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## Review Article

# Sustainable and Renewable Energy initiatives across the globe: Opportunities and challenges

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### ABSTRACT

In 2023, China, USA, India, Russia, and Japan are the top 5 countries in the world with the highest electricity consumption per year respectively. Similarly, Most of the countries across the globe are utilising massive electricity, coal, petroleum, and other natural resources. Hence, it is inevitable to produce sustainable and renewable energy for domestic and industrial purposes. Right now, the majority of the countries have taken initiatives to generate sustainable and renewable energy across the globe. China is at the top list in sustainable and renewable energy initiatives and production, followed by the USA, India, Russia, and Japan.

Hence, an attempt is made to study sustainable and renewable energy initiatives across the globe and also observe the opportunities and challenges on the same across the globe would be very helpful to proceed further in this area of knowledge with the main objectives of understanding the concept of sustainable and renewable energy; reviewing the existing literature on the topic concerned; reviewing opportunities and challenges of the same across the globe. The study is an observatory in nature and revealed that the main opportunity is to get support from respective governments of the countries to exploit the sustainable and renewable energy sources that are abundant and helpful for economic development. Similarly, mitigating environmental impact, ensuring electricity security, applying technological advances and creating jobs are other opportunities to discover. Besides these opportunities, sustainable and renewable energy initiatives also face some challenges, via lack of facilities and infrastructures to bring these initiatives into our lives; additionally, cost, time, manpower and awareness are also becoming challenges for these initiatives. In some perspectives, sustainable and renewable energy is still a new field that needs a lot of time to be fully understood and make it a part of our lives.

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## 1. Introduction

Energy is one of the key factors that affect not only economic development but also every activity in our daily lives. In 2022, the total of global primary energy consumption is about 178,899 TWh (Lucía Fernández, 2023). In 2023, China, USA, India, Russia, and Japan are the top 5 countries in the world with the highest electricity

consumption, with 8312,8 TWh, 3989,6 TWh, 1052,3 TWh, 956,1 TWh, and 902,8 TWh per year respectively (World of Statistics, 2023).

In recent years, the greenhouse effect and other environmental problems have become more severe and people now are more concerned about sustainable and renewable energy. In 2020, the world's total renewable energy consumption is about 1,256.05 TWh, 20 times larger than in 2000 (Lucía Fernández, 2023). Renewable energy only comprised about 6,6% of the world's total

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final energy consumption in 2000, but in 2023, the number jumped to 14%, more than double in amount (International Energy Agency (2001), World Energy Outlook 2001; Lucía Fernández, 2023). To protect our environment and help to sustainable development, many initiatives have been born to help people come closer with sustainable and renewable energy. We're more familiar and relied on fossil fuels and other non-renewable resources for a long time, that's why sustainable and renewable energy initiatives still need a lot of time and effort to be widely accepted and successfully applied in our life.<sup>1-5</sup>

## 2. Sustainable and Renewable Energy

### 2.1. Sustainable energy

Resources that can support present activities without endangering the capacity of future generations to satisfy their own demands are the source of sustainable energy. It is energy that consistently satisfies both society's short- and long-term demands (Megan Crawford, 2018). In theory, sustainable energy never runs out. Because sustainable energy sources don't require replenishment, they can never run out (Routledge, 2023). Sustainable energy is renewable energy but not all renewable energy is sustainable. Renewable energy is considered sustainable when it meets these criterias: preserve the natural environment, foster the growth of society and culture, and promote sustainable development (Megan Crawford, 2018).<sup>6-9</sup>

### 2.2. Renewable energy

Renewable energy is derived from sources such as solar, hydropower, wind, geothermal, and biomass that replenish themselves at a rate that satisfies our energy needs. Renewable energy is not always sustainable, but sustainable energy is. By enhancing the sustainability of fossil fuels and renewable resources will help us lessen our impact on the environment. (Johns Hopkins University, 2011)

Renewable energy which is generated from resources that are already there and gradually sustain or replenish themselves, has the potential to be a far more long-lasting solution than our present energy sources. (Piotr Bojek, 2023). In contrast to fossil fuels, renewable energy sources are becoming more affordable and have a far milder environmental impact. (Mazhar, N., Zia, S., 2019).<sup>10-15</sup>

### 2.3. Opportunities of sustainable and renewable energy

Sustainable and renewable energy is meant to weaken the environment issues and reduce the unwanted impact on the environment and promote development (Dr Kaushik Sridhar, 2023). Therefore, many benefits of sustainable and renewable energy resources can become opportunities for initiatives to embrace.

