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India's Effective Approach to Achieve Sustainable Energy Goal

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ABSTRACT

Renewable energy has become a vital component of India's energy strategy. The value of clean energy sources in the transition to a green energy base was recognised in the early 1970s. The paper emphasises the need for clean energy financing to be made available to states in order to address disparities between RE potential and development costs, as well as to plan for better grid management systems. The RE targets also require intensive capital market development and innovative financial support mechanisms and products. While aligning with renewable energy goals, India must prioritise addressing the energy needs of its rural populace, which have been experiencing power outages and brownouts. In areas with limited or no access to electricity, government officials should strongly encourage off-grid solar energy and microgrids. The research also suggests that private sector investments, rural entrepreneurship, and public-private ventures can fill in the gaps, allowing RE-rich states to realise their true potential.

Keywords: Renewable energy; Sustainable development goals (SDGs); India; Clean energy; Grid integration; Solar mission; Climate change.

1. Introduction

In World Commission on the Environment and Development, also known as the Brundtland Commission, introduced and defined sustainable development as the process by which the exploitation of natural resources, investment allocation, and the process of technological development and organisational change are in harmony with one another for both current and future generations. Developed countries require more energy than developing countries. People today are most concerned about renewable energy sources because they are eco-friendly, easily accessible, less expensive, and exist in abundance on Earth. Figure 1 illustrates the various renewable energy sources [1]. Over the last two decades, people have been most concerned about green technology for clean energy sources for sustainable development purposes which the follow principle of green chemistry [2,3].

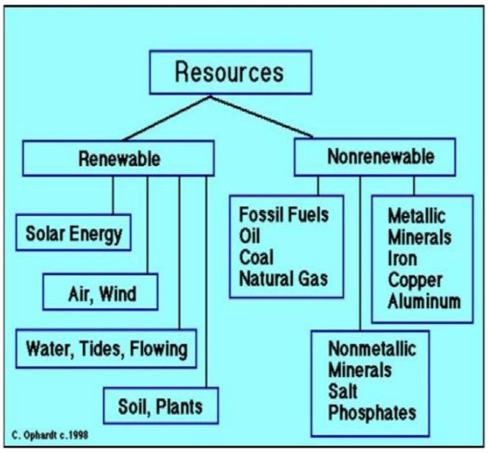

Figure 1. Various resources of renewable energy sectors [1]

The main benefits of using renewable energy sources include social and economic development, increased energy security, reduced climate change, and improved environmental and health energy. People today rely more heavily on fossil fuel energy sources. It is generally expensive and environmentally damaging. Some promising ideas for sustainable houses range from the use of renewable and non-toxic construction materials to the reuse of waste, and from the recycling of grey water in irrigation or flushing water to the use of solar cells for warming and charging electric cars [4]. Figure 2 depicts the flow chart for renewable energy generation and storage [5,6]. Solar energy has been widely used as a renewable, clean, safe, cost-effective, and promising approach to reducing environmental damage and energy conversion. Wind power is expected to have the greatest increase in absolute generation terms of any renewable energy source. Biodiesel is renewable biofuel source of energy [7,8].

