Renewable and Sustainable Energy Reviews 62 (2016) 70–88

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Identification and analysis of barriers in implementation of solar energy in Indian rural sector using integrated ISM and fuzzy MICMAC approach

Sonal Sindhu [a,*], Vijay Nehra [a,1], Sunil Luthra [b,*]

[a] Department of Electronics and Communication Engineering, Bhagat Phool Singh Mahila Vishwavidyalaya, Khanpur Kalan 131035, Sonepat, Haryana, India
[b] Department of Mechanical Engineering, Government Polytechnic, Jhajjar 124103, Haryana, India

ARTICLE INFO

Article history:
Received 11 June 2015
Received in revised form
20 March 2016
Accepted 16 April 2016

Keywords:
Solar energy
Indian rural sector
Barriers
Integrated model
Interpretive Structural Modeling (ISM)
Fuzzy Matriced' Impacts Croise's Multiplication Applique´e a UN Classement (FMICMAC)

ABSTRACT

Energy is the key component in social and economic development of a country. It plays a pivotal role in building the nation and accomplishment of the missions such as "Make in India", "Swachh Bharat Mission", "Start-up India", "Digital India" and "Agricultural Sustainability". Indeed, more than 70% of Indian population resides in rural sectors and agricultural outcome being their only source of income. Deprivation of energy in rural sector and increasing energy demands in urban area is compelling India to exploit Renewable Energy Resources (RES) and reduce usage of fossil fuels. Solar power installations play a pivotal role in this direction. Although efforts are underway for solar energy implementation in rural India but still Renewable Energy Technologies (RET) lack popularity due to various obstacles that hinder its diffusion at grass root level. In this context, barriers of solar power installation in Indian rural sector have been recognized using extensive literature survey and experts' input.

In the present investigation, Interpretive Structural Modeling (ISM) methodology integrated with fuzzy MICMAC is utilized to identify the interrelationship among the identified barriers. Moreover, rankings of the identified barriers have also been obtained. 'Social and Environmental barriers' have been identified as dependent barriers while 'Marketing and Policy barriers' emerged out as independent barriers which needs to be addressed. The developed integrated structured model will be beneficial in understanding the interrelationship and dependencies among the identified barriers in the diffusion and adoption of solar energy in Indian rural sector.

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Abbreviations: RE, renewable energy; PV, photovoltaic; RES, Renewable Energy Source; RET, Renewable Energy Technologies; JNNSM, Jawaharlal Nehru National Solar Mission; MNRE, Ministry of New and Renewable Energy; BOS, Balance of System; GoI, Government of India; NISE, National Institute of Solar Energy; SEC, Solar Energy Centre; SET, Solar Energy Technology; R&D, Research & Development; ICT, Information Communication Technology; EVA, Ethylene Vinyl Acetate; PMMA, Poly Methyl Meth Acrylate; ISM, Interpretive Structural Modeling; CSP, Concentrated Solar Power; SHS, Solar Home System; MICMAC, Matriced' Impacts Croise's Multiplication Applique´e a UN Classement; FMICMAC, Fuzzy Matriced' Impacts Croise's Multiplication Applique´e a UN Classement; IREDA, Indian Renewable Energy Development Agency; NGO, Non-Governmental Organization; NAPCC, National Action Plan on Climate Change; SERAC, Solar Energy Research Advisory Council; NASA, National Aeronautics and Space Administration; SSIM, structural self-interaction matrix; DRM, direct relationship matrix; FDRM, fuzzy direct relationship matrix; IPCC, Intergovernmental Panel on Climate Change; SEM, structural equation modeling; SDM, System Dynamics Modeling; AHP, Analytical Hierarchical Modeling; ANP, analytical network process; IRP, interpretive ranking process; IM, interactive management; GUI, Graphical User Interface

* Corresponding authors. Tel.: +9466594853.
E-mail addresses: sonalpunia8687@gmail.com (S. Sindhu), nehra_vijay@yahoo.com (V. Nehra), sunilluthra1977@gmail.com (S. Luthra).
[1] Tel.: +91 9255229582.

http://dx.doi.org/10.1016/j.rser.2016.04.033
1364-0321/

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1. Introduction

Mahatma Gandhi has rightly said “India lives in its villages”. India is a country having dwellings of 6,00,000 villages [1]. Indeed, a large part of India's population resides in rural areas and constitutes 72.2% of its human resources [2]. It is assessed that India's almost 1,25,000 villages suffer from major shortage of electricity throughout the year out of which 18,000–24,500 villages are classified in extreme remote category that may lack electricity supply from the grid in the near future also [2]. The lack of access to utility grid by the population in rural and remote areas seems to be primary impediment to overall development [3]. Consumption of energy in a country or region indicates prosperity and standard of living of its population [4]. After so many years of independence and development, basic energy services like electricity is still far from reach of 2 billion people in rural India [5–7]. Availability and use of energy is crucial for poverty alleviation, social up gradation of rural India, e-governance and addressing of digital agriculture sustainability in digital era [8]. The access of energy will surely lead to development and “no country so far has managed poverty alleviation without increasing energy access” [9]. At the same time for ensuring sustainable development, continuous supply of clean and affordable Renewable Energy Sources (RES) is mandatory to avoid further environmental degradations [8]. Although appreciable growth has been taken place in power sector yet India is facing severe electricity shortage due to increasing demand of energy on daily basis. So, supply of electricity should also increase at higher rate to pace with current and projected demands.

It is the prime responsibility of government to supply energy services to the concerned population. In order to achieve this objective, development of renewable energies can play a crucial role. By developing environmental friendly RES, the goal of sustainable development would also be achieved [10]. In fact, by escalating solar energy implantation, developing countries like India would also get other incentives like neat, clean and green environment, independence of energy, new opportunities of