Digital Architecture Framework for the Power Sector

A Blueprint for Electric Utilities in India

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Prepared by BIS LITD10 Panel 6

DISCLAIMER

ACKNOWLEDEGEMENTS

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(This will also include the Sample Solution design covering the architecture details as mentioned in the section along-with Benefits and Roadmap)

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To be based on India Specific SGMM. SGMM is being developed – based on Questionnaire to be administered in the workshop.

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1.0 INTRODUCTION

1.1 Purpose of the Document:

The Architecture framework will help in planning, acquiring, building, modifying, interfacing and deployment of IT systems for business operations in the Utility Industry. It will define standard interfaces at business process and information/data exchange levels for transactions spanning multiple organizations (example – ABT based scheduling which requires GENCOs, Transcos, DISCOMS, Open Access Consumers, Distributed Generators, Load Despatch Centres to work in tandem).

1.2 SCOPE

1.2.1 Scope

Recommend Business Architecture and information/data exchange for IT systems to facilitate/enable core business operations of entities engages in the business of electricity. Refer ToR section for detailed scope.

Document will define requirement and assessing toolkit/attributes for, maturity, , flexibility, sustainability, and deployability of solutions on the above criteria.

Selection and successful implementation of any IT implementation depends upon the appropriate business environment, organization culture, and ability to migrate, and in some cases, transform, to the new system. Factors like organization structure, business practices, user skill set and learnability, migration from legacy systems, change management needs for adopting the business solutions will be listed in this document.

Architecture to support various Ownership models of the IT/IS infrastructure: Utility owned and operated; Utility owned operations outsourced; Utility leasing hosted infrastructure and running system on its own, utility leasing services. (In case of infra not owned OR not operated by Utility O&M, security and privacy criteria need additional focus).

1.2.2 Exclusions:

This document does not cover organization support process tools – like ERP (HR/Finance etc.), Business Application tools (mail, MS office etc.). It is assumed that exchange of Information/data between the core business applications and is achievable through standard, secure, interoperable interfaces.

1.2.3. Limitations/Boundary Conditions:

IT, Communications and Automation is a rapidly evolving field and the transformations happening in the Power Sector. Therefore, a lot of innovations – incremental and breakthrough are expected inITC technologies applied to this sector. This document will attempt to balance the Architecture needs from perspectives of interoperability versus design/purchase freedom and stability versus innovation.

1.3 Document Structure:

To be filled later.

2.0 Background

2.1 Introduction

Advances in digital technology and adoption of IT infrastructure are changing the Power sector like never before. On the one hand traditional IT or software as we know it is adapting to most business and non-business application needs and on other hand automation is changing the way we look at controls and operations in interconnected processes (power delivery is a complex process running across generation, transmission, distribution and consumer domains with a fair degree of automation). Thirdly Telecom has become ubiquitous and competitive to ensure a connected world.

Power Sector itself is transforming, resulting in evolving changing expectations from Information systems and automation-control technologies. The next big technological transformation expected to be driven by Smart Grids, the future of electricity. The needs of the “system of systems” (generation, transmission, distribution, trading) poses additional challenges on the electricity and digital technology planes.

India, with low energy intensity and yet large carbon footprint, wide disparities in electrification, poor electricity supply reliability and quality, and to top it all an ageing power sector workforce poses additional challenges.

Indian Power sector therefore, needs to absorb and drive evolutions in Digital space ”symbiotically” to achieve the goals of affordable, sustainable electricity for all.

BIS has formed LITD10 committee to come out with recommendatory guideline “Digital Architecture Frameworks in the Power Sector” and to set up a maintenance team for continuous review and upgrade to match with state of art technology.

This committee has workgroups focussing on specific issues of AMI, Interoperability, Security, CIM and upcoming areas of WAMS and DMS.A separate workgroup – WG6: Digital Architecture WG is mandated to come out with the overall Digital Architecture Roadmap for the India Power Sector.

2.2 BIS LITD10 WG6 –Digital Architecture Workgroup Terms of Reference

This group will:

1. Reviews the existing Digital Architecture being adopted/used.

2. Study the Digital needs of the power sector for a 7 year span.

3. Review the solutions available/expected to be available within aforesaid time in the market.

4. Debate on various frameworks available and emerging. This will cut across generation, transmission, distribution, and trading and include SCADA, IT, Automation and Communication.

