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Research Article

Fossil Fuel to Renewable Energy: A Pathway to Environmental Sustainability in India

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Abstract: The term Sustainability moved fast and made a rapid stride across every corner of the world. The most impactful usage of the phrase 'environmental sustainability' was made by United Nations Environment Programme (UNEP). In Indian parlance, it has been used in the context of energy requirements and the environment. To make 21st-century India, we must convert the crisis into opportunities by seeking alternative energy sources like solar energy, wind energy, hydro energy, etc., instead of currently used fossil fuel energy which is responsible for 76% of the greenhouse. Switching from fossil fuel sources and their mitigation lead to energy conservation and energy efficiency with the ultimate aim of graduating to renewable energy sources. Funding of clean energy has been largely unaffected by the COVID-19 pandemic and pandemic-related economic stimulus package offering possibilities for green recovery. No single interpretation of how the concept of Sustainability applies to energy has been accepted globally. The current energy system is responsible for the climate change, air pollution, and biodiversity loss. The concept of Sustainable energy development has been hovering around emission and energy security. However, since the early 90s, the concept has been broadened to encompass wider social and economic issues. India is producing 37% of its energy through renewable sources, which helped India improve its Renewable Energy Country Attractiveness Index (RECAI) ranking as 3rd in the world with 66.2 scores. This paper deals with the progress of India's commitment to zero carbon emission by 2070 and the challenges and opportunities ahead.

***Keywords*:** environmental sustainability, energy systems, wind energy, solar energy, greenhouse gas emissions, energy efficiency

1. Introduction

According to Mark Twain, the Indian continent is the cradle of the human race, the birthplace of human speech, the mother of history, the grandmother of legends, and the great grandmother of traditions. Though the word 'Sustainability' has become a buzzword in the global corridor after the Brundtland Report in 1987, since ancient times, Indian culture has already followed the sustainability model. The ancient physician 'Charaka' may be aptly quoted "When asked by his teacher to bring plants which were quite useless, he returned empty hand remarking that there was no such plant. People in India not only consider Sun, Moon, Air, Plants, and trees as a source of life but worship them as God. When the

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modern world understands this situation, the environment will be considered the essence of life in all its splendor. As an unfailing source of lives of humans, animals, birds, insects, etc., the environment does not merely serve Sustainability in a most selfless way; still, it becomes a formidable mechanism in the whole ambit. Under the circumstances, it is imperative for us to make it sustainable by searching the alternative energy systems, etc., vigorously and successfully replacing fossil fuel energy that has damaged the environment beyond narration.

Environmental Sustainability (a common heritage of humankind), in an analytical framework, covers in its broad sweep so many interdependent areas vital for the well-being of people that it may be said to be a world of its own. All development activities-Societal economics, Environmental, Cultural technology, and even gender perspective are being integrated into the concept and categories of Environmental Sustainability. These variables are acting and reacting on each other in the endeavour to avoid eco-toxicological impact on the environment, and on the other hand, soft energy systems and options, like renewable energy consisting of solar energy, wind energy, etc., are taken into the fold of Environmental Sustainability. This is a well-thought idea because otherwise, the future development scenario for which the next generation eagerly awaits turns grim. Over the last five decades, many civil society activists and experts have heavily dwelt upon the prospective correlation between the environment and the Sustainability of economic development by reinforcing alternative energy systems. However, the mad rush for industrialization has only increased environmental degradation on a large scale, accompanied by depletion of natural resources endowment. At the heart of the environment, there is a simple truth in the growth of green plants that one can capture the energy of the sun, our most precious asset, and turn it into food, fuel, and other products. Hence, whenever man plants trees and vegetables in small plots, covers a tiny patch with Grass or flowers, or covers the roofs of mud huts or brick buildings with cucurbits and creepers, he plays a role in our environment. This being a collective effort, it should be the endeavour of each of us to shoulder the responsibility of making the environment sustainable.

Sustainability refers to mainly four distinct areas, namely, human, economic, social, and environmental. Considering the importance of Environmental Sustainability and hazards of non-renewable energy and its role in the carbon emission, India was among a few countries which set up the Ministry of New and Renewable Energy. Since then, India has been playing a leading role in the promotion of renewable energy in the world. This paper is an attempt of researchers to understand the importance of non-renewable energy in Environmental Sustainability with special reference to efforts made to make it a zero-emission country by 2070.

