

The Contribution of China to the Global Energy Transition in the Context of Falling Renewable Energy Investment Costs

مساهمة الصين في التحول العالمي للطاقة في ظل انخفاض تكاليف الاستثمار
في الطاقة المتجددة

*Maroua krama

University of Mohamed
Khider Biskra, (Algeria)
maroua.krama@univ-biskra.dz

Fatma rahal

University of Mohamed
Khider Biskra, (Algeria)
f.rahall@univ-biskra.dz

Nadjet Messemeche

University of Mohamed
Khider Biskra, (Algeria)
nadjet.messemeche@univ-biskra.dz

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Abstract : This study addresses the growing environmental and economic pressures linked to achieving carbon neutrality and sustainable energy adoption. It explores how declining investment costs in renewable energy accelerate the global energy transition, highlighting China as a leading case. Despite being the largest carbon emitter, China has become the top producer of solar and wind power, surpassing global output through strategic policies and governmental support. The findings show that falling renewable energy costs enable both developed and developing economies to enter the clean energy market, reshaping global power systems and fostering sustainable infrastructure while balancing economic growth with environmental goals.

Key words:Renewable EnergyEnergy Transition.Solar PV.Carbon Neutrality . Investment Costs

JEL classificationcodes:Q42, Q48, Q54, O13, O53, H23

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*Corresponding author

1. Introduction

In recent decades, the global energy landscape has undergone profound changes, driven by technological innovation, environmental imperatives, and evolving economic priorities. A central aspect of this transformation is the shift away from fossil fuels toward sustainable energy sources such as solar, wind, and hydropower. The sharp decline in renewable energy technology costs has made clean energy more economically viable and increasingly central to national energy strategies. This transition has significant implications for energy security, economic resilience, and global climate goals

The main research question guiding this paper is:

How has the decline in renewable energy investment costs contributed to the global energy transition?

Sub-questions include:

- What are the main drivers behind the global energy transition?
- What factors have enabled China to lead the global photovoltaic (PV) industry?
- Has the decline in renewable energy costs contributed to global job creation?

Hypotheses:

- The significant reduction in renewable energy technology costs has increased clean energy's competitiveness against fossil fuels.
- China's dominance in the PV industry is due to economies of scale and supportive state policies.
- The decline in the costs of producing solar panels and wind turbines has contributed to job creation and lower unemployment worldwide, but to varying degrees depending on each country's policies and industrial strategy.

Importance of the Study:

This research contributes to the understanding of how investment cost trends in renewable energy technologies can reshape global energy markets and labor structures. It also highlights practical lessons for policymakers and stakeholders in other emerging economies to accelerate their clean energy transitions by leveraging cost competitiveness and policy incentives

Research Methodology

This study adopts a descriptive and analytical approach to examine the impact of declining investment costs on the global energy transition. It focuses particularly on China as a case study, highlighting the interplay between policy support, industrial capacity, and technological innovation. The research relies on

secondary data from reputable sources, including IRENA, IEA, EMBER, and other industry reports to provide up-to-date insights and quantitative evidence.

1. Contribution of Renewable Energy to Total Energy

Renewable energy contributes about 14% of global energy supplies, up from 8.7% in 2009 to 14.6% in 2021. According to the International Renewable Energy Agency's (IRENA) scenario aimed at limiting global temperature rise to 1.5°C, it is expected that the share of renewable energy in the global energy mix will increase to 77% by 2050. The total rate of primary energy supply will remain stable, due to the improvement in energy efficiency and the growth of renewable energy sources. The use of renewable energy sources in all end-use sectors will also rise, and the high demand for electrical systems in sectors like transportation and buildings will require a twelve-fold increase in renewable electricity capacity by 2050. (IRENA, World Energy Transitions Outlook 2023, 2023, p. 11)

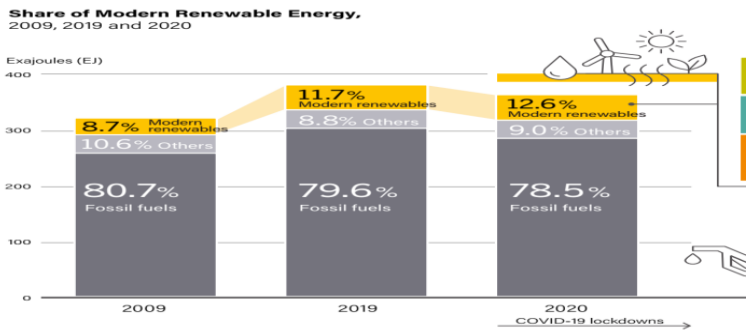
The growing share of renewable energy in the global energy mix presents substantial implications for long-term economic growth and sustainability. This transition toward cleaner and more efficient energy systems is expected to drive job creation across multiple sectors, including the manufacturing, installation, and maintenance of renewable energy technologies. Enhancements in energy efficiency may also result in reduced energy costs, particularly for energy-intensive industries, thereby boosting overall economic productivity and competitiveness.

Moreover, increased adoption of renewable energy can significantly reduce dependence on fossil fuels, leading to greater energy security and stability. Countries with abundant renewable resources—such as wind, solar, and hydropower—stand to gain economically by lowering energy imports, which supports their trade balance and strengthens overall economic resilience.

On the demand side, the expanding use of renewable electricity in sectors such as transportation and buildings may accelerate technological innovation, generate new business opportunities, and foster economic diversification. This shift aligns with global sustainability objectives and has the potential to attract investment through green finance initiatives, thereby supporting long-term economic development in a carbon-conscious global economy.

In summary, the rising role of renewable energy in global energy supplies offers not only environmental advantages but also strong economic opportunities through job creation, cost savings, increased energy security, and enhanced economic resilience.

Figure 01. Contribution of renewable energy to total energy consumption in the world during the period 2009-2020.



source : (RAHAL, 2023)

Figure 02. Contribution of renewable energy to total energy consumption in the world during the year 2021.

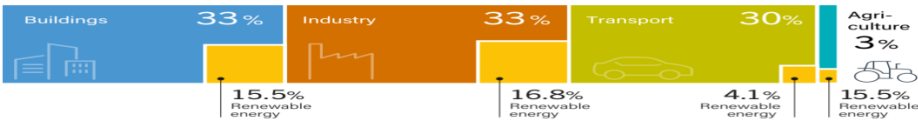


source : PB Statistical Review of world

In 2021, oil and natural gas accounted for more than half of global energy consumption, around 55%, while coal contributed 27% to the total global energy consumption. Renewable energy sources, in all their forms, contributed no more than 14% to the energy consumption structure, whereas nuclear energy’s share stood at about 4%. (Suleiman, 2024, p. 16)

The majority of renewable energy sources are consumed in the construction and industrial sectors, while the transportation sector holds the smallest share of consumption

Figure 03. Renewable Energy Consumption as a Percentage of Total Energy, by Sector, 2020.



