PEER – a tool to Design, Measure and Monitor the performance of Smart Grid

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***Abstract*— India is world's third largest producer of electricity with an installed capacity of 306 GW. However, the per capita electricity consumption in India continues to be well below the world average despite lower electricity tariffs. The nation has a long history of demand-supply shortages on a regular basis. The electricity distribution sector is also under poor financial condition. With an energy mix dominated by fossil fuel based generation, Indian power sector has a significant impact on environment. Thus, for sustainable development of the power sector, it is important to have in place a framework to measure, monitor and improve performance of power systems. PEER (Performance Excellence in Electricity Renewal) is a tool for utilities and system operators for a comprehensive performance assessment of their system and for making subsequent improvements to achieve upper levels of performance. This paper highlights some of the key features of the PEER framework that focus on assessment of environmental impact and reliability performance of power systems. A comparison between projects in the United States of America (USA) and India is also presented to identify performance gaps.**

Keywords— PEER; Reliability; Source Energy Intensity; Power Supply Performance Index;

I. INTRODUCTION

Indian power sector is evolving rapidly in terms of scale and structure. India is world's third largest producer of electricity with an installed capacity of 306 GW [1] which stands fifth largest in the world. Nearly 70% of the presently installed capacity comprises of non-renewable sources of energy including coal, natural gas, nuclear and diesel. However, wind, solar, biomass and other renewable energy sources contribute only 14% of the installed capacity. In spite of having large installed capacity, India has a prolonged history with demand-supply imbalance on a regular basis. A large portion of population in India is still without power. Therefore, there is a huge scope for improvement for the power industry.

With an energy mix dominated by fossil fuels, power generation in India has a significant impact on the environment. As reported by Centre for Science and Environment (CSE), coal based power plants in India operate at lower efficiencies and have higher CO_2 emission rates when compared globally [2]. India stands fourth in global CO_2 emissions with a share of about 7% of total CO_2 emissions [3].

On the power delivery front, the aggregate technical and commercial (AT&C) losses in India are as high as 23%. State owned distribution companies (DISCOMs) in India have accumulated losses of over 3 lakh crore Rupees and outstanding debt of 4.3 lakh crore Rupees [4]. GoI has introduced a scheme called Ujwal DISCOM Assurance Yojana (UDAY), which allows state governments to take over the debt on account of respective state DISCOMs [5]. The scheme also requires adherence to minimum performance standards specified by the Ministry of Power (MoP). GoI also has increasing focus on grid modernization through the National Smart Grid Mission (NSGM). Presently, 14 smart grid pilot projects are under implementation across major Indian cities. A public private partnership (PPP) initiative known as Indian Smart Grid Forum (ISGF), is involved in deploying smart grid technologies and developing policy measures.

Hence, the long term issues associated with power generation and distribution call for a comprehensive assessment of sustainability performance of the industry. Green Business Certification Institute (GBCI) India Pvt. Ltd. an Indian subsidiary of GBCI (USA), is a certification and credentialing body within the green business and sustainability industry and has developed PEER (Performance Excellence in Electricity Renewal)" rating system to address the challenges in power sector. It is a dynamic and adaptive rating system for assessment and improvement of power system performance. PEER rating system identifies 4 critical areas for performance assessment of power systems – (a) Reliability and Resiliency, (b) Energy Efficiency and Environment, (c) Operational Effectiveness and (d) Customer Contribution. PEER focuses on sustainability performance of individual projects rather than that of the entire organization. It can be used as an effective improvement tool by power plants or DISCOMs. GBCI has signed a MoU with ISGF to collaborate on sustainable power market transformation in India and Southeast Asia.

In this paper, leveraging the PEER framework, reliability assessment for DISCOMs and environmental performance assessment for power plants is discussed. The rest of the paper is organized into 3 sections. Section II addresses reliability assessment and improvement for DISCOMs using "Reliability and Resiliency" category from the PEER rating system. Section III presents considerations for environmental and efficiency performance assessment through PEER. In Section IV, conclusions are presented based on analysis of data and key recommendations are proposed.

II. ELECTRICITY DISTRIBUTION RELIABILITY

A. Reliability Assessment – Standards & Methods

In order to assess reliability performance of a utility, it is important to determine indicators that effectively summarise power interruption data. Presently, IEEE – 1366 [6] is most widely used as a standard for reliability assessment across utilities all over the world. The IEEE standard categorizes power interruptions as sustained or momentary depending upon the restoration period. While PEER addresses both the types of interruptions, the scope of this paper is restricted to assessment of sustained interruptions.

