The Economics Society,
Shri Ram College of Commerce

THE FUTURE OF SUSTAINABLE ENERGY IN INDIA: BENEFITS, CHALLENGES AND THE WAY AHEAD

RESEARCH REPORT

Reviews

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This report is a commendable effort to provide a detailed overview of sustainable energy in India. As the country prepares to chart a new path post-pandemic, sustainable development and green growth should be centre-stage and it is crucial to have a proper understanding of the key issues. Based on a mix of theory and empirical evidence, the report makes a convincing case for the transition from fossil fuels to renewables to meet our growing energy needs. At the same time, it is realistic in its acknowledgement of the costs and challenges that such a shift entails – energy demand fluctuations, unpredictability of production volumes, land-use disadvantage, non-sustainable inputs, ecological impacts, need for infrastructure investments in storage and transmission and regular technological upgradation, among others. It presents examples of innovative solutions from the Indian and global contexts, and summarises institutional frameworks and international agreements that are in place.

The analysis captures the tussle between the short and long term when it comes to private decisions around energy, and how policy can incentivise and nudge these in the right direction – for instance, by enhancing priority-sector lending to finance high initial costs of solar projects. It correctly notes that the environmental requirement for sustainable energy is “easily identifiable but not heeded” and highlights evidence on the negative effects of fossil fuels on human health and longevity. Bringing in the business perspective, it outlines

current practices in socially conscious investing and corporate reporting. It emphasises the importance for spreading awareness of the effective costs of green buildings, in order to promote their adoption.

The report engages the readers in an informative discussion of a range of concepts from must-run status of renewables, auctions in India's energy sector, just transition mechanisms in EU, to application of blockchains, 'prosumers' of energy, and smart power grids.

Well-researched and accessible reports such as this can aid in changing common misconceptions of sustainable energy being unfeasible and a far-fetched solution to the climate crisis as well the impending exhaustion of non-renewable resources.

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The research report on 'Sustainable Energies and the way ahead' by The Economics Society of the Shri Ram College of Commerce is timely and relevant in today's volatile and complex energy scenario. While the coronavirus pandemic has rearranged global priorities, the climate crisis has assumed more importance to plan for a better future. The existing situation presents us with an unprecedented opportunity to collectively hit the reset button and make changes to build a better and resilient world through efficiently using the available and alternative energy resources.

I appreciate the timely publication of the report which is not only relevant in the current context, but also shows the way forward in terms of harnessing the green energy sources. The research report is comprehensive, covering most of the aspects related to sustainable energies. I hope more such relevant reports will be published by the Society to create value addition for the knowledge community.

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EXECUTIVE SUMMARY

The population on Earth is growing at an unfathomable rate and along with it increases a consequent demand for energy, since the need for it happens to be incessant. The currently employed sources and methods of generation of energy are visibly exacerbating the health of the planet. This calls for a need to shift towards alternative sources of energy generation that encourage economic growth whilst preserving the environment. This report shall aim at recognizing what have been the challenges and initiatives during the process.

In the next section, we emphasize the need to shift to sustainable methods of energy. The change from the present methods to a more inclusive approach of sustainable energy sources is the need of the hour. The conventional sources of energy are constrained through a limited supply. Additionally, their usage over the years has had a negative repercussion on the health of all living beings and the ecosystem as a whole. The scope of development and utilization has reached its top with fossil fuels, while sustainable sources still house a wide unexplored potential. The use of sustainable sources also contributes to the energy security of the world. It helps in handling the vulnerability in terms of robustness and resilience. A shift towards cleaner and sustainable sources of energy brings along benefits to the business world. Sustainability has not only been used as a key marketing tool by businesses, but has also contributed in reducing costs through green manufacturing. Sustainable policies have also been known to contribute positively towards the stock market performance of the company. Also, a crucial reason for advocating this shift is to counter climate change and global warming. It is evident that our current methods have driven the world into a climate, health and economic crisis. Addressing and implementing methods to reduce and control climate change are dire needs and a shift towards sustainable energy can help in that respect.

Though there is an urgent need for the shift towards sustainable sources, it comes with its own costs and challenges. The initial capital costs for renewable sources are extremely high, which leads to hindrances in proper funds and finance. Additionally, the government provisions for credit in the cleaner energy sector are far below the requisite levels, needed for healthy growth. A silver lining is the decrease in costs of green energy through technological advancements. In spite of enormous contributions to the sector, technology also poses some challenges in the efficient and effective usage of sustainability. The existing infrastructure facilitating energy storage and transmission is not adept at adapting to energy generated through renewable sources. Energy demand fluctuations pose other technological challenges as they are difficult to handle with sustainable sources. The high dependence of sustainable energy production on non-sustainable inputs offsets the benefits achieved through cleaner sources. The use and increased investment in renewables also bring along some unintended consequences, which become a major social cost. There would be a significant loss in employment due to a decrease in the number of thermal power plants. Additionally, the setting up of renewable power plants can have a major ecological impact and can cause damage to the surrounding areas.

One of the major initiatives globally towards a sustainable future is the EU Green Deal that aims to work on a resource-efficient economy with no emission of greenhouse gases. The prime components of the deal are achieving a state of clean energy with sustainable industry and mobility. Besides, the India Energy Policy is critically examined along with appreciating the developments so far and analyzing the prospective changes and additions to the same in the report. This is followed by a thorough evaluation of certain unique initiatives undertaken internationally to assist the goal of sustainability like the Carbon Tax etc. A detailed description of the Cap and Trade programme that aims at limiting carbon emission, has been presented with a fair examination of its limitations and the possible solutions.

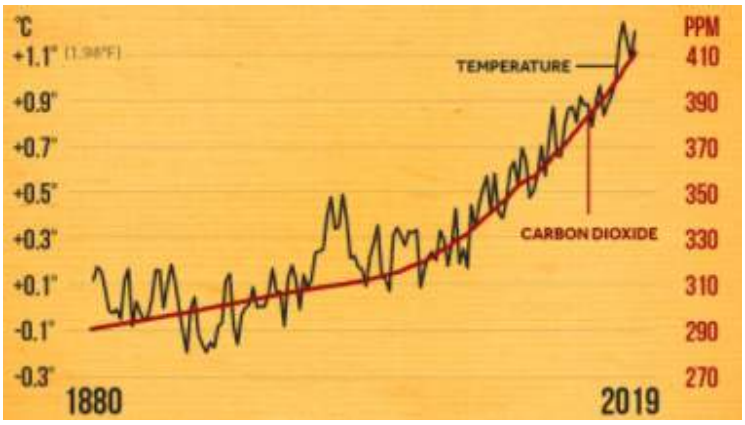
A case study on Electric Vehicles attempts to highlight the excessive emissions of pollutants caused by internal combustion engine vehicles. Since EVs reduce the demand for fossil fuels, they prove to be the most feasible alternative. The status quo and the future prospects have been extensively discussed in the report. The government, realizing the potential of EVs, has implemented multiple policies and frameworks, some of which need a recast and certain additions. The report ends with suggestions for the same.

1. INTRODUCTION

Over the last few decades, the 'health status' of the earth has been in the news quite frequently. The greenhouse impact, rising global temperatures and loss of biodiversity and natural resources, all point out that the health of the planet is not as good as it should be. With the world population increasing sevenfold in the last 200 years, the stress of the human needs on the environment has never been more. Today's world population, roughly 6.5% of the total number of people ever born, demands a lot of energy to meet its needs and to ensure the growth of the human civilization [1].

However, the sources of energy currently in wide use are not suitable for the environment and pose the risks of adding on to the climate change risks. This is highlighted by the fact that energy accounted for 78% of greenhouse emissions in the EU in 2015 [2]. The subsequent graph, based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, shows that atmospheric CO2 has increased since the Industrial Revolution, causing a direct impact on the global temperature levels as well [3].

Figure 1: Global Temperature & Carbon Dioxide Trends



Source: Climate Central

The following statistics reflect the extent to which India is dependent on 'dirty sources of energy' to meet their consumption requirements. According to the World Resource Institute (2017), nearly 6.65% of total global carbon emissions was released by India alone, ranked fourth next to China (26.83%), the USA (14.36%), and the EU (9.66%) [4]. India is also one of the largest coal consumers in the world and imports costly fossil fuel. Close to 74% of the energy demand is supplied by coal and oil [4]. This depicts that economic growth of our country, and the world in general, has come at a huge environmental cost.

Continuous and irresponsible utilization of the conventional sources of energy poses a great threat to the environment and causes an increase in the global greenhouse gas emissions; deteriorating the status of air, water and soil. It has led to a 2-degree increase (Fahrenheit) in global average surface temperature that has occurred since the pre-industrial era which might seem less on an absolute scale [5], but it is a significant increase in the accumulated heat. That extra heat is driving regional and seasonal temperature to the extremes, reducing snow cover, intensifying heavy rainfall, and changing habitat range for plants and animals—expanding some and shrinking others. With increased carbon emissions in the atmosphere, close to 18,000 people [6] die each day due to air pollution, according to a report by the International Energy Agency. When taken into perspective, this equates to 6.5 million deaths each year globally, a number higher than the deaths caused by HIV/AIDS, tuberculosis and road accidents combined[6]. These facts and figures highlight the importance of shifting towards a more sustainable method of development.

1.1 Why Sustainable Energy?

The aforestated figures paint a grim picture, which commands for a need to look at alternatives of energy generation. In the hustle of industrialization and urbanization, the amount of harm caused to the environment has been conveniently disregarded time and again. Environmental degradation under the alias of economic development is no longer obscured. At the same time, given the immediate and perpetual need for energy, the existing resources of energy cannot be disregarded. Sustainable forms of energy is the way ahead. In 2018, there was a 4% rise in global electricity demand, the largest yearly increase since 2010. Encouragingly, renewables met 45% of this increase. This gives hope for the future of sustainable energy [7].

The term sustainable development was first introduced in the Brundtland report, prepared by the World Commission on Environment and Development in 1987, and the definition given herein is: "to satisfy the needs of the current generation in such a way as not to endanger the satisfaction of the needs of future generations and the development of future generations [8]." Simply put, sustainable development is an approach which attempts to encourage economic development whilst preserving the environment. Sustainable energies use inexhaustible and natural resources to generate clean energy. These are notable in reducing the dependency on fossil fuels and other emissions into the environment. Currently, India is responsible for nearly 6.65% of total global carbon emissions [9].

In the near future, the demand for energy is going to increase substantially owing to two major reasons i.e. fast-paced economic development and the increasing population. Renewable energy has the potential to suffice for the increasing demand. The estimated total renewable potential in India given the installed capacity amounts to 1096.080 GW [10]. With increased expenditure and investment, these alternatives hold much greater capacity to provide for the demand swell. A shift towards renewable energy sources will ensure a reduction in greenhouse gases' emission. More importantly, diversification in energy consumption will considerably reduce dependency on imports for the same. The reserves of fossil fuels are diminishing and there is a pressing need for alternative sources of energy that are also environmentally sensitive. IRENA reports that, globally, the renewable energy sector employed 11 million people in 2018 [11]. This proves that this new sector has massive employment generation capacity alongside the virtue of checking pollution to a great extent.

Regardless of the fact that the idea has been in existence for quite some time now, inculcating sustainable energy on a larger extent has proved to be difficult in many countries. This is owing to certain differences and challenges that are faced by people and countries in general that restrict them to accept these relatively newer sources of energy. This report will explore these challenges, costs accruing to the shift, the policies and possible solutions to the same.

2. THE NEED FOR SHIFTING TOWARDS SUSTAINABLE ENERGY

2.1 Exhaustible Sources

The degree to which we use energy has far-reaching consequences. The current system relies extensively on fossil fuels like coal to meet its energy needs. Fossil fuels are carbon-based materials found in the Earth's subsurface, that are alluring as energy sources primarily because they can be transported with relative ease and the energy delivered is highly concentrated. However, fossil fuels aren't the most optimal solution when it comes to meeting energy requirements.

First, fossil fuels are limited in supply. If we run out of fossil fuels without a backup plan, our energy requirements will be unmet. We've often heard the claim that estimates of proven reserves for oil and natural gas tend to increase; this is because improvements in extraction technology and increasing demands change the definition of what is profitable to extract. Nonetheless, the point remains that fossil fuel resources are limited and will not allow human societies to flourish for time spans longer than 50-200 years [12].

Another drawback to relying on fossil fuels is that about 42% of the world's oil is produced by nations in the Organization of Petroleum Exporting Countries (OPEC), and about 50% of that comes from countries like Saudi Arabia, Iran, and Iraq [12].

Fossil fuel use is also unsustainable for our health and the welfare of the environment. For example, releases from coal-fired power plants include particulate matter and mercury and are liable for respiratory illness and premature death especially in vulnerable populations like children and the elderly [13].

Fossil fuels took millions of years to form, and it will take considerable time for them to be replenished. Yet, our need for energy is urgent. From national and energy security perspectives, it will be crucial to increase domestic fossil fuel production in the short term, but this still does not address the issues relating to finite supplies, air quality and climate change. Therefore, it is of utmost importance that we raise the proportion of renewable energy in the energy mix.

2.2 Climate Change

Since the industrial revolution, humans have emitted around 450 billion tonnes of carbon which has led to the present condition of the world's climate crisis [14]. Furthermore, the usage of fossil fuels, industrial activities and dependence on the agro-economy of developing countries have contributed to increased levels of greenhouse gases (GHG) that assisted a changing climate and boosted global warming. India is the second most populous country in the world with an enormous population of 136.64 crores [15]. It accounts for about 30.61% of Asia's total population occupying a geographical area of 3.287 million square km [16].

Fossil fuels contribute to about 75% of India's energy mix but as the world is adopting cleaner fuels and sustainable ways of development, the nation will play a key role in shaping the planet's future climate picture [17].

When the average growth rate of gross state domestic product (GSDP) during 2005-15 for almost all the states was around 7-8 per cent, 11 states registered a decline in their natural capital. While 13 states showed a marginal growth in the range 0-5 per cent, just three states saw their natural capital increase by more than 5 per cent [18].