5.Recommended digital framework for open architecture and “road-map” of digital technology fusion.

6.Publish a brochure to aid the sector

WG is headed by the Chair with the Secretary acting as a Knowledge Partner. It will have Generation companies, Transmission companies, Distribution companies, regulators, traders, equipment manufacturers and service companies. WG composition is appended.

2.3 Drivers and Opportunities:

The business of 21st century Power systems is no longer the monopolistic and monolithic organization of yesteryears. There are specialized entities for Generation, transmission, distribution, operations and markets. However, the systems are much more integrated at the electrical level in the form of large interconnected grids. There is a much higher need for responsive and adaptive control systems for this sector now. IT, Communications and Automation technologies have also evolved almost to the point of transformation. Consumers and providers are much more technology savvy than ever. Some of the key influences on the Architecture for this sector are listed below.

2.3.1 Business Drivers

- Independent Bulk Power Producers - Conventional and Renewable
- Introduction of Power exchanges and Independent System Operators
- Wheeling of power across national interconnected grid
- ABT based power purchase transactions
- Privatization of Distribution and Franchisee operations
- Competitive Retailing
- Commercial viability of power sector business – subsidies, AT&C losses, PPAs.
- Regulations
- Growing Consumer activism – reliability, quality and cost of power
- Ageing workforce in the sector

2.3.2 Social Drivers

- Electrification for all
- Affordable power
- Low energy intensity and yet latent demand met by local captive generation
- GDP growth tied to energy intensity

2.3.3 Environmental Drivers:

- Drive to harness Wind and Solar Energy potential
- Distributed Power Generation – Prosumers
- Electric Vehicles
- Energy Storage

2.3.4 Power Sector Technology Drivers

- Large as well as distributed renewable Generation
- More efficient generation systems
- CO_2 management
- Quick response to grid
- Economic fuel management

2.3.5 Technology aided newer/stronger T&D practices:

- Quick decision making
- Wide Area Monitoring Systems
- Economic load dispatch
- Efficient and fast equipments
- Multi direction load flow (AC-DC)
- New maintenance practices

2.3.6 Customer Service

- Complex billing
- Customer experience
- Bi-directional information flow

2.3.7 Industry Drivers

Markets

- Trading and procurement
- Risk management
- Cap and Trade
- Multiple players
- Complex settlements
- Standards for market integration

OEMs

- High demand
- Supply chain improvement
- Improved efficiency
- Smart equipments
- Advanced materials

- Embedded intelligence
- Standards for communication

3.0 Architecture Governance Principles:

The following criteria must be taken into consideration while designing the Architecture for any solution:

- scalability,
- flexibility,
- openness,
- stability,
- security,
- interoperability,
- maintainability,
- availability,
- usability,
- reliability,
- portability,
- efficiency.

In order to describe the architectures for power sector four perspectives have been chosen focusing on different aspects, namely,

(i) Business Architecture, - Focusing on "Why"
(ii) Information and data Architecture, - Focusing on "What"
(iii) Application Architecture – Focusing on "Who" and "When"
(iv) Technology Architecture – Focusing on "How".

These architectures are described below:

3.1 Business Architecture:

The business environment and processes in Power Sector are changing at a rapid pace. The sector has witnessed splitting of monolithic organization to independent business entities focused on individual pieces of the electricity value chain. Newer organizations/bodies are formed/ coming up – regulators, consumer bodies, OA consumers, aggregators, service providers etc. While decoupled at the business level, they are tightly coupled on the electricity flow level. Need for quick and timely information and process flow across these entities - at a system of systems level is increasing.

As these organizations take shape and get re-aligned, IT systems should be able to evolve and re-align responsively. The Architecture framework should be able to support quick changes in business structures and requirements. Example: Currently, RAPDRP infrastructure at Data Centres is being shared by DISCOMS at state level as joint ownership. In future, each DISCOM may want to hive-out their IT infrastructure.