Source :(RAHAL, 2023)

2. Global Trends in the Levelized Cost of Renewable Energy Technologies

Renewable energy is currently the least expensive energy source in most parts of the world. The prices of renewable energy technologies are falling rapidly. Since 2010, photovoltaic solar energy has seen the fastest cost reduction, with the global weighted average levelized cost of electricity (LCOE) for newly commissioned large-scale solar photovoltaic projects decreasing from \$0.445 per kWh to \$0.049 per kWh between 2010 and 2022, representing a 89% reduction. This decrease is primarily due to a 90% drop in the price of solar panels between December 2009 and December 2022, despite price increases in 2022. Additionally, there have been significant reductions in the overall cost structure of generation plants, including operational and maintenance costs, and capital costs.

The global weighted average LCOE for onshore wind projects also fell by 69% between 2010 and 2022, from \$0.107 per kWh to \$0.033 per kWh. The reduction in wind energy costs was driven by two main factors: lower wind turbine costs and improved capacity factors due to advancements in turbine technology. The price of wind turbines outside of China decreased by 39% to 55% between 2010 and 2022, according to wind turbine price indices, while in China, the reduction was almost two-thirds (64%). The global average capacity factor for newly commissioned projects increased from 27% in 2010 to 39% for projects in 2021, but then declined to 37% in 2022 due to the growing share of new projects in China, where wind sites generally have lower productivity.

For newly commissioned offshore wind projects, the global weighted average LCOE decreased by 59% between 2010 and 2022, from \$0.197 per kWh to \$0.081 per kWh. From 2010 to 2022, the global weighted average LCOE for newly commissioned concentrated solar power projects fell by 69%, from \$0.38 per kWh to \$0.118 per kWh. This reduction was rapid between 2010 and 2020, despite annual fluctuations. Since 2020, the global weighted average LCOE for concentrated solar power stagnated, as delayed projects or new designs were launched. Supportive policies are expected to help improve the position of concentrated solar power, especially given the substantial cost savings achieved by implementing only 6.5 GW of projects.

The global weighted average LCOE for biomass projects showed some fluctuation between 2010 and 2020, with no significant upward or downward trend. However, the global weighted average LCOE for biomass projects in 2022 was \$0.061 per kWh, 13% lower than in 2021 and 25% lower than in 2010, when it was \$0.082 per kWh.

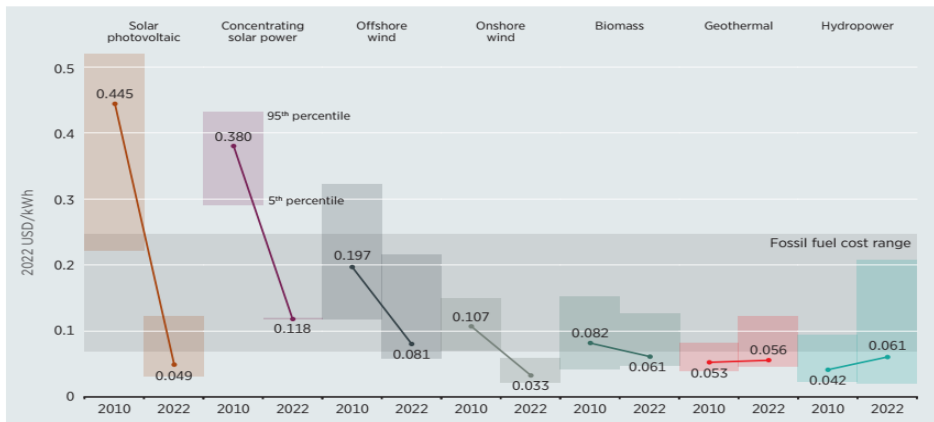
For geothermal energy projects, the global weighted average LCOE decreased by 22% between 2021 and 2022, reaching \$0.056 per kWh. This was 6% higher than in 2010 but within the \$0.091–\$0.053 per kWh range observed between 2013 and 2021. Newly commissioned hydropower projects saw a 47% increase in the global weighted average LCOE between 2010 and 2022, from \$0.042 per kWh to \$0.061 per kWh. Despite this increase, the value remained lower than the cheapest new fossil fuel-based power generation options in 2022, even with an 18% rise in the global average cost in that year. The increase in 2022 compared to 2021 was due to the commissioning of projects that saw significant cost increases, particularly in Canada (IRENA, 2022, pp. 20-22)

Table 1. Total installed cost, capacity factor and LCOE trends bytechnology, 2010 and 2022

	Total installed costs (2022 USD/kW)			Capacity factor (%)			Levelised cost of electricity (2022 USD/kWh)		
	2010	2022	Percent change	2010	2022	Percent change	2010	2022	Percent change
Bioenergy	2904	2162	-26%	72	72	1%	0,082	0,061	-25%
Geothermal	2904	3478	20%	87	85	-2%	0,053	0,056	6%
Hydropower	1407	2881	105%	44	46	4%	0,042	0,061	47%
Solar PV	5124	876	-83%	14	17	23%	0,445	0,049	-89%
CSP	10082	4274	-58%	30	36	19%	0,38	0,118	-69%
Onshore wind	2179	1274	-42%	27	37	35%	0,107	0,033	-69%
Offshore wind	5217	3461	-34%	38	42	10%	0,197	0,081	-59%

SOURCE : (IRENA, 2022, p. 15)

Figure 04. Global LCOE from newly commissioned utility-scale renewable power technologies, 2010_ 2022



SOURCE :(IRENA, 2022, p. 22)

he period from 2010 to 2021 witnessed a fundamental shift in the competitive balance between renewable energy sources and fossil fuel options. In 2021, the global weighted average levelized cost of electricity for utility-scale solar photovoltaic and new hydropower projects was 11% lower than the cheapest new fossil fuel-based electricity generation options, while the average for onshore wind was 39% lower. Geothermal and bioenergy remain, on average, more expensive than the cheapest fossil fuel-based generation options globally, but they provide secure supplies. (**International Renewable energy agency, 2022, p. 5**)