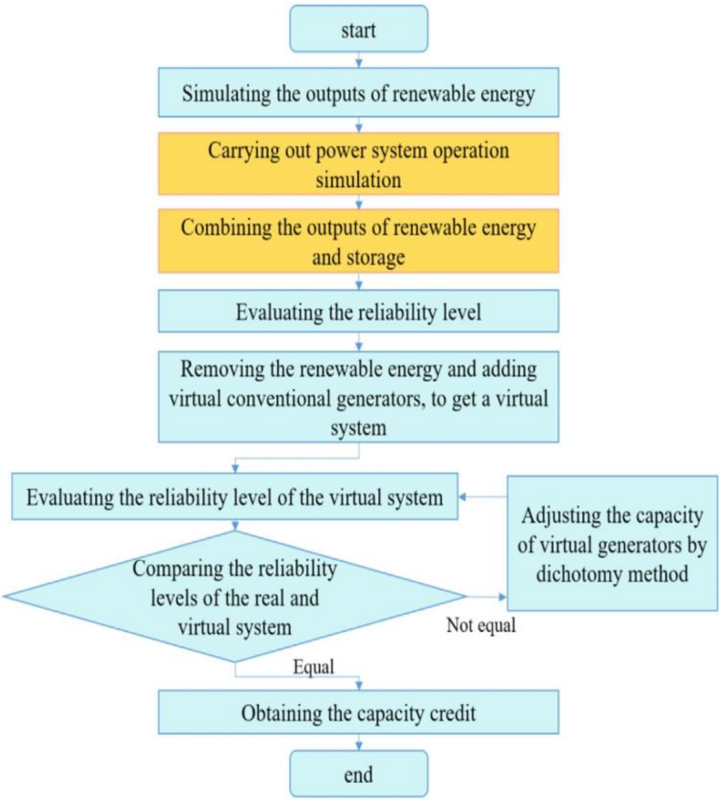

Figure 2. Flow chart of renewable energy generation and storage [3-4]

Using this resource, green photocatalytic nanomaterials, as a promising candidate, can be used for a variety of applications, including hydrogen production, organic pollutant degradation, CO_2 reduction, organic transformation, sensors, and more. Renewable electricity has grown in popularity, while demand for other renewable energy applications has decreased [9]. Renewable energy use increased by 3% in 2020, while demand for all other fuels decreased. Renewable energy will play a critical role in decarbonising our energy systems over the next few decades [10].

2. Green Technologies Criteria

Green technology is the knowledge of conserving the natural environment and resources while reducing human involvement. It can be used in a variety of applications, including biofuel, eco-forestry, renewable energy, and solid waste management. However, it is neither feasible nor necessary to implement all available technologies simultaneously without considering country-specific strengths and weaknesses. The selection of tools and techniques as appropriate technology is an important step in assisting communities in determining what their future should look like. In other words, appropriate technology searches for those technologies that have positive effects on income distribution, human development, environmental quality, and the distribution of political power [11]. In general, Robert (1998) proposed seven criteria to assess the appropriateness of technology in his paper "Design Criteria for Sustainable Development in Appropriate Technology: Technology as if People Matter" [12].

2.1. System Independence

It refers to a technological device's ability to perform the required function on its own. To ensure the technology's system independence, it will be determined whether it will require more capital or labour [13].

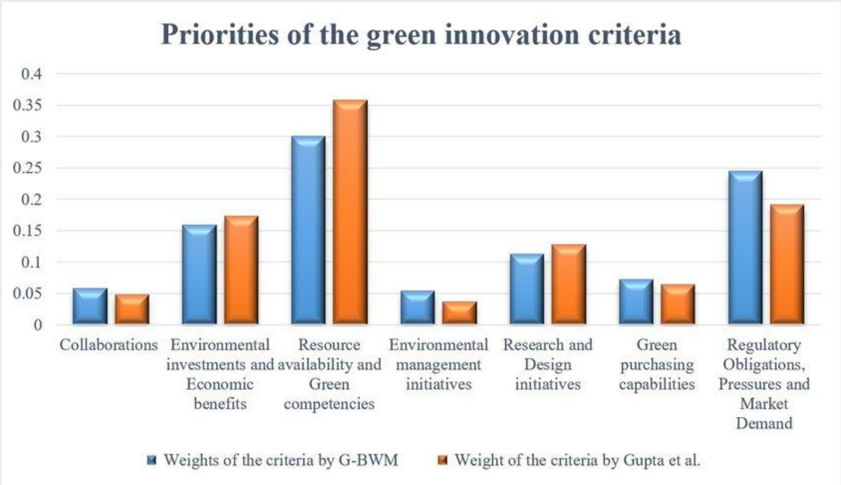

Figure 3. Priorities of green innovation criteria [14]

2.2. Image of Modernity

People should perceive themselves as modern by embracing technology. The message conveys people's realisation that technological devices can elevate the user's social status while also meeting a basic human need. The image of modernity necessitates that the social status of those who adopt it improves or remains constant.

2.3. Individual Technology vs. Collective Technology

It is the criteria for examining the societal/cultural standards under which the technology operates. In other words, it is a careful evaluation of technology that takes a group approach and becomes more system dependent. A society geared towards individuals or single family units will require more system-independent technology. Collective technologies are more easily adopted because collective action lowers transaction costs [15].

