expansion. Renewable energy employment also reached at least 16.6 million jobs in 2024. The study finds that renewable energy can stimulate investment, create employment, improve energy security and support environmental sustainability. However, grid constraints, financing difficulties, skill gaps, supply-chain concentration and unequal access remain major challenges. Strong policy support, investment in infrastructure, skill development and inclusive green industrial policies are therefore essential.

Keywords: Renewable Energy, Energy Transition, Sustainable Development, Green Economy, Employment, Economic Growth

1. Introduction

Energy is a fundamental input for economic production, transportation, communication, agriculture, industry and household welfare. For many decades, economic development has depended heavily on coal, oil and natural gas. However, excessive

dependence on fossil fuels has generated environmental pollution, greenhouse-gas emissions, energy-price instability and concerns about energy security. Consequently, renewable energy has become an important component of the global transition towards a more sustainable economic system.

Renewable energy includes solar, wind, hydropower, bioenergy, geothermal and marine energy. Technological improvements and falling costs have accelerated the deployment of renewable energy, particularly solar photovoltaic and wind power. According to the International Renewable Energy Agency (IRENA), global renewable power capacity reached 4,448 GW at the end of 2024. During 2024, approximately 585 GW of renewable capacity was added, accounting for 92.5% of total global power-capacity expansion. The annual growth rate of renewable capacity was 15.1%.

The renewable energy transition is not only an environmental process but also an economic transformation. It creates demand for infrastructure, manufacturing, construction, engineering, finance, research and development and skilled labour. The IRENA and ILO Renewable Energy and Jobs: Annual Review 2025 estimated at least 16.6 million renewable-energy jobs globally in 2024.

The International Energy Agency (IEA) expects renewable power capacity to increase by approximately 4,600 GW between 2025 and 2030, with solar photovoltaic accounting for almost 80% of the increase.

Thus, renewable energy transition can contribute simultaneously to economic growth, employment generation, energy security and environmental sustainability. However, achieving these benefits requires appropriate public policies, investment and institutional capacity.

2. Review of Literature

The existing institutional literature demonstrates the growing economic importance of renewable energy.

1. IRENA’s Renewable Capacity Statistics 2025 documents the rapid expansion of renewable electricity capacity worldwide. The report shows that renewable energy has become the dominant source of new global power-capacity additions, demonstrating the increasing importance of renewable technologies in the electricity sector.

2. The IEA's Renewables 2025 provides evidence that renewable energy expansion is expected to continue strongly through 2030. Its forecast of approximately 4,600 GW of additional renewable capacity indicates substantial opportunities for investment, infrastructure development and technological innovation. However, the IEA also identifies grid integration, financing, supply-chain vulnerabilities and policy uncertainty as important constraints.
3. IRENA and the ILO have examined the employment implications of the energy transition. Their 2025 review estimates that renewable energy employment reached at least 16.6 million jobs in 2024. At the same time, the report notes that employment growth has been moderated by automation, economies of scale, manufacturing overcapacity and grid-related constraints.

The literature therefore indicates that renewable energy contributes to sustainable development through multiple channels: investment, employment, energy access, industrial development and environmental improvement. However, the economic benefits are not automatically distributed equally. Workforce development, domestic manufacturing, access to finance and inclusive policies are necessary to ensure that the energy transition contributes to broad-based development.

Research Gap

Existing institutional studies provide extensive information on renewable-energy capacity, employment and future deployment. However, these dimensions are often examined separately. This study brings together renewable-energy expansion, economic development, employment and sustainability within an integrated framework. It particularly emphasises the economic opportunities and policy challenges associated with the transition.

3. Statement of the Problem

The global energy system is undergoing a major structural transformation. Although renewable energy capacity is expanding rapidly, many countries continue to face dependence on fossil fuels, energy insecurity, inadequate electricity infrastructure and limited access to finance.

The expansion of renewable energy also creates new economic challenges. Renewable-energy projects require large initial investments, modern transmission networks, storage

systems, skilled workers and supportive regulatory frameworks. Developing countries may face difficulties in mobilising finance and accessing advanced technologies.

Another concern is whether renewable-energy growth will automatically generate sufficient employment and inclusive economic opportunities. The latest IRENA-ILO evidence indicates that renewable-energy employment increased to 16.6 million jobs in 2024, but employment growth was slower than the growth in installed capacity.

