

# Bibliography of Open Data on Indian Power Sector: Part 2: Regulations, Standards, and Smart Grids

Charan Teja S

Department of Electrical Engineering  
Indian Institute of Technology Hyderabad  
Kandi, Hyderabad-502285  
Email: ee14resch01005@iith.ac.in

Pradeep Kumar Yemula

Department of Electrical Engineering  
Indian Institute of Technology Hyderabad  
Kandi, Hyderabad-502285  
Email: ypradeep@iith.ac.in

**Abstract**—In the fast evolving world of information age, the value of open data is being recognized around the world. The information and communication technologies are making it easier to collect and store data. The consequent use of this data is leading to smartness in the respective sectors. Since power infrastructure is critical for national security, the availability and access to data is one of the hurdle for researchers in power sector. However, due to paradigm shift in Government’s view of open data, paired with advancements in technology proactive dissemination of data on various sectors in India, including power sector, has become a reality. Thus this two part paper attempts to compile a bibliography of all such data sources, to the extent possible, pertaining to power sector of India. Part 1 covers the electrical systems operations and markets. Part 2 covers the regulations, standards and smart grids. It is believed that this will help all the stakeholders including researchers in knowing what kind of data is available and possibly give them new ideas in applying this data in their respective research. This paper organises the data sources into various domains and also discusses recent developments in the open data movement across the world and how Indian power sector can be benefited from the same.

## I. INTRODUCTION

Standards and regulations, policies are the fundamental building blocks for proper operation of the power sector. Government open data along with regulations and standards would be a tremendous resource for researchers. The advantages of having open data, regulations, standards how to set up open data and utilization of open data is described in [1]. These standards and regulations are available and they can be applied in reseacch to meet more real time practical scenario. Fig.1 shows the ieee smart grid conceptual model in which foundational support systems is the place where architecture of grid, business process, economics, tariff system, regulations and standards are maintained. The data pertaining to domains of the ieee smart grid model are cited in part 1. Foundational support systems are concentrated in this part. Along with this real-time data that is available in the public domain is also cited. The aim of this part of this paper is to create awareness about the Indian power sector regualtions, standards that are

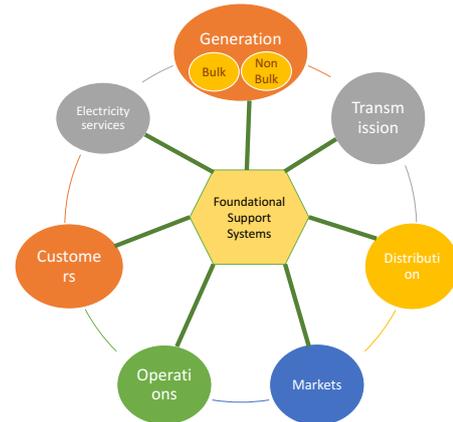


Fig. 1. IEEE Smart Grid conceptual model

available in public domain. The paper is organized by detailed description of this fundamental support systems are presented in subsection of section II [2]. Section III introduces to the time Berners Lee open data paradigm, explaining the 5 star rating of the open data.

## II. FOUNDATIONAL SUPPORT SYSTEMS FOR POWER SECTOR

### A. Financial Data

The financial performance of the power sector of India is provided in the annual report by power finance corporation (PFC) in [3]. The annual report of POSOCO [4] provides an overview of financial status of system operation in India. An insightful high level panel report, also known as Shunglu committee report, on financial position of various state discoms in India is available at [5]. The data regarding the financial results of the national thermal power station can be obtained from [6]. This data is useful for those who are working in the profit maximization or cost cutting measures in thermal power stations. The costs incurred and the financial results of rural electrification in India are available in [7]. This data would be useful for researchers in knowing the detailed description on the shareholders of the power sector as well as the overall debts and assets.