Sustainable and renewable energy can meet both short-term and long-term needs of society (Megan Crawford, 2018). It can support sustainable growth because of its characteristics: renewability, abundance, adaptation, and timeliness (Dominic Tantram, 2014). While our demand for energy is rising day by day, the non-renewable energy resources are predicted to only last until 2090 (Gioietta Kuo, 2019) because we have been relying on them for too long. As sustainable and renewable energy are undepletable and can be organically renewed, it's a good option for our energy requests. There is an abundance of sustainable and renewable resources for us to utilise, from which we can achieve energy independence and ensure energy security.

To apply sustainable and renewable energy initiatives into our life, we will have a chance to apply technological advances to generate energy. By this way, energy will be more easily approachable and produced effectively. In 2023, about 37,55 billion metric tons were emitted worldwide (Ian Tiseo, 2023). Sustainable and renewable energy doesn't emit as much CO<sub>2</sub> as non-renewable resources, using sustainable and renewable energy can help to lessen greenhouse effects, cut down carbon footprint. Not only can we mitigate environmental impact but also protect human health.

Just in 2 years, global low-carbon investment jumped from 626 billion USD to 1,110 billion USD in 2022 (Oktavia Catsaros, 2023). Since then, additional infrastructure for sustainable energy has been created, necessitating the hiring of more workers in order to improve the economy and create jobs. Companies won't need to spend money importing energy, they can use that money on materials and workmanship to support sustainable and renewable energy facilities (Routledge, 2023).

## 3. Challenges of Sustainable and Renewable Energy

Some sources like solar and wind depend on weather conditions, leading to fluctuations in energy generation. This can create grid instability and necessitate backup systems or energy storage solutions to avoid these undesired problems (Shalin Sheth, 2023).

Existing energy infrastructure and facilities might not be able to handle the natural distribution of sustainable and renewable energy generation. That's why we will need a lot of time for building, upgrading the existing facilities and infrastructure to fit with the requirements of generating sustainable and renewable energy. Upgrading grids, transmission lines, distribution systems and building another infrastructure for keeping the stored energy can be costly and time-consuming.

Sustainable and renewable energy needs a high upfront cost to be brought into our life. The expenses for sustainable and renewable energy at first are much higher than non-renewable resources. The cost of equipment may deter investors and governments from committing fully to

sustainable and renewable energy initiatives (Shalin Sheth, 2023).<sup>16-18</sup>

Not only money, we should also spend more time doing research and seeking manpower, sustainable and renewable energy is still a new field that we need to focus on to be fully aware of and able to bring it into daily activities. Research and development must continue in order to create effective storage systems and integrate renewable energy sources into current networks. Large-scale adoption depends on developments in demand management, smart grids, and battery technology (Shalin Sheth, 2023).

Some communities may have concerns about the visual impact of wind farms or the potential environmental risks of geothermal or hydropower projects. But public engagement and addressing concerns are essential for gaining social acceptance (Shalin Sheth, 2023).

#### 4. Review of Literature

Sustainable and renewable energy can meet both short-term and long-term needs of society (Megan Crawford, 2018). It can support sustainable growth because of its characteristics: renewability, abundance, adaptation, and timeliness (Dominic Tantram, 2014). Making the switch to green energy sources for sustainable power generation offers a number of chances to change the way we produce and use electricity. Climate change may be halted and our carbon footprint significantly reduced by using renewable resources. But there are still some challenges. (Shalin Sheth, 2023).

First of all, we need to have a full awareness about sustainable and renewable energy. As people now are more concerned about energy and environment, innumerable sustainable and renewable energy initiatives have been released all over the world and to make these projects work successfully, we have to catch the opportunities and understand the challenges to easily overcome them in the near future. This study explores the many potential and difficulties related to these innovative endeavours by delving into the rich tapestry of academic literature. There are many chances, but there are also many difficulties. We can pave the path for a brighter future powered by clean energy, guaranteeing a fair and sustainable transition for everyone, by tackling these issues by ongoing research, creative solutions, sensible legislation, and international collaboration.

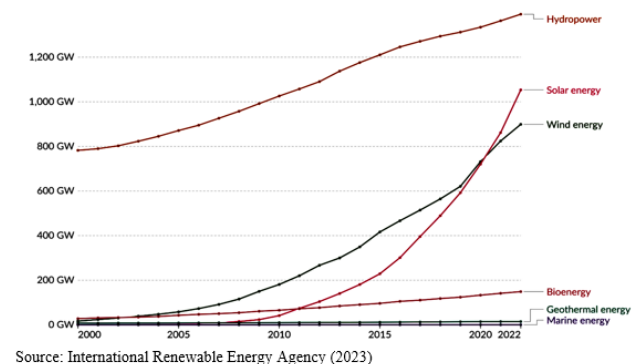
#### 5. Sustainable and Renewable Energy Initiatives Across the Globe

There are many innovative and effective projects that are promoting the transition to sustainable and renewable energy around the world. Knowing their importance, the government has set more supportive policies and focused more on sustainable and renewable energy. From

using fossil fuels, many companies and industries have transitioned into using sustainable and renewable energy.

