An Investigative Study on the Development Strategies for Electric Vehicle Enterprises in India

SATYA SHAH, VINEET PRADHAN
Engineering Operations Management,
Royal Holloway University of London,
UNITED KINGDOM

Abstract: - The paper presents an investigative study on the development strategies for electric vehicle enterprises in India. An in-depth literature review examines the academic evidence of wind power and solar technologies with proper arguments and justifications. Several implementation processes of renewable energy as solar and wind power as sustainable energy strategies in India. Wind energy and solar energy-related information have also been presented in this literature review including financial barriers that prevent the implementation of sustainable energy strategy in India. The research adopts a selection of deductive research approaches, exploratory research design, and realism research philosophy to perform desk research. In addition, secondary data collection including a qualitative research strategy is selected in the research for conducting narrative data analysis. The case study analysis included in this research is based on four major states in India for successfully conducting a narrative analysis. Lastly, the findings have been summarized and linked with the objectives to bring about an understanding of the discussion and recommendations for further research and highlight the limitations of the present research.

Key-Words: - Electric Vehicles (EVs), Strategic Development, India EV Development, Wind Energy, Financial Barriers, Renewable Energy Sources, Transportation, Green Energy, Automotive.

Received: June 19, 2024. Revised: October 28, 2024. Accepted: November 23, 2024. Published: December 6, 2024.

1 Introduction

Energy utilization is important for the advancement of civilization as well as handling issues in the environment. Developed societies use several resources of energy resources for transportation, agriculture, information technology, garbage collection, and human communication. Since the Industrial Revolution, the use of energy has increased in both developed and developing countries across the world. To limit greenhouse gas emissions, the Paris Agreement was agreed upon in 2015 among 196 parties at COP 21. The goal of this Paris Agreement is to limit the global temperature to 2 degrees around the preindustrial region. It is also evident that more than 60% of all global greenhouse gas is generated across the globe due to electricity production, heat generation, and transportation. In the world, India is one of the leading producers of electricity, and mainly coal is used to generate electricity as a non-renewable resource. In this manner, the demand for electricity in India has increased due to an improvement in the economic situation and around 900 million people got electricity in 2019. Moreover, due to the high load in summer, power cuts happened in India that evident an extreme insufficiency of power. The Central Electricity Authority (CEA) stated that India turned into a net exporter of electricity on 29th March 2017 and around 5,798-5,585 GWh, [1]. A program termed 'Power for All' has been launched by the Indian government to provide essential infrastructure to safeguard the uninterrupted supply of electricity to all industries, households, and commercial establishments. In addition to that, switching to renewable energy consumption can improve human well-being as well as overall welfare beyond GDP. The global energy mix would increase up to 1.1% in 2030 which is equivalent to USD 1.3 trillion. The main source for generating electricity in India is non-renewable which is termed coal and in 2020 around 72% of electricity was produced from coal, [2]. In this manner, due to the high population, the energy use per capita is quite high but on a global average, it is half. However, 1.67 million deaths were endorsed because of air pollution in India. Around 64.2% of deaths from household air pollution were decreased because of economic improvement in India. Along with that, a social issue appears because of the increasing number of deaths from ambient particulate matter by 17.8%, [3]. Limited fossil fuel is a key problem for generating energy which can be replaced by

solar and wind farms as a renewable source. India has a renewable energy capacity in November 2021 of 150 GW consisting of wind (40.03 GW), solar (48.55 GW), biomass (10.62 GW), small hydropower (4.83 GW), large hydro (46.51 GW), and nuclear (6.78 GW). By the year 2030, India is committed to achieving the goal of 450 GW of renewable energy capacity.

The aim of the research is to identify the implication and Role of Renewable Energy mainly Solar and Wind Power for the Sustainable Energy Strategy of India.

The **key research objectives** and research question that the research aims to address are:

- To demonstrate a theoretical understanding of Renewable Energy as a Sustainable Energy Strategy
- To identify the need for renewable energy mainly Solar and Wind Power for the Sustainable Energy Strategy of India
- To discuss the ways in which renewable energy mainly Solar and Wind Power for the Sustainable Energy Strategy of India can be implemented.
- To analyze the financial barriers to the transition of implementing this Sustainable Energy Strategy in India.

The **key research questions** for the research are:

- What might be the sustainable Strategy for Energy for India?
- What is the current energy strategy in India?
- What are the current renewable sources of energy in India?
- What are the barriers to disruption of the energy market in India?

According to studies [4], India has accomplished the goal of 40% of its connected electricity production volume using non-fossil energy resources by 2030. In this manner, “the Ministry of new and Renewable Energy of India” additionally confirmed that the nation has accomplished this goal in November 2021. As per the statement, renewable energy capacity installed in India is at 150.05 GW, though its atomic energy-oriented connected power volume is 6.78 GW. Along with that, this has brought the entire non-fossil fuels associated with installed energy capability to 156.83 GW- that is 40.1% of the entire mounted electricity volume of 390.8 GW, in streak by the announcement of the “Prime minister” which is recently comprised COP26 during the conference of “climate change”. Moreover, the administration of India is dedicated to reaching 500 GW of total connected electricity volume driven by non-fossil fuel foundations by 2030. According to [5], in the last 7.5 years, India's installed renewable energy volume has developed by 286% and views at further than 151.4 GW along with hydropower plants which are around 39% of the total capacity of the country as of 31st December 2021. In this manner, in the last 7 years, the installed solar energy capacity has amplified 17 times and stands at 49.5 GW. In March 2014, the installed renewable energy capacity comprising larger hydropower plants additionally amplified to 151.4 GW from 76.37 GW in December 2021, for example, an increase of around 98%, [5].

This research includes expected findings regarding the role of renewable energy like Solar and Wind power as a key sustainable energy strategy in India. In this manner, India has seen remarkable success in its current energy development, nevertheless, numerous issues and challenges remain, as well as a major disruption was created due to the Covid-19 pandemic. This research includes expected findings regarding different projects coming up in the wind farms and Solar farms by accessing secondary data. The expected findings of this research additionally include a financial implication for change in energy generation technology. Moreover, health concerns related to measurements and facts would be also a key expected finding of this research due to over-pollution.

This research includes a key significance of renewable energy like Solar and Wind power regarding sustainable energy strategy in India. The significance of this research additionally emphasizes the role of wind and solar farms in producing electricity to control the global temperature as well as environmental pollution. This research includes a key significance of renewable energy production in India to resist climate change for a better environment and sustainable sounding for developing human civilization. Moreover, fossil fuel-based energy can be considered a non-renewable energy source which is about to finish in a couple of decades and after that, the entire human civilization must rely on solar and wind farms as a key source of renewable energy source for generating energy in India.

2 Literature Review

The impact of the literature review is remarkable for summarizing existing research findings on a specific research topic. In this manner, the literature review section includes core findings of existing research

studies surrounded by the particular social, economic, and environment-related social phenomena. Moreover, the literature review section of this research includes a theoretical understanding of renewable energy as a sustainable energy strategy, for example, solar and wind power. In this manner, this literature review section additionally focuses on the solar and wind energy strategies applied in India along with proper evidence and justifications, including financial barriers to implementing those strategies.

2.1 Theoretical Understanding of Renewable Energy as a Sustainable Energy Strategy

According to [6], global projections with respect to energy consumption define a further expansion of energy demand. These forecasts include reliable information on the forthcoming outline of energy sources. It can be further assumed that the domination of fossil fuels is prophesied until 2035 and even 2050, which concludes that human stimulus on the natural resources would persist and even upsurge. The notion of sustainable energy is derivative of the endeavours to contrivance sustainable growth and development ideologies. Besides that, the accessibility to energy is a primary element regarding the growth and expansion of modern society's civilization. In this regard, energy must be one of the initiatives that would be transformed into development related to sustainability. Apart from that, there is no leading definition that critically illustrates the core concept of sustainable energy. Even several authors try to discuss the concept by developing identical metaphors that fluctuate from each other only through design. Brundtland Commission has forwarded the definition of sustainable development in accordance with the current generation's requirements, not decreasing forthcoming generations' capability for meeting their energy requirements. Studies argued that these definitions mainly emphasize performance-related issues, which is the right approach regarding long-term availability as per the area of interest for the concept of sustainable energy, [7]. In this manner, the aim of this concept is to safeguard energy security for current and upcoming generations, which can be achieved by an amalgamation of efficient solutions, savings, and technologies as well as the use of renewable energy. Based on the finding of these definitions, energy, on many occasions, is regarded as not only a factor authorizing the execution of a particular action but also the whole power transfer towards the final customers. Moreover, the difference between a sustainable energy system and sustainable energy is worthless since the terms are applied interchangeably in most circumstances. In this way, the definition based on the Brundtland Report includes a viewpoint regarding the development of an energy system that would meet the needs of this concept compared to the sources of the acquisition; meanwhile, the problems associated with efficient energy management are significant as its invention.