3. Implications of Declining Renewable Energy Costs on Global Installed Capacity

4.1 Trends in Global Renewable Energy Capacity Growth

Renewable energy has witnessed rapid expansion and remarkable growth across the globe over the past two decades. According to the International Renewable Energy Agency, the global renewable energy generation capacity increased by a factor of 3.7 between 2000 and 2020, growing from 754 gigawatts (GW) to 2 799 GW. as their costs have fallen sharply, driven by steadily improving technologies,

economies of scale, competitive supply chains and improving developer experience(IRENA, Renewable Power Generation Costs in 2020, 2021)

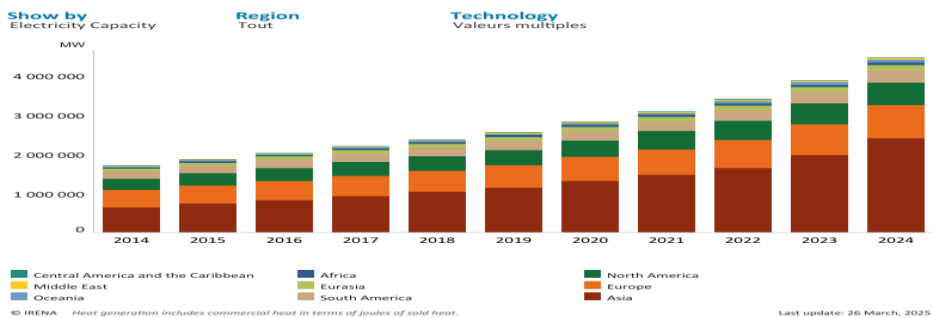
Focusing on the period from 2014 to 2024, the chart demonstrates (Figure 08) a remarkable upward trajectory in globally installed renewable electricity capacity, with capacity nearly doubling from less than 2 million megawatts to over 4 million megawatts. This rapid growth reflects increasing global investments in the renewable energy sector, driven by declining technological costs and supportive policies aimed at achieving carbon neutrality targets.

Asia leads this expansion, accounting for the largest share of installed capacity, primarily due to China’s prominent role in solar and wind energy development. Europe and North America follow, contributing significant shares that reflect their continued commitment to transitioning towards clean energy sources.

However, the chart also shows the relatively limited contributions from other regions such as Africa, Latin America, and Oceania, highlighting the need for greater investment and technology transfer to these areas to ensure a just and balanced global energy transition.

This sustained growth represents a major opportunity to enhance energy security, create green jobs, and stimulate innovation in energy storage and smart grid technologies. Nonetheless, it also requires adequate infrastructure development and stable policies to maximize the benefits of this expansion.

Figure 05. Global Renewable Electricity Capacity Trends (2014–2024)



Source: (IRENA, Statistics Time Series, 2025)

The global shift toward renewable energy continues to reveal significant regional disparities, with China firmly positioned as the unrivaled leader in both investment and deployment. Between 2014 and 2023, China invested an estimated USD 1.572 trillion in renewable energy projects—nearly three times the level of investment made by the United States (USD 550 billion) and about twice that of Europe (USD 785 billion). This level of financial commitment has not only outpaced all other regions but has also enabled China to achieve unparalleled dominance in deploying renewable infrastructure and manufacturing equipment, particularly in the wind and solar photovoltaic (PV) sectors.

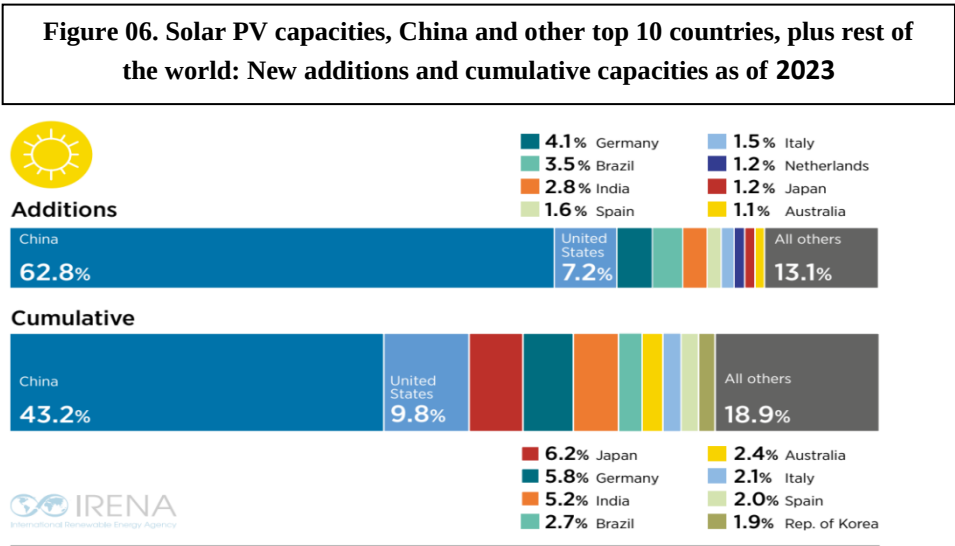
In 2023 alone, China was responsible for 65.5% of all new global wind power capacity additions and 62.8% of new solar PV installations. Its cumulative share of global capacity for these technologies now stands at approximately 43%—a dramatic increase from its 2010 levels of 16% for wind and just 2.6% for solar PV. This remarkable growth far exceeds China's 20% share of the world's population but remains below its 53% share of global coal-fired power capacity. Notably, China's installed solar PV capacity is now four times larger than that of the United States and 1.5 times greater than the combined capacity of the next nine largest markets. Its wind power capacity is also three times higher than that of the United States, further consolidating China's position as the dominant player among major economies. (IRENA & ILO, Renewable Energy and Jobs Annual Review 2024, 2024, p. 15)

China's market leadership is especially pronounced in the PV manufacturing segment. By 2023, the country commanded an overwhelming 96% of global wafer production capacity and 88% of cell production capacity. Chinese manufacturers benefit from substantial economies of scale and enjoy lower input, capital, and labor costs, allowing them to produce solar modules at a highly competitive cost of just USD 0.15 per watt. This is significantly below the average production costs in India (USD 0.22 per watt), Europe (USD 0.30), and the United States (USD 0.40). However, this rapid expansion has also resulted in significant overcapacity between 2020 and 2023 across key production stages: polysilicon capacity grew from 12% to 62%, wafer capacity from -2% to 45%, cell capacity from -2% to 136%, and module capacity from 37% to 123%. This oversupply has exerted downward pressure on both market prices and wage levels.

