

# An analysis on Variable Renewable Energy and the importance of Hybrid systems in India

Karthik Subramanya Bhat, Udo Bachhiesl, Heinz Stigler

Institute for Electricity economics and Energy innovation, Graz University of Technology, Austria

## **Abstract:**

The global energy sector today is in transition into clean and renewable energy, due to increasing concern over climate change and pollution. While most of ‘developed’ countries have a saturated electricity demand, India, along with several other ‘developing’ countries, has been consistently facing the challenge of rapid increase in electricity demand while managing to sustain its economic growth. Along with the goal for battling energy related emissions, renewable energy capacity expansion has always been India’s best solution to the rapidly increasing electricity demand [1]. However, such a strategy involving a high penetration of Variable Renewable Energy (VRE) leads to severe complications, due to their unpredictable nature in availability and reliability. The most suitable option for sustainable VRE integration is to include Large-scale Energy Storage (LES) capacities, which involves building capital-intensive infrastructure. Considering the fact that the Indian energy sector is already in heavy financial debt [2], such capital intensive expansion would just elevate the already available debt. So, an intelligent solution is necessary for the sustained operation of the new Indian power system.

This study discusses the challenges involved in the integration of VRE sources available in India, and several options of hybrid systems as solutions to the situation. As almost half of India is yet to be built [3], intelligent use of infrastructure development could be a cost-effective solution to the country’s problems with VRE integration. Several possibilities of hybrid systems, like VRE + ‘Dispatch-able’ Renewable Energy (DRE), VRE + Electro mobility [4], VRE + Smart Grids, and VRE + Clean conventional technologies [5] are considered, and analyzed for the best possible/probabilistic combination. As conclusion, a futuristic overview of energy technology mix for a sustainable VRE integration in India has been provided.

## **Methodology:**

Initially, the availability of VRE and DRE potential throughout the country is analyzed, and the possible integration capacity is calculated. Additionally, an overall view of the Indian energy sector and its objectives are also reviewed, to have a better understanding of the Indian electricity sector [6]. Also, by overviewing the policies/ strategies related to energy storage, electro mobility and smart grids, the technical viability of such technologies in India is analyzed. The initial capital costs of VRE, DRE, and clean conventional energy integration are to be considered, along with the capital requirements for LES, EV and smart grid technologies. Possible combinations of VRE with each of the other discussed technologies are analyzed and resulting challenges and/or obstacles to the sustainable integration are identified. Possible solutions are also discussed, and based on the technical and economic viability of such a hybrid system, the best possible system for VRE integration in India is identified.

## **Conclusion:**

The study focuses on finding the best possible combination of technologies for a hybrid energy system for India, considering the country’s renewable energy goals. For such a hybrid system, the

technical and the economic challenges, along with possible solutions, is provided to give an overall understanding of the role of hybrid systems in India's energy sector. The importance of less-capital intensive Combined Heat and Power from conventional fossil fuels are also highlighted, and the part played by such technologies in the energy mix is also discussed in detail. Finally, as conclusion, a sustainable, cost-effective and efficient hybrid system is proposed for the Indian energy sector.

## Figures:

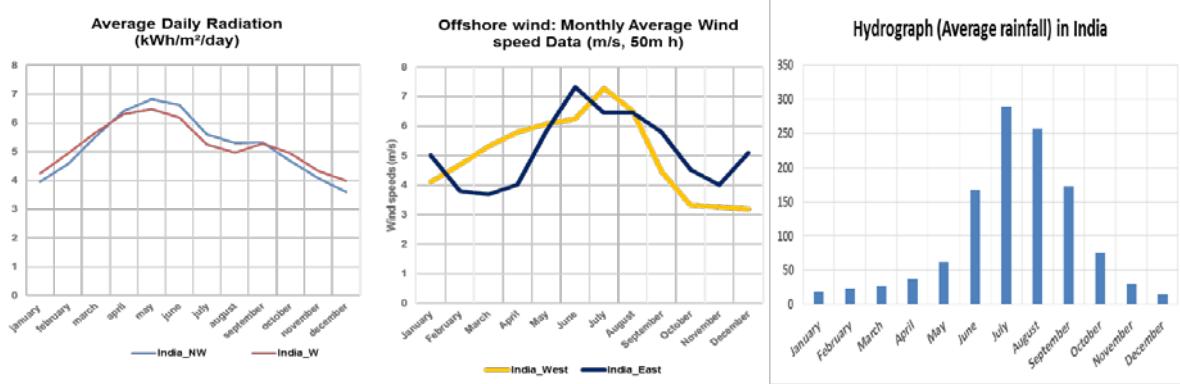


Fig. 1 Seasonal variability of solar irradiation, offshore wind speeds and average rainfall through a year in potential-rich areas, India

## References:

- [1] International Energy Agency, '*India Energy Outlook*', World Energy Outlook, 2015
- [2] Buckley, T., '*India's electricity-sector transformation*', Institute for Energy Economics and Financial Analysis, August 2015
- [3] McKinsey and Company, Inc., '*Environmental and Energy Sustainability: An approach for India*', August 2009
- [4] Bhat, K., Stigler, H., et al, '*Role of electro mobility in India's renewable scenario 2050*', Internationale Energiewirtschaftstagung (IEWT) an der TU Wien, February 2017
- [5] International Renewable Energy Agency, '*From Baseload to Peak: Renewables provide a reliable solution*', Working paper, 2015.
- [6] Central Electricity Authority, '*Executive summary report: Power sector*', Government of India, Ministry of Power, October 2015