The sources of sustainable energy include developing energy sustainability issues with respect to the energy sources that are not meaningfully exhausted through continued use. In this way, the sustainable energy strategy must incorporate the use of energy sources that do not cause pollutant emissions or other hazardous substances to the environment on a huge scale. The application of the energy sources in the event of a sustainable energy strategy must involve the consolidation of the primary intimidations to the social and health injustices. Research [8] argued that despite the extreme generality of the previous standards, it is problematic to determine a sustainable energy source that accomplishes requirements at 100% effectiveness. For this reason, the concept of renewable energy strategy as sustainable energy is relative since a similar source in a solitary circumstance might be sustainable, but not in another one. In terms of the renewable energy strategy, the areas of windmills and solar panels are significant.

The account of local capacity is an influential factor regarding the development of the power plant to produce renewable and sustainable energy, not to over-range their expanse of transport. Moreover, renewable energy as a sustainable energy strategy additionally requires a coordination of longitudinal planning as well as energy permits optimum use of sustainable energy sources, including transmission networks. Apart from that, there is no uncertainty that renewable energy sources as a group are the maximum sustainable technologies; nevertheless, their application should consider numerous factors, involving capabilities, demand of energy in the area, accessibility to resources, and size of the dispersion. It can also be noted that the procurement of renewable energy from sustainable sources additionally causes environmental costs.

Studies argued that it is problematic to envision a condition in which all the energy would be generated only from renewable sources due to several issues, for example, lack of political will, high cost, limited human capacity regarding energy storage and lack of universal capability with respect

to mass production of installation, [9]. In the context of sustainable energy sources, it is certainly revealed around innovative technologies that are not precisely explored. They might be critical regarding the future development and the most significant renewable energy as sustainable energy resources include using hydrogen to build a thermonuclear reactor. It can be observed that both the dissemination of innovation and implementation of inventions take time to practically implement the renewable energy development strategy. The fuel production technologies are often associated with hydrogen and its related fuel cell technology, which does not emit carbon dioxide. In the contexts where it is accumulated in the process of renewable energy production, it must be justified in terms of sustainable sources. The areas of windmills and solar panels are noteworthy in terms of the renewable energy strategy that produces higher voltage electricity for both commercial and domestic purposes. It is certainly revealed around innovative technologies that are not precisely explored in the context of sustainable energy sources in India due to lack of infrastructural expansion.

2.2 Sustainable Renewable Energy Strategy of India as Solar and Wind Power

Sustainable Energy Development Strategies characteristically include three main technological vicissitudes: energy reserves on the demand side, competence enhancements in energy manufacture, and replacement of fossil fuels through several sources of renewable energy. The government aims to upsurge the segment of natural gas in the republic's energy mix from 6% today to 15% by 2030. The India Energy Outlook (IEA) greetings this determination, which would permit India to recover the environmental sustainability and suppleness of its energy scheme. As of 31 December 2021, the total installed capacity for renewable energy in India is 151.4 GW. Renewable energy foundations have a mutual installed capacity of 150+ GW, [5].

- Wind power: 40.08 GW.
- Biopower: 10.61 GW
- Solar Power: 49.34 GW
- Large Hydro: 46.51 GW
- Small Hydro Power: 4.83 GW

The barriers to the growth of renewable energy can be approximately categorized as policy and regulatory barriers, fiscal and financial barriers, institutional barricades, technological barriers, market-related blocks, and social obstacles. Accordingly, India's electricity consumption has doubled in the last decade, outpacing economic development, [10]. In this manner, the key energy supply in India is mainly coal-dominant, through the power segment responsible for around 40 percent of main energy and around 70% of coal ingesting. The power industry of India is characterized by a huge "demand-supply gap". One of India's key needs for a renewable energy strategy is to reduce the storage of coal supply. In this manner, the coal supply is continuously reducing year by year in India, creating an urgency for a "renewable energy as a sustainable energy" strategy. Along with that, the rapid expansion of industries also consumes high energy in terms of advanced economic growth in India could also be measured as another essential need for renewable energy for sustainable energy by replacing the coal-powered energy production process. On the other hand, the electricity supply to rural areas in India is a challenging element for the government, but the pace of rural electrification has been sluggish. In this manner, more than 80,000 communities in India are required to be captivated by a remarkable quantity of such parishes situated in financially backward and challenging regions. Research has argued that the available technologies for generating electricity are myriad, imitating, in turn, the ranges in resource donations across the different regions, fuel transportation infrastructure, "regional development patterns", demand physiognomies, political issues, and socio-environmental issues in India, [11]. In terms of rising industrialization, the overall electricity consumption in India has increased, including the modernization of agriculture and rising earnings. Moreover, the electricity consumption per capita at 318 kWh leftovers little, which is six times lower than the universal mediocre. Due to the rapid expansion of the industrial revolution, daily consumption of energy has increased in India which can be measured as a critical need of renewable energy sources. Moreover, most of the electricity production in India is influenced by coal-based hydropower plants which are limited natural sources. In this manner, limited natural resource is another core reason for the increasing demand for renewable energy resources in India.

Wind Power

In the context of "wind power" installation, India is located among the topmost five nations after Germany, Spain, the USA, and Denmark. As per [12], the capacity of wind power reached approximately 1267 MW through December 2000 by a collective cohort of around 6.5 billion units of power. In this manner, everywhere 95.5% of the

entire volume refers to private projects and the break in protest projects. About 80% of energy consumption out of the total generated power is for captive purposes; meanwhile, the breather is vented to the grid. On the other hand, "wind energy" is one of the spotless and "renewable sources" of energy that grasp the commitment to reaching the demand for energy in the grid-connected and direct styles, including remote 'niche' and stand-alone tenders. For example, water desalination, driving, and telecommunication in developing economies like India. Besides that, "the NINTH PLAN" proposed a volume of "1000 MW" (1997-2002), with a size of "200 MW" in the initial time of the strategy (http://www.mnes.nic.in). Presumptuous 20% grid diffusion, the practical possible is assumed to be "10,000 MW" which is predictable to drive up by the extension of the network capability in possible states in India with great prospective for "wind power", for example, "Madhya Pradesh, Gujarat, Tamil Nadu, Andhra Pradesh, Maharashtra, Kerala and Karnataka". Based on the latest forecasts of the "Ministry of Non-conventional Energy" Source plan supplementary 10 GW of entire "renewable" capability.

Solar technologies

In the present context, solar photovoltaics (SPV) contribute around 2-3% of overall power generation associated with India's renewable energy technology. Along with a collective volume of "47 MWp", solar photovoltaic systems have been arranged for a wide range of applications, including "grid-interactive solar photovoltaic power projects aggregating 1.615 MWp" to offer high power provision in villages as well as peak load-savvy urban regions in India. Studies [13] perceived that "solar thermal technologies" include a very great prospective aimed at solicitations in the event of "solar water heating systems" for domestic and industrial presentations as well as "solar cooking" within the sector of domestic. About 35 MW per square is the "solar thermal power generation" estimates designate 800 MW per annum with respect to "solar thermal-based power" generation throughout the time between 2010 and 2015 in India, with global progressions in the parabolic trough expertise. A project to set up a "140 MW" combined solar shared "cycle power project" has been introduced in "Jodhpur", a state in India called "Rajasthan", which includes a solar thermal component of 35 MW associated with parabolic trough collectors as well as 105 MW power generation grounded on naphtha/gas. Rajasthan State Power Corporation Limited (RSPCL) has implemented this project, one of the largest projects sponsored by the "Global Environment Facility" and "credits from German KfW".