Moreover, China holds a commanding position in the global PV inverter market, with shipments surging by 56% to reach 536 GW in 2023. Nine of the world's ten leading inverter manufacturers are

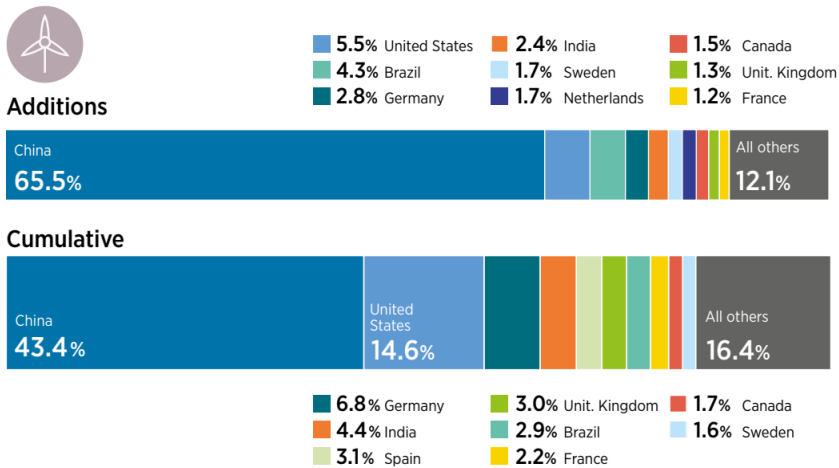
Chinese companies, with industry giants such as Huawei and Sungrow alone accounting for over half of total global shipments. To circumvent U.S. tariffs, Chinese investments have also transformed Southeast Asia into a major export hub for PV products. However, recent U.S. policy moves to extend tariffs on Southeast Asian modules have prompted manufacturers to increasingly shift operations toward India, which has now emerged as the world’s third-largest PV producer after China and Southeast Asia.

In light of China’s overwhelming market dominance, the United States, European Union, India, and other economies are adopting various measures—including tariffs, non-tariff barriers, and targeted industrial strategies—to rebuild domestic manufacturing capacity and reduce reliance on Chinese supply chains. However, recent policy experiences in India, South Africa, and the United States demonstrate that trade barriers alone are insufficient. Without complementary industrial policies—such as direct government incentives—efforts to localize production are unlikely to achieve lasting competitiveness (IRENA & ILO, Renewable Energy and Jobs Annual Review 2024, 2024, pp. 21-22)



Source :(IRENA & ILO, Renewable Energy and Jobs Annual Review 2024, 2024, p. 14)

Figure 07. wind capacities, China and other top 10 countries, plus rest of the world: New additions and cumulative capacities as of 2023



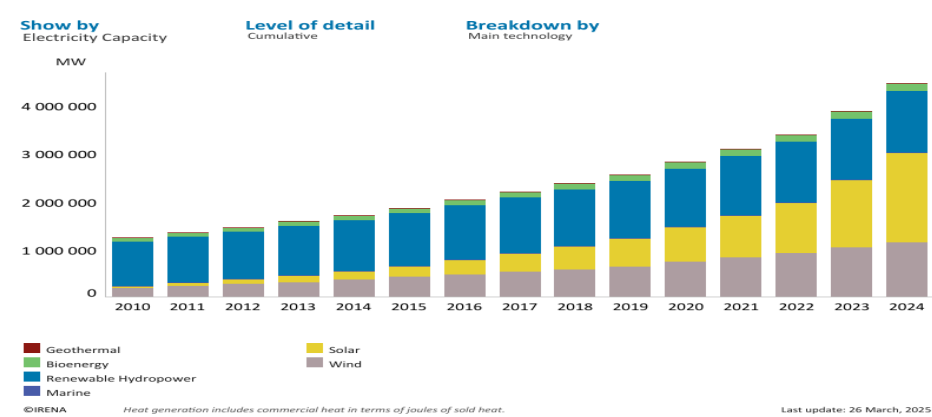
Source : (IRENA & ILO, Renewable Energy and Jobs Annual Review 2024, 2024, p. 14)

4.2. Global Renewable Energy Capacity Growth by technology

The global energy landscape is undergoing a decisive shift toward sustainable, low-carbon systems, marked by a substantial rise in renewable energy investments—particularly in solar and wind capacities. This transition is fueled by supportive policy incentives and ongoing technological advancements that continue to reduce costs. The exponential growth of solar photovoltaic (PV) capacity reflects a fundamental structural change, positioning solar energy as a leading force reshaping traditional energy supply dynamics. This rapid expansion is generating significant employment opportunities across manufacturing, installation, and maintenance sectors, though it also demands strategic workforce development and skill enhancement to meet evolving industry needs. To sustain this momentum, robust policy and regulatory frameworks are essential to foster innovation, ensure stable investment environments, and enable seamless integration of renewables into existing power grids. Collectively, these trends underscore a profound global energy transition with far-reaching economic and environmental implications, highlighting the urgency of long-term strategic

planning to maximize benefits while addressing emerging challenges in the renewable energy sector. (IRENA, World Energy Transitions Outlook 2023, 2023) (IEA, 2023)

Figure 08. Global Renewable Energy Capacity Growth by technology(2010-2024)



Source: (IRENA, Statistics Time Series, 2025)

An in-depth analysis of Figure 11 indicates that installed **hydropower** capacity was approximately 900,000 MW in 2010 and has risen to around 1,300,000 MW by 2024, maintaining its role as the largest single contributor to renewable electricity generation worldwide. However, its growth rate has been comparatively moderate when measured against other renewable technologies.

In contrast, **solar energy** has recorded the most remarkable increase, with its installed capacity expanding from less than 50,000 MW in 2010 to nearly 1,700,000 MW by 2024. This exceptional growth demonstrates the substantial decline in photovoltaic system costs, combined with strong policy support that has driven widespread adoption.

Wind energy has also achieved significant progress, growing from about 200,000 MW in 2010 to over 1,100,000 MW in 2024. This steady rise is largely attributed to continuous technological

improvements and large-scale investments in both onshore and offshore wind projects.

Meanwhile, **bioenergy, geothermal, and marine energy** sources, although accounting for a relatively smaller share of the total capacity, have maintained steady growth. Bioenergy capacity increased from approximately 50,000 MW in 2010 to around 150,000 MW in 2024, while geothermal and marine energy remain marginal contributors yet play a strategic complementary role in diversifying and stabilizing the global renewable energy portfolio.

