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Key Determinants in Solar Power Adoption Among Consumers: A Review

Neelabh Sharma[1], Dr. Anshul Shrivastava[2]

[1]Research Scholar, Dept. of Commerce & Management, Dr. C. V. Raman University, Kargiroad, Kota, Bilaspur (C.G)
[2]Assistant Professor, Dept. of Commerce & Management, Dr. C. V. Raman University, Kargiroad, Kota, Bilaspur (C.G)

Abstract
India can solve its severe power crisis by utilising solar electricity. The promise of solar electricity and the actual results, particularly in the Indian context, differ greatly notwithstanding advances in technology. This study aims to identify the critical factors that might facilitate the rapid dissemination and uptake of solar energy systems in India, while also providing a summary of solar power possibilities. The existing body of research and the opinions of subject-matter experts have identified thirteen factors. Understanding the factors that influence the dissemination and acceptance of solar power systems may assist both academics and professionals in creating critical skills and plans of action.

Keywords: Solar Power, Adoption, Equipment, Panel, Consumers, Government of India

1. Introduction

Among the most important components of infrastructures for any nation's wellbeing and long-term economic growth is energy. The present focus of study is on reducing the creation of electricity from coal and focusing on sources of clean energy in order to conserve biodiversity and the environment [1]. One of the easiest energy sources to utilise nowadays is solar electricity. Since solar energy is carbon-free, it has a lot of potential to meet energy needs. One sustainable energy technique that may be used widely is solar heat [2]. The sunlight is completely free on Earth's surface, making it an excellent option for easing the present energy problem [3].

In India, solar energy utilisation is not very promising. In India, there exists a significant disparity among energy production and usage. Numerous research have brought attention to the obstacles that stand in the way of producing energy from solar power. The rise of solar PVs and solar thermal in India's industry is still in its infancy as compared to wealthy nations. China produces 50% of the photovoltaic (PV) devices sold worldwide, and along with Taiwan, it holds a 60% share of the market [4]. The considerable discrepancy among installed generation and utilisation of solar cells may be attributed to a number of factors, including an absence of government regulations, facilities and funding for technological innovation.

This research aims to give a description of solar possibility, forecast solar electricity's future, and pinpoint the factors that would facilitate the rapid acceptance and spread of solar energy systems in the Indian environment. The remainder of the article is organised into three sections: the next part provides a quick summary of solar power's possibilities and its anticipated contribution to India in the years to come. The

different requirements for solar energy usage in India are covered in Section 3. The final portion concludes with recommendations for next study directions.

2. India's Solar Energy Capabilities and Prospects

India's electricity output has increased significantly, but the country's rapidly growing population is likewise driving up demand for power [5]. India, a developing nation with an estimated population of more than 1.3 billion, has an economy that is expanding quickly. For sustainable growth, closing the gap between supply and demand for electricity is essential. India now generates 72% of its electricity from coal, and by 2050, it is predicted that all of its coal resources would have been used [6]. As stated by Sable (2017) [5], a significant quantity of fossil fuels must be imported in order to fulfil the nation's rising energy consumption. The majority of people in the nation—roughly 70%—live in villages, and over half of those communities are still without electricity [7].

The use of solar power systems can remove reliance on coal-fired power facilities. India's location—between 8 040 and 37 060 north latitude and between 68007 and 97 250 east longitude, north of the equator—makes it advantageous to use solar power. India receives 5,000 trillion kWh of sunshine per year, far more than the country's total annual use and average world exposure of 4-5 kWh per square metre. Solar energy can be extremely important for achieving energy sufficiency at the federal and state levels, in the words of Jamil et al. [3]. Solar Photovoltaic (PV) technologies are very reliable sources of power for a wide range of home and business purposes. Design, production, setup, and upkeep of solar energy equipment are among the economic and social prospects created by small-scale solar photovoltaic (PV) technology. The solar system is likewise unaffected by financial uncertainty and disputes.

To address the issue of global warming, the Jawaharlal Nehru National Solar Mission (JNNSM) was created in 2010 as an element of the "National Action Plan on Climate Change 2008". Eight expeditions were used to carry out the strategy's many components, with an emphasis on clean energy being one of them [8]. The use of solar energy in the form of solar chargers, lights, water heaters, and the establishment of Asia's biggest Solar Park in Gujarat has been facilitated by technological advancements in India.