2.3 "The Implementation of Sustainable Renewable Energy Strategy in India"

Accordingly, India has achieved remarkable and fast financial development, but energy is still scarce, [14]. In this manner, robust financial growing in India is mounting the energy demand, and further "energy sources" are compulsory to meet this demand. Simultaneously, India faces issues related to sustainable development due to increasing population as well as environmental deterioration. Studies [14] observed that slit between supply and demand of energy is predicted to increase in the upcoming future. "INR 3762 crore (USD 581.09 million)" was allocated beneath the combination budget of India "2018-2019 for grid-interactive renewable power schemes and projects" and "the installed capacity of entire renewable power in the nation amounted 74.08166 GW", [14]. Along with that, wind energy is constant in controlling the renewable energy industry, accounting for above 47% of increasing connected renewable competence as "35,138.15 MW" shadowed by "solar power" of "34% as 25,212.26 MW". India attitudes in the fourth and sixth location with respect to the increasing connected volume in renewable energy development in the "wind and solar" sectors, correspondingly.

Solar energy

"Ministry of new and renewable energy" has efficient the milestones of "grid-connected solar power" projects under the "national solar mission from 20 GW by 2021-22 to 100 GW by 2021-22". One of the key strategies for solar energy can be implemented in terms of the "Made in India" initiative for promoting domestic industries reinforcing this countless elevation in solar installation capacity. Presently, India includes the fifth-uppermost solar connected volume in the biosphere. Solar energy had achieved 25,212.56 MW by the 31st of December 2018 against the target of 2022, as well as a further 22.8 GW of capability has been presented out or is below the present implementation. As per the "Ministry of new and renewable energy" is formulating to tender out the residual "solar energy" volume each year aimed at a time of 2018 to 2019 and 2019-20 with the purpose of biding might back by "100 GW" volume accompaniments by "March 2020", [15]. In this manner, 2 years aimed at the achievement of developments would endure; thus, through the

competitive bidding process, tariffs would be determined to bring down tariffs in a significant manner. The lowest solar tariff was acknowledged in July 2018 to be INR 2.44 per kWh; the solar tariff amounted to "INR 18 per kWh; over 100,000 lakh acres of overall land had been segmented regarding numerous planned solar parks, out of which done 75,000 acres had been gained". An entire volume of 26,694 MW was recognized through establishing 47 solar parks as of November 2018. As a result of this implementation policy, the collective volume of "4195 MW of solar projects" has been appointed within different solar parks, including "floating solar power".

Wind Energy

The entire installed volume of India as of 31st December 2018 valued to "35,138.15 MW" as likened to a board of "60 GW through 2022". In the world, India has a position in the fourth position regarding the fitted volume of "wind power". Furthermore, under this implementation, around 9.4 GW capacity has been bided out and the "Ministry of new and renewable energy" has been prepared to tender for a "10 GW wind energy capacity" constantly each year for "2018-2019 and 2019-20". The intention of bidding would permit "60 GW capacity" accompaniments through March 2020, providing the outstanding "two years" for achieving the schemes. Studies have argued that India's uncultured "wind energy" potential presently reaches "302 GW at a 100 m above-ground level", [16]. The bidding method for capacity addition has altered from "feed-in-tariff (FiT)" in terms of the tariff administration. The Ministry published the guidelines on the 8th of December 2017 regarding tariff-based competitive bidding regulations aimed at attaining energy from energy from grid-linked wind energy developments. The industrialised transparent bidding procedure dropped the tariff aimed at wind energy to its lowermost level eternally. The expansion of wind energy has increased, ensuring project execution capacity in a robust ecosystem in terms of an engineering foundation. State-of-the-art innovations are presently accessible for wind turbine production. All the main international companies have their existence with respect to wind power in India, including 24 different replicas of "wind turbines" industrial by 12 different organisations in India. On the other hand, India also exports wind turbine machineries to Europe, "the USA", Brazil, "Australia" and other "Asian nations". In terms of a sustainable renewable generation strategy, around 70-80% of the domestic production has been achieved by robust internal manufacturing organisations. Also, electricity production from "wind-based capacity" has enhanced, however a strike of new volume has been observed "in the first half of 2018-2019".

2.4 The financial Barriers to the Transition of Implementing this Sustainable Energy

According to [17], the challenges of funding renewable energy are tortuously allied with the framework of the industry in India as well as the investment character aimed at the industry, which is principally shaped through the implementation categories and opinions of the investors. Based on the wealth concentrated countryside of the segment and private division led sectoral expansion, drawing attention of obligatory size and type of investment incessant to be primary roadblock for the sustainable energy sector in India. Over many years, a range of advanced funding tools and instruments have been employed and devised, moreover, assembling sufficient funding in terms of conventional terms and conditions is very much challenging issue in the "renewable energy sector in India". In this manner, construction and labour costs are significantly lower with respect to Indian scenario and more critically, a dramatic fall has been observed in the renewable energy costs in specific costs of wind and solar energies.

Moreover, the attempt is made to highpoint a few key berries and challenges to successfully implement the sustainable energy strategy in India. Government of India has been strived in a consistent manner to mature "renewable energy sector" by a set of progressive strategic regulatory and policy measures. Though, the newest policy push to transit with respect to the greener energy system is established as per the transformative energy vision of the Indian government regarding the production of "175 GW of renewable energy by 2022". As per [18], one of the key barriers of this renewable energy sector is to mobilise private capital at a pace as well as rate in tune by the targets of policies and regulatory framework which are less volatile in nature. It can be assumed that an investment required by considering the technological distinctive of this renewable energy industry to meet the target set by the Indian government as 175 GW including a cost of $189 billion [18]. It can be observed that the "renewable energy" sector of India lacks sufficient financial support from the government by which the transition of implementation process has been delayed. Lack of interest of private energy companies can also be measured as another key barrier of this renewable energy industry in India

that must be addressed by the Indian government regarding an easy transition in the renewable energy industry.

This literature has not covered case study projects of solar and wind power as sustainable energy strategies across India. The lack of financial information on solar and wind power plant-related projects can be measured as a literature gap in this study. Along with that, this literature has not discussed any solar and wind farm-related information located in several states of India which is a key gap in this literature review. Moreover, the lack of information about different solar and wind projects in India is a key literature gap in this research. Along with that, financial forecasting of several solar and wind power projects has not been properly investigated in this literature which is a key gap in this literature. This literature review lacks regional information based on several states of India which have implemented solar and wind power plans as sustainable energy strategies in India.

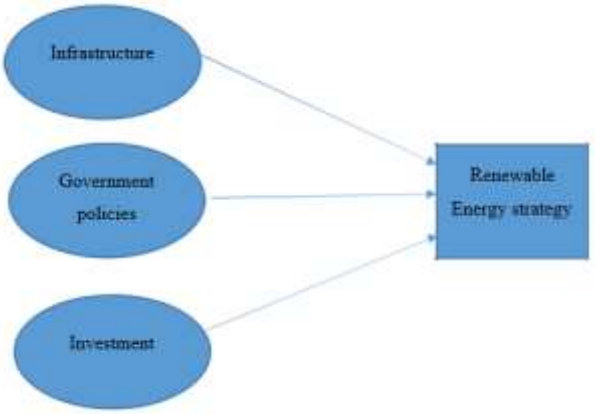

Fig. 1: Theoretical Framework

The literature review has discussed a wide range of information about renewable energy which is produced by solar and wind farms. In addition to that, this literature review has presented a theoretical understanding of renewable energy as a sustainable energy strategy in India. To define the concept and significance of sustainable energy strategy, this literature review has focused on a wide range of peer-reviewed journals and research papers. This literature review has also analyzed the need for renewable energy in terms of solar and wind power as a sustainable energy strategy in India through theoretical framework shown in Figure 1.

3 Research Methodology

This section examines selected research methods to achieve objectives. A deductive research approach is selected in this research methodology to obtain information about solar and wind farms. Besides that, this research methodology section additionally includes exploratory research design to explore contextual evidence for sustainable energy strategy in relation to solar and wind power.