2.4. Cost of Technology

The affordability of technology is an important indicator of its widespread use, as cost is the primary factor in encouraging or discouraging the use of appropriate technology in developing economies.

2.5. Risk Factor

It is critical to determine how smoothly technology operates in the local production system, as this determines whether the technology is system dependent or system independent. This highlights the importance of understanding both internal and external risks. Although risk assessments are required before implementing new technology, it is nearly impossible to eliminate all risks.

2.6. Evolutionary Capacity of Technology

If the chosen device is static, it will primarily reflect short-lived solutions to a much larger problem. The technology, which supports the continuation of development by increasing the ability to expand, is expected to compete at the regional, national, and global levels.

2.7. Single-Purpose and Multi-Purpose Technology

In contrast to single-purpose technology, multipurpose technologies provide a variety of applications (for example, a tiller that can be used to till the land, power a water pump, and dry rice).

3. Sector-wise Energy Consumption in India

The country's major commercial energy-consuming sectors are classified as shown in Figure. The figure shows that industry remains the largest consumer of commercial energy, accounting for 49% of total consumption (reference year: 1999/2000). Economic growth is desirable in developing countries, and energy is required for economic growth. However, the relationship between economic growth and increased energy demand is not always a simple linear one. For example, under current conditions, a 6% increase in India's GDP would result in a 9% increase in demand for the country's energy sector. In this context, the ratio of energy demand to GDP is a useful metric. A high ratio demonstrates energy dependence and a strong influence of energy on GDP growth. The developed countries, by focusing on energy efficiency and lower energy-intensive routes, maintain their energy to GDP ratios at values of less than 1. The ratios for developing countries are much higher.

4. Conventional Energy Sources in India

India currently consumes a large amount of fossil fuels such as coal and crude oil. Energy has become indispensable in recent decades. The demand for electricity is growing at an alarming rate as the population and industrial sectors expand. The rapid increase in energy consumption has caused demand and supply issues. As a result, the future of non-renewable energy sources is becoming uncertain. India ranks sixth in the world for total energy consumption. India's installed power capacity has increased from 1362MW to over 112,058MW since independence, and more than 50,000 villages have been electrified. This accomplishment is impressive, but not sufficient. It is concerning that 44% of households lack access to electricity, and up to 80,000 villages have yet to be electrified. It indicates that India has had a negative energy balance for several decades. According to the 16th electric power survey, the anticipated demands necessitate an additional 1,00,000MW supply. In other words, the accomplishments of the past five decades must be replicated in the next decade.

The task is overwhelming but not unachievable, because India has significant potential for generation of power from renewable energy sources. As India has a large amount of, supply of renewable energy resources, India has decided to organize a program for proper utilization of renewable energy resources. As a result of which, India is the only country in the world to have an exclusive ministry for renewable energy development, The Ministry of Non-Conventional Energy Sources (MNES).

5. Renewable Energy Resource in India

India has an abundance of renewable energy sources. This was the first country in the world to establish a ministry of non-conventional energy sources in the early 1980s. In India, renewable energy capacity (excluding large hydro)

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has reached 33.8 GW. Wind accounts for 66% of these renewable energy sources, while solar energy contributes 4.59%, as does biomass and small biomass. India has numerous renewable energy sources, which are discussed in Table 1. The availability of renewable energy sources varies by state in India.

Table 1. Total renewable energy source in India [16]

Sources	Total installed capacity (MW)
Wind power	22,465.03
Solar energy	3063.68
Small hydro power	3990.83
Biomass power	1365.20
Bagasse power generation	2800.35
Wade to power	107.58
Total	33,791.74

As of December 31, 2021, India's total installed capacity for renewable energy is 151.4 GW. The following is a breakdown of total installed Renewable capacity as of December 31, 2021. The Government of India has set targets to reduce India's total projected carbon emissions by 1 billion tonnes by 2030, reduce the nation's carbon intensity by less than 45% by the end of the decade, achieve net-zero carbon emissions by 2070, and increase India's renewable energy installed capacity to 500 GW by 2030.

