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Electricity demand and supply scenarios for Maharashtra (India) for 2030: An application of long range energy alternatives planning

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HIGHLIGHTS

- Forecasted electricity scenarios by Long Range Energy Alternatives Planning (LEAP).
- Critically analyzed the demand and supply prior to 2012 for a period of six years.
- Used Holt's exponential smoothing method ARIMA (0,1,1) for finding growth rates.
- Devised suitable LEAP model for the generated scenarios.
- Discussed policy implications for the generated scenarios.

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ABSTRACT

Forecasting of electricity demand has assumed a lot of importance to provide sustainable solutions to the electricity problems. LEAP has been used to forecast electricity demand for the target year 2030, for the state of Maharashtra (India). Holt's exponential smoothing method has been used to arrive at suitable growth rates. Probable projections have been generated using uniform gross domestic product (GDP) growth rate and different values of elasticity of demands. Three scenarios have been generated which include Business as Usual (BAU), Energy Conservation (EC) and Renewable Energy (REN). Subsequent analysis on the basis of energy, environmental influence and cost has been done. In the target year 2030, the projected electricity demand for BAU and REN has increased by 107.3 per cent over the base year 2012 and EC electricity demand has grown by 54.3 per cent. The estimated values of green house gas (GHG) for BAU and EC, in the year 2030, are 245.2 per cent and 152.4 per cent more than the base year and for REN it is 46.2 per cent less. Sensitivity analysis has been performed to study the effect on the total cost of scenarios. Policy implications in view of the results obtained are also discussed.

1. Introduction

Electricity infrastructure is vital for overall productivity which results in development of economy for a developing country like India. Maharashtra is the second largest state in India in terms of population and geographical area. The state's population is 115.2 million (ORG and CCI, 2013) and it covers an area of 308,000 km^2. The gross state domestic product (GSDP) for the year 2011–2012 is around Rs. 11,995.4 billion INR (MAHADES ESM, 2011). The industrial and service sectors are the most vibrant sectors and contribute to 89 per cent of the state's income. Electricity consumption for the state is 12 per cent of the country. Since 2005, the state has recorded economic growth of 8.4 per cent and the demand for electricity has gone up. The state has faced scarcity of electricity since 2005 with a peak power shortage of 5000 MW (Kale and Pohekar, 2012). Many parts of the state are still facing power cuts.

From the year 1990 onwards, major shuffle in the policy took place in the regulatory structure of the state's electricity sector. As a result, the state's major utility, Maharashtra State Electricity Distribution Company limited (MSEDCL) was unbundled and separate companies were formed to look after the generation, transmission and distribution of electricity. Conducive atmosphere was created for private sector participation in the power sector. The state government set up Maharashtra Energy Development Agency (MEDA) to promote development of renewable energy and energy conservation.

Forecasting of electricity demand and supply is vital for any state. It can help the state authorities to keep up the pace with growing demands, reduction of power outages and reduction in

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GHG emissions. Demand analysis can be done by extrapolation methods, econometric and bottom up models. Extrapolation and Linear Regression methods are useful for time series predictions (Adom and Bekoe, 2012). Traditionally, Mixed Integer Linear Programming (MILP) is used to arrive at long term electricity forecast.

LEAP is a widely used software tool to forecast energy demand and supply. It can generate various scenarios and can be used for climate change mitigation assessment. It can be used to find energy utilization, generation and resources in all sectors of an economy. It accounts for both energy sector and non-energy sector GHG emission sources (Heaps, 2012). Various authors have carried out energy demand and supply forecast, generated different energy scenarios and analyzed and compared on the basis of cost and GHG emission. Sant and Dixit (2000) analyzed the state's electricity sector problems. Hoseok et al. (2009) developed scenarios in which different levels of nuclear energy utilization is made and discussed its effect on electricity demand and supply situation in Republic of Korea in the year 2030. Argiro et al. (2012) generated scenarios with an emphasis on electricity generation system and its impact on energy and environment for Greek energy system. Implications of changing energy and environmental policies in China were studied by Wang et al. (2011). Dagher and Ruble (2011) studied the economical and environmental impact of different scenarios for Lebanon. Bautista (2012) analyzed the Venezuelan power sector. Kim et al. (2011) generated scenarios consisting of utilization of different levels of nuclear power and the use of renewable energy and compared the effects on GHG emission. Kalashnikov et al. (2009) generated and analyzed three energy scenarios of energy future for Russian Far East. Pan et al. (2013) concluded that demand side management can effectively reduce the pressure on supply side and reduce GHG emission for Beijing city. Several alternative energy options for Japan are discussed by Takase and Suzuki (2011) with an emphasis on possible alternative options for nuclear power and GHG mitigation. The change in GHG emission is analyzed by varying the electricity supply mix for China by various authors (Cai et al., 2007; Shin et al., 2005). Park et al. (2013) used LEAP model to generate three electricity scenarios for Korea and analyzed its energy, environmental and economic influence. The paper highlights the importance of sustainable society scenarios. Yophy et al. (2011) developed LEAP model to check demand and supply patterns for different scenarios and GHG emissions for Taiwan. Amirnekooei et al. (2012) used LEAP to generate energy scenario and carried out demand side and supply side analysis for Iran. Vashishtha and Ramachandran (2003) developed LEAP model and analyzed the possibility of applying demand side management (DSM) programs in Indian utilities for Rajasthan. However, successful implementation of DSM requires very high involvement of customers. Supply side management (SSM) is supposed to be a more reliable approach to ensure the futuristic demand and reduced GHG emissions for a leading state like Maharashtra.