At the same time, planning for Business Continuity at the time of system/solutions upgrade or replacement must be done. Risks of business interruptions must be evaluated in advance and tools as well as practices evolved to manage risks consciously. Adapting by the business users and stabilizing post cutovers to the new system must be planned and managed properly. Example: Skill set upgradation, defining appropriate TO-BE business processes and migration of relevant data from legacy to new systems will be the key CSF to ensure success of this transformation initiative.

3.2 Information and Data Architecture

Currently, GENCOs, TRANSCOs, DISCOMs, Market exchanges, System Operator are independent organizations. Power system of the future will bind these together at the electricity flow plane. These entities will thus be required to interact with each other and respond to situations in “Real-time” to ensure stability and “smart” operations of the system across the electricity value chain. This interaction will require exchanging information in accordance with set policies and functions. Thus security and interoperability will be the critical Success Factors on the information flow plane.

Example: standard interfaces between mobile outreach tools (for meter testing/spot billing/GIS survey/maintenance activities etc.) and back-end. Standard interfaces for 3rd party payment gateways. This will help give unified and thus better experience to end consumers.

Information needs to be treated as an asset. Policies for timely acquisition, ensuring quality, sharing and securing it need to be defined.

Principles for ownership of information and data, including its lifecycle management must be defined – across applications and business entities. This should be driven by objective of maximizing benefits at the Enterprise level rather than at department level. A set policy for common information management must be in place.

Refer Appendix A for Enterprise Data Management Functions.

3.3 Application Architecture

Digital Architecture Framework should provide a cost-effective but nimble technology infrastructure to add new applications and integrate with other enterprise wide applications as per business needs.

Basic principles of Interoperability, standard information exchange model and security should be adhered to in the framework. Interoperability shall take into account Adaptive Data infrastructure (to allow evolution of data exchange models).

Implement a truly service oriented architecture to faster time-to-market the required changes and lessen, if not fully alleviate, pains during upgrades, which are the order of the day.

Applications should support Standards based interfacing for B2B transactions and business workflows.

Applications should be

- Loosely coupled
- Interoperable
- Secure
- Usable
- Reusable for common functionalities
- Balance between globalization and localization
- Compliant with Law

3.4 Technology Architecture

IT and communications technologies are also undergoing transformation phase. It is recommended that changes in the framework should be driven primarily by need of the business and not so much by changes in ITC technology. Any changes on the technology front should be undertaken only if its business benefits are justifiable and it can be done with minimal impact on the business. **Adhering to principles of SOA and interoperability will help in achieving this.**

As far as possible, technical diversity should be controlled in the “production environment” to minimize the non-trivial cost of maintaining expertise in and connectivity between multiple processing environments. It is not recommended to freeze the technology baseline. Technology advances should be welcomed but technology blueprint should be changed when compatibility with the current infrastructure, improvement in operational efficiency, or a required capability has been demonstrated.

Productive lifespan of legacy power/automation/communication infrastructure tools will be evaluated while deciding solutions based on these. Recent investments on these will be used to the maximum extent possible. It may be recommended to directly invest in latest infra in newer areas. Thus solutions based on new and retrofitted to legacy infrastructure may co-exist. Example: DLMS meters installed on DTs under RAPDRP Scheme need not be replaced. But on unmetered DTs, “Smart meters” maybe installed (or we may go in for Smart DCUs here). Similarly, RAMR infrastructure invested in recently for RAPDRP – need not be replaced for supporting SMART features. However, in locations not yet covered by RAMR- AMI maybe installed.
Implement Multi Channel access to stakeholders – on Internet and mobile devices. Example: Web Self Service portals, Kiosks for end customer connect over and above Customer Care Centres and Call Centres. Going forward, system generated notifications to stakeholders are likely to become the norm.

Improve the responsiveness of network and infrastructure management systems to bring outage times to minimal levels

4.0 APPROACH

Digital Architecture WG is expected to define Digital Architecture to support processes across the electricity value chain, applicable for specific business context and mapped to the Indian infrastructure, economic, social and policy environment.