Investment in fossil fuels began to steadily fall in 2015, and in the years that followed, renewable energy sources accounted for an increasing portion of energy investment. In 2015, investment in fossil fuels reached about 1.3 trillion USD (IEA, 2023), declined by about 8% (Climate News Network, 2016), and in renewable energy was about 1.07 trillion USD (IEA, 2023), but after an 8-year period, investment in fossil fuels has sharply declined to approximately 36%. The global energy crisis reaction and the recovery from the Covid-19 outbreak have significantly increased investment in renewable energy. When comparing projections for 2023 with the data from 2021, it is clear that yearly investment in clean energy has increased far more quickly than that of fossil fuels throughout this time (24% vs 15%) (IEA, 2023).

The amount of new renewable capacity added globally is expected to climb to over 440 GW in 2023, representing the highest absolute increase ever of 107 GW (IEA, 2023). Of the expected increase in global renewable capacity in 2023, solar photovoltaic capacity accounted for two thirds, comprising both utility-scale and small distributed systems. And about hydropower, it still remains significant. While new hydropower installations are restricted, existing major plants provide considerable contributions to the entire renewable energy mix. Geothermal and other renewable sources, such as biomass, had modest increases, and playing an increasingly important role in diversifying the renewable energy landscape.



**Figure 1:** Global installed renewable energy capacity by technology

The energy sector employed approximately 67 million people in 2022, up 3.4 million from pre-pandemic levels, as investment in sustainable and renewable energy sources continues to rise. In the same period, the number of employment in the green energy sector increased by 4.7 million worldwide to 35 million. In contrast, the fossil fuel industry recovered more slowly from layoffs in 2020, with 32 million jobs still below pre-pandemic levels.

Consequently, in 2021, employment from renewable energy sources exceeded that from fossil fuels (Figure 1).

The spread of renewable energy has been significantly aided by international policies, and numerous policies facilitate the implementation of renewable and sustainable activities. There are many famous initiatives of renewable and sustainable energy across the world such as: The Mohammed bin Rashid Al Maktoum Solar Park in Dubai, Hornsea Project Two, Gansu Wind Farm, Pinnapuram Integrated Renewable Energy Project, NEOM Green Hydrogen Project, Saudi Arabia, Solaris’ Protevs, The EU’s REGACE agrivoltaic project, Repsol’s Delta II wind project (Matt Nicholson, 2023).

### 6. Sustainable and Renewable Energy Initiatives in India

Recently, the rank of India in Wind Power Capacity is in 4th place and 5th in Solar Power Capacity globally (Atmanirbhar Bharat Abhiyaan, 2023). India has been making great efforts to switch to greener and more sustainable energy sources. An important area of focus for India’s development of renewable energy has been solar power. In the 1-year period, from 2021 to 2022, the largest rise in electricity generation was stated in renewable energy resources for utilities as well as for indoor plants, with 16,2% in growth (Government of India, 2023). In India’s energy industry, the switch from conventional to non-fossil fuel sources has happened gradually. India is unwavering in its commitment to using sustainable and renewable energy resources than fossil fuels. By 2030, India wants to have developed a cumulative 50% of its installed capacity to produce electricity from clean resources. With a rapidly increasing percentage of renewable energy in installed capacity overall, India is well on its way to meeting its goals. The numerous governmental initiatives designed to boost the sustainable and renewable energy industry are the cause of this (Government Survey in India, 2023).

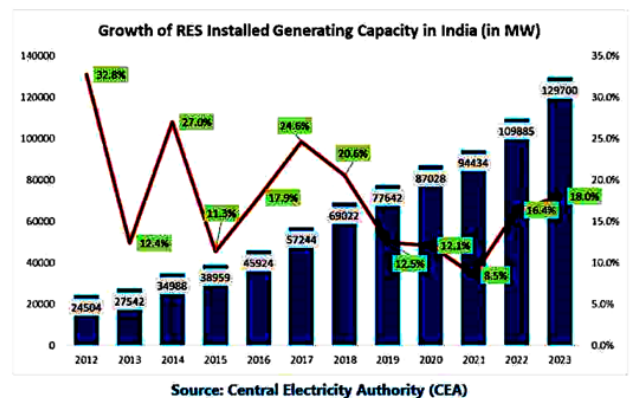
**Table 1:** All India gross electricity generation mode-wise (GWh)

