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Reliability and Environmental Pollution Analysis of an Indian Power Sector in 2016

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Abstract

The objective of this study is to evaluate the reliability index, Energy Not Served (ENS), which is a frequently used index and estimate the pollutants which are emitted from the thermal plants for the year 2016. Reliability is a crucial aspect of power system Generation Expansion Planning (GEP). The reliability index can be used as deciding criteria on new investments in generation capacities. In this paper test system is considered as Telangana State (TS) power system which is the youngest Indian state. To evaluate the reliability and pollutions emitted by thermal plants of TS

power system for the year 2016, Long Range Energy Alternative Planning (LEAP) software package is used. The results show that the value of ENS is 5391.5 GWh and the estimated pollutants from the thermal plants are 34,358,048.5 Metric tons.

***Key Words*:**Energy not served, Generation expansion planning, Pollutants, Power system Reliability, LEAP.

1 Introduction

The primary function of an electric power system is to satisfy the system load requirements with a reasonable assurance of continuity and quality of power supply. Reliability is the ability of the system to provide an adequate supply of electrical energy. The concept of power-system reliability is extremely broad and covers all aspects of the ability of the system to satisfy the consumer requirements. There is a reasonable subdivision of the concern designated as system reliability as system adequacy and system security which is shown in Figure 1.

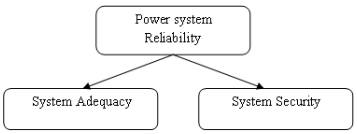

Figure 1 Subdivision of System Reliability

Adequacy relates to the existence of sufficient facilities within the system to satisfy the consumer load demand. These include the facilities necessary to generate sufficient energy and the associated transmission and distribution facilities required to transport the energy to the actual consumer load points. Security relates to the ability of the system to respond to disturbances arising within that system. Security is therefore associated with the response of the system to perturbations [1]. In this study, we analyzed whether system is adequate to meet the demand or not and power system security is considered as a fully secured system. Electricity is the prime driving force for any economy. Unfortunately, electric energy cannot be stored in large quantities; hence, it is necessary to maintain a continuous and instantaneous balance between production

and consumption of electricity. Some additional generation capacity is to be kept as reserve to satisfy the variations in demand. When supply is not adequate to meet the demand, load shedding is unavoidable. The generation system is an important part of the electricity supply chain and it is crucial that enough electricity must be generated at every moment to meet the demand. It was reported that southern region of India had the highest peak demand and energy shortage [2]. The reliability of Tamil Nadu power sector, one of the states in South India, has been analyzed for the years 2012, 2013 and 2015 using WASP-IV [3, 4, 5].

2 Generation Reliability Indices

There are different power system reliability indices are used to estimate the reliability of the given power system. Among the various indices Loss of Load Probability (LOLP) and Energy Not Served (ENS) are widely used indices. The application of probability models to the evaluation of generation reliability allows the integration of different unit sizes and types, the effects of maintenance, the capacity of interconnections and other factors. The analytical methods commonly employed are the loss of load and the loss of energy approaches [6]. Both are probabilistic approaches but ENS is a better index than LOLP. LOLP is a measure of the probability that a system demand will exceed capacity during a given period; often expressed as the estimated number of days over a long period, normally 10 years. This does not indicate the severity of the system. The ENS is defined as the expected amount of energy not being served to consumers by the system during the period considered due to system capacity shortages or unexpected severe power outages. It indicates the probability of severity in terms of energy. The rest of this paper is organized as follows: Chapter 2 describes introduction to TS power sector. Chapter 3 provides the implementation in LEAP. Chapter 4 provides results and discussion and chapter 5 concludes.

3 Introduction to TS Power Sector

Telangana State (TS), located in Southern region of India, roughly extends between 17.366 N latitude to 78.475 E longitude. In accordance with the provisions of the Andhra Pradesh Reorganization Act 2014 (Act 6 of 2014), attested by the President of India on 1st March 2014, the state of Telangana came into existence on 2nd June 2014 as the 29th and youngest state of India, when it was carved out of the north-western hinterland of Andhra Pradesh. It is bordered by the states of Maharashtra to the north and northwest, Chhattisgarh to the north, Karnataka to the west and Andhra Pradesh to the east and south. The capital of TS is Hyderabad, associating in the centre portion of the state. TS is the twelfth largest state in India in area and the twelfth most populous state in India. As per the provisions of Electricity Act 2003, there are independent unbundled utilities operational in state namely:

• **Generating Company**

Telangana State Power Generation Corporation Limited

• **Transmission Company**

Transmission Corporation of Telangana Limited

• **Distribution Companies**

Southern Power Distribution Company of Telangana Limited Northern Power Distribution Company of Telangana Limited The installed capacity of the TS is 12692 MW in which 7652.25MW, 3090.93MW and 1948.5 MW capacities are owned by state, private and central power sectors respectively. The total installed capacity of coal based plants is 7476.47MW (59%) and LNG is 1570.89 MW (12%). The installed capacities from hydro and Renewable Energy Resources (RES) are 3475.87 MW (28%). The Nuclear and oil plants contribute less than 2% of total installed capacity. The technology wise total installed capacity of the TS power system is given in the Table 1 [7]. Figure 2 shows the fuel mix ratio of TS power system in 2016.