Overall, this evolving structure highlights the transformative shift towards a more balanced, diversified, and technologically advanced renewable energy sector that aligns with global sustainability and decarbonization objectives.

4.3 . Geographic and Technological Trends in Renewable Energy Investment

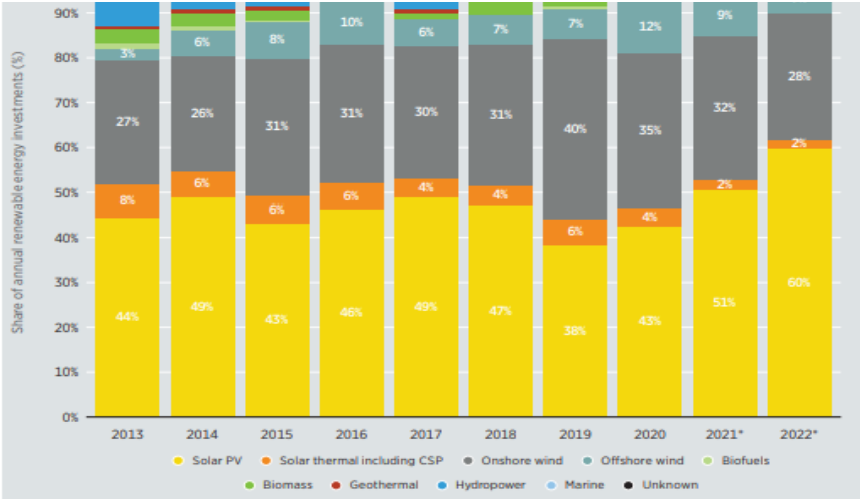
Recent data published by the International Renewable Energy Agency (IRENA) in collaboration with the Climate Policy Initiative (CPI) indicate that global investments in renewable energy have been steadily increasing, yet they remain heavily concentrated both geographically and technologically. From a geographic perspective, the East Asia and Pacific region—led primarily by China—has continued to dominate investment flows, with its share rising from 40% in 2013 to a peak of 56% in 2020, before declining slightly to 49% in 2022. In contrast, Europe’s share fell significantly from 21% to 12% over the same period, while North America (excluding Mexico) maintained relative stability, peaking at 23% in 2018 before dropping to just 6% in 2022. Meanwhile, nearly 120 developing and emerging economies continue to attract only a small portion of global capital, with most investment in these regions concentrated in just three key countries: Brazil, Chile and India. This highlights a substantial imbalance, as more than half of the world’s population—predominantly residing in emerging markets—benefited from less

than 15% of global renewable energy funding in 2022, while the world's least developed countries (LDCs) received a mere 0.84% of total investments. **(IRENA & CPI, GLOBAL LANDSCAPE OF RENEWABLE ENERGY FINANCE 2023, 2023, p. 17)**

From a technological standpoint, global capital for renewable energy projects has been heavily concentrated in solar and wind technologies, which have consistently commanded the largest investment shares by a wide margin. For example, between 2013 and 2022, solar energy alone attracted about 46% of total global investments in this sector, while onshore wind accounted for 32%. Offshore wind showed notable growth, capturing 8% of investments, followed by solar thermal technologies with a share that did not exceed 4% in some years, such as 2020. In contrast, other technologies, including hydropower, biomass, biofuels, geothermal, and ocean energy, remained marginal, jointly representing only about 1% of total investments over the same period.

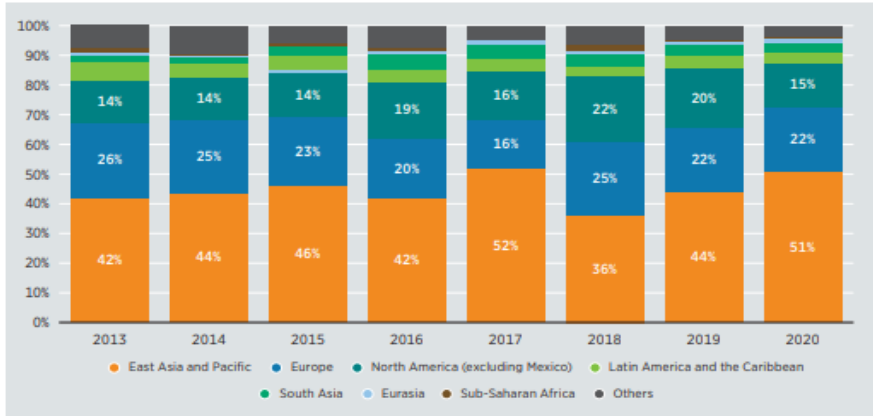
This clear dominance of solar and wind technologies can be attributed to several factors, most notably their continuous technological advancements that have improved operational efficiency and steadily reduced production costs—except for some temporary cost increases observed during 2021 and 2022. Stronger government policy frameworks that provide greater financial and regulatory support for solar and wind projects compared to other renewable technologies have also reinforced their position as the primary focus of investment. Furthermore, the relatively short construction lead times for solar and wind projects, along with the modular and distributed design of solar PV systems, make them particularly well-suited for achieving targeted energy goals flexibly and cost-effectively. **(IRENA & CPI, GLOBAL LANDSCAPE OF RENEWABLE ENERGY FINANCE 2023, 2023, p. 46)**

Figure 09 Share of annual renewable energy investments, by technology, 2013-2022



◆(IRENA & CPI, GLOBAL LANDSCAPE OF RENEWABLE ENERGY FINANCE 2023, 2023, p. 46)

Figure 10 Investment in renewable energy by region of destination, 2013-2022



Note: "North America (excluding Mexico)" includes Bermuda, Canada and the United States. "Others" include the Middle East and North Africa, Other Oceania, Transregional, Other Asia and Unknown. For more details on the geographic classification used in the analysis, please see methodology document (Appendix).