In earlier studies [19], the research approach includes a step-by-step plan that allows the researcher to collect, analyses, and interpret the collected information. In this manner, the research approach has different applications based on the assumptions and thought processes of several researchers. It can be observed that the techniques of data collection are implied by a research approach along with data analysis in both qualitative and quantitative research methods. To conduct research in a successful manner, the selection of a research approach is very important and comprises two divisions, for example, inductive and deductive research approaches. In this way, a deductive research approach permits the researcher to develop a set of perception-oriented hypotheses for research which later could be either accepted or rejected followed by an existing theory. In contrast, an inductive research approach provides an opportunity for the researcher the develop a new theory that starts with the research aim, questions, and objectives throughout the research process.

The deductive research approach is applied in this research for analyzing the role of renewable energy like solar and wind power in the sustainable energy strategy for India. In this manner, a deductive research approach has been applied in this research to collect, analyze and interpret information from secondary sources. Moreover, the deductive research method also allows the researcher to test the research hypothesis associated with the research aim, objectives, and questions for conducting this research in successful research.

Research design has a key role in the research like the research approach. In addition, research design refers to the accumulation of specific techniques based on the studies by [20] to collect and analyses data. To set up a master plan, the research design suggests the most significant explanation of the key terms. Moreover, there are three types of research design that are applied in numerous research studies, for example, descriptive, explanatory, and exploratory. Along with that, descriptive research design refers to an in-depth interpretation that allows the researcher to understand complicated social issues or phenomena. On the other hand, the exploratory research design is mainly applied to an exploration of unidentified or unexplored evidence, facts, and information

associated with the social phenomenon. Moreover, the explanatory research design refers to a direction as well as a set of assumptions regarding the scientific explanation of any specific research problem.

This research has involved an application of exploratory research design to explore contextual case studies, articles, and papers related to solar and wind power as sustainable renewable energy strategies in India. In this manner, exploratory research design has allowed the researcher to collect secondary data associated with unexplored projects in solar and wind farms in India. To successfully perform desk research, the exploratory research has allowed the researcher to collect secondary information for concluding accurate findings.

3.1 Research Philosophy and Approach

As per the studies [21], research philosophy includes an assumption and influences a thought process that provides directions to the researcher on how the evidence and information should be collected, analyzed and interpreted. Along with that, research philosophy refers to a perception by which the researcher can accumulate contextual knowledge, the nature of the research, and critical assumption. In this manner, research philosophy mainly deals with a manner that allows the researcher to accumulate empirical knowledge with respect to a better understanding of their own assumptions. In this way, three types of research philosophies are mainly used in several research studies, for example, positivism, realism, and interpretivism. Along with that, realism research philosophy provides an opportunity for the researcher to focus on the independent concepts or ideas from the human mind that are mainly associated with the scientific approach to knowledge development. On the other hand, positivist research philosophy includes 'factual' knowledge that allows the researcher to accumulate trustworthy measurements through critical observation. Lastly, interpretivism research philosophy refers to a critical definition to provide a direction to the researcher to supervise the social world. Moreover, the core interests of the researcher are mainly reflected by the interpretivism research philosophy regarding the development of successful research.

This research includes an application of the positivism research philosophy to examine real projects and case studies about solar and wind farms. In this manner, the realism research philosophy has allowed the researcher to acquire independent ideas from the human mind based on the scientific approach of solar and wind farm-related sustainable energy strategies toward knowledge development. Along with that, the realism research philosophy has also allowed the researcher to obtain relevant information about solar and wind farms to produce renewable sustainable energy associated with relevant projects and case studies in India.

3.2 Research Strategy

Research strategy refers to guidance for the researcher with respect to a step-by-step planning process including a course of action, [22]. In this way, an appropriate research strategy provides an opportunity for the researcher to perform a systematic analysis associated with the preplanned task and scheduled project activities. Aside from that, research strategy refers to a broad aspect conduct of conducting successful research to accomplish the research aim and objectives. A wide range of research strategies have been applied by the researchers, for example, analytical research strategy, quantitative research strategy, qualitative research strategy, action research strategy, and basic research strategy. However, qualitative research strategy mainly refers to a significant understanding of underlying opinions, thoughts, and causes by which the researcher can accumulate in-depth knowledge of any social issue.

In addition, a qualitative research strategy delivers an insight into the research problem including support to achieve the research aim and objectives followed by several methods like focus groups, oral history, textual evidence, observation, and oral history. Aside from this part, quantitative research strategy refers to a comprehensive evaluation to examine numerical information. In this manner, a quantitative research strategy allows the researcher to focus on the research questions which are oriented by 'what', 'where', 'when', and 'how' including methods like surveys, questionnaires, and polls. Along with that, the analytical research strategy indicates an implication of presenting accessible facts and information for attempting and focusing on the complicated social phenomenon. Moreover, for addressing a particular research issue, an action research strategy refers to finding a resolution for an immediate issue used by an agency, company, or the government.

A qualitative research strategy has been adopted in this research to evaluate the role of solar and wind power in the sustainable energy strategy in India. In addition to that, this research has applied a qualitative research strategy to segment secondary information from different sources, like journal articles and research papers. Moreover, this research

has applied a qualitative research strategy to interpret valuable information about the renewable sustainable energy strategy in India related to solar and wind power.

3.3 Data Collection and Analysis Approach

The role of the data collection method is essential in the development of a successful research study. Along with that, the data collection method indicates a progressive and comprehensive approach to obtaining information, facts, objects, and evidence from a wide range of resources. In this manner, the data collection method allows the researcher to collect information from different sources to meet research aims and objectives in a successful manner. On the other hand, there are two kinds of data assortment approaches that are applied by numerous researchers, for example, "primary data collection" and "secondary data collection" approaches. However, the primary data collection method refers to the involvement of participants. In other words, primary data is mainly collected from the respondents during a field survey based on a set of questions. The primary data collection method allows the researcher to collect first-hand information that cannot be accessed by any other publications. Even though primary data collection provides accurate and relevant information based on the needs and requirements of the researcher. Alternatively, the secondary data collection method involves data that has been already published on numerous platforms. In this manner, the secondary data collection method refers to a process of collecting information from several sources, like case studies, journal articles, newspapers, documents, and the Internet. Different types of published corporate information are also considered a key source of secondary data, for example, annual reports, project reports, cash flow statements, balance sheets, and other financial statements.

In this research, the secondary data collection method has been applied to achieve research aims and objectives. Along with that, desk research has been conducted in this research based on case studies related to solar and wind power for the sustainable energy strategy in India. In this manner, primary data collection could not provide detailed information about the efficiency of energy generation technology which did not happen with secondary data. With the assistance of secondary data, the researcher has accumulated a wide range of information related to solar and wind power as a key sustainable energy strategy in India. In other words, the secondary data collection method has allowed the researcher to closely focus on the dissimilar projects coming up in the wind farms and solar farms across India in terms of a sustainable energy strategy.

This research is mainly based on the role of solar and wind power in sustainable energy strategy and the researcher has considered the secondary data based on a few inclusion criteria. In this manner, the researcher only considered the solar and wind power projects that were conducted in India. In other words, Indian solar and wind power plants have been considered as an inclusion criterion in this research. Along with that, solar and wind power projects in the last 10 years have also been considered as another inclusion criterion of this research. In addition to that, the researcher has only considered those solar and wind power plants that had been completed in the last 10 years in India. Another inclusion criterion is that accessible journals have been retrieved from secondary resources.

On the other hand, the exclusion criteria are also very important for any kind of research. In addition, the researcher has not considered any project outside of India. The exclusion criteria of this research refer to solar and wind projects which have been conducted outside India. Apart from that, another exclusion criteria of this research include those solar and wind power projects which had been undertaken over 10 years. Inaccessible journals also denote another exclusion criterion of this research.

This research includes secondary data associated with solar and wind power projects in India. Along with that, the researcher has considered journal articles, research papers, and corporate documents as a key type of data. Numerical evidence is another type of data that has been collected in this research to significantly define the role of solar and wind power as a sustainable energy strategy in India. In this manner, the researcher has considered only information that is publicly accessible as well as related to the solar and wind power plant-related case studies as a sustainable energy strategy in India.

