

India's climate challenge: Do energy, climate, and socio-economic goals of the country align?

Abstract

India's policy dimensions span from economic growth to socio economic development and from attaining energy self- sufficiency to transitioning to clean energy to achieve climate goals. The complexity of possible linkage and co-dependence between policies related to the economic, social and environmental goals of the country motivates to study certain energy and energy related environmental policy challenges and provide possible directions to resolve them. The challenges faced by energy policy of India can broadly be viewed from energy supply side and energy demand side perspectives.

On the supply side, India has experienced a large number of power projects being stalled due to land acquisition complexities. In this thesis, a framework has been proposed to estimate both the dynamic land transformation and the land occupation of nine energy sources, both conventional and renewable to further determine the magnitude of land requirement that India needs to prepare itself to fulfil its INDC commitments through two different scenarios of energy requirement growth rates viz. conservative and advanced. The findings of this study suggest that while nuclear energy has the lowest dynamic land transformation when land occupation metric is taken into account, waste to energy source possesses least land requirement, followed by coal-fired source. Hydro energy source has highest requirement both in terms of dynamic land transformation and land occupation. It is also seen that land requirement will be 96% and 120% more in INDC scenario than BAU considering a conservative and an advanced growth rate respectively. Apart from the land acquisition difficulties, other challenges associated with reliable functioning of the energy sources, comparative economic feasibility, and implementation challenges should also be taken into account while designing future energy planning of India. In this context, prioritization of seven major energy alternatives for power generation has been done on the basis of their direct and dynamic land requirement, generation cost, carbon emission and reliability of generation. Detailed data of typical power plants in India is used and the energy sources are then ranked using the MCDM TOPSIS technique in five different scenarios of policy focus. The findings from this study indicate that (i) India needs to focus more on gas based

generation to phase out coal and gradually transition to a cleaner energy path and (ii) among renewables, solar is a clearer choice over wind in terms of both cost and land requirement per tonne of carbon abatement.

On the causal linkage between human development and energy consumption is studied for India over the data period 1990-2016 by employing unit root test, Johansen-Juselius (JJ) co-integration test and vector error correction technique. The study confirms that there is causality from HDI to energy consumption in the long run, while the opposite causality is not found for India. This study also provides the evidence of absence of causality in either direction between energy consumption per capita and human development index in the short run. The findings from this study imply that with betterment of health, education and per capita income, rise in per capita energy consumption requirement can be foreseen for India.

The next part of the thesis studies the three-dimensional policy challenge of India to (i) enhance economic growth through FDI, (ii) reduce income inequality and (iii) to comply with its INDC commitment of dipping carbon emissions. The asymmetric impact of income inequality and foreign direct investment on carbon emissions is studied in the presence of the controlled variable of human development index (HDI) by employing non-linear ARDL technique utilizing twenty-six years of annual time series data from 1990-2015. Results indicate that positive shock on income inequality reduces emissions, while the same on FDI increases emissions. The study not only indicates the pollution haven hypothesis holding true for India but also provides evidence of possible conflict between developmental goal of SDG-10 of reducing income inequality and the SDG-13 goal of climate change mitigation. Finally, the thesis investigates if capital formation in India and energy transitioning to renewables complement each other or if they have been divergent in the case of India. The dynamic association between carbon dioxide emissions, economic growth, renewable energy (RE) consumption and gross capital formation is studied and tested for the existence of Environmental Kuznets Curve (EKC) hypothesis for India over the data spanning from 1970-2018. The empirical results not only confirm long run relationship among the underlying variables but also indicate an 'N' shaped EKC in the long run for India. Renewable energy consumption is found to reduce emissions, whereas gross capital formation and the interaction term between renewable energy consumption and gross

capital formation are found to raise emissions in the long run. The study concludes that India needs to align its economic policy of 'Make in India' with its energy policy so that investments under the former facilitate extensive penetration, adaptation and usage of renewable energy.

Keywords: ARDL; carbon abatement; CO₂ emissions; dynamic land transformation; economic growth; EKC; energy choice; energy policy; FDI; generation cost; Human Development Index; income inequality; INDC; India; land occupation; MCDM; NARDL; renewable energy consumption; TOPSIS; VECM