2. Review of literature

Sustainability is a broader term covering human development, economic viability, environmental protection, and social equity. During the last 25-30 years, quite a few experts have tried to find a close correlation among environment, development, education, and Sustainability. Sustainability has imploded as a vital agenda with unprecedented significance. No society can remain healthy while the environment is in a state of deterioration. Indigenous knowledge systems in preserving the environment could help in shaping the future. The Initiative taken by India to promote the concept of ‘pro planet people’ has been well appreciated by the world [1].

Kenis and Mathihs conducted an exploratory qualitative study of a dozen young adult environmentalists. They found that although the participants were involved in individual behavioural change, they were skeptical of its effectiveness in addressing climate change. They concluded that the participants lacked the knowledge and power to engage in the collective social actions which they believed were truly necessary but had difficulty envisioning [2]. Amid the ongoing uncertainty about behavioural change and the availability of a traditional energy source, renewable energy is the only source for the continuity of energy [3]. While studying the limit to growth, Meadows et al. pointed out several non-renewable resources whose current level of consumption will be depleted in the distant future [4]. Irfan et al. observed that India strives to utilize biomass potential to meet the challenges of the energy crisis. While using the modified Delphi approach, they ranked major barriers that hinder the biomass industry’s development and found that ‘technological and infrastructural’ is the top-ranked barrier in this regard. The main reason for the limitation in the use of renewable energy is that it cannot be stored like non-renewable energy sources, and the answer lies with the use of technology [5]. Several scholars examined the connection between pervasive technological and social development [6]. Palmer noted resource conservation and incremental change to technology and human behaviour [7]. IPCC addressed

the scale and complexity that fundamental and transformative changes are required [8].

Irrespective of whether the economy is being developed or underdeveloped, the emission of carbon dioxide has been the main reason for extreme environmental pollution, causing detrimental consequences to human life [9]. Many studies noted the looming crisis of environmental danger because of the pollution. The World Development Report, 1992 asserted that the problem of environmental change could result in undermining development goals by offsetting the benefits of rising income (because of the cost imposed on quality of life by pollution) and adversely affecting future productivity [10]. Climate change is impacting not only national economies but also lives and livelihoods and the last decade (2010 to 2019) has been the warmest in history [11]. Sterling indicated fundamental and transformative changes as well in environmental education [12]. Fischer et al. emphasized the complexity and the interconnections of key drivers of change within socio-technical systems [13]. Chawla conceptualized promoting environmental action in the context of environmental problems [14]. Dresner typically focused on energy conservation and changing energy and use patterns rather than energy systems and more significant societal transitions [15]. Hermwile indirectly examined the environmental benefits of advancing energy systems' transformation from the active participation in social movements to private transitions in daily practice [16]. Avelino et al. connoted individual actors and determining outcomes to capture the multiple actions and actors that emerge within sustainability transitions [17]. However, this environmental behaviour was found to be too narrowly fixed both conceptually and methodologically, Aguirre knew through a study that referred to climate change typically used in global concerns about climate change and energy insecurity as a background context and/or rationale for research on promoting energy conservation in the private sector [18]. Shepardson et al. conceptualized energy as a part of Earth's climate system [19]. Adlong and Dietsch applied a regional energy transition as a context for developing an innovative social collaboration between local citizens and professional scientists and engineers to develop new ecological practices [20]. Mélard and Stassart reported that the members of the regional wind energy cooperative developed a renewable-based society not only to reduce the risks of climate change but also because of the potential for more equitable economic and political power distribution and specialized ecological knowledge [21]. Adlong categorically informed that energy experts and activists around the world are working to strengthen the community control of energy, weaken corporate governance, and resist fossil fuel reliance because it contributes to a concentration of wealth and power in society as well as all the negative health safety and environmental implications [22] .

As part of the Sustainable Development Goal, urgent action is required to combat climate change by regulating carbon emissions and promoting the use of renewable energy [23]. Murray argues that too much regulation is both unnecessary and ultimately harmful because it keeps poor people poor by preventing the competitive use of their resources [24]. Conversely, pro-environment activists justify the strict regulations, and that unregulated economic activity has led to environmental destruction. They accuse the critics of regulated legislation are pursuing the agenda of unfettered capitalist expansion. The necessity of regulation cannot be denied but creating awareness among societies and nations is more important to realize what kind of world they will leave for their successive generations. Between 2000 and 2018, the carbon emission of developed countries decreased by 6.5%, whereas, during the period 2000 to 2013, the carbon emission of developing countries grew by 43%. Prima facie, these figures indicate that developing countries are the villain of carbon emission. Still, detailed analysis suggests that despite a reduction of 6.5%, part of the carbon emission of developed countries is much higher than developing countries. Therefore, in 2019, 120 out of 156 countries have agreed to formulate and implement a national adaptation plan. The performance of India has been exemplary in this area. India has an aggressive agenda to restrict climate change through the Panchamrit Action Plan and achieve the zero-emission target by 2070 [25].

