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Recognition and prioritization of challenges in growth of solar energy using analytical hierarchy process: Indian outlook

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ABSTRACT

The growth of solar energy in India has not reached to satisfactory level due to several challenges faced in its developmental path. To address these challenges, firstly it is imperative to recognize the barriers of solar energy implementation. Therefore, the present investigation aims to identify and prioritize the barriers existing in the developmental path of solar power in Indian perspective using AHP (analytical hierarchy process). Among the identified barriers, "Political and Regulatory Barriers" is found to be the most influential challenge. Further, sensitivity analysis is performed in order to examine the rank stability of challenges faced by solar industry. Recommendations for the eradication of the barriers are also suggested. The present study has implication for policy planners, practitioners, researchers and academicians associated with solar industry for investigating solar perspective in India. Moreover, it can be helpful in structuring strategies for the smooth adoption of solar energy in India.

1. Introduction

Energy is the integral component for improving quality of life, economic development and wealth generation of a country. Presently, the challenges faced by the globe include- inaccessibility to clean and sustainable energy sources, rural electrification and ever increasing energy demands. 675 million people in Asia alone are unable to have access to electricity and 1.9 billion people entirely depend on biomass energy for cooking purposes [1]. India is the 7th largest country in the world with 6000 villages that occupy 72.2% of its human resources [2]. The important component for the poverty alleviation and growth of rural sector is electrifying this sector. India occupies 6th rank in the world in consumption of energy. World bank 2010 report stated that the annual growth of electricity demand of India including rural as well as urban areas is 7.4 percent [3]. In the present century, the challenging task across the globe is the supply of clean and sustainable energy [4]. UN (United Nations) has declared the year 2012 as a year of Sustainable Energy and the decade from 2014 to 2024 for the same. Keeping in view the above facts, the energy access is gaining importance among academicians and practitioners [5]. According to IEA (International Energy Agency), the development of RET (Renewable Energy Technologies) can play a pivotal role in mitigation of climate change, increment of energy security by reducing dependence on imports of fossil fuels and reduction of green house gases emissions [3,6]. Solar energy is considered to be more promising than any other RET due its innumerous benefits [6]. Few of them are stated here:

- Solar energy is clean, abundant, and economical energy source [7].
- The major source of all the energies is Sun. Heat and sunlight is primary forms of solar energy. Environment absorbs solar energy and transforms it in many ways and lead to the formation of other renewable and secondary energies such as biomass and wind energy [8].
- Solar energy plays a vital role to solve present issues such as greenhouse gas emissions and global warming [9]. It is considered as a 'Green Energy Source' [10].
- Solar energy is helpful in generating employment opportunities, diversifying the supply of fuel and in economic growth [11].

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Before using solar energy, it is first collected and converted into some useful forms [7]. In general, it is segmented into two forms:

SPV (Solar Photovoltaic) Technologies: It directly converts the solar energy into electrical energy without use of any heat engine [12].

Solar Thermal Technologies: In this solar collectors absorb irradiation as heat and transfer it to its working fluid (air, water or oil) [13,14]. It further can be used directly for heating, cooking and drying purposes.

- Since from the past solar energy has been utilized for many purposes viz. to dry animal skins and clothes, preserve meat, dry crops and evaporate sea water for extracting salt.
- Now-a-days its use is extended to lighting, cooking, solar water heaters and architecture houses; medium scale equipments include water heating in hotels and irrigation after a great research [15].
- Solar energy is utilized in refrigerating vaccines, purifying and pumping water and providing electricity in remote and rural sectors at community levels [16].
- Industrial scale uses include- pre-heating boiler water [17], generating power [12], detoxification [18], municipal water heating [19], telecommunications as well as transportation [12,20].
- SPV has proved to be more labor oriented than other RET so it is considered that it will create approximately four folds more employment opportunities as compared to wind farms or biomass power plants [21].
- An ordinary middle class family can save Rs 1100–1500/- on monthly electricity bill by installing 2 KW rooftop SPV power equipment costing one Lakh. Indeed, this investment can be recovered in four to five years [22].