## B. Regulations

The fixed and energy charges of different power stations and power companies are presented by central electricity regulatory commission in annual report [8]. This annual report data is useful in performing the real time techno economic analysis of the power plants. Also this data is helpful for researchers working in the area of optimal power flow. The assumptions and regulations corresponding to total transfer capability (TTC) and available transfer capability (ATC) is presented in [9]. The transmission loss regulations and regulations intend to transmission of power is available at [10]. The procedure of load sharing and allocation of load in [11] provides the detailed description of load sharing, allocation and operation. The procedure for collection of data, computation and cerc validation is in [12].

## C. Standards

The Electricity act is presented in [13]. This contains the rules and regulations that are need to be followed by power sector in India. The electricity regulations act [14] is published in 1998 which contains the guidelines for forming tariff, subsidies. The principles for production and supply of electricity are published in [15]. This contains the details of the regulations that need to be performed in electricity supply. The electro technical department (ETD) under BIS published a program of work report [16] in July 2014, which presents the current status of standardisation in the field of electrical power sector. Similarly, the electronics and information technology department (LITD) under BIS published a program of work report [17] in March 2014, which presents the current status of standardization in the field of electronics and IT. Under this department, subcommittee LITD-10 deals with standardization in power control and associated communications.

## D. Availability Based Tariff

Availability based tariff (ABT) is a tariff system that is involved in bulk generation and consumption. This is aimed to improve the accountability and responsibility in bulk generation and consumption. This tariff concept is based on the frequency. The detailed regulations and the tariff calculation are available in [18]. ABC on ABT [19] presents how ABT is being applied in the power system operation and the description with examples are published by NRLDC. The real-time data of ABT is presented by all the RLDCs. WRLDC presents the ABT real-time data in [20].

## E. Power Committee

Power committees are formed for coordinate planning, maintenance between different generating companies. These committees takes the responsibility of planning the outages based on monthly basis, operational planning studies. They also review the reactive compensation requirement by studying the systems. The objective is to maintain the efficiency of the transmission system. Likewise RLDCs power committees are also divided based on the regions as Eastern Regional Power Committee (ERPC), Northern Regional Power

Committee (NRPC), Southern Regional Power Committee (SRPC), Western Regional Power Committee (WRPC), North Eastern Regional Power Committee (NERPC). The reactive power injections of NERPC by different states is available at [21]. North eastern region approved shutdown/maintenance schedule details are at [22]. Complete operation details of the southern region which include outage planning, transmission availability, deviation in prices are presented in [23]. Each region power committee submits a annual report and are made available in their websites. These reports constitutes of grid maps, deviations during that year, reactive power injection details etc. These committees individually maintains a congestion charge account for maintaining the charges against the congestions. This data is also made available in the respective websites.

## F. Real-time Data

Under NLDC there are five regional load dispatch centers which will provide the real time data. Five regions include northern region load dispatch center (NRLDC) [24], eastern region load dispatch center (ERLDC) [25], western region load dispatch center (WRLDC) [26], southern region load dispatch center (SRLDC) [27], north eastern region load dispatch center (NERLDC) [28]. These web portals or websites provides the real time data of power flow, market transactions, operational frequency. Also the inter regional power flow details and each generating station generation data. This data is available in 15-minute time block. Each corresponding RLDCs will provide the unit interchange rate based on frequency individually. Additionally at regional level all the regions provide detailed operational procedures, as shown with the example of WLRDC [29].

## G. Smart Grid Development

India smart grid forum (ISGF) is a public private partnership initiative of MoP for accelerated development of smart grid technologies in Indian power sector. Apart from its many initiatives, ISGF has been active in this area with its flagship event called India smart grid week (ISGW) [30]. The third edition of ISGW is scheduled during March of 2017 in Delhi. ISGF also runs the first of a kind smart grid knowledge portal in India, which provides latest updates on progress of smart grid pilot projects and technical reports on several topics pertaining to smart grids [31]. Another key resource published by ISGF is the India smart grid bulletin [32], which is a monthly bulletin since January 2014. ISGF has played a key role in development of India smart grid vision and roadmap [33], which has been officially released by the MoP in August 2013. This document lays down a vision and roadmap for development of smart grids in India. One of the key recommendation of this document is setting up of national smart grid mission (NSGM) which is further elaborated in following section. PGCIL developed a smart grid primer [34] for India with a vision of "MIGRATION" which means motivating intelligent green reliable affordable transformation, interoperable opportunistic noble. This covers

the overall idea of smart grid and its implementation in India. The present status and applications of the puducherry smart grid pilot project are available at [35].

