PROCESS MAP OF A "UNIFIED DATA PLATFORM" FOR OPERATIONAL INTELLIGENCE AND ANALYSIS OF POWER SECTOR IN INDIA

A thesis submitted to the

University of Petroleum and Energy Studies

For the award of

Doctor of Philosophy

In

Management

BY

Pratik Ghosh

May 2020

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UPES

UNIVERSITY WITH A PURPOSE

School of Business

University of Petroleum and Energy Studies

Dehradun – 248007, Uttarakhand

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I. DECLARATION

I hereby declare that this submission "Process Map of a Unified Data Platform for Operational Intelligence and Analysis of Power Sector in India" under the guidance of Dr. Ratna Banerjee, Astt. Professor (SG), Dept. of General Management, SOB, University of Petroleum & Energy Studies, Internal Co-Supervisor Dr. Vinay Kandpal, Astt. Professor (SS), Dept. of General Management SOB, University of Petroleum & Energy Studies and External Supervisor, Dr. J. T. Verghese, Chairman, STEAG Energy Services. This is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgment has been made in the text.

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II. CERTIFICATE

This is to certify that the thesis on "Process Map of a Unified Data Platform for Operational Intelligence and Analysis of Power Sector in India" by Pratik Ghosh, for completion of the requirement for Doctor of Philosophy (Management) Degree award. This thesis is an original work completed by him under our supervision and guidance.

It is certified that the work has not been submitted anywhere else for the award of any other diploma or degree of this or any other University.

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III. CERTIFICATE

I certify that Pratik Ghosh has prepared his thesis entitled "Process Map of a Unified Data Platform for Operational Intelligence and Analysis of Power Sector in India", for the award of PhD degree from the University of Petroleum & Energy Studies, under my guidance.

He has carried out the work at the Department of Management, University of Petroleum & Energy Studies.

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IV. EXECUTIVE SUMMARY

The research is carried out for the power sector where in the mechanism for data unification is studies and to design a process map to create a "Unified Data Platform" to manage data, which benefits all the stakeholders including operations and analysis, leads to save money and time through decision-making.

The objectives of the research were to analyze the strengths and weaknesses of existing data silos and their viability for data unification and to identify the factors impeding the development and implementation of a "Unified Data Platform". After analyzing, the research work was to design a Process Map for addressing the identified gaps for a Unified Data Framework based on identified factors, constraints and tools for power generation, transmission, distribution and trading.

The research tries to identify the various factors that need to be integrated to implement a Unified Data Platform (UDP) for the power sector and its interoperations. Data and tools from generation, transmission, distribution and trading were readily available but in silos and we added to it the complexity of interoperability between stakeholders affecting the organizations, applications, information systems, social, economic, regulatory and technical infrastructure. The different data silos were studied to identify the factors which need to be analysed and integrated for these silos to interoperate with each other for attaining operational excellence in a competitive environment. The research was important as the last few decades have seen an organic growth of the power sector in India. This growth inherently bought with it the requirement for humongous enhancement of existing systems, restructuring of the sector, modification of the policies and develop frameworks to handle the scale of future capacities. The integration and interconnection of different stakeholders in the sector has increased the quantum of software, hardware, tools and data by manifold. The unification of data at a higher level will improve the operational efficiencies and reduce the losses at silos level due to lack of data unification.

The research tries to define "Process Map" for a Unified Data Platform for the power sector and its interoperations. Data mining and analytics are playing a key role in every modern industrial and process system. The tremendous growth in the field of information technology, communication protocols and support of high performing processors of modern day computer has led to a layer of data and information which can be utilized for management and operational excellence. The different data system, communication protocols, hardware and software applications were studied to identify the factors for designing the process map. The information layer added to the conventional power sector network is studied which is an ever increasing source of data. Additional data is being added by the new generation smartgrid with its automation system that are having numerous sensors embedded in the existing power system for controlling, monitoring and operational activities. The research was important as the last few decades have seen an organic growth in the power sector data which needs a defined framework and process map for Operational Intelligence and Analysis.

In this research we explored the subject with the power sector scenario in India, how to analyse this huge data being produced by the modern technologies, new grid operation methodology and data silos in the generation, demand, transmission, distribution and trading network. The knowledge will help to understand usage patterns, prevent outages, optimise unit's commitment, intelligent system management, amongst many other objectives.

Some of the impacts and benefits of this research are

1. Streamline data management processes saving time and resources
2. Avoid duplicative efforts by operators and planning agencies
3. Best practices in data collection and management
4. Centralize burden of data storage & management
5. Leverage research expertise in data mining and analysis

6. Educate students – creating talent to manage Big Data
7. Improve connection between practitioners, researchers and students

The research also contributes to literature as the third objective is a structured, process-driven approach to improving the data exchange for operational intelligence and analysis of power sector in areas such as cost, service, quality, efficiency and speed etc. This complete redesign distinguishes BPR from other methodologies where incremental improvements are made through regular process improvements and contributes towards the Business Process Improvement ("BPI") very popularly elaborated by Thomas H. Davenport.

V. ABSTRACT

With today's modern and advanced technology, there are numerous infrastructure, technologies and systems available to control, operate and design the power sector network. The network spreads across the generation, transmission, distribution, trading and associated up-streams and down-streams.

Globally this is managed by independent models and systems for each sub-sector of the value chain. Each node and link in the network produces huge amount of data within the system and applications in the silos. In this age of data deluge, such varied forms of data can be handled by platforms capable to handle volumes and variety of data which two-folds or tri-folds each year and this growth of data is not going to slow down.

'Research predicts global data levels will reach 40 zeta bytes (1 trillion gigabytes) by 2020' (Economist Insights, 2013) an estimate by McKinsey (Manyika, 2013). Such large volume of data or as the industry calls it data has its inherent challenges and opportunities for improved operations and researching ways to utilize and analyse has become a key focus area of the major industries worldwide. Data management, storage and analysis are very critical for any industry to be sustainable and develop in accordance to the external business environment and continuous changes.

In this research we will be exploring the subject with the power sector scenario in India, how to analyse this huge data being produced by the modern technologies, new grid operation methodology and data silos in the generation, demand, transmission, distribution and trading network. The knowledge will help to understand usage patterns, prevent outages, optimise unit's commitment, intelligent system management, amongst many other objectives.

Till the time the lights are on and the air conditioner are operating, all of us appreciate the necessary service being provided by the power utilities and their importance in our daily lives. Till now, power and utility firms have

operated in a well-defined and linear method giving us a reliable supply, despite of the fact that the growth and the geographical spread is happening each year. However that is the past scenario, in the current and future world the power sector should become progressively consumer and prosumer oriented and guarantee versatile access to the services being provided by each stakeholder anytime and anywhere. The utilities have redesign and reengineer new business models to facilitate new interactions to handle new dimensions like smartgrid, proliferation of renewables, bi-directional power production, re-shaping markets, heightening competition etc. The utilities need to leverage on the data of the entire value chain and analyse the usage patterns so that it can re-structure and operate efficiently and in cost-effective manner. Power utilities are aware since many decades and are handling industrial and residential user data and knowledge utilizing some or other tools, however most utilities are currently under intense pressure to generate their energy production irrespective of economical parameters, dependency on fossil fuels, transmission and distribution losses and many parameters beyond their control. At the same time, they also have to bear the risks of latest government regulation changes and political interferences. This scenario overall hamper their revenue growth and profitability. On top of that they have to adopt the new and upcoming technologies for the connected world SCADA, IoTs, Knowledge Acquisition Systems, smart-meters, smart-devices, smartgrids etc. The upcoming and modern technologies are providing the utility with new capabilities for data analysis for operational excellence like demand response, client usage patterns, load forecasting, outage management, optimizing unit commitment to name a few. These smart and connected systems are generating huge data volume, variety, speed and complexity of knowledge that can be mined from the datasets.

“The modern systems being deployed by power sector are generating huge volume of data which has changed the dynamics on how business process and analytics is done. Power sector is a massive producer of time-based or telemetry data which are mission critical from generation, transmission, distribution, trading (Urbana World, 2016) and other relevant data sources. There are various applications available in the silos of power sector which are generating data of various formats and nature (Ghosh) (Urbana World, 2016). Taking a scenario of electricity meter which today does one meter reading per month, it will increase to fifteen minutes reading after installation of smart meter and will generate ninety six million dataset per meter per day and for the millions of meters that will be deployed across the country.

The outcome will be an increase of three thousand folds in data that needs to be handled and analysed. And, this flow of data will increase as more smart devices will be installed as time goes on" (IBM Datamag).

"Evolution of National Grid

- Grid management on regional basis started in sixties.
- Initially, State grids were inter-connected to form regional grid and India was demarcated into 5 regions namely Northern, Eastern, Western, North Eastern and Southern region.
- In October 1991 North Eastern and Eastern grids were connected.
- In March 2003 WR and ER-NER were interconnected
- August 2006 North and East grids were interconnected thereby 4 regional grids Northern, Eastern, Western and North Eastern grids are synchronously connected forming central grid operating at one frequency.
- On 31st December 2013, Southern Region was connected to Central Grid (Powergrid) in Synchronous mode with the commissioning of 765kV Raichur-Solapur Transmission line thereby achieving 'ONE NATION'-'ONE GRID'-'ONE FREQUENCY'" (KSE).

Data and tools from generation, transmission, distribution and trading were readily available but in silos and we added to it the complexity of interoperability between stakeholders affecting the organizations, applications, information systems, social, economic, regulatory and technical infrastructure. The integration and interconnection of different stakeholders in the sector has increased the quantum of software, hardware, tools and data by manifold.

The tremendous growth in the field of information technology, communication protocols and support of high performing processors of modern day computer has led to a layer of data and information added to the conventional power sector network which is an ever increasing source of data. Additional data is being added by the new generation smartgrid with its automation system that are having numerous sensors embedded in the existing power system for controlling, monitoring and operational activities. Data mining and analytics are playing a key role in every modern industrial and process system.

The different data silos were studied to identify the factors which need to be analysed and integrated for these silos to interoperate with each other for attaining operational excellence in a competitive environment. The silos had different data system, communication protocols, hardware and software applications which needs to be assimilated on a common platform. The research was important as the last few decades have seen an organic growth of existing systems, restructuring of the sector, modification of the policies to handle the scale of future capacities.

The research tries to identify the various factors that need to be integrated to implement a "Unified Data Platform" (UDP) for the power sector and its interoperations.

It also defines a "Process Map" for a "Unified Data Platform" for the power sector and its interoperations.

The research was important as the power sector needs a well defined framework and process map for Operational Intelligence and Analysis.

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I am thankful and indebted with gratitude to my mother, my wife Sucheta, my daughter Trisha, and my in-laws who were supportive of this journey of mine. They endured long periods of my absence from home when I was busy researching with my guides at Dehradun and pardoned me when I cancelled their vacations.

I have reserved my best for the last. I am eternally grateful to my mentor, my wife, Sucheta Ghosh, who has been my greatest motivation and supporter to pursue this program. She along with my family gave the best of everything at home and made sure to provide disturbance free time to do my studies and research which is so critical to put in long hours on books and notes. But for her, I would have struggled to reach this point in life where I stand today.

Thanking once again all who have supported me and ask forgiveness from those whom I have not mentioned by name but were truly standing beside me during all these years of my life and my doctoral journey.

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1. CHAPTER I - INTRODUCTION

1.1 MOTIVATION

The power sector network is probably the greatest engineering feat of the century, however due to ever changing market dynamics it faces new challenges all the time be it new system, technology shifts, regulatory changes, government policies, security, responsibility, et al.

Developed nations have a well designed and implemented network of grid which they are enhancing further, whereas countries like India which are still developing are increasing their grid spread at one hand and adopting new best practices on the other.

- Power Utilities are generating and using a lot of data
- Numerous data driven opportunities are nascent and remains to be harnessed to improve operations and services
- Utilities are using smart devices to improve customer service
- Big opportunities remain in operational analytics to improve operations
- Utilities expect analytics will drive operational efficiency and boost the bottom line
- Most utilities lack usage of sufficient data analytics

Though data management tools are present in silos, the available literature studied and research done does not provide evidence related to a “Unified Data Platform” across generation, transmission, distribution and trading in Indian power sector.

We can summarise the problem as “Lack of Unified Data Platform, for data analysis of operational parameters across the power sector is leading to decision delays, inefficient operations and losses”.

Motivation for research is to increase operational efficiency, reduce data lags; that leads to operational and business losses.

1.2 RESEARCH PROBLEM

The gap identified after literature review point out towards the fact that "Utilities do not have a Unified Data Platform for Operational Intelligence and Analysis of the sector" (Pratik Ghosh, Factors and Constraints for implementing a Unified Data Platform for Operational Intelligence and Analysis of the Power Sector, 2019).

Proposal is to research and design the architecture of "Unified Data Platform" for Operational Intelligence and Analysis of Power Utilities in India (Pratik Ghosh, Process Map of a Unified Data Platform for Operational Intelligence and Analysis of Power Sector, 2019).

1.3 PUBLICATIONS

1. Process Map of a Unified Data Platform for Operational Intelligence and Analysis of Power Sector
   International Journal of Innovative Technology and Exploring Engineering (IJITEE)
   Volume-8 Issue-10 August 2019
   ISSN:2278-3075, B Impact Factor: 5.54
   Pages: 4037-4046
   doi:10.35940/ijitee.J9809.0881019
   Scopus, UGC, Copernicus International, Google Scholar, NISCAIR, ISSN New Delhi, J-Gate, Research Gate
2. Factors and Constraints to Be Considered for the Implementation of A Unified Data Platform for Operational Intelligence and Analysis of the Power Sector
   International Journal of Recent Technology and Engineering™ (IJRTE)
   Volume-8 Issue-2, July 2019
   ISSN:2277-3878, B Impact Factor: 5.92
   Pages: 5753-5760
   doi:10.35940/ijrte.B3525.078219
   Scopus, UGC, Copernicus International, Google Scholar, NISCAIR, ISSN New Delhi, J-Gate, Research Gate

3. Constructs of process map for the Unified Data Platform for Operational Intelligence and Analysis of Power Sector
   International Conference on Management of Infrastructure (ICMI) 2017, UPES Dehradun
   2017, Pages SI-13
   ISBN 978-1-63535-614-4
4. Paper submission at DCMEIT 2017 - Factors and constraints to be considered for the implementation of A Unified Data Platform for Operational Intelligence and Analysis of the Power Sector, at University of Petroleum and Energy Studies

1.4 **CONTRIBUTION**

The research contributes by way of presenting an information layer for power sector stakeholder to unify the data source available in silos.

The research proposes a process map in a structured, process-driven approach in order to improve the data exchange for operational intelligence and analysis of power sector in areas such as cost, service, quality, efficiency and speed etc. This radical change should start at the highest level of organization, and works down to the minutest details to overhaul the system.

The research also contributes towards the Business Process Improvement ("BPI") very popularly elaborated by Thomas H. Davenport.

2. CHAPTER II - LITERATURE REVIEW

In the light of the above business problem, extensive literature review and research was carried out to identify the factors responsible for non-existence of "Unified Data Platform" across generation, transmission, distribution and trading in the power sector of India.

Our research relied on the information gathered through the literature survey, semi-structured interviews of experts from generation stations, transmission grid, distribution network and trading sectors in India and international best practices and experiences from other countries. Relying upon factors for financial viability and regulatory compliance, this study proposes a process map for the data unification in the power sector. For that study of existing data platforms and its ability to integrate with a "Unified Data Platform" for holistic analysis of power sector become a necessity (Pratik Ghosh, Factors and Constraints for implementing a Unified Data Platform for Operational Intelligence and Analysis of the Power Sector, 2019). Motivation for research is to increase operational efficiency, reduce data lags; that leads to operational and business loss.

The literature review of the emerging technologies of Data Analytics with relevance to power sector was done to understand key concepts and the inherent issues of a connected Data Acquisition Systems, automation solutions, smart and intelligent systems like smart meters and smart grids etc.

It is observed that data flow from various points like capacity management, grid data, power trading data, consumer data, smart devices data, energy management systems, asset management data, cost – revenue and billing data, system monitoring data etc. It is also observed that numerous tools and methods are available for each sub-sector like Generation, Transmission, Distribution, Demand Side Management and Regulations.

Despite the ULDC structure defined earlier, data flow issues arose due to the fact that utilities across the sector are using heterogeneous infrastructure, vendor specific hardware with proprietary software, modified Inter Control

Center Protocol (ICCP), and lack of common standards which make it difficult for seamless and unified data exchange resulting in inefficient operation of the grid.

The easy availability of high speed and less expensive computers today which present the new possibilities for the power utilities to use advanced computer based performance analysis, optimisation strategies, thermodynamic and electrical model designing and development of robust energy management systems. The modern system use methodologies ranging from artificial intelligence to neural networks to expert systems.

Lot of focus and new policies has been implemented by GOI to provide support to the states employing numerous programs and schemes for improvement of the sector like

1. “Integrated Power Development Scheme (IPDS)”
2. “Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY)”
3. “National Electricity Fund (NEF)”
4. “Financial Restructuring Scheme (FRS)”

The objectives of the various schemes are:

1. IT enablement of sector
2. Strengthening urban area T&D network
3. Strengthening rural area T&D network
4. Metering of distribution / urban are consumers
5. Rural and Urban Electrification Programs
6. Segregation of agriculture customers from non agriculture
7. Metering of distribution / consumers in the rural area

The challenge that the smart-grid and modern power plant management systems or energy management systems (EMS) face today are the complexity of numerous disconnected network and their management on numerous platform which act in silos whereas the activities in a power system depend upon information relating to the state of the power network and their interconnection.

Individual tools, software and models record existing network elements in power sector and its infrastructure layers. Records are kept for generation, transmission and distribution equipment in their respective silos. This distributed data approach has disadvantages when it comes to real network integration as independent system use diverse models and standards which make the overall network management difficult. Energy management is not accurate due to disconnected models and data. This also increases the data inconsistencies which result from the disconnected or duplication of information in different silos.

All these systems are data dependent and require communication of data between the independent systems. The analysis of data has barriers and becomes very complex if carried out in the silos (Ghosh). These barriers can be removed by designing a "Unified Data Platform" (UDP) to manage the huge interconnection of data, application, protocols and infrastructure across the intra-regional power network. A data platform designed for storage, managing and analysis of the humongous data to extract the insights and patterns hidden in the data and to utilize it for taking strategic and tactical decisions.

The UDP needs to be designed to facilitate seamless interface between the systems available in silos by standardizing data and information exchange. It should define methods and protocols for better interface between applications, robust interconnectivity and to reduce the number of data adapters for speed and reliability. We can clearly state that the impact due to lack of "Unified Data Platform", for current and future data analysis of operational parameters across the power sector is leading to decision delays, inefficient operations and losses.

2.1 INFORMATION TECHNOLOGY

Power sector applications now run on wide array of devices from handheld to large centralised servers. The advancement of mobile technology for enterprise mobility has provided enhanced capability, usability and affordability. The most visible advantage of the internet is the expansion of ecommerce making most products and services reach the end user. The reach has increased the impact on both business-consumer (B2C) and business-business (B2B) interaction. Availability of huge processing power enables effective and efficient processing of large chunk of information leading to operational efficiency, organizational intelligence and competitive advantages. This bi-directional exchange of data has altered the relationships of stakeholders by developing new products, services and business models. Information Technology is extensively used for integrated data management. Power sector extensively uses IT tools but mostly in silos. The unification of data will bring out new insights and business support system in the near future.

2.2 **LACK OF "UNIFIED DATA PLATFORM"**

The various stakeholders of power sector are generation stations, transmission grids, distribution networks and trading companies which use information technology for management of existing assets, inventories, operations and maintenance. Most of the operational losses are direct result of a lack of integration of processes. The challenge faced by the industry is a combination of legacy and modern technology added with inconsistent regulations and policies. The challenge is further increased due to difference in management and policy at state and center level. This inturn increases the pressure on each stakeholder to become cost effective and efficient in their boundary and silos. An alternative will be to bring the entire sector on a common platform and provide operational, regulatory and financial support at a higher level. The survival of each stakeholder depends on its delivery of quality product and services in cost effective manner to its consumers.

The systems are available in silos and perform tasks like performance analysis, energy management systems, remote monitoring, maintenance management, fault diagnostics, network and protection management, trading etc.

All these systems are data dependent and require communication of data between the independent systems. The analysis of data becomes very complex if carried out in the silos.

The challenge that the smart-grid and modern power plant management systems or energy management systems (EMS) face today are the complexity of numerous disconnected network and their management on numerous platform which act in silos whereas the activities in a power system depend upon information relating to the state of the power network and their interconnection.

Individual tools, software and models record existing network elements in power sector and its infrastructure layers. Records are kept for generation, transmission and distribution equipment in their respective silos.

This distributed data approach has disadvantages when it comes to real network integration as independent system use diverse models and standards which make the overall network management difficult.

Energy management is not accurate due to disconnected models and data. This also increases the data inconsistencies which result from the disconnected or duplication of information in different silos.

These disadvantages may be attributed to the fact that the data is in silos and different system and is difficult to combine for unified management. The advanced networking and communication protocols and systems allow complex systems to be integrated for operation, controlling, management and monitoring (Ghosh).

2.3 **THEMES AND GAPS**

With the business problem in mind, a literature survey was carried out and it was observed that the amount of research that has been conducted in this area is comparatively negligible. We found less than hundred research papers during the survey and found data and themes mostly in whitepapers and product information sheets. Therefore we analyzed that there is a huge scope of research for further development in this area. The themes and the gaps that emerge after the survey of available literature are given subsequently.

S.	Theme	Literature Review	GAPS

No			
1	Data Unification	1. "Big Data deluge threatens utilities, Keith Harrison, Utilities Unbundled – E&Y, 2012 2. Power From Big Data - are Europe's utilities ready for the age of data? , Andrew Bilecki, chief information officer, UK Power Networks, UK, Stephen Fitzpatrick, chief executive officer, Ovo Energy, UK, Ben van Gils, leader, Global Power and Utilities Centre, Ernst & Young, Europe EirikGundegjerde, executive vice president, Smart Utility and Business Development, Lyse Energi, Norway Olaf Köppe, partner, KPMG, Germany Philip Lowe, director general for Energy, European Commission, Belgium Andrew Richards, severe risk analyst, National Grid, UK, ClaesWallnér, head of information technology, Vattenfall,	▪ Data and tools available in silos; ▪ A unified platform for analysis of operational parameters & management data at the utility level is not visible

		Sweden, T-Systems Research, 2013 3. Utilities and Big Data: A Seismic Shift is Beginning, An Oracle Utilities White Paper September 2013 4. Big Data Challenges to Validate Safe, Secure Energy Infrastructure, Brent G. Stanley, Chief Operating Officer, Haystac LLC, Boston, MA 5. Big data can drive big energy savings, Supplement to Control Engineering 6. For better energy management, tap into your data historian, Sidney Hill, Jr., is a CFE Media Contributing Content Specialist, Supplement to Control Engineering 7. Oracle Utilities Operational Solutions, Oracle Operational Excellence 8. Addressing the Big Data Concern in the Utilities	

		Sector, Bret Farrar and Mark Luigs 9. IBM Energy Management, Brad Brech 10. Utilities and Big Data: Accelerating the Drive to Value, Study by Oracle 11. Oracle Utilities Analytics, Oracle 12. How utilities are profiting from Big Data Analytics, Article in Engineering & Technology Magazine 20 January 2014 Martin Courtney 13. What's All the Hype about Big Data and Energy Analytics?, Jack McGowan, CEM, DGCP, is president of Energy Control Inc. (ECI), an Optera Energy Company, and chairman emeritus of the DOE'S GridWise Architecture Council 14. Data Management and Analytics for Utilities, Jason Deign and Carlos Márquez Salazar, Research manager 15. Utilities Dumbstruck By Big Data From Smarter	

		Grid, Jeff McMahon, Sep 2013 16. Intelligent Efficiency: Innovations Reshaping the Energy Efficiency Market, Stephen Lacey, report by Greentech Efficiency, 2013	
2	Technical Capability	17. Managing big data for smart grids and smart meters, IBM Whitepapers, 2012 18. Transforming Energy & Utilities with Big Data Analytics, David Shipman Industry Marketing Manager - Energy & Utilities, IBM, 2012 19. Smart Analytics for the Utility Sector, Business Analyst – Capgemini, 2012 20. THE SOFT GRID 2013-2020: Big Data & Utility Analytics for Smart Grid, GTM and SAS Global Research 21. Demand Side Management, Infosys 22. Smart Grid Analytics: All That Remains to be ready is You, Elliott	▪ Poor information sharing ▪ Inadequate communication between operation centers ▪ Lack of equipment connectivity; poor data analysis, inadequate monitoring and verifications

		McClements, IBM Krishan Gupta	
3	Business Implication	23. Emerging markets opportunity index: high growth economies, Grant Thorton International Business Report 24. Turn Big Data Into Budget Dollars, Allison Hannon, Co founder, Root3 Technologies; and Sumit Ray, director of utilities and engineering, University of Chicago, June 2013 25. The Case for an Industrial Big Data Platform, GE 26. The Evolution of Big Data as a Research and Scientific, GaliHalevi, MLS, PhD, Dr. HenkMoed, 30th issue of Research Trends 27. Acting on the Deluge of Newly Created Automation Data: Using Big Data Technology and Analytics to Solve Real Problems, CJ Parisi, Dr. SiriVaradan, P.E., and Mark Wald, Utility Integration Solutions, Inc.	▪ Poor and untimely decision making; inefficient operations, performance lags, increased risks, cost and time inflation

		(UISOL), 2014 28. Analytics in Action: Breakthroughs and Barriers on the Journey to ROI, Accenture, 2013 29. https://www.ibm.com/developerworks/community/wikis/home?lang=en#!/wiki/Information%20Management/page/Big%20Data%20Fundamentals%20Bootcamp 30. Information Management and Big Data A Reference Architecture, Oracle Whitepaper 2013 31. DECISION AND ANALYTICS 32. The Industrial Internet and Big Data Analytics: Opportunities and Challenges, Jeff Kelly, August 2013 33. The Deciding Factor: Big Data & Decision Making, Capgemini Whitepaper 34. Maximizing the Returns from Big Data, Debasish Mukherjee and Karthik Krishnamurthy, Cognizanti bi-annual journal produced by	

		Cognizant 35. Big Data Creates Predictive Maintenance Opportunities, Jim Chappell, InStep Software, ELP.com 36. Big Data Spectrum and Architecture, Infosys 37. Al-Tuaimeh ,Samia Fares. Building a Proposed Model for Supply Chain Decisions Support System in Express Shipping Companies in Jordan : A Comparative Analysis Study, Middle East University, 2011" (Ghosh)	

2.4 GAPS IN LITERATURE

No	Theme	Gaps	Inference
1	Data Management	▪ Data and tools available in silos; ▪ No evidence found related to "Unified Data Platform" for analysis of operational parameters at the utility level	Data needs to be unified on a common platform for analysis of the power sector

2	Technical Capability	▪ The legacy systems have old data and software protocols ▪ These might not be capable to exchange data across the network	Hardware and software budget needs to be assigned for upgradation of the legacy system
3	Information Sharing	▪ There is no evidence of information sharing and communication between generation, transmission, distribution and trading ▪ There is poor data analysis, and inadequate monitoring at power sector level	National level Regulatory Framework needed to address the technical requirement of data communication across the sector
4	Business Implication	▪ There is a huge impact of decision delays across the sector but there is no readily available data for it ▪ Effects of delays in silo are available for many issues and incidences	Financial benefits needs to be highlighted to promote and implement a "Unified Data Platform" across the sector
5	Existing Data Frameworks	▪ Study the existing tools available in Silos was done for their pros and cons	Process Map to be developed for baselining the communication system across the network to integrate data from the silos

Table 2-1 Themes and Gaps

2.5 GROUNDED THEORY METHODOLOGY

To conduct the research, a quantitative approach was initially thought of, however I could not find any validated research instrument that was adequate to measure the philosophical assumptions of the available technologies. Sonia Ospina regarding her qualitative research states that “the key reason to use qualitative research is to explore a phenomenon that has not been previously investigated, and which may be examined subsequently through quantitative research” (Ospina, 2004) (Qualitative Research). I decided to start the research using the qualitative research methodology, and was hopeful that the adequacy of the initial study will be useful for my quantitative research for succeeding objective.

I started with a phenomenological research, for having an impact on bracketing our biases and former assumptions to enhance the objectivity of the study. However after initial study, a design for generating theory seemed more advantageous, and it was noticeable that research using the grounded theory methodology was more appropriate to extract the theoretical sensitivity, and interpretive insight with respect to building theory (Suddaby, 2006) (Qualitative Research).

While conducting data analysis using grounded theory methods, the methods for comparing data force the researchers to scrutinize their own biases and assumptions, and that of the research participants (Strauss, 2008) (Qualitative Research). GT methodology puts stress for conducting research with n open mind and analyse philosophy of technology their inherent assumptions and the verifications done by the domain experts, to design an explanatory conceptual theory or the conceptual lens (Qualitative Research).

Grounded theory is proposed as no comparable work is evident after literature review that has been done in the area of data unification at the power sector level. Grounded theory is a methodology which is systematically used for social sciences and involved in the generation of theory from data (Martin). It is mainly used in qualitative research, but may also be applicable to quantitative data. The flow of data has mainly been observed and studied at existing silos.

Grounded Theory was developed by two researchers – Barney Glaser and Anselm Strauss (Glaser, 1967). This was initially applied in psychological analysis by psychologists but the basic theory can be applied to any qualitative analysis and study. However, the two researchers separated in its early development only and a division of the theory enveloped (Glaser, 1967). There are now "two fundamental schools for Grounded Theory: the Glaserian School and the Straussian School (Stern, 1994). The differences between these are many. The major differences, however, have an important impact in the direction and execution of the primary research. While Glaser takes the stand that researchers should have an empty mind, while Strauss permits a general idea of the area under study" (Onions, 2006). "Major differences in the two theories are given in the table below.

GLASERIAN	STRAUSSIAN
Start with an empty mind	Have a general idea of where to begin
It is considered to be an Emerging theory, with only neutral questions	The theory is forced, with totally structured questions
This is the development of a conceptual theory	This is a description of situations. In other words this is a Conceptual description
Variables and relationships come from the detailed study of data itself. There is a need to perceive these correctly.	This theory believes that Theoretical sensitivity comes from the methods and Tools used.
The theory is grounded in the data	The theory is interpreted by an independent and neutral observer
The credibility of the theory, or verification, is derived from its grounding in the data	The credibility of the theory comes from the rigor of the method

A basic social process must be identified in the analysis.	Basic social processes need not be identified in this theory
The researcher is very passive and exhibits a disciplined restraint	The researcher is totally active
Data reveals the intrinsic theory	Data needs to be structured to reveal the theory

Table 2-2 Comparison of Glaserian and Straussian theories"

Glaser leads with the principle that theory should emerge, while Strauss uses structured questions to lead a more forced emergence of theory. In the Glaserian method the coding is less rigorous and it compares incident to incident constantly. Whereas in the Straussian theory the coding is very rigorous and the technique of coding is the basis for making comparisons. In the Glaserian method, there are two types of coding, simple and substantive where the data is fractured and then grouped to finally produce categories and properties. In the Straussian methods there are three types of coding; open, or initial, to identify and categorise phenomena; axial, where these codes are related to each other; and selective, to choose a core category and relate others with that. It must be mentioned here that the Straussian school is regarded as a type of qualitative data analysis.

2.6 INITIAL CONCEPTUAL LENS

Review of literature has resulted in five themes related to data unification across the power sector. The themes which impede the data unfication are shown diagrammatically as below. Gap exists in these areas which need to be addresses for implementation of a "Unified Data Platform" for operational intelligence of power sector in India.

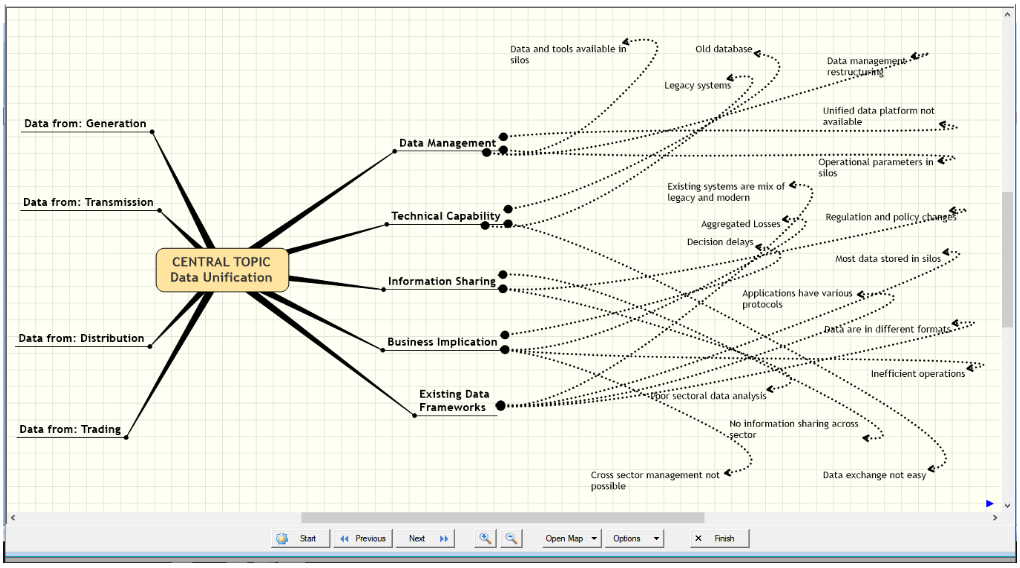


Figure 2-1 Initial Conceptual Lens

2.7 THEORETICAL SIGNIFICANCE

Organisations in modern day are confronting difficult operating situations and are facing growing and stiff competition. Continuous improvement or re-engineering of their operating models and business process are unavoidable if they want to survive the modern and changing environment.

Research study was done related to the application of the information technology and the available tools for recently designed processes which led to theoretical study of

- Business Reengineering
- Business Process Redesign
- Business Process Improvement
- Business Process Reengineering

(Gong, 2013)

A more systematic approach for Business Process Reengineering has been suggested by Davenport and Short. They recommend “a structured and controlled approach to reengineering, which involves the selection of the most critical and important processes of the organisation, the analysis of their current performance and their redesign" (UOA). Additionally, a number of articles from whitepapers, magazines, as well as books on BPR, or related concepts, have been used to support this work. A major support has come from the book Business Process Improvement, by Thomas H "Tom" Davenport (Davenport).

The research contributes towards the Business Process Reengineering ("BPR") very popularly elaborated by Thomas H. Davenport.

3. CHAPTER III – DATA SILOS IN POWER SECTOR

The power and energy domain is a very intricate and integrated structure of multiple hardware, software, technologies and applications connected for different objectives throughout the lifecycle starting from generation stations, transmission network, distribution systems and power trading across the country.

3.1 OVERVIEW - INDIAN POWER SECTOR

- India is a large power generator
- India is a large power consumer
- Due to the geographic spread, India has a large transmission network
- India is developing and adopting New Automation and Technologies

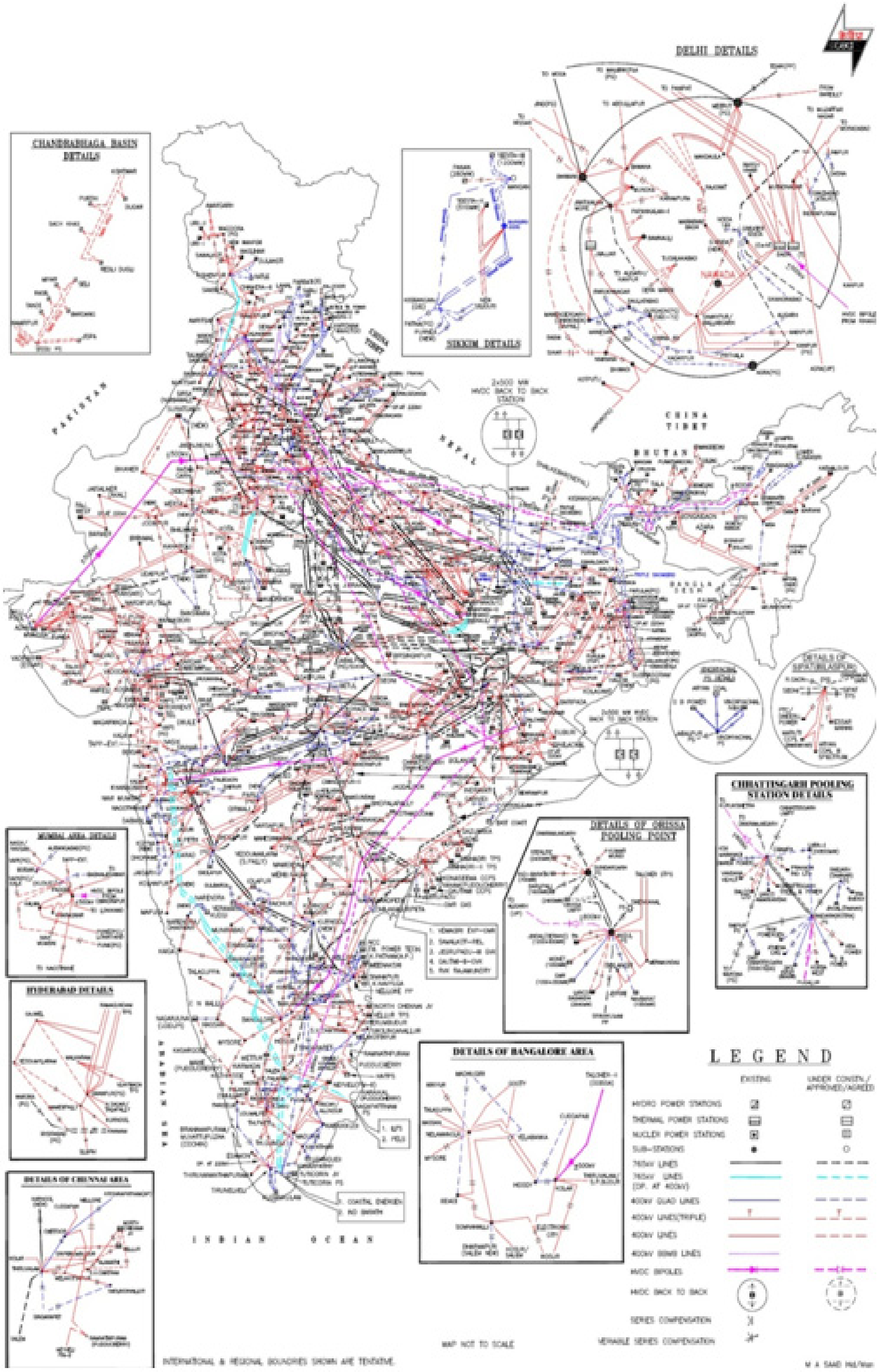


Figure 3-1 Power Sector Network in India (CEA) (PGCIL)

** The large size and latest power sector maps are available at PGCIL and CEA link http://cea.nic.in/powermaps.html and attached as annexure

“Over the past many years, the power generation units, transmission companies and the distributing network across the globe has changed tremendously – and the ancient grid of the twentieth century have been comparatively few points of power generation units or (Ministry of Power, 2013) inject points but several points of power consumers. With speedy proliferation of mini grids, distributed architecture and renewable generation, the twenty first century grid can have varied points of power injection and several points of consumer base. Electrical Vehicle (EV) roll on top of it all has additionally enlarged the complexity of the normal grid. To maintain a powergrid with such range of intermittent energy sources and Electrical Vehicle (Asialeds, 2018), adoption of smarter automation and IT systems were imperative”. Citing an example, for peak load management we need management of production and distribution (utilizing mechanism for demand response, may be thought as a dynamic Demand Supply Management (DSM) system which has assumed high priority for electrical utilities as there's a growing peak demand, resulting in a supply gap throughout peak consumption hours (Asialeds, 2018) across the globe (Ministry of Power, 2013) (Assets Fiercemarkets). On the other side drivers like free market, choice of supplier selection, power cost management, is inherently variable, and lots of a lot of factors needs to be measured for providing a forward thrust to change and adapt the transition to a smartgrid which will provide solutions to these problems.