To explore several external sources of secondary data, an effective search strategy has been followed in this research. The researcher has investigated by entering keywords into the search engine, for example, *'solar farm', 'wind farm', 'solar power, 'wind turbine', 'solar panel', 'sustainable energy', and 'India'*. It can be noted that the search strategy has been associated with the selection of keywords to get relevant and authentic information to achieve all research aims and objectives. On the other hand, the researcher has accumulated relevant and quality information by

entering the right keywords to get the desired results of the search from numerous journal articles, research papers, and websites. Data analysis is the procedure of changing, cleaning, and processing raw information and extracting relevant, actionable information that assists researchers in making informed decisions, [23]. In this manner, this research has included narrative analysis for developing a successful investigation of the role of solar and wind power as a sustainable energy strategy in India. Along with that, narrative analysis has allowed the researcher to implement a cluster of analytic methods for interpreting texts or visual information that have a storied formation. With the help of narrative analysis, the researcher has described the background story of several solar and wind power plant-related projects as a key sustainable strategy in India.

4 Data Analysis and Findings

The four main states in India namely Maharashtra, Tamil Nadu, Rajasthan, and Gujarat are the main renewable energy-creating states. In addition to that, more than 60% of wind energy and about 35% of solar energy 175 GW of renewable board is predicted to be achieved by these four states in India, [24]. In terms of the national renewable energy pool, these four states have the higher contributions at a similar time frame; a huge amount of the power needs of the states are achieved by renewable foundations. This data analysis section includes a narrative analysis by selecting journal articles based on these four states of India to present authentic findings by interpreting research findings.

4.1 "Tamil Nadu: Solar Energy Policy 2012 and Wind Energy Policy"

The policy related to solar energy of 2012 set the goal of 3000 MW in Tamilnadu solar energy production through the year 2015. It can be noted that by producing 1000 MW, the communal number of 3000 MW of solar energy for each year up to 3 years including a mechanism for generating solar energy by utility-scale renewable energy projects (1500 MW), REC (1150 MW), and rooftops (350 MW). Moreover, Solar Purchase Obligation (SPO) has been made by the Tamilnadu state compulsory at 6% [24]. The Solar Energy Policy mandates heavy energy users, for example, telecom towers, information technology parks, educational institutions, special economic zones, continuously powered industries, and buildings with 20,000 square feet. In this manner, "Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO)" governs the solar energy policy by developing a single-window support "Tamil Nadu Energy Development Agency (TEDA)" for providing solar energy projects within a 30-day time.

The study of Nesamalar et al. (2017) showed that a few southern districts of Tamilnadu have strong winds at a speed of 18-24 Kmph (kilometre per hour), for example, Kanyakumari, Coimbatore, Tirunelveli, Thoothukudi and Theni. Moreover, four major breaks in Western ghats have the wind blowing from the Arabian Sea during monsoon, such as Kambam, Aralvaimozhi, Shencottah, and Palakkad passes. In addition, wind turbine clusters in Aralvaimozhi Pass have 3000 windmills which are the largest in Asia, and generate 1500 MW of installed wind energy [25]. On the other hand, in Tamilnadu, solar power projects are evolving, including substantial growth in the last 3 years. 13 million hectares of the total area of Tamilnadu, 0.492 million hectares as recognized hotspots for solar energy among unculturable or arid land. The state government of Tamilnadu announced a solar energy policy in 2012 that covers several renewable energy schemes, for example, solar steam cooking systems, solar air conditioning systems, solar photovoltaic power plants, and solar air heating plants. State-owned and private solar firms have installed solar PV modules across Tamilnadu that generate 1061.82 MW of renewable energy, [25].

4.2 "Rajasthan: Solar Energy Policy 2014 and Policy for Promoting Generation of Electricity from Wind, 2012"

The government of Rajasthan has introduced by a policy related to solar energy because of the vast potential of solar power from situational advantage including an aim to install 25,000 MW of solar power, [24]. The Rajasthan Electricity Regulatory Commission (RERC) has determined the tariff in relation to a reasonable bidding development to the amount of solar power installation. The development of Photovoltaic (PV) solar power plants is also influenced by the solar energy policy of the Rajasthan government for benefiting individual consumers as well as individual manufacturers. In addition to that, hybrid systems include "thermal energy" supplies for commercial and domestic use through their own distribution system. In relation to the preferment of parks as solar energy in Rajasthan, the solar energy policy promotes stand-alone solar systems and local solar grids. The wind power plants for straight sale of control under the strategy for endorsing the cohort

of power, for example, 2013-14: 300 MW, 2014-15: 400 MW and 2015-16: 500 MW.

On the other hand, the state government of Rajasthan has established “Rajasthan Renewable Energy Corporation Limited (RRECL)” by amalgamation of “Rajasthan State Power Corporation Limited" and "Rajasthan Energy Development Agency" to offer a single window permission to all projects related to renewable energy. In addition to that, under phase 1 of the National Solar Mission, 800 MW capacity-based solar power plants have attracted investors which was promoted by “The Union Ministry of New and Renewable Energy", [26]. However, the state government of Rajasthan has faced challenges related to the application of smart grid machinery but presents numerous sources of power generation in operation in this state. It can be anticipated that over the next 10-12 years, Rajasthan will be an international hub of solar power for 10,000-12,000 MW capability to achieve the energy requirements across the state as well as other states in India. Along with that, around 110 million funds are required for successfully implementing the solar power installation to reach the target energy production of 5kWh/m2/day in Rajasthan, [26].

4.3 “Gujarat: Solar Power Policy 2015 and Wind Power Policy 2016”

To endorse huge-scale solar power cohort volume, the “Gujarat Solar Power Policy” aims to set up Megawatt (MW) scale solar control plant projects. Through the assistance of solar thermal and solar PV skills, the "Gujarat Solar Power Policy" goals to achieve solar capacity targets clear by “Gujarat Electricity Regulatory Commission (GERC)”. Along with that, the setup of solar power generators (SPG) has the purpose of selling the produced electricity to distribution licences or any third party in agreement with the Electricity Act 2003 and the rate of power is determined separately for different stakeholders. Moreover, a wind power policy has also been adopted by Gujarat in 2016 that is still in operation till 2021. In this manner, wind turbine generators (WTG) have been installed with the purpose of selling electricity to obligated entities. Gujarat Energy Development Agency (GEDA) has an accountability to provide notice to all eligible sites for WTGs as possible sites inside the state through a nodal activity or designer.

Apart from that, the “Gujarat Solar Power Policy (GSPP)” was unconfined by the government of Gujarat in 2009. The very first solar park was introduced in 2010 in a distant village named Charanka. Along with a connected volume of 216 MW and a speculation price of about US$280 million, the project became Asia's largest solar park, [27]. Large-scale renewable energy plans are highly perceived as a positive thing in terms both socially and environmentally, for example, Charanka Solar Park with a formal assessment regarding social impact. Major growth, for example, Charanka solar park, could be anticipated for bringing infrastructural advantages to the region, and associates of several communities in Charanka focussed that they were missing straight the most fundamental facilities as well as services, for example, schools, paved roads and hospitals for the village. In addition to that, the villagers additionally complain that the reliability of the power supply (electricity) was not specifically purposeful to them due to inconsistency.

4.4 Maharashtra: Renewable Energy Policy 2015

A wide range of renewable energy policies was launched by the Government of Maharashtra under the term "Maharashtra Renewable Energy Policy" in 2015 which enabled opportunities for setting up grid-connected renewable power projects. Along with that, the implementation of the "Maharashtra Renewable Energy Policy" has been governed by “Maharashtra Energy Development Agency (MEDA)” and the tariff is set by “Maharashtra Electricity Regulatory Commission (MERC)” for the projects commissioned under the renewable energy policies. A project related to solar power of 7500 MW would be industrialized under the policy and around 2500 MW capacity would be produced with the help of Maharashtra State Power Generation Co, [24]. By applying the public-private partnership, the remaining 5000 MW would be developed through other developers including lakes, canals, and water bodies in relation to a contract with the "Water Resource Department". In addition to that, the renewable energy policy requirements can be fulfilled by the electricity produced from the projects by applying the public-private partnership and the minimum capability to be produced below the policy would be 1 MW. Solar park, projects can also be developed. Apart from that, the estimated target of these projects is to command 5000 MW capacity related to wind energy projects. To meet the procurement obligation, a total of 1500 MW would be developed in relation to distribution licensees below the regime of renewable energy policy. Lastly, an outstanding 3500 MW volume is available to be used for open access, interstate, captive consumption, intrastate, and REC purposes. As of 31 March 2018, the complete equipped

volume of massive hydro energy installing renewable energy arrangements produces about 45.29 GW of energy in Maharashtra. The government founded the “Maharashtra Energy Development Agency (MEDA)" to promote the development of non-conventional energy. In addition, the state called Maharashtra includes a non-renewable energy capability of 24,105 MW, [28].