3. Theoretical framework

The importance of Environmental Sustainability and the energy system can hardly be overemphasized. The last two decades witnessed efforts toward compatible economic strategies to achieve the avowed environmental goals. It was viewed as important to make choices and decisions that would eventually promote sound development by understanding the environment and all its functions. It is a must for Environmental Sustainability as the human economy is engrossed in a wide range of activities that are enormously damaging to the ecosystem. This calls for appropriate steps to sustain

the Earth's legacy of biodiversity and species around us. This necessity is evident to mitigate the problems like pollution, climate change, global warming, collapsing fisheries, degradation of agriculture, soil and deforestation extinction, and endangerment of species. However, we can ill afford to be a pessimist. The time is right enough to take constructive actions to resolve the environmental problems currently threatening the welfare of people and species. Undoubtedly, within limits, humans are prescient creatures of this society, and as such, they are capable of implementing a sustainable economy that can support our livelihood and healthy ecosystem by adopting an analytical and vibrant framework. Accordingly, there are three chief components of sustainable energy:

(a) Increased production of renewable energy;

(b) Universal availability of safe energy and energy (conservation);

(c) Energy system without compromising future generations to meet their own needs.

Based on this pattern, there are some challenging environmental issues, including greenhouse gas emissions, simultaneously wrapping social and economic factors such as energy poverty, etc.

It is commonly believed that renewable sources such as solar, wind, hydroelectric, and geothermal energy are usually far more sustainable than fossil fuel sources. At the same time, some renewable energy projects, like clearing forests to produce bio-fuel, can severely damage the environment. Nuclear power may be a low carbon source having historical mortality rates comparable to wind energy and solar energy, but its Sustainability is more than often questioned because of glaring concerns about radioactive wastes, accidents, and nuclear proliferation. In fact, switching off from fossil fuel sources like coal is wedded with environmental benefits involving a lesser degree of climate impact, but it may also delay switching over to more sustainable options.

Today fossil fuel accounts for a large proportion, around 85% of energy consumption in the world, and this energy system emits 76% of greenhouse gas. The constraint is that nearly 790 million people in developing countries do not have access to electricity, and 86 billion people largely depend on wood to cook (polluting fuel). As such, reducing greenhouse gas emissions to the levels compatible with the Paris Agreement 2015 warrants a system-wise transformation of the way energy is produced, distributed, stored, and consumed. It goes without saying that air pollution is primarily caused by burning fossil fuels and biomass, leading to the death of 7 billion people each year. Therefore, transiting to low carbon energy will bring co-benefits to human health. Under the proposed global warming mitigation route, the world is phasing out coal-fired power plants at an accelerated rate and rapidly shifting to produce more electricity from clean sources, such as wind and solar energy. Some energy-intensive technology and processes are difficult to explain the expanding role of hydrogen fuel produced from the low emission energy source in many pathways. Energy storage plays a critical role in providing flexibility through infrastructure. The power grid needs to accommodate the larger share of variable renewable energy. To reduce emissions, we need to revamp, to a larger extent, the energy-consuming infrastructure to ensure clean forms of energy and save energy. It should be admitted that some critical technologies for eliminating energy-related greenhouse emissions remain immature.

Table 1. RECAI ranking of India

Country	Score	RECAI Ranking
USA	70.7	First
China	68.7	Second
India	66.2	Third

Source: Central Electricity Authority

While discussing the composition of availability of renewable energy, we find wind and solar power generating 8.5% of the global electricity production in 2019. It is a good sign that this share is growing rapidly, with costs falling all through. The Intergovernmental Panel on Climate Change (IPCC) proposed to spend 2.5% of the world's gross domestic product between 2016 and 2036 with a view to limit global warming to 1.5 degrees centigrade. During this

period, it is projected to display remarkable energy resilience in the period after a COVID-induced slum in growth. However, the world has been grappling with runaway protection of energy. The key indicators probably suggest that the world economy has crossed the pre-pandemic level of renewable energy, and even today, we have a strong revival of clean energy. The quick and decisive policy of governments all over the world duly supported by the private sector has enabled the world energy level to stage a smart rebound. With its strong fundamentals, renewable energy is much better placed now, and India is also playing its role, which can be seen from the fact in Table 1 that with 17% of the world's population, India ranks the second in terms of population but is the third largest consumer of electricity in the world and also the third largest producer of renewable energy in the year 2020 after USA and China. In terms of the RECAI, India ranks the third as of July 2021, followed by USA and China.