The WG will compile Business Use Cases relevant for the Indian Power Sector highlighting business context and expected benefits. It will define the pre-requisite/dependencies of these BUCs on Organization Business practices and skill set, power and ITC infrastructure, stakeholder involvement and policy interventions.

DA WG being an overarching group w.r.t. the other LITD10 WGs will coordinate with these groups to harmonize the Standards emerging from all WGs w.r.t. consistency and cohesiveness. Interoperability, Security and CIM, AMI perspectives will be covered separately in the document.

The document will cover Conceptual, information and infrastructure models of the Architecture.
It will list a set of criteria that should be addressed when architecting solutions for a given problem area. Example portability, scalability, robustness, evolvability, stability and sustainability.

It will recommend Standards required and their current status in terms of availability and relevance. Example – Standard existing but needs further enhancement; or technology is being tested/proven/maturing and hence standards can be defined later etc.

Experience based best practices and learnings of organizations that have implemented Digital transformation projects – in the IT/Communications/Automation areas will be incorporated in the document.

Draft Architecture document will be prepared with participation of the “technology supplier” community. This will be validated from adoptability perspective by the “business user” community. The final document will thus have “implementable” Architecture framework.

5.0 RECENT INITIATIVES in DIGITAL ARENA (IT&C and Automation)

To be filled for each segment .

Examples:

RAPDRP : experience sharing wrt scope depth and roll out ; best practices and learnings; connect with ERP business applications, AMI/SG; data integrity; enterprise wide business process integration across various functions and entities (example passport online application- police verification – issue) – workflow oversight and exception handling; time sync; SCADA.

Business triggered Event lifecycle management: notifications for information/alert/exceptions – actionable and information

Exception/Event/Alarm lifecycle management: system and power events/alarms: alarm occurrence/ discovery/ annunciation/ acknowledgement/ action/ retiring/ closing.

Data – transaction/warehousing; large volumes of insert/update/report/export in specified response times;

RAPDRP – feeder meter reading data in Substation O(instantaneous OR LS also?); DT data is on Load Profile/billing/instantaneous AND consumer data is on current consumption only. Impact? System “Monitoring” viz.“meter reading acquisition” - parameter type and frequency. Should DTs and Consumers also be monitored” going forward?

What type of meter parameter data to be acquired? Meter reading Data required Instantaenously for online monitoring – does not matter if it is of upto 5 minutes latency.

ABT metering – instantaneuous values required online at a scan rate lesser than 15 minutes to help build a consumption profile.

Intercept between monitoring and metering equipment.