Based on the above narrative analysis, it can be discussed that national-level policies related to renewable energy mainly work under the umbrella framework, provided by the federal outline of India. In addition to that, states have a very significant role to play in shaping the entire procedure of encountering the obstacles and challenges related to the renewable energy policies in India. In this manner, a demand-supply balance has been regarded by the state utility companies based on their own grid to store renewable energy. It further needs access for mixing a conventional generator as well as innovative experiments by the several phases of reliability for internalizing the variations in supply and load from natural renewable sources regarding the grid. A mismatch fluctuation has been observed in the above narrative analysis in relation to the demand-supply balance. The government of India needs to pay more attention to the incentives and subsidies to successfully implement solar and wind power plants with a certain degree of accuracy. It can be discussed from the above narrative analysis that unfrozen supply fluctuations are required to be neutralized regarding the successful implementation of solar and wind power plants in several states of India. Moreover, initiatives of the state government related to solar and wind power plants have been analyzed in the above section to promote the concept of renewable energy.

5 Research Findings

5.1 Sustainable Strategy of Energy for India

In the data analysis section, case studies of four major states have been investigated related to solar and wind policies as sustainable renewable energy in India, such as Tamil Nadu, Rajasthan, Gujarat, and Maharashtra. In addition to that, the renewable energy status of Tamil Nadu has been analyzed in the data analysis which is amplifying at an exponential rate because of rapid financial growth as well as the rise in population. It can be projected that the economy is estimated to increase at 7.9% per annum because per capita energy depletion is also growing. As a result, the demand for energy is also anticipated to grow in an exponential manner. The state government of Tamil Nadu is required to assume the massive possibilities of renewable energy as well as make its utmost efforts to attempt the sustainable goal of achieving a capacity of 10.56 GW by 2023. By the year 2012, the setup of wind farms was at its peak, but it was radically summarized in the year 2014 due to poor evacuation infrastructure. It can be anticipated that Tamilnadu must make critical efforts to develop a sufficient transmission green corridor to evacuate sustainable green energy produced in this state. To upsurge the effective implementation of solar and wind power plants, solar PV has created a considerable amount of awareness in many households and industries. The state government of Tamilnadu should provide subsidies, develop strict policies, and promote renewable energy certificates to promote renewable source-based generations.

Studies suggest that the conceivable for energy storage has been reviewed to about 15-20 GW by the year 2020 after the renewable energy market in renewable energy capacity by 2022 has been set, [29]. In addition to that, the commitment of India to the UNFCCC projects 40% of the electricity capacity by the year 2030 to be non-fossil. Apart from that, the contribution of energy storage, in an energy mix comprises a remarkable contribution from wind and solar power that cannot be highlighted sufficiently. Moreover, Rooftop Solar mainly holds an 80% stake in the overall energy storage market for off-grid renewables which would be USD 2 Billion in 2022. In terms of micro and mini-grids, the Ministry of New and Renewable Energy (MNRE) decided to install 10,000 micro/mini-grids with a capacity of 500 MW, [29]. It can be noted that the rapid deployment of rooftop solar storage systems could be supported by advanced battery technologies in the industrial and commercial segment.

5.2 Current Energy Strategy in India

The data analysis section has also focused on the successful implementation of solar energy development in Rajasthan by highlighting the most critical success factors as well as aspects of the surrounding atmosphere. Along with that, crucial infrastructure has been developed by the Rajasthan government, such as power evacuation systems and solar parks. Based on the data analysis, the pace of development of solar energy systems has been usually reduced due to less power production from solar power plants which requires lots of investments. It can also be noted that socio-political

as well as historic framework situations have played an essential role in the effective implementation of sustainable renewable energy options that can be influenced by the "Rajasthan Solar Energy Policy". The state government of Rajasthan likewise attracts investment of around Rs 45,000 crores in the sector related to solar energy within a couple of years in terms of the promotion of infrastructure and policy for solar energy. A single window clearance to approve solar projects has been developed by the Rajasthan government in terms of a robust power evacuation system, effective environmental governance, and early mover advantage which would be committed to the promotion of solar energy. The data analysis section has also shown that Rajasthan could be a global hub of solar power over 10-12 years producing 10,000-12,000 MW for distributing energy across several states across India. To implement a solar power plant, the government of Rajasthan needs to acquire efficient photovoltaic material to exploit the scope overcoming the associated challenges.

5.3 Current Renewable Sources of Energy in India

The data analysis section has also shown a distribution of burdens and benefits associated with the progress of a mega solar energy park in Gujarat state. Despite that fact, solar power development agencies have recognized the accounts of indigent village populations in relation to the strong case for injustice claims in the distribution image. In addition to that, Gujarat and the Indian government both have been working together toward utilitarian standards, whereby the receiving resources related to land from a minority is exploited based on the success of significant change in the solar power plant to meet the carbon emission reduction targets. Appropriate strategies are required to be implemented by the state government of Gujarat by developing stronger procedures and sustainable energy policies. Based on the data analysis, the application of sustainable solar energy policies has been illustrated for solar energy implementation that is rolling out on a global scale. Further analysis is required regarding the solar energy implementation in other states like Madhya Pradesh and Rajasthan would offer useful comparisons. There is a requirement for specific concerns for developing state energy development policies in the context of solar power and wind power-based policy frameworks.

5.4 Energy Market Barriers to Disruption in India

The demand for energy has increased around India in recent years because of the rapid expansion of the population. Moreover, non-conventional energy in Maharashtra has been analyzed in the data analysis section that additionally contributes a measurable RES mixture to the complete installed capability, its far-away estimated capabilities as well as a small comparison to net RES potential. In this manner, the population growth is directly associated with the energy demand of this state, and it must be focused on the renewable resources that are accessible instead of conventional resources. Along with that the state government of Maharashtra has invested in connectivity with the opportunities, strengths, and obstacles related to the future of the RES energy mix. Based on the data analysis section, the scope and challenges related to solar and wind power energy have been investigated across four different states in India, such as Tamilnadu, Gujarat, Maharashtra, and Rajasthan. In addition to that, several initiatives and action plans of the state government related to sustainable solar and wind power plant projects have also been investigated in the data analysis section leading to significant findings of this research. The whole life cycle of wind power was segmented into the following five phases.

1. ***Phase 1***- raw material procurement and manufacture along with including the production of wind turbines and other materials.
2. ***Phase 2***- transport, counting the transport of wind turbines and additional materials excluding wind turbines, [27].
3. ***Phase 3***- installation and construction of wind turbines and other materials.
4. ***Phase 4***- the operation and maintenance of wind farms.
5. ***Phase 5***- end of life (EoL) stage, with equipment disassembly, substantial recycling, and concluding clearance (incineration and landfilling) of wind farm equipment.

The life-cycle stages of photo voltaic include:

1. The manufacturing of fresh resources.
2. Purification and processing.
3. The production of components and balance of system (BOS) mechanisms.
4. The connection and procedure of the structures.
5. Their withdrawal and removal or recycling.

Recycling of parts from wind farms and photo voltaic: components of wind turbines are essentially

100% recyclable. Their dissimilar parts are undone, organized, and then directed over retrieval stations. The real used for their basics is recycled in other places, strengthened and aluminium is directed to steelworks, or foundries, and fiberglass from turbine blades is recycled for other goods, such as fire hydrants. In contrast, the recycling process of photo voltaic parts is initiated through the elimination of the junction box, cables, and border from the PV unit. At that time, the unit is sorted, tattered, and unglued. The departure of the resources permits them to be conducted to precise recycling processes related to all materials.

5.5 Findings Linked to Research Objectives

To understand Renewable energy as a sustainable strategy of energy by theoretical demonstration.

