

ABSTRACT

Energy consumption contributes to economic growth in the long term (Ayres and Warr, 2009; Kummel et al., 2015). India is the fourth-largest nation globally after China, the United States, and the European Union in energy consumption (India energy outlook 2021). A recent international report revealed that economic growth, population, urbanisation, and industrialisation will be the drivers for the increase in energy demand in India by 2040, as envisaged in the stated policies scenario (India energy outlook 2021, IEA). To meet the ever-increasing energy demand, the role of renewable energy as an alternative energy source has recently come to prominence. It addresses the adverse impacts of climate change due to the consumption of conventional energy sources like coal, oil, and natural gas (Apergis and Payne, 2010).

Review of literature revealed limited studies on the association of segregated renewable energy sources with the industrial production in India. Further, the steps for restructuring the REC trading mechanism to facilitate renewable energy and the impact of the electricity market determinants on the REC market, justified the necessity for this study.

Based on the perspective and gaps in existing literature, certain questions arise- Is there a relationship of segregated RE consumption, e.g., solar, wind, biomass, bagasse, small hydropower, waste-heat, with industrial production in India? Which of the four energy-growth hypotheses (growth, conservation, feedback, and neutrality) applies to India? What factors in the Indian electricity market impact the REC market? How are they related and support the promotion of renewable energy in India? How can the REC mechanism in India be redesigned to increase the uptake of various RE sources in the REC market?

To provide appropriate answers, a comprehensive study has been conducted using both primary and secondary data techniques.

The association of the segregated renewable energy sources with industrial production in India has been studied utilizing quantile regression and non-linear granger causality at the all India level. Secondary research has been validated by conducting interviews of Indian experts in the small hydropower domain and analysing the response of survey questionnaire in order to harmonize the findings and come out with appropriate recommendations. Our findings indicate that the impacts of small hydropower and bagasse energy on IIP are statistically significant in practically all the quantiles. Furthermore, the study findings show unidirectional non-linear Granger causality going from segregated renewable energy source development to industrial growth, suggesting the validity of India's asymmetric "Growth Hypothesis".

The interplay between Indian REC market and the electricity market in the long and short-run has been analysed. The study's novelty is that the symmetric and asymmetric impact of the electricity market variables on the solar and non-solar segment of the REC market in the long and short run are studied. Using symmetric autoregressive distributed lag specification, we found evidence of significant association between the solar and non-solar segment of the REC market in the long run. The association between the REC market and the electricity market is established only in the short-run using ARDL method, wherein there is negative effect of day-ahead market cleared volume on the REC non-solar segment market-clearing price. However, the findings from the asymmetric specification using the NARDL method reveals that the dynamics between the REC and Day-ahead markets is indeed asymmetric. The positive impact of the Day-ahead electricity market-clearing price on the REC non-solar segment market cleared volume, in the long run, validates the argument.

The Renewable Energy Certificate (REC) Mechanism, a market-based tool to facilitate renewable energy growth, was launched in 2010 by the Central Electricity Regulatory Commission (CERC) through REC Regulations. Our study presents the detailed study of the REC mechanism in India since its inception, examines the REC market data available through graphical and empirical analysis to understand the regulatory changes in the REC mechanism and its impact on the REC certificates inventory, and lists the challenges and way forward. The international and national literature review reveals the strength and weaknesses of the green certificates/REC mechanism.

The study came out with few recommendations (1) Small hydropower to aid industrial growth in remote & hilly areas (2) Bagasse based generation for industrial growth in rural areas (3) Stringent REC penal mechanism (4) Need for secondary markets in REC (5) Non-solar REC categorisation (6) Harmonisation of policies across electricity and REC markets.