RAMR - AMI

SCADA

EMS

DMS

ABT based scheduling

GIS

CRM

WAMS

SSA

LDCs

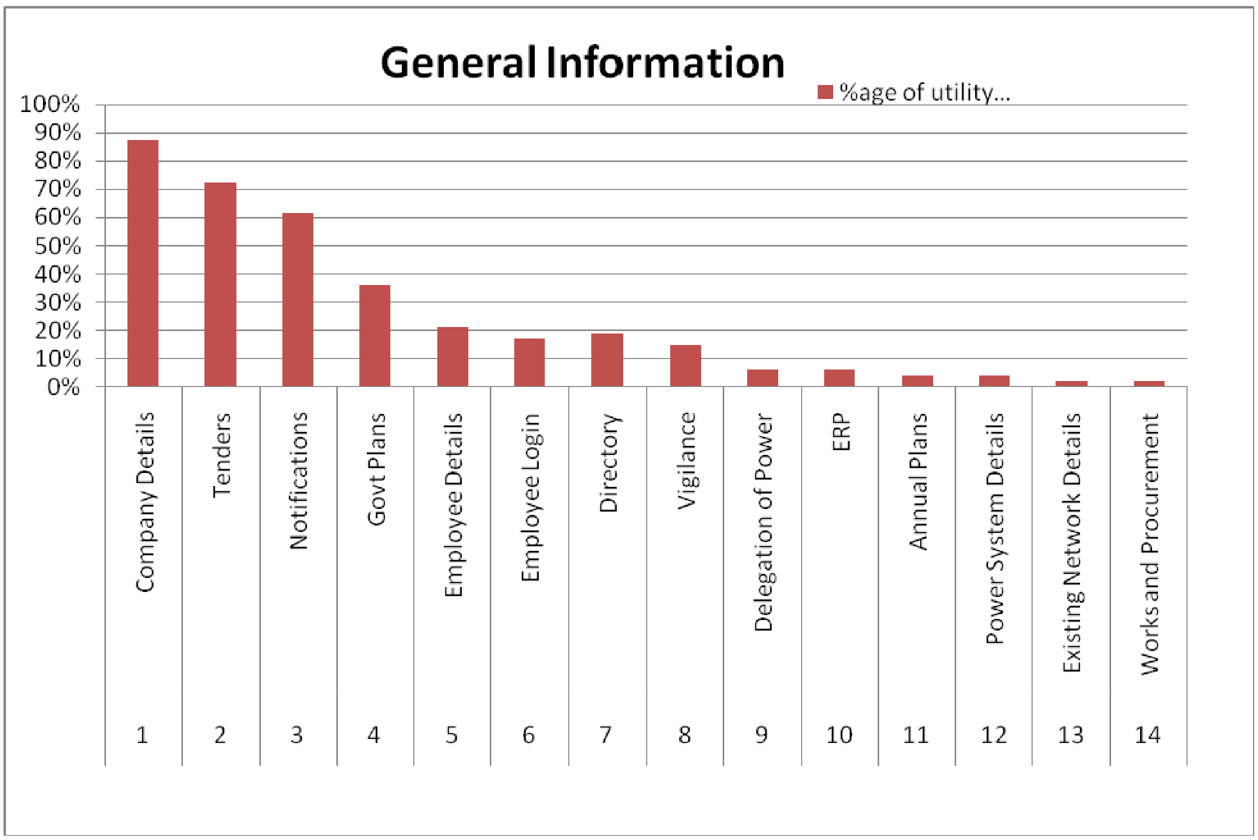
Field Force Automation

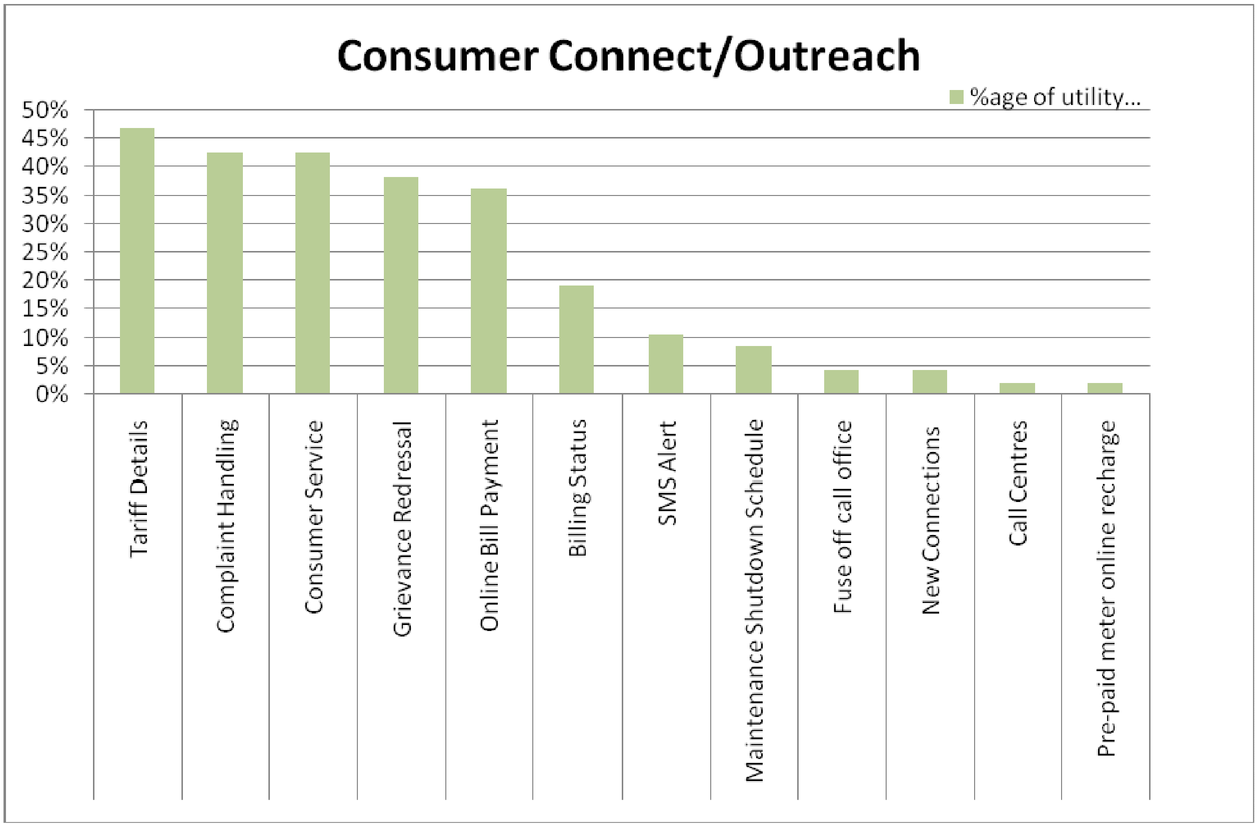