4. Objective and methodology

At the world level, India pioneered an alliance of 121 countries named as International Solar Alliance. At the country level, India was among the first country to set up the Ministry of New and Renewable Energy in the early 1980s. A public sector undertaking named Solar Energy Corporation of India was formed by the Government of India, which is responsible for developing Solar Energy, whereas the Ministry of Power administers Hydro-power. With this setup and policy initiative, India desires to reach zero emission by 2070 and produce 50% of Electricity power through renewable energy sources by 2030, which shows its commitment to fighting against climate change and ensuring Environmental Sustainability. The purpose of the paper is to use secondary data and understand the position of India towards its commitment to zero carbon emission by 2070. While using the secondary data, researchers aim to discuss the following objectives:

1. To assess the various alternative sources of energy systems like wind and solar power, hydro energy, bio-energy, and atomic energy for maintaining Environmental Sustainability.
2. To assess the potent environment policies and their implications for Environmental Sustainability.
3. To understand the contribution of various energy sources and their present position and future expectation.

While discussing, researchers aim to create the importance of non-renewable energy and discuss various efforts made by India, which will create awareness among readers and society about the necessity of switching from a traditional form of energy to renewable energy.

5. Results: India's renewable transition is underway

The transformational path of India is stunning where an Australia travels through the Indian railway, and population equal to the size of London joins its urban population, and 50 million people are provided electricity connection each year during the past decades because of which economic growth of India is among the highest in the world in past two decades. It involves the vast construction of a transportation network, buildings, and factories, and booming manufacturing and service sector. So far, coal and oil have served as the bedrock of meeting the power demand for its industrial growth and modernization, and because of this, India's annual CO_2 emission has risen to the third highest in the world. But if we compare CO_2 per person, India is among the bottom of the world's CO_2 emitters. Even its electric power consumption per population is $1/10^{th}$ of the per-person electricity consumption of the USA. To meet this demand for increased power, India has been struggling to grow its total generation capability between 5% to 9% every year, which is depicted in the Table 2 below.

In 2016, during the Paris Agreement, India committed to fifty percent of its total electricity from non-fossil fuel sources by 2030. Though the source of renewable energy was limited, to fulfill the Paris Agreement's commitment, the Central Electricity Authority of India set up an ambitious target of tracking to double by 2026 and produce 50% of electricity from renewable sources by 2030, and cross-production of 500 Gigawatts. As of March 2020, India has installed a capacity of 365.6 Gigawatts, out of which about 37% is obtained through renewable sources and the remaining 63% from non-renewable sources, details of which are as under (Table 3).

Table 2. The growing trend of power generation in India

Year	Total generation (Including Renewable Sources) (BU) (Megawatt)	% of growth
2009-10	808.498	7.56
2010-11	850.387	5.59
2011-12	928.113	9.14
2012-13	969.506	4.46
2013-14	1,020.20	5.23
2014-15	1,110.39	8.84
2015-16	1,173.60	5.69
2016-17	1,241.69	5.8
2017-18	1,308.15	5.35
2018-19	1,376.10	5.19
2019-20	1,389.10	0.95
2020-21	1,381.83	-2.49
2021-22	1,491.859	7.96
2022-23*	286.486	16.71

