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RESEARCH ARTICLE

RENEWABLE ENERGY EXPORT FROM INDIAN PROSUMER TO GLOBAL CONSUMER

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ABSTRACT

The study investigates the prospects of India entering the global renewable energy market with the distributed energy generated by Indian household prosumers and commercial energy producers. The systematic review relied on a predefined search strategy, which allowed to select fifteen peer-reviewed articles in the English language for critical analysis. The study identified the following themes associated with the feasibility of the project: grid parity, economic barriers, policy targets, government support, solar and wind power development, and renewable energy certificates. The results of the study show that the number and severity of drivers for the country's participation in the global RE market overweigh barriers to it. The study provides a clear perspective on Indian prospects of participating in the global RE trade, thereby opening avenues for future inquiry.

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INTRODUCTION

Global warming is a challenge previously unknown to humanity, which should be confronted with a concerted, homogenous effort by nations around the world. In recent years, distributed energy generation (DEG) has received much attention from international scholars interested in the development of sustainable energy sources (Shrimali and Tirumalachetty, 2013). As a result of ever-increasing interest in renewable energy sources (RES), many developing and emerging economies have taken part in driving the transformation of the global energy grid (Gregoratti and Matamoros, 2015). Government agencies around the world provide strong financial assistance for companies interested in the procurement of renewable energy (RE) (Chattopadhyay, 2014). India is a country with ambitious RE objectives, which in addition to addressing the issue of climate change, also cover the problem of energy security (Shrimali and Tirumalachetty, 2013). The country's Ministry of New and Renewable Energy (MNRE) has formulated a goal of producing "20,000 MW of solar energy by 2022" (Shrimali and Tirumalachetty, 2013, p. 703). Apart from increasing local power capacity, India can help to reduce worldwide greenhouse gas (GHG) emissions by modernizing its energy sources and transforming the global energy greed. A report issued by the International Renewable Energy Agency (IRENA) shows that the country can become the fourth largest producer of RE by 2030 (IRENA, 2017). However, in order to enter the global energy mix, India has to transform its approaches to policy and technology.

In spite of the resent emphasis of energy scholars on the importance of DEG, current knowledge of the prospects of India to enter the global RE market is extremely fragmented. Therefore, the systematic literature review aims to clarify the role of the country in the expansion of the worldwide RE generation capacity. To this end, this paper will report the results of an investigation of the feasibility of India entering the global renewable energy market by utilizing DEG systems. It is essential to answer the question under the consideration because, without a radical transformation of Indian power structure, it is impossible to reach climate action targets outlined in the Paris Agreement. Unprecedented level of economic growth in developing countries especially in south and south East Asia, Middle East and North African region need increased energy consumption. Setting up of Renewable Energy Council, various financial assistance from government of India and schemes such as "Make in India" resulted in more entrepreneurs and industrialist entered into wind and solar energy production and tremendous progress in transmission technology in recent times, rising competition and lack of awareness on renewable energy in local market, renegotiation on power purchase agreements, dollar dominated tariff are some of the factors pushing Indian renewable energy producers into global energy trade.

LITERATURE REVIEW

Photovoltaic Energy Generation To better understand the issue and deduce pertinent terminology for the study, it is necessary to review the extended literature on the topic. Several recent studies have discussed the state of photovoltaic (PV) energy

generation in India. According to Khare, Nema, and Baredar (2013), the country had 240 MW worth of PV capacity in 2013. Currently, PV-based DEG systems produce energy for the use in heating, ventilation, and air-conditioning (HVAC) applications (Khare *et al*., 2013). However, to further diminish the number of conventional energy sources in the country's energy greed, it is necessary to improve grid parity of its RES. Grid parity refers to "the tip at which the cost of generating electricity from alternative energy becomes equal to or less than the cost of purchasing power from the grid" (Khare *et al*., 2013, p. 4). Grid parity analysis conducted by Breyer and Gerlach (2013) suggests that India is a country that can soon achieve this state because it has high electricity prices and intensive solar irradiation. The scholars argue that an overall share of commercial and prosumer PV energy generation can exceed 20 percent by 2020 (Breyer and Gerlach, 2013). This positive dynamic indicates that renewable investments can both confer enormous economic benefits on India and reduce the country's GHG emissions. Distributed Energy Trading Distributed energy trading is an effective method for decentralizing energy production, thereby increasing the flexibility of a local, regional, or global power grid. The effectiveness of local RES has been demonstrated by numerous studies on massive power outages in Europe (Gregoratti and Matamoros, 2015).