For assessment of sustained interruptions, it is important to capture two key aspects – frequency of interruption and duration of interruption. PEER therefore recommends use of Sustained Average Interruption Frequency Index (SAIFI) and Sustained Average Interruption Duration Index (SAIDI) as performance metrics for sustained interruptions. IEEE -1366 classifies any interruption that lasts for a period of more than 5 minutes as sustained interruption. As defined by the standard, methodology for calculation of SAIFI and SAIDI values for any distribution network is presented below.

$$SAIFI = \frac{\sum_{i=1}^{n} N_i}{N_T} \quad \ldots (1)$$

$$SAIDI = \frac{\sum_{i=1}^{n} [N_i * r_i]}{N_T} \quad \ldots (2)$$

Where, N_i stands for number of consumers interrupted during i^{th} interruption, N_T stands for total number of consumers connected to the distribution network and r_i stands for the restoration time for i^{th} interruption.

SAIFI is a measure of average number of interruptions experienced by any consumer connected to distribution network over a specified time interval. Similarly, SAIDI denotes average duration of interruption per consumer over a specified time period and is generally expressed in minutes. Unlike SAIFI, SAIDI is determined as a weighted average to appropriately reflect the severity of widespread interruptions. The numerator in expression of SAIDI is collectively termed as customer duration of interruption and is expressed as consumer minutes of interruption. Naturally, a low value of SAIDI and SAIFI indicates higher reliability. Researches have also estimated the cost of power interruptions to electricity consumers in United States using these indices [7].

B. Distribution Reliability Scenario in India

Despite poor operational performance and unreliable supply issues faced by power distribution sector in India, formal assessment of reliability by Central Electricity Authority (CEA) started only in 2012-2013 based on the data published by the organization [8]. Presently, most of the state electricity regulatory commissions (SERC) have mandated declaration of reliability indices as a part of Standards of Performance (SoP). However, no verification mechanism or incentive program is in place to either validate the data or to promote reliability improvements. In addition, different SERCs specify different methods for calculation which also differ from the IEEE standard. Some of the common deviations [9], from the standard computation methodology are –

- Use of interruption data at 11 kV feeder level instead of consumer level
- Use of connected load data instead of number of connected consumer data
- Different methods for calculation

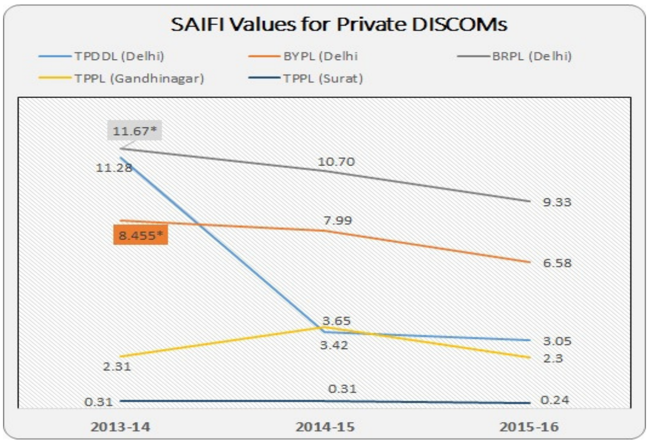

Figure 1 – Feeder level annual SAIFI (in number of interruptions) for Private DISCOMs in India

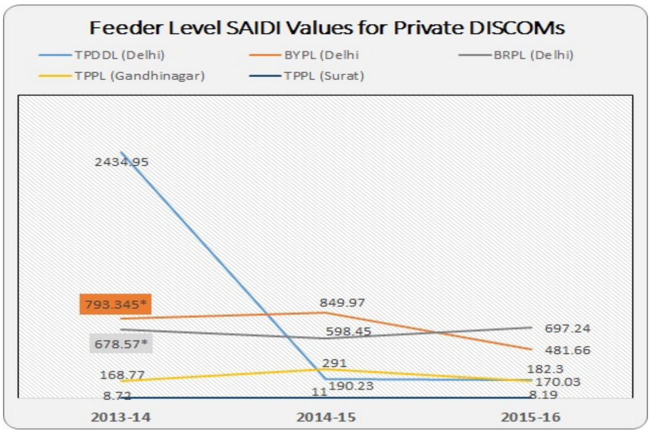

Figure 2 – Feeder level annual SAIDI (in Minutes) for Private DISCOMs in India

*Due to unavailability of data for a particular year, values are determined by interpolation

Apart from the above deviations from the standard, there is an absence of specific provisions to include or exclude Major Event Days (MED), scheduled maintenance or interruptions caused due to disturbances outside the system.

