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Review of barriers to the dissemination of decentralized renewable energy systems

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ABSTRACT

This paper reviews the available literature dealing with the barriers to the dissemination of decentralized renewable energy systems. Decentralized renewable energy systems may face a range of technical, economic, institutional, socio-cultural and environmental barrier to their dissemination. In the paper, barriers impeding the dissemination of decentralized renewable energy systems have been identified and assessed. In addition, appropriate remedial measures and corresponding responsibility centers as reported in the literature have also been discussed.

Inappropriateness of technology, unavailability of skilled manpower for maintenance, unavailability of spare parts, high cost, lack of access to credit, poor purchasing power and other spending priorities, unfair energy pricing, lack of information or awareness, and lack of adequate training on operation and maintenance of decentralized renewable energy systems are found to be the most critical barriers. Long-term conducive policies, appropriate regulatory framework, financial incentives (capital subsidies and soft loans) to users, technology and skill development, internalization of externalities in the cost of energy, withdrawal of subsidies presently being given to fossil fuels, development of specialized institutions, cooperation with international agencies, participation of local community and awareness generation have been recommended for increased dissemination of decentralized renewable energy systems.

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1. Introduction

In view of energy security and climate change concerns, governments and policymakers are promoting increased dissemination¹ of renewable energy technologies. Increased share of renewable energy in the overall energy mix of countries would help the cause of sustainable development. Renewable energy systems are broadly classified into two categories: i) centralized renewable energy system; ii) decentralized renewable energy system (DRES). DRESs such as solar lantern, solar home system, family-type biogas plants, improved biomass cookstoves, etc. have been disseminated worldwide for improving access to energy of the rural households [2]. DRES is also an appropriate option for electrification of remote households located in difficult terrains (islands and hills) that may not be technically and financially feasible through grid extension [3]. Large-scale diffusion and utilization of relatively newer technologies such as DRESs face barriers. These barriers may put DRESs at a technical, economic, regulatory or institutional disadvantage in comparison to conventional energy systems [4]. Sometimes, the barriers may have inter-linkages that can have cascading impact on the diffusion of DRESs [4]. Hence, to accelerate the diffusion of DRESs, it is vital to understand the barriers and their inter-linkages. This would enable the policymakers and the implementing agencies to formulate plans and implement them in a more effective manner.

Based on a review of published literature on barriers and relevant aspects, this paper identifies the barriers to the dissemination of DRESs and classifies them based on their characteristics. It also suggests remedial measures to overcome them for enhanced diffusion of DRESs.

2. Identification and classification of barriers to the dissemination of DRES

A barrier to the dissemination of a DRES may be defined as a factor that negatively affects its adoption and subsequent utilization which hampers its widespread diffusion [5]. Barriers to the dissemination of DRESs may often include technical, economic, institutional, socio-cultural or environmental aspects. In this study, barriers pertinent to the diffusion of DRESs have been identified. In addition, relevant research papers have been cited to highlight the impact of barriers on the diffusion of various DRESs across different regions of the world (Appendix). The identified barriers have been classified under five broad categories depending on the characteristics of the barrier: technical, economic, institutional, socio-cultural and environmental (Table 1). The following sections present a discussion on the categories and subcategories of barriers. For each barrier, all the sub-barriers that have reportedly affected the dissemination of one or more DRESs at different

regions of the world have been discussed along with few examples to present a panoramic view of the barrier. In subsequent sub-sections, the impact of sub-barriers on the dissemination of various DRESs in different regions of the world have been discussed with several examples to support the narrative. In addition, for each barrier and its sub-barriers, the remedial measures recommended to overcome them have been discussed that may help the policymakers to frame policies for accelerated diffusion of DRESs in various parts of the world.

2.1. Technical barriers and remedial measures

Technical or technological barriers to DRESs generally include barriers associated with resource, technology and skill attributes of the system that prevent the utilization from reaching its theoretical potential [6]. Technical barrier has been widely reported as a critical barrier affecting the diffusion of DRESs [5,7–48]. Technical barriers include sub-barriers pertaining to the following: (a) resource availability; (b) technology – design, installation and performance; (c) skill requirement for design and development, manufacturing, installation, operation and maintenance. A brief summary of the published literature reporting different aspects of technical barriers affecting the adoption of DRESs is presented in the following paragraphs.

2.1.1. Resource availability

Renewable energy resources (particularly solar and wind) are intermittent and/or variable in nature. Other renewable energy sources such as biomass and hydro may be inadequate at times to support capacity utilization of respective technologies at economical levels. Because of this intermittency and/or inadequacy, resource availability has been cited widely as an important barrier [12,17,20,24,28,34,35,43–45,49–54]. For example, a study has concluded that lack of resource availability is an important barrier to the diffusion of DRESs such as family-type biogas plant, box-type solar cooker, domestic solar water-heater, and solar photo-voltaic lantern in India [49]. In Turkey, uncertainty with respect to solar resource availability is reported to be hampering the adoption of solar water heaters [34]. Similarly, resource availability issues such as seasonal fluctuation of wind have been reported as barriers to diffusion of wind installations in the Dodecanese islands (Greece) [35]. Thus, it can be inferred that inadequacy and intermittency associated with renewable energy make resource availability an important factor to be considered for the dissemination of DRESs.

2.1.2. Technology – design, installation and performance

Generally, solar, wind and biomass powered renewable energy technologies suffer from lower energy flux (energy output per unit floor area) as compared to fossil fuel fired technologies [34]. Additionally, the intermittent nature of renewable energy sources necessitates usage of energy storage devices to improve the energy dispatch ability of concerned renewable energy technologies (RETs) which further puts them at a disadvantage [34,35,41,43,50].

¹ Some authors restrict the term 'diffusion' to the spontaneous unplanned spread of ideas or innovation and use the concept of 'dissemination' for diffusion that is directed and managed. However, several studies have used them interchangeably [1]. In this study, these terms have been used interchangeably.

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