Therefore, the central problem addressed by this study is:

How can renewable energy transition be effectively utilised to promote sustainable, inclusive and employment-oriented economic development while overcoming financial, technological, infrastructural and institutional constraints?

4. Objectives of the Study

The study has the following three objectives:

1. To examine the growth and structure of renewable energy capacity and its contribution to sustainable economic development.
2. To analyse the relationship between renewable energy transition, investment and employment generation.
3. To identify the major challenges and suggest policy measures for achieving an inclusive and sustainable renewable-energy transition.

5. Scope of the Study

The study focuses on the global renewable energy transition and its relationship with sustainable economic development. It covers major renewable-energy technologies, including solar, wind, hydropower, bioenergy, geothermal and marine energy.

The study particularly examines:

- Renewable-energy capacity expansion.
- Investment and infrastructure development.
- Employment generation.
- Energy security.
- Green economic growth.

- Technological development.
- Policy and institutional challenges.
- Inclusive and sustainable development.

The study primarily uses global-level secondary data, with emphasis on information available up to 2024 and projections to 2030.

6. Research Methodology

6.1 Research Design

The study adopts a **descriptive and analytical research design**. It examines the development of renewable energy and interprets its economic implications.

6.2 Sources of Data

The study is based entirely on secondary data obtained from original institutional publications, particularly:

* International Renewable Energy Agency (IRENA)
* International Energy Agency (IEA)
* International Labour Organization (ILO)

IRENA's *Renewable Capacity Statistics 2025 provides renewable-capacity data for 2015–2024.

The IEA's Renewables 2025 provides forecasts for renewable-energy development up to 2030.

The IRENA-ILO *Renewable Energy and Jobs: Annual Review 2025* provides employment information for 2024.

6.3 Analytical Methods

The study uses:

* Descriptive statistics
* Percentage analysis
* Comparative analysis

* Trend interpretation
* Policy analysis

The purpose is not to establish a strict causal econometric relationship but to interpret the economic significance of the renewable-energy transition using reliable secondary evidence.

7. Data Analysis and Interpretation

Table 1: Global Renewable Power Capacity by Technology, 2024

Renewable source	Capacity in 2024 (GW)	Approximate share
Solar energy	1,865	42%
Hydropower	1,283	29%
Wind energy	1,133	25%
Bioenergy	151	3%
Geothermal	15	Less than 1%
Marine energy	1	Less than 1%
Total	4,448	100%

Source: International Renewable Energy Agency (IRENA, 2025).

Interpretation

The data demonstrate that renewable energy has developed into a major component of global electricity infrastructure. Solar energy had the largest installed capacity at approximately 1,865 GW, followed by hydropower at 1,283 GW and wind energy at 1,133 GW.

Solar energy alone represented approximately 42% of global renewable capacity. This dominance reflects technological progress, declining equipment costs, modular installation possibilities and increasing deployment of both utility-scale and distributed solar systems.

Hydropower continues to provide an important source of renewable electricity and system flexibility, while wind power has become another major source of clean electricity. Bioenergy, geothermal and marine energy contribute smaller shares but remain important for technology diversification.

Table 2: Major Global Renewable Energy Indicators

Indicator	Value
Global renewable capacity, 2024	4,448 GW
Renewable capacity added in 2024	585 GW
Share of total power expansion	92.5%
Renewable capacity annual growth	15.1%
Renewable-energy employment, 2024	16.6 million jobs
Expected renewable capacity addition, 2025–2030	About 4,600 GW

Sources: IRENA (2025); IRENA & ILO (2026); IEA (2025).

Interpretation

The figures indicate that renewable energy is moving from being an alternative source of energy towards becoming a central component of the global energy system.

The addition of 585 GW In 2024 represents a major investment and infrastructure expansion. More importantly, renewables accounted for 92.5% of total global power-capacity expansion during the year. This demonstrates that new electricity investment is increasingly concentrated in renewable technologies.

The employment figure of 16.6 million demonstrates the importance of renewable energy as a source of economic activity. Employment occurs across manufacturing, construction, installation, operations and maintenance, project development, transport and associated services.

However, employment growth has not increased at the same pace as capacity expansion. IRENA and the ILO attribute this partly to economies of scale, automation, technological innovation, excess manufacturing capacity and grid bottlenecks.