3.1.1 THE POWER SECTOR NETWORK

Power companies today cater to large regional or national networks with millions of customers having diverse requirements. Traditionally the power systems are sub divided into generation, transmission, distribution and trading networks.

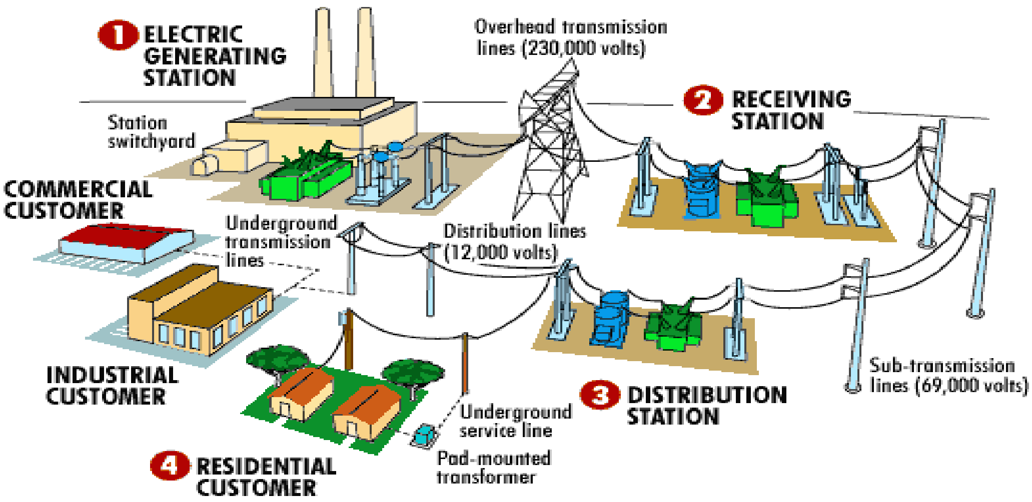


Figure 3-2 Typical Power Sector Structure

(source Google Image)

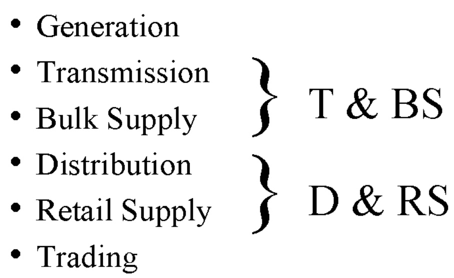
A local power station serves one region and subdivided into numerous districts. The power station is then connected to the districts by the substations. Power supply spread in a tree like structure from the station to the customers and different types of sub stations. Large industries have dedicated lines from their industry to the power station.

The above scenario brings out the sub sectors of the system as power Generation; Transmission; Distribution and Trading networks. We start with a background of the Indian power sector. "Electricity generation, as a factor, is widely accepted as an indicator having a positive correlation with GDP. In India, it has the highest weightage among the eight core parameters in the Index of Industrial Production (Ghosh).

In India, the primary constituents of power sector namely generation, transmission, distribution were integrated within individual utilities till 1991. The subject 'Electricity' made an as Entry 38 of the concurrent list of 7th schedule of Constitution of India.

The amendment of Electricity Act, 2003 provides policies for retail competition which has been appreciated as well as criticized by many due to heterogeneity. Even after this amendment, the commercialization and part privatization of the existing state owned system is not considered enough to be called a complete reform in the Indian power / electricity supply system" as mentioned by Alok Kumar and S.K. Chatterjee (Alok Kumar, 2012) (Ghosh).

The segments of the Power Sector as in figure-3 were structured like a vertical hierarchy for the State Electricity Boards as depicted in figure-4.



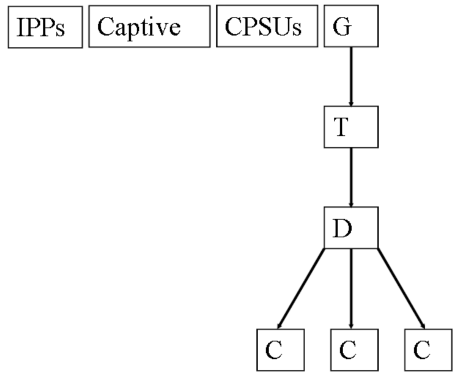


Figure 3-3 Power Sector Segment **Figure 3-4 Power Sector Segment**

"Electricity Act 2003" stipulates promotion of competition in all spheres of electricity sector, be it generation, transmission or distribution.

"An Act to consolidate the laws relating to generation, transmission, distribution, trading and use of electricity and generally for taking measures conducive to development of electricity industry, promoting competition therein, protecting interest of consumers and supply of electricity to all areas, rationalization of electricity tariff, ensuring transparent policies regarding subsidies, promotion of efficient and environmentally benign policies, constitution of Central Electricity Authority, Regulatory Commissions and establishment of Appellate Tribunal and for matters connected therewith or incidental thereto." by Alok Kumar and S.K. Chatterjee (Alok Kumar, 2012) (Ghosh). The same was restructured post "Electricity Act 2003" as figure-5 and with the emerging scenario post "Electricity Act 2003" as figure-6.

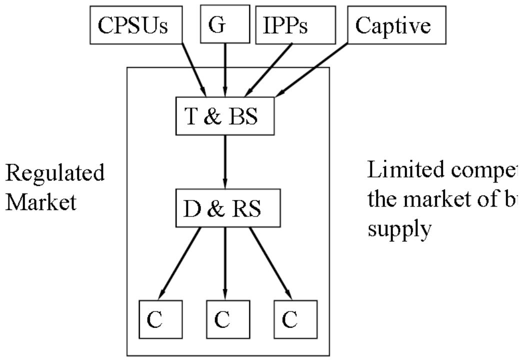


Figure 3-5 Power Sector Restructured Post “Electricity Act 2003”

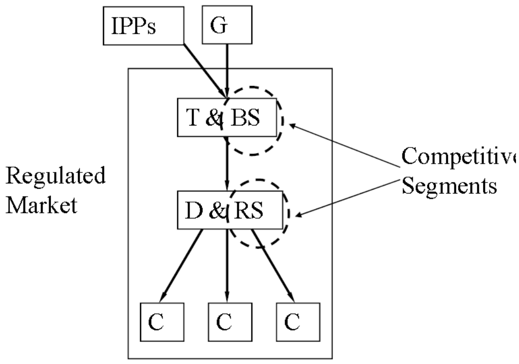


Figure 3-6 Power Sector Restructured Post “Electricity Act 2003”

To operate smoothly across India’s large geographic spread and for necessary periodic restructuring, the national powergrid is controlled by a three tier hierarchy namely National, Regional and State level controllers. Major effort for unification of operation and control was started in early nineties and the protocol Unified Load Despatch & Communication (ULDC) was designed and defined to streamline the power sector for efficient monitoring, operation and controlling in a united manner. The data was provided from the NLDC, RLDC AND SLDC data centers (POSOCO) (Gridwise).

3.1.2 DATA SOURCES IN A POWER SECTOR NETWORK

Power is generated by different sources from thermal like nuclear, coal, biomass or from renewable like tidal, hydro, bio, wind and solar. “The generated power is then fed to transmission lines and transmitted to substations. Substation then distributes the power for real time consumption. The power is then distributed to be consumed by Residential, Commercial, Industrial, Transportation, Emergency services and governmental services, etc. Smart and connected meters at customer end points broadcast utilization data to the service providers at regular interval of period” (Urbana World, 2016).

The advent of modern IP-enabled smart and digital meters and utilities enhance the flow of data in the grid with higher speed and accuracy. At each connection points there are numerous applications that are for operation, monitoring and controlling which are producing real time data of the power sector.

3.1.3 POWER GENERATION

Ministry of Power (MoP) has ambitious plan with multiple objectives, like sufficient energy, power reliability, quality, minimizing cost of energy and commercial viability of power industry.

India has a range of generation companies catering from regional to local level. Regional level has central owned plants like “NTPC, NHPC and NPC etc. Private companies at regional level act as ultra-mega power plants (UMPP) and independent power producers (IPP). These inject their generation in the regional power pool through the central transmission utilities.

At state level the state owned gencos inject their generation into the state power pools via the state transmission utilities. And at local level all the sources of distributed generation, renewable energy sources are listed”.

The power sector in India has an installed capacity as on June’19 357GW. Renewable energy like solar, large-sized hydro is around 34.9% of this capacity. As per the global rankings, India is ranked as third largest base for consumers and the third largest producer of electricity. FY 2015-16, power consumed in the agriculture sector of India was ranked highest worldwide pegging at 17.89% (CEA, 2018) (CERC, 2018).

ALL INDIA INSTALLED CAPACITY (IN MW) OF POWER STATIONS
LOCATED IN THE REGIONS OF MAIN LAND AND ISLANDS
(As on 31.03.2018)
(UTILITIES)

Region	Ownership/ Sector	Mode wise breakup							Grand Total
		Thermal				Nuclear	Hydro	RES * (MNRE)	
		Coal	Gas	Diesel	Total				
Northern Region	State	16888.00	2879.20	0.00	19767.20	0.00	8643.55	689.56	29100.31
	Private	22760.83	558.00	0.00	23318.83	0.00	2514.00	11854.66	37687.49
	Central	13290.37	2344.06	0.00	15634.43	1620.00	8596.22	329.00	26179.65
	Sub Total	**52939.20**	**5781.26**	**0.00**	**58720.46**	**1620.00**	**19753.77**	**12873.22**	**92967.45**
Western Region	State	21280.00	2849.82	0.00	24129.82	0.00	5446.50	311.19	29887.51
	Private	34285.67	4676.00	0.00	38961.67	0.00	481.00	19473.89	58916.56
	Central	15042.95	3280.67	0.00	18323.62	1840.00	1520.00	661.30	22344.92
	Sub Total	**70608.62**	**10806.49**	**0.00**	**81415.11**	**1840.00**	**7447.50**	**20446.38**	**111148.99**
Southern Region	State	19432.50	791.98	287.88	20512.36	0.00	11808.03	518.02	32838.41
	Private	12124.50	5322.10	473.70	17920.30	0.00	0.00	33359.36	51279.66
	Central	14225.02	359.58	0.00	14584.60	3320.00	0.00	491.90	18396.50
	Sub Total	**45782.02**	**6473.66**	**761.58**	**53017.26**	**3320.00**	**11808.03**	**34369.28**	**102514.57**
	State	7070.00	100.00	0.00	7170.00	0.00	3537.92	225.11	10933.03
	Sub Total	**27321.64**	**100.00**	**0.00**	**27421.64**	**0.00**	**4942.12**	**1038.40**	**33402.16**
North Eastern Region	State	0.00	457.95	36.00	493.95	0.00	422.00	254.25	1170.20
	Private	0.00	24.50	0.00	24.50	0.00	0.00	23.31	47.81
	Central	520.02	1253.60	0.00	1773.62	0.00	920.00	5.00	2698.62
	Sub Total	**520.02**	**1736.05**	**36.00**	**2292.07**	**0.00**	**1342.00**	**282.56**	**3916.63**
Islands	State	0.00	0.00	40.05	40.05	0.00	0.00	5.25	45.30
	Private	0.00	0.00	0.00	0.00	0.00	0.00	2.21	2.21
	Central	0.00	0.00	0.00	0.00	0.00	0.00	5.10	5.10
	Sub Total	**0.00**	**0.00**	**40.05**	**40.05**	**0.00**	**0.00**	**12.56**	**52.61**

Figure 3-7 All India Installed Capacity (CEA, 2018)

India produces surplus power but due to lack of developed infrastructure it is unable to supply electricity to all. To enable everyone to have required electric supply for all the people the GoI launched "Power for All" program, which intends continuous supply to all house, industry and commercial organizations by developing the necessary infrastructure.

ALL INDIA	State	64670.50	7078.95	363.93	72113.38	0.00	29858.00	2003.37	103974.75
	Private	75546.00	10580.60	473.70	86600.30	0.00	3394.00	65516.72	155511.02
	Central	56955.00	7237.91	0.00	64192.91	6780.00	12041.42	1502.30	84516.63
	Total	**197171.50**	**24897.46**	**837.63**	**222906.59**	**6780.00**	**45293.42**	**69022.39**	**344002.39**

Figures at decimal may not tally due to rounding off

Abbreviation:- SHP=Small Hydro Project (≤ 25 MW), BP=Biomass Power, U&I=Urban & Industrial Waste Power, RES=Renewable Energy Sources

Note : - 1. RES include SHP, BP, U&I, Solar and Wind Energy. Installed capacity in respect of RES (MNRE) as on 31.03.2018 (As per latest information available with MNRE)

***Break up of RES all India as on 31.03.2018 is given below (in MW) :**

Small Hydro Power	Wind Power	Bio-Power		Solar Power	Total Capacity
		BM Power/Cogen.	Waste to Energy		
4485.81	**34046.00**	**8700.80**	**138.30**	**21651.48**	**69022.39**

Figure 3-8 India Power Generation Capacity (CEA, 2018)

** As per data from “Central Electricity Authority” (CEA, 2018) (Wikipedia), “The power utility of India has single countrywide grid with an installation of 357.87GW as of 2019 June 30th. The trend of growth is as on 31st March 2018 - 344GW, on 31st March 2016 - 302.08GW and as of 21st November 2016, - 307.28GW”. We can clearly see the steady and continuous growth year by year in the power generation. Total capacity is the sum of utilities, captive power plants and non-utilities. With context to our research study we can very well relate and understand the amount of data the ever growing power sector is adding every year.

3.1.4 POWER TRANSMISSION

India has a hierarchical transmission system where “Powergrid Corporation of India Limited (PGCIL) is the central transmission utility (CTU) and at the regional and national level, independent state transmission utilities (STUs) are there for each state”.

Executive summary of Target and Achievement of Transmission Lines during 2019-20

As on Jun-19

(All figures in circuit kms.)

Programme / Achievement		HVDC								765 kV				400 kV				220 kV				Grand Total			
		± 800 kV				± 500 kV																			
		Central Sector	State Sector	JV/Private Sector	Total	Central Sector	State Sector	JV/Private Sector	Total	Central Sector	State Sector	JV/Private Sector	Total	Central Sector	State Sector	JV/Private Sector	Total	Central Sector	State Sector	JV/Private Sector	Total	Central Sector	State Sector	JV/Private Sector	Grand Total
Programme 2019-20		0	0	0	0	0	0	0	0	2727	958	2334	6019	2239	3416	1143	6798	781	10023	0	10804	5747	14397	3477	23621
Jun/19	Programme	0	0	0	0	0	0	0	0	526	0	0	526	282	400	0	682	188	2754	0	2942	996	3154	0	4150
	Achievement	0	0	0	0	0	0	0	0	0	0	0	0	16	349	0	365	0	294	0	294	16	643	0	659
Upto Jun-19	Programme	0	0	0	0	0	0	0	0	1103	416	557	2076	342	1290	226	1858	188	3813	0	4001	1633	5519	783	7935
	Achievement	0	0	0	0	0	0	0	0	53	0	0	53	16	843	0	859	0	1198	0	1198	69	2041	0	2110

Growth in Transmission Sector									
1	Transmission Lines	(All Figures in CKM)							
At the end of	6th plan	7th plan	8th plan	9th plan	10th plan	11th plan	12th plan	During 2017-18 Upto November 2017	Capacity as on November 2017
+500 kV HVDC									
Central	0	0	1634	3234	4368	5948	12,072	0	12,072
State	0	0	0	1504	1504	1504	1,504	0	1,504
JV/Private	0	0	0	0	0	1980	1,980	0	1,980
Total	0	0	1634	4738	5872	9432	15556	0	15,556
765 kV									
Central	0	0	0	751	1775	4839	25,465	1,428	26,893
State	0	0	0	409	409	411	1,177	335	1,512
JV/Private	0	0	0	0	0	0	4,598	283	4,881
Total	0	0	0	1160	2184	5250	31240	2,046	33,286
400 kV									
Central	1831	13068	23001	29345	48708	71023	92,482	3,482	95,964
State	4198	6756	13141	20033	24730	30191	48,240	4,065	52,305
JV/Private	0	0	0	0	2284	5605	17,065	1,613	18,678
Total	6029	19824	36142	49378	75722	106819	157787	9,160	166,947
220 kV									
Central	1641	4560	6564	8687	9444	10140	11,014	62	11,076
State	44364	55071	73036	88306	105185	125010	151,276	2,547	153,823
JV/Private	0	0	0	0	0	830	978	5	983
Total	46005	59631	79600	96993	114629	135980	163,268	2,614	165,882
Grand Total	52034	79455	117376	152269	198407	257481	367,851	13,820	381,671

Figure 3-9 India Transmission Line Network Circuit Kilometer (PGCIL)

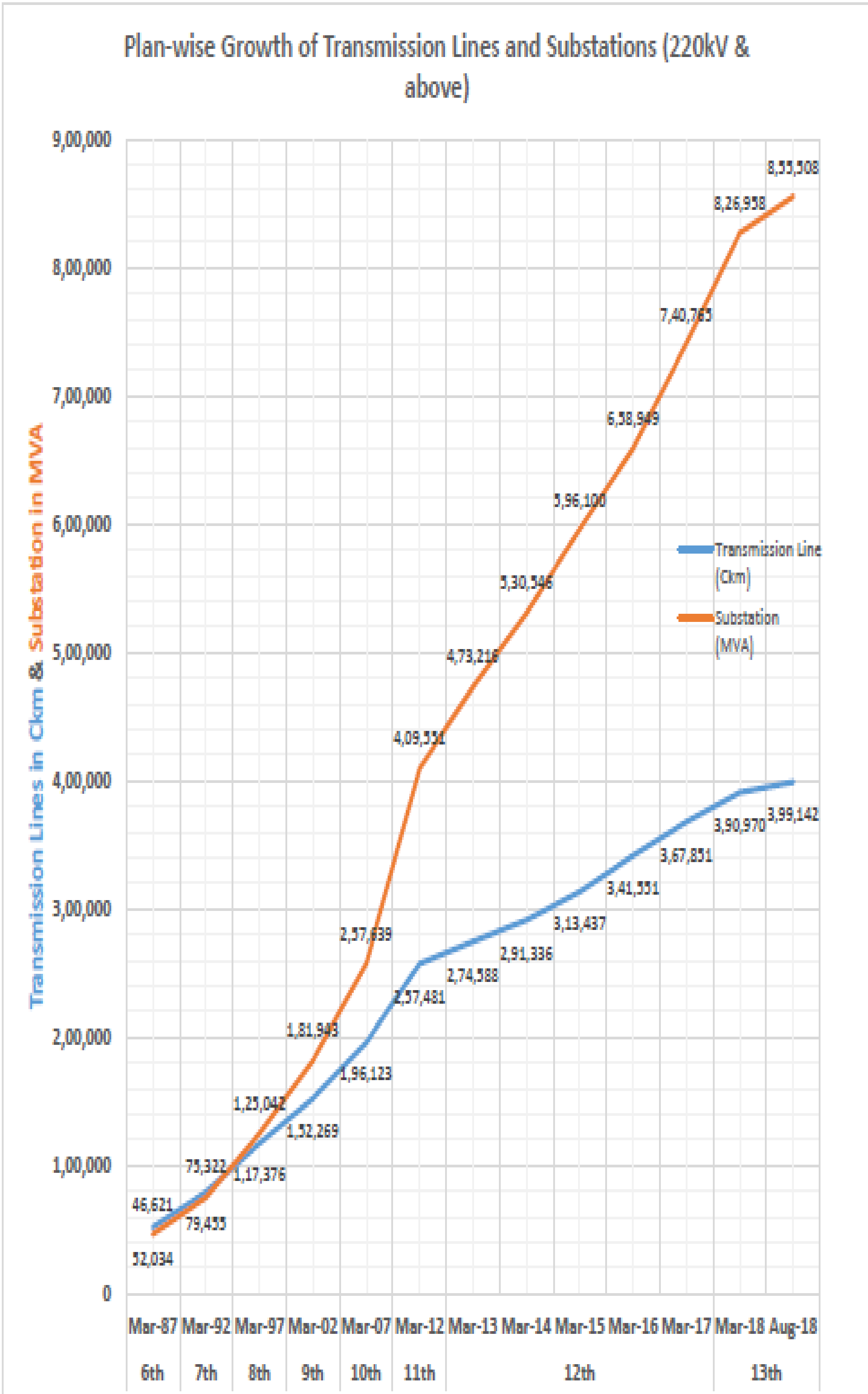


Figure 3-10 India Transmission Line Network Circuit Kilometer and Growth (PGCIL)

** Installed transmission (circuit km) growth is visible and India needs to work towards achieving a national grid which can supply power throughout.

3.1.5 POWER DISTRIBUTION

Distribution is the most critical segment which provides revenue for the entire value chain. 400 GW of load and with 200 million plus consumers makes India one of the largest distribution network in the world. The last mile connectivity in the value chain it holds immense importance as it connects the generators to the consumers, through the transmission system. There have been series of schemes to curb the financial burdens of the sector with the introduction of the APDRP, RAPDRP and now, UDAY.

Central Electricity Authority **ANNUAL REPORT 2017-18**

Annexure

Status of Households Electrification under Saubhagya Scheme(as on 31.03.2018)

State	Total Households	Electrified Households as on 10th Oct,2017	Household Electrified w.e.f 11th Oct,2017	Total Household Electrified,	Household Electrification (%)	Balance Un-electrified Households, Nos
Uttar Pradesh	303,42,104	155,73,943	10,13,392	165,87,335	54.67	13754769
Maharashtra	140,01,920	135,58,912	1,65,565	137,24,477	98.02	277443
West Bengal	146,59,597	141,68,789	1,94,153	143,62,942	97.98	296655
Bihar	124,86,613	86,17,983	4,42,442	90,60,425	72.56	3426188
Madhya Pradesh	106,23,591	77,10,762	11,28,491	88,39,253	83.20	1784338
Andhra Pradesh	113,62,846	112,80,763	81,402	113,62,165	99.99	681
Tamil Nadu	102,85,848	102,83,678	2,170	102,85,848	100.00	
Karnataka	93,83,498	87,27,711	59,134	87,86,845	93.64	596653
Rajasthan	91,82,572	70,00,719	2,12,322	72,13,041	78.55	1969531
Odisha	85,05,179	52,44,064	1,35,336	53,79,400	63.25	3125779
Kerala	71,04,123	71,04,123		71,04,123	100.00	
Gujarat	65,29,055	65,13,307	15,748	65,29,055	100.00	
Telangana	59,71,952	55,74,499	23,803	55,98,302	93.74	373650
Jharkhand	54,91,360	24,31,847	1,25,389	25,57,236	46.57	2934124
Assam	52,24,540	27,81,136	1,10,836	28,91,972	55.35	2332568
Chhattisgarh	49,73,713	43,04,608	1,54,562	44,59,170	89.65	514543
Punjab	36,89,584	36,89,584		36,89,584	100.00	
Haryana	34,24,992	27,42,810	1,71,561	29,14,371	85.09	510621
Uttarakhand	17,37,928	15,37,625	4,960	15,42,585	88.76	195343
Himachal Pradesh	14,71,502	14,56,888	1,943	14,58,831	99.14	12671
Jammu & Kashmir	12,73,430	10,07,155		10,07,155	79.09	266275
Tripura	7,31,404	5,24,308	1,882	5,26,190	71.94	205214
Meghalaya	4,63,022	3,23,755		3,23,755	69.92	139267
Manipur	3,81,181	2,78,773	467	2,79,240	73.26	101941
Arunachal Pradesh	2,31,968	1,50,781		1,50,781	65.00	81187
Nagaland	2,78,128	1,69,693	473	1,70,166	61.18	107962
Goa	1,28,208	1,28,208		1,28,208	100.00	
Mizoram	1,10,386	99,430		99,430	90.07	10956
Puducherry	95,046	94,704		94,704	99.64	342
Sikkim	37,281	31,653		31,653	84.90	5628
Total	1801,82,571	1431,12,211	40,46,031	1471,58,242	81.67	**3,30,24,329**

(Source-Saubhagya Portal)

Figure 3-11 Snapshot of Power Distribution (CEA, 2018)

With the implementation of various programs the AT&C losses have gone down below 23%. The task of power distribution is streamlined by seventy three distribution utilities, thirteen departments of electricity, seventeen private DISCOM, other cooperative DISCOMS and State Electricity Boards.

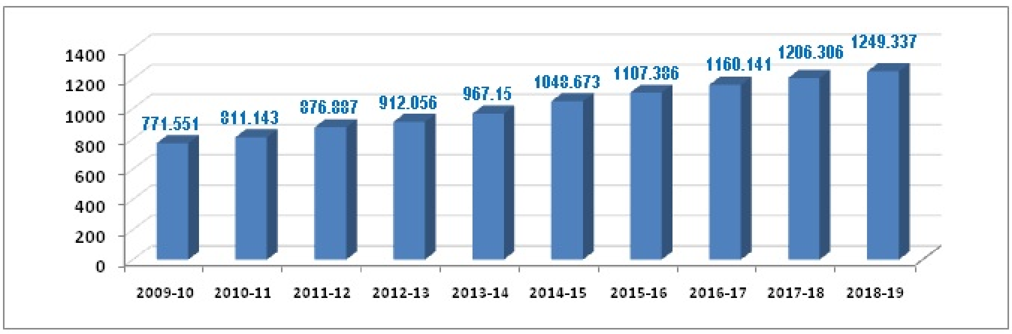
** The CEA brings out reports each month for "energy supplied and energy not supplied in Million Units (MUs) and in percentage. The peak demand, peak matched and unmet demand are given in MW and in percentage. The total energy requirement in the country during 2017-18 was 12,13,326 Million Units (MUs) as against 11,42,928 MUs during the previous year, registering an increase of 6.2%" (CEA Annual Report, 2018) (CEA) (CEA, 2018).

3.1.6 POWER TRADING

There were provisions made for power trading in the EA-2003. Power Trade Corporation (PTC) which was established in 1999 provides power trading solutions to support a commercially viable power market. Around 40 power trading licensees are there in India and two power exchanges are established namely "PXIL (Power Exchange of India Limited) and IEX (Indian Energy Exchange)". Currently, more than 4000 consumers are using the power trading platforms.

3.2 POWER SECTOR AT A GLANCE

Generation (Billion Units)



Generation Growth (%)

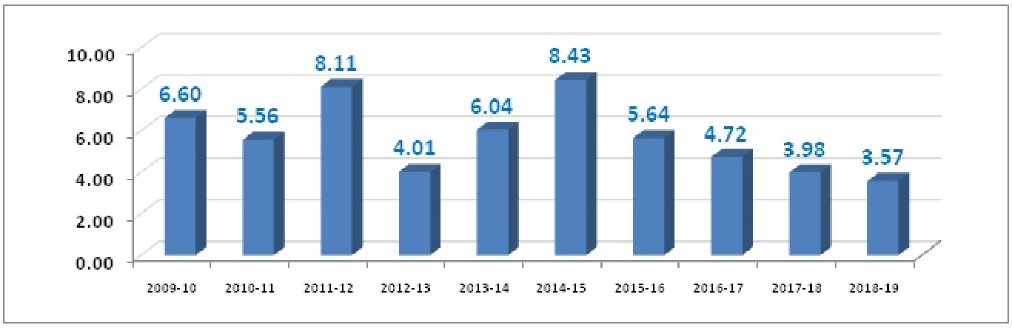


Figure 3-12 Power Generation at a Glance (CEA)

POLICIES AND PUBLICATIONS

- Acts and Notifications
- Chief Controller of Accounts
- Annual Reports Year wise (Ministry)
- Summary of Monthly Accounts
- Annual Report (Autonomous Bodies)
- Monthly Summary of Principal Activities and Important Decisions
- New Government Policies and Programmes
- Outcome Budget
- Demand For Grants
- Parliament Section
- Tenders
- Vacancies
- Immovable Property Return
- Frequently Asked Questions
- Guideline for Release of 75% of Arbitral Awards to eligible Contractor

Power Sector at a Glance ALL INDIA

As on 24-07-2019
Source: OM SECTION

1.Total Installed Capacity (As on 31.05.2019) - Source : Central Electricity Authority (CEA)

Sector	MW	% of Total
State Sector	86,597	24.2%
Central Sector	105,077	29.4%
Private Sector	166,202	46.4%
Total	**3,57,875**	

Fuel	MW	% of Total
Total Thermal	2,26,324	63.2%
Coal	1,94,490	54.3%
Lignite	6,260	1.7%
Gas	24,937	7.0%
Oil	638	0.2%
Hydro (Renewable)	45,399	12.7%
Nuclear	6,780	1.9%
RES* (MNRE)	79,372	22.0%
Total	**357,875**	

Policy Initiatives / Decision Taken

Electricity Act 2003 has been enacted and came into force from 15.06.2003. The objective is to introduce competition, protect consumer's interests and provide power for all. The Act provides for National Electricity Policy, Rural Electrification, Open access in transmission, phased open access in distribution, mandatory SERCs, license free generation and distribution, power trading, mandatory metering and stringent penalties for theft of electricity. It is a comprehensive legislation replacing Electricity Act 1910, Electricity Supply Act 1948 and Electricity Regulatory Commission Act 1998.The Electricity Act, 2003 has been amended on two occasions by the Electricity (Amendment) Act, 2003 and the Electricity (Amendment) Act, 2007. The aim is to push the sector onto a trajectory of sound commercial growth and to enable the States and the Centre to move in harmony and coordination.

Performance of Generation from Conventional Sources

1.0 PERFORMANCE OF CONVENTIONAL GENERATION

1.1 The electricity generation target of conventional sources for the year 2019-20 has been fixed as 1330 Billion Unit (BU). i.e. growth of around 6.46% over actual conventional generation of 1249.337 BU for the previous year (2018-19). The conventional generation during 2018-19 was 1249.337 BU as compared to 1206.306 BU generated during 2017-18, representing a growth of about 3.57%.

1.2 **Generation and growth in conventional generation in the country during 2009-10 to 2019-20 :-**

Year	Energy Generation from Conventional Sources (BU)	% of growth
2009-10	771.551	6.6
2010-11	811.143	5.56
2011-12	876.887	8.11
2012-13	912.056	4.01
2013-14	967.150	6.04
2014-15	1048.673	8.43
2015-16	1107.822	5.64
2016-17	1160.141	4.72
2017-18	1206.306	3.98
2018-19	1249.337	3.57
2019-20*	339.144	6.32

2.0 Plant Load Factor (PLF):

2.1 **The PLF in the country (Coal & Lignite based) from 2009-10 to 2019-20 is as under:**

Year	PLF	Sector-wise PLF (%)		
	%	Central	State	Private
2009-10	77.5	85.5	70.9	83.9
2010-11	75.1	85.1	66.7	80.7
2011-12	73.3	82.1	68.0	69.5
2012-13	69.9	79.2	65.6	64.1
2013-14	65.60	76.10	59.10	62.10
2014-15	64.46	73.96	59.83	60.58
2015-16	62.29	72.52	55.41	60.49
2016-17	59.88	71.98	54.35	55.73
2017-18	60.67	72.35	56.83	55.32
2018-19	61.07	72.64	57.81	55.24
2019-20*	62.83	69.03	60.81	59.83

* Upto June 2019 (Provisional). Source : CEA

3.0 Power Supply Position

The power supply position in the country during 2009-10 to 2019-20 :

Year	Energy				Peak			
	Requirement	Availability	Surplus(+)/Deficts(-)		Peak Demand	Peak Met	Surplus(+) / Deficts(-)	
	(MU)	(MU)	(MU)	(%)	(MW)	(MW)	(MW)	(%)
2009-10	8,30,594	7,46,644	-83,950	-10.1	1,19,166	1,04,009	-15,157	-12.7
2010-11	8,61,591	7,88,355	-73,236	-8.5	1,22,287	1,10,256	-12,031	-9.8
2011-12	9,37,199	8,57,886	-79,313	-8.5	1,30,006	1,16,191	-13,815	-10.6
2012-13	9,95,557	9,08,652	-86,905	-8.7	1,35,453	1,23,294	-12,159	-9.0
2013-14	10,02,257	9,59,829	-42,428	-4.2	1,35,918	1,29,815	-6,103	-4.5
2014-15	10,68,923	10,30,785	-38,138	-3.6	1,48,166	1,41,160	-7,006	-4.7
2015-	11,14,408	10,90,850	-23,558	-2.1	1,53,366	1,48,463	-4,903	-3.2

3.0 Power Supply Position

The power supply position in the country during 2009-10 to 2019-20 :

Year	Energy				Peak			
	Requirement	Availability	Surplus(+)/Deficts(-)		Peak Demand	Peak Met	Surplus(+) / Deficts(-)	
	(MU)	(MU)	(MU)	(%)	(MW)	(MW)	(MW)	(%)
2009-10	8,30,594	7,46,644	-83,950	-10.1	1,19,166	1,04,009	-15,157	-12.7
2010-11	8,61,591	7,88,355	-73,236	-8.5	1,22,287	1,10,256	-12,031	-9.8
2011-12	9,37,199	8,57,886	-79,313	-8.5	1,30,006	1,16,191	-13,815	-10.6
2012-13	9,95,557	9,08,652	-86,905	-8.7	1,35,453	1,23,294	-12,159	-9.0
2013-14	10,02,257	9,59,829	-42,428	-4.2	1,35,918	1,29,815	-6,103	-4.5
2014-15	10,68,923	10,30,785	-38,138	-3.6	1,48,166	1,41,160	-7,006	-4.7
2015-16	11,14,408	10,90,850	-23,558	-2.1	1,53,366	1,48,463	-4,903	-3.2
2016-17	11,42,929	11,35,334	-7,595	-0.7	1,59,542	1,56,934	-2,608	-1.6
2017-18	12,13,326	12,04,697	-8,629	-0.7	1,64,066	1,60,752	-3,314	-2.0
2018-19	12,74,595	12,67,526	-7,070	-0.6	1,77,022	1,75,528	-1,494	-0.8
2019-20*	3,47,771	346,208	-1,563	-0.4	183,673	182,533	-1,140	-0.6

* Upto June 2019 (Provisional). Source : CEA

Figure 3-13 Indian Power Sector at a Glance (CEA)

** The current and updated data is attached as annexure and available at CEA and MoP link https://powermin.nic.in/en/content/power-sector-glance-all-india

3.3 12TH FIVE YEAR PLAN (2017-22) OF INDIA

India will be power surplus by the end of this five year plan (2017 to 2022), and CEA has pegged the peak power surplus indicating that India is going to be an energy surplus country by next five year plan. Power sector in India has seen a tremendous growth in the peak energy demand, which in turn required capability expansions for the generation stations, transmission and distribution networks. Inline to the pace at which the market is adopting new technologies and advancements, India started deploying new devices, infrastructure and adopted new tools for monitoring and management. The entire sector is aiming towards the preparation of smartgrid plans for all the stakeholders of the power sector (DST). "Electricity, being a synchronous subject in India, central government and state governments together manage and monitor its growth, operation and management. The central government frames overall laws whereas each provincial government formulates their policies at based on the government framework. There are separate utilities owning generation, transmission and distribution and Ministry of Power, Government of India deals with management, policy formulation, and methods of investment, technology selections, observation and implementation of power schemes, development, administration & enactment of legislation in respect to the power generation, transmission and distribution" (National Smart Grid, 2018) as mentioned by DST in their reports (DST).

"Central Electricity Authority" advises on matters related with the India's National Electricity Policy and formulates long and short term plans for the power sector. "Central Electricity Regulatory Commission" and State Electricity Regulatory Commissions regulate the tariff, define the required policies for subsidies, encourage economic and ecological compassionate policies at state and central level, jointly as well as severally (National Smart Grid, 2018). CTU/STU guarantees the development of coordinated and economical system of intrastate as well as the interstate transmission network. The central transmission utility, PGCIL is in charge of regional and national power transmission grids, and the states also have separate STUs (DST).

On the basis of region the grid management is distributed. India is sub divided into five zones namely Eastern, North Eastern, Northern, Western, Southern zones.

