Analyzing DSM Strategies' Effects on Reliability

[1]*Mr. Venkateswar Rao Assistant Professor*
[2]*Mr. V.Saidulu Assistant Professor ,*[3]*Dr. M.Naveen kumar Professor*
Department of EEE Engineering,
Nagole Institute of Technology and Science

Abstract— This paper aimed at resolving the power crisis of the Indian state, Tamil Nadu's power system through Demand Side Management (DSM) strategies. DSM is considered as a great tool in energy management because it enables utility consumers to satisfy the power needs with little or no increase in power generation. Energy Planning is carried out on integrated approaches involving energy supply provision and energy efficiency of demand reduction through Integrated Resource Planning. This planning envisages power demand in proportion to the generation against energy consumption patterns. A summative analysis of DSM through Load Management Program (LMP) and Energy Reduction Program (ERP) is worked out. These strategies were investigated for the increasing load demand of the future enhanced 15 years. For this investigation Wien Automatic System Planning -IV (WASP-IV) is used. For the adaptation of each strategy Load demand variations, reliability of the system through its index Energy Not Served (ENS) were investigated. The results were compared with and with no DSM strategies adaptation. Then the best suited DSM strategy is chosen for the considered power system. Chosen DSM strategy which is proposed in this paper will benefit the consumers and the State when properly implemented.

Keywords— Power system reliability, Energy Not Served, Load Management Program, Energy Reduction Program

I. INTRODUCTION

The drastic increase in population and technological developments has necessitated the corresponding increase in the consumption of power. This has made a deep impact on the proportion of demand in the power versus power generation. A gulf, thus, has evolved been bridged in this regard. While this has been the case in almost majority of developing countries, the State of Tamil Nadu in India faces acute shortage of power. With the population of more than 6.5 crore, the State has been undergoing the power demand for the last decade. The condition has become worst during the summer season when there will be a heavy consumption against unstable generation of power. Many factors either contribute or affect the proper management of power or power generation. Some of the serious factors are political uncertainty, huge risk in evolving policies, need of heavy investments and complex seasonal impacts. Thus, a time has come for the Tamil Nadu electricity authorities to explore the strategies to meet the crisis. The government is in a position to arrive at the methods to review the conventional practice of supplying power. Similarly, the government shall evoke measures to advise the public on making use of power in a judicious manner so as to bring in mutual benefit. In this regard, this paper aims at focusing an effective tool in managing power demand called Demand Side Management (DSM). However, this system requires various counts of improvement in all sides based on the reliability [1].

The function of DSM can be classified under two programs namely (a) Load Management Program (LMP) and (b) Energy Reduction Program (ERP). Of these two, ERP involves in reducing the demand through the processes that are more efficient in terms of construction or building the infrastructures. The other, LMP involves in altering the load pattern thereby focusing on less demand during the peak hours. Yet, the promotion of DSM is based on the varied patterns of different consumers involved. Generally, power generation companies look in for the reduction or shift in the consumer's energy demand. Then they execute by way of delaying or withholding further erection of generation sources leading to maximum utilization of the existing power resources.

II. RELATED WORKS

For the sake of effective analysis on DSM in terms of the reliability aspect of Tamil Nadu power system for the year 2017 [2] has been taken for consideration. Similarly, to meet over increasing load demand, different penetration level of Renewable Energy Sources (RES) with regard to the Generation Expansion Planning for Tamil Nadu has been proposed in [3]. The cost effective means in Climate Aware Generation Planning is discussed in [4]. An overview of electricity crisis in Nigeria, the policy issues and environmental ramifications of the power sector reform Act as well as dispersion modeling of emissions from Nigeria's pioneer NPP is presented in [5].

III. OUTLINE VIEW OF TAMIL NADU POWER SECTOR

In Tamil Nadu, the power supply is managed by Tamil Nadu Generation and Distribution Corporation (TANGEDCO) and it plans for the effective implantation of power generation methods. The corporation has the net installed capacity of 23,762 MW as of December 2017 [6] is shown in Table I. This includes the shares distributed by the State, Central government and Independent Power Producers (IPPs).

The cumulative contribution of various sources for this net installed capacity of 23,762 MW comes from the generation mix of i) Coal plants: 27.4%,ii) Gas plants: 4.3%,iii) Nuclear plants : 4.2% iv) Diesel plants : 1.73% v) Lignite plant: 17.4%. These sources account for 55.03% of the total installed capacity with the remaining 44.97% coming from the renewable sources. Out of this 44.97% installed capacity, wind energy accounts for 31% followed by Hydro plants with 9% and 5% put together by bio-mass and solar energy. The condition of power demand in the State of Tamil Nadu during the last five years has been very critical. Being

Copyright @ 2019 Authors

not able to generate adequate amount of power against the demand, the State has witnessed huge power cuts. This has led to the lack of reliability of power generation affecting the economic growth with more industrial prosperity being lost. It is true that the installing capacity of the State during the year 2014 was 21,794 MW against the peak demand of 13771 MW. Then the installing capacity for the year 2017 faced a slight increase to 23,762 MW due to increase of Renewable Energy Sources (RES), yet against almost similar peak demand of 13766 MW. This RES increase has somewhat account for the net installed capacity but not in tune with the peak demand which also increases simultaneously.