	Hydro	Thermal	Nuclear	Renewables	Total
2020-2021	1.5	12.5	0.4	1.5	15.9
2021-2022	1.5	13.4	0.4	1.7	17.2
Growth (in percent)	0.9	7.3	9.5	16.2	7.6

Source: Ministry of Power

The nation’s solar capacity has increased significantly, and more expansion in solar power output is anticipated. To encourage the use of solar energy, India has launched programmes like the Jawaharlal Nehru National Solar Mission (JNNSM) (Sharada Prahlada, 2023). The Indian government has been pushing a dynamic renewable energy initiative with the goal of achieving energy security and accessibility while simultaneously lowering the country’s

economic carbon footprint. Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM), seeks to de-dieselize the farm sector, offer energy and water security, and increase farmers’ income by producing solar electricity in order to minimise the carbon footprint of the agricultural sector. Furthermore, in order to provide land, power evacuation facilities, road connections, water facilities, and other essential infrastructure along with the required legislative permissions, the government has also launched the Solar Park Scheme. The government has approved the whole 40 GW goal capacity as of September 30, 2022, for the construction of 59 Solar Parks across 16 states (Government Survey in India, 2023). On March 31, 2022, 482.2 GW of installed power capacity was available for utilities and captive power plants, an increase of 4.7% from 460.7 GW on the same day in 2021, and installed capacity in utilities was 399.5 GW, up 4.5% from 382.1 GW the previous year. (Government of India, 2023). With big hydro excluded, India’s installed renewable energy capacity as of March 31st, 2023, was close to 130 GW, or almost 31% of the country’s total installed power capacity. The expected contribution of solar electricity is 66.8 GW, with wind power coming in second at 42.6 GW, biomass at 10.8 GW, small hydropower at 4.9 GW, and pumped storage projects (PSP) at 4.8 GW (Sharada Prahlada, 2023).



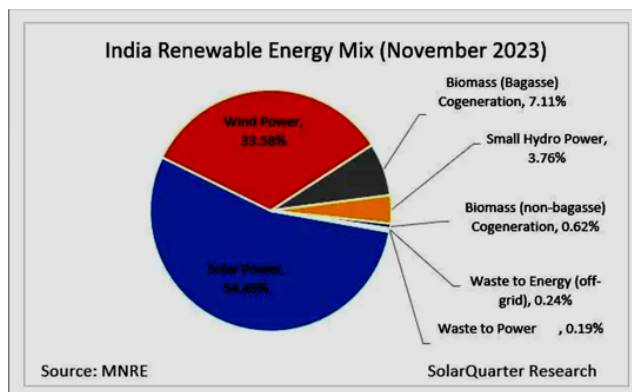
Source: Central Electricity Authority (CEA)

**Figure 2:** Growth of renewable energy sources installed generating capacity in India (in MW)

Falling technological costs, expanding investor interest, and supporting government regulations have all contributed to India’s recent fast growth in renewable energy capacity. India is investing in geothermal, biomass, hydropower, and other renewable energy sources in addition to solar and wind energy (Renewable Mirror, 2023). Building a more robust and sustainable energy system requires this diversity. In India, the renewable energy industry is generating millions of employment and advancing the country’s economy. India’s aggressive goals for renewable energy are essential to the nation’s efforts to tackle climate change and lower its

carbon footprint (Atmanirbhar Bharat Abhiyaan, 2023).

India will use 256 million tonnes of renewable energy by 2040, up from 17 million tonnes in 2016. By 2040, India's energy consumption is likely to increase at the quickest rate of any large economy. By 2040, the percentage share of consumption from renewable sources is expected to rise from 2% in 2016 to 13% (Charles Rajesh Kumar. J, 2020). India met its goal of having 40% of its installed power capacity come from non-fossil sources by November 2021. As of November 2023, installed solar energy capacity has increased to 72.31 GW, a 30x increase in just 9 years. Since 2014, installed renewable energy capacity, particularly large hydro, has increased by more than 128%. (Atmanirbhar Bharat Abhiyaan, 2023). India has stepped up its renewable energy capacity targets to 450 gigawatts by 2030. By 2030, it wants to get half of its electricity from renewable sources, and by 2070, India wants to have zero emissions. (Dr Fatih Birol et al., 2022).