Climate change has taken a toll on the water resources as well. The report shows a 24% decline in the area under snow and glacier in some states and also notes the impact of climate change on wetlands/water bodies in Himachal Pradesh, Sikkim and Jammu Kashmir [18].

Additionally, unsustainable extraction of groundwater resources is causing a decline in the water levels in Tamil Nadu, Chhattisgarh, Goa, Odisha and Rajasthan. In the last 6 years, the rate of growth of forest stock has reduced by more than 10% in almost all states. From 2006-07 to 2010-11, all states, except Goa and Sikkim, have shown such a decline. However, from 2010-11 to 2015-16, even though there was a marginal change in forest cover in Assam and Uttarakhand, growing stock has reduced by more than 10 per cent [18].

Clearly, the unsustainable approach towards economic growth has led to this crisis and these grave consequences are nothing more than the results of our negligence towards the environment.

2.3 Reliability and Resilience

Renewable Energy will turn out to be more consistent and less vulnerable to external environment and demands. Wind and Solar energy as distributed sources of power are efficient and resilient to any major disruption. They are decentralized / modular and therefore are not impacted by large disruption due to severe weather. Since green energy is designed as modular, any equipment damage or system failure will not result in total shut down and operations can continue seamlessly.

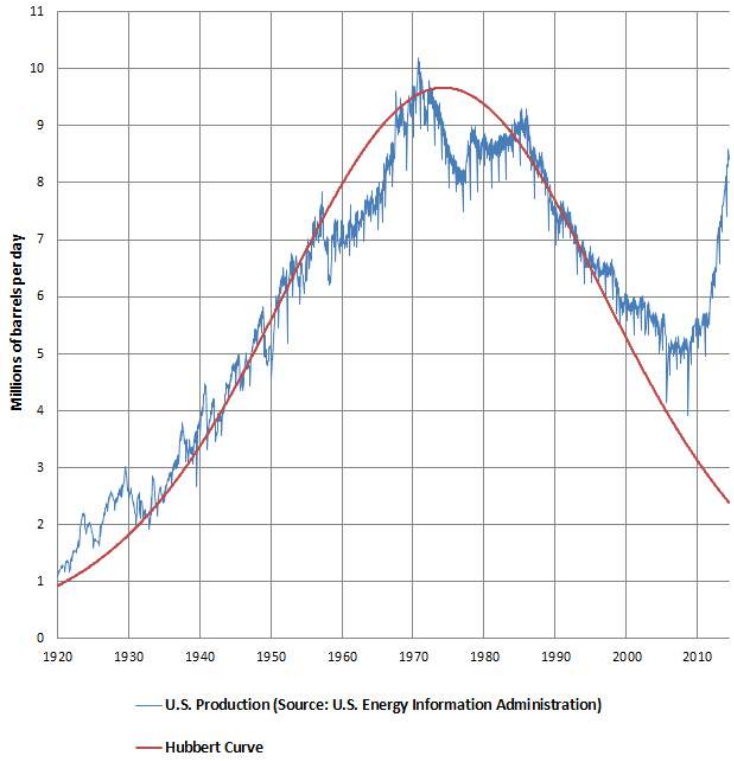
2.4 Scope of Development

We have been using fossil fuels and coal to power the world since the industrial revolution. Though, from the 19th century to now, the consumption patterns and derived efficiency have changed and evolved but our dependence on fossil fuels has been increasing. Researchers and scientists have explored countless avenues of usages and increased efficiency and effectiveness of its uses. Today, we can produce more energy by the same fuel than we could a hundred years before. But it is believed that fossil fuels usage has reached the zenith of its development. There are scarcely any avenues left that haven't been charted already.

Another aspect to view this is Hubbert's peak theory. The theory states that because the supply of oil is finite, the global crude oil production will reach its maximum value (peak) and then start declining, forming a bell shaped curve. Though, this theory is used in terms of oil production but can also be applied to any non renewable source [19].

Hubbert's predictions of when the world will reach its peak were proven wrong and the world is nowhere near the peak in the near future. But, it is common consensus, that the supply of sources such as oil and fossil fuels are exhaustive and will reach the top level of production, which will be followed by a decline. Hence, reconfirming the theory but the time frame of this event is still disputable [20].

Figure 2: U.S Crude Oil Production versus Hubbert Curve



Source: Energy Education | University of Calgary (2015)

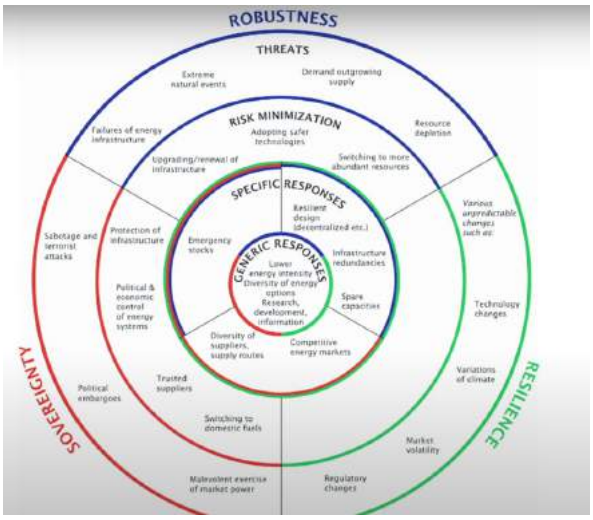
The scope and potential for growth and further development is available with a vast playing when it comes to sustainable sources of energy. Additionally, the premise of Hubbert's theory that requires the supply to be finite does not apply to sustainable sources. These factors demonstrate the scope of advancement available when sustainable sources are utilized on a wide scale.

2.5 Energy Security

Energy Security encompasses a wide variety of sub headers ranging from economics, politics, foreign relations, social, technological, environmental and many more. Even though the concept of energy security has been in existence since the 1960s, its interpretation has varied diversely. The IEA defines energy security as "uninterrupted availability of energy sources at an affordable price [21]." Hence, to ensure safety on the energy front, undeterred supply and reasonable and accessible pricing needs to be ensured. The exhaustible nature of the conventional sources of energy is widely known and in the long run our dependence on fossil fuels are bound to drive the prices higher.

There is another important element to consider while talking about energy security: vulnerability. It deals with how fragile the systems are when energy becomes a variable element of the system. Researchers have explained these vulnerabilities by analysing how our security concerns have changed over the centuries and have come up with three persistent types of concerns: sovereignty, robustness and resilience [22]. Sovereignty is more of a political phenomenon than economic or environmental. It deals with from where do we procure the energy from; is it imported or self-produced by the country. The second is robustness. It talks about how long our sources will last, and it is widely known that our current sources fail to fulfil this parameter. Fossil fuels are believed to last barely a century from a now. The third element is resilience; it deals with a system's ability to recover from disruptions of any kind [23].

Figure 3: The three perspectives on energy security: intellectual history, disciplinary roots and the potential for integration.



Source: Cherp, A., & Jewell, J. (2011, September 1)

Resilience can be better understood with a bifurcation. It can be divided into 2 aspects: long term energy security, which mainly deals with timely investments to supply energy in line with economic developments and environmental needs, and short-term energy security mainly focuses on the adaptability of our systems to respond to fluctuations and variations in supply and demand [24].

In the short term, the conventional fossil fuel usage stands the test of energy security for being able to adjust its supply in response to a changing demand. But in the long term, fossil fuels are not likely to last long enough to comply with the rising economic developments of a nation. Another way of looking at this is, currently 80% of the world energy requirements are derived from fossil fuels [25]. When this supply collapses, will the economy be able to adjust easily to other sources? The long term risks outweigh the short term benefits derived from fossil fuels.

2.6 Benefits to Businesses

Sustainability and profitability can very well co-exist. Adopting sustainable methods for carrying out operations can not only provide an improved brand image but also a competitive advantage. Sustainability has become more than just an ethical issue these days. In a world of growing environmentalist population, sustainability can prove to be a key marketing tool.

Sustainability can also play a major role in increasing efficiency and productivity which leads to cost reduction. Green manufacturing focuses on using fewer materials and less energy and reducing the carbon footprint while emitting less pollution. Physical waste and emissions are reduced to a minimum [26]. One of the major goals of any company is to increase the value of its shareholders and it doesn't have to be at odds with maximizing sustainability. Numerous studies depict a positive correlation between firms' sustainability initiatives and their long term financial performance. Sustainable business practices garner bona fide benefits, primarily the easier access to capital, accessibility to new markets since sustainability is relatively still a new concept and further shedding light on the arguments that environmental and growth and social concerns are rivals, instead of partners.

2.7 Health Concerns

Carbon in thermal power plants poses huge health concerns. Coal power is falsely considered cheap since it doesn't take into account the health costs resulting out of pollution. In 2019, it was discovered that 21 of the 30 most polluted cities of the world were in India[27]. India's PM 2.5 was recorded at 58.08μg/m^3. This concentration is dismally 5 times higher than that recommended by the World Health Organisation (WHO) [28]. The excessive amount of permeation of sulphur and other chemicals in the air later leads to the phenomenon of acid rain. The acidity that they cause in rains can have implications like corrosion of machinery, damage to trees, animals and the environment. The addition of chemicals to the water bodies causes an increase in temperature that affects aquatic life and in turn, humans, through the consumption of seafood. We do not realise the amount of harm our indiscriminate activities are causing to the health and longevity of human beings. It is high time we discern our actions and own up to them and take responsibility.

SRI and ESG

Socially Responsible Investing and Environmental, Social and Governance investing are terms which stand similar to each other and are often used interchangeably, but are slightly different with regards to their primary objectives. Both SRI and ESG refer to socially conscious investing. The objective behind SRI is to comply with one's own values, beliefs and social conscience. It supports companies which are profitable as well as have a positive social impact, both being given an equal weightage while consideration. [29] For example, SRI means investing in mutual funds that put one's money in companies which create a positive sustainable impact like being an all female-run business, and excluding those which do not follow one's ethics and values like a drug related business. However, every person has different analysis and interpretation of how they wish to perform SRI as strong beliefs vary person to person. According to a Morgan Stanley survey, 85% of the individual investors are interested in sustainable investing as of 2019. [30]

ESG stands for Environmental, Social and Governance practices and it is one of the tools used for analysing a company's financial performance, risk, and growth. The main objective of this tool is to gain profit as responsible business entities with sustainable operations are attractive long term investments. Few examples of aspects that are covered by ESG are climate change impact and energy consumption under 'Environmental', human rights support under 'Social', and Board independence under 'Governance'. It is not mandatory for a company to disclose their ESG, however, many have recently started including this aspect in their annual reports as it is gradually gaining importance. It is so because many users of these reports including investors, policy makers and companies look for corporate sustainability reporting for making various decisions. For this purpose, internal as well as external sources are used to obtain data which are relevant and reliable, a wide range of organisations also provide ESG ratings for the same in which companies are analysed and rated on the basis of their ESG performance .

The result of a survey by CFA institute shows that 63% practitioners use ESG ratings as a part of their data analysis. Moreover, SABS (Sustainability Accounting Standards Board) along with GRI (Global Reporting Initiative) and a few other organisations are jointly working towards encouraging sustainable reporting and have recently announced a prototype climate related financial disclosure standard. In India, BSE has three main indices measuring corporate sustainability namely S&P BSE 100 ESG INDEX, S&P BSE GREENEX and S&P BSE CARBONEX, while NSE has NIFTY 100 ESG INDEX and NIFTY 100 ENHANCED ESG INDEX. [31]

3. COSTS AND CHALLENGES OF SHIFTING TO SUSTAINABLE ENERGY

With the advent of sustainability and increasing incorporation of Sustainable Development Goals in the international framework, a lot of countries have pledged to shift towards 100% renewable energy in the near future. In the United Nations Climate Change Conference, 2016, more than 50 countries agreed to use only renewable energy by 2050 [32]. While renewable energy ostensibly has the capacity to provide for the growing energy needs and is seemingly the only alternative we have towards mitigating climate change, one cannot be oblivious to the numerous challenges that India, and the world in general has to face while embracing this transition. The following section provides a comprehensive understanding of these challenges.

3.1 Monetary Costs

The world, as of now, has a billion people who do not have proper access to electricity and 3 billion people who do not have access to clean cooking [33]. 80% of the global primary energy consumption is currently accounted for by fossil fuels, leaving economies vulnerable to volatile fuel prices and dependent on energy imports.[33] The key challenges facing the global scenario are to meet our current energy needs and also those of a projected 10 billion people by 2050[33] with low cost, zero-carbon energy.

The change towards sustainable energy is economically and environmentally desirable to keep the wheels running. However, years of traditional modelling and politics based upon cost-benefit analysis and outdated statistics have made us believe that shifting to sustainable energy is not feasible economically.

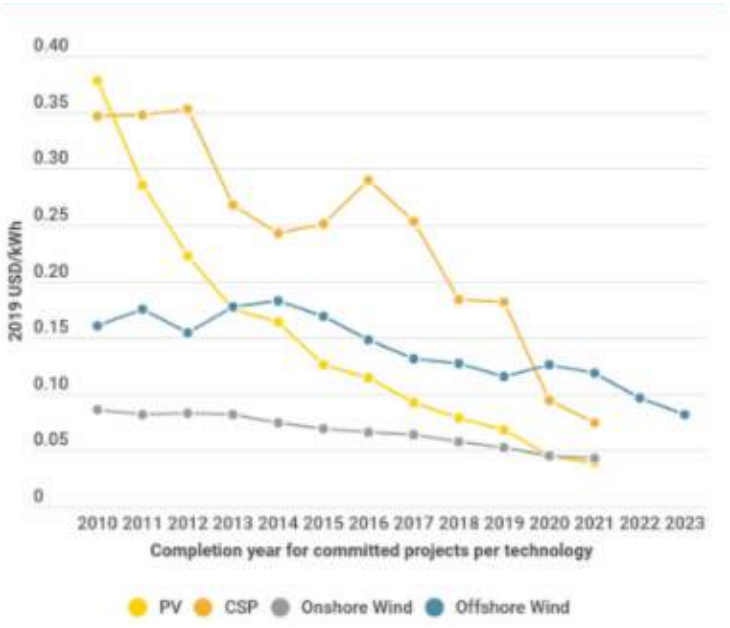
The inherent systems make us more inclined towards the comfort of the status quo. Neglecting innovation makes it difficult to predict or quantify their longer term benefits. The short-term costs usually arise in the form of transitional costs in terms of infrastructure, overcoming the losses in demand for conventional sources and R&D. For instance, crude is amongst the most impacted commodities facing steep losses of almost 30% globally due to changes in energy demand[34]. Energy demand fluctuations become one of the various challenges that hinder major players in the market to even consider a shift towards renewable energy, only in order to avoid monetary losses. Furthermore, the initial capital costs for establishing renewable energy units are very high, which leads to reluctance in financing and initial burden.