TABLE I. INSTALLED GENERATION CAPACITY OF TAMIL NADU IN 2017

Serial No.	Name of the plant Type of fuel	No. of units	Capacity (MW)
	Coal /Lignite based Power stations		
1	Ennore Thermal Power Station (ETPS)	3	450
2	Tuticorin Thermal Power Station (TTPS)	5	1050
3	Mettur Thermal Power Station (MTPS - Stage I&II)	4	840
4	Mettur Thermal Power Station (MTPS – Stage III)	1	600
5	North Chennai (Stage I)	3	630
6	North Chennai (Stage II)	2	1200
7	Independent Power Producer-III (IPP-III)	1	1750
8	Share from Central I	1	4155
	Gas based Power stations		
9	Tamil Nadu Generation and Distribution Corporation (TANGEDCO)	5	524
10	Independent Power Producer-I (IPP-I)	10	503
	Nuclear based Power stations		
11	Share from Central II	1	987
	Diesel based Power stations		
12	Independent Power Producer-II (IPP-II)	20	412
	Renewable Energy Sources		
13	Biomass	1	657
14	On shore Wind		7394
15	Solar	1	419
16	Hydro	42	2191
	Total		23762

IV. Implementation In WASP-IV

WASP-1V is one of the popular application software packages used for Generation Capacity Expansion Planning (GCEP) studies [7]. In this study, WASP-IV is used to analyze the reliability of the Tamil Nadu power system in terms of ENS with DSM strategies from the year 2017 to 2029.

A. Load Demand Data

Among the available power systems in the state of Tamil Nadu, the complete data related to the state is given in [8]. FIGURE 1 illustrates the load profile of Tamil Nadu power system during the year 2017. The maximum demand of 13,766 MW was met on July 2017 while the minimum demand of 7359 MW was on November 2017. From these two levels, the average load for the year 2017 is arrived at as 11,981.84 MW. Hence we can observe that the annual load factor for the year was 87.36% against the total energy demand of 105353.1GWh.

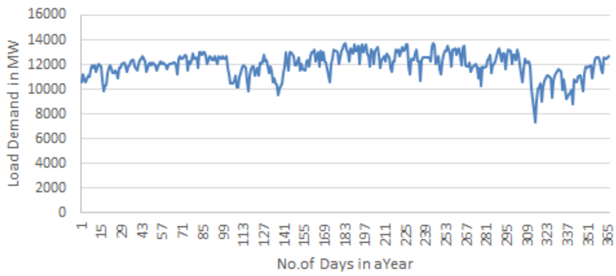


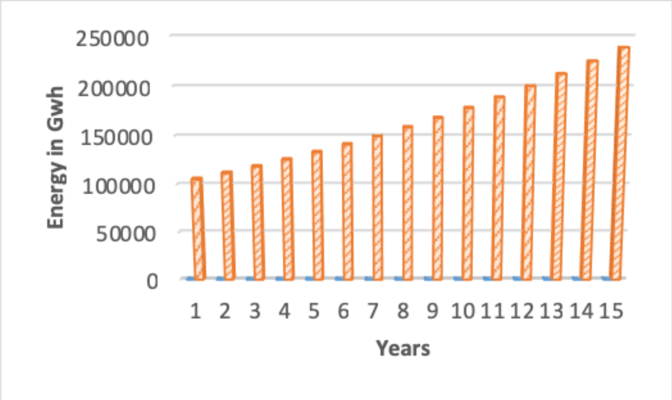
Fig. 1. Daily Load Demand of Tamil Nadu in 2017

B. Load Demand growth

For an accurate analysis of the load demand for the past eleven years was referred from [16]. It is further observed through time series analysis that there had been an increase of 6% in demands accounted in the history. This is done in a view to arrive at the forecast level for the next 15 years peak demand of Tamil Nadu.

Based on this calculation it is estimated and projected that the peak demand for the state of Tamil Nadu during the year 2029 could be 238262.6 Gwh. FIGURE 2 provides the year-wise projected split up of peak energy demand for the period from 2017 to 2029.

Copyright @ 2019 Authors



1

Fig. 2. Forecasted peak demand for fifteen years

V. MODEL ANALYSIS

This section deals with model analysis by applying different Demand Side Management (DSM) methods. In addition, strategies, effects, influences over power system generation reliability in terms of generation system reliability index Energy Not Served. For the analysis under DSM, three strategies are proposed is suitably listed in TABLE II.