As of the last day of the 2nd half of 2020, India was producing about 36GW of solar electricity. The National Solar Mission's goal of producing 20GW of solar electricity by 2022 has already been surpassed ahead of schedule. With broad implementation targets, long-term policy, rigorous R&D, and regional production of materials, components, and products, NSM seeks to reduce the expense of the production of solar energy. It is projected that grid tariff equality will be reached by 2022. The situation necessitates a rapid and significant increase in the installed generating capabilities [9]. Solar panels on roofs and panels over waterways were both built to get around the problem of the enormous space required for solar power system assembly. India's solar power systems will continue to expand rapidly during the coming ten years. Indian experts have just put up a really creative use for solar energy. Arora et al. [10] talked about the technical layout, manufacture, marketing, and use of solar study lights that were created to help students in four Indian states with their schoolwork, night studies, preparing for exams, and various other educational programmes. In Udaipur, Rajasthan, India, a Concentrated Solar Power plant was constructed and its efficacy was assessed by Bishoyi and Sudhakar [11]. In the Indian Humid Subtropical Climatic Region, solar radiation has been detected by Jamil et al. [3]. The possibility of solar process heating was evaluated by Sharma et al. [12], taking the Indian paper making sector into consideration. A summary and debate of the solar energy applications for milk pasteurisation were given by Panchal et al. [13]. In-depth research is being done on the nation's potential for producing and distributing solar electricity.

3. Factors Influencing Deployment of Solar Energy

Reduction in cost of solar power generation

The past few years have seen a sharp decrease in the cost of setting up and commissioning solar energy systems, as large-scale solar installations are being pushed by market dynamics and government initiatives. Because of the decrease in production costs, it is now feasible. The cost of solar panels and inverters has gradually decreased. Photovoltaic panels, a major component of solar power systems, have grown by 30% in the past year. The consumer is unable to invest in a solar system due to its costly installation [14].

Solar potential converging in different states

Convergence of the solar potential throughout India's states is required to fulfil the government's solar energy objectives. The National Institute of Solar Energy (NISE) computes India's state-by-state solar potential using information from the India Waste Land Atlas. Three percent of a state's landfill space has been contemplated for solar power initiatives. Sunshine is abundant in states like Rajasthan and Gujarat, but the southern area is seeing a rapid increase in the construction of solar power facilities. Karnataka state has the most operational solar power producing capacity in the nation, as reported by Mercom Indian Solar Power Tracker.

Development of standards

The growth of solar power is being supported by extensive rules and regulations developed by the Ministry of New and Renewable Energy (MNRE). Large-scale solar power projects in recent years have led to the creation of standards of procedure for suppliers of services, the introduction of producers to international norms, and the training of professionals in implementation techniques. Standards for the manufacture and quality assurance of solar collectors made of flat plates and other related components have been developed by the Bureau of Indian Standards (BIS). There are five locations with equipped research facilities, comprising Ahmedabad and Indore, to test the instruments. In order to lower installation costs, PV systems must be standardised.

Improvement in expected performance

Increasing panel efficiency over time is essential to boosting the solar business's profitability. The capacity of photovoltaic cells to transform sunlight into energy is represented by the panel efficacy. Just over one percent of the earliest solar cells produced in the 1800s were efficient, making them unsuitable as sources of energy. Bell Labs created the first practical solar panel in 1954, and it had an efficiency of around 6%. Solar photovoltaic (PV) technology has advanced quickly since then. Currently, solar panels may be produced with an efficiency of close to 30%. Quality standards and product quality have significantly improved, as noted by professionals. Consumer worries regarding reliability, effectiveness, resilience, and intricacy have all been sufficiently handled. By improving performance and sending regular reminders to potential customers regarding this, PV purchases may be made more appealing. Customers ought to be shown open initiatives to facilitate greater interaction.

The improvement of planning engineers' proficiency and understanding of complicated systems

Planners that are knowledgeable about solar technology will suggest photovoltaic for structures that are new or already in place. Technology fusion may be severely hampered by the lack of planning engineers' experience and understanding for intricate systems and numerous installers [15]. If a product isn't set up correctly, even of the highest calibre might cause issues. The low annual installation over the past 20 years has been partially attributed to a lack of trust and knowledge. Therefore, a solid foundation of

understanding and expertise must be developed before solar photovoltaic technology may be widely applied.

Availability of trained and competent installers in most markets

For the solar revolution to be successful, installation and auditors must be skilled, certified professionals. Enhancing one's actual understanding and expertise in a field requires training. It is necessary to have specialised training programmes and workshops in order to adequately teach engineers and expert installers. Online courses and training programmes on solar power construction and design are being launched by several universities [15]. As a result, the market now has access to a pool of skilled and qualified installers. In order to properly design and build a complete solar PV array, the GoI established the Centre for Energy Studies, whereby both basic and advanced training in solar energy, encompassing the physics and idea underlying photovoltaic, is taught.

Pay attention to R&D (research and development) initiatives

Even with technological advancements, ongoing research and development is necessary to lower the cost and increase the trustworthiness of solar systems. This may be accomplished by making improvements to the installation instruments substance, and layout. The National Solar Mission has worked to accelerate ongoing research and development on various solar photovoltaic technology elements in an effort to reduce costs and enhance system efficiency and effectiveness.