A review of the multiple years of annual reliability data published by CEA revealed that most state owned DISCOMs have poor reliability performance as compared to private DISCOMs. The reliability indices for some of the private utilities in Delhi and Gujarat are summarized in Figure 1 & 2. As it can be seen from the above graphs, private utilities have achieved remarkable improvements in terms of distribution reliability over past few years. However, it is important to compare the performance of these utilities on a global scale. One of the key principles of PEER is to share the global best practices and support power utilities in improving their performance. As a result PEER helps DISCOMS to benchmark their reliability & environmental index at global, regional & local level. For instance, the annual average SAIFI value for US is 1.5 interruptions per consumer [10]. Similarly, the annual average SAIDI value for US at consumer level is 240 minutes, which is only comparable to feeder level SAIDI values of the best performing DISCOMs in India.

C. Reliability Improvement through PEER

PEER emphasizes on adopting designs that enable monitoring of parameters for reliability measurement and also focuses on reliability improvement by assessing capabilities on the utility side which lead to better performance. Some of the key features of PEER framework that are closely associated with reliability monitoring and improvements are listed below.

1. Advanced Metering Infrastructure (AMI)
   PEER identifies AMI as the fundamental infrastructural requirement in order to enable continuous measurement of reliability, power quality at consumer level. It also offers access to advanced capabilities such demand response, bidirectional communication, etc.

2. Supervisory Control and Data Acquisition (SCADA) Systems
   SCADA systems allows real time monitoring and control of the entire distribution network. If integrated Outage Management Systems (OMS), it helps to quickly identify interruptions and also enables remote access to important components of the distribution infrastructure.

3. Damage Prevention
   Damage to power distribution infrastructure is a common cause of interruption. PEER evaluates measures implemented by the utility to avoid such exposure and subsequent damage to equipment and components from external factors.

4. Distribution Redundancy
   Network configuration plays an important role in reducing impact of interruptions on customers. PEER recognizes distribution network design that incorporates ring main units or interconnected network topologies.

5. Alternative Electricity Supply Options
   Availing an alternative primary source of supply is another approach to improve reliability. This involves investing in onsite and local generation or connectivity through multiple independent feeders.

Figure 3 shows SAIDI values for some of the US based projects for years 2010 & 2011. It may be noted that University of Texas (UT), Austin – a PEER certified project demonstrates better reliability performance as compared to other projects. Also, UT Austin has a lower SAIDI than Austin Energy - the utility from which it draws power.

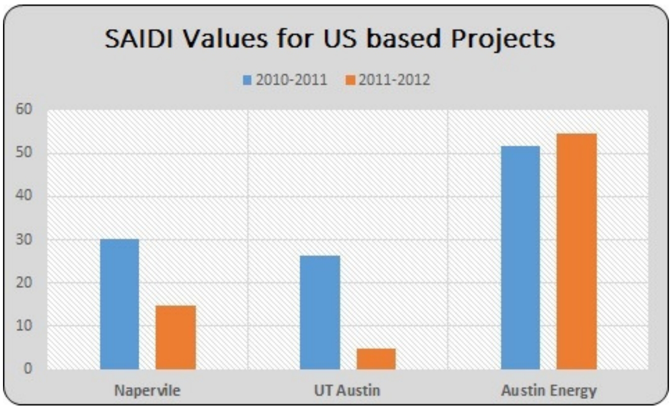

Figure 3 – Comparison of annual SAIDI (in Minutes) of US based projects

III. ENERGY AND ENVIRONMENTAL PERFORMANCE

Considering the share of GHGs emissions from power industry, it is essential to focus on environmental sustainability of the power sector. While increasing renewable energy based electricity generation is expected to reduce environmental impacts, existing fossil fuel based generation still forms a significant portion of the installed capacity. PEER framework defines a Power Supply Performance Index (PSPI) to quantify the environmental impact of the power system infrastructure. Apart from stimulating sustainable performance in power generation sector, PEER also helps utilities and other system operators to assess their environmental impact footprint.