#### H. National Smart Grid Mission

NSGM is envisaged to have own resources, authority, functional and financial autonomy to plan and monitor implementation of the policies and programmes prescribed in the roadmap. NSGM publishes useful information [36] on status of smart grid pilot projects [37], smart grid technologies, use cases, and reports.

### III. OPEN DATA PARADIGM

In this section, we outline a paradigm shift in handling data which every organization has already started or will be starting in this information age. Tim Berners Lee proposed a 5 star linked data vocabulary in order to boost the engineers, data owners to publish data on web. This star rating is not about the quality of data (e.g., accuracy) but rating is mostly depending on the readable format of the data [38].

\*\*\*\*\* zero star is given for the data which is not web accessible. For example a data published like LA temp 27 which may refer to Los Angeles, but LA is also the US postal code for Louisiana. So, here the statement provided is doesn't give precise information.

\*\*\*\*\* This star is given for the information provided in human readable data. For example a page of documentation provided in pdf file with some examples. This is more like providing the data with image scan type.

\*\*\*\* Here the information is available in machine readable structured format. This is comparable with 4 star data reading.

\*\*\*\* This star is linked with vocabulary to other vocabularies. Here the data will contain alignments and often for direct reuse with external vocabularies. For example in both csv and excel.

\*\*\*\*\* This star is for metadata which means that the data is both in human readable and the machine readable format. Here universal resource identifier (URI) denotes the stuff.

\*\*\*\*\* Here the vocabulary is linked to other vocabularies. This is the compliment of three star rating.

This analogy can be used for analysis of the open data in Indian power sector. As it is observed that most of the data is presented with their own vocabularies. The interoperability between the vocabularies need to be done in order to get 5 stars. Each organization is following its own vocabulary irrespective of other organization data. So, provision of linked data along with URIs will be more useful for researchers as well as government for transparency.

### IV. DISCUSSION AND CONCLUSION

In this part 2 of the paper several useful resources on open data available in public domain pertaining to regulations, standards, smart grids have been cited. While part 1 of the paper focused on the traditional electrical domains, namely, bulk generation, transmission, distribution, markets, system

operation, end consumers and services etc. Contrary to the popular view that - it is difficult to obtain data on power sector data, it is observed that, many resources exist where not only the past but also the present scenario is made available online. Various stakeholders, and specifically budding researchers in this field will benefit from understanding the practical aspects of power sector in India by going through the references cited in this bibliography. This practical knowledge will complement the theoretical knowledge gained from well established text books on power system analysis. While effort has been made in compiling an exhaustive list of useful resources, due to the vastness of the power sector and due to space limitation of the paper, this bibliography is far from being complete, and should only be considered as an initial but growing list. The authors shall gladly welcome and appreciate comments on this paper, suggestions for new resources to be included in the bibliography, any omissions or corrections needed in this paper. This paper is to be viewed as a living document with regular updates.

### V. ACKNOWLEDGMENT

The idea behind writing this paper has emerged from the industry - academic joint interaction session on 18th March 2016 at the NRLDC Control Center chaired by Shri. S. K. Soonee (CEO, POSOCO) and attended by industry experts and several faculty researchers in the area of power systems from reputed IITs and NITs. The authors would like to extend sincere thanks to POSOCO and IIT Delhi for organizing the event, and all the participants for their valuable discussion points.