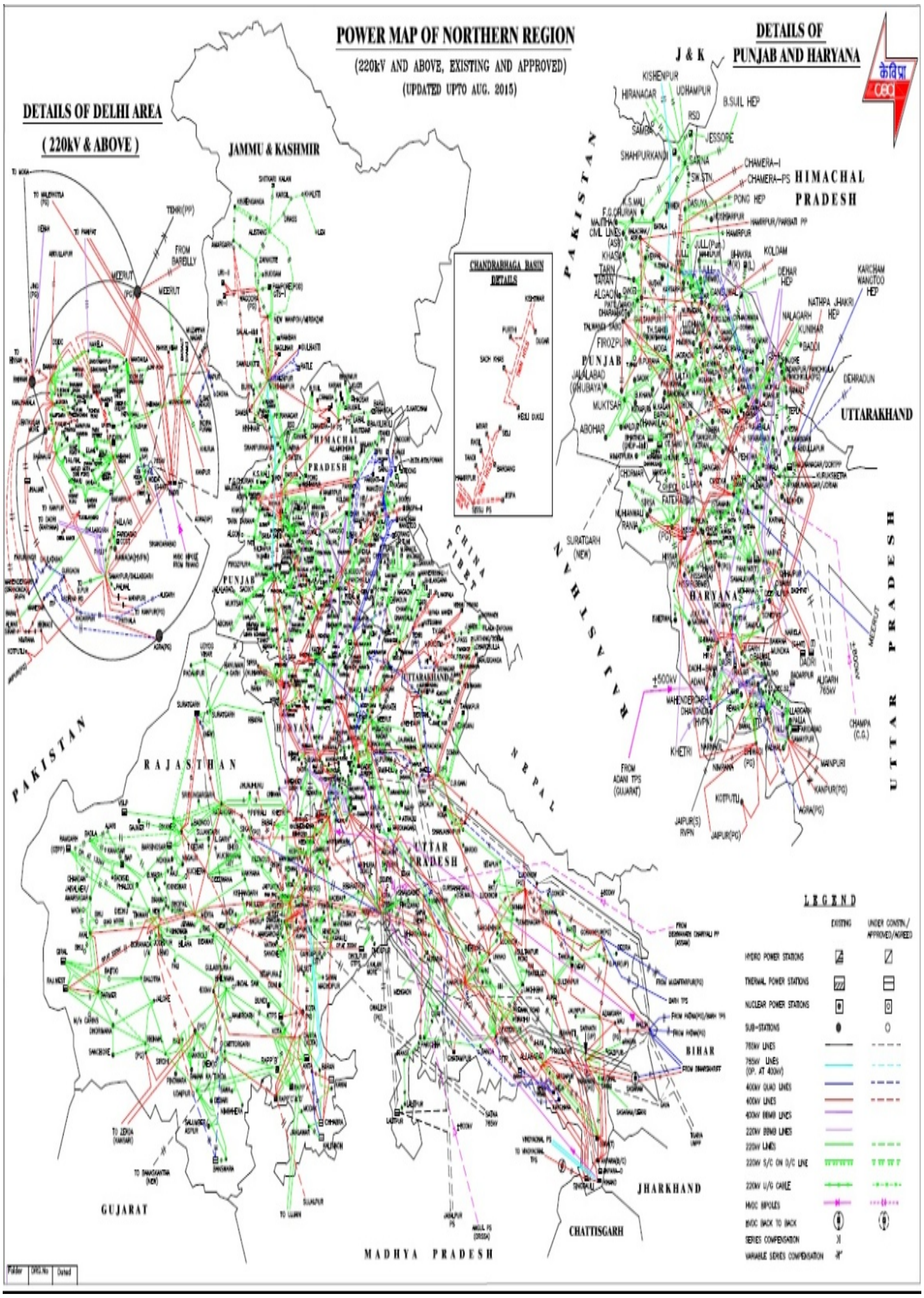


Figure 3-14 Northern Grid of India (PGCIL) (CEA)

** The large size and latest power sector maps are available at PGCIL and CEA link http://cea.nic.in/powermaps.html

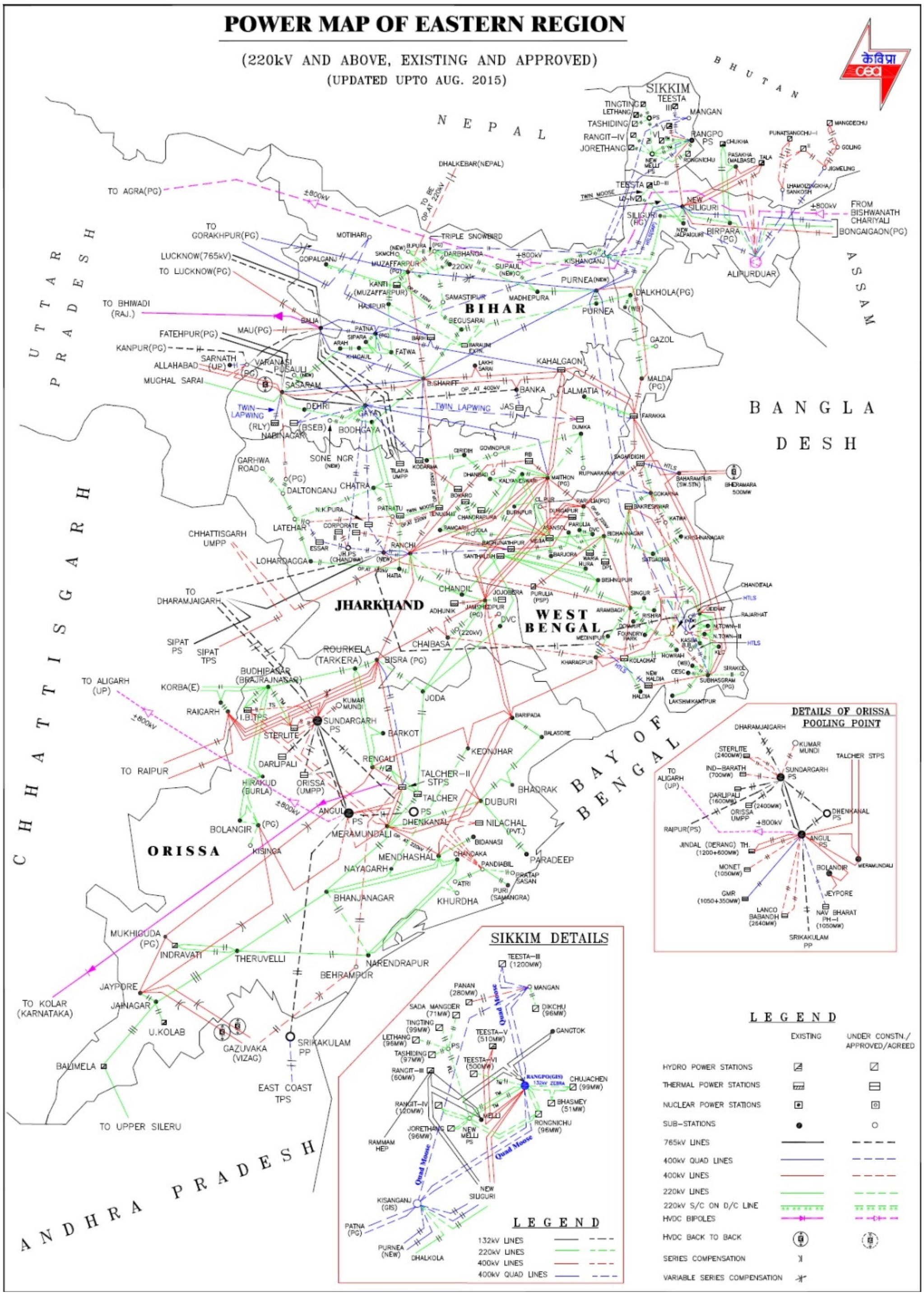


Figure 3-15 Eastern Grid of India (PGCIL) (CEA)

** The large size and latest power sector maps are available at PGCIL and CEA link http://cea.nic.in/powermaps.html

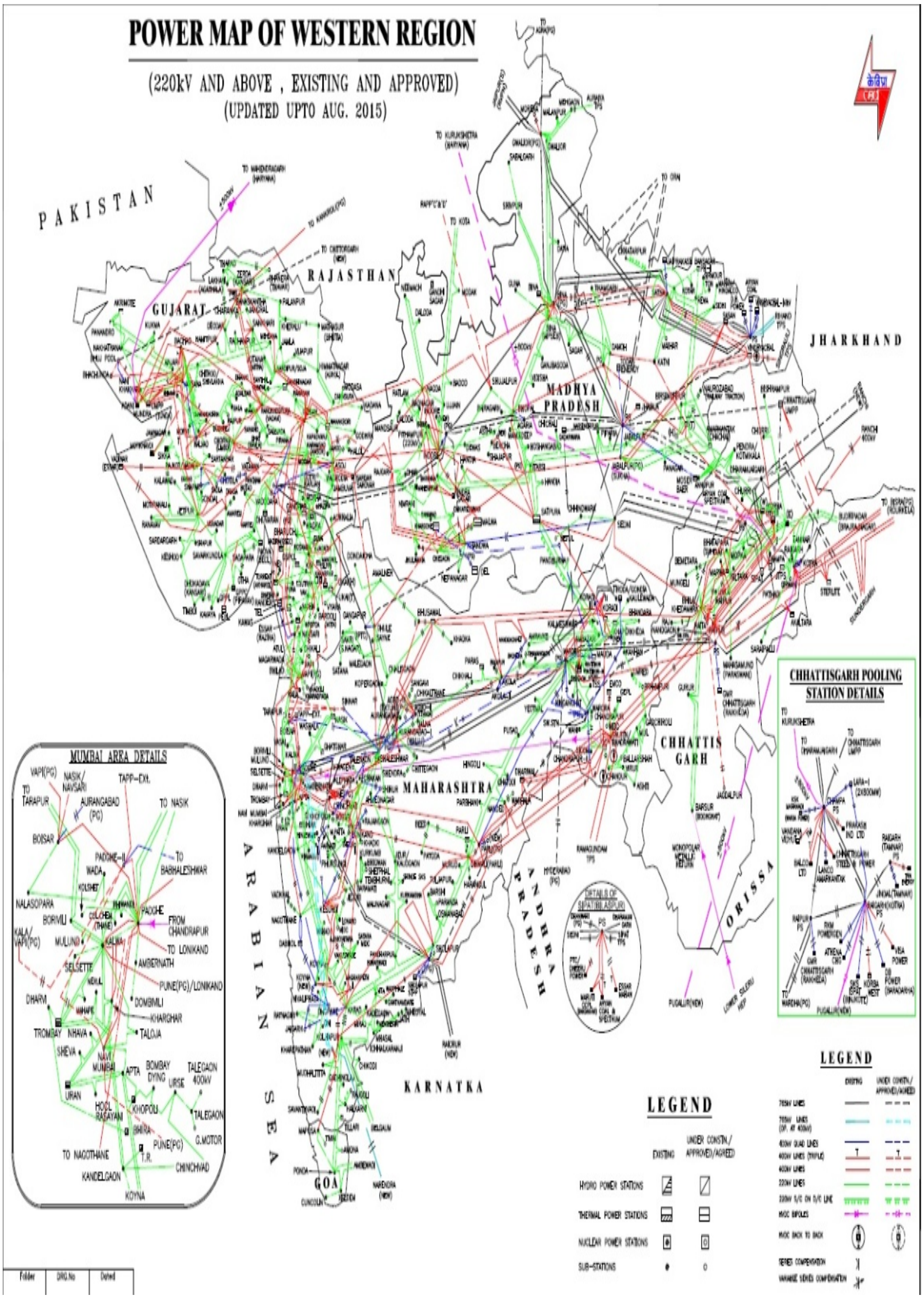


Figure 3-16 Western Grid of India (PGCIL) (CEA)

** The large size and latest power sector maps are available at PGCIL and CEA link http://cea.nic.in/powermaps.html

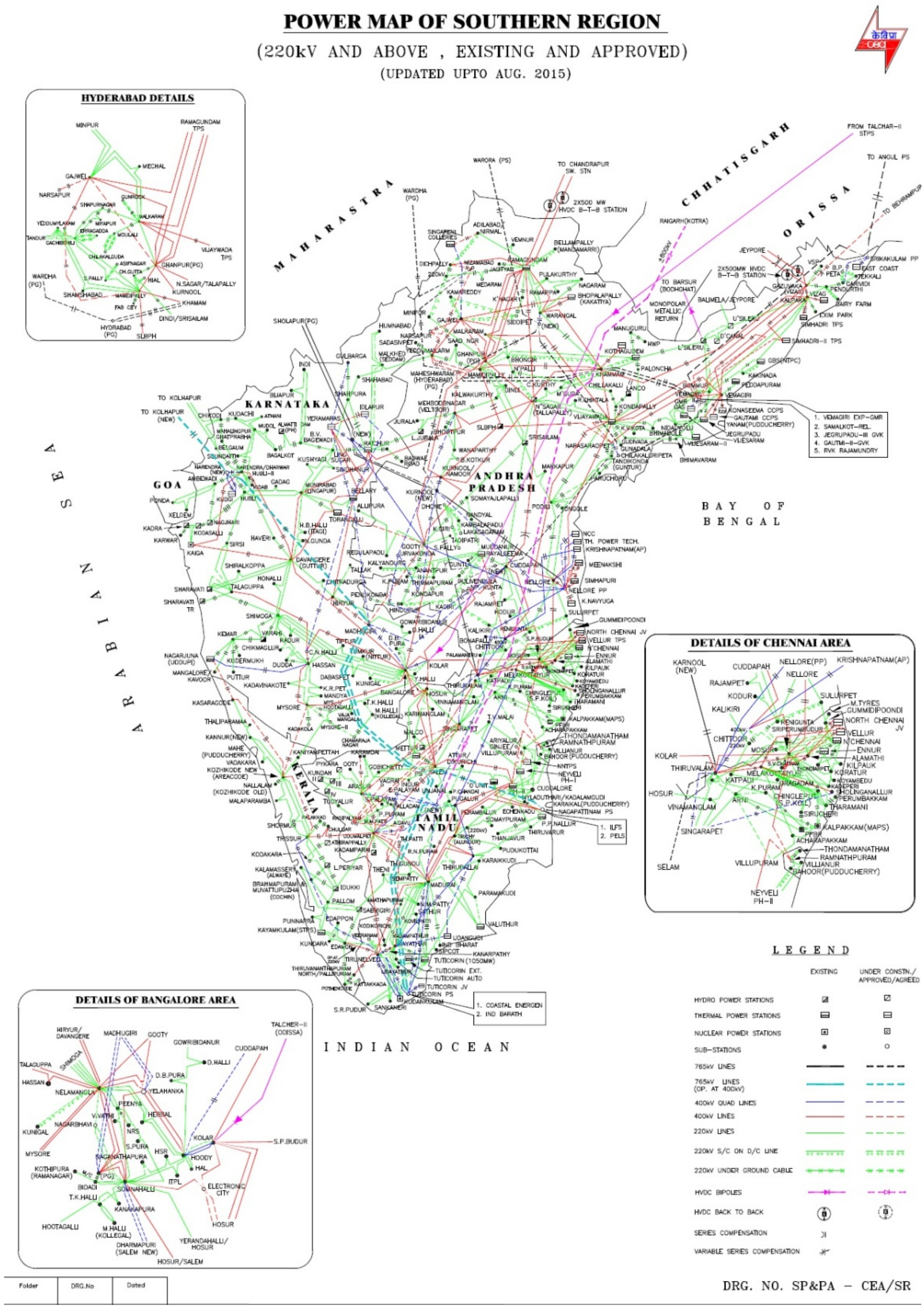


Figure 3-17 Southern Grid of India (PGCIL) (CEA)

** The large size and latest power sector maps are available at PGCIL and CEA link http://cea.nic.in/powermaps.html

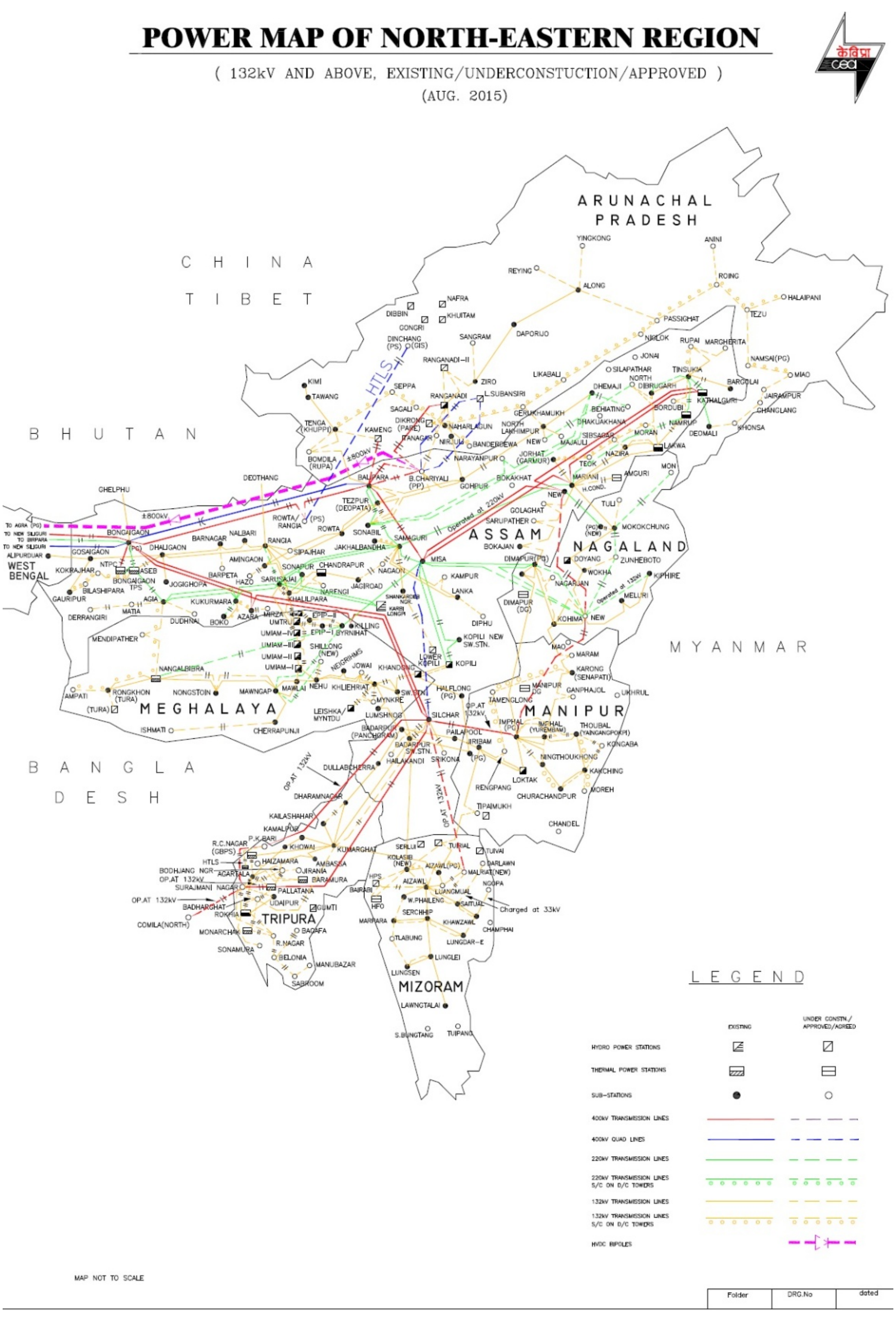


Figure 3-18 North-Eastern Grid of India (PGCIL) (CEA)

** The large size and latest power sector maps are available at PGCIL and CEA link http://cea.nic.in/powermaps.html

Since 2013, Indian grids are operational at a single frequency. As per the EA-2003, each of the five zone maintains a RLDC for the concerned zone. At country level, the NLDC has been established for managing, programming and despatching of electricity among the zones. The RLDCs, together with the SLDCs, manage the operations carried by the grid and the despatching of electricity at intervals of the zone utilizing as per the regional grid's economic and security guidelines. All activities are carried out as per guidance of grid-standards and grid-codes defined by the CEA and rules notified by the CERC. Since Jan'17, POSOCO, as a freelance government body support and operate the RLDC and NLDC (CEA) (POSOCO).

3.4 **"POWER FOR ALL"**

It is a vision of GoI, developed jointly between the Central Government and all States and Union Territory Governments for providing 24x7 power for all residential, industrial, commercial and sufficient power to the agriculture sector as defined in the state level policy. The scheme is geared to guarantee uninterrupted and quality power to all unconnected and existing users the end of 2019 in a phased and planned manner (CEA).

3.5 **"INTEGRATED POWER DEVELOPMENT SCHEME" (IPDS)**

Started on 3rd Dec 2014 with the agenda for urban India (CEA) (PFC):

1. Development & enhancement of sub-transmission
2. Development & enhancement of distribution
3. Meter for consumers, distribution transformers and feeders
4. Enable Information Technology at distribution network
5. Overlooking the target completion stipulated under erstwhile R-APDRP Twelfth and Thirteenth Plan

3.6 **"RESTRUCTURED ACCELERATED POWER DEVELOPMENT AND REFORMS PROGRAMME" (R-APDRP)**

R-APDRP - In 2008, Ministry of Power GoI (Ministry of Power, 2013), started the central government program of R-APDRP to reform the sector. The scheme was to help reduce the AT&C losses for the state level utilities to fifteen percent. The program had two mechanisms for the investment which will help in reducing the loss level one was to enable higher degree of Information Technology and SCADA and second was to strengthen the distribution architecture. The total expense of the program was Rupees Fifty one thousand five hundred seventy seven crores, out of which Rupees Ten Thousand Crores was for the first part and Rupees Forty Thousand Crores for the second part of the program (CEA).

India has accepted a challenge which is far-fetched and the goals can be achieved by implementation of a robust and data driven smartgrid to improve efficiency along with optimization of performance of the sector in India.

The standard definition for the smartgrid would then be a transformation of journey that is legacy grid to a smart and connected grid with collection of smart-systems, smart-applications and smart-devices. The transformation process has to be in a phased manner taking into consideration the regulatory policies, implementation strategy, methodology, financial implications, technical challenges, processes, choice of technologies, industry standards, assets management and capability building programs for all stakeholders, regulators, implementing agents, technology suppliers in accordance with the business priorities of each utility so that we achieve this transformation successfully (ISGF).

A clear and comprehensive setup and directions for the implementation of smartgrid will facilitate technical development, capability enhancement and investments by the various companies in the utility network and this will guarantee the completion in defined deadlines.

The inherent outcome of smartgrid will be multifold increase in the data that will be produced by the connected systems from legacy technology to modern applications.

3.7 THE LEGACY GRID

The legacy electrical grid can add further layers of automation, newer communication systems and modern IT tools to remodel it into a smarter grid. For smartgrids addition of numerous applications become the building block (Ministry of Power, 2013) and many of such applications are deployed worldwide as well as in India). Some of them are listed below:

1. SCADA with EMS and DMS
2. For all substations Enterprise IT network
3. Robust and reliable communication systems
4. Outage Management
5. ERP and Asset Management Systems
6. Substation modernization
7. Customer Support and Management
8. AMI, MMDS and bi-directional communication meter
9. Substation Automation
10. Crew Management
11. Electronic Billing Systems
12. Control Systems and Dispatch Tools
13. Data Analytics and BI
14. Distribution Automation

3.8 THE SMART GRID

With the power sector business caught between the demands for higher value, higher reach, quality of power, adequate power for all and increased environmental protection norms etc, power and energy is an extremely charged-up topic. Utilities today face the challenges of delivering electricity at a reasonable cost and combating global changes like demand response and advent of connected devices. Moreover, there is a political pressure to chop carbon emissions, to increase the utilization of renewable power, to participate in carbon credits, and to assist consumers save energy. This got the utilities to offer power and tariff on actual consumption that adjust in line with the time of day or grid load. Households and industries need bigger visibility into their power usage to cut wastage. All this suggests that a lot of refined grid management is needed. The upcoming smarter energy management systems need to be robust, intelligent, process driven to handle the mass information that when properly analysed will provide the utilities with the knowledge they need to meet these challenges.

A smartgrid is a framework of multiple grid actors connected for communication, operation, automation and other IT functionalities that control and monitor power from the generation stations to the point of consumption drilling down to monitoring at device level. It manages the energy flow and load to match the generation in real time or near real-time. The management of generation and demand brings flexibility to each generation station to alter the capacity and to integrate intermittent renewable generation which in turn will reduce the peak power cost. The legacy grid could handle many of the issues by over-engineering, but a smartgrid is efficient, responsive, and designed for dependability. The smartgrid can have self-healing and auto-management operations.

3.9 SMARTGRID DEVELOPMENT

GoI has launched NSGM or 'National Smartgrid Mission' in 2015 for development and implementation of regulations, policies & programs for a staged smartgrid integration in India. The mission incorporates a three layer structure - Governing Council, chaired by the Honourable Minister (MoP), Empowered Committee, chaired by the Secy (Power) and Technical Committee chaired by the CEA Chairperson (CEA Annual Report, 2018) (CEA). NSGM is supported by the Technical Committee on the technical aspects, choice of technology, development of standards, alternate technologies, preparation of model, RFP documents etc for smartgrid project. CEA has the nodal division looking after the development of smartgrid within the country and assists the NSGM technical committee for examination and analysis of smartgrid outcomes (CEA).

3.10 SMART GRID MISSION IN INDIA

Powergrid, the Central Transmission Utility, is accountable for designing, expansion and operation of National and State transmission grid network (PGCIL). They have already established across all Indian states, a huge and interconnected power transmission network. They operate and maintain the network along with National and Regional Load Despatch Centres within the country utilizing SCADA, EMS and other management systems. Powergrid provides help to state utilities to implement the APDRP/RGGVY and other scheme for distribution improvement along with the rural electrification programs. They have aided the distribution utilities in implementation of smartgrid systems and preparation of reports for improvement of power sector utilities through smartgrid technologies and application.

Recognizing the necessity and importance of smartgrid and to implement a state-of-the-art distribution network, they have undertaken the development of interactive pilot smartgrid projects across India through open collaboration with numerous organizations, technology partners and national and international consulting firms. Numerous organisations and their CEOs signed declaration to participate within this open collaboration. They are implementing and modifying the strategy and plans as per technology challenges, policy support, standard etc. which might need amendments and check if replicable for other projects (PGCIL) (Powergrid).

3.11 KEY DELIVERABLES OF SMARTGRID

The following are the key deliverables of smartgrid for key position holders in India

For Utilities:

1. Load management
2. Power purchase cost management
3. Asset management
4. Reduction of T&D losses
5. Renewable power injection
6. Grid visibility

For Customers:

1. Access to quality power
2. Reliable supply of power
3. Data Transparency for users
4. Increase choices of supply for users
5. "Prosumer" (pro-ducer and con-sumer)

For Government and Regulators:

1. Customer satisfaction
2. Emission reduction
3. Financial stability of a utility
4. Upgradation and modernization of tariff system
5. Prominent Schemes for sector development

3.12 SMART GRID MILESTONES AND ACTIVITIES

During 12th Plan	During 13th Plan	During 14th Plan
A) Enable Access and Availability of Quality Power for All		
▪ Electrification of all households by 2017 ▪ Reduction in power cuts; ▪ 24 hrs availability of power at principal cities, 22 hrs for all towns and Life line supply (8 hrs, including evening peak) to all by 2017	▪ 24 hour supply in all urban areas; Minimum 12 hour supply to all consumers (including evening peak) by 2022	▪ Stable and quality 24x7 power supply to all categories of consumers across the country
B) Loss Reduction		
▪ Reduction of AT&C losses in all Distribution Utilities to below 15% ▪ Reduction of transmission losses (66 kV or above) to below 4%	▪ Reduction of AT&C losses in all Distribution Utilities to below 12% ▪ Reduction of transmission losses (66 kV or above) to below 3.5%	▪ Reduction of AT&C losses to below 10% in all Distribution Utilities ▪ Reduction of transmission losses (66 kV or above) to below 3%

(ISGF) (National Smart Grid, 2018)

During 12th Plan	During 13th Plan	During 14th Plan
C) Smart Grid Rollouts including Automation, Micrgrids and other improvements		
▪ SG Pilots, full SG roll out in pilot project cities ▪ Infrastructure for AMI roll out for all consumers with load >20kW or as per prioritized target areas of Utilities ▪ Deployment of Wide Area Monitoring Systems (WAMS) ▪ Development of micro grids in 1,000 villages/industrial parks/commercial hubs ▪ Enablement of "Prosumers" in select areas	▪ SG roll out in all urban areas ▪ Nationwide AMI roll out for customers with 3-phase connections ▪ Deployment of WAMS at all substations and grid connected generation units ▪ Development of micro grids in total 10,000 villages /industrial parks/ commercial hubs ▪ Enablement of "Prosumers" in metros and major urban areas	▪ SG rollout nationwide ▪ Nationwide AMI roll out for all customers ▪ Development of micro grids in 20,000 villages/industrial parks/commercial hubs ▪ Active Participation of "Prosumers"

(ISGF) (National Smart Grid, 2018)

During 12th Plan	During 13th Plan	During 14th Plan
D) Policies and Tariffs		
▪ Implementation of Dynamic Tariffs ▪ Mandatory Demand Response programs for select categories of consumers ▪ Tariff mechanism for roof top solar PV's – Net Metering/ Feed in Tariffs	▪ Choice of electricity supplier (open access) to consumers in metros and select urban areas ▪ Mandatory Demand Response programs for larger sections of consumers	▪ Choice of electricity supplier (open access) to all Consumers
E) Green Power and Energy Efficiency		
▪ Renewable integration of 30 GW ▪ Energy Efficiency Programs for lighting and HVAC in Metros and state capitals; initiation of Dynamic (smart) Energy Efficiency Programs ▪ Policies for mandatory roof top PV and Energy efficient building code for all new large public infrastructures by 2014	▪ Renewable integration of 80 GW ▪ Energy Efficiency Programs for lighting and HVAC in all urban areas; expansion of Dynamic (smart) Energy Efficiency Programs to all urban areas	▪ Renewable integration of 130 GW ▪ Dynamic (smart) Energy Efficiency Programs nationwide

(ISGF) (National Smart Grid, 2018)

During 12th Plan	During 13th Plan	During 14th Plan
F) Electric Vehicles and Energy Storage		
▪ Development of EV and smart grid synergy plan (in coordination with National Electric Mobility Mission) ▪ EV charging stations in urban areas and along selected highways ▪ Introduction of Battery Parks and other Energy Storage Systems on trial basis	▪ Large roll outs of Energy Storage Systems ▪ EV charging stations in all urban areas and strategic locations on highways	▪ EV charging stations in all urban areas and along all state and national highways

(ISGF) (National Smart Grid, 2018)

During 12th Plan	During 13th Plan	During 14th Plan
G) Enablers and Other Initiatives		
▪ First set of technical standards after completion of pilots, including standards for EVs and its charging infrastructure ▪ Cost-Benefit Analysis of smart grid projects with inputs from the pilots and assessment of direct and indirect benefits to consumers and other stakeholders ▪ Development of indigenous low cost smart meter by 2014 ▪ Finalization of frameworks for cyber security assessment, audit and certification of power utilities by 2013 ▪ Initiation of Customer Outreach and Engagement Programs ▪ Research & Development, ▪ Training & Capacity Building ▪ 10% Utility technical personnel to be trained in smart grid technologies	▪ Standards Development for Smart Infrastructure (SEZ, Buildings, Roads/Bridges, ▪ Parking lots, Malls) ▪ Export of SG products, solutions and services ▪ Development of business models to create alternate revenue streams by leveraging the smart grid infrastructure to offer other services (security solutions, water metering, traffic solutions etc) to municipalities, state governments and other agencies; integration of meter data with other databases etc.	▪ Continuous Research & Development ▪ Training & Capacity Building

Figure 3-19 Highlights of Smart Grid Milestones and Activities

(ISGF) (National Smart Grid, 2018)

* Detailed table is provided in annexure

3.13 SMARTGRID BENEFITS

The smartgrid is designed to facilitate and enhance benefits to power utilities, its consumers & the society as below (PGCIL-SG)

3.13.1 BENEFITS FOR IMPROVED RELIABILITY

Utility	Consumer	Society
▪ Reduced operational cost ▪ Increased employee safety ▪ Increased revenue ▪ Higher customer satisfaction ▪ Reduced capital cost	▪ Improved level of service with fewer inconveniences ▪ Reduced out-of-pocket costs resulting from loss of power	▪ Reduction in cost ultimately help keeping the prices of goods and services lower than they would be otherwise ▪ Virtual elimination of blackouts ▪ Improved infrastructure boosts economic development

Figure 3-20 Benefits for Improved Reliability

3.13.2 BENEFITS FOR IMPROVED ECONOMICS

Utility	Consumer	Society
▪ opportunities to leverage its resources and enter new markets ▪ Increased revenues as theft of service is reduced ▪ Improved cash flow from more efficient management of billing and revenue management processes ▪ A flatter load profile will reduce operating and maintenance (O&M) costs	▪ Downward pressure on energy prices and total customer bills ▪ Increased capability, opportunity, and motivation to reduce consumption ▪ Opportunity to interact with the electricity markets through home area network and smart meter connectivity ▪ Opportunity to reduce transportation costs by using electric vehicles in lieu of conventional vehicles ▪ Opportunity to sell consumer produced power back to the grid	▪ A more robust transmission grid will accommodate larger increases in wind and solar generation i.e. green energy. ▪ Downward pressure on prices through improved operating and market efficiencies ▪ Creation of new electricity markets enabling society to offer its electricity resources to the market and creating the opportunity to earn a revenue stream on such investments as demand response, distributed generation, and storage

Figure 3-21 Benefits for Improved Economics

3.13.3 BENEFITS FOR IMPROVED EFFICIENCY

Utility	Consumer	Society
▪ Increase asset utilization ▪ Reduction in lines losses on both transmission and distribution ▪ Reduction in transmission congestion costs ▪ Reductions in peak load and energy consumption leading to deferral of future capital investments ▪ Increased asset data and intelligence enabling advanced control and improved operator understanding ▪ Extended life of system assets using improved asset "health" management ▪ Improved employee productivity using the smart grid information that improves O&M processes ▪ Improved load forecasting enabling more accurate predictions ▪ Reduced use of inefficient generation	▪ Increased capability, opportunity, and motivation to be more efficient on the consumption end of the value chain ▪ Increased influence on the electricity market	▪ Deferral of capital investments as future peak loads are reduced and more accurately forecasted through the combined efforts of consumers and delivery companies ▪ Reduced consumption of KWh's through conservation, demand response, and reduced transmission and distribution (T&D) losses

Figure 3-22 Benefits for Improved Efficiency

3.13.4 BENEFITS FOR IMPROVED ENVIRONMENT

Utility	Consumer	Society
▪ Increased capability to integrate intermittent renewable resources ▪ Reduction in emissions as a result of more efficient operation, reduced system losses, and energy conservation ▪ Opportunity to improve environmental leadership image in the area of improving air quality and reducing its carbon footprint ▪ Increased capability to support the integration of electric-powered vehicles ▪ Reduction in frequency of transformer fires and oil spills through the use of advanced equipment failure / prevention technologies	▪ Increased capability, opportunity, and motivation to shift to electric vehicle transportation ▪ Improved opportunity to optimize energy-consumption behaviour resulting in a positive environmental impact ▪ Increased opportunity to purchase energy from clean resources, further creating a demand for the shift from a carbon-based to a "green economy"	▪ Reduced CO_2 emissions ▪ Improved public health

Figure 3-23 Benefits for Improved Environment

* Detailed table is provided in annexure

4. CHAPTER IV - DATA UNIFICATION

With each new day we are pushing in more data into the system. We are in the phase of large and complex data. With today's modern and advanced technology, there are numerous infrastructure, technologies and systems available to control, operate and design the power sector network. The network spreads across the generation, transmission, distribution, trading and associated up-streams and down-streams. Globally this is managed by independent models and systems for each sub-sector of the value chain. Each node and link in the network produces huge amount of data within the system and applications in the silos (Ghosh).

In this age of data deluge, such varied forms of data can be handled by platforms capable to handle volumes and variety of data which two-folds or tri-folds each year and this growth of data is not going to slow down.

Research estimates the global data to increase and reach forty zetabytes (1 trillion gigabytes) by the year 2020 an estimate by McKinsey (Manyika, 2013). Such large volume of data or as the industry calls it bigdata has its inherent challenges and opportunities for improved operations and researching ways to utilize and has become a key focus area of the major industries worldwide. Data management, storage and analysis are very critical for any industry to be sustainable and develop in accordance to the external business environment and continuous changes.

The upcoming technologies in the power sector are providing new mechanism for automation and forecast of generation, demand, transmission and distribution. The knowledge helps to understand usage patterns, prevent outages, optimise unit's commitment, intelligent system management and manage other objectives.

"Today smart power systems are generating huge volume of data which has changed the dynamics on how business process and analytics is done. Power sector is a massive producer of time-based or telemetry data which are mission critical from generation, transmission, distribution, trading and other relevant data sources” (Urbana World, 2016). Numerous applications are producing data in different forms and structure in the silos of power sector. Taking a scenario of electricity meter which today does one meter reading per month, it will increase to fifteen minutes reading after installation of smart meter and will generate ninety six million dataset per meter per day and for the millions of meters that will be deployed across the country. The outcome will be an increase of three thousand folds in data that needs to be handled and analysed. And, this flow of data will increase as more smart devices will be installed as time goes on (IBM Datamag). In the current and future scenario, the power sector must be more customers centric and provide flexible means to receive utility services.

During the decades of eighties and nineties, the telecom corporations faced equivalent challenges. With upcoming technologies which were adopted, telecoms were flooded with new types and sources of information which they had very little expertise on the way to manage or utilize it. They struggled to store data, process it and managing it to analyse for business enhancement. But these days, the telecommunication companies are the biggest and best data and analytic savvy in the world. Decision making details (their equivalent of utility smart-meter or smartgrid information) could be a wealth of data that is mined extensively by their business departments with astounding results.

Power sector firms have for long handled data coming from their industrial and residential users, but now they are under pressure to make their power generation, transmission, distribution and trading more efficient, reliable and robust. Simultaneously, the risks of latest regulation and political intervention are bound to increase, and the continuing demand and supply gaps is hampering income and profits and thereby raising an issue within the sector over revenue flow and balance sheet strength (Economist Insights, 2013).

In this age power utilities need to take quick action in securing capabilities by interpreting client usage trends and pattern to developing the necessary competencies by forecasting the demand and managing supply as per daily requirement. The connected devices and smartgrid challenge is one of the largest technology and information management challenges the planet has ever seen. The utilities need to store and explore this outburst of data and knowledge as a chance to analyse and find insights for competitive advantage, operational intelligence and analysis of power sector as a whole.

- Are the utilities and organization prepared for this data deluge future?
- Are they able to utilize the data and repository to provide strategic insights?
- Are the strategies in place for organizing data to facilitate analysis for business decisions?
- Do they have access to cross-functional departments like operations, load managers, users and meter data for analysis?
- Are the operational data organized on legacy models and spread over disparate systems or technologies?

To extract insights, data needs pre-processing to represent the utilities business process requirements. The strategic view should be that all essential data is available and properly analysed to provide answer to questions raised by all stakeholders, executives and regulators.

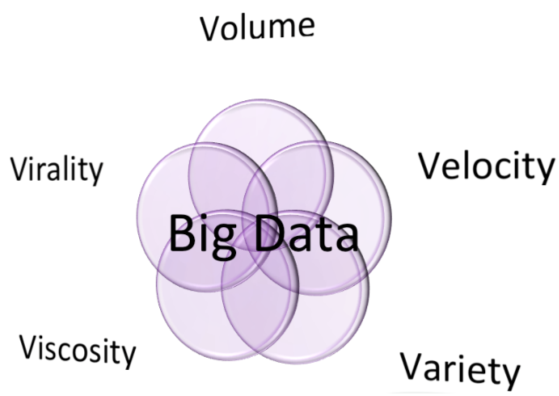
The utilities need to create new business models to facilitate new interactions to handle re-shaping markets, new dimensions, bi-directional power production, growing competition etc. Leveraging the knowledge of users and analyzing the usage trends and patterns will help utilities swiftly implement adequate organizational re-structures.

This research is conducted to assess the strengths and weaknesses of existing data silos and their viability for data unification. What financial and regulatory factors impede the development of a "Unified Data Platform" and suggest a Process Map Framework for a Unified Data Framework for power generation, transmission, distribution and trading.

4.1 **CHALLENGES**

This compounding increase in the volume, velocity, variety, virality and viscosity is referred as bigdata (IBM Bigdata Hub).

According to industry and Intel, the term bigdata is new generation's big buzzword. General definition of bigdata is to utilize and consume datasets which are beyond the industry size and with intricacies which are difficult to capture, process, maintain and manage on erstwhile traditional databases. Difficulties are faced capturing this dissimilar datasets, storage limits, searching speed and performance, sharing capabilities, analysis, visualization and many such requirements (Intel).



The mechanism to unravel the power and knowledge of data is by utilizing both unstructured and structured data and then deriving the right insights. Industries will achieve competitive benefits and business intelligence by interpretation of data.

4.2 **THE FIVE V'S OF DATA**

Volume: denotes the size of structured or unstructured data that needs to be processed. This size is ever growing and huge data today may be 10 TB which in next year might be 50 TB, as trend given by Moore's Law. Handling the volume requires tools and methods that store huge amounts of data which can be then scaled or used in distributed architecture for finding key information.

Velocity: represents the frequency of data generation and sharing. The data received from devices and sensors are growing and needs real-time management to be able to parse, detect and identify patterns.

Variety: represents the different data types that are coming from structured and non-structured environments including social media, mobile platforms, machine that adds different data types to the existing legacy datasets. Today data have no well defined structure and can have content, geo-spatial, location based, machine data, mobile, process, sentiment, social and web based data types. In addition the speech and language can add more unstructured data for data mining and analytics.