The introduction of renewable sources of energy is playing a crucial role in the development of a sustainable strategy. The usage of solar and wind power will help to reduce the impact of air pollution which has been a leading cause of death in India. It has been found that there is no specific definition that broadly explains the prime concept of sustainable energy. Several authors tried to define the core concept of sustainable energy, but they tried to define it by producing several similar metaphors. However, one of the authors stated that these concepts put much more focus on the issues that are related to performance. Most of the studies have suggested that the areas of solar panels and windmills are significant for developing sustainable energy strategies as they help in developing high-voltage of electricity which is used for domestic and commercial purposes. It has also been found while reviewing the existing literature that some innovative and advanced technologies were not explored in a precise way due to the poor expansion of technological infrastructure in India. These technologies can also be used as sources for developing sustainable energy in India.

To analyze the need for renewable energy such as Wind and Solar Power for developing the strategy of achieving Sustainable energy in India.

The findings from one of the articles suggested that the consumption of electricity in India has almost doubled in the last year, which is also rising faster than the financial development of the country. It has been found that the major source of electricity supply is coal, which is also increasing the environmental pollution in the country. It has been found that there is a prime need for developing a strategy of renewable energy to make a reduction in the coal supply storage. Thus, due to the huge population of the country, there is high demand for the supply of coal. As a result, the supply of coal is also reducing every year and there has been a huge gap in demand and supply in the energy industry of India. This emergency condition of India has made them develop a sustainable energy strategy which includes renewable energy. It has also been stated that the increase in growth of several industries is also responsible for the consumption of high energy which in turn affects the financial development of the country. Thus, it can also be measured to identify the need of renewable energy mainly wind and solar power for developing a sustainable energy strategy in India.

The ways of Implementing Wind and Solar Power for the development of the

In this study, one of the authors stated that India has gained a fast and remarkable economic development however still there is lack of development in the energy industry. India is also facing several issues in implementing sustainable strategies for the development of the country due to the deterioration of the environment and rapid increase in the population. Further, one of the authors suggested that the gap between the demand and supply of energy will increase rapidly shortly. Thus, a major strategy for implementing solar power is through the initiative of Made in India which will be promoted to increase the capacity of solar installation in the domestic industries. Wind energy is also implemented by the Ministry of New and renewable energy in a very planned way. They have prepared to tender for the wind energy capacity of around 10GW consistently for years from 2018 to 2020, [30].

The Economic Barriers to the transition of implementing Sustainable energy in India.

The labour and construction cost of India is very low compared to other countries. The remarkable fall in the cost of renewable energy has been observed specifically in the cost of wind and solar energies. However, the government of India consistently made initiatives to develop the sector of renewable energy by implementing a set of progressive policy measures. It has also been noticed that there has been a lack of interest among the private companies of energy for implementing a sustainable energy strategy in India. The economic support from the government is also very less, thus implementation of the process is getting delayed.

6 Conclusions, Recommendations, and Research Limitations

In this study, the role of wind and solar power in developing a strategy of sustainable energy in India is broadly discussed. The secondary data is collected to find out the objectives of the study. The first section of the study discussed the prime significance of conducting the research. Wind and Solar power energy can be used as Renewable energy to control the air pollution in India. It has been stated that due to poor availability of power in India especially in rural areas people suffer from frequent power cuts mainly in summer. The reason for conducting this research is also justified as most of the people die in India due to excessive air pollution. The second section provided a broad literature review which discussed the key objectives of the research Section 3 of the study explored the research methodology which will be conducted to find out the objectives of the research study. The secondary data collection method was conducted to meet the objectives of the study. The deductive research approach has been applied as it allows the researcher to obtain, analyses and interpret the relevant information achieved from the secondary data, [31]. The exploratory research design has been selected to explore various papers, articles and case studies related to the topic. This research design has helped the researcher in obtaining data from the projects in India which were unexplored. However, some limitations were also identified while researching on the topic such as inability to access full pdfs of various articles. The reliability and validity of the data is also not up to the mark in this research.

However, in the fourth section, the data which were collected from several articles were discussed broadly. The analysis is mainly based on the four states which are considered as the prime producer of the renewable energy: Gujrat, Maharashtra, Tamil Nadu and Rajasthan. It has also been stated that around 35% of solar energy and 60% of wind energy will be gained by these four states of India. The fifth section states the findings of the research after analysing the data. It has been found out that various initiatives are taken by the governments of these states to introduce solar and wind power to develop a sustainable energy strategy in India, [29].

6.1 Key Research Recommendations

Low-Cost Funding and Innovation in the Economic Development

The Government needs to develop new and innovative economic products and should also make huge investments in vehicles. These steps are essential for initiating low-cost funding for the long duration of 25 years in the renewable sector. To enhance the Wind power alone, Rs 40,000 crores need to be invested for the 8000MW every year. The government of the country should also introduce a 5% subsidy for making use of indigenous manufactured products. The relaxation in the group and sectoral exposure norms by Reserve Bank of India RBI will also help the government immensely in the funding of renewable energy. India can also take some significant lessons from the economic schemes of Brazil. The addition of local value has motivated the long duration of the low costing funds in Brazil. In terms of domestic energy storage systems, integrated ESS applications should be installed in India including the following components:

- Power variation rate limitation
- Grid power variation support.
- Voltage regulation
- Frequency regulation
- Grind and Land Infrastructure

The Government of India to enhance the renewable energy sector should make available the land for scaling up the sources of renewable energy. Collaboration needs to be made between the state and central governments to find out the availability of the exclusive lands so that renewable projects can be started. The definition according to the Brundtland Report states that renewable energy is the production of a system of energy which will meet the needs of the people. It has been suggested that strategies for developing sustainable energy should include sources of energy which are environment friendly and do not emit any harmful pollutants.

To increase interest of private energy companies for enhancing the renewable energy sector.

The above studies have shown that much interest has not been shown by the private companies in implementing the sustainable energy strategy in India. Thus, the government should initiate promotional companies to spread awareness about the benefits of implementing the sustainable energy strategy in India. India mainly makes use of coal which is a non-renewable source for generating electricity. However, usage of coal is very high due to the increase in population which has resulted in severe air pollution. Thus, wind and solar plants can be used as an alternative to develop a sustainable strategy to produce renewable energy in India. The process of implementing wind and solar power in developing a sustainable strategy for producing

renewable energy in India. However, few barriers were also identified by reviewing various articles. The private energy companies of India have shown less interest in making use of wind and solar power in developing a sustainable energy strategy.

It has been noticed that involvement of India in global trade for electricity equipment is very less. However, it is the prime importer of electric equipment. The exportation incentives of the Wind power need to be increased from 2 to 5% for a certain period and it will increase the exportation of the energy resources globally.

6.2 Research Limitations and Future Scope

The researchers, while researching about a topic, face several challenges or limitations to complete the study. However, the limitations should not be the excuse for not developing an authentic paper. However, researchers conducted a secondary data collection method to find out the authentic data for the analysis. The first limitation which was faced by the researcher was relevant articles required for analysing the significant role played by wind and solar power for developing the strategy of sustainable energy in India. It has been noticed that while collecting secondary data most of the researchers face issues while accessing the relevant articles. Thus, in this study the same issue was faced which can be considered as one of the significant limitations of the study. The researchers faced issues as they could not access the full pdf of the article, thus in-depth analysis on the topic could not be discussed. The researcher also used several journal articles to research on this topic and there is a lack of verification of sources which were used. Thus, reliability and validity of the data used does not have much authenticity.

The future scope of this research is that India can introduce Wind and Solar energy power to develop a sustainable energy strategy in India. This research will provide a pathway to other researchers to conduct further in-depth analysis of how to enhance the renewable energy sector of India. This research study is very informative and will help several energy companies to get detail about the benefits of introducing Wind and Solar energy power in the energy industry to reduce environmental pollution. This study is unique as in-depth analysis on the role of mainly wind and solar energy power has not been discussed before. The government of India will also get various information about various ways in which sustainable energy can be implemented. The recommendations which were discussed will help the government and energy industry to enhance their facilities. Recommendations such as financial support of the country need to be provided to mature the sector of renewable energy. The exportation incentives need to be increased so that it can become a major exporter of energy equipment at a global trade level. Thus, this research will help future researchers to study on this topic in a broad way. The limitations which were identified in this research study should be avoided in near future to get a better outcome.