The Government of India established a target for installing 175 gigawatts of Renewable Energy Capacity by 2022 which has now been added on by 450 gigawatts by 2030[35]. The total investment required to reach the initial target is being estimated at $150-200 billion with the current technological infrastructure [36]. The lack of incentives for financing renewable energy projects comes off as a major financial obstacle for our country. The current limit for funding of solar rooftop projects under priority sector lending by the banks is set at Rs 30 crores per project [36].This may be a major deterrent since the overall credit requirements for such long term projects are much higher. India's energy sector is one of the fastest growing in the world [37]. The current average clean energy investment by India is $10-11 billion on an annual basis [37]. However, monetary resources are also required for the complete establishment and maintenance including investments in power distribution companies, transmission upgrades, storage and dispatch management. The average annual finance required to fund sustainable transportation projects increased by 43% in 2017-18 from 2016-17[34]. The development of sustainable transportation is instrumental for India to align with its renewable energy goals and thus, the funding should increase by at least 50%. In overall terms, India's investments in alternative sources of energy with respect to coal based power is highly disproportionate. In the Union Budget of 2019-20, the allocation for the Ministry of Coal stood at Rs 20,121 crore while the Ministry of New and Renewable Energy was allocated Rs 12,353.81 crore, which accounts for 63% less funds for alternative sources of energy as compared to funds for traditional sources of energy [38].

The Economic Survey 2018-19 estimated India's requisite investment in renewable energy at more than $250 billion over the next decade, which accounts for an annual investment of more than Rs 1.77 lakh crore for 10 years[38].

Over the years, the renewable sources of energy have become cost-effective and as competitive as traditional sources of energy. In some instances, the non-conventional means are getting cheaper than fossil fuels, oil and gas. The main reason behind the attainment of feasible prices by green energy is the decreasing cost for energy technologies and equipment, the availability of storage technologies at low cost and the introduction of smart energy management systems like energy blockchains and the 'Internet of Things' (IoT). These technologies can make the transition towards a near-total renewable power network more feasible for most of the economies. Moreover, the cost of solar and wind energy has been plummeting, down by 86% and 67% since 2009 respectively[39]. IRENA reports that the cost of solar photovoltaic panels have gone down by more than 80% since 2009. IRENA also notes that their costs continue to decline[40].

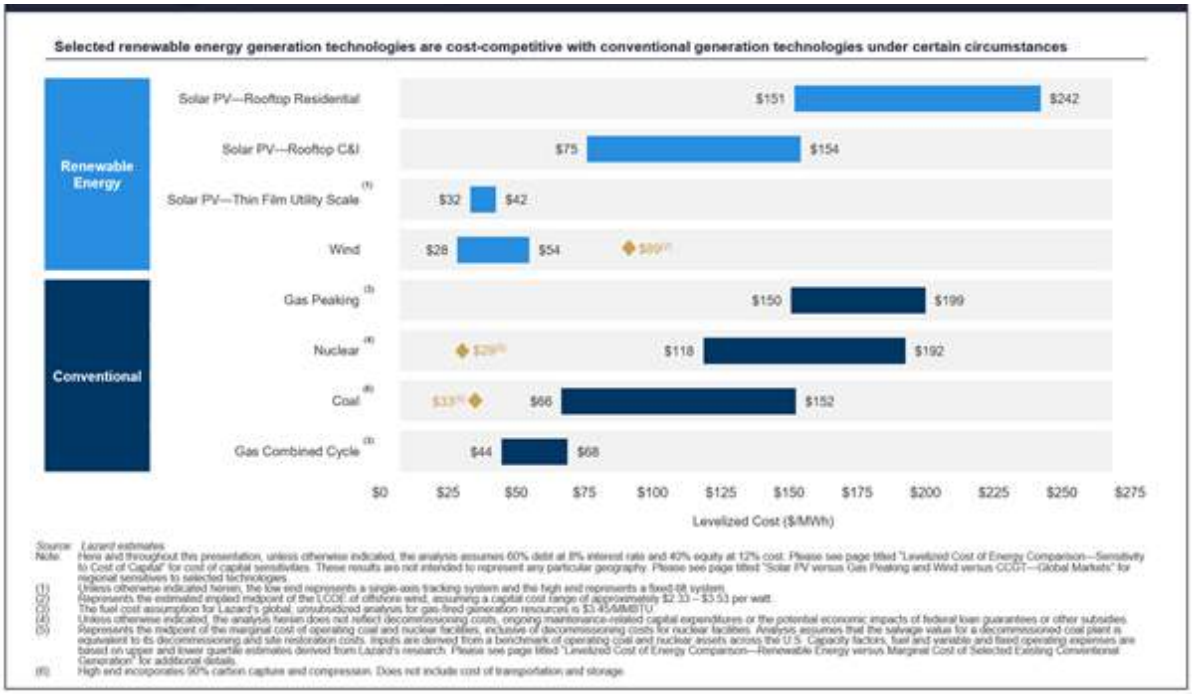
Figure 4: Costs Falling for Solar and Wind Power Technologies



Source: IRENA, 2019

Lazard, an investment bank based in New York, in one of its reports published in 2019 defined solar and wind energy as one of the cheapest electricity technologies. Their average costs were $37/MWh and $40/MWh as compared to electrical energy coal at $102/MWh and combined cycle gas turbine power plants at $56/MWh[41].

Figure 5: Levelized Cost of Energy Comparison - Unsubsidized Analysis



Source: Lazard, Annual Levelized Costs of Energy Comparison, 2019

On the other hand, the costs of fossil fuels tend to increase, even before the calculation of externalities. The market for fossil fuels isn't able to hide the fact that due to over-exploitation of these resources, they are getting even more difficult and expensive to extract leading to higher costs. Moreover, the inclusion of externalities takes the costs to another level. Financial analysts at Trucost, a company that estimates the hidden costs of use of unsustainable energy sources, have come to the conclusion that the highest externalities are caused by coal-fired power in Eastern Asia and Northern America, being estimated at $453 billion per annum and $317 billion, respectively[42]. These include the damages in the form of GHG emissions, health costs and the degradation in the air quality.

Despite the evident upper hand of renewable sources of energy over the conventional means, bottlenecks still arise in the form of initial costs when it comes to construction and technological development, especially in developing countries. The average costs to install solar panels can range from almost $2000 per kilowatt for larger scale systems to almost $3700 for residential systems[40]. This makes financial institutions perceive renewables as risky and the scarcity of quantifiable information makes it arduous to compare utilities to justify the investment. However, as the investors are beginning to indulge into the practices of Socially Responsible Investments, flow of money in the renewable energy sector is likely to increase in the coming years.

With due policy formulation and incentivisation by the governments, the investors can receive a boost in their confidence in order to ensure displacement of investments no longer needed in the fossil sector.

Moreover, in the eventual time period, the value that accrues the shift to sustainable energy is greater than the immediate or the perceived costs. For instance, reducing fossil fuel use can significantly lower public health expenditure, improving human health and well-being. The shift to sustainable technologies would save trillions of dollars through 2030 supplemented by increased productivity, increase in the pace of economic activity, employment opportunities, improved government budgets focusing towards inclusive growth and resilience, and reduced health costs. The value would be compounded in the longer run as the fundamental transition towards sustainability would be utilised by all subsequent generations.

According to the New Climate Economy Report, 2018, low carbon employment is set to rise by 65 million people by 2030. Offsetting employment reductions in the incumbent sectors of the fossil fuel industry, it will lead to a net employment gain of 37 millions jobs globally by 2030.

Instruments such as carbon-pricing and carbon taxes can generate substantial revenues for the government while promoting the application of sustainable energy. Sweden introduced carbon tax in 1991 with a revamping of the tax reforms. This policy shift was able to reduce carbon emissions in Sweden by 25% since 1995, while the economy has grown by 75%. As predicted by the New Climate Economy Report, the carbon pricing revenues and fossil fuels savings could be approximately US$ 2.8 trillion in 2030. The revenues generated by such tools can be effectively re-invested to provide assistance to disproportionately affected households, boost investments in clean energy and finance the SDGs.

Moreover, NCER also ascertains that humanity can save US$26 trillions by 2030 through a global shift to sustainability. The savings are worth up to US$17 trillion for more compact, coordinated and connected cities and it will stimulate economic growth by improving access to jobs and housing. This will also strengthen the resilience towards physical climate risks, making them less prone to costs incurred due to destructive losses and then reconstruction efforts.

3.2 Technological Costs and Challenges

The shift from our current pattern of consumption to sustainable sources of energy is not an easy one in any aspect. Technological gaps are a crucial impediment in the path towards sustainable energy. Technological challenges occur when there are some barriers to implement or execute a concept due to scientific limitations in the field. It is true that it is technology that has made the shifts and changes from one source to another possible through the course of history. But in the present times, we as a community face some hurdles on the technological front that are making the shift to more sustainable sources difficult.

3.2.1 Fluctuations in Demand

The demand for energy, though on an upward trajectory, faces ups and downs. One of the major struggles is in regulating and shifting the supply of energy to meet the fluctuations in demand. This hurdle can be analyzed at two fronts: Production and Logistics.

3.2.1.1 Production

When energy is produced through the conventional sources of energy, a change in demand is met by a similar change in supply. Increased demand leads to more coal being put in the furnace or more diesel in the generator and this change can happen quickly, without any significant delay (assuming no red tape). However, the scenario is different when the energy demand is dependent on more sustainable sources, like solar power, wind power, etc.

As stated in economic terms, fixed endowments for production cannot be altered in the short run, whereas variable ones can be tailored according to the scenario. Increasing the amount of energy generation in traditional sources like coal has a marginal cost of the extra raw material required, whereas when dealing with novel energy sources, increasing production requires heavy investment such as, installing more solar panels or building more windmills, or expanding the dams, and such changes are difficult to implement in the short run, thus, making production non-adjustable to the changes in the environment.

3.2.1.2 Logistics (Output)

Another problem that hinders sustainable sources from responding accurately to demand is the unpredictability of the volume of output. In conventional sources, with a given technology a fixed input results in a fixed output, on the other hand, in sustainable sources the inputs being natural elements are contingent on the weather conditions, which in turn cannot be accurately predicted.

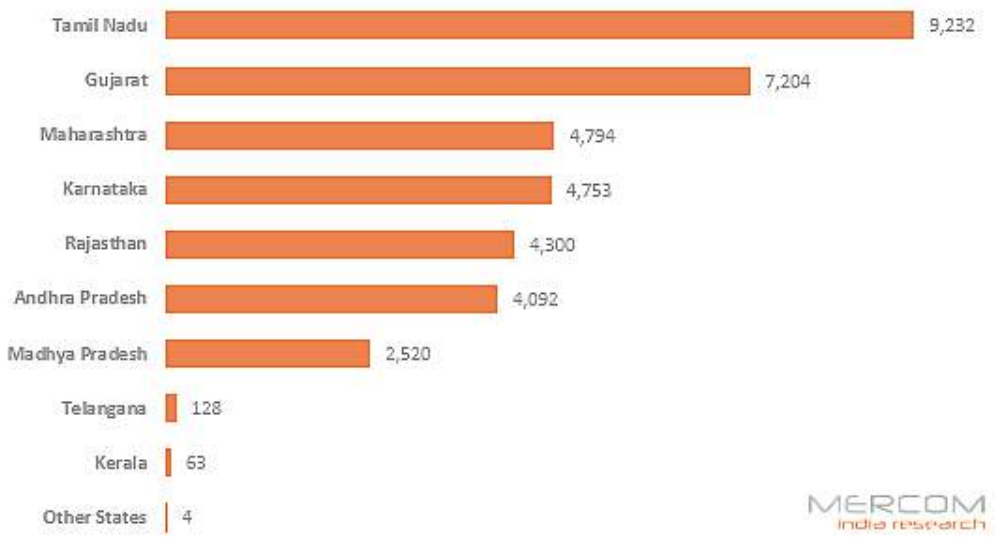
For example, the energy generated by run-of-river plants depends on the flow of the river which in turn depends on the rainfall and temperature, both of which cant be accurately speculated. Similarly, wind plants depend on the speed and direction of the wind and solar panels on the intensity and direction of the sun rays. This hampers the determination of the amount of energy that can be produced in a given timeframe, which in turn makes it difficult to regulate to counter fluctuations in demand.

3.2.2 Location and Storage

The power plants are constructed and established at one place and then through transmission, the energy is transported to areas where it is consumed. The land is one of the resources that have a lot of alternative uses, so it is imperative that the available land is put to best possible use. Conventional energy generation plants have their inputs produced at a different place and the energy generation plants in a different place, so there is flexibility when it comes to the choice of location for setting up the plant and is not restricted in respect to the location of the raw material, which makes it highly pragmatic and flexible in terms of land usage.

Sustainable energy power plants have a vast dependency on forces of nature and need to be located strategically to fully utilize the inputs. Thus, we do not have a lot of discretion in terms of the choice of the location. As a result, we need to evaluate and choose the most optimal locations for setups. For example, In India, wind energy can majorly take place in the coastal states of Gujarat, Maharashtra[43], Andhra Pradesh and Tamil Nadu. The resource for Geothermal power plants is also not widely available and is very[44] region-specific. Similarly, solar power's efficiency varies depending on the climate and weather of the places or countries.