Viscosity: represents the resistance offered by various systems to the flow of data. This resistance is there because of various data sources, integration friction which required additional methods to extract data insight.

Virality: represents the speed of information dispersion across P2P networks. It measures the speed of data at which it spreads and is being shared across unique datapoints.

4.3 **DATA ANALYTICS – USES AND BENEFITS**

'The energy chain and utility comprises of powerplants generating electricity and transmitted across the country and finally distribited to consumers. The industry is undergoing a largescale transformation through modern technologies. Grids are getting smarter. Power sources are becoming cleaner and consumers have more choices. Data and analytics is supporting utilities overcome the challenges through insights and informed decisions.

Data of businesses are increasing daily but it is not the volume of data which is important; rather what utlities do with the data is. "Data Analytics use various tools like mathematics, statistics, predictive modeling, predictive analysis, and machine-learning to find meaningful patterns in large data sets. Energy and utility organizations apply smart technology to their landscape, including sensors, cloud computing technologies, wireless, power planning, and network communication. Utilities need to analyse this data to bring in operational efficiencies, reduce costs, lower carbon emissions, and manage energy demand for end consumers.

Utilities optimize their power planning and generation using analytics. Analytics helps in forecasting the consumption and demand supply management. Asset management, efficiency, Smartgrids management, power sustainability, load forecasting, grid operation management, predict the failure, power quality, maintenance, inspection are some of the key areas where data analytics can support. In order to harvest the true benefits of data and analytics, utilities need to invest to get insights out of the data for informed decisions" (Handoo, 2018).

4.4 **"UNIFIED DATA PLATFORM" - NEED OF THE HOUR**

"The modern grid integrates information, computer, and communication to form a new type of smartgrid management system. The general framework of power network is available in silos but a Unified Data Platform will define the means to bring all functional procedure, technology, architecture integrated into a multi layered framework, which comprises of the data sources, integration, storage, data processing, data analysis, and application integrated for different sub-sectors in a unified platform" (MA Ruiguang, 2017).

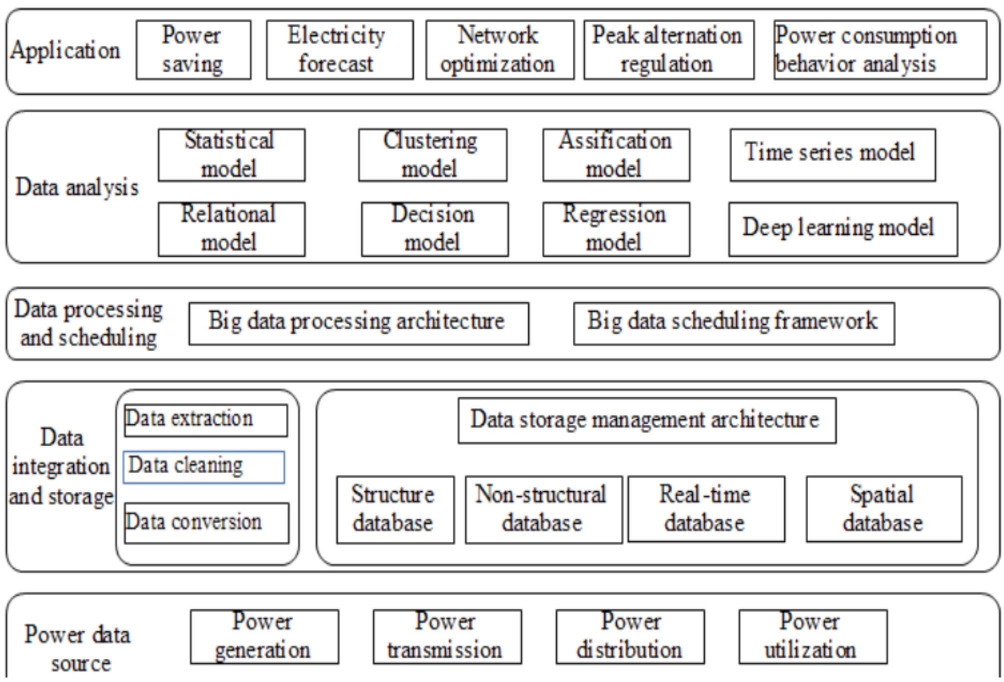


Figure 4-1 Unified Data Platform

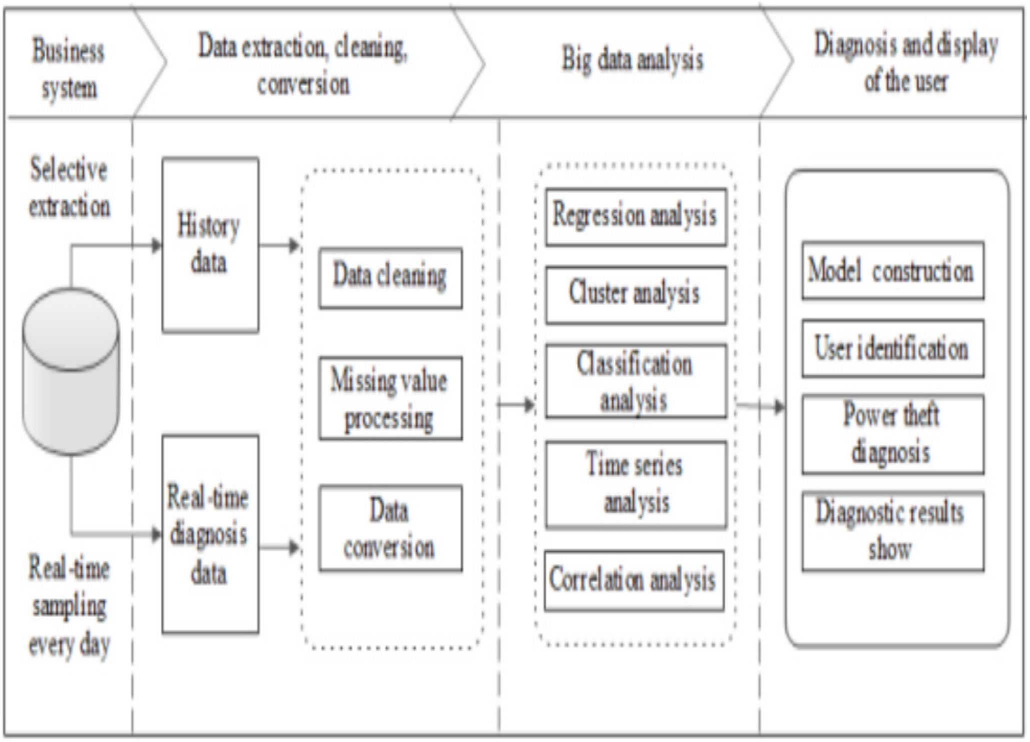


Figure 4-2 Data Processing (example)

(MA Ruiguang, 2017)

5. CHAPTER V - BUSINESS PROBLEM

We can summarise the problem as “Lack of Unified Data Platform, for data analysis of operational parameters across the power sector is leading to decision delays, inefficient operations and losses”. Though data management tools are present in silos, the available literature studied and research done does not provide evidence related to “Unified Data Platform” across generation, transmission, distribution and trading in Indian power sector.

5.1 THE BOTTLENECKS AND CHALLENGES

The systems are available in silos and perform tasks like performance analysis, energy management systems, remote monitoring, maintenance management, fault diagnostics, network and protection management, trading etc. This is a huge disadvantage that the data is available in silos and different system which makes it difficult to combine for unified management. The advanced networking and communication protocols and systems allow complex systems to be integrated for operation, controlling, management and monitoring. However this will require sectoral intent, government push, financial, regulatory and technical support and environment to happen.

The immediate implication is that due to a mix of legacy and modern systems, India needs to manage a huge data which is both structured and unstructured coming from various silos of the power sector. In the same time the sector too needs to understand how to use this data for Operational Intelligence.

“As this data becomes huge and complex, the storage as well as the processing becomes crucial. The existing and legacy systems must be upgraded to handle the data storage and management. Add to that the new generation smart grids with automation system having numerous sensors embedded in the existing power system for controlling and monitoring. On one hand the volume, the variety, the variability, the velocity of heterogeneous data collected from these sensors have all added to the complexity; while on the other hand with the availability of today’s cost effective storage solutions and processing power of the devices, it has now become possible to process data at small time buckets

for better analysis. We can capture time streaming information from devices for interpretation of current system or to predict future events with higher accuracy. The grid will become additional intelligent by the process of data management from the information stored and analyzed" (Urbana World, 2016).
A cornerstone of this transformation will be analysis of large datasets and growing volume of information generated by the power and energy related industrial instrumentation, smart devices and smartgrid all of which needs to be analysed to boost efficiency and help in developing improved services for end users. Huge information gathered will give higher understanding of client segmentation, their behavior and the way utilities influence the usage. The firms have the potential to analyse the information.

According to industry data veterans and IBM, the possibilities don't end there. With the increase in data and information from smart meters and smart grids and other smart systems, it is now needed to modify the network and data platforms to improve key performance indicators, efficiency, scheduling etc. However, the proliferation of intermittent data sources like renewable power plants, micro and mini grids the entire network requires more granular forecasting, planning and analysis (IBM Bigdata Hub).

The potential of finding insights in the power sector are available at both ends of lifecycle - generation and consumption. Stakeholders can utilize data for fault detection or predictions for equipment failure and take preventative measures. A step ahead, business intelligence and analytics can be applied to comprehensive data and allow stakeholders to optimize their operations and have a better fleet management, ensuring that individual plants are working in tandem to meet their desired objectives.

5.2 MOTIVATION FOR RESEARCH

It was necessary to undertake detailed research to identify the financial and regulatory factors responsible for (non) implementation of mechanism for data unification in the power sector. We relied on the literature survey, benchmarking study of various systems available and identified the critical factors. This research study proposes a “Unified Data Platform” for implementation in the power sector.

Research motivation

- Power Utilities are generating and using a lot of data
- Numerous data driven opportunities are nascent and remains to be harnessed to improve operations and services
- Utilities are using smart devices to improve customer service
- Big opportunities remain in operational analytics to improve operations
- Utilities expect analytics will drive operational efficiency and boost the bottom line
- Most utilities lack usage of sufficient data analytics

The fact remains that “Utilities do not have a Unified Data Platform for Operational Intelligence and Analysis of the sector” (Pratik Ghosh, Factors and Constraints for implementing a Unified Data Platform for Operational Intelligence and Analysis of the Power Sector, 2019).

Proposal is to research and design the architecture of “Unified Data Platform” for Operational Intelligence and Analysis of Power Utilities in India (Pratik Ghosh, Process Map of a Unified Data Platform for Operational Intelligence and Analysis of Power Sector, 2019).

5.3 BUSINESS OBJECTIVE

Strategies for unraveling the enormous power of data and the knowledge within the Indian power sector are at a nascent stage of development partly because the focus is on policy and regulatory issues and on overall sector management.

Having a platform to use the legacy and upcoming technology and data at the same level with an intelligent use of smart devices and systems will allow utilities to

1. Monitor, control and forecast power consumption trends
2. Identify inefficient power usage at micro and macro levels

3. Predict potential equipment failures and power shortages
4. Better customer demarcations
5. Tailor made offerings based on customer requirement

5.4 BUSINESS THRUST FOR SMART ANALYTICS

Demand Response – To realize one of the key benefits of implementing 'smart' technologies, utility companies need to design and install the DR system enabling end users to support the load reduction during peak times.

Revenue Management – As requests for rate increases become more challenging, companies need to demonstrate that business operations are functioning optimally. Ensuring all meters to be accurately billed is essential to maximizing revenue recovery. Utilities are finding proactive process monitoring to be the key to quickly identifying meters that are not billed or under billed.

Maintenance and Asset Management – The ability to identify potential issues in powergrid and supply equipment can prolong the life of equipment and assets and avoid unscheduled interruptions.

Fraud & Loss Prevention – Utilities need real time or near-real time data about loads to detect system losses due to theft or fraud. Such capabilities can realize significant monetary benefits.

Energy Efficiency – Utilities need to create, pilot, monitor and run trainings and camps to educate consumers in their service areas about efficiency and conservation of power. These activities will need to be supported with timely analysis and data-driven insights.

Load Forecasting and Management – Accurate forecasting is essential to well-timed and cost-effective demand supply management. Power companies should analyse and utilize data based on consumption, climatic conditions and constraints to manage effectively their operations – and reduce the requirement for costly spot market power procurement.

Compliance – Regulatory policies push the need for accurate, consistent and completed reports on Key Performance Indicators. Non-compliance result in companies incurring penalties.

Customer Care and Management – Utilities are now mandated to facilitate users with internet based interactive websites to view and manage all aspects of their associations beyond the basic enrolling, bills, payment, and historical details. Utilities need to design customised tariff plans and incentivize consumers to use power efficiently.

Utilities should improve their storage of client usage trends and their network usage patterns. Analysis of this information will facilitate in forecasting new tariffs and different contract terms. At the same time analysis of social media data might provide details of customer sentiments and introduction of new service or product range. Utilities will generate additional business if they exploit and analyse the information they collect (Economist Insights, 2013).

Opportunities are being opened up as well as challenges for the utilities, which might not have the required skills and tools to handle this new world of data based knowledge. Managing the deployments of new technology is unquestionably necessary for both incumbent operators and for new market entrant; however what tools and technology they use for leveraging the information are definitely mission-critical if they need to stay competitive. Business leaders should overcome obstacle, adopt standards, privacy, security, quality and structure along with their internal obstacles, like organisation silos, talent and skills gaps (Economist Insights, 2013).

5.5 BUSINESS BENEFITS THROUGH SMART ANALYTICS

1. Customer Participation
2. Distribution Optimization
3. Asset Management
4. Smart Grid Analytics

5. Grid optimization
6. Demand response
7. Demand-side management
8. Utility Monitor and Control
9. Energy storage
10. Advanced Metering
11. Renewable energy generation and distributed
12. Smart Meter Technology
13. Energy Theft Stops
14. Generation optimization – Economic Dispatch
15. Transmission optimization
16. End-use optimization
17. Load forecasting
18. Load shifting

Utilities taking such methodologies will reduce their power and money wastage due to inefficient operations. They will potentially identify new methods, packages and produce deliverables to enhance their revenue. Instead of being reactive to market changes, conditions and stakeholders behavior, companies need to be proactive in their business and system management.

5.6 BUSINESS USAGE OF SMART ANALYTICS

1. Calculation and verification of demand response at a customer level
2. Identification of fraud/theft of power via bottom-up consumption analysis
3. Meter-to-Cash Analysis
4. Customer Usage Pattern Analysis
5. Service reliability and performance reporting to regulatory bodies
6. Transformer overload detection and circuit analysis
7. Extension of the life of assets via predictive and pro-active maintenance
8. Load profile characterization and definition for segmented customers – residential and commercial
9. Calculation, verification and audit of assured load relief performance by load aggregators

10. Capacity Offset Forecasting for load reduction programs (like demand response and interruptible load control programs)

While initial research will focus on strategies for variable data acquisition of single data node, eventually the research will be scaled to handle multiple data nodes to work smartly with the goal of optimizing the entire business setup. It is significant that we identify a network platform to support, provide environment and have the ability to model the work flow that incorporates all the requirement of analysis, neural learning so as to optimize and provide decisions in real-time.

5.7 HYBRID ARCHITECTURE FOR SMART ANALYTICS

The research will evaluate the hybrid architectures required to handle the heterogeneous nature of data environment and provide a platform to manage the need for incorporating both legacy and established database utilizing a common architecture or a hybrid architectures that each participating data-management system is appropriately designed (IBM Datamag).

1. Ease of use – Import, export, explore and analyse data
2. Flexibility – Implementable on existing or new industry standards
3. In-memory analytics – intelligent usage and compute complex data
4. Linear scalability – With data volumes increase, the query performance should not become incremental and slow
5. Lower total cost of ownership – Systems to be cost effective and finance should not be a major hinderance
6. Parallel Processing technology – to handle multiple queries simultaneously

5.8 DATA DEPLOYMENT STRUCTURE

The research will evaluate the data deployment structure based on the following parameters:

1. Data acquisition
2. Collection
3. Transformation

4. Movement
5. Cleansing
6. Staging
7. Governance
8. Access
9. Delivery
10. Interactive exploration
11. Archiving

The possible benefits of addressing the new landscape and unprecedented data volumes with an initiative such as Operational Intelligence are manifold. Utilities will be able to attach to the information-spigot once and address their operational, energy delivery, customer care and security challenges through non invasive, real-time data analysis. Utilities will be able to identify trends, anomalies and patterns within given organizational boundaries to identify opportunities and threats. Utilities will be able to achieve these objectives not by rewiring their entire existing infrastructure, but by creating a fabric on top of that infrastructure to provide a common operating picture.

5.9 FRAMING THE THESIS

When the advent of smartgrids, which are electricity network having intelligence, self healing properties, integrated for numerous actions for all stakeholders like generation stations, transmission grids, distribution network, consumers, power traders for economic and secured management and power supply utilizing innovative tools and services for control, communication, and management technologies (Luca Ardito, 2013). However, due to the non-existence of the "real" smartgrid, the scope of my study was difficult to research. Most researchers therefore opt to separate smartgrid hardware, software, networking and communication as separate topics for implementation or research. This research identifies factors and constraints that are either hindrances or are impeding the data unification across the sector. With the data used for research, these subgroup areas are based either on financial, economic, social, technology, regulatory or policy related. However, during this research, some attention grabbing facts came up related to the selection of subgroups. During preparation of conceptual lens and identifying factors, subgroups were found to be influencers despite having conflicts between intra-subgroups (Wikibon).

6. CHAPTER VI - RESEARCH CONTEXT

In today's business and management parlance, there should remain no doubt in the minds of management of organizations whether to be analytics-driven or not, but they should start concentrating on how to adopt and implement the changes required. Analytics-driven organizations need to relook at the way their information architectures are built and design the changes to get the outcomes required for their business. The standard ready to use data structure and databases are long dead, and so are the one-design-fits-all type data analytic platforms.

Almost all large organizations have multiple disconnected databases that are used by different silos of their business since last few decades. The applications are providing data and services for that domain of the organization, but usually not accessible to other data users in the organization. The challenge is how to combine all the different data sources, data types and applications that are having different formats and protocols into a common master source. This becomes even more difficult when we see the scale and speed at which data is getting added daily.

To most, data unification will seem to be an insignificant task. After all, how hard can it be to unify your disconnected datasets, right?

Unfortunately, it is a huge misconception as data unification is a tedious, arduous and complex process which will be the biggest challenges that most large organizations face today. But to extract insights from the end-to-end data and utilizing its knowledge, we need to migrate towards scalable data unification platforms and explore the principles, key components and future trends of the new ecosystem.

Before getting deep into how to unify the datasets and the associated ecosystem, let's see the dictionary definition of the words:

"Data Unification (n): The process of ingesting data from numerous functioning systems and combining them into a single source by performing transformations, schema integrations, de duplications, and general cleaning of all the records. Some of the tenets that need to be addressed for a scalable Unified Data Platform are:

Data Ingestion from the numerous operational systems in the enterprise

Data cleaning, as different parameters and coding standards are used by different data platforms

Data transformations, between datasets as well as within the data platform like currency conversions or unit conversions

Data schema integration, where similar data might be having different headers like salary in one and wages in another database

Data de-duplication or consolidation, in which data stored in different databases, might have different nomenclature like "Pratik Ghosh" in one source and "P. Ghosh" in another

Data classification for complex analytical activities, to classify transactional or operational data sets into meaningful buckets

Data import, exporting and migration between different data sources for generating a Unified Data Platform

Large organizations need to spend a huge amount of time, effort and money for preparation of this Unified Data Platform or ecosystem, as Gartner reveals that organizations are expanding data preparation and is expected a growth of over 18% YoY through 2021. Organizations spend 60% of time on data-preparation and are moving towards new standards and tools that will reduce this time to around 50% by 2020 as per Gartner's research".

Data unification is an integral part of this new data preparation ecosystem and is an essential input to tools used by analysts and consumers, such as self-serving data preparation tools and data catalogs. These users can't be expected to be productive and generate meaningful business insights without a foundation of trustworthy data, which data unification provides.

There are numerous approaches to data unification starting from legacy to modern day agile which use powerful data unification platform, machine-learning and human expertise to channelize the usage and unification of data (TAMR).

Forbes states that "we are going to generate 2.5 quintillion-bytes of data per day and this is growing" (Forbes).

6.1 RESEARCH STATEMENTS

The sector faces many challenges like power outages, sub-optimal usage of resources, deterioration in quality of power, wastage of power, gaps in generation and distribution, irrational tariff structure for industrial, commercial and residential consumers etc. If the entire data flow be managed on a common platform it will lead to cost effective power supply which inturn will lead to better and competitive industrial and domestic products and services. Lack of such platform is adversely affecting the sector due to either inadequate regulatory framework or financial constraints to implement such a mechanism for free flow of data.

The absence of such a platform dents the economic development of the country. There is an urgent need to address this issue not only for the sake of improvement of the power sector but also for improving the health of the economy.

6.2 RESEARCH PROBLEM

The research problem arises from the research gap in the literature review. The central problem that arises from the perspective of theoretical underpinning shows that though data management tools are available in silos, the available literature does not provide evidence related to financial and regulatory policies for establishing a "Unified Data Platform" across the power sector. The lack of "Unified Data Platform" for data analysis of operational parameters across the power sector is leading to decision delays, inefficient operations and losses. The data exchange across the sector is in a nascent stage and the theoretical frameworks and processes are yet to be established.

The research problem for the study that emerges is as below:

"Is a unified data platform across power sector financially viable and aligned with Indian regulatory policies?"

6.3 RESEARCH QUESTIONS

In the light of the above discussions the research questions that arise are as follows:

Research Question 1 - What are the strengths and weaknesses of the existing data silos for generation, transmission, distribution & trading and the financial and regulatory viability of a unified data platform?

Research Question 2 - What are the financial and regulatory factors impeding the development and implementation of a unified data platform?

Research Question 3 - How to develop a Process Map for unified data platform across Generation Stations, Transmission Grids, Distribution Networks and Trading Companies?

The purpose of the RQ1 and RQ2 are to determine the relevant financial and regulatory factors and establish their significance in the Indian power sector. However in terms of sequencing, the study first focused on eliciting the data unification challenges that affect the Indian power sector and subsequently identifying the factor and their relevance to the industry. The RQ3 develops a Process Map for "Unified Data Platform". The Research Questions lead to the Objective of the Research.

6.4 RESEARCH OBJECTIVES

Based on the research questions, the following research objectives are formulated:

6.4.1 RESEARCH OBJECTIVE 1

To analyze the strengths and weaknesses of existing data silos and their financial and regulatory viability for data unification across generation, transmission, distribution and trading

6.4.2 RESEARCH OBJECTIVE 2

To identify the financial and regulatory factors impeding the development and implementation of a “Unified Data Platform”

6.4.3 RESEARCH OBJECTIVE 3

To develop a Process Map for addressing the identified gaps for a Unified Data Framework based on identified factors, constraints and tools for power generation, transmission, distribution and trading

7. CHAPTER VII - RESEARCH DESIGN

The design of a research is the blueprint detailing out how the researcher intends to achieve the end objective. It includes the research methodology, the approach to collection, measurement and interpretation of data. The research design needs to consider the research strategy and research philosophy. This chapter identifies the objectives of research, the research questions and proposed strategy to address these questions. It details out the qualitative research strategy that is used to elaborate on the first research question and followed by the quantitative research strategy to elaborate on the second research question. The third research question is addressed using descriptive methodology by using modeling languages and tools like MS-Visio to develop a process map. The chapter also delves into the rationale and theoretical framework to justify the choices made at the various points in the research framework. Lastly, the chapter includes the metrics and thresholds to establish the reliability and validity of the research design.

7.1 INTRODUCTION

The research design provides the framework for addressing the research objectives.

- Express relations between variables
- To generalize the result of the investigation to a larger group
- To understand the behavior of factors to the specific scenario

Research design has a number of components

- Sampling design or the method of selecting items that are to be part of the study
- Statistical design or the details on the sample size, frequency and analysis of the data gathered
- Operational design or the execution of the decision or conducting the research

The research design needs to consider the means of obtaining the information, the objective and nature of the problem and the practical issue of the resources – including time and money that are available with the researcher to carry out the research.

Research design can be categorized as

1. Exploratory research: Is aimed at formulating the problem for more precise investigation or to develop a working hypothesis.

2. Descriptive Research: Is concerned with describing the characteristics of the subject being investigated or aims to establish a causal relationship.

Exploratory research focuses on discovery of new ideas and the research design therefore needs to be flexible to accommodate less precise or broad definition of the research problem at the initial stage, which would evolve into a more precise meaning during the course of the research. Research design for **Exploratory Research** involves

1. Literature Review – that involves a detailed analysis of the existing literature on the domain to understand the current body of knowledge on the subject. This would help and help formulate the hypothesis for the proposed research.
2. Expert Opinion – that involves the survey of experts to extract responses
3. Analysis of "insight-stimulating" example – that involves intensive study of the phenomenon of interest (Ghosh).

Descriptive Research is more rigid, prevent bias and ensure reliability. The design must focus on

1. Formulating the objective
2. Defining the methods to collect the data
3. Defining the sample
4. Collecting the data
5. Data Analysis

6. Conclusion

7.2 **RESEARCH STRATEGY**

Research Strategy is generally classified either as Qualitative or Quantitative. At a superficial level the difference between the two strategies is often construed as quantitative research as those that involve measurement and qualitative research as those that do not involve measurement. There are fundamental differences with different epistemological and ontological considerations.

In this research the qualitative analysis is executed first using the Grounded Theory Methodology with the objective to understand the data unification challenges in the power sector to elaborate on the first research question. This is followed by the detailed quantitative analysis using Exploratory Factor Analysis to elaborate on the second research question. The last research question is addressed using modeling languages to suggest a process map.

	Qualitative	Quantitative
Definitions	“a systematic subjective approach used to describe life experiences and give them meaning”	“A formal, objective, systematic process for obtaining information about the world. A method used to describe, test relationships, and examine cause and effect relationships”
Goals	“To gain insight; explore the depth, richness, and complexity inherent in the phenomenon”	“To test relationships, describe, examine cause and effect relations”

Characteristics	▪ "Soft science ▪ Focus: complex & broad ▪ Holistic ▪ Subjective ▪ Dialectic, inductive reasoning ▪ Basis of knowing: meaning & discovery ▪ Develops theory ▪ Shared interpretation ▪ Communication and observation ▪ Basic element of analysis: words ▪ Individual interpretation ▪ Uniqueness"	▪ "Hard science ▪ Focus: concise & narrow ▪ Reductionist ▪ Objective Logistic, deductive reasoning ▪ Basis of knowing: cause & effect, relationships ▪ Tests theory ▪ Control ▪ Instruments ▪ Basic element of analysis: numbers ▪ Statistical analysis ▪ Generalization" (UMSL, 2012) (Coventry University)

Table 7-1 Qualitative vs Quantitative Research

7.3 DATA COLLECTION INSTRUMENT AND PROCEDURE

We framed our interview schedule and questionnaire based on gathered information on the current status of the industry and the problems faced due to data in silos. This information was obtained from literature survey and benchmarking of Indian Power Sector. The instrument comprised of

- Research Objective 1 - for qualitative analysis an un-structured and open ended interview schedule was used as a data collection instrument and administer to industry experts
- Research Objective 2 - for quantitative analysis semi-structured questionnaire with 30 questions was used for the survey and this tool was easy to administer, easy to tabulate and analyze
- Questionnaire was designed on a five point “likert scale”. The designed scale had options:
  - Strongly agree
  - Agree
  - Neutral
  - Disagree
  - Strongly disagree

The Questionnaire was designed in such a way that items divided with relation to

- Regulatory Components
- Financial Components
- Application Components
- Hardware Components

Research Strategy involved sending out the questionnaire to 250 respondents, followed by in-person or telephonic conversations for filling up survey tool along with a few personal interview.

7.4 TESTING THE INSTRUMENT

Pilot Testing

We carried out a pilot, to test if statements are debatable and have discriminatory value on 30 respondents. This resulted in rewording of few questions to remove ambiguity and bring in clarity before the questionnaire was administered again.

Reliability

As a measure of concept this refers the consistency factor.

Cronbach's alpha is widely used for testing the internal reliability. Computed Cronbach's alpha co-efficient would vary from 0 (or no internal reliability) to 1 (to denote perfect internal reliability). It is standard practice to have Cronbach's alpha score of 0.7 or above to be deemed as acceptable.

Validity

Validity of a measurement deals with whether or not the measure of the concept truly measures the concept. Validity of instrument can be measured in multiple ways. Face Validity or Construct Validity which includes both Convergent and divergent Validity. We discuss the face validity in this section to measure expert's attitude. We made a few modifications however based on the suggestions from industry experts, and then we carried out our final data collection.

Face Validity is a subjective process where the experts in the field of context of study are asked to give their judgment whether or not the measure reflects the concept concerned. In this research the semi structured interview was administered to 30 respondent but we received response from 25 respondents with experience in the power sector to establish the face validity of the instrument.

7.5 **RESEARCH SITES AND SUBJECTS SELECTION**

The research site which was selected as the context of the research was India and the subjects or respondents were similar to the audience in the qualitative research that included a mix of policy makers from both power sector and academics. The categories on the basis of which the samples was stratified were

- Senior Officers/ Director Level
- State Electricity Board Officer
- Generation Companies
- Electricity Regulators

- Distribution Companies
- Financial Institution
- Transmission Companies
- Power exchanges
- Academicians
- Load Despatch Centers
- Software and Application Vendors
- Hardware and Communication Vendors
- Users of the power sector systems
- Industry persons in conferences and meets

7.6 DETERMINATION OF SAMPLE SIZE

Determining the sample size requires statistical calculations. Researchers normally consider minimum 100 participants as the sampling size with a large population. Practically for research study the sampling size is calculated by analyzing two factors: (a) the nature of data-analysis being proposed and (b) the estimated response rate. Many research scholars prefers to have at least 10 responses per item being tested within the factor analysis, and other researchers upto 300 responses can also be considered for Likert scale development (Research Gate).

For qualitative analysis of research objective – 1, non probabilistic judgmental sampling was done with a population of 25 industry experts.

For research objective – 2, data was collected using proportionate stratified sampling methods. The strata was divided into Government Officers (Director and above), State Electricity Boards, Electricity Regulators, Financial Institution, Generation Stations, Transmission Grids, Distribution Network, National and Regional Load Dispatch Centers, Power exchanges.

The target respondents were senior experts of their sector and their contribution and proportion of compliance to our research was expected to be around 75%, with 95% of confidence level, and an error margin of 5% for a population of size 774. Calculated sample size was 211. Calculation was done using "formula for the sample size n:

$n = N*X / (X + N - 1)$, where, $X = Z_{\alpha/2}^2 * p*(1-p) / MOE^2$, and $Z_{\alpha/2}$ is the critical value of the Normal distribution at $\alpha/2$ (e.g. for a confidence level of 95%, α is 0.05 and the critical value is 1.96), MOE is the margin of error, p is the sample proportion, and N is the population size. Note that a Finite Population Correction has been applied to the sample size formula" (Select Statistics, 2018).

Size of Sample calculated with

Confidence Level – 95%

Population Size – 774

Proportion – 75%

Margin of Error – 5%

Sample Size = 211

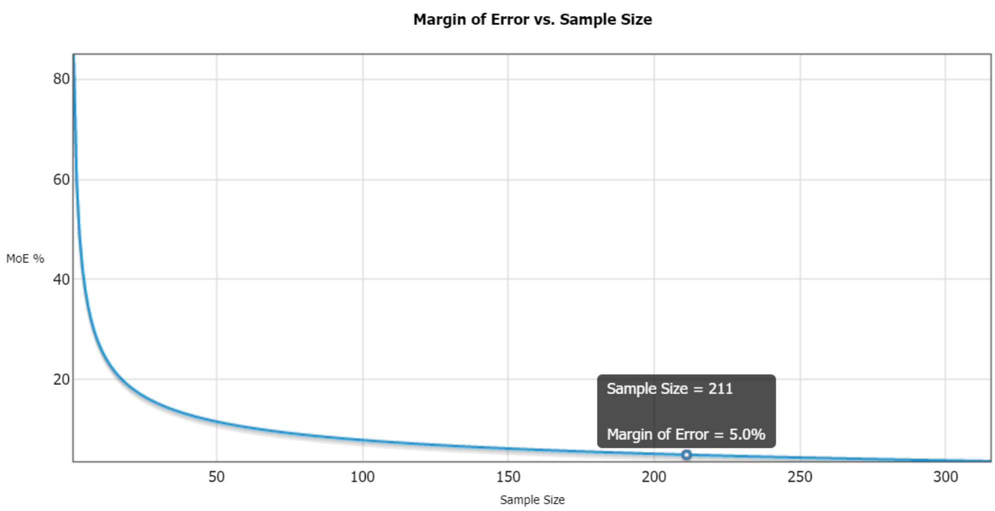


Figure 7-1 Sample Size Calculation

For convenience we have taken sample size as 200

Sample Size Calculation Source: (Select Statistics) (Select Statistics, 2018)

Formula for proportionate stratified sample size determination

Sample size of the strata = size of entire sample / population size * layer size (Andale, 2013)

7.7 APPROACH TO SAMPLING

Data was collected with an interview schedule for RO-1 and questionnaire with 30 questions evoking response on 5 point Likert Scale for RO-2. Schedule and questionnaire was prepared based on research gaps obtained through secondary data as well as study of various software and systems used across the power sector. The schedule was administered to 30 industry experts and the questionnaire was then sent to two hundred and fifty respondents. Some of the questionnaire received was not complete. So, the incomplete ones were removed from data analysis. Finally, we had one hundred and sixty six complete responses - a response rate of 66.4% and acceptable (Malhotra, 2010). 166 respondents are higher than the number needed to do exploratory factor analysis and therefore satisfies that condition.

7.8 ADEQUACY OF SAMPLE SIZE

KMO index and Bartlett's test of sphericity was used for establishing adequacy of sample and to tests the hypothesis whether the correlation matrix is an identity matrix or the variables are uncorrelated.

7.9 ADMINISTER THE INSTRUMENT

The instrument was administered in person. The in person administration of questionnaire was done largely in power sector, smartgrid and industry body organized conferences.

7.10 PROCESS DATA

The data gathered from the survey was processed through coding tool QDA-Miner for RO-1 and SPSS software for Exploratory Factor Analysis (EFA) or simply called Factor Analysis (FA) for RO-2.

7.11 ANALYZE DATA

FA is a statistical data reduction technique to identify the number of factors that are needed to best represent the original dataset of variables. In EFA, all the identified variables are related to every factor by a factor loading estimate. Factor Analysis helps identify the loadings.

7.12 DEVELOP FINDINGS

The outcome of the data analysis sets the stage for interpreting the data. Developing the finding would involve validating the outcome of the analysis phase, with the original objective that was set out for the research. This could take the form of accepting or negating the hypothesis and articulating the inference of the findings. It would finally need to be tied back to the implication of the findings to the theoretical framework that formed the background for the research.

7.13 WRITE-UP CONCLUSIONS

The culmination of the research activity is placing the report in the public domain in the form of a conference proceeding or report or journal article etc. The researcher would need to convince the readers on the robustness of the finding. The report serves one other important function. The research find would become part of the existing knowledge and serve to create a feedback loop to the first stage.

7.14 LIMITATIONS

Excluding all flaws from an interview or enquiry is not possible. Therefore, during this paragraph, the constraints of the Methodology during this analysis are delineated.

At first, as a result of its qualitative analysis, all conclusions will be thought of as indications, however it's unattainable to generalise the conclusions. Further multiple area meant more stakeholders concerned during this analysis that provided totally different perceptions and unknown factors. As a result of limits and focus, these actors or area unit chosen as a result of this included external specialists, initiators of the outcomes and context connected actors. This combined ought to provide a well-integrated combination of things.

Some interviews were done over the telephone; so, it's unattainable to check facial expressions or minor variations in tone of the spoken communication. This is often vital to write the transcripts. To blindly trust a specialist is difficult. Specialists will tell unknown options, however it's still laborious to verify some explanations. At last, the result is a collection of fragments for transcripts rather than the complete transcript, but thanks to the cryptography method we may miss some valuable knowledge. At the opposite hand, it's a decent methodology to structure all knowledge and position it within the cryptography tree that eventually results in the key factors.

7.15 CONCLUDING REMARKS

This section articulates the methods used for research and sequence of steps for qualitative and quantitative research to address research objective 1 and 2 respectively. The qualitative research was conducted using the semi-structured in-depth interview. The literature review, the global experience and the original set of variables identified after doing a thorough literature review served as the inputs for the Interview Protocol. The interview reports were transcribed and they served as the data for qualitative analysis.

The output of the qualitative research also helped narrow down the initial set of variables that became the input for second research question. The variables were the parameters administered on a five point Likert Scale for the respondents.

And finally a “unified Data Framework” process map was developed for addressing the gaps. The Process Map was developed using the tool Microsoft-Visio and Unified Modeling Language which was validated by the experts.

8. CHAPTER VIII - RESEARCH METHODOLOGY

This chapter expands the outline given in the Research Design section and defines the methodologies used for the research objectives.

8.1 RESEARCH METHODOLOGY (RO-1)

To analyze the strengths and weaknesses of existing data silos and their financial and regulatory viability for data unification across generation, transmission, distribution and trading

8.1.1 DESIGN METHODOLOGY AND APPROACH

Qualitative Data Analysis for Objective 1

Exploratory Research Design

- Identified variables from literature survey and analysis of data applications in silos
- Used Grounded Theory Methodology (with conceptual lens by Kathy Charmaz (Charmaz, 1996)
- Prepared the Conceptual Lens
- Prepared the interview schedule for domain experts
- Conducted one-to-one un-structured interview and record response
- Made a list of the different type of information from the notes
- Identified and coded (key points of the data) using QDA-Miner as a tool
- Grouped similar concepts into Categories
- Continued with the loop till data saturation was reached

8.1.2 **GROUNDED THEORY METHODOLOGY**

To conduct the research, a quantitative approach was initially thought of, however I could not find any validated research instrument that was adequate to measure the philosophical assumptions of the available technologies. I decided to start the research using the qualitative research methodology, and was hopeful that the adequacy of the initial study will be useful for my quantitative research for succeeding objective.

I started with a phenomenological research, for having an impact on bracketing our biases and former assumptions to enhance the objectivity of the study. While conducting data analysis using grounded theory methods, the methods for comparing data force the researchers to scrutinize their own biases and assumptions, and that of the research participants (Strauss, 2008) (Qualitative Research).

The research described in this paper adopts the methodology of Strauss. This is due to the fact that the researcher has a general idea where to begin. A structured interview schedule was used in collection of data and its analysis. The process followed in the analysis is, Initial coding and categorization of data followed by Concurrent data generation or collection and analysis. The theoretical sensitivity allows intermediate coding, also called axial coding. The axial coding was identified through networking of the initial codes. This is followed by identifying a core category through networking of the axial codes. This is then followed by generating the theory, through selective coding. The selective codes are also used to generate a structured framework (Ghosh) for implementation of "Unified Data Platform".