Due to disadvantages of macro energy generation such as a lack of flexibility, low precision, and ineffectiveness of storage units, governments around the world explore the possibility of supplementing their power grids with prosumer microgrids. According to Gregoratti and Matamoros (2015), benefits of microgrids include, but are not limited to, the reliability of power supply, scalability, investment dissolution, and ancillary services. These are nontrivial qualities of decentralized energy production that can ameliorate the issue of energy security in India. Smart Grid In order to implement distributed energy production in India, its power infrastructure has to be completely transformed to facilitate the introduction of multiple power micro-units. To this end, conventional energy grids have to be replaced with new power systems or Smart Grids (SGs), which are capable of aggregating and distributing power produced by commercial and prosumer RES (Hossain *et al*., 2016). Such systems are already utilized in India, Canada, the US, and Japan among other countries (Hossain *et al*., 2016). The innovative use of SGs revolves around Virtual Power Plants (VPPs) or automated electric systems that aggregate "interconnected DGs placed in different locations by managing them to work as a unique power plant" (Aghaei and Alizadeh, 2013, p. 66). Demand Response In order to understand the demand side of commercial and prosumer global RE trading, it is necessary to review triggers of RE consumption. A study by Aghaei and Alizadeh (2013) shows that all demand response programs are driven either by economy, environment, or network. Economic-driven demand is focused on the reduction of energy supply costs and mitigation of price volatility through the use of flexible prosumer and commercial RE producers. Environment-driven triggers are environmental and social considerations of the use of GHG emitting energy sources. Network-driven demand arises from the concerns about system reliability and capacity. All governmental initiatives focused on energy efficiency augmentation are based on these demand triggers (Aghaei and Alizadeh, 2013). When it comes to drivers of DEG in India, the country's widespread energy scarcity is the most important trigger of the change (IRENA, 2017).

A large body of academic literature on the topic points to the fact that the current state of the country's energy security necessitates the development of solar and wind energy farms (Chandel, Shrivastva, Sharma, and Ramasamy, 2016; Gunatilake, Roland-Holst, and Sugiyarto, 2014). The commitment to transform its current power grid is underscored by RE targets outlined by ministry of new and renewable energy (MNRE). The triggers for DEG implementation in India differ from those in European and North American countries. For example, during the following decades, population and income levels are expected to grow faster in India than in Germany and the US. It is projected that the country's population will experience an 18 percent increase by 2030, which will put a strain on its energy system (IRENA, 2017). A rapid rate of population growth requires the creation of more than ten million jobs each year (IRENA, 2017). Therefore, India's need for renewable and affordable energy exceeds that of other countries.

Neighbourhood RE Trading Currently, the Indian power grid is based on a hundred-year-old electricity generation paradigm (Ilic, Silva, Karnouskos, and Giesemer, 2012). For global prosumer –generated RE trading to be realized, India has to expand the capacity of its neighbourhood RE trading system. The system accumulates excess energy produced by local prosumers and sells it to the local government. At later stages of energy trading, large-scale distribution involves district and regional levels, thereby allowing global export (Ref RE Business Model in Annexure I). However, in order to enter the global energy market, India has to develop demand-driven energy trading at local levels. By participating in a SG, participants can avoid "the transportation costs and energy losses" (Ilic *et al*., 2012, p. 6).

