Energy Research & Social Science 48 (2019) 1–12

Contents lists available at ScienceDirect

Energy Research & Social Science

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

Original research article

Multi-scalar energy transitions in rural households: Distributed photovoltaics as a circuit breaker to the energy poverty cycle in India

Prabhakar Yadav[a,*], Yuwan Malakar[b], Peter J. Davies[a]

[a] Department of Environmental Sciences, Macquarie University, NSW, 2109, Australia
[b] Centre for Communication and Social Change, School of Communication and Arts, Energy and Poverty Research Group, UQ Energy Initiative, The University of Queensland, St. Lucia, Brisbane, QLD, 4072, Australia

ARTICLE INFO

Keywords:
Decentralised electrification
Solar photovoltaic system
Multi-level perspective
Energy transition
Enabling policies
Rural communities

ABSTRACT

A transformation in energy structures and governance models are required to meet the needs of communities living in rural and remote areas and particularly for those subject to energy and economic poverty. New models must be reflexive to global climate concerns, align with social, economic and environmental agendas of national, state, and local governments, and be compatible with embedded energy infrastructure. Decentralised solar solutions are a resilient technology which can support energy transformation to spatially, economically and socially disadvantaged communities yet the deployment of this technology is hamstrung by path dependencies including policy frameworks, business models and infrastructure. In this study, the multi-level perspective has been used to examine energy transformation within rural and remote communities in India through interviews with regime and niche level actors. We identify various barriers impeding successful deployment of decentralised solar PV including a disconnect between policy makers and implementers, poor coordination within and between actors, and limited institutional focus and competence. To support a successful transition to off-grid solar based regimes for rural and remote communities, participants suggested strong political determination, setting enabling policy frameworks, and implementing a collaborative ecosystem with businesses, system suppliers, financial intermediaries, distribution companies, civil society and end users.

1. Introduction

India is committed to transforming its electricity system with a goal of providing power to all by 2019 [1]. This policy builds on previous commitments by the national government that has provided electrification to 500 million people since the year 2000 and has seen a two-fold increase in access to electricity between 2000 and 2016, rising from 43% to 82% of the population respectively [2]. The complexity of the electricity landscape is embedded within the country's socio-political context and technical infrastructure. 276 million people (23% of the population) live below the poverty line [3] and 70% of the generated electricity is sourced from centralised coal-fired power stations [4]. This 20th century electricity generation and distribution infrastructure has inherent challenges and embedded inertia to meet 21st century social, environmental and economic challenges [1].

To address the current energy challenges, India has three fundamental objectives to support a rapid shift to non-fossil fuel based electricity generation. First, to deliver on its commitments under Nationally Determined Contributions (NDCs) and contribute to global efforts in limiting mean temperatures under 2° [5]. Second, to reduce its reliance on coal for electricity generation, which translates into emissions intensity higher than the global average [6,4,7]. Third, to address the challenge of crippling energy poverty by extending modern energy access to 239 million people who rely on kerosene for lighting [2,8].

The International Energy Agency (IEA) has projected that decentralised solutions can serve half of the new and required electricity connections and this will be the most cost-effective option for 70% of the population in rural areas [2]. Many researchers have also proposed that the conventional grid-based electricity supply model need to be complemented with off-grid renewable energy sources to alleviate enduring energy poverty [9–12].

India's policymakers recognise the role of renewable energy. Past

Abbreviations: DDUGJY, Deendayal Upadhyaya Gram Jyoti Yojana; DISCOMs, distribution companies; JNNSM, Jawaharlal Nehru National Solar Mission; MLP, multi-level perspective; NDCs, Nationally Determined Contributions; MNRE, Ministry of New and Renewable Energy; PV, photovoltaic; RESCO, Renewable Energy Service Company; SDG, Sustainable Development Goals; SE4ALL, Sustainable Energy for All; UP, Uttar Pradesh

* Corresponding author.
E-mail addresses: prabhakar.yadav@hdr.mq.edu.au (P. Yadav), y.malakar@uq.edu.au (Y. Malakar), peter.davies@mq.edu.au (P.J. Davies).

https://doi.org/10.1016/j.erss.2018.09.013
Received 17 January 2018; Received in revised form 14 September 2018; Accepted 20 September 2018

Table 1
Barriers to scaling up decentralised solar PV technologies in India. Source: [16–24].

Type	Key barriers
Policy and regulatory	Ambiguous regulatory framework
	Preference to centralised grid based rural electrification model
	Lack of provisioning for decentralised solutions in mainstream electrification
Financial	High installation cost
	Low affordability
	Competing spending priorities
	Financial risk perception
Technical	Limited confidence in technology due to quality and performance issues
	Unreliable maintenance
	Skill requirement for installation and maintenance
Institutional	Less developed/specialised institutional infrastructure
	Ineffective monitoring and implementation
	Lack of coordination between various stakeholders
	Administrative delays in approval
Social	Limited understanding of needs and social values
	Limited awareness
	Risk perception
	Mistrust in the technology

and current energy policy has supported, to varying levels, deployment of renewables for electricity generation, along with the continuation of conventional coal-based systems. Nationally, India has a plan to generate 175 GW of electricity from renewable sources by 2022 [13]. The majority of this new supply is to be sourced from large-scale grid-connected solar plants supporting the main grid. Arguably, this approach undermines the emergence of a decentralised energy sector [14]. In addition, the renewable energy sector faces significant impediments due to multi-dimensional barriers (Table 1) [15] including those associated with the poor scaling-up of decentralised solar PV systems.

