



The potential of electricity imports to meet future electricity requirements in India[☆]



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ABSTRACT

As resources of electricity generation in India are not sufficient, this paper analyses the potential of electricity import from neighboring countries to meet the future electricity requirements of India. Based on the data of electricity generation, consumption, and future generation potential, we work out projected electricity generation/ demand of India and its neighboring countries by 2050 to identify the possibility of India's cross-border electricity trading with its neighboring countries, more particularly the electricity import potential.

1. Introduction

Electricity is a critical infrastructure for the socio-economic development of a country, with a strong correlation between electricity consumption and economic growth (Kantara and Keskin, 2013; Shukla and Thampy, 2010, 2011a). An increase in electricity consumption raises real GDP (Shiu and Lam, 2004) while lack of electricity acts as a constraint on development (TERI, 2007), though electricity growth is highly sensitive to regional differences and countries' income levels (Karanfil and Li, 2015). The per capita electricity consumption in India, although substantially increased from 16 kWh in 1947–917 kWh in 2012–3, is still very low compared to other countries (CEA, 2013, 2014b).

Various countries have taken initiatives to reform their electricity industry. While the reforms in developed nations were driven by the need to improve efficiency, those in developing countries are often intended to attract private investment (Shukla, 2010; Chao and Huntington, 1998). In India, electricity sector reforms commenced in 1991 with the opening up of generation to private players, though most

of the planned projects failed to materialize due to inconsistent policies, procedural hurdles, and the poor state of state electricity boards' (SEBs') finances (Chakravarty, 2007). In continuation of the reform process, the Electricity Act of 2003 provided various measures for power sector development with the key objective of increasing the access and availability of electricity at reasonable and competitive prices. With this in mind, the government of India (GoI) also established the National Electricity Policy on Feb. 12, 2005; a Tariff Policy,¹ on Jan. 6, 2006; guidelines for the determination of tariffs via a bidding process for procurement of power by distribution licensees on Jan. 19, 2005²; and guidelines for tariff-based bidding for transmission projects on Apr. 13, 2006. The central electricity regulatory commission (CERC) facilitated the reform by regulating the availability-based tariff³ Indian electricity grid code,⁴ open access⁵ in inter-state transmission, inter-state trading,⁶ and power exchanges⁷ (Shukla, 2012; Shukla and Thampy, 2009, 2011b). In addition, state governments and state electricity regulatory commissions took several policy and regulatory measures. Despite these steps, the gap between electricity demand and supply did not disappear (Shrivastava et al., 2012) and substantial peak

[☆] With India's electricity generation resources insufficient to meet the country's growing demand, what possibilities do imports hold for resolving the problem? Some possibilities for cross-border electricity trading with neighboring countries can be teased out by analyzing data on electricity generation, consumption, and future generation potential.

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¹ amended vide resolution dated 31.03.2008, 20.01.2011 and 08.07.2011.

² amended on 30.03.2006, 18.08.2006 and 27.09.2007.

³ implemented in western/northern regions in 2002 and southern/eastern/northeastern regions in 2003. It has three parts: fixed charge for making capacity available; energy charge per kWh of energy supplied; and unscheduled interchange charge for variation from pre-committed schedule (varying inversely with the system frequency).

⁴ lays down rules, guidelines and standards to be followed by agencies and participants using interstate transmission system (ISTS).

⁵ issued on 30.01.2004, to enable to seek access to ISTS for wheeling electricity, were amended in 2008 to cater to collective transactions in power exchanges.

⁶ The regulations prescribing procedure, terms and conditions for grant of trading licence were notified to provide enabling framework for bilateral trading, between generator and trader and trader and licensee.

⁷ The guidelines for setting up and operation of power exchange were issued in February 2007.

and energy shortages still exist (CEA, 2013, 2014b). As the resources of electricity generation in India are insufficient, there is a pressing need to identify an alternative solution to bridge the gap. This article analyzes the potential of electricity imports from neighboring countries to meet the future electricity requirements of India. The remainder of the article is organized as follows. Section 2 presents a literature review and discusses the usefulness of the study. Section 3 discusses our methodology and sources of data. Section 4 discusses the existing structure of the electricity sector in India. Section 5 works out projected electricity generation and demand of India's neighboring countries by 2050 to identify their electricity shortages or surpluses. Section 6 presents the results of the study. Section 7 offers some recommendations.

2. Literature review

The future growth of electricity demand in the world would surpass the growth of total energy consumption, requiring the need for electricity market integration (Wu, 2013). Globally, electricity exports are about 3% of total production, in comparison to 64% for oil, 31% for gas, 16% for coal, and 31% for average for all goods and services, signifying the prospect of increased cross-border electricity trade (CBET) (Oseni and Pollitt, 2014). The economic benefits of CBET are extensively acknowledged (Gately, 1974; Gnansounou and Dong, 2004; Pierce et al., 2007) and, among others, include more diversified plants producing over a broader geographic area (Bahar and Sauvage, 2013), savings from harmonization of regional least-cost investment, better supply and efficiencies (ESMAP, 2010), enhanced system reliability, lower reserve margins, reactive power support, energy exchanges (ESMAP, 2013a), economies of scale, and competition (Nikandrova and Steinbuks, 2014). CBET and transmission grid development encourages renewable sources (Puka and Szuleckib, 2014) and provide cost-saving solution to regional electricity demand (Chang and Li, 2013).

