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MODEL BASED ANALYSIS OF THE INDIAN ELECTRICITY ECONOMICS

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Introduction

India is a country with a huge electricity system having a transmission network spanning over more than 145,400 circuit kilometres [1], 330 GW of installed power plant capacity [2], and 900 TWh of annual electricity consumption [3]. In between an energy transition process towards carbon free energy, India has to successfully manage the transition while maintaining its rapidly increasing economic growth. India's agreement to the COP 21 Paris treaty to reduce its carbon intensity of energy generation has shown its intent towards battling the adverse effects of climate change, on a global level. Additionally, the lessons that were learned from the unchecked expansion of cheap coal power plant capacity resulting from the economic reforms of 1990 [4], puts the Indian policy makers on their toes with respect to the present 'Make in India' industrial initiative. The Indian electricity sector faces several problems already and would face even more challenges when considering such a drastic change in its system.

For a sustainable and successful transition, the country has to strategize its energy transition to such an extent that it not only solves the already prevailing problems of electricity access, security of supply, and exponentially increasing demand, but also prevents the financial failure of the country's energy sector. Thus, a model-based analysis is an absolute requirement, if we are to strategize the energy transition on such a level. Interestingly, the model developed for this study is one of the first of its kind, taking into account both the physical and the economic structures and limitations of the Indian electricity sector. Using such a techno-economic model, studies can be conducted with several scenarios for a target year of say 2050, to check the sustainability of its energy strategies and if necessary, to provide the best possible alternatives. The development, analysis and the possible results of such a techno economic simulation model is thoroughly discussed in the scope of this study.

Methodology

The development of such a large model would of course require a significantly large amount of input data. Initially, the energy strategies and policies set up by the Indian government for the next few decades are intensively studied, to get a general idea of the direction in which the electricity sector would develop. The annual electricity demand growth rates and electricity generation values over the years are then analysed to be taken as a part of the input data. Subsequently, the Indian transmission network is physically modelled along with the physical constraints as close to reality as possible (with reference to the techno-economic model ATLANTIS, developed at the Institute for Electricity economics and Energy innovation (IEE), Graz University of Technology) [5].

The power plant fleet of the Indian electricity sector, also along with the technical and the economic parameters are also to be included along with the input data. The electricity demand for each region is distributed locally by assigning weightages to each node in the physical model accordingly, based on the concentration of the population, industrial, and agricultural regions in the surrounding vicinity of the node. It is to be noted that the demand weightage in the model can also be eventually altered over the course of time, in the case of a higher demand growth at a particular node, if and when necessary. Full Load Hours for renewable based power plants, Inter-regional cross border capacities, power plant Availability Factors and Net Transmission Capacities are also included so as to provide a real-life simulation of the load flows in the network. The visualization of the physical structure and the simulated load flows are also made possible by the visualization software VISU developed at the IEE. The economic structure of the sector is analysed next, including the two different electricity markets operational in the country.

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The investment costs, working capital, interest rates, depreciation rates, fuel costs and several other economic parameters are then analysed for the development of the economical part of the model.

The net export / import of electricity in India is later on analysed, and the electricity systems of Bangladesh, Bhutan, Nepal and Sri Lanka are also additionally included in the model, as the energy strategies of these countries are considered to also play a significant role. Base simulations are conducted to validate the results of the completed model, and necessary alterations are to be identified and made. Several possible scenarios for India, including possibilities of electro mobility [6] and centralized variable renewable systems [7] until the target year 2050 are to be then discussed.

Probable conclusions

With this model, the electricity sector of not just India, but also the electricity sectors of most of the Indian subcontinent can be simulated together for the target year 2050. The future of the Indian electricity sector would not just have serious implications on the welfare of the sectors of Bangladesh, Bhutan, Nepal, and Sri Lanka, the development of the energy sectors in these countries may also play a similar role for India ex. by providing the much needed hydro power capacity and pump storage options for India. By studying the load flows, the existing transmission network, and the expansion plans for each power region can be optimally strategized. Similarly by analysing the economic simulation results, investments in specific technology types can also be planned for sustainability in the long run. In a nut shell, several probabilistic scenarios for the overall welfare and sustainability in the region can be suggested as conclusion.

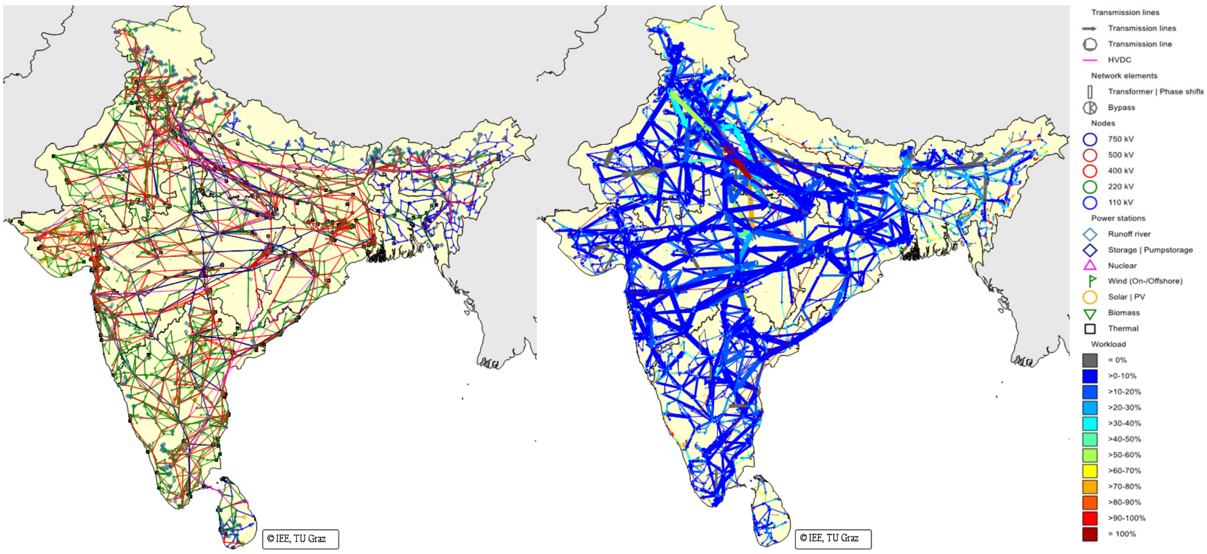

Figure 1: The physical structure of the electricity system (right) and Initial simulations for the Indian subcontinent showing the physical load flows in the transmission network (left)

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