In addition, neighbourhood RE trading allows more efficient management or power networks when compared to conventional power grids. RE Power Generation Policies in India The development of RES in India hinges on a set of overarching policies. The first piece of legislation controlling the country's RES was issued in 2003 (IRENA, 2017). The policy stipulated the development of regional power networks and capacity adaptations necessary for transmission and generation. The National Electricity Policy of India requires regional governments to consume a fixed quota of RE. In 2012, the minimum was 0.25 percent (IRENA, 2017). Recent amendments to the policy presuppose the gradual increase of the minimum to 3 percent in 2022 (IRENA, 2017). Under the Indian Electricity Grid Code (IEGC), which was introduced in 2010, power system operators in the country are mandated to "evacuate the available power from renewable energy sources" (IRENA, 2017, p. 47). The Indian Electricity Policy drafted by the Planning Commission of India requires the creation of RE incentive structures such as net-metering policies, feed-in tariff (FIT), and tax rebate certificates (TTRCs) (Tripathi, Mishra, Dubey, Tripathi, and Baredar, 2016). Other legislation approaches supporting the development of DEG in the country have been envisioned by Remote Village Electrification Programme (RVEP) (Tripathi *et al*., 2016). The use of RES is also supported by the Indian Bureau of Energy Efficiency and the Indian Ministry of Railways that launched energy consumption plans several years ago (Tripathi *et al*., 2016). These policies propel the country towards the attainment of self-sustaining levels of RE production.

MATERIALS AND METHODS

For the purpose of investigating the prospect of India entering the global energy market through the utilization of DEG systems, it is necessary to conduct the systematic review process. The advantage of this type of study over other methods of research output evaluation is its limitation of researcher bias that can substantially diminish the validity of inquiry outcomes (Booth, Sutton, and Papaioannou, 2016). A systematic literature review necessitates a structured approach to the selection and analysis of sources, which reduces the possibility of one's personal views interfering with the context of a study (Booth *et al*., 2016). By conducting a systematic review, it is possible to generate relevant evidence on the utilization of DEG systems in India that can inform both policy and practice. The following key elements of systematic reviews guided the choice of the method: transparency, focus, accessibility, reliability, and clarity. The aim of this study is to systematically summarize the extant literature on RE trading in India and identify emergent themes, thereby expanding the current state of knowledge on the subject.

Literature Search: The following databases were searched to identify pertinent studies: the Alternative Fuels and Advanced Vehicles Data Centre (AFDC) Publications database, the Office of Scientific and Technical Information (OSTI) Information Bridge and Energy Citations Database, and EBSCO databases. Despite substantial limitations of Google Scholar, the resource was also used to perform the review. Combinations of the following keywords were used during the search process: renewable energy, distributed energy generation, decentralized energy generation, prosumers, energy trading, microgrids, Smart Grids, India, and energy exchange. The search was limited to studies published in peer-reviewed journals prior to 2012 perform the review. Combinations of the following keywords were used during the search process: renewable energy, distributed energy generation, decentralized energy generation, prosumers, energy trading, microgrids, Smart Grids, India, and energy exchange. The search was limited to studies published in peer-reviewed journals prior to 2012. The adopted search strategy also focused on the English language studies.

Selection: Titles of articles were scanned in order to exclude duplicates and studies that fell beyond the scope of this investigation. The initial search led to 654 academic publications. In addition, two scholarly articles were discovered by using Google Scholar. Studies were considered potentially relevant when they matched inclusion criteria. The first stage of the search process produced 65 studies. All abstracts of the pertinent studies were read and analysed based on the inclusion and exclusion criteria. The second stage of the selection process led to 23 articles. The number was increased to 28 after backward and forward reference checking. Including the two studies discovered through Google Scholar search, the initial sample size of studies for the review was 30. After reading and analysing full-text versions of the articles, their number was reduced to 15.

Inclusion and Exclusion Criteria: The aim of this systematic review is to investigate the feasibility of India entering the global RE market; therefore, the inclusion criteria were set to maximize the number of studies that could be used for the analysis. All studies that did not focus on RE, SGs, RES, DEG systems, RE trading, or PV energy generation were discarded after the initial search. In addition, all papers that did not address the role of RE in either global or Indian energy sectors were excluded from the analysis. The key inclusion criteria for the systematic review were either primary or secondary data on RE, RES, DEG systems, SGs, RE trading, or PV energy generation in India.

RESULT AND DISCUSSION

The renewable energy literature can be characterized along numerous characteristics; however, only several themes pertinent to the feasibility of global energy trading through distributed energy generation (DEG) emerged during the systematic review. These themes were grid parity, economic barriers, policy targets, government support, solar and wind power development, and Renewable Energy Certificates (REC). According to Khare *et al*. (2013), the cost of photo voltaic (PV) energy generation dropped precipitously during the last decade due to the carefully designed governmental policy instruments and financial supports, which encourage innovation and technological advancement that enable companies produce large production of solar panels and wind turbines and its parts, hence the cheaper capital expenses made renewable sources of energy more competitive in global energy market.