Figure 6: India - State Wise Wind Power Installed Capacity (in MW) as on October 2019



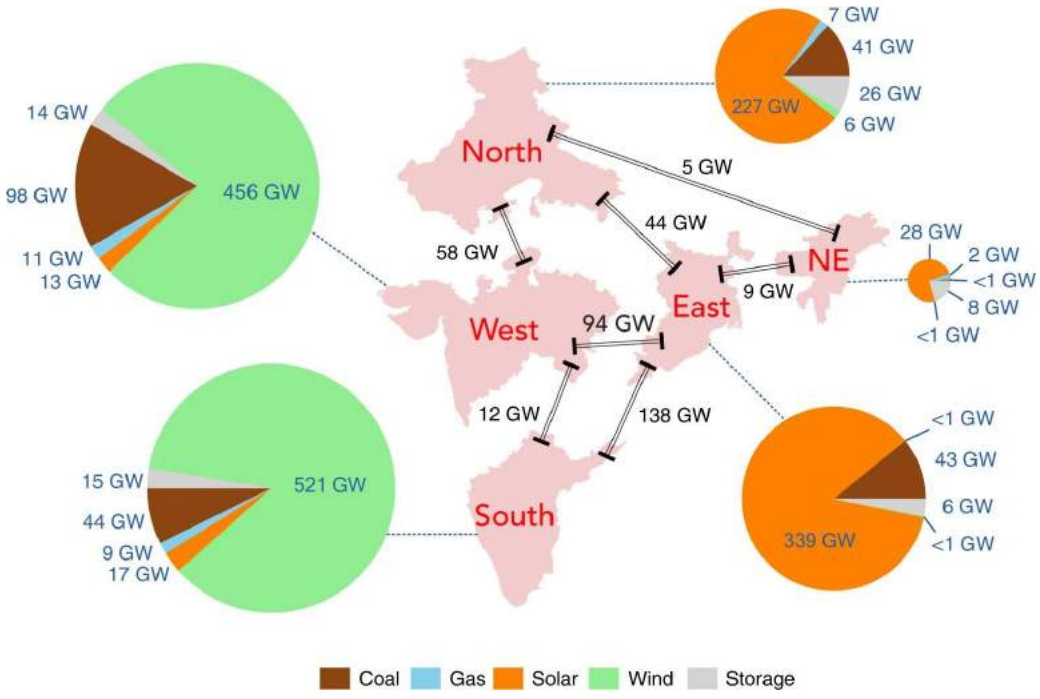
Source: MNRE (Mercom India Research) (2019)

Regional differences can be very well depicted within the Indian context. For instance, according to the CEA, GoI report of 2015, Lakshadweep generates 100% of its energy through renewable sources, followed by Himachal Pradesh which has a 94% share of renewable sources. In stark contrast, only 10% of the energy requirements in Delhi come from renewable energy[43].

The major reason behind such geographical differentiation in establishing sustainable energy generation systems is transmission costs. The transmission of power from the generating station to the load center comes with a high cost. These costs are specifically high in the case of offshore wind power plants. Hence, this is one of the reasons that has hindered the usage of sustainable sources in Delhi, where overrun costs from both wind power and hydropower are high[43].

To overcome the problems of intermittent supply and non-predictability of volume, the only feasible solution is the presence of proper storage mechanisms. This will help us store excess energy from time of high production to redistribute and manage supply in times of low production. But there is a hindrance in incorporating needed storage technology. Energy storage system (ESS) has a high-priced investment cost paired with a high maintenance cost. Additionally, the incorporation of ESS requires a power electronic interface unit which not only increases the initial expenses of installation but also leads to a decrease in the power quality[45]. The storage R&D is developing but it needs to be advanced to make renewable and sustainable sources, reliable options.

Figure 7: India's potential for integrating solar and on - and offshore wind power into its energy system.



Source: Lu, T., Sherman, P., Chen, X. et al. Nat Commun 11, 4750 (2020).

3.2.3 Dependence of Sustainable Sources on Non-Sustainable Inputs

The production of energy requires energy as an input. In the current scenario, a vast majority of our renewable sources are directly or indirectly dependent on non-renewable and conventional sources. These conventional sources are highly non-sustainable and ecologically and environmentally harmful[46]. Thus, the benefits derived by the generation of sustainable energy to some extent are offset by the costs of using conventional sources.

For instance, one of the integral raw materials used in the production of solar panels is quartz. Quartz is processed to produce the high-quality silicon which is needed in the production of Photovoltaic (PV) cells. PV cells are solar cells, which are arranged together to make the solar panel. This process of conversion of quartz into PV cells is very energy-intensive, and this energy is derived from fossil fuels. This offsets the total energy production of solar panels across their lifetime of usage. Producing quartz also produces toxic by-products like tetrachloride, which can end up spilling into the environment and causing damage to the soil[47]. Another example is Electric Vehicles. Though EVs are aimed to reduce the consumption of oil the power grids or the electricity charging stations that are used to charge these vehicles are powered by traditional sources for their power[48].

3.2.4 Infrastructure

Energy is one of the three core factors that define an industrial revolution. With the fast advent of technology and widespread reach of the internet, Energy is the skeletal structure that supports the entire infrastructure. At the same time, Energy's growth and development also needs a regular upgradation of the associated infrastructure, and that reform comes with barriers of its own.

3.2.4.1 Grid

A grid is a crucial element of any nation's energy infrastructure. The grids used for fossil fuels or other non-renewable sources cannot be used for the transmission of power generated by their sustainable counterparts. They are not compatible to accept and balance electricity generated from variable output sources, like solar or wind. A modern grid enables implementation and maximum utilization of the renewable energy capacity while simultaneously minimizing the cost associated with it, by efficient management of demand and supply, facilitation of spread of power generation, and cooperation of storage technologies.

The major hindrance here is the cost; the installation of new grids or the upgradation of old ones to meet the sustainable energy transmission is extremely expensive. The Power Grid Corporation of India added 9,072 km of extra high voltage transmission lines, and 41,620 Mega Volt Ampere (MVA) transformation capacity with 15 new substations in the FY2017/18 year, which cost nearly Rs25,791 crore (US$3.6bn)[49].

Figure 8: India's Moonshot Renewable Energy Goals

Source: Ministry of New and Renewable Energy, GOI (2016)

3.2.4.2 Need for Regular Upgradation

The technology used in generating sustainable sources is improving and augmenting continuously, which requires power plants to regularly upgrade their equipment and machinery but the upgradation to new technology has high costs, which hinders full and efficient utilization of the resources. In India, Tamil Nadu leads in wind energy generation but more than 80% of the state's wind power is generated through obsolete turbine technology[49]. According to IEEFA, an upgradation would result in a tenfold increase in wind power generation, and such an upgrade would require an investment of estimated US$ 40 bn[49].

3.2.4.3 Distributed Energy Systems

Sustainable energy sources have different levels of scalability. One major benefit with these sources that could never have been implemented with traditional sources is the fact that these can be deployed at a small scale[50]. Solar power is leading in this sector with a lot of businesses and homes installing their own solar panels on rooftops. That is the energy generation gets distributed, this generates the problem of controlling the voltage and managing the supply and demand.

Moreover, most of the power generation sites, commercial and individual and widely distributed which makes it hard to regulate and monitor the sources[49]. For this purpose, there is a requirement of distributed energy systems or smart grids[51]. These systems enable monitoring, analysis and control of the supply chain, along with reducing electricity consumption, cost and increasing reliability.

The major problem in its implementation is that it requires highly sophisticated technology, like intelligent appliances, smart power meters and smart substations. This technology is highly costly. Additionally, it needs an implementation pan nation, for example smart power meters will have to be installed at every household, this level of execution comes with its fair share of challenges on all fronts of cost, time, energy and logistics. The successful usage of smart grid also requires extensive connection of technology, the associated equipment is only in its innate stages of development.

So, the necessary infrastructure required to maximize output and efficiently manage supply of energy from sustainable sources, is not well developed and has a lot of technological challenges in its implementation as well.

It is true that the implementation and utilization of sustainable energy has a lot of hurdles in its way, but what is also needed to be kept in mind is that technology is always evolving and developing. Something that seemed difficult or even impossible in the present, might not remain the same way in the future. To sum up, Technology supporting sustainable energy has come a long way, but it still has a long path ahead.

3.3 Social Costs

It's comparatively easy to notice the monetary and technical costs. However, inconspicuous social costs of the shift aren't clearly observable.

A greater investment in renewable sources of energy will reduce the operational capacity of coal based plants. There is a cause and effect relationship between investment in renewables and functionality of thermal power plants[52]. As a consequence of higher investments in the former, there will be job losses because of transfer of labour in the short run. However, it is true that in the long run, these plants will generate job opportunities and help in improving the living standards of the population. It is also important to note that there will be a demand for skilled labour which can pose a problem given the fact that most of the labour are skilled in traditional methods of energy generation i.e. in thermal power plants.

The Ministry of Environment, Forests and Climate Change in India has exempted certain renewable power projects from the mandatory requirement of Environmental Impact Assessment (EIA)[53]. The conventional thermal power plants will thus be underutilised since they will not be used to their maximum capacities given that the firms involved in energy generation will want to shift towards renewable power plants however high the costs. Investment in coal plants will be considered a sunk cost and hence, would eventually be considered a loss of revenue. The problem of 'stranded assets' will arise here.

Another aspect of social cost can be the opportunity cost of land required for setting up a renewable energy plant. A possible destruction of ecology and wildlife in the area poses a serious concern. Besides, building hydro structures can affect the water velocity and depth, reduce river flows, and severely minimize the habitat quality for fish and aquatic organisms. However, it is difficult to ascertain and quantify the same, it can still be considered. Also, it has been reported that even though renewable energy would form 43 per cent of the installed capacity in the country in 2027, the share in electricity supply would be only around 25 per cent[54]. This clearly indicates that the huge amount of investment that renewables demand does not command a similar quantum of outcome anytime soon. This makes it clear that India's dependence on coal as a source for energy generation is difficult to overcome and even with the emergence of renewable methods of energy generation, coal could continue to be the dominant force provided how efficient and consistent the country has become with the conventional methods.

A wind or solar power project has a PLF (plant load factor- a measure of efficiency of the plant) of 18-20%. A thermal power plant, on the other hand, has a PLF of 65-70%[53]. While at the same time, to generate the same quantity of electricity as a thermal power plant, a solar or wind powered plant would need to operate at three times the capacity[53]. This statistic is definitive of how a shift towards renewables gives the stakeholders no incentives to invest in the same, since they see minimal if any returns.

Another fact that needs to be thrown light onto is that certain project developers often use empty claims of providing electricity and economic benefits to impoverished, local communities in order to jumpstart the projects[53]. There is no mechanism to monitor the amount of electricity provided and to how many households at the local level. A case study that can be used to back this argument is the 113 MW, Andhra lake Wind power project, promoted by the multi-national Enercon, on the outskirts of Bhimashankar Wildlife Sanctuary in the Western Ghats of Maharashtra. The villagers who live next to the project site don't have access to electricity, even though the project threatens their livelihoods and the rich biodiversity of the region[53].

4. NATIONAL-INTERNATIONAL FRAMEWORKS & POLICIES

4.1 International Framework

Clean energy technology innovation has a vital role to play in attaining a rapid decline in emissions of greenhouse gases to zero on a net basis over the coming decades, in line with the United Nations energy-related Sustainable Development Goals (SDGs), including the climate goal of various international agendas.

4.1.1 EU Green Deal

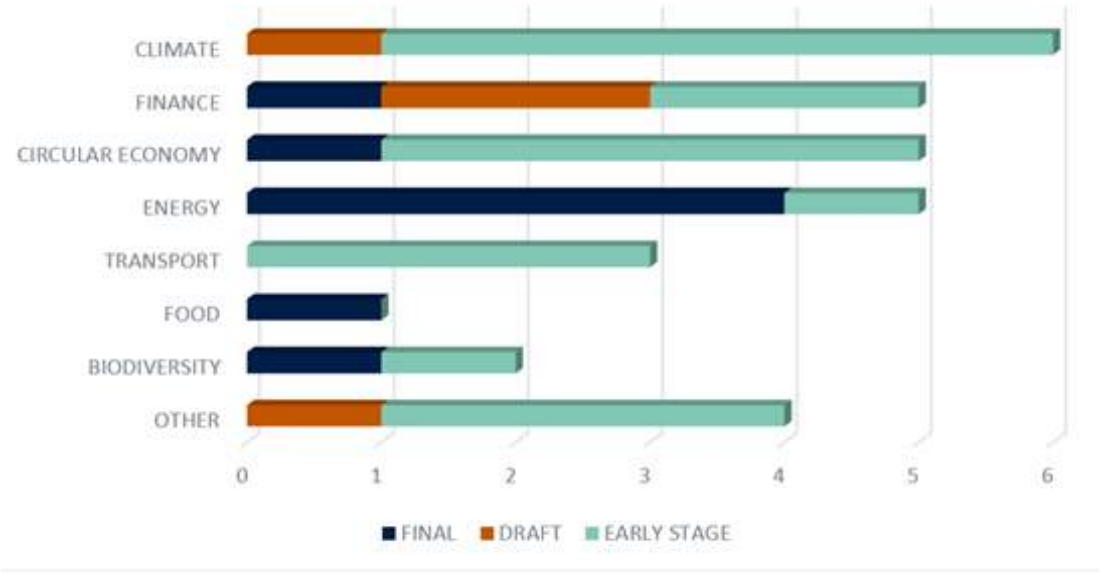
The AIM of the EU Green Deal is to transform the European Union into a modern, resource-efficient and competitive economy, where there are no net emissions of greenhouse gases by 2050, economic growth is decoupled from resource use and no person and no place is left behind[55].