5.1. Hydro Power

Hydroelectric power is the use of water to generate energy. The force of flowing and falling water powers water turbines, which generate energy. The dominant annual rainfall is located in the north/east part of India: Arunachal Pradesh, Assam, Nagaland, Manipur, and Mizoram, as well as on the west coast between Mumbai. India has twelve primary hydroelectric power plants: Bihar (3), Punjab, Uttaranchal, Karnataka, Uttar Pradesh, Sikkim, Jammu and Kashmir, Gujarat, and Andhra Pradesh (2). The estimated potential for small hydropower in India is 15000 MW.

5.2. Wind Energy

It is one of the most environmentally friendly, clean, and reliable energy sources. The ten wind turbines near Okha, Gujarat, were among the first to be installed in India. India has the world's fifth largest installed wind power capacity, at 3595 MW. The development of wind power analysis in India began in the 1990s, as shown in Table 2, and has grown year after year.

Table 2. State wise wind energy generating in India [17]

State	Wind power
Tamil Nadu	7162.18 MW
Maharashtra	3021.85 MW
Gujarat	3174.58 MW
Karnataka	2135.50 MW
Rajasthan	2684.85 MW
Madhya Pradesh	386 MW
Andhra Pradesh	447.65 MW
Kerala	35.10 MW
West Bengal	1.10 MW

Today, India's wind power capacity was 20149.50 MW. The Indian government has set a target of adding 18.5 GW of renewable energy sources, of which 11 GW is wind energy. Tamil Nadu is one of the most significant sources of wind energy in India [18].Wind energy in India has an estimated potential of 45,000 MW.

5.3. Solar Energy

India has enormous solar potential. The sunniest areas are along the south/east coast, from Calcutta to Madras. Solar energy can be used in two ways: solar heating and solar electricity. A solar power plant is an excellent option for electrification in remote areas such as hilly regions, forests, deserts, and islands where other resources are not available or exploitable in a technologically and economically viable manner. The majority of the country experiences between 250 and 300 sunny days per year. In 2009, India launched the Jawaharlal Nehru National Solar Mission to generate 1000 MW to 20,000 MW of solar power for electricity production.

The daily average solar power plant generation capacity in India is 0.25 kWh/m2 of used land area, with a total solar electricity production capacity of 1700-1900 kWh/kWp [19]. Table 3 shows that solar capacity in India is 7860 MW up to October 2020, broken down by state.

Table 3. State wise installed solar power plant [20]

State wise	MWp
Andhra Pradesh	279.44
Gujarat	1000.05
Karnataka	104.22

Madhya Pradesh	673.58
Punjab	200.32
Rajasthan	1199.70
Tamil Nadu	157.98
Uttar Pradesh	71.26

45 solar parks with an aggregate capacity of 37 GW have been approved in India. Pavagada has 2 GW of solar parks, Kurnool has 1 GW, and Bhadla-II has 648 MW, all of which are among the top 5 operational solar parks in the country with a capacity of 7 GW. Gujarat is currently building the world's largest renewable energy park, with a 30 GW solar-wind hybrid project. India provides an excellent investment opportunity in the renewable energy sector, with $196.98 billion in projects currently underway. Solar power in India has an estimated potential of 20,000 MW.

5.4. Tidal Energy

Tides are caused by the gravitational forces of the sun and moon on the earth's waters. Tidal energy is an excellent source of renewable energy; in India, the total potential for tidal energy was 40,000 MW. Gujarat established 310 MW in January 2018, and the West Bengal Ganga delta has a 120 MW tidal power project, as shown in Table 4.

Table 4. Tidal energy potential in India [21]

Region	State	Total Potential (MW)
Gulf of Cambay	Gujarat	7000
Gulf Kutch	Gujarat	1200
Ganges Delta, Sunderban	West Bengal	100

According to the study, India used approximately 8000 MW of tidal energy. This includes 7000 MW in the Gulf of Cambay and 1200 MW in the Gulf of Kutch.