"Grounded theory		
	Purpose - theory development	
		• Used in discovering what problems exist in a social

		scene &how persons handle them • Involves formulation, testing, & redevelopment of propositions until a theory is developed
	Method - steps occur simultaneously; a constant comparative process	
		• Data collection - interview, observation, record review, or combination (UMSL, 2012) (UMSL)
	Analysis	
		• Concept formation • Concept development - reduction; selective sampling of literature; selective sampling of subjects; emergence of core concepts • Concept modification & integration (UMSL, 2012) (UMSL)
	Outcomes - theory supported by examples from data”	

Table 8-1 Grounded Theory

My research began with purposive sampling with participants who were experts and technology leaders in power sector. The experts were selected purposefully who were involved with technology, policies and management roles in the power sector. As data and analysis progressed, the process moved towards development of the conceptual categories and the emerging theory (Charmaz, 1996) (Stern, 1994). We can seek out experts who have particular domain expertise for significant concepts to emerge (Morse, 2007), to gather data correlated to conceptual categories and associated properties (Strauss, 2008). While conducting data analysis, the emerging theory required more interviews to develop the abstract concepts. This process continued till theoretical saturation was reached (QualitativeResearch) (Qualitative Research).

8.1.3 DATA COLLECTION

My study used a semi-structured interview protocol suggested by Harrell, M.C. and Bradley, M.A. and a funnel principle where I begin with a wide scope and open ended question, drilling down to focused one to extract information and clarify responses (Qualitative-Research, 2016) (Harrell, 2009).

8.1.4 VALIDITY

To augment the validity and reliability of this qualitative study, a method of triangulation of data was conducted where the semi-structured interviews were followed by a written questionnaire with open-ended questions. Triangulation of data is valuable for qualitative study as using different data source can improve analysis of phenomenon under study and thereby development of better and comprehensive output. This also helps in reducing inherent biases as suggested by Kitto, Chesters and Grbich (Simon C Kitto, 2008) and A. Kuper, L. Lingard and W. Levinson (A. Kuper, 2008) (Qualitative Research) (Qualitative-Research, 2016).

8.1.5 DATA ANALYSIS

Though software cannot formulate concepts on its own, but data analysis tools can support in reducing the manual work of data parsing, and help in organization, management, and searching, and data coding (Strauss, 2008). I used the software program QDA-Miner to import the transcripts, type the memos, code conceptual categories, data dimensions, analysis, and refine the emerging conceptual theory (Qualitative Research) (Qualitative-Research, 2016).

8.1.6 **MEMO WRITING**

For data analysis we have to start writing memos to jot down data collected and to think decisively about the emerging trend, and connect with the concept (Strauss, 2008). By maintaining the memos, I could understand the data trends, prepare queries, and integrate relevant outputs of the literature to support the theoretical significance and extract the emerging patterns and concepts as they are the building blocks that may become theory (Lempert, 2007) (Strauss, 2008) (Qualitative Research) (Qualitative-Research, 2016).

8.1.7 **OPEN AND AXIAL CODING**

In GT methodology, data and analysis work in a circular pattern, with multiple rounds of data collection and analysis (Glaser, 1967). I began coding after the first interview data was collected and continued this process till the end of the study. Two types of coding was used open and axial coding (Strauss, 2008). In open coding, the data is parsed and transcribed line by line, and segments or incidents are categorized to identify concepts. In axial coding data was reintegrated to identify correlations between the emerging concepts and their relevance (Charmaz, 1996) (Strauss, 2008). The process of integrating concepts and categories was there for multiple rounds for refinement of theory, checking logical gaps, the final categories well defined (Qualitative Research) (Qualitative-Research, 2016).

8.1.8 **THEORETICAL SATURATION OF CATEGORIES**

The transition from description to conceptualization denotes the system of integrating into a core category till theoretical saturation of data is reached (Strauss, 2008). The core categories were defined once no new dimension for the property emerged which inturn means the category is inline to technology and is a core category (Glaser, 1967). I linked the concepts around the core category, and the progress was achieved for integration between abstract and interrelated concepts which explained the variations and differences in the data (Strauss, 2008) (Qualitative Research) (Qualitative-Research, 2016).

8.2 RESEARCH METHODOLOGY (RO-2)

To identify the financial and regulatory factors impeding the development and implementation of a “Unified Data Platform”

Research was conducted to identify the structured and unstructured factors that need to be incorporated for a seamless and “Unified Data Platform” for managing information coming from various data sources like economic, social, regulation, policies, market, consumers, competition, organization, application, information system and technical infrastructure to name a few. Empirical Research design and expert survey was conducted in Semi Structured interview form to identify financial and regulatory factors supporting or hindering/ impeding the development of the “Unified Data Platform”. Primary data was collected through semi structured interviews and one-to-one interactions and the Secondary data to be collected through Reports of MoP, GoI, Planning Commission of India, “Central Electricity Authority” (CEA), “Central Electricity Regulatory Commission” (CERC), Scholarly journals, whitepapers etc.

8.2.1 EMPIRICAL RESULTS

In this chapter, when the event of a theoretical framework, the analysed knowledge derived from interviews is employed to induce a solution on the sub queries. This chapter starts with the policy analysis and therefore the vision of lecturers on success and failure at smartgrid implementation. This is often additionally the place to begin with the empirical discussion during this thesis.

- What’s the state of affairs (actor) of policy around unified data implementation?
- Was that actor(s) was/ were enclosed within the upscaling process?
- What are/ were their incentives and what role did they have?
- What factors of governance area unit crucial for achievement in upscaling unified data projects?

- What factors of governance don't seem to be stimulating the upscaling of unified data projects?

After the policy analysis the answer of the primary sub question, the roles and incentives of the vital stakeholders was analysed. This thesis elaborates the key players. This considers the energy provider, the operator (including operators at centralised and distributed grid), government organisations and end users. The generators of technology/ infrastructure are not represented on an individual basis. The selection is formed as results of the information derived from the interviews and therefore the analysis. In further sections, the framework to realize the factors of success and failure as a result of the existence of various subgroup and different levels of upscaling are classified and analysed.

In the end, the process map and framework are going to be proposed for unification of data across the sector.

8.2.2 **DESIGN METHODOLOGY AND APPROACH**

Quantitative Data Analysis for Objective 2

Empirical Research Design

1. Conducted expert survey using Semi Structured Interview to finalize factors
2. Prepared Questionnaire based on the factors with five point Likert Scale. The scale was between strongly agree to strongly disagree
3. Reliability of the questionnaire was tested through pilot study with 25 domain experts
4. The finalized questionnaire after the pilot study was sent to 200 respondents
5. 166 valid response to the questionnaire was received and coded in Microsoft excel and then exported into IBM SPSS Software Tool for analysis

6. Conducted Factor Analysis with five point Likert Scale to modify the qualitative nature of the data for quantitative processing using Excel and SPSS statistical package

8.3 RESEARCH METHODOLOGY (RO-3)

To develop a Process Map for addressing the identified gaps for a "Unified Data Platform" based on identified factors, constraints and tools for power generation, transmission, distribution and trading

8.3.1 WHAT IS A PROCESS MAP

'A process map is a tool used by management for designing plans which can depict the flow of tasks in a visual manner. We can use software to map processes to define a series of tasks or events, interconnects between the tasks and the end result. A process map can be referred by various nomenclatures like "flowchart, process-chart, functional-chart, functional flowchart, process-model, workflow-model, business-flow-diagram or process-flow-diagram" (Lucid Chart, 2017) (Lucid Chart, 2019) (Lucid). "It depicts tasks and methods that are connected within the process and utilized by most organization to define areas in which process can be improved. Process mapping is used by companies to improve their process or task efficiency by extracting insight, management to brainstorm ideas, improve inter and intra department documentation and communication" (Lucid).

As defined by Lucid Charts (Lucid), "in business, a process is a group of interconnected tasks which has well defined outcome and set of events. Process mapping can be used for reengineering, work measurement, business process improvement (BPI), documentation, business process redesign (BPR), training, operational process design, quality improvement, acquisitions, simulation, information technology, analysis, integration, mergers etc of business operations" (Lucid).

8.3.2 UNIFIED MODELING LANGUAGE

A picture is worth a thousand words. Unified Modelling Language (UML) was introduced to provide a common visual language for process mapping which can be easily understood by management as well as team members. UML provides a standard, semantic and syntactic visual modelling language for the defining, designing, and implementing work flows or process flows. It is equivalent to the blueprints that are used in other fields to depict the boundary conditions, the structure of the process and the behaviour of the process or sub-processes within it. International standards for drawing process map provide symbols that are defined in Unified Modeling Language or UML. Using the symbols and UML methodologies a process map helps in identifying the repetition of tasks, bottlenecks and reasons for delays. Process mapping uses the symbols standardized by UML for key elements which are activity steps, people involved, time required, decision points, process measurements, inputs/outputs, functions and actions. Standard symbol that are used are diamond, an arrow, oval, circle, box or rectangle (Lucid).

IBM defines the use of UML as below (Bell, 2003) (Jain, 2017)

"Unified Modeling Language (UML) is a general purpose modeling language. The main aim of UML is to define a standard way to visualize the way a system has been designed. UML is not a programming language; it is rather a visual language. We use UML diagrams to portray the behavior and structure of a system. UML helps engineers, businessmen and system architects with modeling, design and analysis.

1. Complex applications need collaboration and planning from multiple teams and hence require a clear and concise way to communicate amongst them
2. Businessmen do not understand code. So UML becomes essential to communicate with non programmers essential requirements, functionalities and processes of the system
3. A lot of time is saved down the line when teams are able to visualize processes, user interactions and static structure of the system

Diagrams in UML can be broadly classified as:

Structural Diagrams – Capture static aspects or structure of a system

Behavior Diagrams – Capture dynamic aspects or behavior of the system

The image shows the hierarchy of diagrams as per UML 2.2

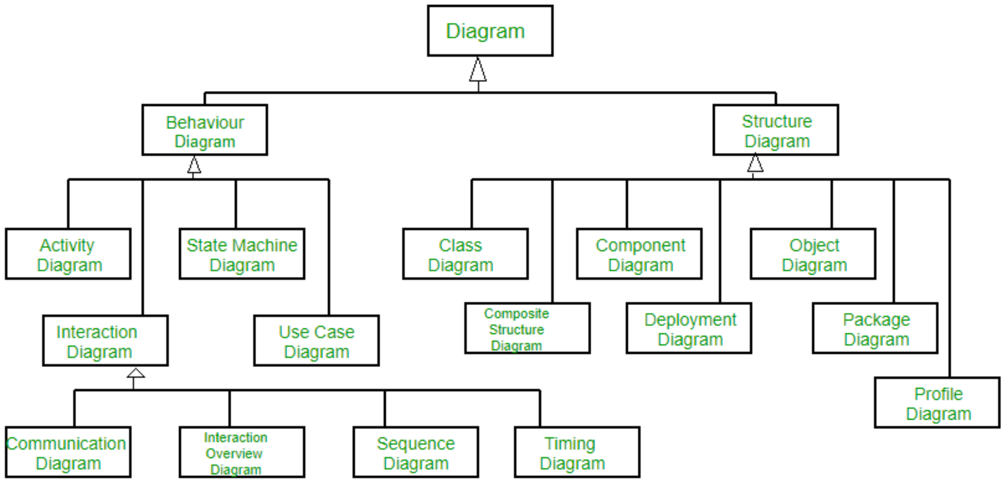


Figure 8-1 Hierarchy of Diagrams as per UML 2.2

Structural UML Diagrams –

Class Diagram – The most widely use UML diagram is the class diagram. It is the building block of all object oriented software systems. We use class diagrams to depict the static structure of a system by showing system's classes,their methods and attributes. Class diagrams also help us identify relationship between different classes or objects.

Composite Structure Diagram – We use composite structure diagrams to represent the internal structure of a class and its interaction points with other parts of the system. A composite structure diagram represents relationship between parts and their configuration which determine how the classifier (class, a component, or a deployment node) behaves. They represent internal structure of a structured classifier making the use of parts, ports, and connectors. We can also model collaborations using composite structure diagrams. They are similar to class diagrams except they represent individual parts in detail as compared to the entire class.

Object Diagram – An Object Diagram can be referred to as a screenshot of the instances in a system and the relationship that exists between them. Since object diagrams depict behaviour when objects have been instantiated, we are able to study the behaviour of the system at a particular instant. An object diagram is similar to a class diagram except it shows the instances of classes in the system. We depict actual classifiers and their relationships making the use of class diagrams. On the other hand, an Object Diagram represents specific instances of classes and relationships between them at a point of time.

Component Diagram – Component diagrams are used to represent the how the physical components in a system have been organized. We use them for modelling implementation details. Component Diagrams depict the structural relationship between software system elements and help us in understanding if functional requirements have been covered by planned development. Component Diagrams become essential to use when we design and build complex systems. Interfaces are used by components of the system to communicate with each other.

Deployment Diagram – Deployment Diagrams are used to represent system hardware and its software.It tells us what hardware components exist and what software components run on them.We illustrate system architecture as distribution of software artifacts over distributed targets. An artifact is the information that is generated by system software. They are primarily used when a software is being used, distributed or deployed over multiple machines with different configurations.

Package Diagram – We use Package Diagrams to depict how packages and their elements have been organized. A package diagram simply shows us the dependencies between different packages and internal composition of packages. Packages help us to organise UML diagrams into meaningful groups and make the diagram easy to understand. They are primarily used to organise class and use case diagrams.

Behavior Diagrams –

State Machine Diagrams – A state diagram is used to represent the condition of the system or part of the system at finite instances of time. It's a behavioral diagram and it represents the behavior using finite state transitions. State diagrams are also referred to as State machines and State-chart Diagrams . These terms are often used interchangeably. So simply, a state diagram is used to model the dynamic behavior of a class in response to time and changing external stimuli.

Activity Diagrams – We use Activity Diagrams to illustrate the flow of control in a system. We can also use an activity diagram to refer to the steps involved in the execution of a use case. We model sequential and concurrent activities using activity diagrams. So, we basically depict workflows visually using an activity diagram.An activity diagram focuses on condition of flow and the sequence in which it happens. We describe or depict what causes a particular event using an activity diagram.

Use Case Diagrams – Use Case Diagrams are used to depict the functionality of a system or a part of a system. They are widely used to illustrate the functional requirements of the system and its interaction with external agents(actors). A use case is basically a diagram representing different scenarios where the system can be used. A use case diagram gives us a high level view of what the system or a part of the system does without going into implementation details.

Sequence Diagram – A sequence diagram simply depicts interaction between objects in a sequential order i.e. the order in which these interactions take place.We can also use the terms event diagrams or event scenarios to refer to a sequence diagram. Sequence diagrams describe how and in what order the objects in a system function. These diagrams are widely used by businessmen and software developers to document and understand requirements for new and existing systems.

Communication Diagram – A Communication Diagram(known as Collaboration Diagram in UML 1.x) is used to show sequenced messages exchanged between objects. A communication diagram focuses primarily on objects and their relationships. We can represent similar information using Sequence diagrams, however, communication diagrams represent objects and links in a free form.

Timing Diagram – Timing Diagram are a special form of Sequence diagrams which are used to depict the behavior of objects over a time frame. We use them to show time and duration constraints which govern changes in states and behavior of objects.

Interaction Overview Diagram – An Interaction Overview Diagram models a sequence of actions and helps us simplify complex interactions into simpler occurrences. It is a mixture of activity and sequence diagrams" (Bell, 2003) (Jain, 2017).

8.3.3 UTILITY OF PROCESS MAP

Process mapping highlights and streamlines the areas where work processes can be improved and builds understanding. It allows visual communication of the vital details of a task or work flow instead of providing directions only. They are used to

1. Augment a process understanding
2. Analyze and improve process
3. Demonstrate process steps
4. Develop team communication and engagement
5. Document and plan process steps
6. Create the project flow design
7. Depict sequences and interconnects

Process maps support the team in understanding the vital flow of the process and ask strategic questions that improve the work flow.

8.3.4 TYPES OF PROCESS MAPPING

The common types to map a process include:

1. Activity Map: depicts the non-value and value added activity

2. Work Flow Diagram: depicts only the flow of work and tasks
3. Detailed Map: furnish more details of steps in a process
4. Document Map: the output and of a process are in the form of documents
5. Value-Added Chain Diagram: a disconnected simplified view for quick understanding
6. High-Level Map: depicts at a higher level the process interactions between various stakeholders
7. Rendered Map: depicts the process state at present and/or future to analyse tasks that can have process improvement
8. Cross-functional/Swimlane Map: demarcates and separates the sub-process and their responsibility in the larger process map
9. Value Stream Map: analyzes and improves process for product or service

(Lucid)

8.3.5 **STEPS FOR PROCESS MAPING**

"Step 1: Identify the problem

- What is the process that needs to be visualized?
- Type its title at the top of the document.

Step 2: Brainstorm activities involved

- At this point, sequencing the steps isn't important, but it may help you to remember the steps needed for your process.
- Decide what level of detail to include.
- Determine who does what and when it is done.

Step 3: Figure out boundaries

- Where or when does the process start?
- Where or when does the process stop?

Step 4: Determine and sequence the steps

- It's helpful to have a verb begin the description.
- You can show either the general flow or every detailed action or decision.

Step 5: Draw basic flowchart symbols (Lucid Chart, 2017)

- Ovals show the beginning of a process or the stopping of a process.
- Rectangles show an operation or activity that needs to be done.
- Arrows represent the flow of direction.
- Diamonds show a point where a decision must be made. Arrows coming out of a diamond are usually labeled yes or no. Only one arrow comes out of an activity box. If more than is needed, you should probably use a decision diamond.
- A parallelogram shows inputs or outputs.

Step 6: Finalize the process flowchart

- Review the flowchart with others stakeholders (team member, workers, supervisors, suppliers, customers, etc.) for consensus.

Make sure you've included important chart information like a title and date, which will make it easy to reference.

Helpful questions to ask:

- Is the process being run how it should?
- Will team members follow the charted process?
- Is everyone in agreement with the process map flow?
- Is anything redundant?
- Are any steps missing?

Process maps provide valuable insights into how a businesses or an organization can improve processes. When important information is presented visually, it increases understanding and collaboration for any project" (Lucid Chart, 2017) (Lucid Chart, 2019) (Lucid).

8.3.6 DESIGN METHODOLOGY AND APPROACH

The process and sub-processes of the power sector is a well defined structure for both power and data flow. "Central Electricity Regulatory Commission" under its document File No. L-1/210/2016/CERC dated 15th May 2017

(CERC) (CERC India) has been assigned the function to regulate the Grid Code and Grid Standard of the Electricity Act, 2003 to define the communication system which forms the backbone of the inter-state transmission of electricity and smooth operation of the power system (CERC India). A section of the document with heading “boundary of the communication system” states all stakeholders of the Indian power sector bound for the implementation of the communication system (CERC).

The primary stakeholders are:

1. NLDC
2. RLDCs
3. SLDCs (ISTS interconnection)
4. ISTS sub-stations of transmission licensee
5. ISGS, Central Generating Stations, Solar generation plants/ solar parks and wind generation pooling stations connected to ISTS as required
6. STU
7. Distribution Companies
8. State Generating Stations including renewable generators connected to State network
9. Sub-stations of STU and State Transmission licensees

(CERC) (CERC India)

Though the policy initiates the process of implementation of a physical communication layer for the entire power sector, there are lots of financial, regulatory, hardware, software and data exchange protocol barriers which needs to be addressed for effective usage of data for operational intelligence. The barriers are mapped on the process map which becomes the blueprint for a “Unified Data Platform”.

8.3.7 **BPR METHODOLOGY**

Process mapping is an integrated step for any Business Process Reengineering (BPR) is a well designed properly structured and process based methodology for improving the performance of an organization or system in areas of costing, service, management, efficiency, quality and speed.

8.3.8 CONTEMPORARY BPR METHODOLOGIES

- Hammer and Champy Methodology
- Object-Oriented Business Engineering Methodology (OO-BEM) by Jacobson et al
- Davenport methodology
- Accenture BPR Methodology
- Process Reengineering Life Cycle (PRLC) Methodology
- McKinsey BPR Methodology
- Integrated BPR Methodology by Muthu, Whitman and Cheraghi

“Some comparative of the steps for BPR methodology are given for reference below.

8.3.9 HAMMER AND CHAMPY METHODOLOGY

1. Introduction into business reengineering

2. Identification of business processes

3. Selection of business processes:

4. Understanding the selected business processes

5. Redesign of the selected business processes

6. Implementation of redesigned business processes

8.3.10 DAVENPORT METHODOLOGY

1. Visioning and goal setting

2. Identification of business processes

3. Understand and measure

4. Information technology

5. Process prototype

6. Implementation

8.3.11 PROCESS REENGINEERING LIFE CYCLE (PRLC) METHODOLOGY

For this research we selected one of the more recent methodologies proposed for BPR, the Process Reengineering Life Cycle (PRLC) (SmartSheet) Methodology developed by Guha, et al (Subashish Guha, 2007). The new paradigm of Business Process Improvement seeks to achieve dramatic performance improvement by radically redesigning the organization processes. The PRLC used in this research is a comprehensive, six-stage methodology with guidelines for envisioning a reengineering project, getting started, diagnosing process pathologies, and redesigning, reorganizing, and measuring the newly configured process" (SmartSheet) (UTA Influuent) (Research Gate).

The six sequential stages include:

- Envision new processes
- Initiate change
- Process diagnosis
- Process redesign
- Reconstruction
- Process monitoring (SmartSheet)

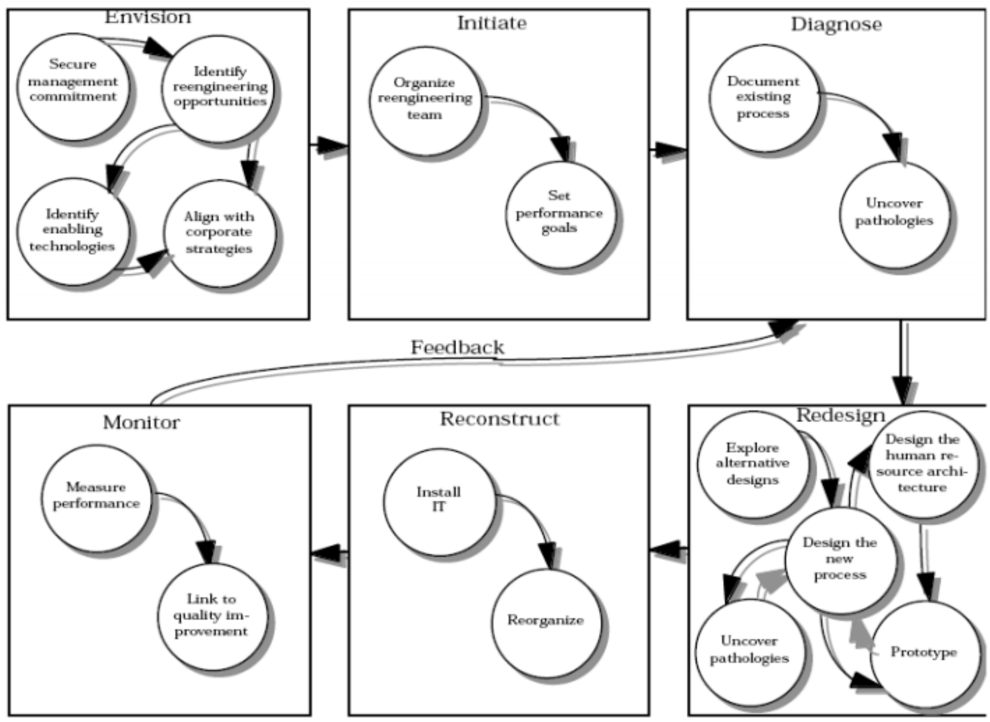


Figure 8-2 Process Reengineering Life Cycle (PRLC) Methodology

The PRLC then advocates for looping back to the beginning to diagnose processes that are again in need of change (SmartSheet).

Development of Process Map was done using the outputs of individual steps and the map was designed using Microsoft Visio Tool and UML.

8.3.12 PROCESS DESIGN STEPS

8.3.13 STEP-1 SETTING OBJECTIVES

The first step of process mapping is setting the vital details or objectives to implement or improve a business process. The objectives should be measurable so that performance indicators to monitor how well the objectives align with the process. The objectives can be both quantitative and qualitative to encompass the expected design and lifecycle of the process.

8.3.14 STEP-2 PROCESS SCOPE

The process scope must define the actors (users, organizations, externalities etc) who will use the process and their usage patterns, along with details of information, security levels, communication protocols and connectivity to external processes.

User: the process owner? the process user? how the process is used? is the process automated or need human interactions?

Information: business information that the process consumes and delivers? the expected output of the process?

Security: controls and security concerns of the process?

Communications and Connectivity: connections to external systems? how to access internal and external information? how to use applications?

8.3.15 STEP-3 PROCESS DIAGRAM

Using Microsoft Visio and United Modelling Language as tools, one can quickly draw out the process diagram; create the starting points, main steps, nodes and branches, decision points, end points and boundary conditions. While designing we need to keep in mind that though most business processes have a single start and end, however it is possible for multiple starts and ends. Parallel activities can use symmetric nodes to map out the parallel processes.

8.3.16 STEP-4 PROCESS DETAILS

This is the main process development level and requires to address several steps and aspects.

Data: Define the inputs and outputs of each system or sub-system. Define data models, source, sink, storage, and data types.

Steps: Define steps for dataflow, data type, descriptive name for each step.

Transitions: Define transitions of data, default path, branches, loops and descriptive labels.

Connectors: Attach connections with the steps, split steps where required. Connectors can be human activity, automated activity or mixed.

Actors: Define the actors, their connectivity, data flow.

Monitoring: Specify the key performance indicators (KPIs) to be monitored and their level in the overall process. KPIs will provide the data to monitor the objectives defined.

Error handling: Plan for exceptions, errors and unexpected behaviour of the system.

Maintainability: The process and the steps should be documented for maintenance and scalability where each element has descriptive labels.

8.3.17 STEP-5 PROCESS APPLICATION DESIGN

At the completion of this step we will have a design which defines interaction of users with each process step.

8.3.18 STEP-6 TESTING

We validate the process map for errors or omissions in the definition and correct the flagged errors. We test the process with and without connectors, test independent actors, connectors and steps. Once the process design is free from local errors we might need to test the process in a real world system with a limited number of users or use cases.

8.3.19 STEP-7 DEPLOYMENT

When testing is complete, the process is ready to be deployed in real world system for entire user base and use cases.

8.3.20 STEP-8 CONTINUOUS IMPROVEMENT

After deployment, the process is monitorored using key performance indicators, to assess and improve to meet the objectives defined.

9. CHAPTER IX - ANALYSIS AND INTERPRETATIONS

9.1 OVERVIEW

This chapter on Data Analysis is the execution of the blue-print outlined in the Research Design and Research Methodology sections. It deals with the data gathering, analysis and interpretation of the data leading to the answering of the research questions and addressing the objective of the research.

The first section of the data analysis focuses on the qualitative aspects that focuses on understanding the data unification challenges in the Indian power sector and output of the analysis helps identify the variables for the factor analysis. The methodology of Grounded Theory was applied for analyzing this objective.

The second section answers the question on the factors that support or hinders / impede the implementation of "Unified Data Platform" in the Indian power sector using Exploratory Factor Analysis and understand their significance.

The third section develops a process map for "unified Data Framework" necessary to unify data from silos to a unified platform for operational intelligence and analysis of power sector in India (Pratik Ghosh, Factors and Constraints for implementing a Unified Data Platform for Operational Intelligence and Analysis of the Power Sector, 2019).

9.2 ANALYSIS & INTERPRETATION OF OBJECTIVE-1

The various systems that exist today were analysed to assess their viability and compatibility to connect with a "Unified Data Platform". Some of the systems in silos discussed with users, vendors and experts are analysed below

Generation	Customer
▪ Plant Control System ▪ Capacity Management System ▪ Energy Synchronization System ▪ Security Management	▪ Meter Management (AMI / AMR) ▪ Customer Management ▪ Customer Energy

Transmission ▪ Transmission RTU ▪ Transmission IED ▪ Phasor Management ▪ Continuity Management Distribution ▪ Distribution RTU or IED ▪ Field Operation System ▪ Geographic Information System ▪ Distributed Information ▪ Sensors and Metering System ▪ Data Collection System Service Provider ▪ Retail Energy Management ▪ Billing Management ▪ Energy Service Provider System ▪ Third Party Interface	Management ▪ Energy Service Interface (HAN) Operations ▪ Transmission Engineering ▪ Distribution Engineering ▪ Network Management System ▪ Outage Management System ▪ Distribution Operator ▪ Energy Storage Management ▪ Load Management System ▪ Transmission SCADA ▪ Distribution SCADA ▪ Energy Management System ▪ Bulk Storage Management ▪ Meter, Billing, Back Office ▪ Customer Information System ▪ Customer Service Interface ▪ Customer Portal and Access

Table 9-1 System Analysis and Interpretation

9.2.1 TEST OF RELIABILITY

We conducted 3 in depth interviews till no new variable emerged. The interviews were transcribed and served as the inputs for interpretation. The final list of variable was discussed with the experts to validate and ensure its adequacy.

The respondents were a mix of domain experts and policy makers from power sector. The instrument was administered to

- State Electricity B Senior Officers/ Director Level
- State Electricity Board Officer
- Generation Companies

- Electricity Regulators
- Distribution Companies
- Financial Institution
- Transmission Companies
- Power exchanges
- Academicians
- Load Despatch Centers
- Software and Application Vendors
- Hardware and Communication Vendors
- Users of the power sector systems
- Industry persons in conferences and meets

9.2.2 CONCEPTUAL LENS

Review of literature has resulted in themes related to data unification across the power sector. Gaps are identified within the themes and data need to be managed in more effective and efficient manner across the power sector. This conceptual lens is directly or indirectly related to data unification which leads us to the fact that the lack of “Unified Data Platform” is leading to delays and inefficient operation management. Coding the data was done on QDA-Miner as a tool as shown below.

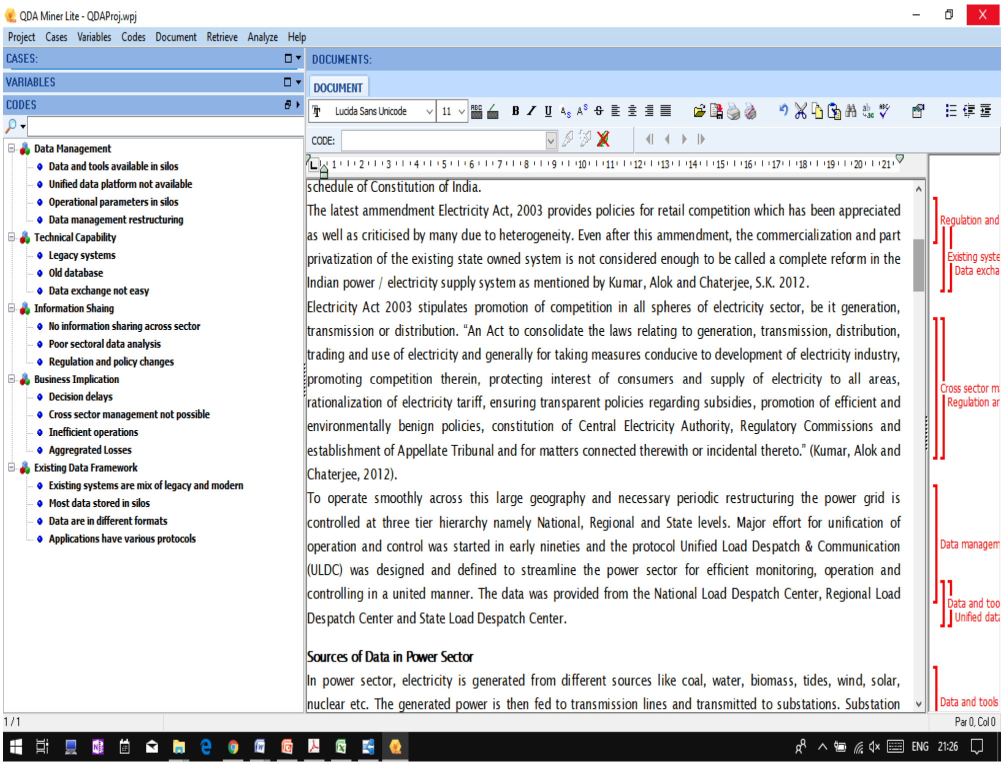


Figure 9-1 Data Coding

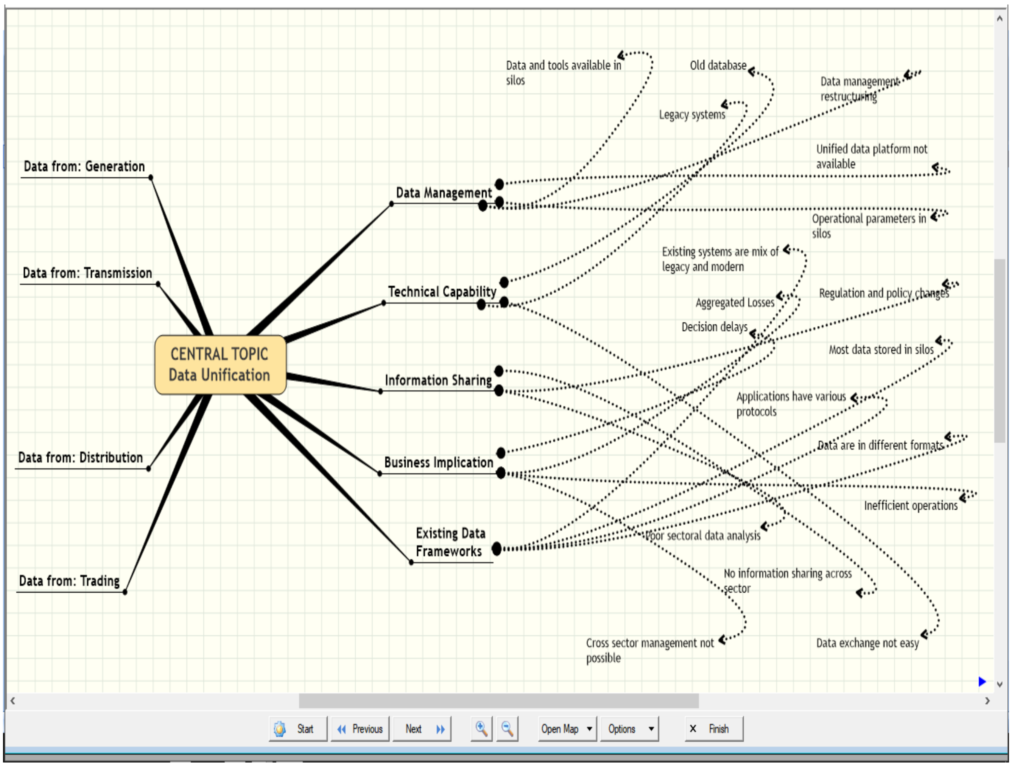


Figure 9-2 Conceptual Lens Schema

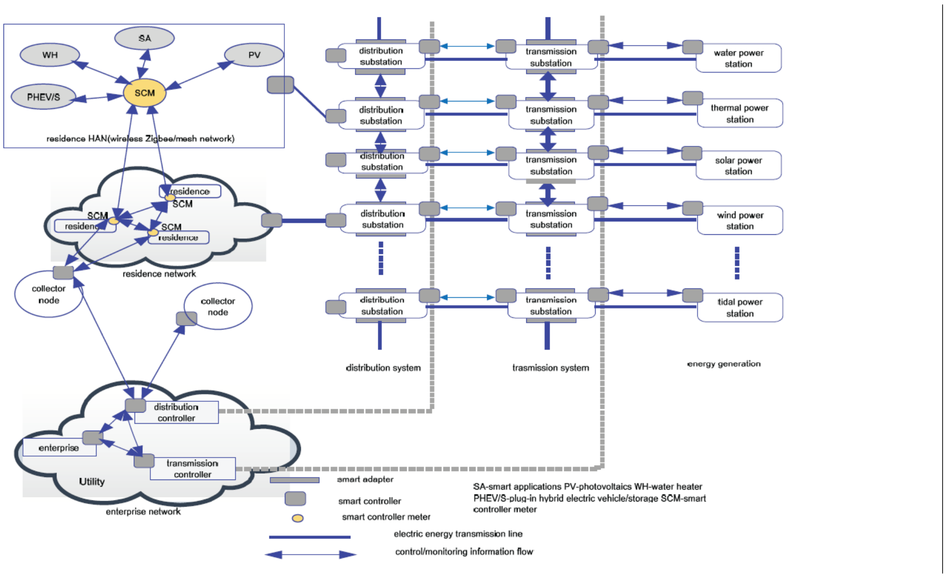


Figure 9-3 Data Flow Schema

9.2.3 ANALYSIS DERIVED FROM THE INITIAL CONCEPTUAL LENS

1. More interconnects are required between internal communication amongst the basic main system and the subsystems to be framed as an abstract Model
2. Bulk generation stations produces and supplies bulk energy into the grid and directly connect to the transmission network and utilizes smart applications
3. Grids transmits current from generation over longer distances and is usually controlled and supervised by a remote grid operator. This network includes the transmission of meter data, equipment and instrument condition data for management applications
4. Distribution network distributes the electrical energy delivered by transmission to users. The distribution network is usually controlled and supervised by a distribution operator remotely
5. The service network offers numerous opportunities for variety of service and packages. New business models will emerge due to smartgrid. The service network has to rely and interconnect with various interfaces of the entire network

6. The operations include the network management centers, energy management systems and distribution management systems (DMS). Enhancing the data usage can be used for planning and commercial functions transmitted to or from the market system or demand response systems
7. Trading platforms manages and distribute time and cost based power to a bigger extent and to participants within the system that don't receive adequate power (AC-UK)

9.2.4 CODING OF DATA

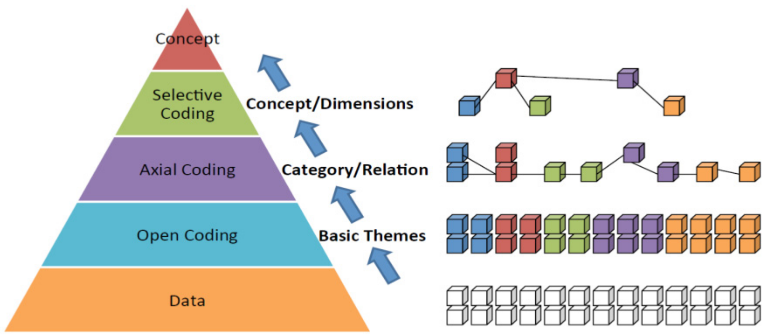


Figure 9-4 Data to Coding to Concept

1. The open coding as the first step on the transcripts of interview schedule conducted with the experts provided 180 codes
2. Axial Coding was done for further refinement to differentiate as well as develop relationships between the codes. This refinement provided us with 45 groups
3. Selective Coding was further done over the axial codes to get 30 final (selective) codes or factors. A deeper study of the axial codes also helped in indicating the selective codes. The final codes are the factors that need to be addressed to implement the "Unified Data Platform" for the power sector

These were mapped with the initial conceptual lens (the themes) to obtain the factors that impede the development of "Unified Data Platform" in the Indian power sector. An in-depth discussion with the industry experts and decision makers was conducted to validate the coding process from identifying open codes to finalize the selective codes. The major factors that have emerged after analysis of data and reiteration of the codification process are listed below.

