

Assessment Of Solar Energy Potential and Its Ecological & Economic Efficiency with Respect to Indian Geographical Location

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Abstract

The Indian estimated potential of renewable energy sources in 2022 is 175 GW, out of which 100 GW holds for solar power plants, 60 gigawatts for wind, 10GW for biomass, and 5 for small hydropower plants. Because of climate change and global warming, the essentiality of alternate energy has become the need of the hour. Exploring the potential of alternative resources of energy is enormously searching on the worldwide level. Countries are generating extreme levels of carbon emission like India and more desperately researching for new opportunities for alternative energy. The study significantly analyzes the potential of solar energy and its utility to enhance economic feasibility and its role in economic sustainability. It is also comprehensively analyzed, concentrating specifically on the Indian geographical location. For evaluating the objective and obtaining relevant results, the paper selected empirical methodology and conducted a survey among the 101 participants based on numerous questions. The outcome demonstrates that solar energy has immense potential for economic efficiency by generating wealth from saving resources, utilizing cost-effective and fuel saving approaches, endeavoring for innovative strategies that open the doors for the abundance of opportunities and enhance the credential and brand value of the company.

Keywords: Solar Energy potential, Solar energy and its economic efficiency, Solar energy and its ecological efficiency.

Chapter 1 - Introduction

Sun is an inexhaustible carbon-free energy-giving source that is freely and abundantly available in every tropical and subtropical zone of Earth. Contemporary innovative technology is being utilized to generate electricity from solar radiation. Solar energy can act as a game-changer from an economic and ecological perspective by harnessing advanced and innovative methodology (Gong, J., et al., 2019). Solar energy has already enormously manifested its potential all over the world as the most suitable renewable source of energy. It has the potential to suitably fulfill the demand of power of the world as a whole if appropriate technology is implemented based on ready-to-supply and proper infrastructure. The adoption of solar energy technology has immense capability to significantly mitigate and elevate challenges correlated with energy security, global warming, climate change, unemployment, clean environment, environmental sustainability (Rabaia, M. K. H et al., 2021). It also anticipates that it has potential and plays a significant role in the transportation sector.

Potential of solar energy

Solar energy is usually generated from the enriched solar location where solar radiation or solar waves are abundantly available in the location. From a global perspective, solar radiation is highly and actively available throughout the year in the subtropical and tropical belt of the Earth. Other prominent factors that demonstrate solar energy and its potential to generate electricity depend on latitude, above sea level, diurnal variation, climate, and geographical variation (Shahsavari, A et al., 2018). Other prominent factors which act as a suitable condition for establishing a solar Power plant depend on high altitude, low fugitive dust, increased transparency, and low humidity. The umbrella for efficiently appropriating solar power to generate energy is the solar cell photovoltaic and the solar thermal collector by harnessing technology (Zhang, Y. et al., 2020). Photovoltaic technology transforms sunlight into electrical power while

the solar thermal receiver warms the solution relating the sunlight heat to generate thermal energy. The photovoltaic technology would be performed with different silicon corporealities set up to the other arrangement established in diverse conditions (Sultan, S. M., & Efzan, M. E., 2018).

Solar power is one of the advanced renewable energy sources due to its cost-effectiveness. It emitted zero-emission, and more limited noise and other associated characteristics make it more inherent and reliable to meet the requirement for energy and power for a giant population. The energy sector is one of the prominent vital sectors contributing indispensable to expand the country's economy. In India, there is a sizable gap between energy production and energy dissipation. India is striving immensely in the renewable sector as the 11th five-year plan and the twelfth five-year plan concentrate on the National solar mission to practice large-scale solar energy power plants comprising the off-grid system, on-grid system, and rooftop (Dubey, S., & Tay, A. A., 2014). The appropriate technology used is the umbrella for efficiently appropriating solar power to generate energy is the solar cell photovoltaic and the solar thermal collector. Photovoltaic technology transforms sunlight into electrical power while the solar thermal receiver warms the solution relating the sunlight heat to generate thermal energy. The photovoltaic technology would be performed with different silicon corporealities set up to a distinct arrangement and established in diverse conditions (Sultan, S. M., & Efzan, M. E., 2018).