A number centres of excellence have been established by GoI in its pursuit of superiority in solar power-related advancement and research. These include the National Centre for Photovoltaic Research and Education (NCPRE) at IIT Bombay, which focuses on education and training in Crystalline Si solar cells, and the Centre for Environmental Planning and Technology (CEPT) in Ahmedabad, which studies solar apathetic design and green construction techniques.

Applicability in comparison to other green power sources

The anticipated expenses and outcomes can be met with the available technology. When comparing an individual's solar power system with different inconsistent renewable energy frameworks, the yearly particular performance has risen. The environmental effect of producing electricity with solar power is minimal when compared to other renewable energy sources. Solar power from an electrical transmission infrastructure may efficiently meet the summertime peak demand for electricity. Since the quantity of installed solar panels significantly impacts a solar system's producing capability, solar technology use is both modular and flexible. Solar energy apparatus has an extended longevity, unlike hydro and wind energy, which have intricate elements that need regular maintenance. Using solar energy, an expected outcome may be guaranteed; however, this isn't the situation with wind energy, that can produce inconsistent results in some locations [7]. When it comes to setup and upkeep, solar equipment is often less complicated than hydroelectric and wind energy generating devices.

Financial incentives and subsidies

One of the biggest obstacles to household solar systems is their high start-up expenses and lengthy payback period [15]. Due to the high upfront cost combined with little income and the long repayment times, solar energy devices had a significant related risk of creditworthiness up until ten years ago [16]. GoI has begun providing a number of incentives to promote the sector's expansion in the hopes that rising renewable energy technology would perform better and become less expensive. The Remote Village Electrification Programme has been awarded a larger amount of funding with the goal of electrifying the unconnected Indian communities. The relevant state government agencies are responsible for covering the entire cost of the solar array for the below-poverty-line (BPL) community [17].

After ten years of work, which included funding programmes for companies involved in the installation and commissioning of solar power plants on large buildings, it is true that a majority of the stated accomplishments are linked to some form of state or federal support. Government subsidies not just lower upfront costs but additionally increase citizens' willingness to switch to solar power, indicating that technology is sound and that the acceptance of solar power is important for everyone's health.

Knowledge of the technology's present state and future prospects

Diffusion may be severely hampered by ignorance [16]. It is necessary to increase customer confidence and understanding of solar power systems' potential and related benefits. The Indian public's ability to disseminate knowledge is deficient. Extensive technology demonstration on suitable platforms can provide significant outcomes. One of the most important aspects of comprehensive assistance approaches to market rollout might be the development of skills and education programmes [14]. In addition to technical issues, marketers and salespeople ought to undergo knowledge and instruction so they can defend the use of technology to prospective clients. In order to actively include solar capacity in the construction of new structures, it is just as crucial for individuals and commercial institutions to raise knowledge.

Sunlight energy absorption with current power systems

The GoI must investigate integration-related issues that state and national grid operators are facing if it is to aggressively carry out its National Solar Mission by 2022. This integration necessitates methodological methods to solving problems, such as centralised control and adaptable power plant operation, improved predictions for the output of renewable energy, enrichment of the functional practices and instruments, and technological improvement [2]. Sweden and Denmark are two prominent examples of nations that have integrated and implemented renewable energy generating.

The accessibility of knowledgeable workers for upkeep and repairs

For solar energy to be widely used as a renewable energy source, dependable set up, upkeep, and inspection assistance must be readily available. Even though solar power systems are supposed to be very reliable, maintaining and repairing solar power equipment still requires a staff with the necessary technical and industrial capabilities. The potential of the educational system to adequately teach people in new technologies will lead to a supply of competent workers for upkeep and repair.

Possessing adequate space to install solar panels so that power may be produced

India's climate and architectural design lend themselves to the utilisation of solar energy. There is a common argument that installing a solar plant with solar panels takes up a significant amount of land that cannot be used for other reasons for several years. Mega solar power plants are being planned to be installed on wastelands and deserts. Structures provide solar cell space on their roofs. Therefore, the broad adoption of solar power has been enhanced by the accessibility of rooftop space. India has set a target of building 100 GW of solar power generation by 2022, of which 40 GW will be rooftop solar PV systems linked to the grid [18]. Several states have mandated the usage of solar electricity by commercial companies based on suggestions given by the GoI. In response, solar electricity has been installed on rooftops by state government buildings, hotels, engineering institutes, and various other businesses.

4. Conclusion

The aim of this study is to determine the critical factors that might facilitate the rapid uptake and spread of solar power systems in India. Thirteen factors were found to be facilitators of the adoption and spread of solar power in India after a thorough analysis of literature as well as interviews with subject matter experts.

To improve the model's comprehension or applicability, more investigation is needed. Experts from academia and business provided the replies for the present investigation. Future studies can be extended to include consumer feedback on environmental and social issues as well as environmental elements. Subsequent investigations may enhance other elements and sub-elements that may impact the business decision-making procedure in the developing domain of solar energy production in India.

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