9.2.5 FACTORS/ DIMENSIONS

S.NO.	Factors	Descriptions
1	Central Regulatory Policies	Policies or guidelines from Central Electricity and Regulatory Commission (CERC)
2	State Regulatory Support	Policies from State Electricity Regulatory Commission (SERC) to provide support
3	Data Interconnection Guidelines	Guidelines for interconnection of data from generation, transmission and distribution
4	Compliance to Hierarchical Structure	ULDC scheme which defines a high level hierarchical organization structure
5	Intra-Device Compatibility Guidelines	Guidelines to check compatibility between all the tools, sensors, hardware and software
6	Citizen Participation for proposing Amendments	Methodology to propose amendments to the Electricity Acts
7	Authority for Central Governing Body	Governing Authority to National Load Dispatch Centre or designated Central Controlling body

8	Inter-System Interface Guidelines	Guidelines to connect systems with central control platform
9	Budgetary Allocations	Investment, budget or capacity expansion policies
10	Incentive for Implementing	Performance based incentives must be offered to implement additional system
11	Transaction Cost Benefit	Transaction costs for generation to supply of electricity produced
12	Quality Benefits	Quality Service Manuals (QA / QC)
13	Performance Benefits	Financial performance indicators
14	End User Benefits	Customer Satisfaction for power usage payment
15	Application Protocols and Interfaces	Protocols to manage interactions between different applications in the network
16	System Asset Management	Asset management guidelines for hardware and software
17	Intra-System Communication Protocols	Protocols or application interface for data communication between System
18	Syntactic Interoperability	Guidelines to maintain syntactic data interoperability like data formats and communication protocols
19	Semantic Interoperability	Guideline to maintain semantic data interoperability to interpret the information exchanged

20	Information Models	Common or Specific Information Models as per requirement of the system
21	Variable Naming Schema	Industry Standard Naming System and mapping matrix of the variables
22	Structured and Un-Structured Data Handling Capability	Guidelines to handle different data types and how to import them in the new system
23	Information Mapping System	Guidelines for mapping of information systems and exchange of data
24	Standardized Protocols	Industry Standard Protocols and Codes that needs to be followed
25	Data Storage and Management	Guidelines for handling, interaction and storage of large operating dataset
26	System Scalability	Guidelines to handle the scalability issues of current system
27	Technical Capability	Technical capability to store and disseminate large data
28	Physical Communication Layers	Physical medium of connectivity for data transfer
29	Hardware Investment Budget Allocation	Investment allocation for deployment of the system
30	Capability to handle Network Externalities	Guidelines and Protocols for existing systems in silos to handle merger into larger data network (Thakur, 2005)

Table 9-2 Factors and Dimensions

9.2.6 VALIDATION

- For validation we used the Triangulation Method
- Validity for a qualitative research refers to the findings of the study whether they are true and certain in the sense that research findings accurately reflect the situation supported by the evidence. The qualitative interview data was analysed by applying the grounded theory method. The interview was supplemented by studies of articles and whitepapers to give further insight for the concept. The method of triangulation was used to check and establish validation of the qualitative research by analyzing the research question from multiple perspectives (Lisa A. Guion, 2012)

9.3 ANALYSIS & INTERPRETATION OF OBJECTIVE-2

We identified that the stakeholders have already deployed systems for operation management of their system. However due to less clarity on regulations and financial budgets for implementation of additional system for data unification at the sector level. Each data silo will have to spend additional on hardware, software and communication system for interoperability and interconnection with “Unified Data Platform”.

Regulations and Policy guidelines needs to be in place for connecting to the larger framework of Unified Data Framework at a sector level.

9.3.1 TEST OF RELIABILITY

Cronbach’s Alpha

The questionnaire was first piloted in person to respondents and then corrected to remove ambiguity. The response of the initial set of 25 respondents was assessed for reliability and validity using SPSS.

Cronbach’s alpha was measured for internal reliability. The Cronbach’s alpha score of 0.855 is more than the threshold of 0.7 and is deemed as an acceptable score. This proves that the instrument meets the reliability requirement for further process.

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.855	.879	30

Cronbach’s Alpha Score based on first 25 respondents

The CBA was repeated for the entire 166 respondent’s data. The new Cronbach’s alpha score of 0.891 is also above minimum acceptable score.

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.891	.892	30

Cronbach’s Alpha Score with all 166 the respondents

KMO and Bartlett’s Test

The Kaiser-Meyer-Olkin (KMO) was performed for each logical grouping or themes to measure the sampling adequacy and Bartlett’s Test of Sphericity tests the hypothesis that the variables form an identity matrix with no co-relation between them.

Extraction

Principal Component Analysis was used for extraction of the variables and to seek a linear combination with maximum variance is extracted.

Rotation

Rotation facilitates interpretation by differentiating the data. Orthogonal and Oblique are the two alternative approach to rotation. Varimax rotation was used in this research.

Communalities

A communality is measure to which an item correlates with all other items. Higher the communality, better the correlation.

The Factor Analysis conducted with Likert-5 point scale was to convert qualitative nature of the data into quantitative processing using Excel and SPSS statistical package. PCA used to condense 30 items, Eigen value Method and scree plot method used to determine factors. The number of extracted factors were four with eigen value greater than 1.

Compo-nent	**Initial Eigen values**			**Extraction Sums of Squared loadings**			**Rotation (Varimax) Sums of Squared Loadings**		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.739	28.764	28.764	3.739	28.764	28764	2.445	18.806	18.806
2	1.575	12.112	40.875	1.575	12.112	40.875	2.149	16.530	35.336
3	1.151	8.852	49.727	1.151	8.852	49.727	1.469	11.299	46.635
4	1.052	8.095	57.822	1.052	8.095	57.822	1.454	11.187	57.822
5	.928	7.139	64.961						
6	.808	6.212	71.174						
7	.767	5.899	77.072						
8	.680	5.229	82.301						
9	.635	4.888	87.189						
10	.515	3.965	91.154						
11	.472	3.635	94.789						
12	.412	3.172	97.961						
13	.265	2.039	100.000						

For better interpretability - Varimax Rotation was done to compute all variables have high loadings only on one factor. High loadings (near 1), low loadings (near 0) and 0.5 indicate intermediate. Here the absolute value of variable changes, however differentials are constant.

After SPSS PCA and Rotation we extracted the similar variables into four distinct factors

- Regulatory Factors
- Financial Factors
- Application Factors
- Hardware & Device Factors

9.3.2 EXPLORATORY FACTOR ANALYSIS – REGULATORY FACTORS

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.832
Bartlett's Test of Sphericity	Approx. Chi-Square	889.895
	df	28
	Sig.	.000

Communalities

	Initial	Extraction
Central_Regulatory_Policies	1.000	.540
State_Regulatory_Support	1.000	.817
Data_Interconnection_Guidelines	1.000	.766
Compliance_to_Hierarchical_Structure	1.000	.669
Intra_Device_Compatibility_Guidelines	1.000	.751
Citizen_Participation_for_proposing_Ammendments	1.000	.778
Authority_for_Central_Governing_Body	1.000	.657
Inter_System_Interface_Guidelines	1.000	.874

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.735	59.183	59.183	4.735	59.183	59.183	4.307	53.838	53.838
2	1.117	13.962	73.145	1.117	13.962	73.145	1.545	19.307	73.145
3	.737	9.218	82.363						
4	.463	5.787	88.150						
5	.365	4.567	92.717						
6	.270	3.378	96.095						
7	.187	2.332	98.427						
8	.126	1.573	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component 1	Component 2
Central_Regulatory_Policies	.592	
State_Regulatory_Support	.871	
Data_Interconnection_Guidelines	.860	
Compliance_to_Hierarchical_Structure	.814	
Intra_Device_Compatibility_Guidelines	.856	
Citizen_Participation_for_proposing_Ammendments	.870	
Authority_for_Central_Governing_Body	.796	
Inter_System_Interface_Guidelines		.879

Extraction Method: Principal Component Analysis.
a. 2 components extracted.

Rotated Component Matrix[a]

	Component 1	Component 2
Central_Regulatory_Policies		.613
State_Regulatory_Support	.901	
Data_Interconnection_Guidelines	.863	
Compliance_to_Hierarchical_Structure	.792	
Intra_Device_Compatibility_Guidelines	.850	
Citizen_Participation_for_proposing_Ammendments	.867	
Authority_for_Central_Governing_Body	.695	
Inter_System_Interface_Guidelines		.935

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]
a. Rotation converged in 3 iterations.

Figure 9-5 Exploratory Factor Analysis – Regulatory Factors

9.3.3 EXPLORATORY FACTOR ANALYSIS – FINANCIAL FACTORS

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.761
Bartlett's Test of Sphericity	Approx. Chi-Square	219.047
	df	15
	Sig.	.000

Communalities

	Initial	Extraction
Budgetary_Allocations	1.000	.861
Incentive_for_Implementing	1.000	.401
Transaction_Cost_Benefit	1.000	.500
Quality_Benefits	1.000	.539
Performance_Benefits	1.000	.745
End_User_Benefits	1.000	.620

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.620	43.662	43.662	2.620	43.662	43.662	2.614	43.572	43.572
2	1.046	17.437	61.099	1.046	17.437	61.099	1.052	17.527	61.099
3	.812	13.531	74.630						
4	.648	10.801	85.431						
5	.551	9.177	94.608						
6	.324	5.392	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component 1	Component 2
Budgetary_Allocations		.927
Incentive_for_Implementing	.606	
Transaction_Cost_Benefit	.656	
Quality_Benefits	.688	
Performance_Benefits	.854	
End_User_Benefits	.785	

Extraction Method: Principal Component Analysis.
a. 2 components extracted.

Rotated Component Matrix[a]

	Component 1	Component 2
Budgetary_Allocations		.928
Incentive_for_Implementing	.594	
Transaction_Cost_Benefit	.640	
Quality_Benefits	.702	
Performance_Benefits	.860	
End_User_Benefits	.787	

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]
a. Rotation converged in 3 iterations.

Figure 9-6 Exploratory Factor Analysis – Financial Factors

9.3.4 EXPLORATORY FACTOR ANALYSIS – APPLICATION FACTORS

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.787
Bartlett's Test of Sphericity	Approx. Chi-Square	466.488
	df	28
	Sig.	.000

Communalities	Initial	Extraction
Application_Protocols_and_Interfaces	1.000	.816
System_Asset_Management	1.000	.497
Intra_System_Communication_Protocols	1.000	.608
Syntactic_Interoperability	1.000	.599
Semantic_Interoperability	1.000	.618
Information_Models	1.000	.358
Variable_Naming_Schema	1.000	.565
Structured_and_Un_Structured_Data_Handling_Capability	1.000	.850
Extraction Method: Principal Component Analysis.		

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.518	43.972	43.972	3.518	43.972	43.972	2.594	32.419	32.419
2	1.393	17.411	61.383	1.393	17.411	61.383	2.317	28.964	61.383
3	.840	10.497	71.880						
4	.655	8.193	80.072						
5	.504	6.305	86.377						
6	.491	6.134	92.511						
7	.410	5.127	97.639						
8	.189	2.361	100.000						
Extraction Method: Principal Component Analysis.									

Component Matrix[a]

	Component 1	Component 2
Application_Protocols_and_Interfaces	.689	-.584
System_Asset_Management	.553	
Intra_System_Communication_Protocols	.651	
Syntactic_Interoperability	.693	
Semantic_Interoperability	.754	
Information_Models	.559	
Variable_Naming_Schema	.673	
Structured_and_Un_Structured_Data_Handling_Capability	.707	-.593
Extraction Method: Principal Component Analysis.		
a. 2 components extracted.		

Rotated Component Matrix[a]

	Component 1	Component 2
Application_Protocols_and_Interfaces		.893
System_Asset_Management	.704	
Intra_System_Communication_Protocols	.772	
Syntactic_Interoperability	.748	
Semantic_Interoperability	.714	
Information_Models	.560	
Variable_Naming_Schema		.696
Structured_and_Un_Structured_Data_Handling_Capability		.911
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.[a]		
a. Rotation converged in 3 iterations.		

Figure 9-7 Exploratory Factor Analysis – Application Factors

9.3.5 EXPLORATORY FACTOR ANALYSIS – HARDWARE AND DEVICE FACTORS

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.866
Bartlett's Test of Sphericity	Approx. Chi-Square	770.772
	df	28
	Sig.	.000

Communalities	Initial	Extraction
Information_Mapping_System	1.000	.689
Standardized_Protocols	1.000	.889
Data_Storage_and_Management	1.000	.444
System_Scalability	1.000	.833
Technical_Capability	1.000	.586
Physical_Communication_Layers	1.000	.750
Hardware_Investment_Budget_Allocation	1.000	.568
Capability_to_handle_Network_Externalities	1.000	.771
Extraction Method: Principal Component Analysis.		

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.343	54.291	54.291	4.343	54.291	54.291	3.389	42.361	42.361
2	1.186	14.829	69.120	1.186	14.829	69.120	2.141	26.759	69.120
3	.791	9.883	79.003						
4	.576	7.204	86.207						
5	.429	5.360	91.566						
6	.327	4.092	95.659						
7	.235	2.934	98.592						
8	.113	1.408	100.000						
Extraction Method: Principal Component Analysis.									

Component Matrix[a]

	Component 1	Component 2
Information_Mapping_System	.712	
Standardized_Protocols	.898	
Data_Storage_and_Management	.528	
System_Scalability	.885	
Technical_Capability		.669
Physical_Communication_Layers	.780	
Hardware_Investment_Budget_Allocation	.705	
Capability_to_handle_Network_Externalities	.849	
Extraction Method: Principal Component Analysis.		
a. 2 components extracted.		

Rotated Component Matrix[a]

	Component 1	Component 2
Information_Mapping_System	.829	
Standardized_Protocols	.907	
Data_Storage_and_Management		.630
System_Scalability	.861	
Technical_Capability		.763
Physical_Communication_Layers		.743
Hardware_Investment_Budget_Allocation		.610
Capability_to_handle_Network_Externalities	.832	
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.[a]		
a. Rotation converged in 3 iterations.		

Figure 9-8 Exploratory Factor Analysis – Hardware and Device Factors

The factors that emerged from the Exploratory Factor Analysis address the first part of the RQ2. The four factors that needs consideration for unification of data on a common platform in the Indian Power Sector below.

9.3.6 FACTORS RELATIONSHIP MAP

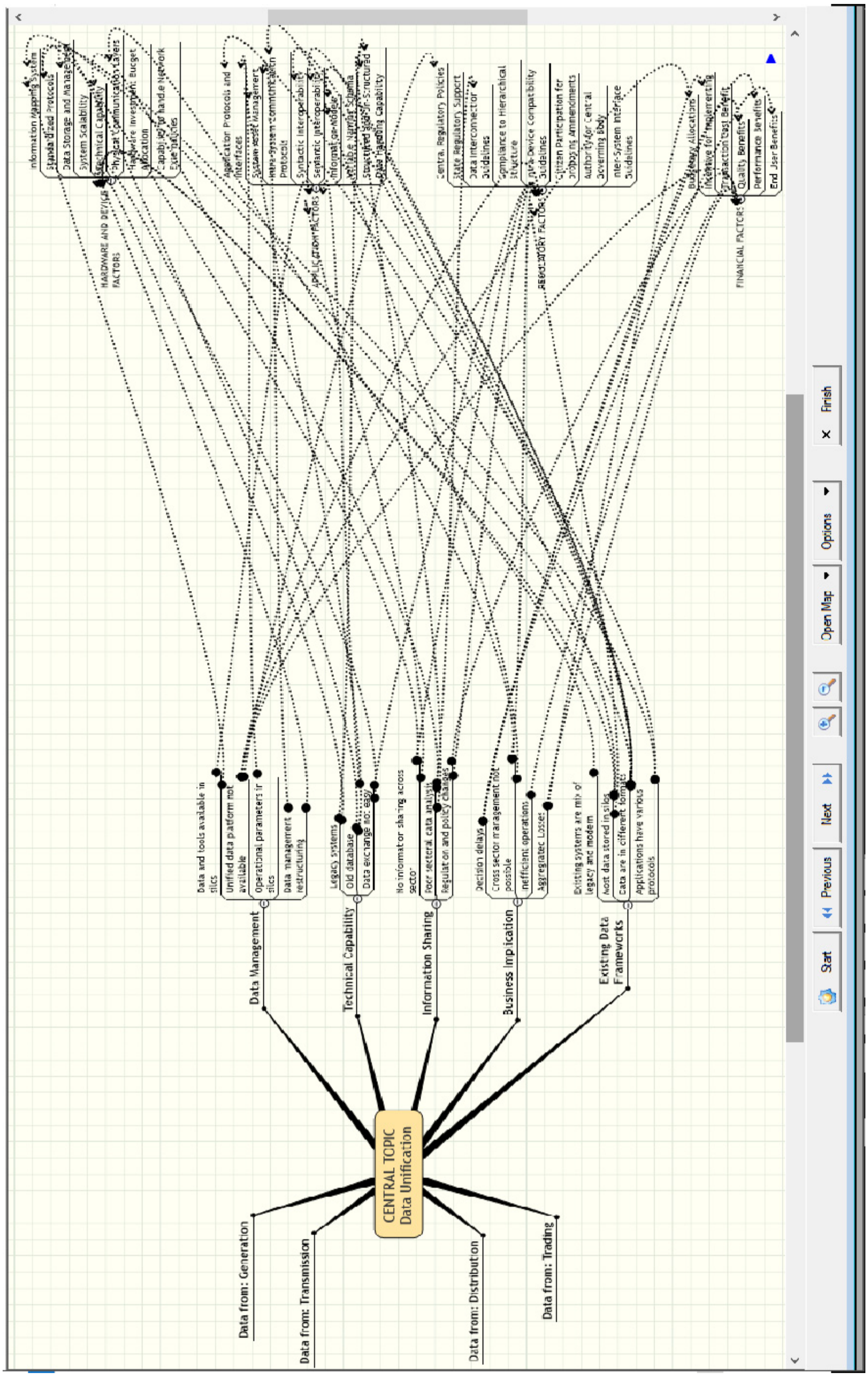


Figure 9-9 Factors Relationship Map

* a larger relationship map is provided as annexure

9.4 ANALYSIS & INTERPRETATION OF OBJECTIVE-3

For a “Unified Data Platform” we have to interface and manage information from various data sources like economic, social, regulation, policies, market, consumers, competition, organization, application, information system and technical infrastructure to name a few that needs to be interfaced to communicate and share data for analysis.

Most organizations have distributed applications and their interactions should be ensured by an inter application protocol. Similarly, the technical interactions need to be ensured by device level protocols. The data from social, economic and policies guidelines have their own roles in interactions which regulate the sector. We must ensure that interactions between the various levels are also achieved independently. Therefore the system should allow the developer to choose standards and levels based on priorities, policies and applicable regulations.

While the ownership of policy and regulation lies with the government, the emergence of new Electricity Acts and their amendments suggest positive approach by Government of India towards data and it’s effective usage.

We identified few of the factors and interfaces that we need to incorporate in the “Unified Data Platform” for increasing operational excellence, competition and reliability of the power sector (Pratik Ghosh, Factors and Constraints for implementing a Unified Data Platform for Operational Intelligence and Analysis of the Power Sector, 2019) as a whole. Some of them are listed below though this is just an limited subset of the actual data that might go into the UDP system.

9.4.1 PRACTICAL IMPLICATIONS

Individual systems available in silos record huge data in layers. Independent data records are available for generation, transmission, distribution and trading sub sector. The data in silos have disadvantages though data management system is available within the sub sector. The diverse systems and network management is difficult as they are not coordinated due to disconnected systems and data management which leads to inconsistencies in records like duplication of information etc. It does not allow the analysis and diagnosis of the diverse activities to evaluate the sector as a whole. These disadvantages are primarily due to separate systems and data management which cannot be unified for management decisions.

9.4.2 FINDINGS

The process map for the Unified Data Framework is the base on which the system can be developed using models. The process map is based upon the real-life scenarios and organisation principles. The data must be designed and defined so that it can be used for classification, abstraction, association and aggregation as a whole or part of the larger structure.

Analysing performance among power plants is difficult, as each power plant works within a unique context of resource, physical plant settings, and organizational goals. Benchmarking provides indicators that allow us to examine individual circumstances and performances within groups of similarly-sized power plants. It must be suitable for storing and performing data analytics for the legacy as well as the future applications.

The diverse systems and network management is difficult as they are not coordinated due to disconnected systems and data management which leads to inconsistencies in records like duplication of information etc. It does not allow the analysis and diagnosis of the diverse activities to evaluate the sector as a whole. These disadvantages are primarily due to separate systems and data management which cannot be unified for management decisions (Ghosh).

9.4.3 THE PROCESS MAP

The process map was based on the theoretical premise that the applications available in silos are based on the real-world power sector network. This made it possible to design a unified platform which supports the individual applications based on the sector specific structure. The baseline analysis did not take into account the functionality of individual applications. The design philosophy was based on guidelines by National Institute of Standards and

Technology, USA (NIST). The basis of overall sector functionality was encompassed and the reference diagram of conceptual smartgrid information sharing network was used as n guidance rather than the underlying sub sector and domains. A process built around the sector structure is more stable than based upon individual functionality. The process map is designed based upon the principles of thought process of the domain knowledge and experts.

9.4.4 **UTILIZATION OF THE PROCESS MAP FOR UDP**

The unified framework integrates the various elements of the power sector and its activities. The process map is the base of the overall systems architecture. It defines the methods of data storage and data usage for different applications available in silos. This integrated system will have different and distributed databases. Therefore, the process map addresses the design of data layers, application layers and protocols for data usage etc.

9.4.5 **CONSTRUCTS OF THE PROCESS MAP FOR UDP**

- The basic structure of the power sector can be represented as a set of nodes and links. The nodes are individual or a group of component of the entire system. A link connects and binds these nodes together for specific relationship.
- Cross-Platform Access to Data and Analytic - To seamlessly migrate from the legacy and existing applications and have cross-platform data and analytical engines to operate as a cohesive analytic environment. This transition should be transparent and the framework should combine the power of multiple analytic engines to address a business scenario.
- Include & distribute fast moving data through the ecosystems - The framework should provide an intelligent, self-reliant solution for inclusion and distribution of legacy and future data.
- Integrated hardware and application layer for speed and scale - For a powerful and ready-to-run enterprise framework the system should be easy to configure and optimize. An integrated hardware and application layer will have additional benefits like ease of manageability and reliability. The

Platform should design keeping the existing infrastructure in mind and leverage current investments in technology and resources.

Source: Teradata

- A “Unified Data Platform” is proposed for the unification of the platforms which will address the activities in the power sector defined by the individual elements and their interconnection.
- The effectiveness and accuracy of the management system should have closeness to the real-world network like the multilevel process map figure below.

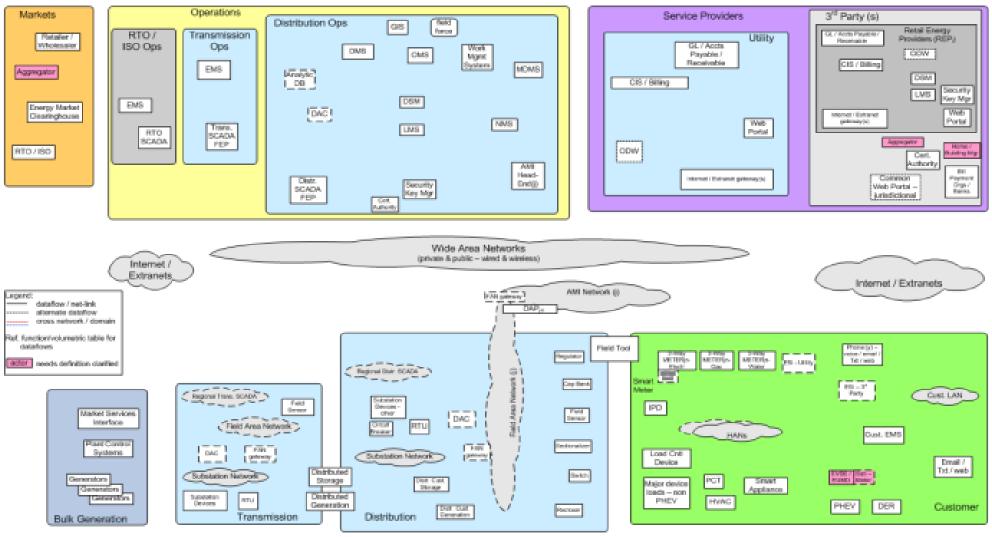


Figure 9-10 Process Map Structure

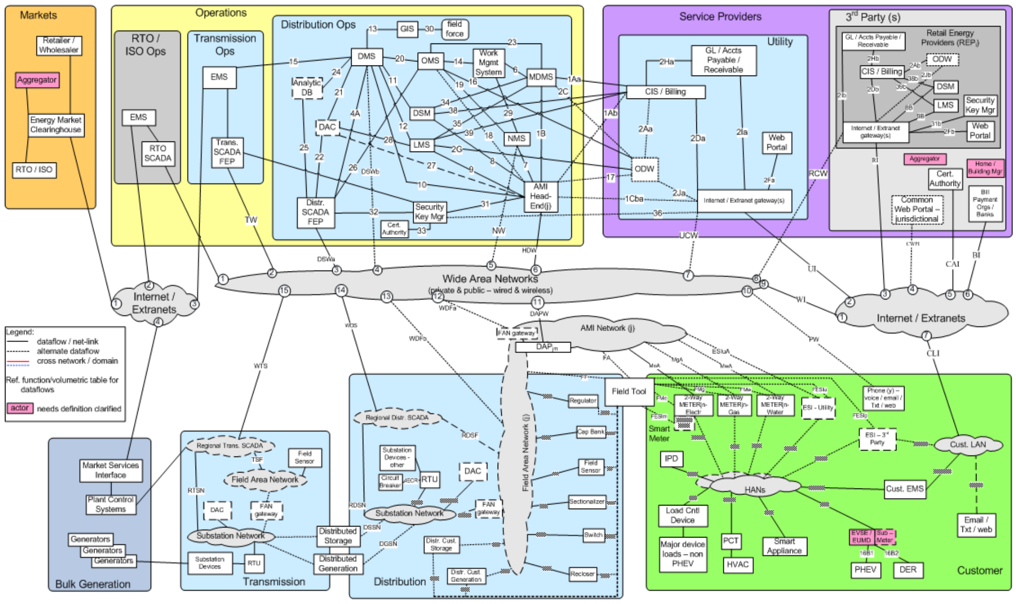


Figure 9-11 Process Map Block

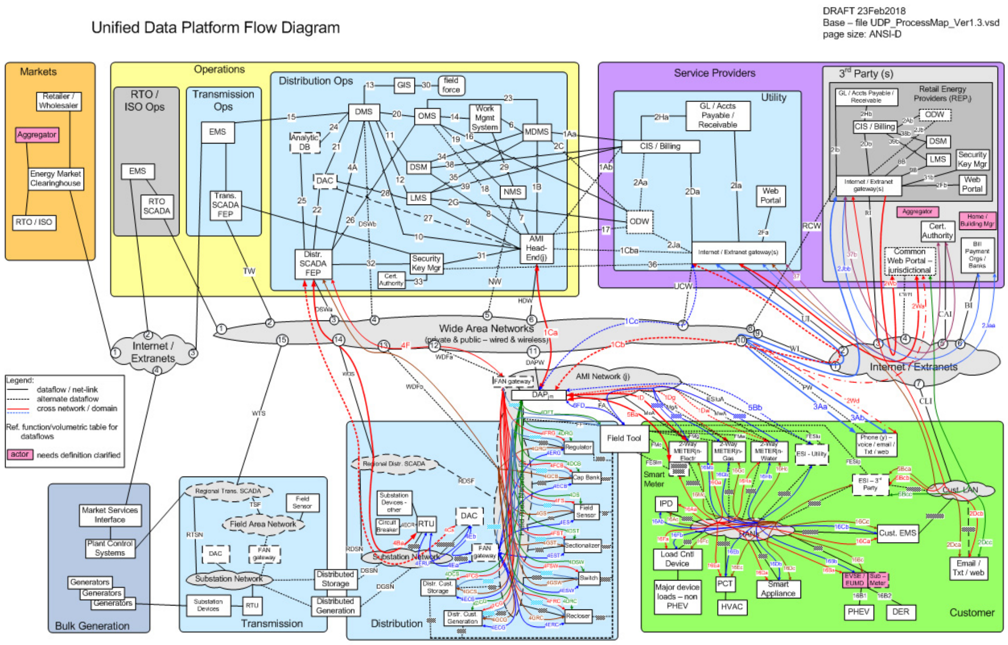


Figure 9-12 Process Map Detailed

The referenced process maps above are as defined by Smartgrid forums and NIST (NIST).

* Larger maps provided in annexure

- “The Platform should be scalable to handle the increasing customer base and numerous technologies which have increased the complexity of the energy management networks.
- A Unified Data Platform should improve the management of the independent applications as well as integrating the numerous technologies and infrastructure available in silos.
- Current system is customized for specific power application management and represents much specialized design and modeling. However, each of these applications in silos is based on the real-world network. It is therefore possible to build a Unified Data Platform which supports all data, protocols and systems to replicate the power domain structure.
- The unified platform should consider the increasing customer base on one side and installation of new and independent technologies which makes the system a large and complex model. In the yester years administrators and designers had an overview of the technical requirement for the design, scalability and management of the models. But today it is much difficult a task to manage the complex systems available even in silos and add to that the problem of the increasing data that needs to be processed.
- The Platform also needs to define interface for various data mining or data analysis methods like Pattern Matching, Classifications, Training and testing sets, Decision trees, Support Vector Machine (SVM), Clustering, Regression Analysis to name a few. The Platform must be defined so that the legacy systems and modern systems can co-exist.
- The Platform should be scalable and flexible to adapt and interface the future protocols and systems. The Platform should broadly classify data into generation data, transmission data, distribution data, consumer data and other relevant data (Urbana World, 2016).
- The Platform should define methodology for data centre to define intelligent data networks from all aspects of the system, be it technical, commercial, operational, maintenance, collection and other stake in order to design the power grid into a smart and robust network.
- The Platform should allow users to define mechanism for filtering and cleaning the raw data to evaluate the data in necessary time buckets. These

datasets will grow to hundreds of gigabytes the Platform needs to be designed with power and flexibility to meet all such requirements.

- The Platform should support numerous processing techniques like batch, stream, iterative processing. We need to design a Unified Data Platform to accumulate the large and distributed data and perform the required analysis" (Urbana World, 2016) (Ghosh).

9.5 INTERFACES REQUIRED FOR UNIFIED DATA PLATFORM

- Organizational Interfaces
- Technical Interfaces
- Financial Interfaces
- Application Interfaces
- Regulatory Interfaces
- Socio-economic and Organizational Interfaces
- Information Interfaces
- Hardware and Device Interfaces

The factors, constraints and interfaces for implementing a Unified Data Platform for Operational Intelligence and Analysis of the Power Sector (Pratik Ghosh, Factors and Constraints for implementing a Unified Data Platform for Operational Intelligence and Analysis of the Power Sector, 2019) was studied and published in author's paper. The details of each individual interface are summarized below.

9.5.1 ORGANIZATIONAL INTERFACES

- Link the large network of generation stations, transmission grids and distribution networks and units scattered across large geographical area
- Control level platform for the operation of the network
- Management of the distributed and areawise control centers

9.5.2 TECHNICAL INTERFACES

- Technical investments and returns
- Assets not widely traded

- Reduction of transaction costs
- High sunk costs
- Network externalities

9.5.3 FINANCIAL INTERFACES

- Financial performance under public ownership
- Financial performance under private ownership
- Price of power generation and supply
- Quantity - spectrum, banking of power
- Investors Entry & Exit policies (for FDIs, Banks etc)
- Investment – capacity expansion
- Access to Resources – mining rights for power (coal)

9.5.4 APPLICATION INTERFACES

- Numerous Application interface from the control room of an utility
- Interaction and storage of operating dataset
- Management of applications like SCADA, Business Process and Energy Management System
- Integration of data from different servers
- Asset management of different hardware configurations
- Software and network management developed by various programmers ranging from legacy to modern software languages on different platforms
- Application Interface for the unified data platform so that different applications communicate in a common methodology, integrated and platform neutral
- Standardize services and applications using information exchange protocols
- Achieve application interoperability
- Manage Service Orientated Architecture and Event Driven Architecture
- Design options to scale and integrate the UDP

9.5.5 REGULATORY INTERFACES

- Comply Central Electricity and Regulatory Commission (CERC) mandate for reporting
- Comply State Electricity and Regulatory Commission (SERC) mandate for reporting
- Provide data from generation stations, transmission grids and distribution network of the power sector
- Comply to the ULDC scheme which defines a high level hierarchical organization structure
- Comply compatibility between all the tools, sensors, hardware and software used

9.5.6 SOCIO-ECONOMIC AND ORGANIZATIONAL INTERFACES

- Quality of services
- The need of a central management and control system
- Erstwhile owned by government but now moving towards joint public private organizations
- Citizen right is important to ensure a minimum supply of power daily

9.5.7 INFORMATION INTERFACES

- Develop information models and protocols
- Defined variable and naming schema for data storage and processing
- Mapping of information exchange between devices and application
- Manage multiple mapping due to different protocols, programs, platforms and systems
- Define standard information model to be followed by vendors
- Represent all the system data like primitive data types, aggregated data types, naming schema and universally identifiable conventions

9.5.8 HARDWARE AND DEVICE INTERFACES

- Identify and map the physical medium of connectivity for data transfer between various devices and networks
- Establish syntactic data interoperability
- Manage hard wired communication networks on standard protocols for data transfer
- Design scalable and modern IP based Intelligent Electronic Device
- Define unique identification for devices and interfaces

9.6 VALIDATION

The process map is designed on the outputs of defined power sector communication flow and the factors identified in this research. The map is not implemented and therefore the method of process walk-through was used to validate the process map defined in this objective.

The steps in walkthrough are

1. The respondents with whom the process map was validated are independent from the experts who gave the data for designing the process
2. The researcher puts together the data collected from experts to design the process map
3. This is an iterative process to run the process map with the experts for accuracy of the flow
4. Checklist protocol is provided to validation group along with inputs, outputs and the process map
5. The final process map is then presented to a different set of experts independent from the original data providers for validating the map as per the design specifications

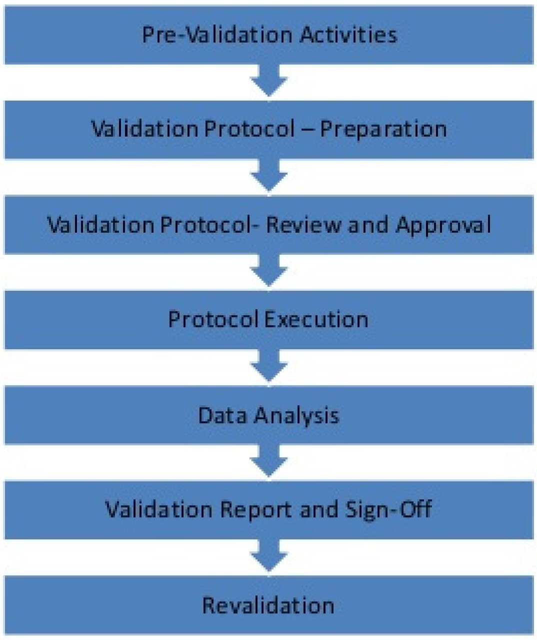


Figure 9-13 Process Map Validation Method

10. CHAPTER X - CONCLUSIONS AND REMARKS

10.1 OVERVIEW

This section reviews the recommendations for implementation of a Unified Data Platform for Operational Intelligence and Analysis of Power Sector in India. The constituents that would enhance the implementation – (i) Regulatory Framework, (ii) Financial Parameters, (iii) Application Interfaces, (iv) Hardware & Device Interfaces. The subsequent section in this chapter highlights the research contribution and opportunities for further research.

10.2 CONCLUSION

The data can be used to extract the dynamic state of the power sector and processed for numerous analysis like fault diagnosis, performance management, optimization systems, load forecasting (Urbana World, 2016). The unified data analysis can lead to economic advantages for each stake holders of the power sector as well as their consumers. For the prediction and forecasting system we can use historical data and conduct a pattern analysis. "The network can be used for the demand side management and plan for future generation based on forecasts. Utilities can save huge revenue by proper data analysis (Urbana World, 2016).

The application range of intelligent output can be numerous if we design the Platform adaptable and flexible for current and future requirement. To achieve this, we not only need to upgrade or modify our existing systems in power sector but also need policy level changes to ease the flow of data across the sector".

The analysis with the in-depth interview with experts in the power sector identified the key challenges in the sector and helped identify the variables that are relevant to the Indian context. After a detailed survey with 166 respondents, the variables are under 4 major factors. The process map has been studied, discussed and verified by power sector experts. Once again the research outcome has been discussed with the four industry experts, who were in agreement with the research outcome.

10.3 CHALLENGES FOR THE TECHNOLOGY PLATFORM

Challenges to develop such a platform to use the legacy and upcoming technology with huge sets of structured and unstructured data at the same level will need to have

1. Scalability
2. High Availability
3. High Security
4. Flexibility and Openness
5. Orchestration

While initial Industrial applications can doubtless specialize in single applications, but eventually corporations and industrial sectors need to orchestrate multiple applications for extracting intelligence side by side to the goal of optimizing their entire operational environments.

It is important that an extremely networked platform to support this kind of data unification be designed with the flexibility to model and outline these workflows and incorporate machine learning to optimize analytic decision-making in real time.

The analysis can access "the hybrid designs needed to deal with the heterogeneous reality of massive information environments and answer the necessity to include each established and new analytic info approaches into a typical architecture. The elemental principle of hybrid architectures is that every constituent massive information platform is fit-for-purpose to the role that it's best suited.

These unified data deployment should include any or all of the following:

1. Data acquisition
2. Collection
3. Transformation
4. Movement
5. Cleansing

6. Staging
7. Sandboxing
8. Modeling
9. Governance
10. Access
11. Delivery
12. Interactive exploration
13. Archiving”

(IBMDataMag, 2013) (IBM DataMag, 2019)

According to data management companies and IBM – “Hybrid is that the way forward for massive information management and the result is that more and more users have started understanding that no single variety of analytical platform is usually best for all necessities. Also, different platforms will churn heterogeneousness and will always produce hybrid architectures requirement with common massive information deployments.

The inexorable trend is toward hybrid environments that address the subsequent enterprise massive information imperatives” (IBM DataMag, 2019) (IBMDataMag, 2013) (IBM Datamag).

“Hybrid architectures spring from the principle that no single information storage, persistence, or structuring approach is perfect for the various roles and workloads. As an example, in spite of well-designed dimensional information model inside most systems, users eventually outgrow these constraints and demand additional versatile support. Alternative information architectures such as columnar, in-memory, key-value, graph, and inverted indexing may be additionally acceptable for such applications, however they are not generic enough to handle alternative broader data ready and management roles” (IBM DataMag, 2019) (IBMDataMag, 2013) (IBM Datamag). Aligned information models with underlying structures and applications along with the hybrid architecture leverage the principle that no massive information modeling approach both physical and logical can do justice to the ever-shifting mixture of queries, loads, and alternative operations (IBM DataMag, 2019) (IBMDataMag, 2013) (IBM Datamag).