Solar energy and its economic efficiency:-

- Solar energy is an economically sustainable resource not because it is a renewable source of energy but also because PV technology demonstrates low carbon emissions for generating electricity.
- Photovoltaics technology is entirely safe for the environment as they do not generate any noise nor emit any toxic greenhouse gases.
- Technology is highly efficient at high temperatures.
- The technology also has the feasibility to operate from onshore and offshore to generate enormous amounts of energy without producing any harm to the environment, less utility of land.
- Solar energy reduces air, noise, and water pollution and ultimately plays a significant role in reducing global warming.

Solar energy and its ecological efficiency

- Solar energy is one of the most cost-effective renewable sources of energy as compared to all the other resources which have been utilized for energy generation.
- The maintenance cost of the solar power stations is also considered moderate.
- Solar power plants have immense potential because of innovative and advanced technology utilities that have a bright future and abundance of opportunity from an employment generation perspective.
- The lifetime of the photovoltaic panel is estimated to be about 30 years which demonstrates it has the capability for providing long-term economic benefit.
- Solar energy saves fuel and energy.
- Organizations can generate income from solar energy, for instance, by selling extra electricity, paying less carbon tax, generating carbon offset.
- The organization became self-reliant by meeting its electricity demand.

Feasibility Study of Solar Energy in India

India has the potential to obtain high solar radiation because of its favorable geographical location, which offers an opportunity to convert solar heat into electricity appropriately. Initially, in the year 2019, India launched a 19 billion dollar plan to produce 20 gw solar energy by the year 2020. This scheme covers all the government buildings and institutions encompassing hospitals and hotels. Later on, India initiated a solar mission under the name of a national action plan on climate change. Under this mission, the

government aims to generate solar electricity and enhance the implementation of renewable energy resources up to 10% of total power generation capacity (Raina, G., & Sinha, S., 2019). Presently India is one of the most leading and holding forth positions in carbon emission all over the world, which in force India to take rapid and appropriate actions to curtail its emission capability by using innovative and advanced technology like generating renewable energy resources, implementation of electric vehicles program, carbon-capturing technology among others (Elavarasan, R. M. et al., 2020).

Presently, India is one of the most attractive and emerging renewable energy sectors in the world as it ranked fifth in the solar power generating capacity. The vision to become self-sufficient in electricity generation can be manifested from the prime minister's solar mission that the solar energy production proportion will be up to 30% by 2024 among the entire energy formation since independence. Indian extended its solar generation ability eight times from 2.6 MW in the year 2014 to stretched upto 20 GW by the year 2018. The Ministry of new and renewable energy (MNRE) contributes a subsidy of thirty percent to install solar photovoltaic systems (MNRE, 2020). The estimated potential of renewable energy sources in 2022 is 175 GW, out of which 100 GW holds for solar power plants, 60 gigawatts for wind, 10GW for biomass, and 5 for small hydropower plants (Irfan, M. et al., 2020). With this ambitious objective, India will become one of the most comprehensive reliable energy producers in the world among several developed countries.

1.1 Background

The solar energy program was initially implemented in the late 1990s to promote and generate awareness regarding renewable energy by providing various means of subsidies under the ministry of non-conventional energy sources, which is the responsible department for providing grants and promoting solar energy-related technology. Till the end of the tenth five-year plan, the capacity of solar energy resources is achieved around 900 megawatts for grid connection and around off-grid connection is 46 MW. The technology gained pace after 2014 when the new government took adequate measures to promote renewable energy sources and set a target to obtain 175 GW by 2022 energy accomplishment (Kapoor, K., et al., 2014). The target was reframed, and the new aim was 450 GW renewable energy resource generation capacity till the year 2030. Presently around 95 gw of renewable energy resources capacity is installed, out of which about 40.5 gw energy came from solar resources¹. Under this target, solar energy holds a dominating position of generating around 60% of total capacity, about 280 gigawatts². Besides this, India is a leading promoter and supporter of the Paris agreement and taking appropriate action under the international solar alliance (ISA) to meet the demand of ecological sustainability and economic feasibility for India and the world.

This makes India one of the most emerging industrial sectors for financial upliftment under solar energy involving technology generation, equipment and machinery creation, innovation practice, research and development, and energy transportation which has an abundance of scope to generate enormous employment and establishment of new small and medium businesses (Schwalbach, C., 2016). This also provided a dual benefit for the country's economy as India became self-reliant to meet the energy needs and became a leading business for exporting efficient technology to the world in a cost-effective manner.