TABLE II. CONSIDERED CASES

Case 1.	Without implementing DSM
Case 2.	DSM Implementation through LMP
Case 3.	DSM Implementation through ERP
Case 4.	Concurrent implementation of LMP & ERP

Case 1 - Without implementing DSM

For this concrete study based on WASP-IV modeling, Onshore Wind Power Plant (WPP) is taken for consideration as hydro plant. Thus, energy produced in the WPP is said to be the energy inflow from the proposed hydro plant. The need for considering WASP-IV on the basis of WPP is the impact of seasonal forms of wind sources. Taking all these factors, it can be arrived that the proposed study is laid on the platform of run-off- river modelling as reference model.

Case 2- DSM Implementation through LMP

In this Case, Load Management Program is adopted on the basis of accounting the Peak-load shifting. By this process, mitigation of the effects of large energy load blocks during a given period of time is implemented. This is done by advancing or delaying their load shift effects under the fixed power distribution system to readily accommodate the additional load.

Case 3- DSM Implementation through ERP

In this Case, energy conservation scheme is adopted to reduce the load demand by 5%. What makes ERP ideal for conservation is the practice of switching over to Compact Fluorescent Lamps (CFL), replacement of copper chokes with electronic chokes for fluorescent lamps. Through these measures, it is measured that 5% electricity can be conserved in all consumer sectors.

Case 4 - Concurrent implementation of LMP & ERP

This Case aims at carrying out both the activities of energy conservation and peak shifting modes, in order to meet the power demand against power shortage.

VI. RESULTS AND ANALYSIS

This section deals with the results arrived at the study using WASP-IV simulation methods. Various strategies are suggested and adopted to arrive at these results and the individual results are placed for discussion. Factors taken for the result analysis process are load demand variations and generation system reliability index Energy Not Served (ENS).

A. *Generation system reliability*

Power system reliability is defined as the reliable factor or capability for the proposed system to match the load demand in an effective manner. In practice, there are several different reliability indices to analyze the reliability of power generation. For effective analysis of the reliability, Energy Not Served (ENS) reliability index is employed. In addition, run- of river modeling for wind power plant under WASP-IV is adopted. As such, the ENS gathered from all the cases were illustrated in Table III in the frequency of 5 year term.

TABLE III. ENS FOR ALL THE CASES

End of	Case 1	Case 2	Case 3	Case 4
Base year	6863.5	6509.7	4951.8	4687.1
5thyear	1926.1	1820.2	1195.7	1128.0
10thyear	1054.4	1020.5	441.2	419.8
15thyear	973.4	938.3	265.3	243.2

Regarding Case 2 which involve adopting LMP, and changing the load pattern and promoting less demand during peak times (peak shifting) of the load. Under this method the minimum ENS obtained in the third term of five year tenure, i.e at the 15th year, is accounted as 938.3 GWh. When compared this value with Case 1 ENS, there is a lesser index by 3.6%. In Case 3, Energy Not Served is reduced to 265.3 GWh i.e.72.7 % improvement in reliability that of the future expansion of Energy reduction DSM strategy for 15 years. This is possible with the implementation of ERP through energy efficient schemes.

To enhance the suggestive aspects of this study, the observations in Case 4 proves the factors of reliability by implementing simultaneous adoption of both LMP & ERP. Case 4, there are better improvements in terms of reliability with reduced energy shortage. This is accounted as 243.2 GWh in the 15th year with the reduction of 75%. FIGURE 3 shows the comparison of ENS obtained from all four considered cases

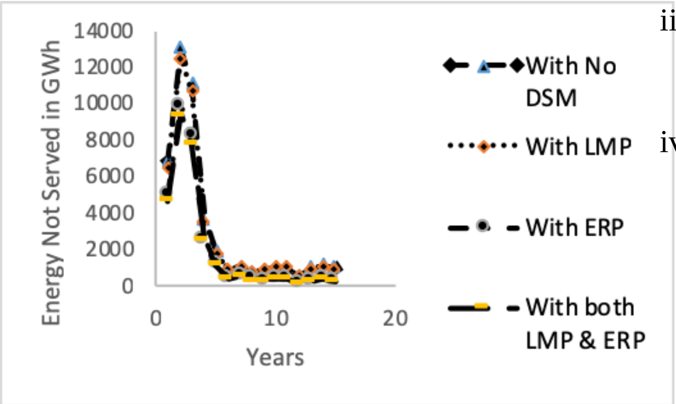


Fig. 3. Comparsion of ENS obtained from four considered cases

B. Load Demand

This section deals with the changes in load demand under DSM strategies. It is observed that there are two possible ways to meet the reliable power system. i) By increasing the generation capacity and satisfying energy needs ii) By reducing demand and satisfying energy needs.