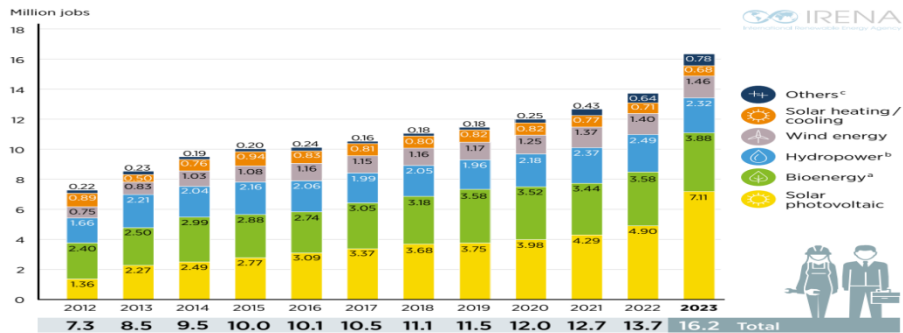
(IRENA & CPI, GLOBAL LANDSCAPE OF RENEWABLE ENERGY FINANCE 2023, 2023, p. 16)

This dual concentration — both geographic and technological — highlights the critical need to channel greater investment into underfunded regions as well as into emerging technologies with substantial untapped potential, such as green hydrogen. Achieving a fair and inclusive energy transition that aligns with global net-zero targets and the Sustainable Development Goals requires proactive government action through effective incentive frameworks. Additionally, strengthening international cooperation and expanding access to concessional finance are vital to help developing and least developed countries overcome structural barriers that limit their ability to attract private investment

Analyzing the Relationship Between Falling Renewable Energy Costs and Employment Trends in the Sector

In 2023, the global renewable energy sector saw a significant increase in job opportunities, with 16.2 million jobs, up from 13.7 million in 2022. A large portion of these jobs is in solar photovoltaic (PV) energy, which accounted for 7.1 million jobs, or 44% of the global renewable energy workforce. China dominated the sector with 4.6 million jobs, while the European Union (EU) followed with a distant 720,000 jobs. Hydropower, on the other hand, employed 2.3 million people, though this marked a 4% decrease compared to 2022, reflecting a slower pace in new installations. The biofuels sector also contributed 2.8 million jobs, with the majority found in the agricultural supply chain, including seasonal and part-time work. Brazil led this sector with 994,000 jobs, followed by Indonesia with 798,600. Wind power, which provided 1.5 million jobs, saw China at the forefront with 745,000 jobs, while Europe, a technology leader, held the second position with approximately 316,300 jobs. This diverse job creation across various renewable energy sectors highlights the growing importance of clean energy in the global economy.

Figure 11 Number of Jobs Provided by Renewable Energy Sources



Source : (IRENA & ILO, Renewable Energy and Jobs Annual Review 2024, 2024, p. 19)

5.1 Jobs Provided by Renewable Energy Sources

- Solar PV leads job creation: The solar photovoltaic (PV) sector has emerged as the foremost driver of employment creation within renewable energy industries, reflecting its position as the most labor-intensive segment of the green economy. This phenomenon correlates strongly with worldwide investment patterns that have prioritized solar infrastructure development, manufacturing expansion, and installation projects. The sector's preeminence can be attributed to two fundamental factors: robust policy mechanisms—including feed-in tariffs and tax incentives—and the consistent downward trajectory of technological costs, particularly in panel production. Notably, the labor-intensive nature of solar PV operations has rendered it particularly instrumental in fostering economic growth within emerging markets, where abundant solar resources coincide with available pools of low-skilled workers. This synergy between natural advantage and workforce characteristics positions solar PV as both an economic development tool and a cornerstone of sustainable energy transitions in developing nations. The sector's dual capacity to generate employment while responding to policy and cost efficiencies underscores its unique role in contemporary energy-economic paradigms.
- Liquid biofuels rank second, likely due to agricultural labor inputs (e.g., crop cultivation for biofuel feedstocks). Regional policies (e.g., U.S. ethanol mandates, EU biodiesel targets) may drive this demand.
- Hydropower and wind energy employ fewer workers (1,457K and 765K, respectively), as these sectors are more capital-intensive and require specialized skills.

5.2 Employment in the Renewable Energy Sector by country

In 2023, employment in renewable energy technologies was widely distributed across various sectors, totaling 16.24 million jobs worldwide. China stood out as the dominant force, contributing nearly 7.39 million jobs—approximately 45.5% of the global renewable energy workforce. This notable concentration underscores China's strategic investments and its leading role in the development of renewable energy industries.

table 2 Renewable energy employment in selected countries

	World	China	Brazil	United States	India	European Union (EU 27)
Solar photovoltaic	7107	4590	264	279	319	720
Liquid biofuels	2803	60	994	342	35	150
Hydropower	2324	788	177	68	453	71
Wind power	1457	745	80	131	52	282
Solid biomass	765	200		47,4	58	333
Solar heating and cooling	681	514	51	30	17	22
Biogas	316	165			85	49
Geothermal energy	160	94		9		7
Concentrated solar power	118	98				5
Total	16235	7388	1567	1056	1019	1812

:**Source** (IRENA & ILO, Renewable Energy and Jobs Annual Review 2024, 2024, p. 38)

Solar Photovoltaic (PV) Energy is the largest employment sector, providing over 7.1 million jobs globally. China alone contributes 4.59 million jobs, underscoring its dominance in solar PV manufacturing and installation. The European Union follows with 720,000 jobs, reflecting its strong commitment to expanding solar capacity. Brazil and India have comparatively smaller but notable contributions, with 264,000 and 319,000 jobs respectively, indicating emerging markets in solar energy adoption.

Liquid Biofuels sector employs 2.8 million people worldwide, with Brazil leading significantly at 994,000 jobs due to its extensive bioethanol and biodiesel industries rooted in agriculture. The United States and the European Union also have considerable employment in this sector, with 342,000 and 150,000 jobs respectively, illustrating the biofuel market’s importance in these regions.

Hydropower employs over 2.3 million workers globally, though China’s share of 788,000 jobs and India’s 453,000 highlight the reliance of large emerging economies on hydropower as a stable renewable source. The relatively smaller figures for the United States and the European Union suggest slower growth or saturation in hydropower infrastructure in these regions.

Wind Power generates approximately 1.46 million jobs worldwide, with China leading at 745,000, followed by the European Union’s 282,000 jobs. The United States also maintains a significant

workforce in this sector with 131,000 jobs. This reflects robust investments in wind energy technology and infrastructure, particularly offshore wind in Europe.