¹ <https://science.thewire.in/environment/with-80-gw-to-go-india-looks-set-to-miss-2022-renewable-energy-target/>

² <https://scroll.in/article/995567/in-charts-india-needs-a-robust-solar-power-policy-to-meet-its-renewable-energy-targets-by-2030>

1.2 Literature Reviews

Solar energy is playing a game changer role in the future of energy supply all over the world. The world has already identified its dynamic potential and capability through the way its sector is flourishing in developing countries like India, where electric consumption is holding a leading position globally because of the giant population. It was predicted that the future of solar energy is much in demand to integrate high insulation of solar heat into the country's power grid system (Raina, G., & Sinha, S., 2019). This is mainly because of the fluctuating nature of solar radiation and its compelling utility. It is possible to rely on live forecasting information, and its availability and accessibility depend on multiple disciplines. Solar power is one of the advanced renewable energy sources due to its cost-effectiveness. It emitted zero-emission, and more limited noise and other associated characteristics make it more inherent and reliable to meet the requirement for energy and power for a giant population (Gong, J., Li, C., & Wasielewski, M. R., 2019). The energy sector is one of the prominent vital sectors contributing indispensable to expand the country's economy.

The paper (Mohanty, S. et al., 2017) demonstrates the present condition of forecasting solar radiation for energy production through creating a review of solar generating waves and their application in a swiftly enhancing economy of the country. Another paper intended to analyze the economic feasibility of solar photovoltaic power energy generation. To adequately study the paper (Concolato, C. D. O. F., et al., 2020), choose various literature resources comprising the year 2015-2019 to suitably complete the study and obtain the outcome. The article highlighted the photovoltaic system as well as related obstacles and opportunities regarding solar energy. The study focuses on solar energy and its relevance from an Indian perspective after announcing a national solar mission to generate renewable sources of power with a target set of 100 GW in 2022. The paper tries (Rathore, P. K. S. et al., 2018) to reveal and explore the ground reality of large-scale solar photovoltaic developers and investors as international players dominate this market. The findings demonstrate the obstacles, bottlenecks, and loopholes faced by the solar sector in India in order to accomplish the target in the dedicated time. The paper also emphasizes the prominent and dynamic side of solar industries, which have an abundance of opportunity from an environmental perspective and an economic perspective to assure India's secured sustainable energy future (Tuominen, P. et al., 2015).

India is one of the leading and emerging nations for generating renewable energy resources as it occupies the second position among the significant commercial countries in the year 2018. The present scenario manifested that the contribution of renewable power in the energy sector met Indian needs of about 35%, which is targeted to accomplish around 40% by the end of 2030 (Yalla, T. P., & Vanitha, R., 2021). The motive of the research is to comprehensively analyze the Indian energy sector, its potential future needs, and the technology. The paper (Srivastava, R., et al., 2020) emphasizes two prominent sectors: first, the current status of renewable resources of energy and its relevant technologies, and another was its future and its potential to fulfill and meet the demand of Indian ground. The research illustrates government policies, public awareness, and the opportunity for future resources to utilize cost-effective mechanisms for consuming electricity appropriately. Solar energy can act as a game-changer from an economic and ecological perspective by harnessing advanced and innovative methodology. Solar energy has already enormously manifested its potential all over the world as the most suitable renewable source of energy.

The paper (Gulaliyev, M. G. et al., 2020) determines prominent factors such as technical, commercial, financial, and market opportunity and the ecological and economic efficiency of the solar energy industry in Azerbaijan. The paper demonstrates that solar energy has the potential to replace carbon emission technology used in the country to generate and meet the electricity demand. Although the primary challenge was its cost prices as fossil fuels generated, our supply is much cheaper as compared to solar energy.

1.3 Research Gap

The gap of the study is the implementation of google survey method although it is an innovative method but still acts as the limited survey data.