5.5. Geothermal Energy

Geothermal energy is a sustainable and renewable source of energy. The National Thermal Power Corporation (NTPC) and the Chhattisgarh Renewable Energy Development Agency (CREDA) collaborated to establish India's first geothermal energy power plant in the Balrampur district of Chhattisgarh. The geothermal energy successfully met both domestic and industrial energy requirements. Geothermal energy contributes to approximately 6.5% of total global energy production [22].

5.6. Biomass energy

India is rich in biomass. India has become the world leader in small-scale biomass gasification due to significant technological development efforts. Biomass accounts for approximately 32% of total primary energy used in the country, and 70% of the country's population relies on it. It is a colourless, non-toxic, flammable gas. The ignition temperature ranges from 650 to 750 degrees Celsius, the density is 1.214 kg/m^3, and the calorific value is 20 MJ/m^3. Every year, the Indian government invests 600 crore in biomass power generation, which generates more than 5000 million units [23]. Table 5 shows that India currently has approximately 640 million metric tonnes of biomass energy available per year.

Table 5. State-wise biomass power/cogeneration projects [24]

State	Power generation (in MW)
Andhra Pradesh	363.25
Bihar	9.50
Chhattisgarh	231.90
Gujarat	0.50
Haryana	35.80
Karnataka	365.18
Madhya Pradesh	1.00
Maharashtra	403.00
Punjab	74.50
Rajasthan	73.30
Tamil Nadu	488.20
Uttarakhand	10.00
Uttar Pradesh	592.50
West Bengal	16.00
Total	2664.63

A 500 KW grid-interactive biomass gasifier linked to an energy plantation has been commissioned as part of a demonstration project. Biomass energy in India has an estimated potential of 19,500 MW. The following are some of the states with the highest potential for biomass production: Andhra Pradesh (200 MW), Bihar (200 MW), Gujarat (200 MW), Karnataka (300 MW), Maharashtra (1,000 MW), Punjab (150 MW), Tamil Nadu (350 MW), and Uttar Pradesh (1,000MW).Because India has such a vast potential for renewable energy sources, it is possible to provide power to everyone.

6. India's Approach towards Sustainable Development

In recent years, the country has developed a sustainable energy supply strategy. Citizens have been encouraged to become more aware of energy conservation in order to increase the use of solar, wind, biomass, waste, and hydropower energy sources. Clean energy is clearly less harmful and, in many cases, cheaper. India aims to achieve 175 GW of renewable energy by 2022, with 100 GW coming from solar energy, 10 GW from bio-power, 60 GW from wind power, and 5 GW from small hydropower plants. According to recent estimates, solar potential will exceed 750 GW by 2047, with wind potential reaching 410 GW.

6.1. Integration of Science and Policy

India recognises the importance of incorporating scientific concepts and knowledge into development plans and policies, particularly in the context of climate change and its effects across sectors. Efforts are being made to reduce the information asymmetry regarding climate change implications between governance institutions and scientific/ research bodies.

(a) Data-Driven Decision Making

The availability of comprehensive environmental data is viewed as critical for effective climate change policymaking. Improved data on environmental indicators allows for a more comprehensive understanding of casualties and impacts, especially in adaptation and mitigation strategies.

(b) Emphasis on Technological Solutions

India has demonstrated a commitment to leveraging technology to address sustainable development challenges. Integrating technology-based solutions with public policies centred on sustainability is thought to have cascading effects and contribute to better governance.

(c) Policy and Fiscal Incentives

The Indian government has implemented policies and fiscal incentives to promote renewable energy, including solar power. These measures have helped to transform the energy sector and can serve as a model for future sustainable governance initiatives.

(d) Swachh Bharat Mission

India's Swachh Bharat Mission directly addresses Sustainable Development Goal 6 by emphasising sanitation, cleanliness, and hygiene. It seeks to achieve universal sanitation and cleanliness throughout the country.

(e) Technological Innovation for Carbon Neutrality

India understands the role of technology in achieving systemic changes such as carbon neutrality. Market-based carbon pricing mechanisms, as well as cutting-edge knowledge of carbon sequestration, are viewed as critical to increasing transparency, delivering sequestration benefits, and designing compliance and liability frameworks.