EU has proposed a European Climate Law to achieve this aim where reaching this target would require action by all sectors of their economy, including :

- Investing in environmentally-friendly technologies
- Supporting industry to innovate
- Rolling out cleaner, cheaper and healthier forms of private and public transport
- Decarbonising the energy sector
- Working with international partners to improve global environmental standards[55]

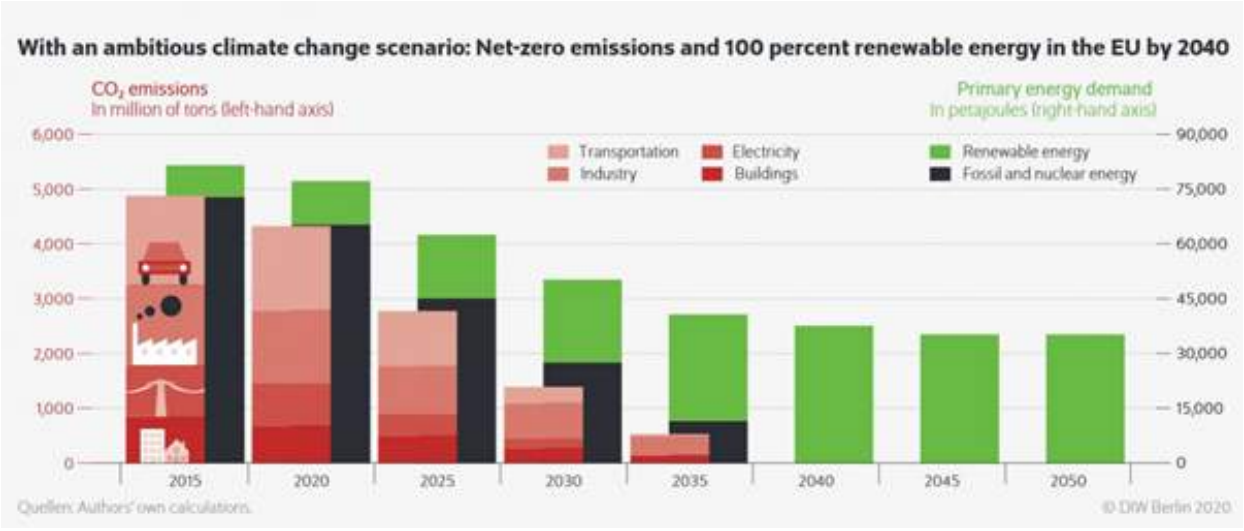
The EU will also provide financial support and technical assistance to help those who are most affected by the move towards a green economy. This is called the 'Just Transition Mechanism'. It will help mobilise at least €100 billion over the period of 2021-2027 in the most affected regions[55].

Figure 9: Number of Green Deal Legislative and Policy Initiatives, by topic



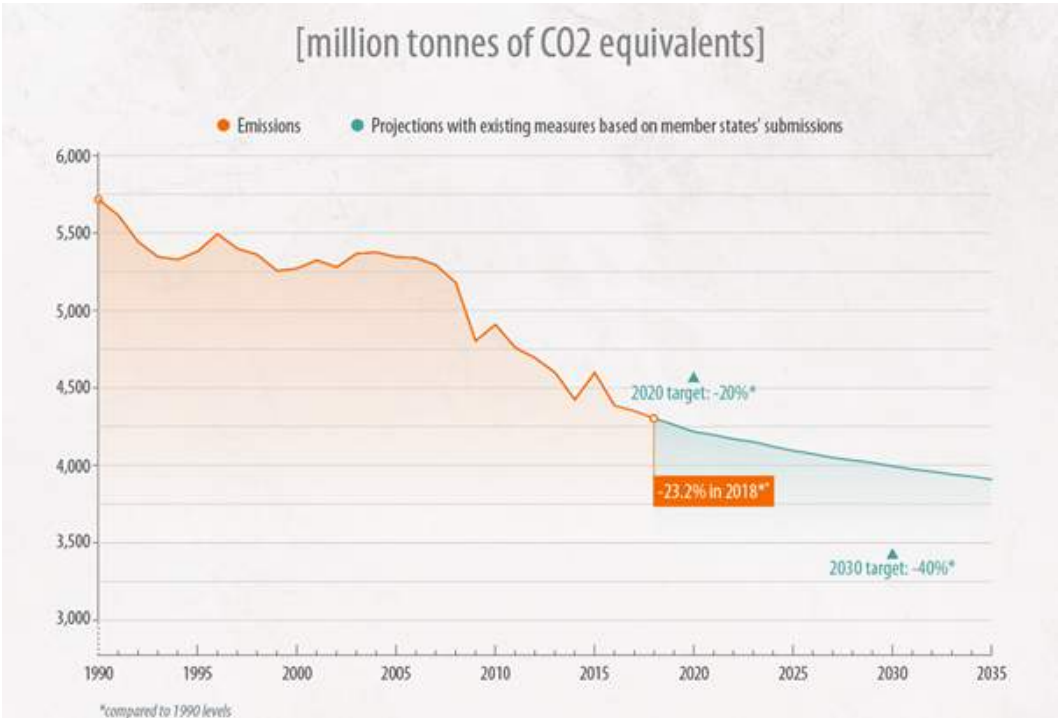
Source: Travers Smith LLP-EU Green Deal Status Report

Figure 10: Net-Zero emissions and 100% renewable energy in the EU by 2040



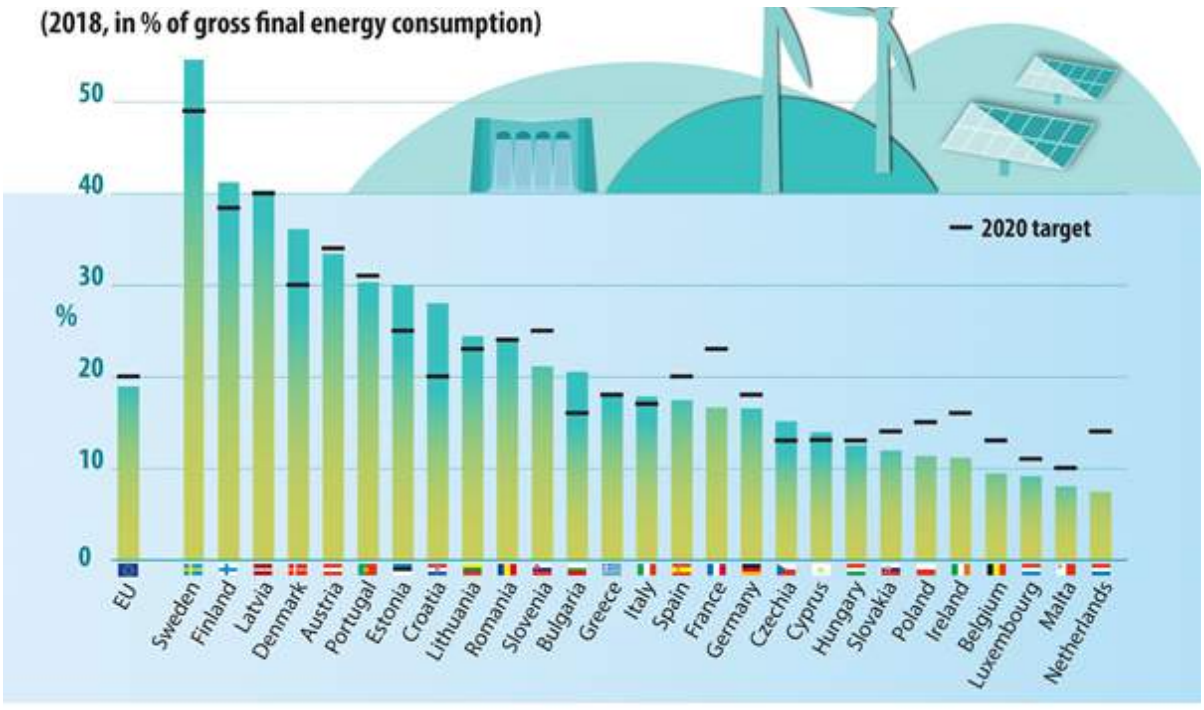
Source: DIW Berlin 2020

Figure 11: Emissions, projections and targets for the EU



Source: European Environmental Agency

Figure 12: Share of energy from renewable sources in the EU Member States



Source: Eurostat

The major facets of the EU Green Deal are as follows:

- **Clean Energy**

Decarbonising the EU's energy system is critical to reach the climate objectives. The policies related to clean energy are creating a more circular energy system, investing in cleaner fuels (to unlock the potential of sustainable biomass and biofuels, green hydrogen, and synthetic fuels). Consumers and investors should be able to choose the option that best matches their needs.

- **Sustainable Industry**

In March 2020, the EU adopted an industrial strategy that would support the green transformation. Industries would be helped to modernise and exploit opportunities domestically and globally. The decarbonisation and modernisation of energy-intensive industries such as steel and cement would be focused on. The Commission would present a 'sustainable products' policy, which would prioritise reducing and reusing materials before recycling them. Minimum requirements would be set to prevent environmentally harmful products from being placed on the EU market. False green claims would also be tackled.

The Commission would propose measures to ensure that all packaging in the EU is reusable or recyclable by 2030.

- **Sustainable Mobility**

The Green Deal seeks a 90% reduction in these emissions by 2050 that can be achieved by going digital, use of different transport (more freight would be transported by rail or water) - boost the supply of sustainable alternative transport fuels and reduce pollution.

4.2 India Energy Policy

The fact that India is the world's fourth-largest carbon emitter with its population of 1.3 billion people with the power sector contributing majorly to the same is not hidden from anyone. But in recent years, India has made substantial strides in the renewable energy space.

4.2.1 Current Situation

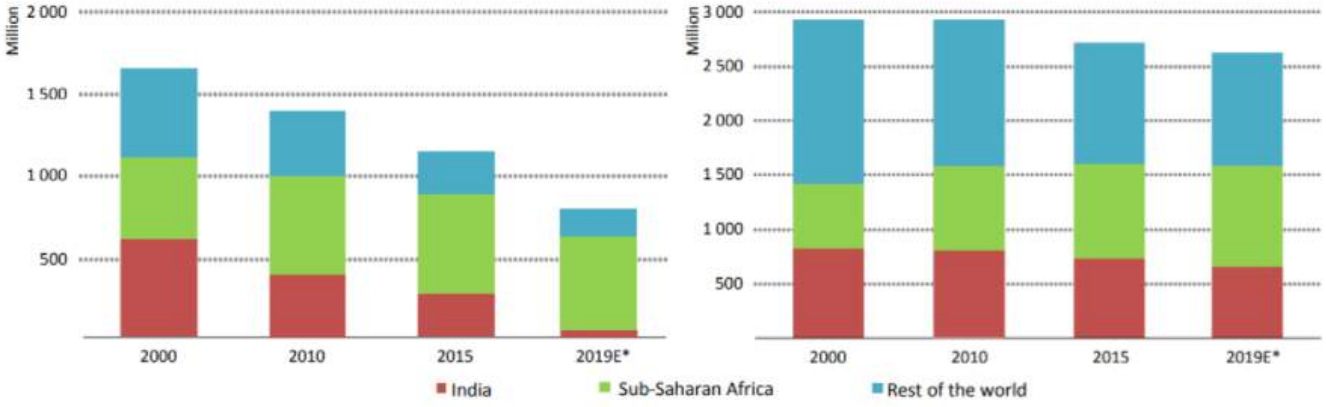
The Climate Change concern across the Globe has further pushed the Government and Decision Makers to develop a comprehensive blueprint for clean and sustainable power for all.

As part of the initial commitments to the Paris Climate Accord, India plans to slash its carbon emission intensity - emission per unit of GDP - by 33-35% from 2005 levels over 15 years. It is aiming towards producing 40% of its installed electricity capacity by 2030 from non-fossil fuels[56]. This would lead to a major shift from coal-based power generation to renewable energy sources. To achieve these ambitions, it has to produce 100 gigawatt from solar, 60 gigawatt from wind, 10 gigawatt from biomass and 5 gigawatt from small hydropower by 2022[57].

And this seems quite an arduous task as the renewable energy development in India is still in its nascent stage. As per the Ministry of Power, Govt. of India, India's energy mix is evolving slowly with the share of coal in the energy mix expected to fall to 50% by 2040 from 57.9 % now, while the share of renewables rises significantly[58]. Renewables will surpass gas and then oil by 2020 as the second largest source of energy production.

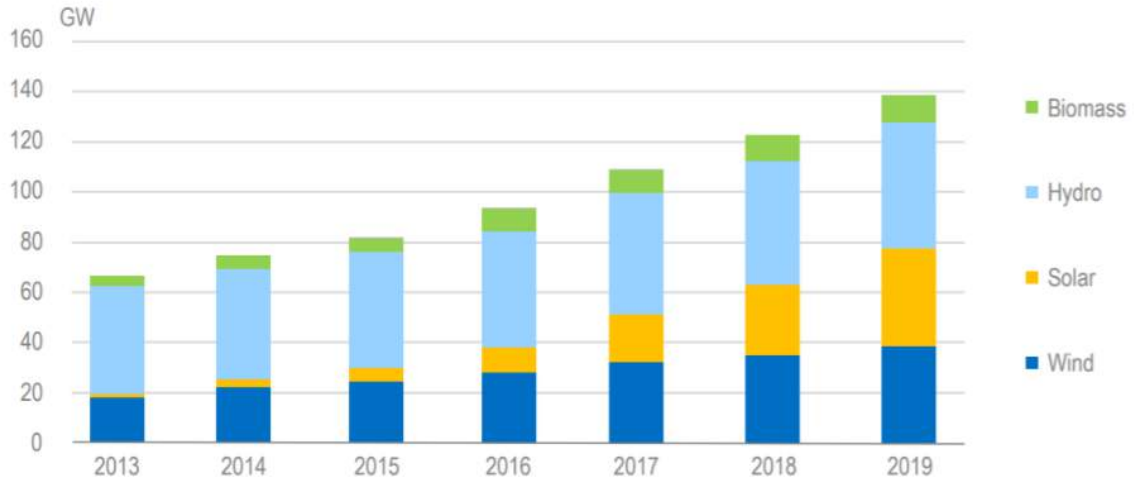
Figure 13(A): Number of people without access to electricity

Figure 13(B): Number of people relying on traditional use of biomass



Source: India - Energy Policy Review, International Energy Agency, 2019

Figure 14: India's renewable power generation capacity, 2013-19



Source: India - Energy Policy Review, International Energy Agency, 2019

4.2.2 Greener Technologies

Solar and Wind represent 90% of the country's capacity growth, which is the result of auctions for contracts to develop power-generation capacity that have ceded some of the world's lowest prices for both technologies. The country, which currently has low conventional energy resources in comparison to the energy needs of the huge population and the swiftly growing economy, can foster the enormous potential of solar energy. Solar photovoltaics is the most cost-effective electricity source and batteries satisfy the night-time electricity demand.