1.4 Research Question

Q. Identify the factors of solar energy which assure the economic feasibility from an Indian business perspective?

Q. Determine the solar energy potential to attain economic efficiency in the marketplace?

1.5 Importance of the Study

Because of climate change and global warming, the essentiality of alternate energy has become the need of the hour. Exploring the potential of alternative resources of energy is enormously searching on the worldwide level. Countries generating extreme levels of carbon emission like India and more desperately researching for new opportunities for alternative energy. The study significantly analyzes the potential of solar energy and its utility to enhance the economic feasibility as well as its role in economic sustainability is also comprehensively analyzed, concentrating specifically in the Indian geographical location.

1.6 Research Objectives

The motive of the research is to exclusively determine the impact of solar energy in the Indian ecological and economic sector and how it plays a crucial role in attaining economic and environmental sustainability. Comprehensive analysis regarding the challenges and the opportunities of solar energy.

1.7 Hypothesis

H0: Solar energy is economically feasible.

H1: Solar energy is not economically feasible.

Chapter 2 - Research Methodology

2.1 Research Method & Design

The topic is related to identifying the impact and potential of solar energy in the Indian ecological and economic sector. Subsequently, the quantitative methods appropriately suited to obtain the desired outcomes.

2.2 Research Approach

Primary Data

Primary data is a data type that is real and authentic. Primary data is usually collected from real-time sources such as surveys, questionnaires, experiments, and interviews. These are not concentrating on exploring the existing articles that mean it is singular and peculiar. This is because specific types of theories, methodology are used in every research. In this research, the researcher implements primary data to obtain accurate results. In this research, the investigator has conducted a Google survey, including close-ended questions. The survey was conducted among the 101 participants based on numerous questions. First, it is not time-consuming, and it is very reliable considering objectives. Through research, investigators examine in-depth the potential of solar energy and its relevance to acquire economic efficiency.

Secondary Data

The secondary is data which many scholars use in their research. In simple terms, some investigators have already collected and documented for its persistence and not for the current research challenge. It is accessible from various sources such as government publications, books, journal articles,

websites, and reports. These are concentrating on exploring the existing theme. They are less reliable and less suitable. This research selected data from several journals such as Scencedirect, Web of Science, JSTOR, Emerald Insight, and others. The researcher has used secondary data to upgrade their knowledge. Secondary data is also crucial as a primary empirical method to conduct this study in this methodology section. It assists in enhancing the knowledge and significant role in determining the hypothesis.

To enhance the knowledge and perception regarding the topic and try to determine the question, the study selected broader perspectives and gathered data from the related terms encompassed under solar energy, its potential in economic feasibility, ecology efficiency in Indian perspective. All the relevant data should contain any one of the key components in search, such as under the abstract, title, or comes under keywords.

2.3 Sampling Technique

Researchers used Google forms to collect as a sampling method. There are two reasons to do so: the first is a pandemic (Covid-19) going on, and secondly, it is an easy and efficient way to collect fast results.

2.3 Research Limitation

The limitation of the research is the sample size, as the study concentrated on very small data. Moreover, about one hundred and one samples were retrieved from the survey based on the questionnaire.

Chapter 3 - Analysis of Data

Factors	Agreed & Strongly Agreed	Neutral	Disagreed & Strongly Agreed
Cost effective technology	74%	19%	7%
Solar technology is the best way to save company wealth	67%	28%	5%
Energy and fuel saving technology	72%	17%	11%
Long-term investment	77%	18%	5%
Company generate income	60%	30%	10%
Enhance the company's Research and Development program.	70%	20%	10%
Company brand value increases	61%	34%	5%
Companies become innovative	60%	30%	10%

T test

P-value and analytical importance:

The two-tailed P value is less than 0.0001

By conservative standards, this variation is recognized to be notably statistically important.

Assurance interval:

The average of all the factor and their agreed and disagreed mean= 59.75

95% confidence interval of this variation: From 53.32 to 66.18

Intermediate values implement in calculations:

$t = 21.9884$

$df = 7$

Standard error of variation = 2.717

When the value of P is near to 0.5, then it demonstrates that Hypothesis H_0 (Null hypothesis) is correct; however, when the value of P is bending far away from the mean value, then it is assumed that Hypothesis H_1 (alternative hypothesis) is correct.

The above description shows that the value of $P > 0.001$ means H_0 is correct and accepted, and H_1 is rejected.

Hence, H_0 , that is, Solar energy is economically feasible and is accepted. While H_1 , the Solar energy is not economically feasible is rejected.