8. Renewable Energy Transition and Economic Development

8.1 Investment and Capital Formation

Renewable energy development requires significant investment in generation facilities, transmission networks, energy storage, digital systems and supporting infrastructure. This investment creates demand for construction, engineering, manufacturing and financial services.

Large-scale solar and wind projects can stimulate local economic activity during both construction and operation. Renewable-energy investment can therefore contribute to capital formation and technological development.

For developing countries, renewable-energy investment can also reduce dependence on imported fossil fuels and improve the long-term stability of the energy system.

8.2 Employment Generation

Employment generation is one of the most visible socio-economic benefits of renewable energy. According to IRENA and ILO, global renewable-energy employment reached at least 16.6 million jobs in 2024.

Employment opportunities arise in:

* Solar-panel manufacturing
* Solar installation
* Wind-turbine manufacturing
* Construction
* Electrical engineering
* Project management
* Operations and maintenance
* Research and development
* Transport and logistics
* Financial and professional services

However, the transition also changes the structure of employment. Some traditional fossil-fuel jobs may decline while new jobs emerge in renewable-energy industries. Therefore, reskilling and vocational training are essential.

8.3 Energy Security

Renewable energy can improve energy security by reducing dependence on imported fossil fuels. Countries with adequate solar, wind, hydro, biomass or geothermal resources can diversify their domestic energy supply.

Energy security has direct economic implications. Lower dependence on imported fuels can reduce exposure to international price fluctuations and supply disruptions.

Distributed renewable-energy systems can also improve electricity access in rural and remote areas. Solar mini-grids and decentralised systems can support agriculture, small businesses, education and healthcare.

8.4 Industrial Development

Renewable energy can promote green industrialisation. Countries can develop domestic manufacturing capacity for solar modules, batteries, wind equipment, electrical components and other technologies.

The IRENA-ILO evidence highlights the importance of supply chains and industrial policies for employment creation. Building domestic value chains can allow countries to capture a larger share of the economic benefits associated with renewable-energy deployment.

8.5 Environmental Sustainability

Renewable energy reduces dependence on fossil fuels and supports the transition towards a lower-carbon economy. Cleaner electricity can also support the electrification of transport, industry and other sectors.

The environmental benefits of renewable energy contribute to sustainable development by reducing pollution and supporting climate objectives. Thus, renewable-energy investment can produce both economic and environmental returns.

9. Future Outlook for Renewable Energy

The global renewable-energy outlook remains strong. According to the IEA, renewable power capacity is expected to increase by approximately **4,600 GW between 2025 and 2030**. Solar photovoltaic is expected to account for almost 80% of the global increase.

However, the IEA indicates that the projected expansion under its main case would bring global renewable capacity to approximately 9,530 GW by 2030, which remains below the roughly 11,500 GW level associated with the global tripling objective.

This indicates that technological progress alone will not be sufficient. Governments need to address:

* Transmission and distribution constraints
* Energy storage requirements
* Project financing
* Permitting procedures
* Supply-chain risks
* Skilled-worker shortages
* Policy uncertainty

The economic implications are significant. Faster renewable deployment can generate additional investment and employment, while delayed deployment can increase energy-security and climate-related economic risks.

10. Major Challenges

10.1 Financing Constraints

Renewable projects often require substantial upfront investment. Developing economies may face high financing costs, limited fiscal capacity and difficulties in accessing international capital.

10.2 Grid Infrastructure

Rapid growth in solar and wind power requires modern electricity grids, storage facilities and flexible generation. Grid bottlenecks can delay projects and cause renewable electricity curtailment. The IEA identifies grid integration as one of the important challenges facing future renewable deployment.

10.3 Skill Gaps

The renewable-energy transition requires workers with technical, digital, engineering and project-management skills. Lack of appropriately trained workers can constrain expansion.

10.4 Supply-Chain Concentration

Renewable-energy manufacturing is geographically concentrated in a limited number of countries. This creates vulnerabilities associated with trade restrictions, geopolitical tensions and supply disruptions.

10.5 Unequal Distribution of Benefits

The economic benefits of renewable energy are not automatically distributed equally. Some regions may receive substantial investment while others remain excluded because of inadequate infrastructure, finance or skills.