### REFERENCES

- [1] D. Dietrich, J. Gray, T. McNamara, A. Poikola, P. Pollock, J. Tait, and T. Zijlstra, "Open data handbook," 2009.
- [2] D. Von Dollen, "Report to nist on the smart grid interoperability standards roadmap," *Electric Power Research Institute (EPRI) and National Institute of Standards and Technology*, 2009.
- [3] PFC. (2015, Jul.) *Power Finance Corporation limited - Annual report*. [Online]. Available: [http://www.pfcindia.com/Content/Annual\\_Reports.aspx](http://www.pfcindia.com/Content/Annual_Reports.aspx)
- [4] POSOCO. (2016, Jun.) *Power system operation corporation limited - Annual report*. [Online]. Available: <http://posoco.in/AnnualReports.aspx>
- [5] V. Shunglu *et al.*, "Report of high level panel on financial position of distributed utilities. new delhi. planning commission," 2011. [Online]. Available: <http://planningcommission.nic.in/reports/genrep/hlpf/hlpf.pdf>
- [6] NTPC. (2016, Jun.) *National Thermal Power Corporation - Financial Results*. [Online]. Available: <http://www.ntpc.co.in/en/investors/financial-results>
- [7] REC. (2016, Jun.) *Rural Electrification Corporation Limited - Annual report*. [Online]. Available: [http://www.recindia.nic.in/index.php?option=com\\_content&view=article&id=412&Itemid=540&lang=en](http://www.recindia.nic.in/index.php?option=com_content&view=article&id=412&Itemid=540&lang=en)
- [8] CERC. (2016, Jun.) *Central Electricity Regulatory Commission - Annual report*. [Online]. Available: [http://www.cercind.gov.in/annual\\_report.html](http://www.cercind.gov.in/annual_report.html)
- [9] PGCIL. (2016, Jun.) *Power grid corporation of India limited - TTC/ATC regulations*. [Online]. Available: [http://www.powergridindia.com/\\_layouts/PowerGrid/User/ttc-atc-declarations.aspx?LangID=English](http://www.powergridindia.com/_layouts/PowerGrid/User/ttc-atc-declarations.aspx?LangID=English)
- [10] POSOCO. (2016, Jun.) *Power system operation corporation limited - NLDC - Transmission loss regulations*. [Online]. Available: <http://www.nldc.in/Regulation.aspx>
- [11] ——. (2016, Jun.) *Power system operation corporation limited - NLDC - Procedure for load sharing*. [Online]. Available: <http://www.nldc.in/ApprovedProcedures.aspx>