(f) Just and Equitable Energy Transition

As India prepares to phase out coal, efforts are being made to ensure a just and equitable transition for those working in the coal industry. The goal is to use science and policy to provide equitable solutions that meet the needs of affected individuals and communities.

(g) Multi-Institutional Collaboration

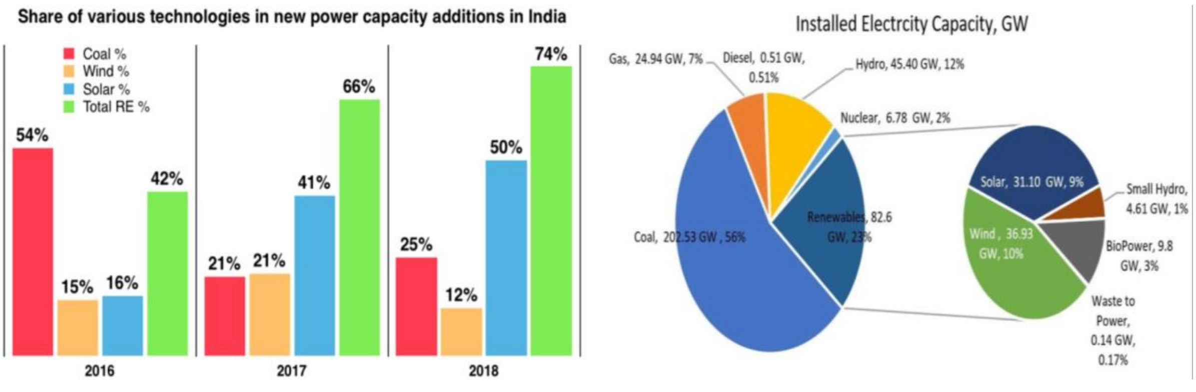
Collaboration between the public and private sectors is viewed as critical for scalable solutions and systemic change. Technological innovation, public participation, and sustainable development solutions are seen as opportunities to empower individuals and promote sustainable governance.

(h) Planning for Structural Shift

India intends to plan for structural changes and governance innovation to promote sustainable practices. These changes are expected to contribute to good sustainable governance, and as India takes the lead in the G20, it could inspire and lead in sustainable governance practices.

7. Renewable Energy Policy of India

India's reliance on imported energy resources, as well as inconsistent energy sector reform, present challenges in meeting rising demand. Figure 4 of the 2019 edition of BP's energy outlook projected that India's energy consumption would increase by 156% between 2017 and 2040. It predicts that the country's energy mix will gradually shift by 2040, with fossil fuels accounting for 79% of demand in 2040, down from 92% in 2017. In fact, between 2017 and 2040, primary energy consumption from fossil fuels is expected to increase by 120%. There is a high demand for more reliable power supplies, even though it is early in 2019.



(a) (b)

Figure 4. (a) Renewable energy technologies production capacity in India, and (b) Installed electricity capacity announced by the government of India [25]

India aimed to have 100% of its households connected to electricity. The government's 12th five-year plan for 2012-18 aimed to add 94 GWe for a total cost of $247 billion. By 2032, the plan called for a total installed capacity of 700 GWe to meet 7-9% GDP growth, including 63 GWe of nuclear [26]. The OECD's International Energy Agency predicts that India will require $1.6 trillion in power generation, transmission, and distribution by 2035. In March 2018, the government announced that nuclear capacity would fall far short of its target of 63 GWe, with total nuclear capacity expected to be around 22.5 GWe by 2031. India has five electrical grids: Northern, Eastern, North-Eastern, Southern, and Western.

All of them are interconnected to some extent, except the southern grid. All are run by the state-owned Power Grid Corporation of India Ltd (PGCI), which operates more than 95,000 circuit km of transmission lines.