With the right investments in green technologies, India is well set to achieve all this. This is significant given India's growing electricity demand and the persistent supply demand gap along with the summer shortages and outages, the pursuit towards cleaner energy sources will have a vital role in enabling the country's transition to a fully sustainable energy system.

4.2.3 Major Developments

Amongst the various advances that have taken place in the solar and wind power segments this year, the ones that would have a long-term impact on the power sector include bidding in the wind segment, which would mean that utilities would not lookout for wind sites and choose wind turbine suppliers through competitive measures.

Another vital strand is the government would tender 20,000 MW of solar capacity, which would possibly be the largest block of capacity to be auctioned in a single tranche for the first time globally. The government's strong resolve to heightened quality standards for imported solar photovoltaic (PV) modules, enforced through inspections will also help procurers get over 25 years of module life. This signifies a national commitment to green energy and shows how the country is fast transitioning towards a renewable-focused economy expediting renewable capacity build-up and removing the difficulties being encountered by developers and manufacturers.

Figure 15: Falling Solar Prices in India

Source: GreenTechMedia, 2021

Auctions mark a new era in India's energy transition. The government is taking these new kinds of bids with a view to make renewable energy more acceptable into the grid and enabling India's discoms to buy more renewable energy. As the share of renewables on India's power grid continues to expand, so too does the demand for new technologies to better integrate these intermittent resources. In January 2020, the Solar Energy Corporation of India (SECI) declared the results of its first peak power tender, obliging developers to couple wind and solar with energy storage to meet grid needs at times of peak demand. At 1.2 gigawatts, the auction was one of the largest renewables-plus-storage tenders in the world[59]. SECI also held the country's first tender for "around-the-clock" clean power last year, which entails developers to bundle solar with wind, hydropower or energy storage to provide an 80 percent plant load factor throughout the year.

4.2.4 The Way Forward

Renewable energy storage system market in India is anticipated to witness robust growth, over the next decade, once the cost of storage declines, which is likely to happen because of the utter volume growth through the electric vehicle route.

The need of the hour is tackling the bankability of renewable energy projects which has always been an issue in India, owing to off-takers' inability to absorb power and pay for it. The power purchase agreement structure needs to be reinforced further to make renewable energy projects more bankable. There are states which, owing to their fiscal problems, are not encouraging the must-run status of renewables and are forcing such capacities to back down when wind velocities are unfavourable [60].

The government, therefore, should enforce must-run status as an obligation for all consumers to buy a good quantity of clean and green power. We also need to address some problems faced by power producers which include high fuel supply risk, time overruns at plants, and the limited paying capacity of the economically weak distribution utilities due to pre-defined laws.

Last but not the least, in order to remain energy positive and to make the most of renewable energy sources, we will have to parallelly concentrate on aggressive promotion of energy efficiency practices as India's Energy demand will witness an exponential rise due to the lighting and cooling requirements owning to the varied climatic conditions, the advancements in the Electric Mobility, development of the industries as well as rural electrification. This will also create a very good market for companies manufacturing energy efficient lighting and appliances.

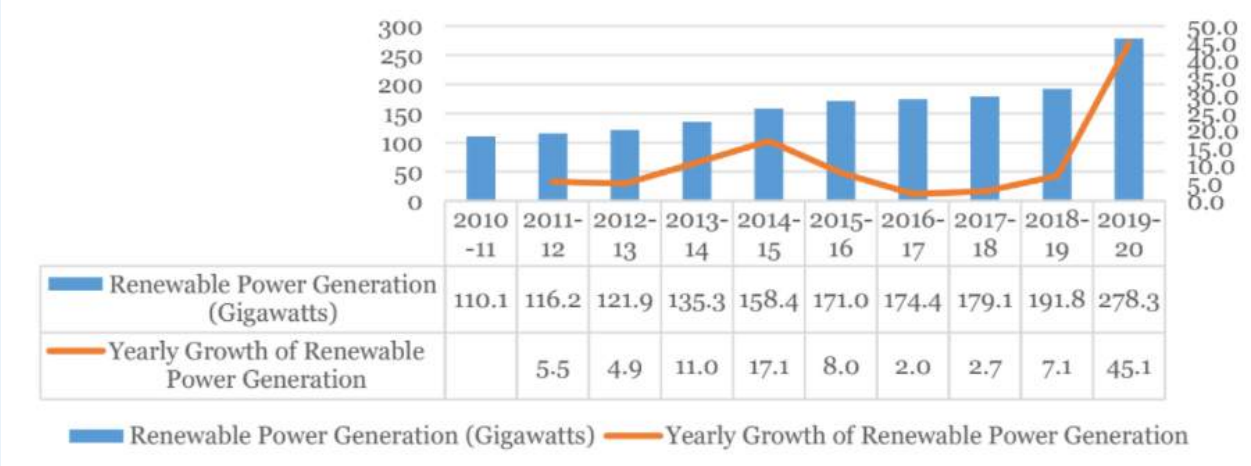
India's Potential

It may be noted that renewable power generation in India has grown at the fastest rate in the past two decades. According to a report from the International Energy Agency, renewable capacity additions in 2020 have grown 45% from 2019 by adding 278 gigawatts of capacity. This massive growth was led by a whopping 90% increase in wind capacity additions. The growth is even more inspiring considering that it took place in a year that was affected by pandemic-induced supply chain challenges and construction delays.

According to a study by British Business Energy, India ranked fifth in the world in terms of the size of its energy economy. India climbed up 2 steps to rank third globally when it comes to the size of its renewable energy economy. Additionally, India also ranked third in the Renewable Energy Country Attractiveness Index (RECAI) by EY.

Thus, there is no doubt that India is full of potential and possesses ample opportunities for becoming a major and valuable nation when it comes to the adoption and development of renewable energy.

Figure 16: Renewable Power Output (Gigawatts) from 2011 to 2020



	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
Renewable Power Generation (Gigawatts)	110.1	116.2	121.9	135.3	158.4	171.0	174.4	179.1	191.8	278.3
Yearly Growth of Renewable Power Generation		5.5	4.9	11.0	17.1	8.0	2.0	2.7	7.1	45.1

Source: Statista

4.3 Some Initiatives to Ensure the shift towards Sustainable Energy

Now that this report has shed some light on the policy being followed by India to make a shift towards sustainable energy, the progress made and the way forward, let us look at some of the unique initiatives that are being followed by India and the world in the light of sustainability and how can these initiatives be made more efficient and result-oriented.

4.3.1 Carbon tax

Carbon Tax is a unique taxation measure being implemented in various countries in the world in which the government levies tax on companies that burn fossil fuels like coal, oil, gasoline, and natural gas.

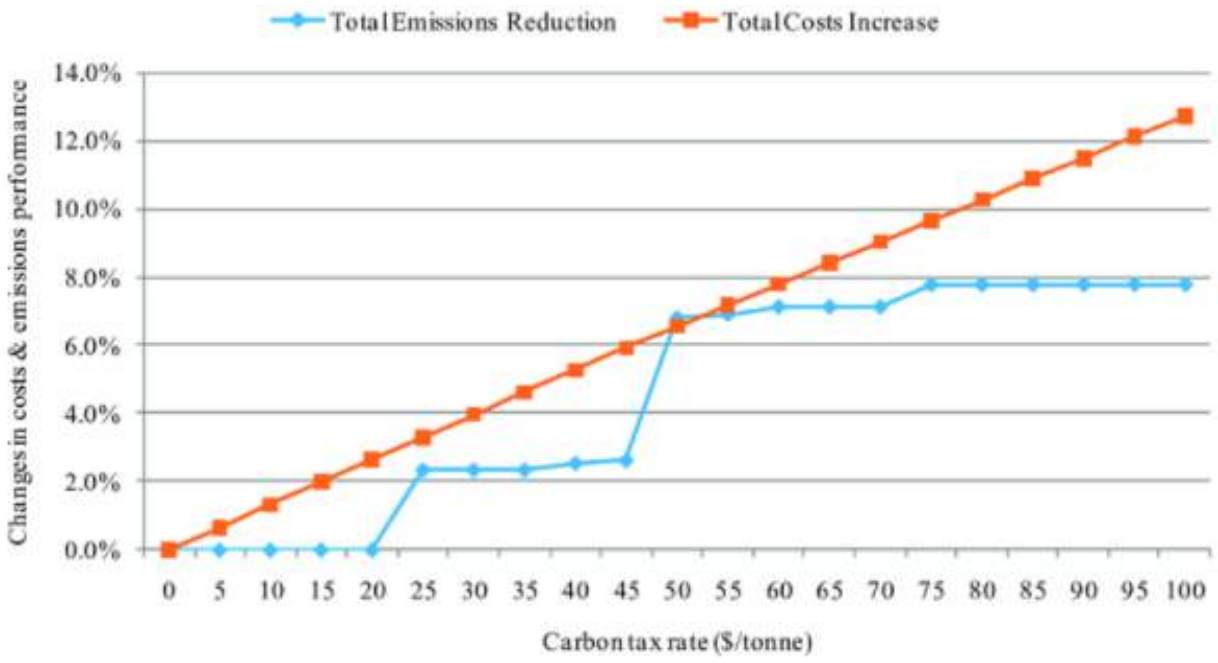
4.3.1.1 Purpose

Carbon emissions are a type of externality which have to be borne by homeowners, farmers and other ordinary citizens, which ultimately affects the government. The purpose of the Carbon Tax is to reflect the true cost of burning carbon and making sure that companies are held liable for the external costs and effects they impose on society. Carbon Tax comes under the category of Pigouvian Taxes i.e. the taxes levied by the government on any stakeholder for creating socially harmful externalities[61].

4.3.1.2 How it works

The government, in order to impose a carbon tax, should first adopt some measures to decide how the cost of each ton of greenhouse emissions will be calculated. Once decided, the companies will be charged at some determined rates for each ton of greenhouse emissions that they produce through their activities. However, scientists and economists have, yet, found it difficult to come to a consensus on how these emissions should be priced[62].

Figure 1 7: Implications of Carbon Tax Rates



Source: Wuhan Institute of Technology

4.3.1.3 Benefits

- Inducing consumers to seek cleaner energy by adding a negative incentive of increased costs.
- Boosting government revenues that can be used to fund economic growth and the country's sustainable energy program.
- Increased government funding to NGOs fighting for the cause of managing climate change effects.

4.3.1.4 Disadvantages

- Regressive in nature i.e since the tax is applied uniformly, it takes a larger percentage of income from low-income earners than from high-income earners.
- Implementation of carbon tax will show slow results and will lead to red tapism and bureaucracy.
- Penalizes and restricts firms to make a change towards alternative sources of energy by taking away their funds.

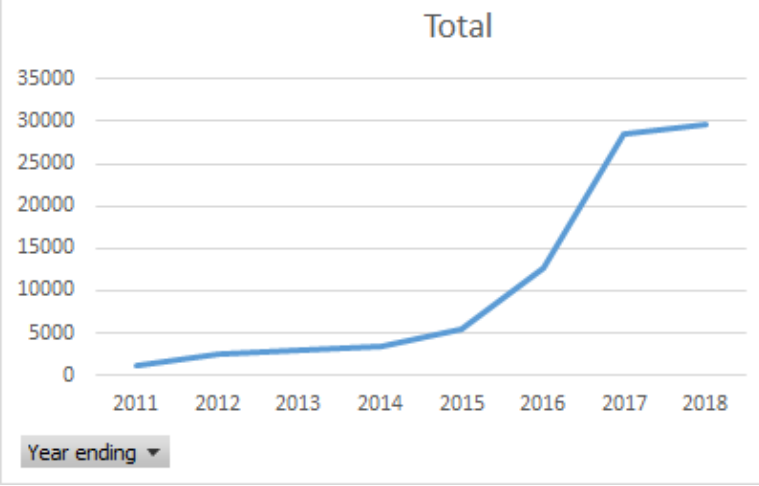
4.3.1.5 History in India and Current Implementation

India was way ahead of other countries in realizing the harmful effects of carbon emissions and developing a mechanism to price coal usage by charging a coal cess from the companies. As the Central Board of Excise and Customs (CBEC) puts it, "The cess applies to the gross quantity of raw coal, lignite or peat, raised or dispatched from a coal mine. At the same time, the cess is applicable on washed coal or any other form, provided the appropriate cess has not been paid at the raw stage."[63] Initially set at a rate of Rs.50, the cess has undergone various changes and currently stands at a rate of Rs.450. The following table highlights how the coal cess has been collected and utilized by the government.

Figure 18(A): Coal Cess collection and utilizations

Year	Coal Cess collected (INR crore)	Amount transferred to National Clean Energy Fund (NCEF) (INR crore)	Projects financed from NCEF (INR crore)
2010-11	1,066	0	0
2011-12	2,580	1,066	221
2012-13	3,053	1,500	246
2013-14	3,472	1,650	1,219
2014-15	5,393	4,700	2,088
2015-16	12,676	5,123	5,235
2016-17	28,500	6,903	6,903
2017-18 (BE)	29,700	8,703	-
Total	**86,440**	**29,645**	**15,911**

Figure 18(B): Coal Cess collection and utilizations



Source: Government of India

Figure 18(C): Coal Cess collection and utilizations

Year	Rate of cess (INR)	Weighted average emission factor tCO_2/ MWH	Average emission rate from coal based power plants $kgCO_2$/ KWH net
2010-11	50/ tonne	0.79	1.06
2011-12	50/ tonne	0.78	1.05
2012-13	50/ tonne	0.83	1.04
2013-14	50/ tonne	0.82	1.03
2014-15	100/ tonne	0.82	1.01

Source: National Electricity Plan, Central Electricity Authority, Ministry of Power, Government of India

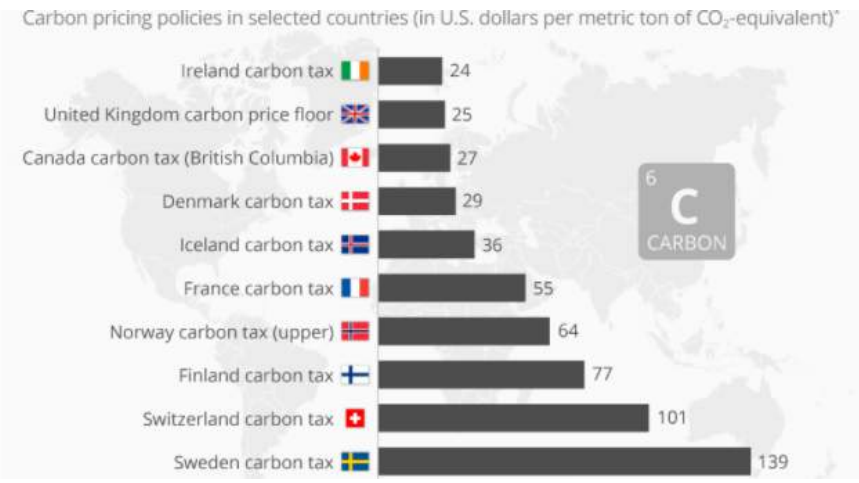
4.3.1.6 The Way Forward

With the aim of achieving 450GW renewable energy capacity by 2030 and reducing its **carbon footprint** by 30 to 35 per cent, India requires other measures to incentivize companies and consumers to adopt renewable sources of energy such as Carbon Tax[64].