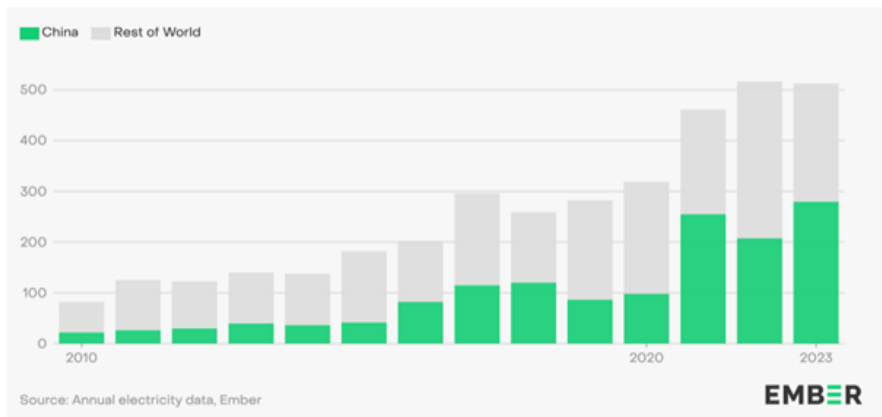
Employment in Solid Biomass stands at 765,000 globally, with the European Union holding the largest share at 333,000 jobs, indicating its focus on biomass as a renewable heat source. China and India also have substantial employment in this sector.

Other sectors such as Solar Heating and Cooling, Biogas, Geothermal Energy, and Concentrated Solar Power contribute smaller but important shares of employment, showing the diversification of the renewable energy labor market.

4. China as a Global Leader in the Energy Transition

Countries around the world are racing to mitigate the negative impacts of greenhouse gas emissions, aiming to prevent climate disasters that are likely to occur if reliance on fossil fuels continues. China stands at the forefront of this energy transition thanks to its massive investments in renewable energy. In 2023, China added nearly double the capacity of solar and wind power through utility-scale installations. Meanwhile, Western countries, including the United States and other developed nations, are experiencing a much slower pace of energy transition. With the rapid expansion of solar and wind power in recent years, China's renewable energy generation is now approaching the level of its traditional fossil fuel-based energy, especially coal, which has historically been its main energy source. This progress consolidates China's position as a global leader in the shift toward clean energy, as the country now accounts for half of the world's solar and wind energy output. Achieving this milestone marks a significant practical step toward China's goal of carbon neutrality by 2060 and reinforces its crucial role in global efforts to combat the climate crisis (**Al Jazeera News, 2025**)

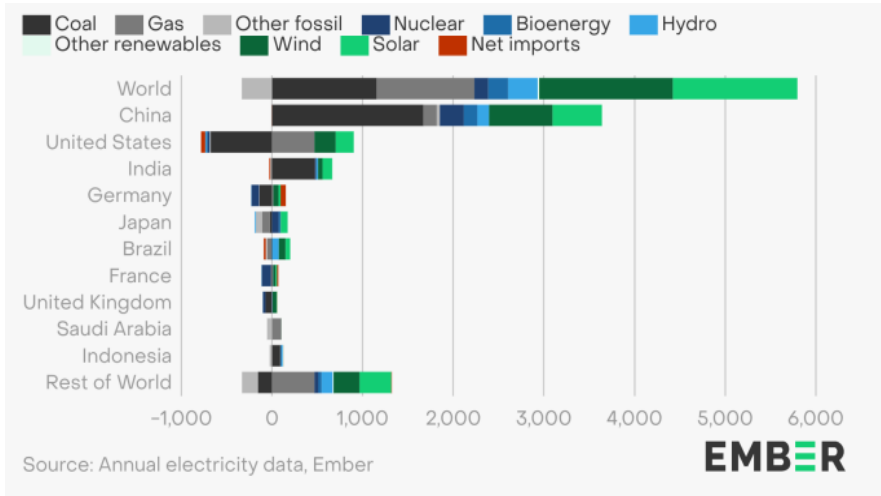
Figure 12. annual additions of electricity generation from wind and solar (TWh)



source: (EMBER, MAY 2024, p. 50)

Currently, China has a total of 339 gigawatts of electricity capacity under construction, including 159 gigawatts from wind energy and 180 gigawatts from solar energy. This is nearly twice as much as the rest of the world combined. Wind and solar energy together account for 37% of China’s total installed electricity generation capacity, an 8% increase compared to 2022. Clean energy capacity is expected to surpass coal-fired capacity, which contributed 39% of total electricity generation in 2023. China’s renewable energy capacity far exceeds that of the United States, which has an installed wind and solar capacity of over 200 gigawatts Error! Bookmark not defined.. Between 1990 and 2023, China underwent a massive industrial transformation and became the main driver of global energy growth. Since 2015, China’s transition towards renewable energy has accelerated significantly. Between 2015 and 2023, China accounted for approximately half (47%, 700 terawatt-hours) of the global growth in wind energy and 40% (545 terawatt-hours) of the increase in solar energy production **(EMBER, MAY 2024, p. 58)**

Figure 13. Change in electricity generation from each source(TWH)



source :(EMBER, MAY 2024, p. 58)

The global energy transition is quantitatively uneven, with the rising demand for electricity in India and emerging markets offsetting the gradual decline in advanced economies. This shift can be measured by analyzing the share of new electricity demand being met by renewable energy sources. Notably, China is far ahead of the rest of the world in the adoption of electric vehicles, and it also leads in electrifying heating and transportation sectors as well as in building capacity for electrolysis.

In 2023 alone, electricity demand in China from the battery swapping and charging services industry surged by 78%, contributing approximately 56 terawatt-hours—3.5 times more than the combined increase in the rest of the world. Economically, this underscores China’s dominant role in shaping future energy markets. China now accounts for 60% of global sales of light electric vehicles and holds the world’s largest market for heat pumps, installing more units annually than any other nation.

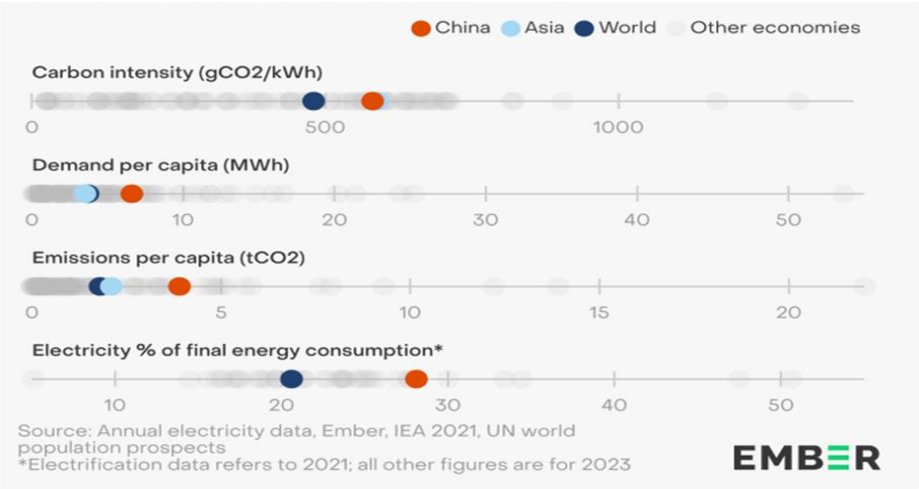
Electrolyzers—devices crucial for green hydrogen production and widely used in experimental chemical and petrochemical applications—have also been expanding faster in China than anywhere else. As a result, China controlled 50% of global

electrolyzer capacity in 2023, positioning itself as a central player in the hydrogen economy and in broader low-carbon industrial development.