The hybrid massive information setting can continue the semi permanent trend aloof from the centralized and hub-and-spoke system topologies toward the new worlds of cloud-oriented and united architectures. These platforms are evolving aloof from one master "schema" and moving towards the virtualization and abstraction of layered data. Underneath this new paradigm, the hybrid massive information setting would require virtualized access to the disparate schemas of the relative, dimensional, and alternative represent package and alternative repositories that represent a logically unified cloud-oriented resource (IBM DataMag, 2019) (IBMDataMag, 2013) (IBM Datamag).

10.4 **IMPEDIMENTS**

Utilities even have an oversized portfolio of existing heritage operational applications and systems that may still perform key functions. As utilities face competition and commit to harness the information to deal with challenges, they'll be tempted to integrate heritage systems as required or quickly deploy new solutions. This approach may appear just like the path of least effort, however following it will result in numerous complications wherever all the new data and knowledge will combine from the different silos, creating it nearly not possible to achieve an end-to-end management of the operations.

Utilities that perceive that this new information doesn't align with existing boundaries and is worthy only when correlated with broad knowledge from all corners of the business and then only will gain new insights, better visibility, control and management over basic operations, process, their client interactions, skill, energy delivery methods and security.

10.5 **OPERATIONAL INTELLIGENCE**

It is one issue to know this conceptually and another to attain it. It needn't be as arduous as it may appear, as there has been no compelling reason to wire, re-factor or merge existing systems till some years back. Operating with utilities, it is normally a trend toward overlaying with a non-invasive analytics layer on the existing network and operational systems to attain the visibility and management insights or extract the operational intelligence (OI).

An OI resolution will consume knowledge and events from a broad array of sources, maintaining and streaming data, perform continuous analytics against that data knowledge, searching for anomalies, patterns and associated trends that may indicate a problem; provide actions and supported rules and policies; and supply strong, business-centric insights through dashboards to key stakeholders.

Utilities don't have an alternative for addressing the approaching deluge of information but will opt for all available means and methods for handling it. Utilities may leverage existing infrastructure by looking for new events, sorting and searching for trends and patterns, checking boundary conditions and valuable data tracked to be acted upon in near real time. Utilities will need to do this by deploying operational intelligence type of solutions to provide visibility, insights and directions to utilize the new knowledge volumes.

10.6 **POTENTIAL BENEFITS**

Based on Capgemini experience and reported in Smart Analytics for the Utility, the potential impact of unified data management in power sector can be as below

Revenue Management:

Improvements of 2% - 4% of annual revenues

Collections Management:

Improvements of 3% - 5% of annual Accounts Receivable

Customer Management:

Cost improvements of 4% - 8% per campaign

Demand response:

Reduction in peak load by 5%

Energy conservation:

Reduction in technical losses by 15%

Energy conservation:

Reduction of non-technical losses by 50%

Outage Management:

First call resolution Improved by 50%

* Based on Capgemini experience

Report Smart Analytics for the Utility Sector, 2012

10.7 PROPOSAL CONCLUSION

Utilities will leverage solutions like OI and Data Unification Platforms to look at this information from a micro and macro level. At a micro level, utilities are going to be ready to analyze usage patterns at the meter level and supply this usage info back to consumers with the intent of achieving demand-side energy reduction. At a macro level, utilities are going to be ready to analyze the energy usage patterns of neighborhoods, villages, cities and districts to facilitate infrastructure capability designing and cargo demand for their service territories.

Utilities can also offer the data they garner from their smartgrid infrastructures back to clients to boost the customer expertise. For example, by group action advanced metering and outage management systems, utilities are going to be ready to address proactively a lot of outages that occur among their territories and supply a lot of correct outage info to customers. Leverage the information at their disposal, utilities are going to be ready to address basic client considerations by providing interactive outage maps to customers through net and mobile platforms. Implied within the eventualities they get to embody key client processes and interaction points into the analysis and action. Several of those core processes lack end-to-end visibility and management, resulting in high rates of exceptions, poor efficiencies and negative impact on the client experience. This is often very true once processes span various systems and interface with partners. Augment these requirements with more disconnect-reconnect processes with usage information originating on the grid level, and the challenge becomes bigger. There is a necessity to be ready with a layer of OI tools on top of available processes and systems to trace key transactions which will produce the mandatory visibility, insight and action to rectify problems and improve efficiency before they impact customers.

10.8 IMPACTS / BENEFITS OF THIS RESEARCH

1. Streamline data management processes saving time and resources
2. Avoid duplicative efforts by operators and planning agencies
3. Best practices in data collection and management
4. Centralize burden of data storage & management
5. Leverage research expertise in data mining and analysis
6. Educate students – creating talent to manage Big Data
7. Improve connection between practitioners, researchers and students

10.9 CONTRIBUTION TO LITERATURE

The present research contributes by way of presenting financial and regulatory factors to address the non implementation of a Unified Data Platform for the power sector in India. Our study is on the information layer of power sector stakeholder for unification of data originating from the data source in silos.

This research would provide a theoretical construct of how effectiveness of alternatives available should be explored and understood, before policy decision. The research also at the same time seeks to contribute to management practices. It is expected to enhance knowledge in emerging field of data unification or communication in the smart grid network in development of power sector.

The third research objective is to design a process map in a structured, process-driven approach to improving the data exchange for operational intelligence and analysis of power sector in areas such as cost, service, quality, efficiency and speed etc. This radical change starts at the highest level of organization, and works down to the minutest details to overhaul the system. This complete redesign distinguishes BPR from other methodologies where incremental improvements are made through regular process improvements (SmartSheet) (Pratik Ghosh, Factors and Constraints for implementing a Unified Data Platform for Operational Intelligence and Analysis of the Power Sector, 2019).

The term "reengineering" suggests that something has already been developed and is being re-developed. In most businesses, change to a pre-existing process happens relatively slowly and incrementally. Within the context of BPR however, the most modern tools are put to use in a way that uses them from the ground up. The fundamentals of already existing processes, ideas, and designs are rethought (SmartSheet) (Pratik Ghosh, Factors and Constraints for implementing a Unified Data Platform for Operational Intelligence and Analysis of the Power Sector, 2019) (SmartSheet).

A more systematic approach for Business Process Reengineering has been suggested by Davenport and Short. According to them "reengineering is a mix of the radical change approach and continuous process improvement discipline. According to them business process reengineering is the analysis and design of workflows and processes within and between organizations". They recommend a structured and controlled approach to reengineering, which involves "the selection of the most critical and important processes of the organisation, the analysis of their current performance and their redesign" (UOA). Additionally, a number of articles from whitepapers, magazines, as well as books on BPR, or related concepts, have been used to support this work. A major support has come from the book Business Process Improvement, by Thomas H "Tom" Davenport (Davenport).

The research was conducted to study the applicability of the software applications and information technology tools for modern work process which led to keywords like

- Business Reengineering
- Business Process Redesign
- Business Process Improvement
- Business Process Reengineering

(Gong, 2013) (Research Gate)

The research contributes towards the Business Process Improvement ("BPI") very popularly elaborated by Thomas H. Davenport (Davenport).

10.10 LIMITATION OF RESEARCH

Power sector is a complex network and addressing the directly and indirectly related factors and parameters will be a huge and time consuming task. The study had to be conducted with boundaries and limitations.

1. The study was limited to India
2. The model might not be possible to be extrapolated to other geographies or nations

10.11 FUTURE SCOPE OF STUDY AND RESEARCH

This research can be a building block which along with other industrial standards and research outcomes can be the guiding framework for a Unified Data Framework across the power sector.

1. The scholars can study the impact on independent data silos
2. The scholars can research on adaptability of the each systems in silo to the Unified Data Platform
3. Scholars can also study the role of individual regulatory and financial factors identified from this research for Regulatory Policy or to conduct a Financial Analysis
4. The scholars can check the applicability on smartgrid

11. CHAPTER XI - ANNEXURES

11.1 INTERVIEW SCHEDULE (RO-1 QUALITATIVE)

The Interview Schedule has been based on the initial conceptual lens and has been validated through expert opinions. The schedule is given below.

1. How much experience do you have in the field of power sector?
2. How much will implementation of a unified data platform improve the operational intelligence across the power sector in India?
3. What changes are suggested in the current system network for improving the sharing of information across the power sector in India?
4. What are the technical capabilities of current system to share internal and external information?
5. What financial supports are required for system upgradation and from whom?
6. What regulatory supports are required for system upgradation and from whom?
7. What operational benefits can be achieved by sharing data across the power sector in India?

Annexure 1 INTERVIEW SCHEDULE (RO-1 QUALITATIVE)

11.2 QUESTIONNAIRE (RO-2 QUANTITATIVE)

Thanks for taking time to answer this research for a Unified Data Platform across Indian Power Sector. Thanks for your support.

You represent

- Senior Officers/ Director Level
- State Electricity Board Officer
- Electricity Regulators
- Financial Institution
- Generation Companies
- Transmission Companies
- Distribution Companies
- Load Despatch Centers
- Power exchanges

Regulatory Interfaces

1. We have policies or guidelines from Central Electricity and Regulatory Commission (CERC) for unified data management
   ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree
2. State Electricity Regulatory Commission (SERC) provided adequate regulatory support for data unification regulations
   ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree
3. We have policies or guidelines to interconnect data from generation, transmission and distribution of the power network
   ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree
4. Our current system comply to the ULDC scheme which defines a high level hierarchical organization structure
   ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree
5. We have policies and guidelines on how to comply for compatibility between all the tools, sensors, hardware and software used
   ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree
6. Adequate measures have been initiated in the proposed amendments to the Electricity Act, 2003 for encouraging data unification

( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree

7. National Load Dispatch Centre or designated Central Controlling body must be made independent in decisions pertaining to monitoring and controlling the power sector

   ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree
8. Current management of the distributed and areawise control centers will need to merge with central control platform

   ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree

Financial Interfaces

9. Investment, budget or capacity expansion policies is in place for data unification

   ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree
10. Performance based incentives must be offered to incur cost for implementing additional data system

    ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree
11. Data unification will reduce the transaction costs across the sector

    ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree
12. Unification of data across sector will improve the quality of services

    ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree
13. Unification of data will improve the financial performance of the sector

    ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree
14. Unification of data will reduce the price of power by optimizing generation and supply

    ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree

Application Interfaces

15. Protocols are available to manage interactions between different applications in the network developed by various companies ranging from legacy programs to modern software languages on different platforms

    ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree
16. We have system for interaction and storage of large operating dataset coming from different system and servers

( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree

17. Protocols are available for asset management of different hardware and software configurations

    ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree

18. Protocols or application interface are available for the unified data platform so that different applications communicate in a common methodology and be platform neutral

    ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree

19. We have the system to establish syntactic data interoperability by using specified data formats and communication protocols

    ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree

20. Our current system are capable to manage Application Interoperability, Service Orientated Architecture and Event Driven Architecture to automatically interpret the information exchanged meaningfully and accurately in order to produce useful results as defined by the end users of both systems

    ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree

21. Our current system are designed to scale and integrate with enormous data that will be part of a unified data platform

    ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree

22. Current technology has capability to analyse data across the sector

    ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree

23. We have ready to deploy information models and protocols for data unification

    ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree

24. We have ready to deploy variable and naming schema for data storage and processing across sector

    ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree

25. We have the system for mapping of information exchange between devices and application and manage multiple mapping due to different protocols, programs, platforms and systems

    ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree

26. We have system ready to enforce standard protocol model to be followed by vendors
    ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree
27. We have the system to represent all the data like primitive data types, aggregated data types, naming schema and universally identifiable conventions
    ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree

Hardware and Device Interfaces

28. We have the system to map the physical medium of connectivity for data transfer between various devices and networks across the sector
    ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree
29. R&D investments to localize production of expensive equipment, to bring the overall costs down, will be crucial to implement the unified data platform
    ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree
30. The current systems available in silos are ready for the network externalities
    ( ) Strongly Agree ( ) Agree ( ) Neutral ( ) Disagree ( ) Strongly Disagree

Annexure 2 QUESTIONNAIRE (RO-2 QUANTITATIVE)

11.3 QUESTIONNAIRE RESPONSE BY USER

	RESPONSE -->		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Q.NO.	QUESTIONS		1	2	3	4	5
	Regulatory Interfaces						
1	We have policies or guidelines from Central Electricity and Regulatory Commission (CERC) for unified data management			1			
2	State Electricity Regulatory Commission (SERC) provided adequate regulatory support for data unification regulations						1
3	We have policies or guidelines to interconnect data from generation, transmission and distribution of the power network						1
4	Our current system comply to the ULDC scheme which defines a high level hierarchical organization structure					1	
5	We have policies and guidelines on how to comply for compatibility between all the tools, sensors, hardware and software used					1	
6	Adequate measures have been initiated in the proposed amendments to the Electricity Act, 2003 for encouraging data unification			1			
7	National Load Dispatch Centre or designated Central Controlling body must be made independent in decisions pertaining to monitoring and controlling the power sector		1				
8	Current management of the distributed and areawise control centers will neet to merge with central control platform		1				
	Economic / Financial Parameters						
9	Investment, budget or capacity expansion policies is in place for data unification						1
10	Performance based incentives must be offered to incurr cost for implementing addtional data system		1				
11	Data unification will reduce the transaction costs across the sector		1				
12	Unification of data across sector will improve the quality of services		1				
13	Unification of data will improve the financial performance of the sector		1				
14	Unification of data will reduce the price of power by optimizing generation and supply		1				
	Application Interfaces						
15	Protocols are available to manage interactions between different applications in the network developed by various companies ranging from legacy programs to modern software languages on different platforms				1		
16	We have system for interaction and storage of large operating dataset coming from different system and servers					1	
17	Protocols are available for asset management of different hardware and software configurations					1	
18	Protocols or application interface are available for the unified data platform so that different applications communicate in a common methodology and be platform neutral				1		
19	Our current system are capable to manage Application Interoperability, Service Orientated Architecture and Event Driven Architecture						1
20	Our current system are designed to scale and integrate with enormous data that will be part of a unified data platform						1
21	Current technology has capability to analyse data across the sector		1				
22	We have ready to deploy information models and protocols for data unification				1		
23	We have ready to deploy variable and naming schema for data storage and processing across sector					1	
24	We have the system for mapping of information exchange between devices and application and manage multiple mapping due to different protocols, programs, platforms and systems				1		
25	We have system ready to enforce standard protocol model to be followed by vendors				1		
26	We have the system to represent all the data like primitive data types, aggregated data types, naming schema and universally identifyable conventions						1
	Hardware and Device Interfaces						
27	We have the system to map the physical medium of connectivity for data transfer between various devices and networks across the sector				1		
28	We have the system to establish syntactic data interoperability						1
29	R&D investments to localize production of expensive equipment, to bring the overall costs down, will be crucial to implement the unified data platform		1				
30	The current systems available in silos are ready for the network externalities						1

Annexure 3 QUESTIONAIRE RESPONSE

11.4 ATTRIBUTES OF THE DATASET

S.NO.	Attribute/ Variable	Descriptions
1	Central Regulatory Policies	Policies or guidelines from Central Electricity and Regulatory Commission (CERC)
2	State Regulatory Support	Policies from State Electricity Regulatory Commission (SERC) to provide support
3	Data Interconnection Guidelines	Guidelines for interconnection of data from generation, transmission and distribution
4	Compliance to Hierarchical Structure	ULDC scheme which defines a high level hierarchical organization structure
5	Intra-Device Compatibility Guidelines	Guidelines to check compatibility between all the tools, sensors, hardware and software
6	Citizen Participation for proposing Amendments	Methodology to propose amendments to the Electricity Acts
7	Authority for Central Governing Body	Governing Authority to National Load Dispatch Centre or designated Central Controlling body
8	Inter-System Interface Guidelines	Guidelines to connect systems with central control platform
9	Budgetary	Investment, budget or capacity expansion

	Allocations	policies
10	Incentive for Implementing	Performance based incentives must be offered to implement additional system
11	Transaction Cost Benefit	Transaction costs for generation to supply of electricity produced
12	Quality Benefits	Quality Service Manuals (QA / QC)
13	Performance Benefits	Financial performance indicators
14	End User Benefits	Customer Satisfaction for power usage payment
15	Application Protocols and Interfaces	Protocols to manage interactions between different applications in the network
16	System Asset Management	Asset management guidelines for hardware and software
17	Intra-System Communication Protocols	Protocols or application interface for data communication between System
18	Syntactic Interoperability	Guidelines to maintain syntactic data interoperability like data formats and communication protocols
19	Semantic Interoperability	Guideline to maintain semantic data interoperability to interpret the information exchanged
20	Information Models	Common or Specific Information Models as per requirement of the system

21	Variable Naming Schema	Industry Standard Naming System and mapping matrix of the variables
22	Structured and Un-Structured Data Handling Capability	Guidelines to handle different data types and how to import them in the new system
23	Information Mapping System	Guidelines for mapping of information systems and exchange of data
24	Standardized Protocols	Industry Standard Protocols and Codes that needs to be followed
25	Data Storage and Management	Guidelines for handling, interaction and storage of large operating dataset
26	System Scalability	Guidelines to handle the scalability issues of current system
27	Technical Capability	Technical capability to store and disseminate large data
28	Physical Communication Layers	Physical medium of connectivity for data transfer
29	Hardware Investment Budget Allocation	Investment allocation for deployment of the system
30	Capability to handle Network Externalities	Guidelines and Protocols for existing systems in silos to handle merger into larger data network

Annexure 4 WORKING DEFINITIONS OF THE VARIABLES

11.5 DETERMINATION OF SAMPLE SIZE

The size of 200 as stratified sampling is considered for this research work.

	INDIAN POWER SECTOR BREAKUP TAKEN FOR SAMPLE SIZE AND POPULATION													
	Organizations	**Regulatory Commission**	**Generating Companies**	**Transmission Companies**	**Distribution Companies**	**Administrative Bodies**	**Field Organisations**	**Load Dispatch Centres**	**Power Exchanges**	**Financial Institutes**				
	Number of Organizations	**21**	**23**	**26**	**49**	**3**	**7**	**6**	**2**	**10**				
	STRATA	**Population per Strata**									**Total**	**Sample Size of Strata**	**Calculated Sample Size**	**Rounded**
1	Senior Officers/ Director Level	21	23	26	49	3	7	6	2	10	147	200/774*147	37.98	38
2	State Electricity Board Officer	42	46	52	98	6	14	12	4		274	200/774*274	70.8	71
3	Electricity Regulators	63				9			4		76	200/774*76	19.64	20
4	Financial Institution									30	30	200/774*30	7.75	8
5	Generation Companies		69								69	200/774*69	17.83	18
6	Transmission Companies			52							52	200/774*52	13.44	13
7	Distribution Companies				98						98	200/774*98	25.32	25
8	Load Despatch Centers							18			18	200/774*18	4.65	5
9	Power exchanges								10		10	200/774*10	2.58	3
							Population				**774**	**Sample Size**	200	**200**

Figure 11-1 Determination of Sample Size

Annexure 5 DETERMINATION OF SAMPLE SIZE

11.6 BREAK UP OF STRATA AND BASIS

Figure 11-2 Breakup of Strata and Basis

INDIAN POWER SECTOR BREAKUP TAKEN FOR SAMPLE SIZE AND POPULATION

	Organizations >	Regulatory Commission	Generating Companies	Transmission Companies	Distribution Companies	Administrative Bodies	Field Organisations	Load Dispatch Centres	Power Exchanges	Financial Institutes	
	Number of Organizations >	21	23	26	49	3	7	6	2	10	
	STRATA	Population per Strata									Total
1	Senior Officers/ Directors	21	23	26	49	3	7	6	2	10	147
2	State Electricity Board Officer	42	46	52	98	6	14	12	4		274
3	Electricity Regulators	63				9			4		76
4	Financial Institution									30	30
5	Generation Companies		69								69
6	Transmission Companies			52							52
7	Distribution Companies				98						98
8	Load Despatch Centers							18			18
9	Power exchanges								10		10
										Population Size	774

(Indian Power Sector, 2019)

Annexure 6 BREAK UP OF STRATA AND BASIS

11.7 **INDIAN POWER SECTOR AT A GLIMPSE**

“Andra Pradesh				
Govt	Regulatory Commission	Generating Companies	Transmission Companies	Distribution Companies
	APERC	APGenco	APTransco	APEPDCL
				APCPDCL
				APNPDCL
				APSPDCL
Arunachal Pradesh				
Govt	Regulatory Commission	Generating Companies	Transmission Companies	Distribution Companies
	——	Arunachal Pradesh Electricity Department		
Assam				
Govt	Regulatory Commission	Generating Companies	Transmission Companies	Distribution Companies
	AERC	APGCL	AEGCL SLDC	LAEDCL
				UAEDCL
				CAEDCL
Bihar				

Govt	Regulatory Commission	Generating Companies	Transmission Companies	Distribution Companies
	BERC	BSPGC——————-BSPTC——————— NBPDC/SBPDC		
Chhattisgarh				
Govt	Regulatory Commission	Generating Companies	Transmission Companies	Distribution Companies
	CSERC	CSPGCL ————————————-CSPTCL——— ——————————CSPDCL		
Delhi				
Govt	Regulatory Commission	Generating Companies	Transmission Companies	Distribution Companies
	DERC	IPGCL	Delhi Transco Ltd	BRPL/BYPL
			SLDC Delhi	NDPL
Goa				
Govt	Regulatory Commission	Generating Companies	Transmission Companies	Distribution Companies
	Goa JERC	Govt. of Goa Electricity Department		
Gujarat				

Govt	Regulatory Commission	Generating Companies	Transmission Companies	Distribution Companies
	GERC	GSECL	GETCO	MGVCL
				PGVCL
				UGVCL
				DGVCL
Haryana				
Govt	Regulatory Commission	Generating Companies	Transmission Companies	Distribution Companies
	HERC	HPGCL	HVPNL	DHBVNL
				UHBVNL
Himachal Pradesh				
Govt	Regulatory Commission	Generating Companies	Transmission Companies	Distribution Companies
	HPERC	Himachal Pradesh State Electricity Board (HPSEB)		
Jammu & Kashmir (Indian Power Sector, 2019)				
Govt	Regulatory Commission	Generating Companies	Transmission Companies	Distribution Companies
	JKSCRA	J&K State Power Development Corporation(JKSPDC)		

<table>
<tr><td colspan="5">Jharkhand</td></tr>
<tr><td>Govt</td><td>Regulatory Commission</td><td>Generating Companies</td><td>Transmission Companies</td><td>Distribution Companies</td></tr>
<tr><td></td><td>JERC</td><td colspan="3">Jharkhand State Electricity Board (JSEB)</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5">Karnataka</td></tr>
<tr><td>Govt</td><td>Regulatory Commission</td><td>Generating Companies</td><td>Transmission Companies</td><td>Distribution Companies</td></tr>
<tr><td rowspan="5"></td><td rowspan="5">KERC</td><td rowspan="5">KPCL</td><td rowspan="5">KPTCL</td><td>BESCOM</td></tr>
<tr><td>MESCOM</td></tr>
<tr><td>HESCOM</td></tr>
<tr><td>GESCOM</td></tr>
<tr><td>CESCOM</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5">Kerala</td></tr>
<tr><td>Govt</td><td>Regulatory Commission</td><td>Generating Companies</td><td>Transmission Companies</td><td>Distribution Companies</td></tr>
<tr><td></td><td>KSERC</td><td colspan="3">Kerala State Electricity Board (KSEB)</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5">Madhya Pradesh</td></tr>
<tr><td>Govt</td><td>Regulatory Commission</td><td>Generating Companies</td><td>Transmission Companies</td><td>Distribution Companies</td></tr>
<tr><td></td><td>MPERC</td><td>MPGCL</td><td>MPTCL</td><td>MPPKVVCL</td></tr>
</table>

			MPSLDC,Jabalpur	MPPKVVC
				MPMKVVC
Maharashtra				
Govt	Regulatory Commission	Generating Companies	Transmission Companies	Distribution Companies
	MERC	MahaGenco	MahaTransco	BSES
			Maharastra SLDC,Kalwa	MahaVitran
				REL
				TPCL
Orissa				
Govt	Regulatory Commission	Generating Companies	Transmission Companies	Distribution Companies
	OERC	OPGC	OPTCL	CESU
		OHPC	GRIDCO	NESCO
			SLDC Orissa	SouthCo
				WESCO
Punjab				
Govt	Regulatory	Generating	Transmission	Distribution

	Commission	Companies	Companies	Companies
	PSERC	PSPCL ———————— PSTCL		
Rajasthan				
Govt	Regulatory Commission	Generating Companies	Transmission Companies	Distribution Companies
	RERC	RVUNL	RVPNL	JAIPUR AJMER JODHPUR
Uttar Pradesh				
Govt	Regulatory Commission	Generating Companies	Transmission Companies	Distribution Companies
	UPERC	UPRVUNLUPJ VNL	UPTCLUPPCL	KESCoNPCLP AVVNL
				PUVVNL
				DVVNL
				MVVNL
Tamil Nadu				
Govt	Regulatory Commission	Generating Companies	Transmission Companies	Distribution Companies
	TNERC	TANGEDCO	TANTRANSCO	TANGEDCO
Uttarakhand				

Govt	Regulatory Commission	Generating Companies	Transmission Companies	Distribution Companies
	UERC	UJVNL	PTCUL	UPCL
West Bengal				
Govt	Regulatory Commission	Generating Companies	Transmission Companies	Distribution Companies
	WBERC	WBPDCL	WBSETCL	WBSEDCL (IndianPowerSector) (Indian Power Sector, 2019)

Load Dispatch Centres
1. National Load Despatch Centre (NLDC)
2. Five Regional Load Despatch Centres
Northern Regional Load Despatch Centre (NRLDC)
Western Regional Load Despatch Centre (WRLDC)
Eastern Regional Load Despatch Centre (ERLDC)
Southern Regional Load Despatch Centre (SRLDC)
North-Eastern Regional Load Despatch Centre (NERLDC)

(Indian Power Sector, 2019)

Administrative Bodies
"Central Electricity Authority" of India
"Central Electricity Regulatory Commission"
Bureau of Energy Efficiency

Power Exchanges

Power Exchange of India Ltd. (PXIL)

Indian Energy Exchange (IEX)

Field Organisations
Nuclear Power Corporation of India
PowerGrid Corporation of India
NHPC Limited
NTPC Limited
Power System Operation Corporation
Neyveli Lignite Corporation
Damodar Valley Corporation

Table 11-1 Indian Power Sector at a Glimpse"

Centralized energy grid	Smart grid
Electromechanical	Digital
One-way communication	Two-way communication
Centralized generation	Distributed generation
Few sensors	Sensors throughout
Manual monitoring	Self-monitoring
Manual restoration	Self-healing
Failures and blackouts	Adaptive and islanding
Limited control	Pervasive control
Few customer choices	Many customer choices

Table 2.1. A brief comparison between the existing grid and the smart grid. Source: Fang et al., 2012.

Figure 11-3 Comparison between Existing and Smartgrid

11.8 PLANS – 12TH, 13TH AND 14TH

"During 12th Plan	During 13th Plan	During 14th Plan
A) Enable Access and Availability of Quality Power for All		
Electrification of all households by 2017 • Reduction in power cuts; 24 hrs availability of power at principal cities, 22 hrs for all towns and Life line supply (8 hrs, including evening peak) to all by 2017	•24 hour supply in all urban areas; Minimum 12 hour supply to all consumers (including evening peak) by 2022	•Stable and quality 24x7 power supply to all categories of consumers across the country (Ministry of Power, 2013)
B) Loss Reduction		
Reduction of AT&C losses in all Distribution Utilities to below 15% • Reduction of transmission losses (66 kV or above) to below 4%	• Reduction of AT&C losses to below 12% in all Distribution Utilities • Reduction of transmission losses (66 kV or above) to below 3.5%; overall EHV and UHV strengthening	• Reduction of AT&C losses to below 10% in all Distribution Utilities • Reduction of transmission losses (66 kV or above) to below 3% (Dudi)
C) Smart Grid Rollouts including Automation, Microgrids and other improvements		
• SG Pilots, full SG roll	• SG roll out in all urban	• SG rollout nationwide

out in pilot project cities • Infrastructure for AMI roll out for all consumers with load >20kW or as per prioritised target areas of Utilities • Enablement of Prosumers in select areas • Development of micro grids in 1,000 villages/industrial parks/commercial hubs •Deployments of WAMS including PMUs by CTU • Gas insulated EHV/HV and automated distribution substations in all metros by 2017 • Grid connection of all consumer end generation facilities where feasible • Development of 5 smart cities	areas • Nationwide AMI roll out for customers with 3-phase connections • Enablement of Prosumers in metros and major urban areas • Development of micro grids in total 10,000 villages/industrial parks/commercial hubs • Extended deployments of WAMS at all substations and grid connected generation units • Gas insulated EHV/HV and automated distribution substations in all state capitals and principal cities by 2022 (Kabi, 2015) • Development of 25 smart cities	• Nationwide AMI roll out for all customers • Active Participation of Prosumers • Development of micro grids in 20,000 villages/industrial parks/commercial hubs • Gas insulated EHV/HV and automated distribution substations in all urban areas by 2027 • Development of 100 smart cities

D) Policies and Tariffs		
• Implementation of Dynamic Tariffs • Mandatory Demand Response programs for select categories of consumers • Tariff mechanism for roof top solar PV's – Net Metering/Feed in Tariffs	• Choice of electricity supplier (open access) to consumers in metros and select urban areas • Mandatory Demand Response programs for larger sections of consumers	• Choice of electricity supplier (open access) to all consumers
E) Green Power and Energy Efficiency		
• Renewable integration of 30 GW • Energy Efficiency Programs for lighting and HVAC in Metros and state capitals; initiation of Dynamic (smart) Energy Efficiency Programs • Policies for mandatory roof top PV and Energy efficient building code for all new large	• Renewable integration of 80 GW • Energy Efficiency Programs for lighting and HVAC in all urban areas; expansion of Dynamic (smart) Energy Efficiency Programs to all urban areas	• Renewable integration of 130 GW • Dynamic (smart) Energy Efficiency Programs nationwide

public infrastructures by 2014 • Setting up of Renewable Energy Monitoring Centre's (REMC) at 5 RLDCs for better forecasting, scheduling and dispatching of renewable generation (in coordination with MNRE)		
F) Electric Vehicles and Energy Storage		
• Development of EV and smart grid synergy plan (in coordination with National Electric Mobility Mission) • EV charging stations in urban areas and along selected highways • Introduction of Battery Parks and other Energy Storage Systems on a trial basis	• Large roll outs of Energy Storage Systems • EV charging stations in all urban areas and strategic locations on highways	• EV charging stations in all urban areas and along all state and national highways”

G) Enablers and Other Initiatives		
• First set of technical standards after completion of pilots • Finalization of frameworks for cyber security assessment, audit and certification of power utilities by 2013 • Standards for EVs and their charging infrastructure • Cost-Benefit Analysis of smart grid projects with inputs from the pilots and assessment of direct/indirect impacts on all societal stakeholders • Development/adoption of appropriate performance standards for smart grid development in India by 2014 ·• Development of indigenous low cost smart meter by	• Standards Development for Smart Infrastructure (SEZ, Buildings, Roads/Bridges, Parking lots, Malls) • Strengthening of Research & Development as well as Training and Capacity Building. 25% of Utility technical personnel to be trained in smart grid solutions • Export of SG products, solutions and services • Development of business models to create alternate revenue streams by leveraging the smart grid infrastructure to offer other services (security solutions, water metering, traffic solutions etc) to	• Continuous Research & Development; Training & Capacity Building

2014 • Augmentation of Control Centre's and Data Centre's for deployment of smart grids • Strengthening of EHV/Distribution Systems • Strengthening of optical fiber communication systems along and for transmission lines and substations • 1200 kV UHV AC testing and simulation studies • Initiation of Customer Outreach and Engagement Programs • Research & Development, Training & Capacity Building - 10% of Utility technical personnel to be trained in smart grid solutions • Planning for smart grid	municipalities, state governments and other agencies; integration of meter data with other databases etc. (Dudi)	

synergies with other activities such as multi-utility meter, automation, security, and monitoring services, traffic Management, etc. • Establishment of Smart Grid Test bed by 2014 and Smart Grid Knowledge Centre by 2015”		

Table 11-2 12th, 13th and 14th Five Year Plans”

(Ministry of Power, 2013) (Dudi) (Kabi, 2015) (Asialeds, 2018)

CEA Annual Report 2017-18 (CEA, 2018)

11.9 **BENEFITS OF SMARTGRIDS**

"Area	Utility	Consumer	Society
Improved Reliability	Reduced operational cost Increased employee safety Increased revenue Higher customer satisfaction Reduced capital cost	Improved level of service with fewer inconveniences Reduced out-of-pocket costs resulting from loss of power	Reduction in cost ultimately help keeping the prices of goods and services lower than they would be otherwise Virtual elimination of blackouts Improved infrastructure boosts economic development
Improved Economics	opportunities to leverage its resources and enter new markets Increased revenues as theft of service is reduced Improved cash flow from more efficient management of billing and revenue management processes A flatter load profile will reduce operating and maintenance (O&M) costs	Downward pressure on energy prices and total customer bills Increased capability, opportunity, and motivation to reduce consumption Opportunity to interact with the electricity markets through home area network and smart meter connectivity Opportunity to reduce transportation costs by using electric vehicles in lieu of conventional vehicles Opportunity to sell consumerproduced	A more robust transmission grid will accommodate larger increases in wind and solar generation i.e. green energy. Downward pressure on prices — through improved operating and market efficiencies Creation of new electricity markets — enabling society to offer its electricity

		electricity back to the grid	resources to the market and creating the opportunity to earn a revenue stream on such investments as demand response, distributed generation, and storage
Improved Efficiency	Increase asset utilization Reduction in lines losses on both transmission and distribution Reduction in transmission congestion costs Reductions in peak load and energy consumption leading to deferral of future capital investments Increased asset data and intelligence enabling advanced control and improved operator understanding Extended life of system assets through	Increased capability, opportunity, and motivation to be more efficient on the consumption end of the value chain Increased influence on the electricity market	Deferral of capital investments as future peak loads are reduced and more accurately forecasted through the combined efforts of consumers and delivery companies Reduced consumption of KWh's through conservation, demand response, and reduced transmission and distribution (T&D) losses

	improved asset health management Improved employee productivity through the use of smart grid information that improves O&M processes Improved load forecasting enabling more accurate predictions on when new capital investments are needed Reduced use of inefficient generation to meet system peaks		
Improved Environment	Increased capability to integrate intermittent renewable resources Reduction in emissions as a result of more efficient operation, reduced system losses, and energy conservation Opportunity to	Increased capability, opportunity, and motivation to shift to electric vehicle transportation Improved opportunity to optimize energy-consumption behaviour resulting in a positive environmental impact Increased opportunity to purchase energy	Reduced CO_2 emissions Improved public health

	improve environmental leadership image in the area of improving air quality and reducing its carbon footprint Increased capability to support the integration of electric-powered vehicles Reduction in frequency of transformer fires and oil spills through the use of advanced equipment failure / prevention technologies	from clean resources, further creating a demand for the shift from a carbon-based to a	

Table 11-3 Benefits of Smart Grids"

(Ministry of Power, 2013) (Dudi) (Kabi, 2015) (Asialeds, 2018)

CEA Annual Report 2017-18 (CEA, 2018)

12.CHAPTER XII - REFERENCES AND BIBLIOGRAPHY

12.1 INDUSTRY / EXPERT DISCUSSIONS

1. Steag Energy Services
2. Powergrid Corporation of India
3. Reliance Energy
4. Reliance Energy Power Distribution
5. Power Plant Simulator Experts
6. Solar Energy Corporation of India
7. L&T Controls and Instrumentaton
8. Central Electricity Authority

12.2 CURRICULUM VITAE AND AUTHOR'S PAPERS

Pratik Ghosh, has an experience of 24+ years spanning across product and service organizations. He has worked 10 years with a leading German power engineering company with an extensive exposure on various responsibilities. He is Director at Plexus Infratech Private Limited, India.

He managed portfolios at an apex level for Project Cost Estimation, International Bidding, Feasibility Analysis, Commercial aspects of indigenous and import functions, negotiation, contracting, sourcing and delivery with deep understanding of Manufacturing, Service, Information Communication Technology, Infrastructure Services for Energy and Power, Telecom. He has International experience working in US, Germany, Turkey, Russia and UK. His research area includes smart grid, ITES and IOT technologies, big data analytics, statistics and operational intelligence for the sector.

He holds a Bachelor of Engineering in Computer Science and Masters in Business Administration and has done senior management training programs from Indian Institute of Management, Indore and Indian Institute of Technology, Delhi. He is a certified ISO 9001:2008 Auditor, CMMI level 5 Implementation Partner and certified Mathematical Modelling and Optimization System Designer.

An avid information technology professional with deep knowledge and experience in programming using languages Python, C# .Net, ASP .Net, C++, C, VB with database management of Oracle, MS-SQL, ADO .Net and experience in AI/ ML/ Neural Network for data analysis, statistical process management, system architecture design, Human-Computer Interaction.

He has designed and developed software solutions for performance optimization and statistical process control for large power plants and executed residential and utility scale solar plants. He has implemented Network Data Center for large scale utilities and has conducted technical and commercial advisory for projects in rural & urban area.

His career spans across various organizations and currently consultant for Essjay Ericsson and Artheon Electronics for power and telecom projects. He is director of Plexus Infratech Private Limited.