Learnings to be taken while designing a carbon tax structure for India[63]:

- **Phased and incremental Approach**- All the countries with a successful implementation of carbon tax structure have gradually increased its applicability. For example, In 1990, Finland imposed a carbon tax of US$1.4/TON CO2 [60], later increasing to USD$22 in 1998. Further, it was implemented initially for heating applications and electricity production but later extended to cover transportation.
- **Reduced Rebates over a Period of Time-** Denmark implemented a system of high initial refunds. The rebate was decreased over a period, from 50% in 1993 to 10% in 2000. This helped in wider acceptance over time and gave time to industries to make adjustments in their business[63]
- **Globally Accepted Rates-** India should keep its carbon tax in accordance with the global average of $32 to ensure that carbon tax rates for companies in different countries remain at an equal level which will help to maintain good international trade relations. It is estimated that a carbon tax rate of $35 will help India generate an amount equivalent to 2% of its GDP by 2030[65].

Figure 19: How the World Puts a Price on Carbon

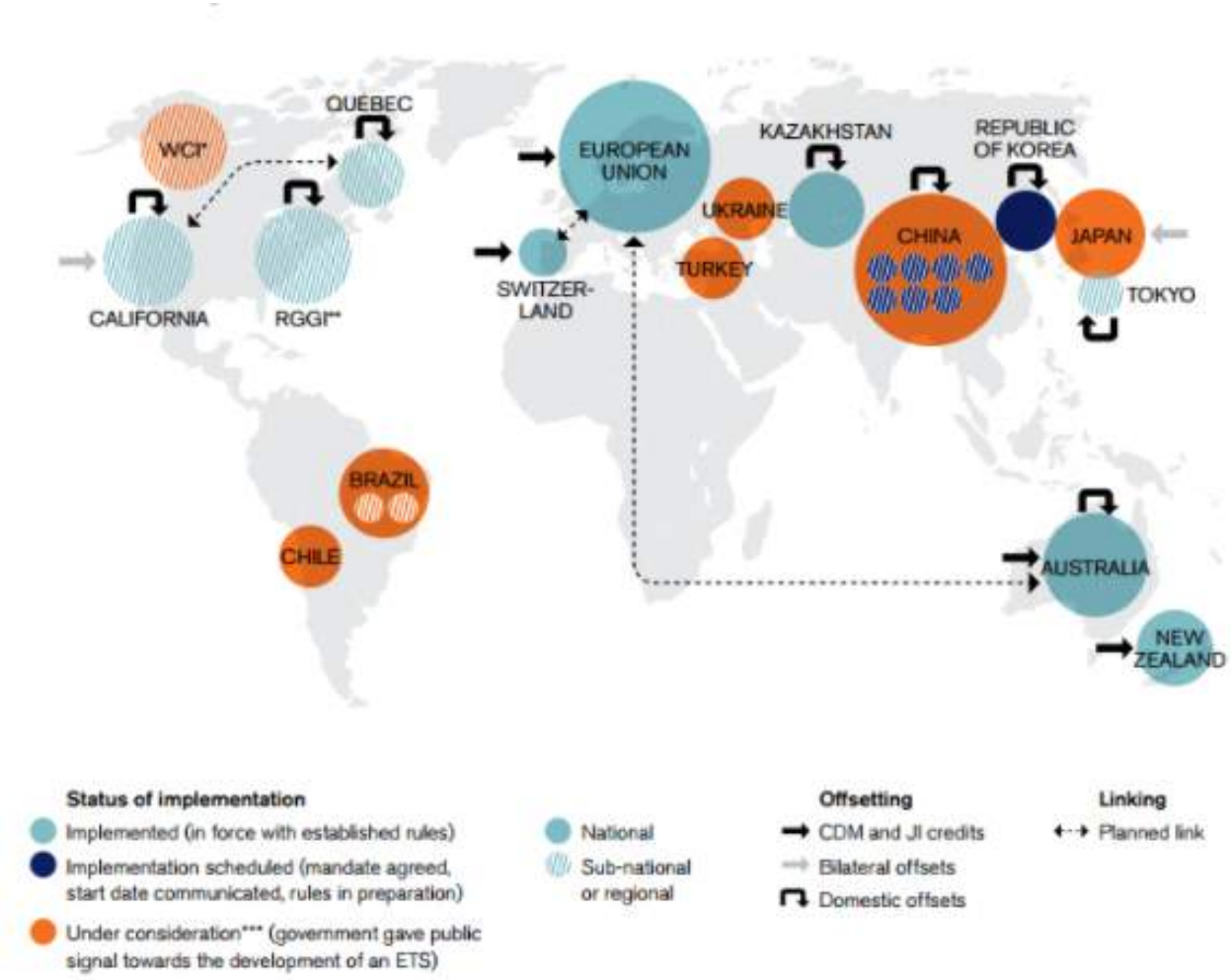


Sources: Ecofys, World Bank and Vivid Economics

4.3.2 Cap and Trade

Cap and Trade is a type of government programme to regulate and control or cap the total level of carbon emissions produced in the environment by some industrial activity. It is considered as an alternative to Cap and Trade policy is being widely implemented in various countries like EU, New Zealand and in-fact India (in the states of Gujarat, Maharashtra and Tamil Nadu)[66]

Figure 20: Implementation around the world



Source: World Bank

4.3.2.1 How does it work?

The underlying commodity to be traded in this emissions trading scheme is the particulate matter, emitted by industrial activities [67].

Under this scheme, industries, as a whole, are given a permit to release only a certain level of particulate matter in the environment and must comply with the prescribed standard of "150 milligrams per cubic metre of particulate matter released in the atmosphere"[67] The role of trading comes in the picture when industries are allowed to trade these permits within themselves, thus keeping the total emissions per industry constant [67].

For example, suppose there are two industrial units A and B with a permit of releasing an x amount of particulate matter in the atmosphere. If A doesn't use its entire permit of emission release, then it can sell its permits to B, which may have been finding it difficult to comply with the originally set limits. This shows how both A and B, both, are able to meet their business goals while keeping the total emissions per industry constant.

4.3.2.2 Benefits

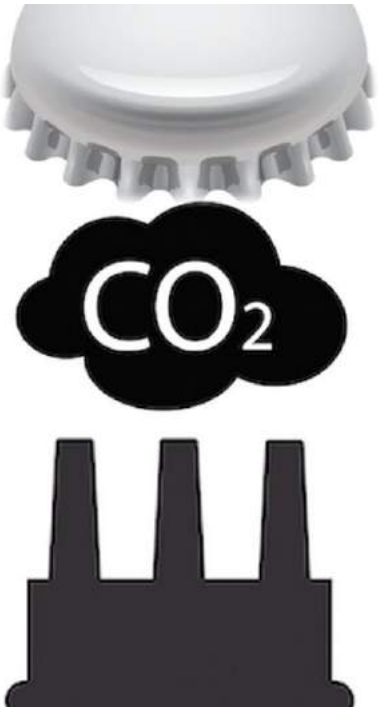
- Incentivizes firms to reduce their carbon emissions and become more efficient because they can sell their permits to other business units and can make money from that.
- Keeps the emissions released per industry constant while ensuring economic growth of the country.
- Less government intervention than carbon tax and relies on the use of market force to ensure sustainable development.

4.3.2.3 Disadvantages

- Transparent Allocation of Permits - Big industries may pile up all the permits driving the small competition out of the picture
- Balancing Economic Competitiveness with Emissions Trading - Government faces a trade-off between the economic growth of a nation and the speed of emissions reduction
- Companies may shift their industrial base from India to some other country with relatively lax regulations - offsetting the progress made by one country in this respect

4.3.2.4 Way Forward

- In order to ensure transparency, an auction system of distributing permits and a public website for displaying the allocated permits will serve its purpose. As far as equity is concerned, the government should work on creating a formula for allocating these permits while considering the needs of each and every segment of firms.
- The government should start with a high cap on emissions and should look to reduce it gradually every year so that the industries are able to adapt to tightening environment regulations, this would prevent public criticism as well and will help to check its usefulness on Year On Year basis. While the norms become tighter, the government should also help the small and medium enterprises in making a shift to alternative sources of energy by incurring capital expenditure on technology and machinery.
- Countries sensitive towards environmental degradation should come together and approach a world body like the UN to make it mandatory for each country to implement the system of Cap and Trade, preventing countries from taking advantage of the companies leaving a country with strict environmental laws.



Energy Blockchain

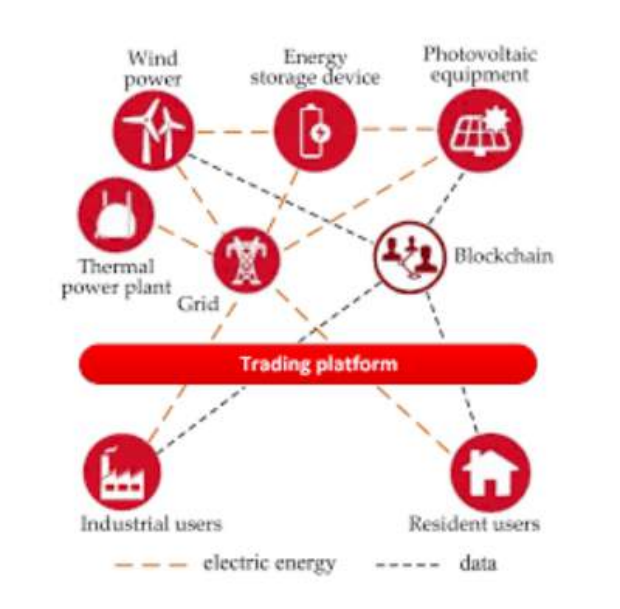
The efficient use of blockchain in the financial sector has given way to its application in other industries as well, the latest being the energy sector. The energy sector is looking forward to the development as well as the optimisation of a decentralised electricity system with a subsequent shift from transmission grids to smart power grids. [68] The main technological aspects of the blockchain like encryption codes, consensus mechanisms, smart contracts and distributed data storage can be applied in the energy trading sector.

Currently, the energy sector faces a lot of problems that hinder its shift from traditional sources to a network of renewable sources of energy. The introduction of blockchain technology in the energy trading sector eliminates all these issues.

It establishes a decentralized P2P network for energy transactions where the data of each participant such as the date, time, amount of energy and subsequent cost, details of buyers and sellers are automatically recorded, verified and stored. [69] This makes sure that there is no other intermediary in the transaction and reduces the cost of transactions. This also reduces the cost of transmission leading to feasibility in access of renewable energy for everyday purposes. In effect, consumers benefit from lower rates of renewable energy, producers can monetize the excess electricity they have left and ask for incentives from the government based on that. Moreover, this also enables consumers to sell the self-generated energy that they produce at their homes with solar panels, making them ***prosumers***.[70] Due to the ease of information availability regarding power storage in blockchains, there is a proper maintenance of the record of transactions that reflects transparency and accountability.

It establishes a decentralized P2P network for energy transactions where the data of each participant such as the date, time, amount of energy and subsequent cost, details of buyers and sellers are automatically recorded, verified and stored. [69] This makes sure that there is no other intermediary in the transaction and reduces the cost of transactions.

Figure 21: Application of Blockchain Technology in Sustainable Energy Systems: An Overview



Source: BCPG Group

The T77 in Bangkok, Thailand is the world's largest blockchain based peer-to-peer solar energy trading project. Three major buildings of Bangkok are equipped with rooftop solar panels of different sizes totalling 635 kilowatts capacity to meet their own electricity needs or to distribute excess electricity to other buildings within the network. [71] Buildings can sell electricity to each other through this network and buy as well. In Singapore, a blockchain registers solar energy production by small producers with an authorisation of renewable energy certificates. This energy can be bought by big businesses to offset their carbon emissions. [71]

Bangladesh has been able to develop a P2P blockchain based energy trading network for rural households to ensure availability of sustainable, reliable and affordable electricity.

With the ever-increasing energy consumption in our country, blockchains will be of significant utilisation. In India, with the significant energy gap between rural and urban areas, blockchains can definitely help to bridge the chasm.

Electricity distributor BSES Rajdhani Power Limited (BRPL) has partnered with Power Ledger, a specialist in blockchain-based renewable energy trading, to install a large-scale peer-to-peer (P2P) energy trading trial in Delhi, India. [72] The government of Uttar Pradesh, with the assistance of Indian Smart Grid Forum, is looking forward to kick-starting a project to introduce blockchain technology to its rooftop solar power segment. [72]

Although the scope of energy blockchain seems quite ideal for a country like India, especially in ensuring equitable distribution of energy throughout; the technological constraints, high levels of population with terrain difficulties and bureaucratic bottlenecks will be the possible hindrances to be overcomed to ensure the successful development of this network.