6.0 AS-IS Picture

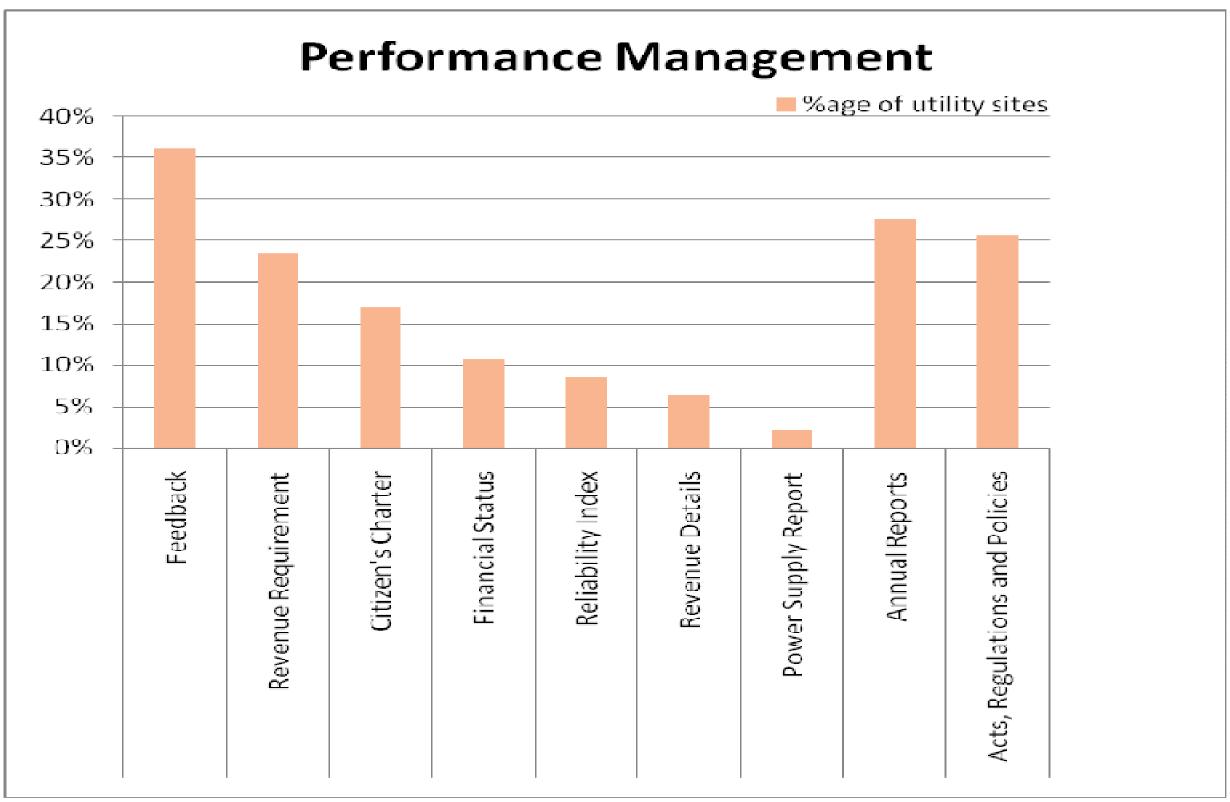
6.1 Business Perspective

(To be derived from the response of Interview questionnaire to depict as is IT scenario in Industry).