- [12] —. (2016, Jun.) *Power system operation corporation limited - NLDC - Data collection procedure*. [Online]. Available: <http://www.nldc.in/Downloads.aspx>
- [13] GoI. (2016, Jun.) *Government of India - Electricity Act, 2003*. [Online]. Available: <http://www.cercind.gov.in/Act-with-amendment.pdf>
- [14] —. (2016, Jun.) *Government of India - Electricity Regulations Act, 1998*. [Online]. Available: <http://www.cercind.gov.in/ElectReguCommiAct1998.pdf>
- [15] —. (2016, Jun.) *Government of India - Electricity Supply Act*. [Online]. Available: <http://www.cercind.gov.in/ElectSupplyAct1948.pdf>
- [16] BIS. (2014, Jul.) *Bureau of indian standards - List of electrotechnical standards*. [Online]. Available: <http://www.bis.org.in/sf/pow/etd.pdf>
- [17] —. (2014, Mar.) *Bureau of indian standards - List of electronics and information technology standards*. [Online]. Available: <http://www.bis.org.in/sf/pow/powlitd.pdf>
- [18] CERC. (1999, Jul.) *Central electricity regulatory commission - Availability based tariff*. [Online]. Available: <http://cercind.gov.in/orders/2-1999GOIABT040100.pdf>
- [19] NRLDC. (2005, Jun.) *Northern region load dispatch center - Availability based tariff*. [Online]. Available: [http://nrlc.org/docs/documents/Articles/abc\\_abt.pdf](http://nrlc.org/docs/documents/Articles/abc_abt.pdf)
- [20] WRLDC. (2016, Jun.) *Western region load dispatch center - Availability based tariff deviation online*. [Online]. Available: <http://www.wrlc.com/onlinestate.aspx>
- [21] NERPC. (2016, Jun.) *North eastern region power committee - Reactive power injections*. [Online]. Available: <http://nerpc.nic.in/rereport.php>
- [22] —. (2016, Jun.) *North eastern region power committee - Shutdown/Maintenance Schedule*. [Online]. Available: <http://nerpc.nic.in/MaintenanceSchedule.php>
- [23] SRPC. (2016, Jun.) *Southern region power committee - Operational data*. [Online]. Available: [http://www.srpc.kar.nic.in/html/all\\_uploads.html](http://www.srpc.kar.nic.in/html/all_uploads.html)
- [24] POSOCO. (2016, Jun.) *Power system operation corporation limited - NLDC - Northern region load dispatch center*. [Online]. Available: <http://www.nrlc.in/>
- [25] —. (2016, Jun.) *Power system operation corporation limited - NLDC - Eastern region load dispatch center*. [Online]. Available: <http://www.erlcc.org/>
- [26] —. (2016, Jun.) *Power system operation corporation limited - NLDC - Western region load dispatch center*. [Online]. Available: <http://www.wrlc.in/>
- [27] —. (2016, Jun.) *Power system operation corporation limited - NLDC - Southern region load dispatch center*. [Online]. Available: <http://www.srlc.org/>
- [28] —. (2016, Jun.) *Power system operation corporation limited - NLDC - North-Eastern region load dispatch center*. [Online]. Available: <http://www.nerlcc.org/>
- [29] —. (2016, Jun.) *Power system operation corporation limited - Operational Procedure*. [Online]. Available: [http://www.wrlc.in/docs/WR\\_OPERATING\\_PROCEDURE\\_2014.pdf](http://www.wrlc.in/docs/WR_OPERATING_PROCEDURE_2014.pdf)
- [30] ISGF. (2016, Jun.) *India smart grid forum - india smart grid week*. [Online]. Available: <http://www.isgw.in/>
- [31] —. (2016, Jun.) *India smart grid forum - Resource center*. [Online]. Available: <http://www.indiasmartgrid.org/resourcecenter.php>
- [32] —. (2016, Jun.) *India smart grid forum - News letter*. [Online]. Available: <http://www.indiasmartgrid.org/newsletter.php>
- [33] S. G. Vision, "Roadmap for india," *Ministry of Power*, 2013. [Online]. Available: [http://www.nsgm.gov.in/upload/files/India-Smart-Grid-Vision-and-Roadmap\\_DSG.pdf](http://www.nsgm.gov.in/upload/files/India-Smart-Grid-Vision-and-Roadmap_DSG.pdf)
- [34] PGCIL. (2016, Jun.) *Power grid corporation of India limited - smart grid primer*. [Online]. Available: [http://apps.powergridindia.com/flex/split\\_document.aspx?doc=A23508FE-EC7F-45E2-B3BE-4F94E138A22B.pdf](http://apps.powergridindia.com/flex/split_document.aspx?doc=A23508FE-EC7F-45E2-B3BE-4F94E138A22B.pdf)
- [35] —. (2016, Jun.) *Power grid corporation of India limited - smart grid pilot project status puducherry*. [Online]. Available: [https://apps.powergridindia.com/smartgrid/smart\\_home.aspx](https://apps.powergridindia.com/smartgrid/smart_home.aspx)
- [36] NSGM. (2016, Jun.) *National smart grid mission - Resource center*. [Online]. Available: <http://www.nsgm.gov.in/content/reports.php>
- [37] —. (2016, Jun.) *National smart grid mission - Smart grid pilot project status*. [Online]. Available: [http://www.nsgm.gov.in/content/sg\\_status.php](http://www.nsgm.gov.in/content/sg_status.php)
- [38] T. Berners-Lee, "star deployment scheme for open data," 5.