5. CASE STUDY: ELECTRIC VEHICLES

It is well known that Electric vehicles, the new hype in the automobile industry, are a huge step forward towards sustainable and environmental-friendly living. However, EVs and their market are intricate and complex, and it'll take years before there is any substantial reversal effect on the damaged planet.

5.1 Need for EVs

Internal combustion engine vehicles are responsible for 27% of the air pollution in India which causes thousands of deaths each year. This includes emission of pollutants and greenhouse gases like Carbon monoxide and Nitrogen Oxide, the magnitude of which varies according to fuel and engine efficiency. [73] These emissions are extremely hazardous to human health as well as the environment and are one of the leading causes of climate change. In India, air pollution owing to vehicles has been rapidly rising due to manifold reasons including urbanisation, high penetration of vehicles in cities, improper public transport system and fuel adulteration. [74]

A study for CO2 emission carried out by a Delhi based organization Centre for Science and Environment has depicted that the emission of CO2 on Indian roads is expected to reach a value of 1212 million tonnes during 2035 from a value of 208 million tonnes during 2005. [74] Moreover, fossil fuels used in combustion engines are exhaustive non-renewable resources and must be consumed sustainably in order to protect the planet and its environment.

5.2 Benefits of Electric Vehicles over Internal Combustion Engine Vehicles

Electric vehicles have gained a lot of attention and demand in the past decade. Replacing combustion vehicles that burn fossil fuels with electric vehicles that use batteries will reduce greenhouse gasses emissions as well as the consumption of limited resources. From the economic point of view, having an EV would decrease the dependence on these fuels and the consequences of rising oil and gas prices. The manufacturing, charging and production of Lithium batteries used aren't fully eco-friendly as they require more energy consumption than making a conventional car but the negative impact an EV causes on the environment in its entire lifetime is still substantially less than that caused by a combustion vehicle. [75] Moreover, the cost of production, as well as energy utilised, will gradually be reduced with rapid technological advancements in the field and other improvements leading to increased efficiency. To cut the environmental impact of using electricity as a source for charging and make it sustainable, one can even use renewable sources like solar panels for the same.

5.3 Status Quo and Future Prospects

According to SMEV, 1.56 lakh units of electric vehicles were sold in 2019-20 which showed a 20% year-on-year increase. These sales were led by two-wheelers, followed by cars and then buses, e-rickshaws excluded from the statistics. The major players in the Indian market are Tata Motors, Mahindra & Mahindra and MG, while many new startups are being established, encouraged by the success of these domestic manufacturers as well as global companies like Tesla.[76] Tesla is entering the Indian market soon with their cheapest model costing roughly Rs. 30 lakh. However, this price will double when around 50-100% duties are added on. [77]

Even though India makes up for just 0.5% of the global EV market share [75], the country is showing signs of fast growth in the next decade if the right steps are taken. According to a report by India Energy Storage Alliance, the EV market is expected to grow at a CAGR of 44% till 2027. The market is forecasted to hold a 30% share in the automobile sales by 2030 and could be worth $206 billion creating lakhs of jobs by the Council of Energy, Environment and Water. A rise in sales of EV would reduce the ICE cars in use, thus taking the demand for crude oil with it. This would save the large amounts spent by the government for crude oil and petroleum imports. [78]

To achieve this desirable situation, the EV market needs huge investments allocated by the government for improving and establishing production as well as charging infrastructure. Along with promoting private electric cars, this technology must be implemented for public transport like buses as well in order to be benefited, help create a sustainably developed environment and control pollution.

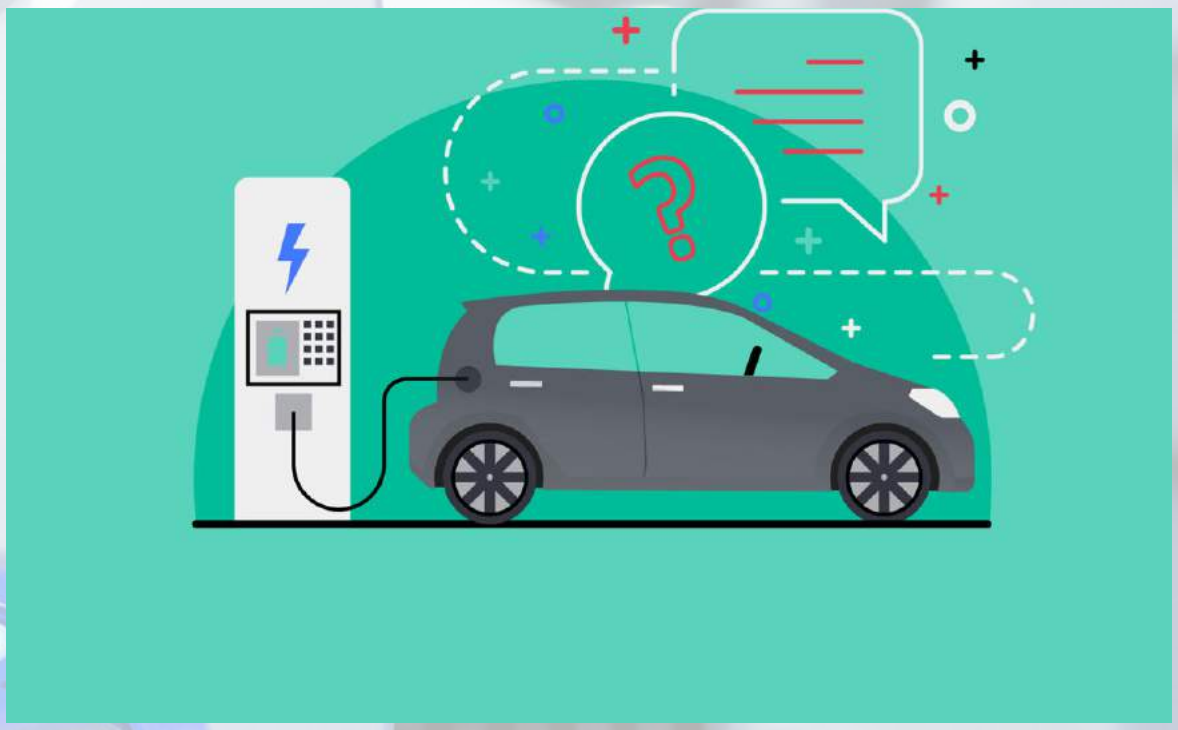
5.4 Favourable Government Policies and Plans

In order to make India an EV hub by 2030, the Government of India has taken many fruitful steps. Phase II of FAME (Faster Adoption and Manufacture of Electric vehicles in India) has been approved with an outlay of Rs. 10,000 crore for a period of 3 years. A majority of these funds have been allocated to incentivise the demand for EVs in the country and focuses on supporting 7000 electric buses, 5 lakh e-3 wheelers, 55,000 passenger cars and 10,000 e-2 wheelers.[79]

Along with this, there are deals in place for the manufacturing of buses as well as various incentives to be provided for e-rickshaws in order to revolutionise public transport. The Power Ministry plans to establish a charging station in every 3-by-3 km range in urban areas and many on highways too.

Subsidies for manufacturing EV parts and tax benefits on GST and Income tax on purchase of EVs and interest on loans for the same respectively are provided by the Government to support both, the supply and the demand. [80]

In conclusion, the Electric Vehicle market is one with a lot of scopes environmentally as well as economically. Substituting combustion vehicles, one of the main causes of pollutant emissions, with electric vehicles would certainly have a positive impact on the environment and could slow down climate change. The Government of India is aware of this opportunity and is striving to exploit it, however, better and more comprehensive schemes are needed to succeed.



Green Buildings

A ‘green’ building is a building that, in its design, construction or operation, reduces or eliminates negative impacts, and can create positive impacts, on our climate and natural environment.

The countries leading in the race of designing the maximum number of green buildings are Canada, China, India and Brazil.[81] Green buildings are commonly seen to be costlier than conventional buildings. The majority of this cost is due to the increased architectural and engineering (A&E) design time, modeling costs and time necessary to integrate sustainable building practices into projects.[82] Generally, the earlier green building features are incorporated into the design process, the lower the cost.

The cost of green design has dropped in the last few years as the number of green buildings has risen. Although the costs of green buildings vary, experts believe that it is a myth that green buildings cost more.[83] Once people plan to build green, they have a tendency to look at it as a competitive advantage personally and for their organization.

The Indian Green Building Council (IGBC) was formed by the Confederation of Indian Industry (CII) in 2001 with the vision “Sustainable built environment for all.”Various national policies are EDGE Program in India, BEE certification, Green house etc.[84] The Indian government has provided for numerous initiatives like the Green Rating for Integrated Habitat Assessment (GRIHA) to promote green buildings.[85] This system restricts the utilization of resources by 30 percent. Government has mandated for all central government and PSU buildings to urge a minimum of 3-star ratings under GRIHA. [86]

The reason why people don’t want to go for it is, they think that the materials to be used are not available in the market or it is difficult to construct such houses which is completely untrue. The material is out there in abundance within the market and it's available at costs that are not any costlier than the artifact used otherwise.

It is only an issue of engaging and understanding all of those things in a better way. People need to be explained how if we construct a green building, or resource-efficient building, then in the long run we enjoy reduced operating costs. Additionally, they should also be told if we design the building envelope in a way that reduces dependence on air-conditioning and artificial lighting, then it will bring down the initial construction cost of the building as well as its operating costs.

6. CONCLUSION

The report extensively covers why there is a pressing need to shift to sustainable energies throughout the world. There are not just potential advantages of shifting to non conventional sources but alarming disadvantages of delaying the shift too. The environmental and climatic requirements of moving towards renewable sources are easily identifiable but are not heeded. A longer dependence on conventional sources that pollute excessively will ail the planet. Another notable inference here is that given these sources are finite, the dependence on them is temporary; however, the demand for energy is permanent and in order to make provisions for a future paucity that might occur, a change in the attitude of people and how they perceive renewable energy has become the need of the hour. The realisation that their actions have far reaching consequences that are irreversible and that sincere efforts need to be put in soon to ensure an improved living for the future generations, needs to come for tangible results. Instead of continuing to rely upon them in the long term, domestic fossil fuels can be used in the short-term to boost renewable energy technologies until these technologies are dependable enough to stand on their own.

However, it is essential to understand that the shift will not and cannot come with relative ease and will necessitate certain costs and challenges. The shift will take a long time to be fully implemented and accepted given the obstacles it faces. Challenges are inherent with all new technologies. Even so, there are others that come with a skewed regulatory framework and unstable markets. The most conspicuous and feared is the capital and monetary cost. Ironically, the costs of fossil fuels are expected to rise in the future given their finite availability and extraction costs. Encouragingly, the capital costs of renewable energy have fallen drastically and will continue to decline. Investors fear change and because of the prospect of short term profits from fossil fuels, they tend to ignore the long term losses and effects of the same. The well established nature of current technologies poses a formidable problem for renewable energies to enter the market. Most investors want large quantities of energy with low costs which is difficult to accomplish since technologies have not been harnessed yet to exploit the true potential of renewables. To attract private investment, increased government investment in clean energy in the form of subsidies, loan assistance, alongside research and development would be required.

While computing the costs of fossil fuels, the enormous costs of climate change and other externalities are not included which means the price we pay for them is not a true representative of what they actually cost us and the environment. It can hence be noted that it is not a level playing field for renewable energies since they're competing with subsidised prices. Energy planners miss the bigger picture by overlooking the long term opportunities offered by renewables and focusing on narrow parameters of cost and short term gains. Increased awareness of the same and a willingness to shift towards climate healthy choices is sorely needed.

The present mechanisms and commitments for climate change are not enough and all countries can certainly do more. Efforts like the EU Green Deal and other existing frameworks have been discussed in the report. However, realising the need for better, more sustainable and achievable goals, the report recommends two new frameworks that can possibly sail the ship in the direction of positive change. A Carbon Tax and a proposed Cap and Trade programme will aid and align with the sustainable development goals. Additionally, in order to remain energy positive and to make the most of renewable energy sources, we will have to parallelly concentrate on the aggressive promotion of energy efficiency practices as India's Energy demand will witness an exponential rise due to the lighting and cooling requirements owning to the varied climatic conditions, the advancements in the Electric Mobility, development of the industries as well as rural electrification. This will also create a very good market for companies manufacturing energy efficient lighting and appliances.

Talking about the way forward, COP26 is expected to come as a landmark for 2021 amidst the relentless spread of Covid19 with the unmitigated deterioration of the Earth's atmosphere. For this climate crisis to see an end, global heating must be brought down to 1.5 degrees celsius. This implies that most of the nations must cut global greenhouse gas pollution by at least 45 per cent by 2030 compared to 2010 levels. The most requisite step towards this would be entirely phasing out the use of coal from the electricity sector, which must fall down by 80% below 2010 levels by 2030, globally. However, getting climate change in control is not the only priority. A fair transition of workers employed in the impacted industries and informal sector while also involving more women and girls in this transformation will have to be ensured for climate change to inclusively benefit the society.

We are already standing on the edge of a permanent climate catastrophe. No one can afford to be complacent about this anymore. Each and every government along with the global leaders and youth have to continue raising their voices against environmental damage while also taking necessary steps to ensure that actions for climate change are being implemented.

In an attempt to note the effects of a potential shift towards sustainable energies, the case study on Electric Vehicles and Internal Combustion Engine Vehicles clearly bring the fact forward that the amount of pollution caused by vehicles is staggering. Electric Vehicles are marginally dependent on conventional sources i.e. for the lithium batteries that these vehicles run on, but on a relative scale, their impact on the environment is immensely low. Governments must cater to the environmental disruptions caused by vehicular emissions by promoting people to welcome the newer technologies through incentives and subsidies. There is a need for an influx of a huge investment in EVs along with research for it to suit the Indian context.

Government spending hence is an essential part of bringing about a change alongside the need for a change in people's mindset. The change for India will take decades, but once brought, it shall bring about changes in the industrial, manufacturing, transportation and energy sector which can slow climate change and ensure a sustainable future. In order to attract foreign and domestic investment, the technologies should be welcomed and accepted by the Indian public. A need to look at the bigger picture and note the future opportunities and benefits of renewables will assist the process.

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