We attempted to analyze the Information content on websites of Utilities and findings are summarized in the charts below. Data from websites of 47 utilities (State Electricity Boards, Electric Companies and DISCOMS) was collected regarding the availability of information.




Consumer Connect/Outreach
%age of utility...
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Tariff Details
Complaint Handling
Consumer Service
Grievance Redressal
Online Bill Payment
Billing Status
SMS Alert
Maintenance Shutdown Schedule
Fuse off call office
New Connections
Call Centres
Pre-paid meter online recharge


Performance Management
%age of utility sites
40%
35%
30%
25%
20%
15%
10%
5%
0%
Feedback
Revenue Requirement
Citizen's Charter
Financial Status
Reliability Index
Revenue Details
Power Supply Report
Annual Reports
Acts, Regulations and Policies

- The present analysis indicates web interface are inconsistent in presenting information. Standardization of information on websites that can be considered useful for consumers, business, stake holders etc. can be one of the objectives that RAPDRP IT implementation will facilitate in the form of standard consumer outreach functions available on the portal. The R-APDRP primarily aims at reducing Aggregate Technical and Commercial (AT&C) losses in urban areas. It is a necessary condition of the scheme that the utilities would need to demonstrate performance improvement for availing financial benefits provided under the scheme.
- Projects under the R-APDRP program are being taken up in Two Parts.
    - Part-A includes the projects for establishment of baseline data and IT applications for energy accounting/auditing, IT based consumer service centres as well as SCADA/DMS Implementation.
    - Part-B includes regular distribution strengthening projects.

6.2 Business processes mapping to Stakeholders

A typical list of business processes spanning multiple actors is provided below:

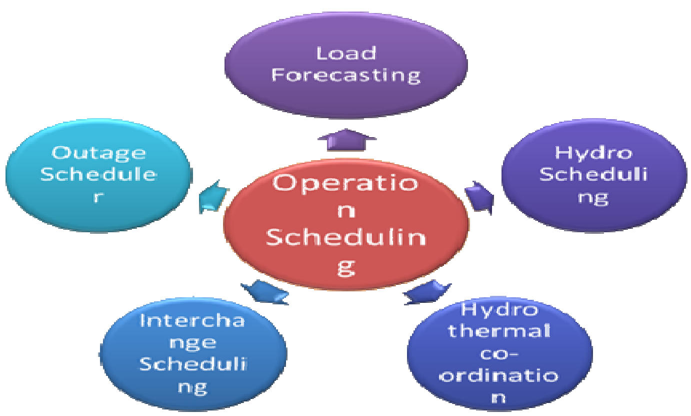
Appendix C: Business Process mapping to Stakeholders

Various utilities have differing level of business processes being followed as per the prevailing environment.