This shows that solar energy has economic efficiency, which can be proven by the sample collected from the survey and implementation of T-test that companies can effectively appropriately utilize solar resources to enhance their economic wealth and ecological sustainability.

Chapter 4 - Results & Findings

Solar energy is an enormously available source of power that is freely accessible in extensive amounts nearly all the time. Currently, the fossil fuel availability situation is deteriorating at an alarming rate. There is a necessity to competently practice alternate sources, which is a more substantial energy source, where the highest solar radiation is obtainable everywhere the year. Solar energy is also a reliable source of energy and support to diminish the vulnerable impact of global warming. It is free from carbon and other destructive greenhouse gases and, through power generation, does not wreck the ecosystem.

One of the questionnaires demonstrates whether companies are implementing solar energy technology in their building infrastructure or not. The results demonstrate that 60% of the respondents agreed that their company has appropriately utilized solar energy resources, while another 20% agreed, and another 20% were in the neutral phase. The prominent factor used to determine whether a company implemented solar technology and how these approaches converted into economic feasibility for generating company wealth and saving company resources and assisting them in endeavoring towards sustainability economically and ecologically. These ingredients are -

- Solar energy is reliable because of generating cost-effective electricity because of low maintenance, one time investment in building the infrastructure.
- Solar technology is one of the most efficient and effective methods to preserve company wealth by saving an abundance of resources.
- Solar energy has immense potential to save and secure companies fuel and energy for attaining sustainability.
- It has a potential for economic feasibility because investing in solar technology is long-lasting. It acts as a one-time investor for 20 to 30 years except for the maintenance, which is very minute compared to fossil fuel energy generation expenditure.
- By utilizing and harnessing solar energy technologies, companies can also generate carbon offset, which acts as a source of income for the company. Moreover, by generating additional solar energy, companies can also sell out their extra power. Along with this company also secure its green budget, which provides a better opportunity for green investment in the future.
- By implementing advanced technology for generating solar energy resources, a company must prior work for a robust research and development section until that company cannot have enough potential to harness advanced alternative technology. Henceforth solar energy is also associated with the company's research and development segment, which provides an innovative and green

methodology for the betterment of the environment and economic feasibility accomplishment from a company perspective.

The data revealed that around 67% of the participants agreed that solar energy is one of the best ways to save company wealth. Although 5% of the participants agreed and about 28% of the participants were neutral. Another question demonstrates that companies attain credentials and brand value by implementing innovative methods in the competitive world; around 60% of the participants agreed, while 30% were neutral, and 10% disagreed.

Chapter 5 - Conclusion

The necessity for energy demands has enormously increased because of population and insufficient supplies of energy or power, which typically depend on fossil fuel burning for thermal and coal-based plants. Renewable energy technology has grown mainstream through the last three decades. Solar power is one of the advanced renewable energy sources due to its cost-effectiveness. It emitted zero-emission, and more limited noise and other associated characteristics make it more inherent and reliable to meet the requirement for energy and power for a giant population. Solar energy can act as a game-changer from an economic and ecological perspective by harnessing advanced and innovative methodology.

Solar energy has already enormously manifested its potential all over the world as the most suitable renewable source of energy. Solar energy is reliable because of generating cost-effective electricity because of low maintenance, one time investment in building the infrastructure. Presently India is one of the most leading and holding forth positions in carbon emission all over the world, which forces India to take rapid and appropriate actions to curtail its emission capability by using innovative and advanced technology like generating renewable energy resources, implementation of electric vehicles program, carbon-capturing technology among others.

Eventually, Solar technology has immense potential because it is one of the most efficient and effective methods to preserve company wealth by saving an abundance of resources. Solar energy has immense potential to save and secure companies fuel and energy for attaining sustainability. It also generates new opportunities for the market, enhances the innovation approach and R&D sector, and also creates employment possibilities for the human resource. solar energy has the potential to replace carbon emission technology used in the country to generate and meet the electricity demand. Although the primary challenge was its cost prices as fossil fuels generated, our supply is much cheaper as compared to solar energy.

Chapter 6 - Future Scope

In the future, the paper will comprehensively analyze the economic feasibility of the company with the solar energy perspective and initiative practices to attain the concept of green economy encompasses factors like building, technology, manufacturing sector, among others.

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