Table 1 Installed capacity (MW) of Telangana state in 2016

Sl. No.	Sector/Plant	Coal	LNG	Oil	Nuclear	Hydro	RES	Total
1	State	5406.59	-	-	-	2245.66	-	7652.25
2	Private	270.00	1570.89	19.83	-	-	1230.21	3090.93
3	Central	1799.88	-	-	148.62	-	-	1948.50
4	Sub-Total	**7476.47**	**1570.89**	**19.83**	**148.62**	**2245.66**	**1230.21**	**12691.68**

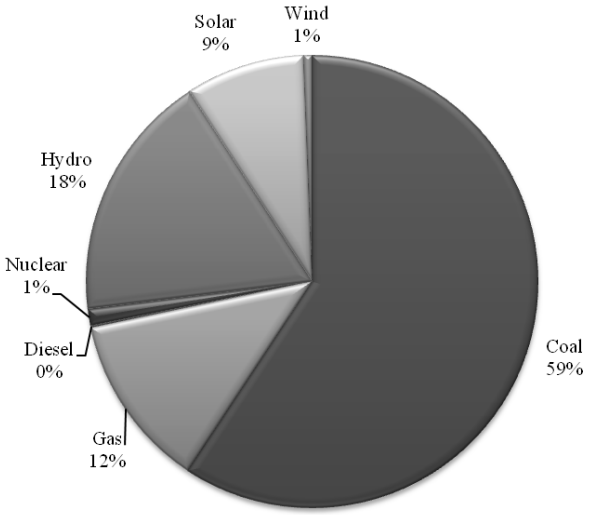

Figure 2 Fuel Mix Ratio in the year 2016

4 Implementation in LEAP

LEAP is widely used software for energy policy analysis and climate change mitigation assessment [8]. In this research work, it is used to evaluate the reliability of the system and to estimate the environmental pollutions which are emitted from thermal plants in the year 2016.

4.1 Load Data

The load data detail for TS power grid is available in [9]. The maximum demand of 8284 MW occurred in the month of September 2016 and minimum demand of 6114 MW occurred in June 2016. The annual load factor is 85.9%. The load profile of TS power system in 2016 is shown in Figure 3.

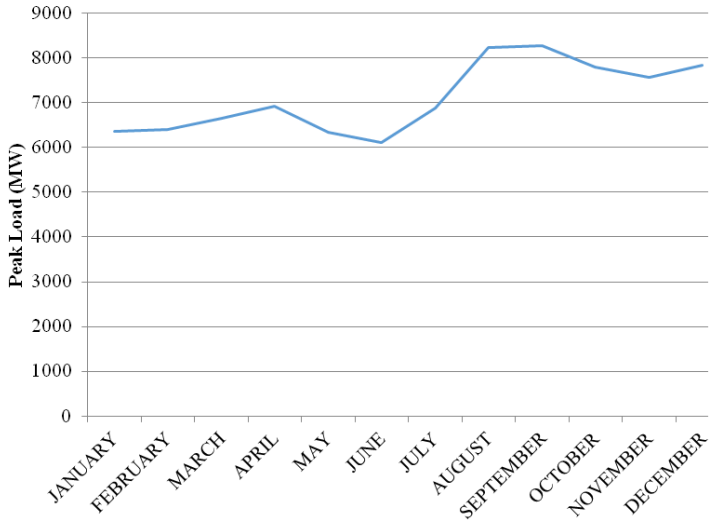

Figure 3 Load demand in 2016

4.2 Exogenous Capacity

Table 2 shows that the technical data of existing plants. The technology wise installed capacity is also shown. The availability of each plant is calculated based on the following equation. Availability=

Table 2 Technical data of existing plants

Sl. No	Name of the plants	Capacity (MW)	Availability (%)
1	Coal	7476.47	73
2	Gas	1570.89	58
3	Diesel	19.83	46
4	Nuclear	148.62	86
5	Hydro	2245.66	35
6	Solar	1073.41	40
7	Wind	77.7	19

5 Results and Discussions

In this chapter, the results obtained by LEAP software such as, Energy Not Served and emission of pollutions are discussed.