8. Conclusion and Future Recommendations

The sustainability concept focusing on energy is a critical and multifaceted approach that recognizes the importance of preserving and efficiently utilizing our planet's finite resources. As we continue to witness the escalating challenges posed by climate change and resource depletion, it has become increasingly evident that our current energy practices are not sustainable in the long term. By shifting toward renewable and clean energy sources, such as solar, wind, hydro, geothermal, and bioenergy, we can significantly reduce greenhouse gas emissions and curb the detrimental impact of fossil fuels on our environment. Embracing sustainable energy solutions not only mitigates the effects of climate change but also fosters energy independence and resilience, as these sources are naturally replenished and less susceptible to geopolitical tensions. The transition to clean energy technologies and infrastructures opens new avenues for innovation and investment, stimulating green industries and green-collar employment opportunities. it can be concluded that the use of renewable energy sources, the application of sustainable energy policies, and the integration of energy efficiency measures are crucial factors in achieving long-term viability and alignment with sustainable development goals in the energy sector. This article highlights the importance of transitioning to renewable and clean energy sources, reducing environmental impacts, and promoting energy efficiency to create a more sustainable energy future.

Embracing the sustainability concept focusing on energy is not merely an option but an imperative for the well-being of current and future generations. By committing to sustainable energy practices, we can create a cleaner, healthier, and more prosperous world while safeguarding the planet's natural resources for the benefit of all life forms. It is a collective responsibility and a beacon of hope for a brighter and more sustainable future.

Societies should be made mindful of renewable energy sources, and their socio-cultural customs should receive careful consideration. To hasten the practical application of these technologies, governments ought to encourage financing in the growth of renewable energy. The declaration of a well-defined fiscal aid plan by the Indian government should include tariffs, loan deductions, and credit provision. To ensure that all power DISCOMs have power purchase agreements (PPAs) to meet 100% of their RPO commitment, the government should enhance regulations making PPA obligations statutorily binding. It is highly recommended that renewable energy be used in a hybrid configuration with traditional source and storage devices, combining two or more resources to achieve a dependable system.Regulatory authorities should formulate the necessary standards and regulations for hybrid systems.

Declarations

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Competing Interests Statement

The author has declared no competing interests.

Consent for Publication

The author declares that she consented to the publication of this study.

References

[1] Adedoyin, F.F., Gumede, M.I., Bekun, F.V., Etokakpan, M.U., & Balsalobre-lorente, D. (2020). Modelling coal rent, economic growth and CO_2 emissions: Does regulatory quality matter in BRICS economies? Sci Total Environ., 710: 136284. https://doi.org/10.1016/j.scitotenv.2019.136284.

[2] Jaiswal, S., Kapoor, D., Kumar, A., & Sharma, K. (2017). Applications of green chemistry. International Journal on Cybernetics & Informatics, 6: 127–133. doi: 10.5121/ijci.2017.6215127.

[3] Jaiswal, S., & Mojahid, A. (2020). Innovation in Society through Green\Eco-Friendly Technology. International Journal for Modern Trends in Science and Technology, 6: 37–43.

[4] Huang, J., & McElroy, M.B. (2014). Meteorologically defined limits to reduction in the variability of outputs from a coupled wind farm system in the Central US. Journal of Renewable Energy, 62: 331–340. https://doi.org/10.1016/j.renene.2013.07.022.

[5] Bibi, A., & Li, X.M. (2022). The asymmetric dilemma of renewable energy, financial development, and economic growth: Fresh evidence from Pakistan. Environmental Science & Pollution Research, 29: 31797–31806. https://doi.org/10.1007/s11356-021-17914-4.

[6] Wang, B., Wang, Q., Wei, Y.M., & Li, Z.P. (2018). Role of renewable energy in China's energy security and climate change mitigation: An index decomposition analysis. Renewable and Sustainable Energy Reviews, 90: 187–194. https://doi.org/10.1016/J.RSER.2018.03.012.

[7] Dwivedi, S., Jaiswal, S., & Kushwaha, A. (2022). Renewable biofuel resources: introduction, production technologies, challenges, and applications. Bio-Clean Energy Technologies, 2: 27–52. https://doi.org/10.1007/978-981-16-8094-6_3.

[8] Jaiswal, S. (2018). Sustainability of Biodiesel: Sources and Production Strategies. International Journal for Modern Trends in Science and Technology, 4: 1–7. https://ssrn.com/abstract=3291411.

[9] Lewis, M., Neill, S.P., Robins, P.E., & Hashemi, M.R. (2015). Resource assessment for future generations of tidal-stream energy arrays. Journal of Energy, 83: 403–415. https://doi.org/10.1016/j.energy.2015.02.038.