Despite limited national and state government focus on decentralised solutions, various private sector-led clean energy initiatives have begun to address the energy poverty by supporting basic solar lighting for poor households and communities. To-date, such initiatives have been unable to gain sufficient traction to upscale [25] due to less developed value chain (marketing and distribution), as most of the enterprises are startups operating on limited capital and other funding resources [26,27]. These enterprises and their associated business models and services must also: compete with the embedded infrastructure, operate within changing and uncertain policy landscape, the national government's current priority to extend the electricity grid (as a centralised distribution network) and overcome customers' expectations of an entitlement to free or highly subsidised electricity. Therefore, with the emergence of low cost distributed technologies, there is an opportunity to rethink and reposition off-grid solar power based energy as a key element in India's energy transition. However, this requires political confidence in new technologies, a commitment to greater collaboration between the private and public sectors [28], and a need to establish integrated systems that support both centralised and decentralised approaches [29] as elements that are particularly relevant for rural and remote areas [30,12].

The feasibility of solar PV to support energy transition in developing countries is an emerging and needed area of research. From a socio-political perspective it seeks to provide direction to assist 10% of the world's population that live at or below the poverty line and are caught in the energy-poverty cycle [31]. Existing studies have argued that there is a high potential to rely on solar energy as the mainstay for electricity provision within developing countries. However, the literature also identifies that few nations, or parts therein, have achieved significant success [32–36]. The research to-date has recognised the importance of financial, policy, institutional and technical aspects to prosecute the case for energy transition. However, most often the recommendations have examined energy transitions from narrower perspectives that have focused on either technology, economy, social, or political disciplines [37–39,16,40]. Also, the gap that exists in the current literature, especially in the context of developing countries, is of studies that juxtapose barriers and opportunities embedded in different levels of actors that are inherent key players in energy transition.

This study moves beyond these discipline-specific boundaries and attempts to offer interdisciplinary insights that builds on existing barriers and opportunities, as summarised in Table 1. The novelty that this paper presents is a relational juxtaposition of ideas designed to shed light on pathways for India's energy transition. In order to do so, we rely on the conceptual boundary of sustainable transitions.

Sustainability transitions are often envisioned through transformative innovations [41]. We argue that implementing new technology is complex and involves a mix of interactions and tensions among actors across multiple areas and disciplines. In this context, we adopt a 'socio-technical' perspective for this study as the theoretical framework [42]. Among socio-technical perspective frameworks, we found multi-level perspective (MLP) suitable for our analysis due to its capacity to coherently draw on effects of regime lock-in while explaining rapid and non-linear changes that lead to, or otherwise, regime destabilization from the influence of larger scale external pressures and the impact of niche innovations [43,44].

This study is focused on the Indian state of Uttar Pradesh (UP). UP is the most populous state (over 200 million people) within which half of the households are not covered by electricity networks and a large section of the population suffer from frequent and intermittent electricity supply disruptions [45,46]. The research questions are framed around uncovering options to overcome energy transition barriers to provide energy to rural and poor communities. Specifically, we ask:

1 In what ways can India's energy policy support the electrification of rural areas?
2 What are the barriers and opportunities that exist to promote electricity access through off-grid solar PV?
3 What avenues are available to harness the opportunities and overcome the barriers to ensure reliable electricity provision for rural and remote households and communities?

The study attempts to present how opportunities and barriers interact in the context of rural communities through the views and perspectives corroborated by regime level and niche level stakeholders involved in facilitating electricity access and supply. Whilst some studies have considered decentralised solar transition under the socio-technical framework in Indian context [47], we believe this study is first to present rural energy transition in India through the lens of MLP.

The rest of the paper advances as follows: Section 2 describes theoretical framework followed by the methods in Section 3, then the study results are presented in Section 4, and finally, we present discussion and conclusion in Sections 5 and 6 respectively.

2. Theoretical approach: the multi-level perspective

The MLP has been widely applied in energy transition research [48–50]. The MLP provides a valuable conceptual platform for understanding processes of energy transitions within a 'socio-technical' perspective that conceptualises the multiple interactions between policies, institutions, technologies, markets, users and user preferences [51–53]. The MLP offers an analytical and heuristic concept to understand the enablers and impediments to the socio-technical transition by unfolding influences from different levels of actors, mechanisms and exogenous factors [42,54]. A core concept of the MLP is the socio-technical transitions and structural transformations which are informed by the interplay between three interconnected analytical levels: niches, socio-technical regimes and landscape [54–57].