5.1 Reliability analysis (ENS)

In this study reliability of the TS power system is evaluated by the reliability index, ENS. If the value of ENS is less, the reliability of the power system is good and vice versa. The ENS is the expected amount of energy not being served to consumers by the system during the period considered due to system capacity shortages or unexpected severe power outages. The value of ENS of the TS power system is 5391.5 GWh in the year of 2016. It means the system is not able to supply the 5391.5 GWh of electric energy to meet the demand. The estimated value is compared with Load Generation Balance Report (LGBR) [10]. The value of ENS obtained by using LEAP is very close to the LGBR and the deviation is only 0.064%. It indicates that the availability assumed in this study is valid ones. The ENS value of TS power system according to the LGBR is 5388 GWh in 2016. This result can be used for planning the future power system for this state.

5.2 GHG Emissions

In general, thermal based power plants emit the Green House Gases (GHG) which is responsible for global warming. It includes Carbon Dioxide, Carbon Monoxide, Methane, Non Methane Volatile Organic Compounds, Nitrogen Oxides, Nitrous Oxide and Sulfur Dioxide. These pollutants are quantitatively estimated by using LEAP software. It is given in Table 3. The total GHG emission is 34,358,048.5 metric tonnes. The estimated value of Carbon Dioxide is 33,919,572.2 metric tonnes and it is very high when compared to the all Green House Gases. It is 98.72% of the total GHG emission. The value of Sulfur Dioxide, Nitrogen Oxides and Carbon Monoxide are 319,699.5, 108,252.1 and 7,729.7 metric tonnes respectively. The Sulfur Dioxide and Nitrogen Oxides are 0.93% and 0.31% of the total GHG emission.

Table 3 Green House Gases Emission in Metric Tonnes

Sl. No.	Green House Gases Emission	Metric Tonnes
1.	Carbon Dioxide	33,919,572.2
2.	Carbon Monoxide	7,729.7
3.	Methane	387.6
4.	Non Methane Volatile Organic Compounds	1,933.1
5.	Nitrogen Oxides	108,252.1
6.	Nitrous Oxide	474.3
7.	Sulfur Dioxide	319,699.5
Total		**34,358,048.5**

6 Conclusion

In this paper, reliability and environmental pollutions which are emitted from thermal plants are quantitatively estimated for the youngest Indian state, Telangana for the year 2016 using LEAP software. The reliability index, ENS used to find the reliability of the power system and it is found to be 5391.5 GWh. This is the base to carry out the generation expansion planning study for this state. The estimated pollution from the thermal plants is 34358048.5 Metric tonne. The global warming potential can be minimized to lower value by installing the solar plants since the state has good potential in solar energy. It has been estimated that for every MW of thermal plants excluding Nuclear plants emit approximately 3800 Metric tonne global warming potential. If the coal and gas plants which are going to be retired in future can be replaced by solar power plants, the pollution impacts can be reduced.

References

[1] Roy.Billinton, Ronald N.Allan, Power-system Reliability in Perspective, IEE J. Power, vol.30, pp.231-236, Mar. 1984.

[2] S.R.Rallapalli, S. Ghosh , Forecasting monthly peak demand of electricity in India-A critique, Energy Policy, vol. 45, pp. 516-520, 2012.

[3] Karunanithi, K., S. Kannan, and C. Thangaraj. "Reliability evaluation of Tamil Nadu power grid for the year 2012." Power Electronics and Renewable Energy Systems. Springer, New Delhi, 2015. 1067-1076.

[4] Karunanithi, K., S. Kannan, and C. Thangaraj, Reliability Analysis of Tamil Nadu Power Grid for the Year 2013 International Journal of Applied Engineering Research, ISSN 0973-4562 Vol. 10 No.55 (2015).

[5] Jayapalan, Booma, Karunanithi Kandasamy, Mahadevan Krishnan, and Kannan Subramanian. "Analyzing Reliability of Tamil Nadu Power Grid for the Year 2015 using WASP-IV", Indian Journal of Science and Technology Vol.9, no. 38 (2016).

[6] Dan Zhu, Power System Reliability Analysis with Distributed Generators, MSc dissertation, Dept. Electrical Engg., Virginia Polytechnic Institute and State University, 2003.[Online]. Available: http://etd.aau.edu.et/bitstream/123456789/12606/1/Abeba%20Debru.pdf (accessed online on 10.2.2018)

[7] Installed capacity (in MW) of power utilities in the states/uts located in southern region including allocated shares in joint & central sector utilities Available: http://www.cea.nic.in/reports/monthly/installedcapacity/2016/installed_capacity-03.pdf (accessed online on 10.1.2018)

[8] [8] LEAPTools for Sustainable Energy Analysis. http://www.energycommunity.org/default.asp?Action=47

[9] Monthly Progress report of SRPC for the month of January 2016. Available: http://www.srpc.kar.nic.in/website/2015/reports/mprjan16.pdf (accessed online on 10.1.2018)

[10] Load Generation Balance Report 2016-2017, Central Electricity Authority of India, Available: http://www.cea.nic.in/reports/annual/lgbr/lgbr-2016.pdf (accessed online on 10.1.2018)