In view of the large benefits of CBET, a number of regions, including Northern Europe, United States, Western and Southern Africa, and Latin America have encouraged the integration of electricity systems (Ochoa et al., 2013). In the European Union, cross-border transmission interconnections (CBTIs) are a vital means of national electricity market integration (ESMAP, 2013b; Gebhardt and Höffler, 2013) and regional market coupling is a step towards integration (Balaguer, 2011). In the ECOWAS region, increased regional power trading is expected to bring economies of scale, better reliability, and market liquidity (Castalia, 2009). A study of SEE region quantified €3 billion in savings during the period from 2005 to 2020 from the expected economic efficiencies resulting from least-cost investment in generation and transmission (ESMAP, 2010). The SIEPAC experience suggests the prospect of integration of regional electricity trading between countries at differing stages of internal market development having different types of electricity industry and institutional schemes (Reinstein et al., 2011).

The studies have shown that integrated Asian electricity market would help in dealing with peak demand and supply (Wu, 2011) and CBET would provide a solution through diversified energy sources, dependable access to larger generation assets, and efficient management of peak loads (Enrique Crousillat, 1998). CBTIs would also supply cheaper electricity and improve system reliability (ESCAP, 1988). In South Asia, the need for promotion of CBET is well recognized (Singh, 2013). The energy resources of South Asia are spread across the region, with large untapped hydroelectric potential in Nepal and Bhutan that may be exploited through regional cooperation (SARI/EI, 2013; SARI/EI 2014; Tuli, 2008). The studies have recommended establishing CBTIs for India with Bhutan (Tamang, 2007) and Nepal for hydropower development (ESMAP, 2006); and with Bangladesh and Pakistan for power trading (Lama, 1999). The CBTIs of contiguously located countries in South Asia would provide immense technical, economic, environmental, and reliability benefits (Saroha and Verma, 2013;

Chattopadhyay and Fernando, 2011).

India has nine neighboring countries: Afghanistan, Bangladesh, Bhutan, China, the Maldives, Myanmar, Nepal, Pakistan, and Sri Lanka, but the studies on CBET have generally focused on Bhutan and Nepal and to a lesser extent the other South Asian countries. As no significant research has been made to assess the potential of CBET of other neighboring countries, this study may prove useful in filling this research gap.

3. Methodology

Based on the analysis of data of electricity generation, consumption, CBET, CBTIs, and future generation potential, we work out projected electricity generation/demand of India and its neighboring countries by 2050 to identify the possibility of India's CBET with its neighboring countries, more particularly electricity imports. The data from CEA, USEIA, SARI/EI, ADB, CASA-1000, GMS, and the electricity departments of the respective countries have been used in this article. The data have been analyzed using descriptive statistical measures.

4. Present structure of electricity sector in India

4.1. Electricity generation

With an increase in installed electricity generation capacity from 2 GW in December 1947 to 267 GW in March 2013 and better performance of generation capacity, total electricity generation increased from 5 billion units (BU) in 1947 to 1112 BU in 2012–13 (CEA, 2013). The electricity generation capacity in India is dominated by the state sector with a 37% share, followed by the private and central sector with 36% and 27% shares, respectively, with the main sources of electricity generation in India being coal (72%), hydro (10%), gas (7%), and renewables (5%) (CEA, 2014a).

4.2. Electricity consumption

Electricity consumption, which was only 4 BU in 1947, increased to 853 BU in 2012–13 (CEA, 2013). The electricity sold by public utilities in 2012–13 shows that industrial customers consumed about 45% of the electricity, followed by 22% by domestic consumers and 18% by agricultural customers (CEA, 2014b).

4.3. Transmission

The Indian transmission and distribution (T & D) system is a three-tier structure comprising distribution networks, state grids, and regional grids. To transfer electricity between neighboring states, state grids are interconnected through high-voltage transmission lines to form five regional grids. The length of T & D lines increased from 23,238 ktm. in 1947 to 8,970,112 ktm. in March 2013 (CEA, 2013) and interregional electricity transfer capacity amounted to 31,850 MW as of Nov. 30, 2013 (MoP, 2014). The T & D system in India is characterized by high T & D losses exceeding 25% (CEA, 2014b).

4.4. CBET

The electricity export decreased from 0.04 BU in 1980 to 0.01 BU in 2012, while electricity import increased sharply from 0.01 BU in 1980 to 4.79 BU in 2012 (USEIA, 2015). India imports electricity from Bhutan and exports to Nepal, and Bangladesh. In 2013–14, the net electricity import from Bhutan was 5.56 BU and net export to Nepal and Bangladesh was 0.70 BU and 1.45 BU, respectively.

4.5. CBTIs

India is bounded by the Indian Ocean on the south, the Arabian Sea

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