As per MNRE (Ministry of New and Renewable Energy), India receives 5000 trillion kWh of solar energy annually [9]. The Data of IMD (Indian Meteorological Department) indicates that India has approximately 250–300 sunny days annually. It is evident from MNRE data that Rajasthan and Gujarat are the states which receive highest global radiation [11]. Sensing vast untapped potential of solar energy, it is evident that it can act as catalyst to achieve green energy solution, accessibility to clean and sustainable energy, rural electrification and energy security issues to achieve the mission of "Make in India" and digital life. There is just the need to recognize and exploit it for useful applications. Despite of its several promotional efforts in India for a long time by government sponsored R&D (Research & Development) and production facilities, it has not been able to reach to the large-scale and grass root levels. Hence its contribution in country's total electricity generation capacity was negligible up to 2009. Therefore, in an effort to increase its penetration in market, the GoI (Government of India) introduced JNNSM (Jawaharlal Nehru National Solar Mission) under the NAPCC (National Action Plan on Climate Change) in November 2009 [23]. With this green energy initiative, India has taken a strong step towards the implementation of solar energy. Reviewing the sufficient past studies on solar energy, certain research gaps are observed. These gaps necessitate the need of present research. The forthcoming section discusses the need and motivation for carrying out present study.

1.1. Motivation for present investigation

Since the last two decades, global climate changes and security of energy supplies have received much attention worldwide [24]. Many scientific studies have revealed that the present level of CO_2 in the environment is 31% more than level before 200 years [8]. WHO (World Health Organization) statistics reveal the death of 1,60,000 people annually due to climate disturbances and it may get two folds by 2020 [17]. Moreover climate changes cause several natural calamities also such as flood and drought etc. Realizing the alarming situation, the international community is focusing towards the reduction of greenhouse gases emissions and handling the climate change [24]. In reality, the adoption of alternative energy sources is the key solutions to these issues. However a lot of barriers are prevalent which prevent the investment and diffusion of RES (Renewable Energy Sources) [24,25]. Form the literature survey; it has been observed that many scholars and practitioners have reported the barriers of RES including solar energy. Some of the studies relevant to present investigation are summarized below:

- Painuly et al. (2001) presented a framework for the identification of barriers in RET and suggested some measures for overcoming these barriers. In this study, market imperfections and its distortions, economical and financial, institutions and technology related, social cultural and behavioral barriers in the penetration of RET is presented [26].
- Martinet et al. (2004) has identified the various barriers of RES such as cost and pricing; legal and regulatory; and market performance etc. This study concluded that the existence of barriers put the RES economically, institutionally and regulatory disadvantage in comparison to other energy sources and presented some promotional policies also which might support its diffusion in near future [25].
- Reddy et al. (2004) conducted survey in Maharashtra state of India among households, industrial and commercial personnel; and policy experts for identifying barriers in diffusion of RET. Authors have identified economical, technological, market and institutional barriers on dissemination of RET in India and ranked these barriers on the basis of perceptions of various stakeholders [27].
- Margolis et al. (2006) discussed some non-technical barriers in relation to solar energy usage such as awareness issues, government policies issues, inadequate financing options and workforce etc. Authors have recognized barriers of various SET (solar energy technologies) such as SPV, solar thermal, PV (building focus and utility focus), building integrated PV, solar domestic hot water systems and some other RET also [28].
- Timilsina et al. (2011) observed economical, technical and institutional barriers in the development of SET and further presented key policy instruments that support the penetration of solar energy [29].
- The research studies conducted by Kapoor et al. (2014) has listed several potential issues of solar energy sector in India like technical, policy and regulatory, socio-economic and institutional. It also discusses the government initiatives taken for the adoption of SET [30].

It is obvious from literature survey that studies regarding the barriers of SET are available but studies which deals with analysis of barriers to find the priority or rank or intensity of the barriers are missing. A few of the studies which emphasize the analysis of barriers is as follows.

- Ansari et al. (2013) has attempted to categorize the barriers of solar energy in India on the basis of dependence and driving powers by using ISM (Interpretive Structural Modeling) technique and used MICMAC analysis for its validation [31].
- Luthra et al. (2015) ranked the barriers of renewable or sustainable energy adoption in India. It further uses sensitivity analysis for the model verification [32].