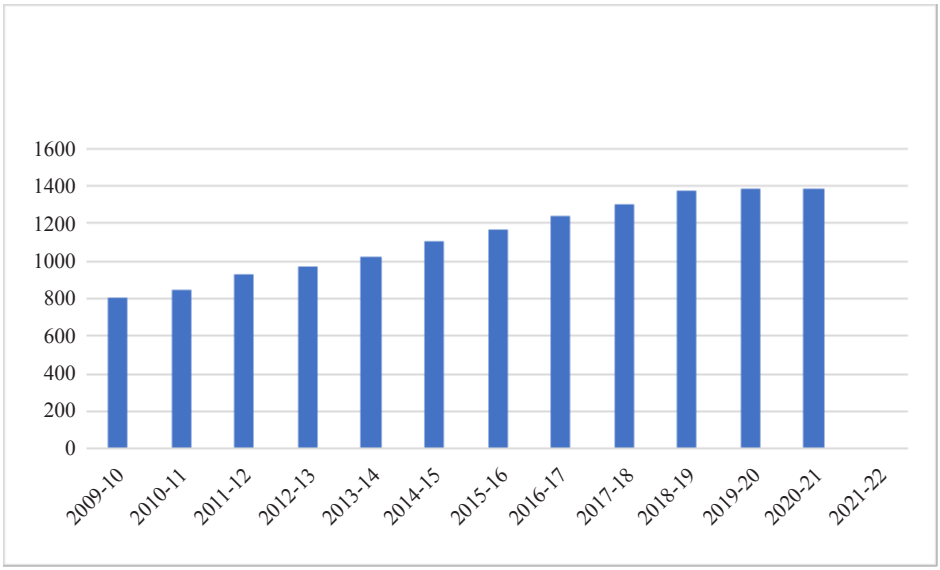

Figure 1. Total generation (Including Renewable Sources)

Table 3. Contribution of renewable energy

Type	Source	Installed capacity (Gigawatts)		% share	
		As of March 2020	As of 31.05.2022	As of March 2020	As of 31.05.2022
Renewable Sources	Waste to power	0.2	0.47	0.05%	0.1%
	Biomass power	0.2	1.02	0.05%	2.5%
	Nuclear	6.7	6.78	1.83%	1.7%
	Wind power	38.7	40.70	10.59%	10.1%
	Solar power	38.8	56.95	10.61%	14.1%
	Small Hydro-power	4.7	4.88	1.29%	1.2%
	Large Hydro-power	45.7	55.92	12.05%	11.3%
	Subtotal	135.0	166.72	37%	41.4%
Non-renewable sources	Diesel	0.5	N/A	0.14%	N/A
	Gas	25.0	N/A	6.84%	N/A
	Coal	205.1	N/A	56.04%	N/A
	Subtotal	230.6	236.09	63%	58.6%
Total- Renewable + Non renewable		365.6	402.81	100	100%

Source: Central Electricity Authority

Table 4. RECAI score of India vis-à-vis other USA and China

Technology	RECAI score of India	Position of India	RECAI score of USA	RECAI score of China
Solar PV	62.7	1	57.6	60.3
Solar Concentrating Solar Thermal Power (CSP) power plants	9.2	4	46.2	54.3
Hydro-power	46.4	3	57.6	60.3
Onshore wind power	54.2	6	58.1	55.7
Offshore wind power	28.6	29	55.6	60.6
Geothermal power	23.2	16	46.0	31.7
Biofuels	47.4	10	45.3	52.8

Source: Central Electricity Authority

Hydro-power, solar, and wind are major sources of environmentally mental friendly and cheaper power sources that replace foreign imported coal fire power, a major source of pollution. One of the major sources of renewable energy is solar energy. As of September 2020, about 89.22 Gigawatt energy is already being produced through solar energy, and projects of 25.64 Gigawatts are underway in the implementation stages. Three out of the five largest solar parks in the world are in India. Out of which, Bhadla Solar Park in Rajasthan, with a capacity of 2,255 MW, is the largest solar park, and Pavgada Solar Park Tumkur in Karnataka, with a capacity of 2,000 MW, is the second-largest solar park in the

world. India's second major renewable energy source is hydroelectric power, with an installed capacity of 50079 MW (13.65% of its total utility power generation) and ranking the fifth globally.

The sincerity of India to adopt renewable sources can be seen from the fact that the RECAI score and ranks of technology-specific renewables sources have improved till 2021, which can be observed from the above Table 4.

6. Limitations of sustainable energy sources: Challenges ahead

Most sustainable energy sources are plagued with their strong limitations. India has progressed a lot in terms of providing electricity, especially through renewable sources. It has been able to place its position among the most significant economic powers of the world. Still, everything is not as rosy as it looks, and there are several challenges before India, and a few of them are delineated hereunder:

• Under the Pradhan Mantri Sahaj Bijli Har Ghar Yojna, the Government aims to connect all villages with electricity by 2022. However, it is still away from the target, and on the other hand, looking at the initial cost involved in renewable energy, poor people living in the remotest area of the country are not able to use alternate sources.