Papers

1. Process Map of a Unified Data Platform for Operational Intelligence and Analysis of Power Sector
   International Journal of Innovative Technology and Exploring Engineering (IJITEE)
   Volume-8 Issue-10 August 2019
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12.3 ABBREVIATIONS

ABT	Availability Based Tariff
A.C.	Alternating Current
AC	Average Cost of Supply
ADB	Asian Development Bank
ALDC	Area Load Despatch Centres
AMR	Automatic Meter Reader
APDRP	"Accelerated Power Development and Reform Programme"
AR	
ARR	Average Revenue
AT&C	Aggregate Revenue Requirement
ATE	Aggregate Technical and Commercial
BEE	Appellate Tribunal for Electricity
BIS	Bureau of Energy Efficiency
BOLT	Bureau of Indian Standard
BOT	Build Operate Lease Transfer
BSES	Build Operate Transfer
BSP	Bombay Suberban Electric Supply
BST	Bulk Supply Price
CAC	Bulk Supply Transmission

CAG	Commission Advisory Committee
CAGR	Comptroller and Auditor General
CAPEX	Compound Annual Growth Rate
CDM	Capital Expenditure
CEA	Clean Development Mechanism
CERC	“Central Electricity Authority”
CESCO	“Central Electricity Regulatory Commission”
CESU	Central Electricity Supply Company
CGP	Central Electricity Supply Utility
CGRF	Captive Generation Plant
GGS	Consumer Grievance and Redressal Forum
CPRI	Central Generating Station
CPSU	Central Power Research Institute
CRISIL	Central Power Sector Undertaking
CSP	Credit Rating Information Services of India Limited
CT	Concentrating Solar Thermal Power
CUF	Current Transformer
D.C.	Capacity Utilisation Factor
DGBDF	Direct Current
DISCOM/DISTCO	Distributed Generation Based Distribution Franchisee
DoE	Distribution Companies
DPR	Department of Energy
DPS	Detailed Project Report
DRDC	Delayed Payment Surcharge
DSM	District Rural Development Cell
DSOCC	Demand Side Management
DTR	Distribution system Operation & Control Centre
EA	Distribution Transformer
EC	2003 “Electricity Act 2003”
ED	Act Energy Conservation Act, 2001
EHV	Electricity Duty
EPS	Extra High Voltage

ERCs	Electric Power Survey
ERLDC	Electricity Regulatory Commissions
ERP	Eastern Regional Load Dispatch Center
ERPC	Enterprise Resource Planning
FAR	Eastern Regional Power Committee
FCA	Fixed Asset Register
FOCA	Fuel Cost Adjustment
FOIR	Fuel and Other Cost Adjustment
FOR	Forum of Indian Regulators
FPA	Forum of Regulators
FY	Fuel Price Adjustment
GDP	Financial year
GENCO	Gross Domestic Product
GIS	Generation Companies
GoI	Geographic Information System
HC	Government of India
HEP	High Court
HP	Hydro Electric Power
HT	Horse Power
HV	High Tension
HVDS	High Voltage
IEX	High Voltage Distribution System
IPPs	Indian Energy Exchange
IREDA	Independent Power Producers
ISS	Indian Renewable Energy Development Authority
IT	Indian Standard Specification
KPIs	Information Technology
KW	Key Performance Indicators
LDC	Kilowatt
LTOH	Load Dispatch Center
LTTS	Low Tension Over Head
LV	Long Term Tariff Strategy

MBM	Low Voltage
MIS	Multi Buyer Model
MNRE	Management Information System
MoP	Ministry of New and Renewable Energy
MoU	Ministry of Power
MRI	Memorandum of Understanding
MU	Meter Reading Instrument
MW	Million Units
MYT	Mega Watt
NABARD	Multi Year Tariff
NATO	National Bank for Agriculture and Rural Development
NEEPCO	Net Approved Transmission Cost
NEP	North Eastern Electrical Power Corporation
NFA	National Electricity Policy
NHPC	Net Fixed Asset
NLDC	National Hydro Power Corporation
NREP	National Load Despatch Center
NTP	National Rural Electrification Policy
NTPC	National Tariff Policy
O&M	National Thermal Power Corporation
OA	Operation and Maintenance
PAT	Open Access
PF	Profit After Tax
PFC	Power Factor
PGCIL	Power Finance Corporation
PLCC	Power Grid Corporation of India Ltd.
PLF	System Power Line Carrier Communications System
PPAs	Plant Loader Factor
PPC	Power Purchase Agreements
PPFCA	Power Purchase Cost
PRDC	Power Purchase and Fuel Cost Adjustment
PTC	Power Research Development Corporation Pvt. Ltd

RE	Power Trading Corporation
REC	Rural Electrification
REDB	Rural Electrification Account
RIMS	Rural Electrification Distribution Backbone
RLDC	Regulatory Information Management System
RoCE	Regional Load Despatch Center
ROE	Return on Capital Employed
RPS	Return On Equity
RTU	Renewable Energy Portfolio Standards
SAC	Remote Terminal Unit
SCADA	State Advisory Committee
SEB	Supervisory Control and Data Acquisition
SERC	State Electricity Boards
SLA	State Electricity Regulatory Commission
SLDC	Service Level Agreement
SMD	State Load Despatch Center
SPV	Simultaneous Maximum Demand
SRS	Solar Photo Voltaic
STQC	Software Requirement Specifications
STS	Standardization Testing Quality Certification
STU	State Transmission System
T&D	State Transmission Utility
TERI	Transmission and Distribution
TRADECO	The Energy and Resource Institute
TRANSCO	Trading Company
Ul	Transmission Company
ULDC	Unscheduled Interchange
UMPP	Unified Load Dispatch Center
	Ultra Mega Power Project

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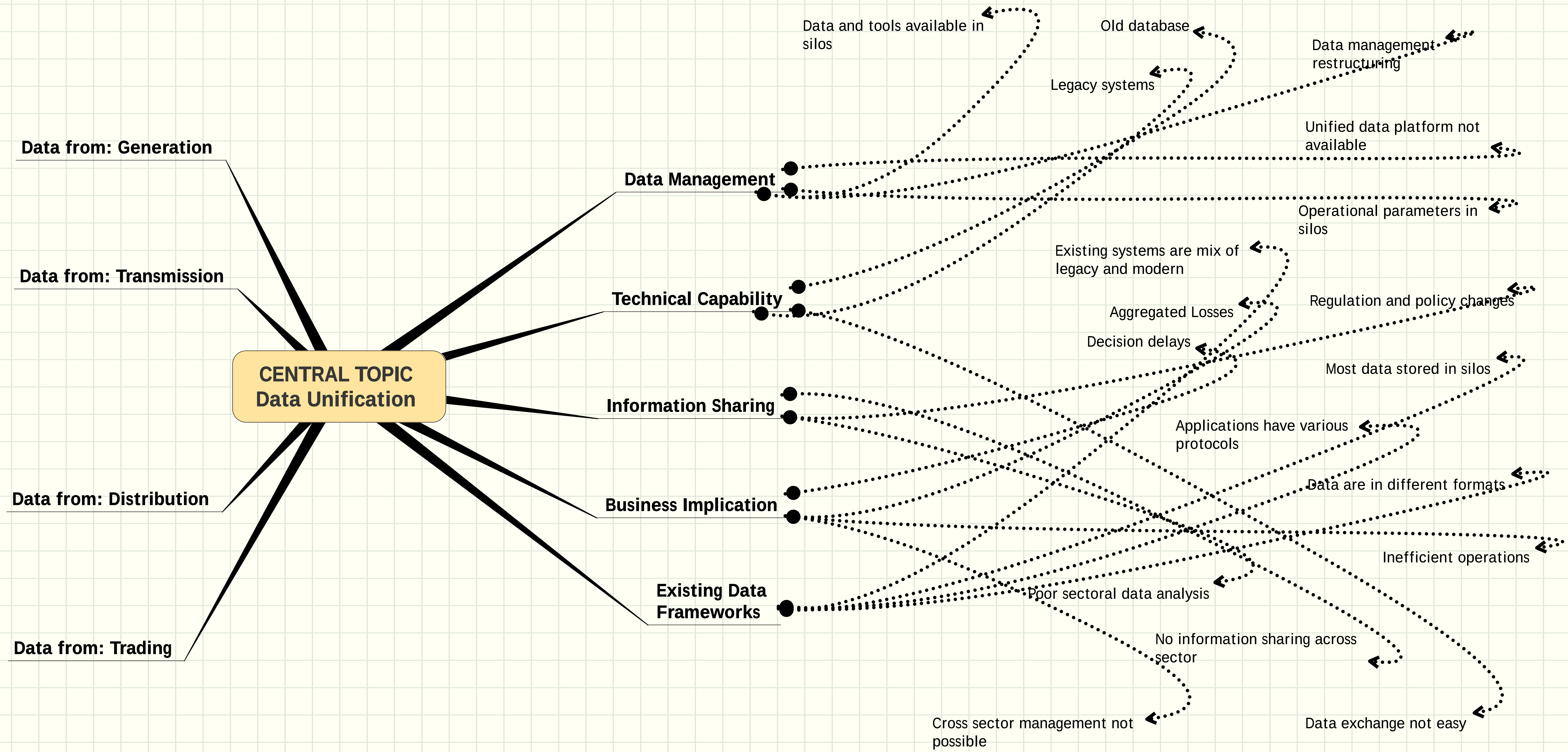
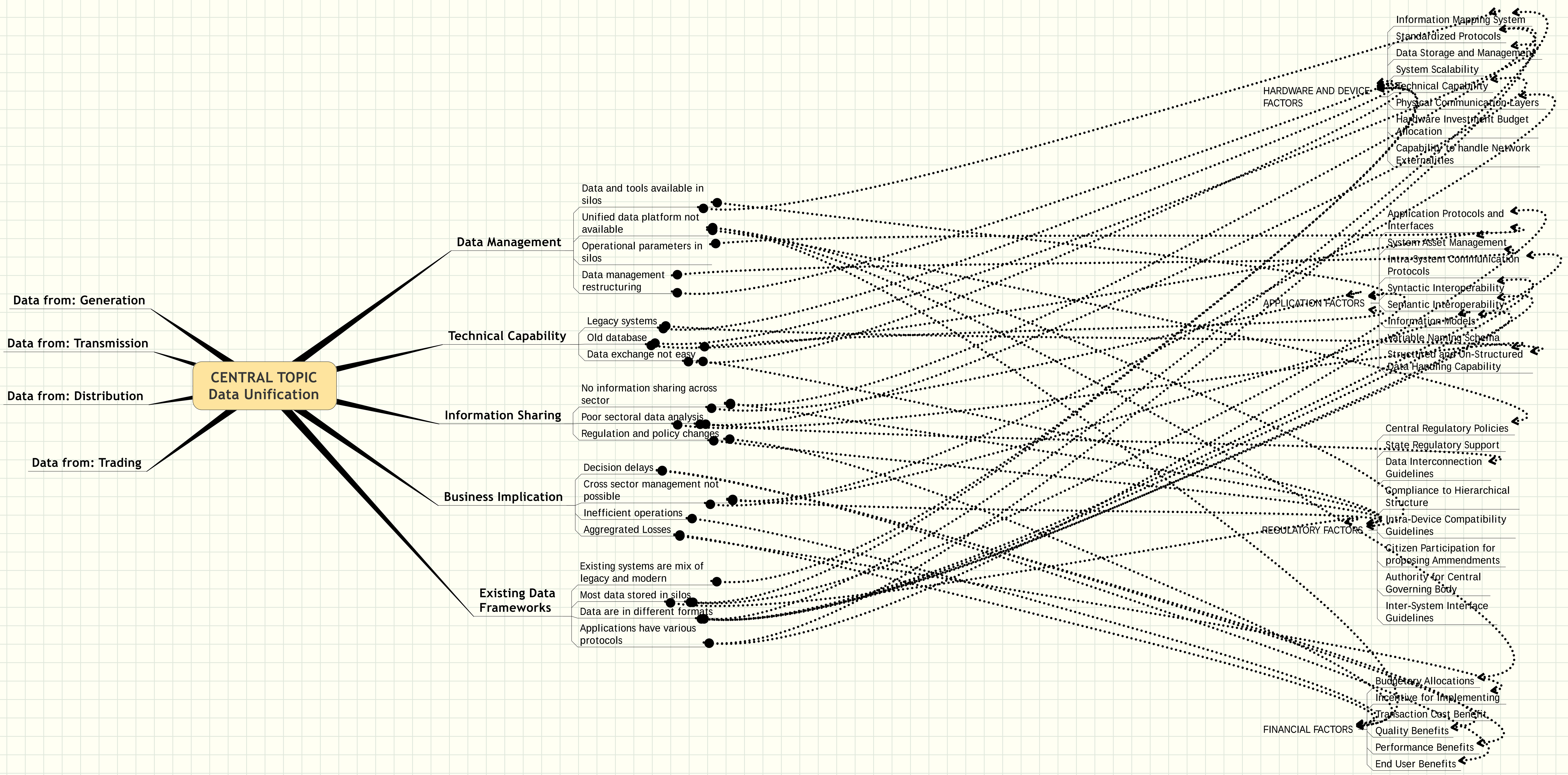
Smart Grid Conceptual Actors / Data Flow Diagram – Cross Domain Network Focused – OpenSG / SG-Network TF

DRAFT 14Feb2012
Base – file SG-NET-diagram-r5.1.vsd
page size: ANSI-D

	RESPONSE -->		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Q.NO.	**QUESTIONS**		**1**	**2**	**3**	**4**	**5**
	Regulatory Interfaces						
1	We have policies or guidelines from Central Electricity and Regulatory Commission (CERC) for unified data management			1			
2	State Electricity Regulatory Commission (SERC) provided adequate regulatory support for data unification regulations						1
3	We have policies or guidelines to interconnect data from generation, transmission and distribution of the power network						1
4	Our current system comply to the ULDC scheme which defines a high level hierarchical organization structure					1	
5	We have policies and guidelines on how to comply for compatibility between all the tools, sensors, hardware and software used					1	
6	Adequate measures have been initiated in the proposed amendments to the Electricity Act, 2003 for encouraging data unification			1			
7	National Load Dispatch Centre or designated Central Controlling body must be made independent in decisions pertaining to monitoring and controlling the power sector		1				
8	Current management of the distributed and areawise control centers will neet to merge with central control platform		1				
	Economic / Financial Parameters						
9	Investment, budget or capacity expansion policies is in place for data unification						1
10	Performance based incentives must be offered to incurr cost for implementing addtional data system		1				
11	Data unification will reduce the transaction costs across the sector		1				
12	Unification of data across sector will improve the quality of services		1				
13	Unification of data will improve the financial performance of the sector		1				
14	Unification of data will reduce the price of power by optimizing generation and supply		1				
	Application Interfaces						
15	Protocols are available to manage interactions between different applications in the network developed by various companies ranging from legacy programs to modern software languages on different platforms				1		
16	We have system for interaction and storage of large operating dataset coming from different system and servers					1	
17	Protocols are available for asset management of different hardware and software configurations					1	
18	Protocols or application interface are available for the unified data platform so that different applications communicate in a common methodology and be platform neutral				1		
19	Our current system are capable to manage Application Interoperability, Service Orientated Architecture and Event Driven Architecture						1
20	Our current system are designed to scale and integrate with enormous data that will be part of a unified data platform						1
21	Current technology has capability to analyse data across the sector		1				
22	We have ready to deploy information models and protocols for data unification				1		
23	We have ready to deploy variable and naming schema for data storage and processing across sector					1	
24	We have the system for mapping of information exchange between devices and application and manage multiple mapping due to different protocols, programs, platforms and systems				1		
25	We have system ready to enforce standard protocol model to be followed by vendors				1		
26	We have the system to represent all the data like primitive data types, aggregated data types, naming schema and universally identifyable conventions						1
	Hardware and Device Interfaces						
27	We have the system to map the physical medium of connectivity for data transfer between various devices and networks across the sector				1		
28	We have the system to establish syntactic data interoperability						1
29	R&D investments to localize production of expensive equipment, to bring the overall costs down, will be crucial to implement the unified data platform		1				
30	The current systems available in silos are ready for the network externalities						1


CENTRAL TOPIC
Data Unification
Data from: Generation
Data from: Transmission
Data from: Distribution
Data from: Trading
Data Management
Technical Capability
Information Sharing
Business Implication
Existing Data Frameworks
Data and tools available in silos
Old database
Data management restructuring
Legacy systems
Unified data platform not available
Operational parameters in silos
Existing systems are mix of legacy and modern
Aggregated Losses
Regulation and policy changes
Decision delays
Most data stored in silos
Applications have various protocols
Data are in different formats
Inefficient operations
Poor sectoral data analysis
No information sharing across sector
Cross sector management not possible
Data exchange not easy


CENTRAL TOPIC
Data Unification
Data from: Generation
Data from: Transmission
Data from: Distribution
Data from: Trading
Data Management
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Unified data platform not available
Operational parameters in silos
Data management restructuring
Technical Capability
Legacy systems
Old database
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Information Sharing
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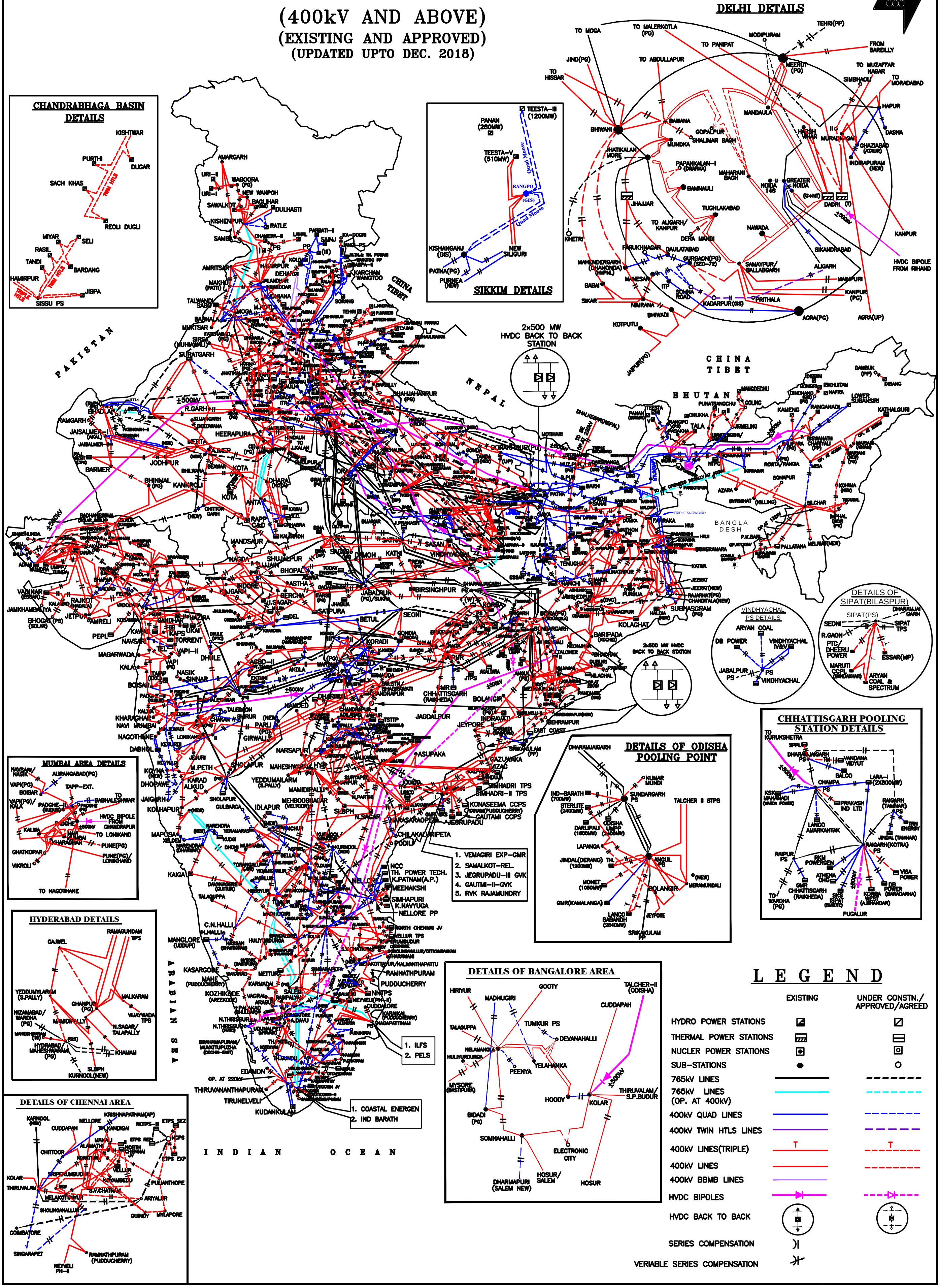
Business Implication
Decision delays
Cross sector management not possible
Inefficient operations
Aggregrated Losses
Existing Data Frameworks
Existing systems are mix of legacy and modern
Most data stored in silos
Data are in different formats
Applications have various protocols
HARDWARE AND DEVICE FACTORS
Information Mapping System
Standardized Protocols
Data Storage and Management
System Scalability
Technical Capability
Physical Communication Layers
Hardware Investment Budget Allocation
Capability to handle Network Externalities
APPLICATION FACTORS
Application Protocols and Interfaces
System Asset Management
Intra-System Communication Protocols
Syntactic Interoperability
Semantic Interoperability
Information Models
Variable Naming Schema
Structured and Un-Structured Data Handling Capability
REGULATORY FACTORS
Central Regulatory Policies
State Regulatory Support
Data Interconnection Guidelines
Compliance to Hierarchical Structure
Intra-Device Compatibility Guidelines
Citizen Participation for proposing Ammendments
Authority for Central Governing Body
Inter-System Interface Guidelines
FINANCIAL FACTORS
Budgetary Allocations
Incentive for Implementing
Transaction Cost Benefit
Quality Benefits
Performance Benefits
End User Benefits

MAJOR TRANSMISSION NETWORK OF INDIA

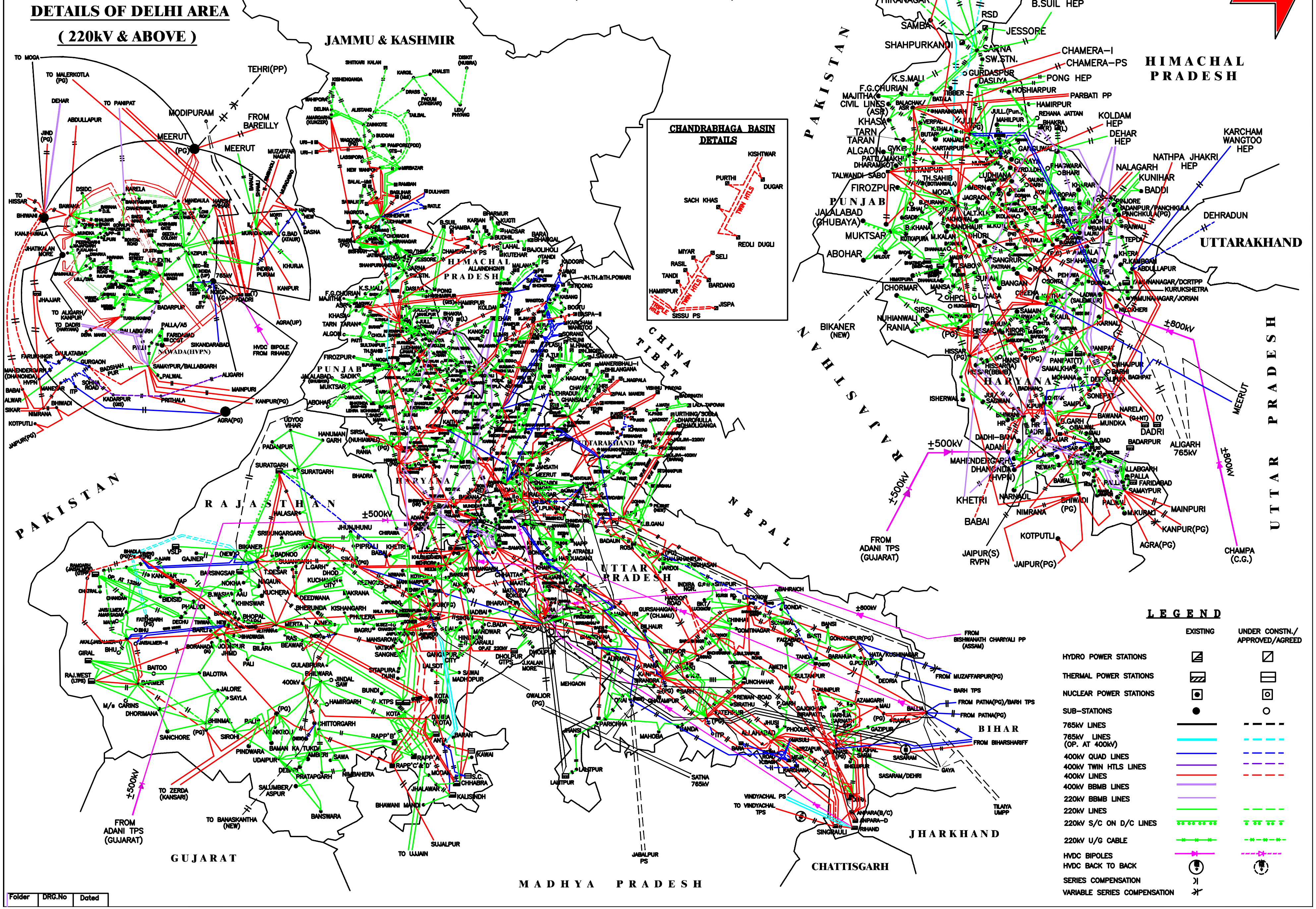
(400kV AND ABOVE)
(EXISTING AND APPROVED)
(UPDATED UPTO DEC. 2018)



POWER MAP OF NORTHERN REGION

(220kV AND ABOVE, EXISTING AND APPROVED)

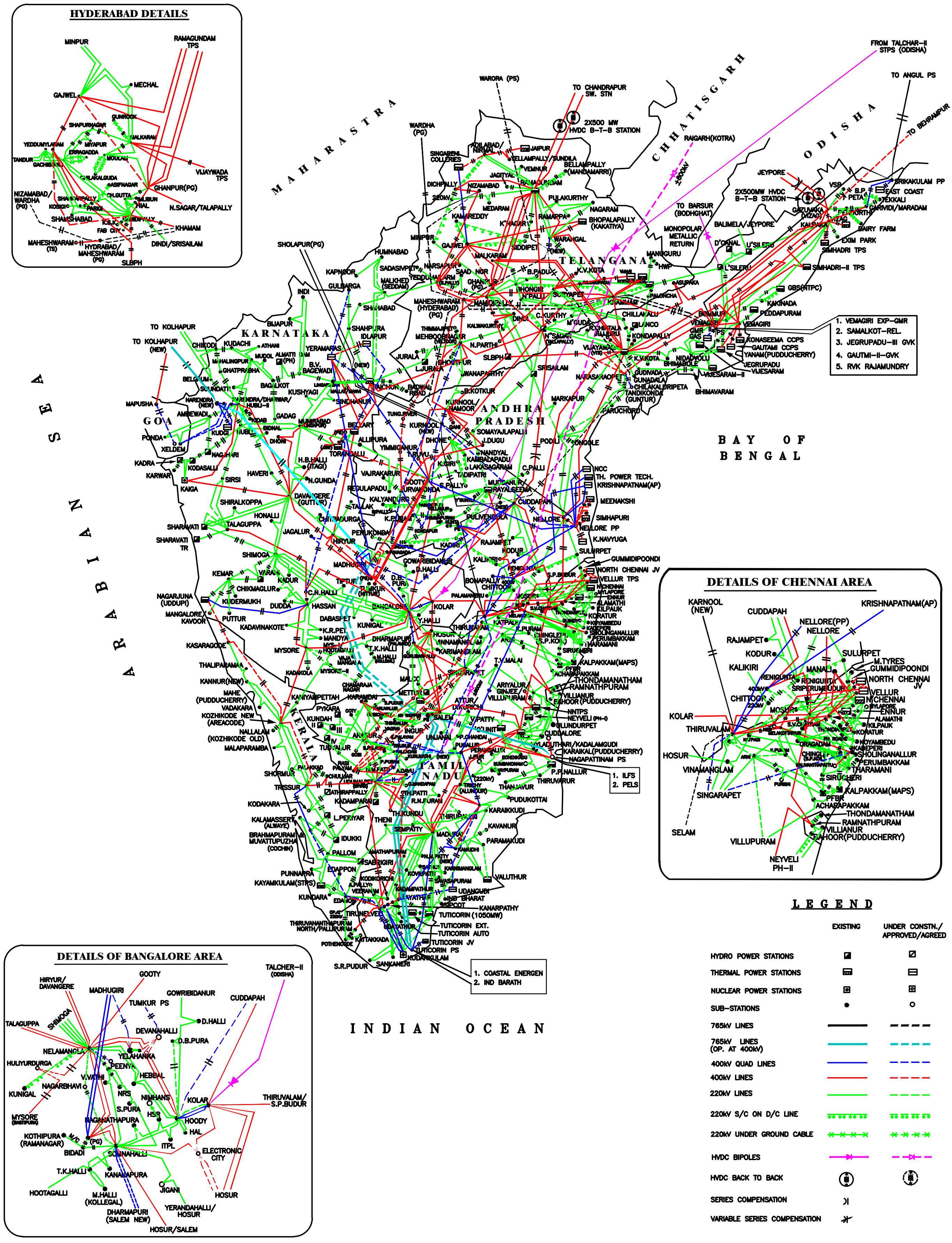
(UPDATED UPTO DEC. 2018)



POWER MAP OF SOUTHERN REGION

(220kV AND ABOVE , EXISTING AND APPROVED)

(UPDATED UPTO DEC. 2018)



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POWER MAP OF NORTH-EASTERN REGION

(132kV AND ABOVE, EXISTING/UNDERCONSTUCTION/APPROVED)

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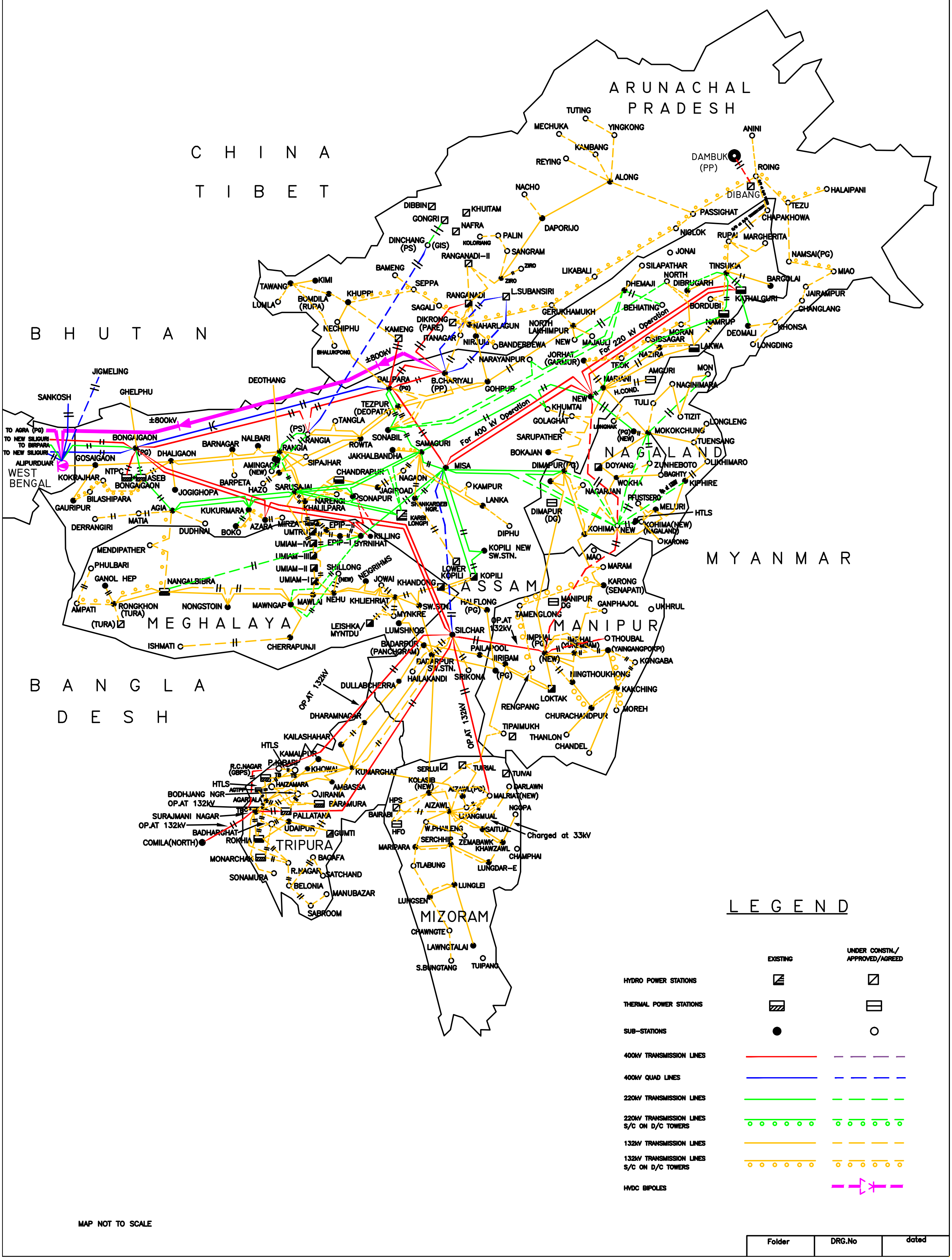
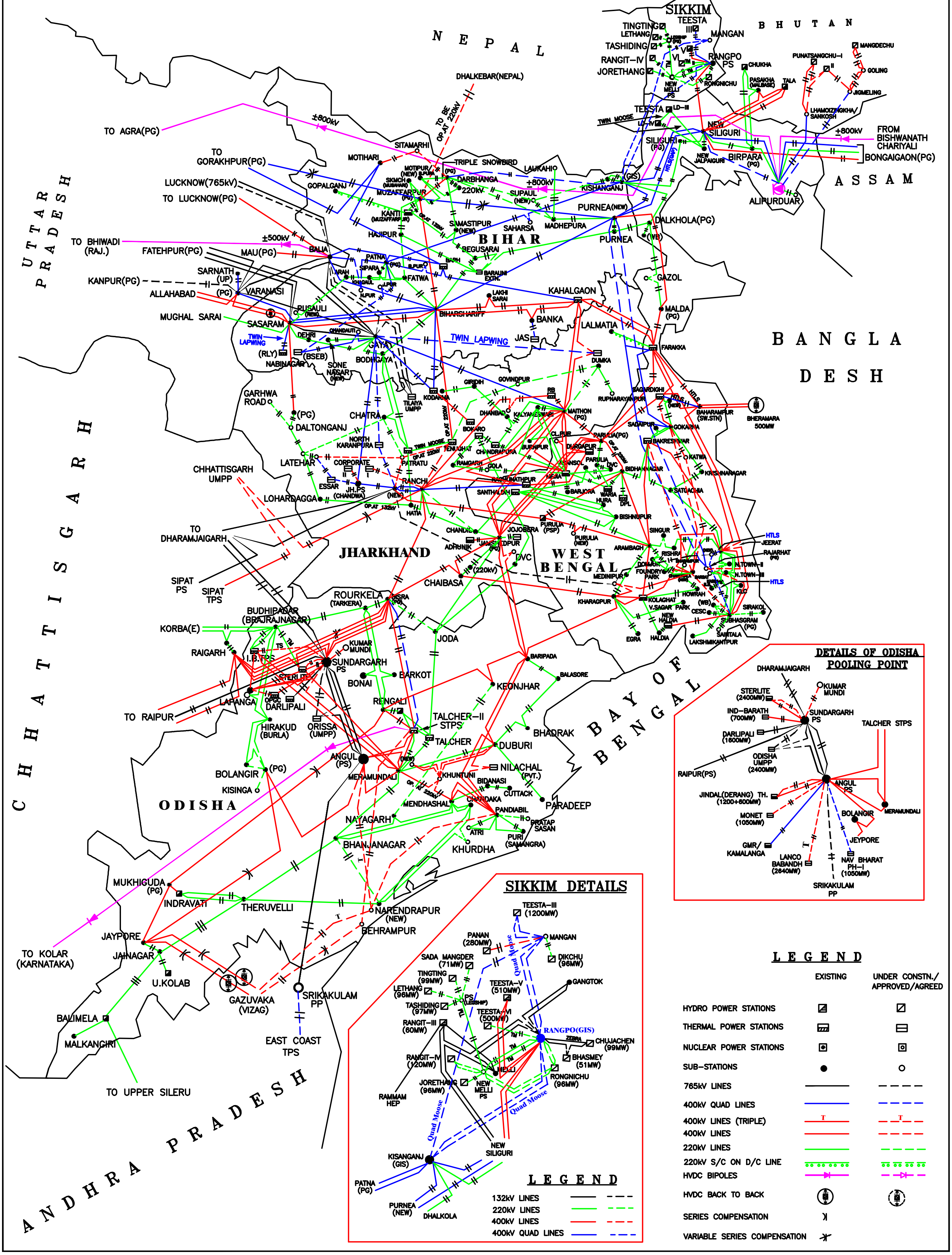


POWER MAP OF EASTERN REGION

(220kV AND ABOVE, EXISTING AND APPROVED)
(UPDATED UPTO DEC. 2018)



POWER MAP OF WESTERN REGION

(220kV AND ABOVE , EXISTING AND APPROVED)
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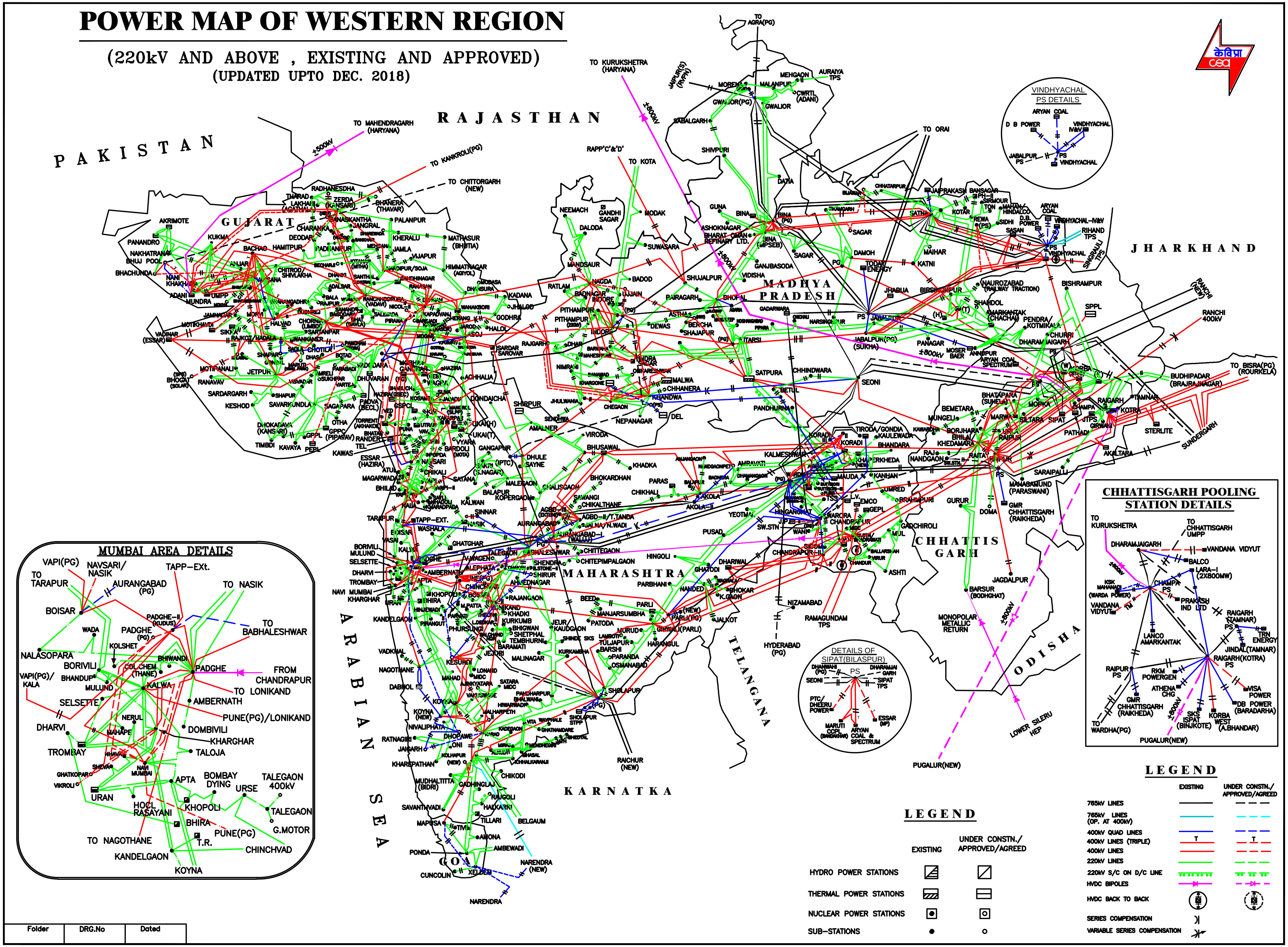

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