TABLE IV. DEMANDS OBTAINED FROM ALL THE CASES

End of	Case 1	Case 2	Case 3	Case 4
Base year	105383.8	105185.2	100114.6	99925.9
5th year	133044.6	132793.8	126392.4	126154.1
10th year	178043.8	177708.1	169141.6	168822.7
15th year	238262.6	237813.6	226349.5	225922.9

As such, the energy demand of the commencement of study period was 105383.8 GWh in base Case1 it increased to 238262.6 GWh at the end of the study period. The demand variations for the entire study period for the proposed Cases are provided in TABLE IV. As for Case 2, there has been a reduction of 0.188% each year when LMP is implemented. However, better results are observed in the Case 3 as reduction of 5%, when ERP is implemented. Comparatively, there has been a demand reduction of just 5.18% in Case 4. These factors again prove that ERP alone plays significant role in shaping the reduction of power demand for the systems of Tamil Nadu state. Hence it is suggested that ERP is suited for the Tamil Nadu power systems. In order to manage power demand and power generation methods effectively, the following measures are more suited for Tamil Nadu State:

i. In general, ground water plays a crucial role for irrigation purposes in the state of Tamil Nadu. This necessitates the demand for power utility to derive water for agriculture purposes too. Hence to manage the demand, alternative measures can be devised on efficient water management rather than dependence on electricity.
ii. Conventional lighting systems can be replaced with LED bulbs / energy saving lighting system and CFL.
iii. Frequent and periodical Energy auditing can be implemented in domestic power utility, commercial sectors, household power usage, and corporate offices. Proper power conservative measures can be apprised to these sectors.
iv. In order to reduce Green House Gas (GHG), the State can adopt green tree plantation whereby energy can be conserved, ground water can be saved and sufficient amount of oxygen can be preserved. If temperature is maintained at low with by creating micro climate, then the need for more electricity, especially for fans and air-conditioners will be lesser.

VII. CONCLUSION

This paper investigates the effects of Demand Side Management Strategies on power system reliability through LMP and ERP on Tamil Nadu State power system for 15 years. From this analysis, it could be observed that, the reliability of the said power system improved in the implementation of Energy Reduction Program than other strategies. Reliability of the power system is measured through its index Energy Not Served. Hence it could be concluded that according to the analysis carried out in this paper, for reducing load demand Energy Reduction Program is highly opted for Tamil Nadu power system. Then the best suited measures to reduce the load demand further are also suggested in this paper. The ultimate purpose of this measure is to enhance reliability on power system which will definitely save erection or construction of additional power plants in near future. The concurrent implementation of LMP and ERP also have comparatively derived same ENS that of ERP, but opting peak shifting is not ideal for the considered power system.

REFERENCES

[1]. K.Karunanithi,, S.Saravanan, B.R.Prabakar, S.Kannan, C.Thangaraj, “Integration of Demand and Supply Side Management strategies in Generation Expansion Planning”, Elsevier- Renewable and sustainable energy reviews, 73, 2017, pp 966-982.
[2]. J.Booma, K. Karunanithia, K.Mahadevan and S. Kannan, “Analyzing Reliability of Tamil Nadu Power System for the Year 2015 using WASP-IV”, Indian Journal of Science and Technology, Vol 9(38), DOI: 10.17485/ijst/2016/v9i38/101963, October 2016.
[3]. K.Karunanithi, S.Kannan and C.Thangaraj, “Generation Expansion Planning for Tamil Nadu : a Case study”, International transaction Electrical energy systems, John Wiley & Sons Ltd 2014.
[4]. D.Chattopadhyay, M.Chattopadhyay, “Climate-Aware Generation Planning”, A Case Study of the Tamil Nadu Power System in India. The Electricity Journal. 2012 Jul; 25(6):62–78.
[5]. Abubakar Sadiq Aliyu, Ahmad Termizi Ramli, Muneer Aziz Saleh, "Nigeria electricity crisis: Power generation Capacity expansion and environmental ramifications", Elsevier- Energy 61, 2013, pp 354-367.
[6]. Installed capacity (in MW) of power utilities in the states/UTS located in southern region [Online]. Available: ⟨www.cea.nic.in/reports/monthly /inst_capacity/jan16.pdf⟩ [Accessed 15.05.16].
[7]. Computer manual series no. 16, Wien Automatic System Planning (WASP) Package: A Computer Code for Power Generating System Expansion Planning Version WASP-IV, International Atomic Energy Agency, Vienna, 2001.
[8]. Southern Regional Power Committee, Bangalore, Progress Report-2017 (from Available: ⟨www. srpc. kar. nic. in /website / 2017 / reports / mprjan17 .pdf⟩ [Accessed 10.05.2016]. pp. no.79.

Copyright @ 2019 Authors

Copyright @ 2019 Authors