Declaration of Generative AI and AI-assisted Technologies in the Writing Process

The authors wrote, reviewed and edited the content as needed and They have not utilised artificial intelligence (AI) tools. The authors take full responsibility for the content of the publication"

References:

[1] Cea.nic.in, 2022. [online] Cea.nic.in, [Online]. https://cea.nic.in/wp-content/uploads/2020/04/Long_Term_Electricity_Demand_Forecasting_Report.pdf (Accessed Date: June 2, 2024).

[2] Seetharaman, G., 2022. Coal is here to stay despite India's ambitious goals for renewable energy. The Economic Times, [Online]. https://economictimes.indiatimes.com/industry/energy/power/india-will-not-be-able-to-achieve-its-renewable-energy-targets-anytime-soon/articleshow/69286279.cms (Accessed Date: June 2, 2024).

[3] Green Car Congress, 2022. New study puts air-pollution related deaths in India in 2019 at 1.67 million. Green Car Congress, [Online]. https://www.greencarcongress.com/2020/12/20201227-india.html (Accessed Date: June 2, 2024).

[4] BS.com - Business-standard.com, 2022. India hits target of 40% power generation capacity from non-fossil sources. Business-standard.com, [Online]. https://www.business-standard.com/article/economy-policy/india-hits-target-of-40-power-generation-capacity-from-non-fossil-sources-121120201289_1.html (Accessed Date: June 2, 2024).

[5] Investindia.gov.in, 2022. Renewable Energy in India - Indian Power Industry Investment. Investindia.gov.in, [Online]. https://www.investindia.gov.in/sector/renewable-energy (Accessed Date: July 18, 2024).

[6] Prandecki, K., 2014. Theoretical aspects of sustainable energy. *Energy and Environmental Engineering*, 2(4), pp.83-90.

[7] Nam, K., Hwangbo, S. and Yoo, C., 2020. A deep learning-based forecasting model for renewable energy scenarios to guide sustainable energy policy: A case study of Korea. *Renewable and Sustainable Energy Reviews*, 122, p.109725.

[8] Hosseini, S.E., 2020. An outlook on the global development of renewable and sustainable energy at the time of COVID-19. *Energy Research & Social Science*, 68, p.101633.

[9] Palys, M.J., Allman, A. and Daoutidis, P., 2018. Exploring the benefits of modular renewable-powered ammonia production: A Supply Chain Optimization Study. *Industrial & Engineering Chemistry Research*, 58(15), pp.5898-5908.

[10] Debyani, G., Shukla, P.R., Amit, G. and Ramana, P.V., 2001. Renewable energy strategies for the Indian power sector. Occasional Paper, *Centre de Sciences Humaines*, New Delhi, India, August.

[11] Gielen, D., Boshell, F., Saygin, D., Bazilian, M.D., Wagner, N. and Gorini, R., 2019. The role of renewable energy in the global energy transformation. *Energy Strategy Reviews*, 24, pp.38-50.

[12] Siram, O., Sahoo, N. and Saha, U.K., 2022. Changing landscape of India's renewable energy and the contribution of wind energy. *Cleaner Engineering and Technology*, p.100506.

[13] Pahlavan, S., Jahangiri, M., Alidadi Shamsabadi, A. and Khechekhouche, A., 2018. Feasibility study of Solar Water heaters in Algeria, A Review. *Journal of Solar Energy Research*, 3(2), pp.135-146.

[14] Majid, M.A., 2020. Renewable Energy for sustainable development in India: Current Status, prospects, challenges, employment, and investment opportunities. *Energy, Sustainability and Society*, 10(1), pp.1-36.

[15] Kashyap, K., Towhidul Islam Nayim, S.M., Thakur, R., Kumar, A. and Thapa, S., 2020. A study of solar energy in India; utility, status, and procurement. *Intelligent Communication, Control and Devices,* pp. 435-443. Springer, Singapore.

[16] Irfan, M., Zhao, Z.Y., Mukeshimana, M.C. and Ahmad, M., 2019, January. Wind energy development in South Asia: Status, potential and policies. *Proc. of 2019 2nd International Conference on Computing, Mathematics and Engineering Technologies (ICOMET)*, pp. 1-6. IEEE Xplore.

[17] Sarangi, G.K., 2018. Green energy finance in India: Challenges and solutions (No. 863). Asian Development Bank Institute (ADBI) Working Paper, Tokyo, [Online]. https://www.econstor.eu/handle/10419/190284 (Accessed Date: June 10, 2024).

[18] Rathore, P.K.S., Chauhan, D.S. and Singh, R.P., 2019. Decentralized solar rooftop photovoltaic in India: On the path of sustainable energy security. *Renewable Energy*, 131, pp.297-307.

[19] Kostere, S. and Kostere, K., 2021. *The generic qualitative approach to a dissertation in the social sciences: A step-by-step guide*. Routledge, ISBN: 9781032050249.

[20] Dannels, S.A., 2018. Research design. In *The reviewer's guide to quantitative methods in the social sciences* (pp. 402-416). Routledge.

[21] Žukauskas, P., Vveinhardt, J. and Andriukaitienė, R., 2018. Philosophy and paradigm of scientific research. *Management culture and corporate social responsibility*, 121(13), pp.506-518.

[22] Oliva, R., 2019. Intervention as a Research Strategy. *Journal of Operations Management*, 65(7), pp.710-724.

[23] Browne, J., Coffey, B., Cook, K., Meiklejohn, S. and Palermo, C., 2019. A guide to policy analysis as a research method. *Health Promotion International*, 34(5), pp.1032-1044.

[24] Dasgupta, S. and Sankhyayan, P., 2018. A narrative analysis of state-level renewable energy policies in India. *Sustainable Energy and Transportation: Technologies and Policy,* pp. 137-148. Springer, Singapore.

[25] Nesamalar, J.J.D., Venkatesh, P. and Raja, S.C., 2017. The drive of renewable energy in Tamilnadu: Status, barriers and future prospect. *Renewable and Sustainable Energy Reviews*, 73, pp.115-124.

[26] Pandey, S., Singh, V.S., Gangwar, N.P., Vijayvergia, M.M., Prakash, C. and Pandey, D.N., 2012. Determinants of success for promoting solar energy in Rajasthan, India. *Renewable and Sustainable Energy Reviews*, 16(6), pp.3593-3598.

[27] Yenneti, K. and Day, R., 2016. Distributional justice in solar energy implementation in India: the case of Charanka solar park. *Journal of Rural studies*, 46, pp.35-46.

[28] Madurai Elavarasan, R., Selvamanohar, L., Raju, K., Rajan Vijayaraghavan, R., Subburaj,

R., Nurunnabi, M., Khan, I.A., Afridhis, S., Hariharan, A., Pugazhendhi, R. and Subramaniam, U., 2020. A holistic review of the present and future drivers of the Renewable Energy mix in Maharashtra, state of India. *Sustainability*, 12(16), p.6596.

[29] CEEW.in. (2022). Energy Storage in India. CEEW, [Online]. https://www.ceew.in/publications/energy-storage-systems-market-applications-policy-in-india#:~:text=The%20potential%20for%20energy%20storage,2030%20to%20be%20non%2Dfossil (Accessed Date: September 6, 2024).

[30] Li, Q., Duan, H., Xie, M., Kang, P., Ma, Y., Zhong, R., Gao, T., Zhong, W., Wen, B., Bai, F. and Vuppaladadiyam, A.K., 2021. Life cycle assessment and life cycle cost analysis of a 40 MW wind farm with consideration of the infrastructure. *Renewable and Sustainable Energy Reviews*, 138, p.110499.

[31] Olabode, S.O., Olateju, O.I. and Bakare, A.A., 2019. An assessment of the reliability of secondary data in management science research. *International Journal of Business and Management Review*, 7(3), pp.27-43.

Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

The authors equally contributed in the present research, at all stages from the formulation of the problem to the final findings and solution.

Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself

No funding was received for conducting this study.

Conflict of Interest

The authors have no conflicts of interest to declare.