**Figure 3:** India renewable energy mix (November 2023)

There are countless initiatives in India that shaping India's energy transition, these could include the new national biogas and organic manure program (NNBOMP), The off-grid and decentralised solar photovoltaic application program, Pradhan Mantri Sahaj Bijli Har Ghar Yojana (SAUBHAGYA), Green Energy Corridor (GEC), National Smart Grid Mission (NSGM), Smart Meter National Programme, Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME) and International Solar Alliance (ISA) (Shri R.K. Singh, 2021). Research and development in the field of sustainable and renewable energy has been aggressively promoted by India. The government here plays a vital role in developing and materialising the initiatives because attracting investment and promoting ideas and steady growth require effective laws and long-term regulatory frameworks. Smart grids, energy storage solutions, and advancements in solar cell and wind turbine technologies are crucial for grid stability and cost reduction.

India is an ideal environment for a thriving patchwork of sustainable and renewable energy initiatives. Communities

are empowered by rooftop solar initiatives, millions of homes are illuminated by massive solar farms, and wind turbines along the coast create whispering waves of energy that power distant regions and propel economies. Beyond the well-known, initiatives including geothermal, biomass, and hydropower are woven into the framework of India's energy future. This country has a strength of technology and that can help a lot when the initiatives are being carried out. India can create a future where clean energy permeates every area and brightens everyone's future by supporting these projects and advancing technologically. There are plenty of sustainable and renewable energy initiatives all over the world, they have received numerous support, from which their opportunities are various. The sustainable and renewable energy initiatives' main opportunity is supporting sustainable growth. Then we can be independent in energy, ensuring energy security, jeopardising the negative impact of environmental issues on the Earth, applying technological advancements and creating jobs for people across the globe. Beside these opportunities, not only India, all over the world also has to deal with challenges while performing the initiatives such as: grid modernization, financing gaps, knowledge, time-consuming and lacking manpower.

## 7. Observations

In recent years, the greenhouse effect and other environmental problems have become more severe and people now are more concerned about sustainable and renewable energy as the cleaner energy initiatives are coming closer to our lives. In 2023, people spent more than 1,7 trillion USD on clean energy investment, more than 60% of total energy investment globally (IEA, 2023). International regulations have played a major role in the expansion of renewable energy, and many rules make it easier to implement sustainable and renewable practices. Globally, new renewable capacity additions are hoped to reach over 440 GW in 2023, marking the largest growth of 107 GW ever (IEA, 2023). Solar power remains unopposed, with projected investments set to eclipse world oil output for the first time ever. This rise is being driven by large-scale solar farms and rooftop solar, which lowers the cost and increases the accessibility of clean energy with a total amount of investment is about 380 billion USD in 2023 (IEA, 2023). Significant investment is also being made in other renewable energy sources including hydropower, geothermal, and wind. This diversity improves energy security and fortifies the renewable energy portfolio globally. Becoming the world's largest offshore wind farm, the Dogger Bank Wind Farm has achieved an important turning point by generating its first power (Dimitris Mavrokefalidis, 2023). In India, the Khavda Project will serve as the biggest green energy park in the world as India fights climate change and sets an example for the rest of the globe (Sibu Kumar Tripathi, 2023). These projects

will open a new pace for other scientists to carry out their ideas and lead the others in the right direction, sustainable development. They are being hailed for their potential to bolster energy security, create jobs, reduce electricity costs, and contribute to achieving net zero emissions. Besides the pros, the initiatives still need to recognise the cons so that they can quickly overcome them in the future.

## 8. Conclusion

Sustainable and renewable energy initiatives across the globe is a hot topic currently, since the investment in clean energy is rising rapidly and the awareness of sustainable and renewable energy and environmental problems are catching more concern than ever. With the support of government policies, sustainable and renewable energy initiatives are able to be materialised because it'll create an attractive environment for these projects. As this would provide a long-lasting, clean, and stable energy supply, policies to support sustainable and renewable energy projects for more dependable and efficient sustainable and renewable energy systems must be created. Each country has their own strength on each kind of green resources appropriate with the geography, so that they need to fully understand sustainable and renewable energy, from that they can utilise the green and stable resources, boost energy independence and security, create jobs and deduct adverse impact of carbon footprint on the environment. Humans play an important role in bringing sustainable and renewable energy initiatives into reality. We are now dignifying sustainable and renewable energy and more than ever, we care about our environment and how to achieve sustainable development, from that we put a lot of effort on performing sustainable and renewable energy initiatives. That's why, we need to seize the opportunities and be conscious of the challenges to successfully bring these initiatives into real life.

## 9. Source of Funding

None.

## 10. Conflict of Interest

None.

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