A. Source Energy Intensity (SEI)

The SEI is a measure of the primary energy requirement to produce a unit of electricity by a power plant. It is generally expressed as heat rate of the power station.

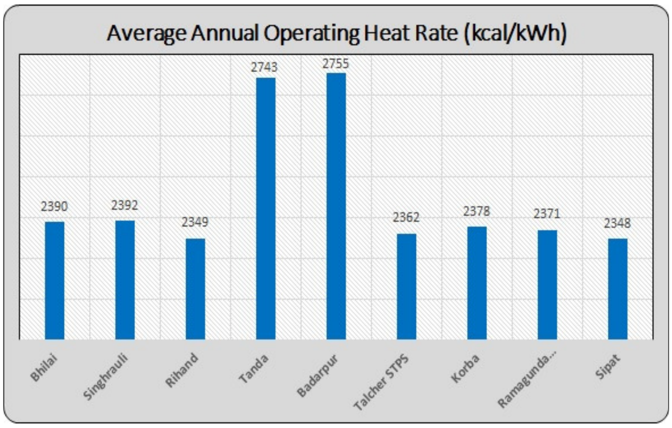

Figure 4 – Average annual Operational Heat Rate for some Indian power plants

Figure 4 shows the average annual heat rate for some NTPC plants for a period of 2008 to 2013 [11]. It can be observed in the above graph that the average annual operating heat rate value for NTPC power plants is lower than 2400 kcal/kWh in most cases. The average efficiency of Indian coal-fired power plants is in the range of 25% to 30%. Whereas, US, China, Korea and few other countries have efficiencies more than 35% along with Japan and Nordic countries achieving efficiencies over 40% [12].

B. Environmental Emissions

The process of burning fossil fuel to generate heat, results into emission of various gases including oxides of carbon, sodium and nitrogen. Power Supply Performance Index (PSPI) evaluates emission intensities in kg/MWh since the actual emissions depend on number of factors including technology of the power plant, age, fuel used etc. Figure 5 shows average annual CO_2 emission intensities for some private and centrally owned power plants in India [13].

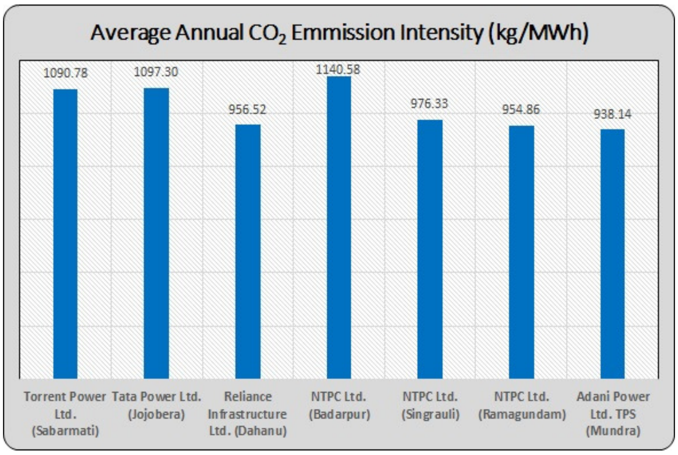

Figure 5 – Average annual CO_2 emission intensity for power plants in India

A recent report on international level comparison of CO_2 emission intensities of fossil fuel based electricity generation states that India has the highest CO_2 emission intensity but also has highest CO_2 reduction potential [12]. Aligning PEER with national policies would help in continuous monitoring and improvements in emission performance of the power plants. The US average carbon dioxide emission intensity is within the range of 700 – 800 kg/MWh, while the Indian average is 1080 kg/MWh. Understanding the importance of measuring the environmental impact of thermal power plants, Ministry of Environment and Forestry (MoEF) has developed regulations on emission standards for thermal power plants in India [14].

C. Resource Utilization

Water consumption and waste disposal are important issues associated with most fossil fuel based generating plants. PSPI evaluates performance of power plants in efficient water utilization and effective disposal of solid waste. The problem of solid waste disposal is more prominent with coal based thermal power plants. Figure 6 shows number of thermal plants with particular ash utilization percentage range [15].

It is worth noting that some of the power plants have reported more than 100% ash utilization which is only possible if the power plants have backlogs from previous years. The national average ash utilization percentage is reported to be 55.69%. However, considering the possibility that many power plants including those with lower than 100% utilization are also including previous backlogs for utilization. Thus there exists a huge scope for ash utilization and strong policy measures need to be implemented to prevent illegal dumping of ash.