The present paper analyses the electricity situation in the state for various sectors of the economy. The electricity demand and supply analysis is presented for a period of six years prior to 2012. Electricity demand up to the target year 2030 has been forecasted by using a statistical method and by generating four scenarios. In the first method, Holt's exponential smoothing method (i.e. ARIMA 0,1,1) (Auto-Regressive Integrated Moving Average) has been used for finding the growth rates for various sectors of economy. Rests of the scenarios are generated considering GDP and varying values of elasticity of demand (NEP, 2012). On the supply side, three electricity scenarios viz. BAU, EC and REN have been formulated. LEAP framework has been used to forecast the electricity supply mix for these scenarios. A comparison has been drawn vis a vis GHG emissions for these three scenarios. A cost analysis has been done for these scenarios. A sensitivity analysis has been done to study the effect of varying parameters on total cost of the scenarios.

2. Methods

The present study uses the base line scenario of the year 2012. Electricity demand analysis for various sectors of the economy for six year prior to 2012 has been presented. On the electricity supply side, the analyses of installed capacity of the state's electric utilities, various sources of electricity and load shedding for the period May 2011 to September 2013 have been presented. LEAP has been used to forecast three different scenarios for the period 2012 to 2030.

2.1. Electricity demand analysis

The electricity consumers in the state are broadly classified as domestic, commercial, industry, railway and agriculture. The number of residential consumers is 14.3 million, agriculture consumers are 3.17 million, commercial consumers 1.38 million and industrial consumers are 363 thousand. The domestic sector consists of Low Tension below poverty line (LT BPL), LT domestic and group housing. LT commercial, temporary connections, hoardings/advertisements, and crematorium/burial are grouped under commercial sector. The high Tension (HT) consumers are HT commercial and HT commercial complex. The industrial sector is a combination of LT industry, LT power loom, HT industry (express) HT industry (non-express) HT seasonal, and HT temporary supply. The agriculture sector comprises of LT and HT agriculture and LT and HT poultry. Pumping of water, purification of water and sewage treatment plants and allied activities are grouped under Public Water Works (PWW) sector. Street light category covers lighting of the streets which are open to general public, streets under residential area, commercial compound and industry.

Table 1 shows the sectoral electricity consumption of Maharashtra. In the year 2012, electricity consumption for domestic sector was 22,305 million kW h. The consumption of electricity in industrial sector was 38,932 million kW h. Electricity consumption for commercial sector was 13,180.2 million kW h, for agriculture it was 22,931.4 million kW h, for PWW it was 2154 million kW h and

Table 1
Sectoral consumption of electricity for Maharashtra (million kW h).
Source: MAHAGENCO (2013), MERC (2012), MERC (2010), MERC (2012).

Year	Domestic	Commercial	Industry	Railway	Agriculture	PWW	Street light	Total
2007	15,381.3	06,004.5	28,084.8	2024.1	05,011.1	1550.1	757.1	56,505.8
2008	16,583.1	06,375.0	32,640.8	2090.0	05,752.0	1612.7	778.9	63,440.9
2009	18,177.7	10,410.9	31,379.1	2123.1	06,271.8	1733.7	801.5	68,362.8
2010	19,484.2	10,706.0	35,028.7	2198.9	07,780.8	1863.8	824.6	75,198.6
2011	21,123.7	11,735.3	36,915.9	4394.8	10,662.3	2003.7	848.5	84,832.0
2012	22,305.1	13,180.2	38,932.8	2269.6	22,931.4	2154.0	873.0	102,646.1