Dynamic Modelling of Electricity Demand and Supply with Sustainability Scenarios in the Indian Context

Rashmi Varma
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Abstract

Efficient and reliable electricity supply is critical for economic growth. India is facing multiple challenges of meeting country’s electricity requirement, finding suitable resource transition from depleting fossil fuels and addressing the concern of climate change. It is obvious and has been noticed by mankind over more than hundred fifty years. The changes though gradual and supported by data sets collected by scientific agencies in climate change areas, definitely demonstrate a tendency towards global warming. Today entire world is looking forward for the success of ‘climate change mitigation’ strategy and its effective implementation. It is the strategy for bringing down the harmful emissions of green house gases (GHGs) in the atmosphere causing degradation of environment.

Economy of India is growing at a very fast pace in the world with increasing demand for electricity. However, it has volunteered to share the responsibility at international level to effectively participate in reducing global temperature rise “well below” 2 degree centigrade and pursuing efforts to limit it to 1.5 degree centigrade of pre-industrial level. This leads to responsibility of reducing country’s carbon emission intensity, in terms of emission per unit of GDP, to the tune of 33-35% from the base year of 2005 level over a 15 years period, i.e. by the year 2030. Government of India has already initiated it on 2nd October, 2016 ratifying the Paris Agreement of 2015. To achieve this target, it has multiple plans to produce 40% of its cumulative electric power requirements from non fossil fuel based energy resources, such as, solar, wind, hydro and other renewable energy (RE) sources by the year 2030. Thermal power is expected to continue to dominate the scene for quite a longer period in India as renewable power comes with some hidden costs. It may go for some more time (by around 2050) till renewable and storage gets commercially surpassing the thermal electricity. The technology of carbon dioxide capture and sequestration (CCS) is progressing but its momentum is too slow to support the widespread commercial deployment needed to tackle climate change risk mitigation.
This research using System Dynamics has developed models for population growth, electricity demand and supply in the country with sustainability conditions from the years 1971 till 2041. Population model, which is based on Census of India, 2011 data, gives a fair view of population growth year on year for per capita electricity consumption forecasting. Demand model, taking care of national missions like, ‘Make in India’, ‘Power for all by 2019’, ‘House for all by 2022’ and fuel replacement from petrol to Electric vehicles to take off in next 20 years is projecting the growing demand of electricity in the country in line with the Gross Domestic Product. In order to meet the growing demand of electricity having per capita electricity consumption to be of the order of 3500 kWh by 2041 and 10% growth in electricity generation per year, the research gives a supply model. This is a flexible electricity supply system from various electricity resources, supported by smart grid and transition towards renewable sources. Ultimate aim of the research is to meet the electricity demand as per the growth plans of the country with sustainability. The sustainability model gives different scenarios of various resources mix to meet the electricity demand and emission level of carbon dioxide (CO₂) gas. This gives a guideline for policy makers to understand the various aspects of resources for electricity generation, their impact on CO₂ emissions, and India’s commitment to international climate agreement, financial, technical and social strengths and transformations required for achieving sustainability in meeting growing electricity demand.

Based on ambitious transition to renewable to be 29% to 36% of total generation by 2040 (NITI Aayog, 2017), key findings of this research are mentioned. By 2041, thermal, renewable, nuclear and hydro contributions shall be 34%, 40%, 16% and 10% of total generation respectively. Under this scenario, the CO₂ emission is maintained below Paris agreement. However, there is a requirement of huge fund of Indian Rupees (INR, ) 11,53,621 crores from 2018 till 2022. Resources from Government Budget, clean energy fund, World Bank and Asian Development Bank together are available to the tune of merely around 10% to 2% over different years during 2015 to 2022. It needs attention of policy makers to design suitable mechanism to enable this sustainable transitions a success.