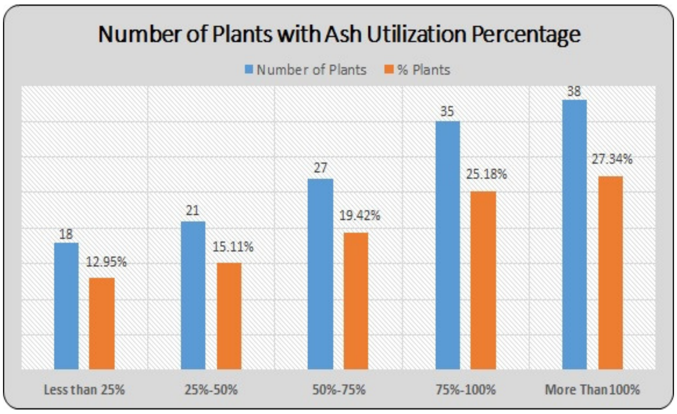

Figure 6 – Number and Corresponding percentage of power plants with specific Ash utilization

IV. Conclusion & Recommendations

It is important to tackle the issues associated with power distribution in a structured manner. The PEER framework can be an integral tool to effectively measure and monitor performance of individual projects rather than the overall performance of utilities. Schemes like UDAY which are focused at revival of state DISCOMs can be implemented more effectively with targeted operational milestones. Adopting PEER framework can help in meeting these goals through performance monitoring and improvement followed by rigorous verification leading to award of certification. The scope of PEER framework also includes comprehensive development and planning of smarter and sustainable grids.

As it may be seen from some of the numbers presented in this paper, utilities and small scale power systems in U.S. have achieved significant improvements through PEER certification process. GoI and regulatory bodies for power sector in India should emphasize on continuous measurement of important parameters of power plants, DISCOMs, etc. and subsequent verification of the performance reports. Adopting a structured and outcome based framework such as PEER and integrating it with national policies would help in effective achievement of performance targets by power system operators. An inclusive policy has to be formulated for power industry to thrive in a world with increasing importance on sustainability.

References

[1] "Executive Summary report for the month of September 2016", CEA.

[2] Chandra Bhushan et al. "Heat on Power: Green Rating of Coal-based Power Plants", Centre for Science and Environment, New Delhi.

[3] "Trends in Global CO_2 Emissions", Background Study, PBL Netherlands Environmental Assessment Agency.

[4] "UDAY (Ujwal DISCOM Assurance Yojana) for financial turnaround of Power Distribution Companies", Press Information Bureau, GoI Cabinet, 5th November 2015.

[5] "UDAY Scheme for Operational and Financial Turnaround of Power Distribution Companies", Office Memorandum, No. – 06/02/2015 – NEF/FRP, Dated: 20th November 2015.

[6] "IEEE Guide for Electric Power Distribution Reliability Indices", IEEE Standards Association, IEEE, 2012.

[7] K. H. LaCommare & J. H. Eto, "Understanding the Cost of Power Interruptions to U.S. Electricity consumers", Energy Analysis Department, Ernest Orlando Lawrence Berkeley National Laboratory, University of California Berkeley.

[8] "Reliability Index of the Cities/Towns/Villages – DISCOM wise", Power For All Monitoring Division, CEA, Years: 2015-16, 2014-15, 2013-14.

[9] "Tamil Nadu Electricity Distribution Standards of Performance Regulations", Notification No. TNERC/SPR/9/1, Tamil Nadu Electricity Regulatory Commission, Dated: 31/07/2008.

[10] John Kelly, Ruth Nechas & G. R. Rouse, "Metrics for the Perfect Power Seal of Approval – Reliability", Galvine Electricity Initiative, April 2011.

[11] "Recommendations on Operation Norms for Thermal Power Stations (Tariff Period – 2014-19)", CEA, January 2014.

[12] C. Hussy, E. Klaassen, J. Koornneef & F. Wigand, "International comparison of fossil power efficiency and CO2 intensity - Update 2014", Ecofys, Mitsubishi Research Institute Japan, September 2014.

[13] "Baseline Carbon Dioxide Emission Database – Version 11.0", CEA.

[14] Notification - S.O. 3305 (E), Ministry of Environment, Forest and Climate Change

[15] "Report on Fly Ash Generation at Coal/ Lignite based Thermal Power Stations and its Utilization in the Country for the Year 2014-15", CEA, October 2015.