10.6 Gender and Social Inclusion

The IRENA-ILO report highlights continuing barriers affecting women's participation and career advancement in renewable-energy employment.

Therefore, the transition should not be assessed only in terms of installed capacity. Social inclusion and quality employment are also important indicators of sustainable development.

11. Findings of the Study

The major findings are:

- Renewable energy has become a major source of new global power capacity. In 2024, renewables accounted for 92.5% of total power-capacity expansion.
- Global renewable capacity has reached a significant scale, with total installed capacity of 4,448 GW in 2024.
- Solar energy is the leading renewable technology, accounting for approximately 42% of global renewable capacity in 2024.
- Renewable energy contributes to employment generation. At least 16.6 million people were employed in renewable energy worldwide in 2024. L
- Employment growth is slower than capacity growth, partly because of automation, economies of scale and technological changes.
- Renewable energy can strengthen energy security by reducing dependence on imported fossil fuels.
- The future expansion potential is substantial. The IEA expects around 4,600 GW of additional renewable power capacity between 2025 and 2030.
- Infrastructure and financing are major constraints that could slow the energy transition.
- Skill development is essential to ensure that the transition generates adequate employment opportunities.
- Inclusive policies are necessary to ensure that women, young people, rural communities and other underrepresented groups benefit from the emerging green economy.

12. Suggestions and Policy Recommendations

1. Increase Renewable-Energy Investment

   Governments should create stable investment environments through transparent regulations, predictable policies and appropriate financial incentives.

2. Strengthen Green Financing

   Green bonds, concessional finance, blended finance and international climate finance should be expanded, particularly for developing countries.

3. Modernise Electricity Grids

   Investment should focus not only on renewable generation but also on transmission, distribution, smart grids and energy-storage infrastructure.

4. Promote Domestic Manufacturing

   Countries should develop appropriate industrial policies to establish domestic supply chains for renewable-energy equipment while avoiding excessive protectionism that increases costs.

5. Develop Green Skills

   Universities, technical institutions and vocational-training centres should introduce programmes related to solar installation, wind technology, battery systems, electrical engineering, energy management and green entrepreneurship.

6. Promote Inclusive Employment

   Renewable-energy policies should encourage women's participation, youth employment and opportunities for disadvantaged communities.

7. Encourage Decentralised Renewable Energy

   Solar rooftops, mini-grids and other decentralised systems should be promoted in rural and underserved regions to improve energy access and support local economic activities.

8. Support Research and Innovation

   Governments should increase investment in battery storage, green hydrogen, smart grids, offshore wind, advanced solar technologies and other emerging technologies.

9. Strengthen International Cooperation

Countries should cooperate in technology transfer, financing, research, skills development and supply-chain resilience.

10. Adopt a Just Transition Approach

The renewable-energy transition should protect workers and communities affected by the decline of fossil-fuel industries through reskilling, social protection and alternative employment opportunities.

13. Conclusion

Renewable energy transition represents both an environmental necessity and an economic opportunity. The rapid expansion of renewable power capacity demonstrates that the global energy system is increasingly moving towards cleaner technologies. In 2024, global renewable capacity reached 4,448 GW, while renewable sources accounted for 92.5% of total power-capacity expansion.

The transition can contribute to sustainable economic development through investment, employment generation, energy security, industrial development and technological innovation. The employment of at least 16.6 million people in renewable energy in 2024 demonstrates the sector's growing economic importance.

Nevertheless, renewable-energy expansion alone does not guarantee inclusive development. Grid constraints, financing difficulties, supply-chain vulnerabilities, skill shortages and unequal distribution of economic opportunities remain important challenges. The IEA's forecast of approximately 4,600 GW of additional renewable capacity between 2025 and 2030 indicates the enormous scale of future investment and economic transformation.

Therefore, governments should adopt an integrated policy framework combining renewable-energy deployment with green finance, infrastructure development, domestic manufacturing, skill development and inclusive employment policies. A successful energy transition should be measured not merely by the number of gigawatts installed, but also by its ability to create decent employment, strengthen energy security, reduce environmental damage and improve the quality of life.

In conclusion, renewable energy can serve as a powerful foundation for sustainable economic development when technological progress is accompanied by sound economic policies, social inclusion and effective institutions.

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