[10] Meereboer, K.W., Misra, M., & Mohanty, A.K. (2020). Review of recent advances in the biodegradability of polyhydroxyalkanoate (PHA) bioplastics and their composites. Green Chemistry, 22: 5519–5558. https://doi.org/10.1039/D0GC01647K.

[11] Korten, D. (1990). Getting to the 21st Century: Voluntary Action and the Global Agenda. Hartford, CT: Kumarian Pres. Getting to the 21st Century: Voluntary Action and the Global Agenda – David Korten.

[12] Wicklein, R.C. (2004). Design Criteria for Sustainable Development in Appropriate Technology: Technology as if People Matter. Corpus ID: 18406818.

[13] Reganold, J.P. (2000). Effects of Alternative and Conventional Farming. Systems on Agricultural Sustainability, Washington State University, WA, Corpus ID: 3057810.

[14] Haseli, G., Sheikh, R., Wang, J., Tomaskova, H., & Tirkolaee, E.B. (2021). A Novel Approach for Group Decision Making Based on the Best–Worst Method (G-BWM): Application to Supply Chain Management. Mathematics, 9: 1881. https://doi.org/10.3390/math9161881.

[15] Houghton, J.T., Jenkins G.J., & Ephraums J.J. (eds.) (1990). Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, Great Britain, New York, NY, USA and Melbourne, Australia, 410 Pages, IPCC - Intergovernmental Panel on Climate Change.

[16] Panwar, N.L., Kaushik, S.C., & Kothari, S. (2011). Role of renewable energy sources in environmental protection: A review. Journal of Renewable and Sustainable Energy Reviews, 15: 1513–1524. https://doi.org/10.1016/j.rser.2010.11.037.

[17] Monroy, C.R., & Hernandez, A.S.S. (2008). Strengthening financial innovation energy supply projects for rural communities in developing countries. The International Journal of Sustainable Development and World Ecology, 15: 471–483. https://doi.org/10.3843/SusDev.15.5:8.

[18] Baghali, M., Jayathilaka, W.A.D.M., & Ramakrishna, S. (2021). The Role of Electrospun Nanomaterials in the Future of Energy and Environment. Materials (Basel), 25: 558. https://doi.org/10.3390/ma14030558.

[19] Chen, J., Poon, C., & Sun, J. (2009). Photo-catalytic construction and building materials: From fundamentals to applications. Building and Environment, 44: 1899–1906. https://doi.org/10.1016/j.buildenv.2009.01.002.

[20] Koch, D., Bond, T.C., Streets, D., Unger, N., & van der Werf, G.R. (2007). Global impacts of aerosols from particular source regions and sectors. Journal of Geophysical Research Atmospheres, 112: D02205. https://doi.org/10.1029/2005JD007024.

[21] Güney, M.S., & Kaygusuz, K. (2010). Hydrokinetic energy conversion systems: A technology status review. Renewable and Sustainable Energy Reviews, 14: 2996–3004. https://doi.org/10.1016/j.rser.2010.06.016.

[22] Jose, R., & Ramakrishna, S. (2021). Comprehensiveness in the research on sustainability. Materials Circular Economy, 3: 1. https://doi.org/10.1007/s42824-020-00015-x.

[23] Isaac, O.I., & Daniel, M. (2006). Engineering mechanics of composite materials (2nd ed.). USA: Oxford University Press, Corpus ID: 106529126.

[24] Abbasi, T., Premalatha, M., & Abbasi, S. (2011). The return to renewables: Will it help in global warming control? Renewable and Sustainable Energy Reviews, 15: 891–894. https://doi.org/10.1016/j.rser.2010.09.048.

[25] Farhad, S., Saffar-Avval, M., & Younessi-Sinaki (2008). Efficient design of feed water heaters network in steam power plants using pinch technology and energy analysis. International Journal of Energy Research, 32: 1–11. https://doi.org/10.1002/er.1319.

[26] Patel, R.V., & Srivastava, A. (2019). Present status and future scope of renewable energies in India. International Journal of Engineering Research & Technology, 8: 26–32. doi: 10.17577/IJERTV8IS020009.