India is not well experienced with commercial renewable energy market, however recent announcement of reserve bank of India and various measures taken by central and state governments, which included renewable energy as a priority sector, under this the renewable producer gets various fiscal incentives such as feed-in-tariff (FIT), concessional transmission, renewable purchase obligation (RPO), renewable energy certificate (REC). Furthermore, the scholars estimate grid parity to be achieved by 2019 (Khare *et al*., 2013). It follows that the improvement of operational efficiency of DEG units can make prosumer DEG and trade economically feasible. When it comes to barriers to the adoption of commercial and prosumer solar-to-electricity and wind-to-electricity conversion systems, economic considerations have the highest level of influence. The findings of a study by Allan, Eromenko, Gilmartin, Kockar, and McGregor (2015) show that "higher capital costs, longer payback periods, and the payments for exporting excess electricity" prevent the widespread adoption of DEG use and trading (p. 546). Several lines of evidence suggest that market structure problems such as competition from incumbent substitutes prevent the diffusion of DEG units in the country (Dogl, Holtbrugge, and Schuster, 2012; Negro, Alkemade, and Hekkert, 2012). A study by Alternburg and Engelmeier (2013) shows that the current policy targets of India are aligned with the adoption of DEG systems, which will allow trading energy on the global market. The Jawaharlal Nehru National Solar Mission (JNNSM) has set a target of deploying 2000 MW worth of off-grid solar projects (Quitzow, 2014). It is now well established in several studies that government support of solar and wind power projects in India plays a major role in motivating the commercial use of DEG (Abdmouleh, Alammari, and Gastil, 2015; Khare *et al*., 2013; Sahoo, 2016). It is argued that the following governmental steps have contributed to the adoption of RE in the country: capital subsidy allocation scheme, tax exemption of solar cell imports, generation-based incentives (GBIs), and 80 percent tax depreciation of solar products manufactured according to ministry of new and renewable energy (MNRE) standards (Khare *et al*., 2013; Sahoo, 2016).

A number of authors have considered the effects of solar and wind power development in India (Chattopadhyay, 2014; Luthra, Kumar, Kharb, Ansari, and Shimmi, 2014). Luthra *et al*. (2014) argue that despite the fact that India has a large number of RES, the adoption of SGs is hindered by technical challenges such as wind forecasting, reliability of RES, transmission to load centre, power flow optimization, reactive power compensation, and design of electric appliances. The need for adoption of energy storage systems (ESS) also discourages Indian consumers from the participation in SGs (Ilic *et al*., 2012; Luthra *et al*., 2014). Two studies point to the fact that RE certificates are an effective mechanism for the promotion of DEG in India (Gupta and Purohit, 2013; Shrimali and Tirumalachetty, 2013). However, Gupta and Purohit (2013) state that FIT is more effective in terms of cost competitiveness. The findings of the systematic review suggest that the number and severity of drivers for the widespread adoption of DEG in India overweigh barriers to it. It follows that the current policies of the Indian government aimed at solar and wind energy capacity expansion strengthen the prospects of the country entering the global RE market. The growing global demand for renewable electricity and its production reveal that the gradual implementation of cross border renewable electricity transmission projects on large scale and long distance will create a regional super grids and finally global interconnected network. If regional super grid and long distance global interconnected network emerges increasingly interconnected world, however it require regional consensus and transparent and efficient cross border trading and distribution system between trade partner countries and geo political stability and shared vision for long term mutual trade benefit. A limitation of the study is the inclusion of papers on SGs, which might have diminished the review's reporting quality. The study systematically summarized existing research on the topic, which is extremely fragmented, thereby providing a clear perspective on the country's prospects of entering the global RE trading market.

CONCLUSION

The study investigated the feasibility of India entering the global RE market. It was argued that the widespread adoption of DEG systems and SG technologies is the key to the participation in the global cross border energy trade. The following themes influencing the country's prospects emerged during the systematic review: grid parity, economic barriers, policy targets, government support, solar and wind power development, and REC.The results of the review suggest that the number and severity of drivers for the country's participation in the global RE market overweigh barriers to it.

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