• Uninterrupted supply is still a nightmare even in villages and towns where electricity wire has reached.

• The sharp increase in inflation has made energy less affordable.

• Though the Government claims to distribute ten crores free Liquefied Petroleum Gas (LPG) gas cylinders, poor people's reliability on traditional cooking fuels still exists due to their inability to refill LPG cylinders causing environmental and health issues.

• Electricity distribution is still faulty, leading to financial and power leakage, and urgent transformation is required in this area.

• Society and Governments have failed to educate farmers to avoid burning stubble.

• Air pollution caused by vehicles and factories coupled with stubble burning has made several cities of India a gas chamber.

• Availability of solar energy is not ensured for 365*7/365*24, which necessitates storing energy in the form of a battery, but that has its hazardous consequences.

• The price of grid energy technologies is high; hence it becomes expensive though it could solve some problems. The same is true for wind energy.

• This leaves to depend on three types of energies: hydropower, geothermal power, and biomass power. There are obvious limitations to hydro-power. Yes, comparatively cheap biomass could be a way out, but this requires technology that is hardly considered to be eco-friendly.

• The limited energy sources cannot be commensurate with indefinite energy demand growth, no matter how we improve energy efficiency. It appears that the whole question is intensively driving energy prices.

• Economic policies of countries, social awareness, public concerns, and technological constraints are other limitations and constraints that we are facing now. The moot question is how many public policies are willing to support environmental, social, or economic Sustainability.

• Sustainability in implementation, patriarchal thinking, the silo approach to environmental and other socio-economic issues, confusion over cause and effect, lack of information, and insufficient learning mechanisms are other major deterrents leading to limitations.

The energy can be conserved by increasing appliances' technical efficiency and observing behaviour changes, healthy consumption patterns, building codes, performance standards, carbon pricing, etc. However, full de-carbonization of the energy system is expected to take several decades and can mainly be achieved with the existing technology. But developing countries like India still have an opportunity to leapfrog to renewable energy through cost-effective methods.

7. Conclusion

Through various policy measures, India aims to reach zero emission by 2070 and meet 50% of its electricity

requirement through renewable energy sources by 2030, showing its commitment to fighting against climate change and installing environmental Sustainability. Like selected major economic powers, India has joined a new model of providing carbon-reduced economic development. It works as a role model for several developing economies providing a blueprint for such a model. Despite the high demand for energy and all other odds, India is committed and moving on the pathway to net-zero emission by 2070, which can be seen from the fact that well before 2009 years, India achieved its commitment made at the 21st Conference of the Parties (COP 21) Paris Summit to produce 40% of electric power from non-fossil fuel. In this journey, the share of solar and wind energy has grown phenomenally. Apart from the economic opportunity, India has a lot of scope to become a global leader in green hydrogen and renewable batteries. Low-carbon technology is expected to create a market of about $80 billion in India by 2030. The International Energy Agency (IEA) estimates that $160 billion annually is required to reach net-zero carbon emission by 2030. Hence, a lot of scope for FDIs/FIIs and private players invest in research and development projects in this emerging market of renewable energy. Adaptive research studies are essential for the transfer of technology to make the environment more sustainable and realize economic and social benefits. In fact, there is a sheer need to undertake integrated research on developing a technology suited to the alternate technology system, particularly biomass energy.

Renewable energy is growing faster than any other major economy and expected to be double by 2026. The IEA expects India to overtake China and Canada in the next 5-7 years and become the third largest ethanol user after the USA and Brazil. To achieve these milestones, India took numerous policy measures, like subsidies for diesel and petrol removed in 2010, and subsidies for electric vehicles introduced in 2019. If policy measures are implemented appropriately, they will address challenges to a great extent and provide clean air to its citizens. Robust Energy Efficiency programs in India have successfully reduced energy consumption and wastage from transport, buildings, and major industries. Though the Government's program to provide free LPG cylinders has always been subject to criticism, its effort to encourage poor people to avoid using biomass like wood, etc., is the right step in the right direction. The country is also laying the groundwork to scale up emerging technologies for massive production of non-fuel energy and its storage through batteries etc., and researchers are hopeful that India will achieve its target of zero emission well before the targeted deadline, and its policies and initiatives will work as a torch bearer to other developing countries.

Conflict of interest

There is no conflict of interest.

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