China is currently the world’s second-largest economy and the leading emitter of greenhouse gases contributing to climate change. The country has recently experienced several episodes of extreme weather, and alongside high pollution levels, climate change poses a significant challenge to its sustainable development. In response, China is actively addressing these issues by investing in renewable energy production. However, its motivation extends beyond environmental concerns. Strategically, China aims to position itself as the world’s foremost producer and a global hub for the renewable energy economy and its associated technologies, including solar panels, wind turbines, and batteries.

Moreover, China's robust manufacturing infrastructure enables it to produce these technologies at lower costs, which in turn drives down global prices and enhances access to renewable energy worldwide. The country is also investing heavily in scientific research to advance renewable energy technologies. Innovations in areas such as battery storage, grid integration, and efficiency improvements are helping to overcome traditional limitations associated with renewable energy sources. (SHADI, 2024)

Figure 14. China : power sector status in 2023



source:(EMBER, MAY 2024, p. 115)

In 2023, China was the world's largest emitter of energy sector emissions, releasing 5,491 million tonnes of carbon dioxide (MtCO₂) from electricity generation—more than three times the amount emitted by the United States (1,570 MtCO₂) and India (1,404 MtCO₂). The primary reason for China's emissions is its heavy reliance on coal for electricity generation.

In 2023, China generated 65% (6,102 terawatt-hours) of its electricity from fossil fuels, with 60% of that coming from coal. China's coal share exceeds the regional average in Asia of 56%, and is significantly higher than the global average of 35%. In 2023, China was responsible for more than half (55%) of global coal-fired electricity generation. **(EMBER, MAY 2024, p. 116)**

7. Conclusion :

In conclusion, this study demonstrates that the sharp decline in renewable energy investment costs has played a critical role in accelerating the global energy transition. The Chinese experience, in particular, highlights how strategic investments, large-scale manufacturing, and supportive policy frameworks can transform a nation into a global leader in clean energy. Despite being the world's largest emitter of greenhouse gases, China has leveraged its manufacturing capabilities and abundant resources to become the dominant force in both solar photovoltaic (PV) and wind energy capacity, production, and employment.

The global data confirm that renewables are not only becoming more cost-competitive than fossil fuels but are also reshaping the labor market and industrial structures. The significant growth in solar PV, wind, and other renewable energy technologies reflects the combined impact of declining technology costs, technological innovation, and policy incentives.

7.1 Key Findings

➤ The decline in renewable energy technology costs has significantly boosted the implementation of new projects such as solar power plants and wind farms, increasing demand for jobs in design, manufacturing, installation, operation, and maintenance. The solar sector, in particular, remains more labor-intensive than fossil fuel plants. China stands out as a leading example, combining technological advancement, large-scale production, and relatively low labor costs to become the world's largest manufacturer and exporter of solar panels and wind turbines—creating millions of local jobs. This expansion has also turned many rural areas into hubs for installation and maintenance, helping reduce structural unemployment. Similar effects are seen, to varying degrees, in

countries like India, Brazil, and the United States, while countries relying mainly on imports benefit less in terms of job creation. Overall, lower costs drive more investment and employment, making renewables one of the main sources of new jobs in the global green economy.

➤ China has firmly established itself as a dominant global force in the renewable energy sector, particularly in the production of photovoltaic (PV) cells. This competitive edge stems from Chinese companies' ability to leverage economies of scale, along with lower costs of raw materials, capital, and labor. These factors have enabled China to manufacture solar panels at significantly lower costs than their counterparts in India, Europe, and the United States. This advantage is further reinforced by strong state support for the sector.

➤ The significant decline in the costs of producing and installing renewable energy technologies is one of the key drivers of the global energy transition. This cost reduction has made clean energy more economically viable, with the cost of generating electricity from solar and wind often lower than from fossil fuels in many regions. Continuous improvements in technology, large-scale manufacturing, and increased investment in research and development have reduced capital costs (CAPEX) and the levelized cost of electricity (LCOE), enabling countries and companies to adopt renewable projects without heavy financial burdens. This has encouraged governments and investors to expand renewable capacity, achieve economies of scale, and create a positive cycle of further cost reductions, making this trend a crucial factor in reducing reliance on polluting fossil fuels.

➤

➤ The total installed renewable energy capacity worldwide has more than tripled since 2010, driven mainly by rapid solar PV expansion.

➤

➤ China accounts for nearly half of global renewable energy employment, underscoring its strategic focus on becoming a global hub for clean energy production and technology.

➤ The levelized cost of electricity (LCOE) for solar PV and onshore wind has dropped by over 70% since 2010, making renewable energy the cheapest source in many regions.

➤

- The renewable energy sector created more than 16 million jobs in 2023, with solar PV alone providing over 7 million jobs globally.
- Despite progress, the global energy transition remains uneven, with advanced economies progressing slower than emerging markets like China.

7.2 Recommendations

- **Strengthen Policy Support:** Governments should continue to implement and expand supportive policy frameworks—such as feed-in tariffs, tax incentives, and subsidies—to encourage investment in renewable energy technologies.
- **Promote Local Manufacturing:** Developing countries should leverage declining technology costs to build domestic manufacturing capacity for renewable energy equipment to boost job creation and economic resilience.
- **Invest in Workforce Development:** Stakeholders must invest in training programs and skill development initiatives to prepare the workforce for new employment opportunities in installation, maintenance, and advanced manufacturing.
- **Diversify Energy Portfolios:** Countries should diversify their renewable energy mix to balance reliance on solar and wind with other sources like hydropower, geothermal, and biomass to ensure energy security and stability.
- **Enhance International Collaboration:** Strengthen global cooperation and technology transfer to support equitable access to clean energy technologies, particularly for developing nations.
- **Address Remaining Emissions:** Policymakers should adopt complementary measures to reduce reliance on coal and other fossil fuels, especially in countries with high coal consumption, to maximize climate benefits.

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