6.3 Current Level of Adoption and Usage of IT Tools

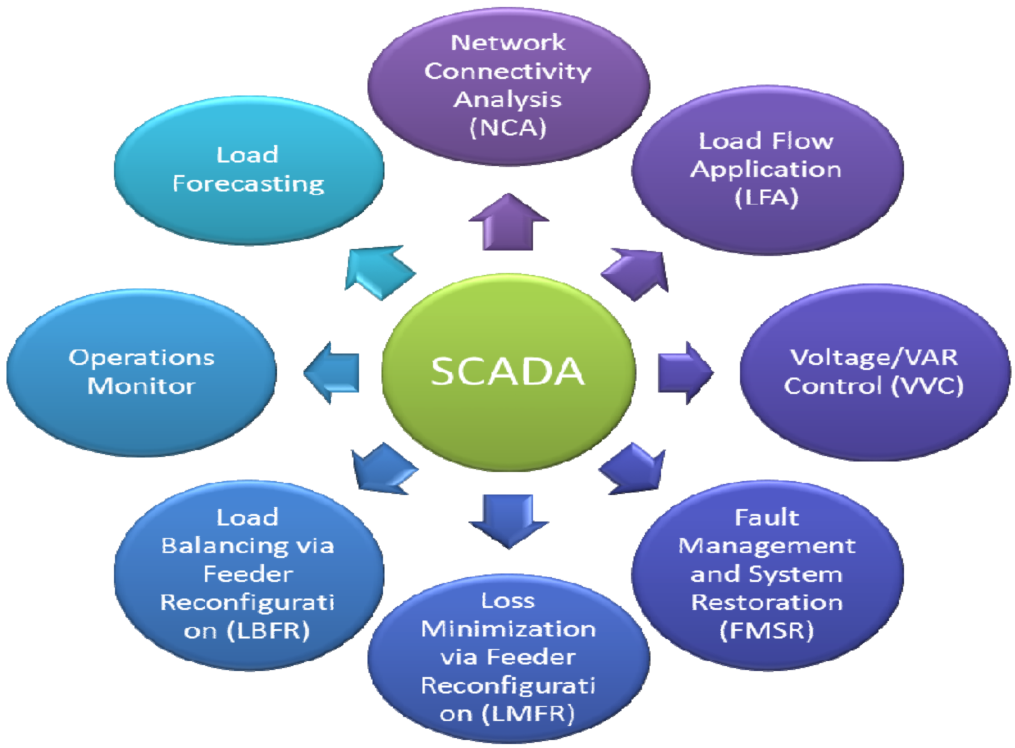
TRANSMISSION

Operation and Scheduling is detailed below:

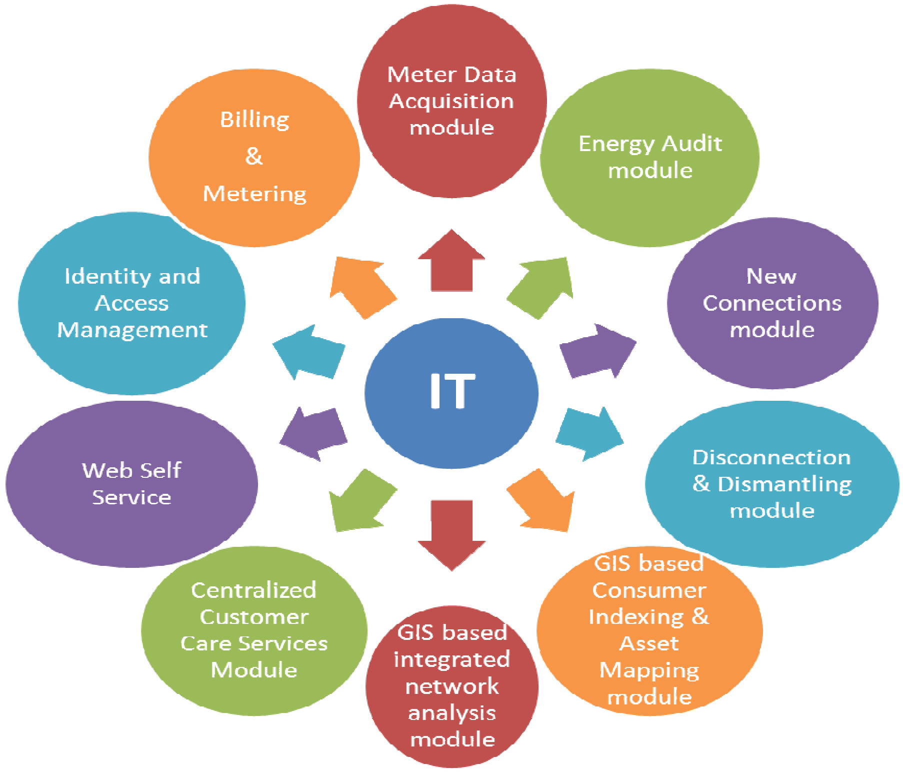


DISTRIBUTION

Fig below depicts the application modules that will be implemented in SCADA/DMS project.



The applications that will be implemented as part of RAPDRP-IT implementation are as given in the figure below.



RAPDRP-IT covers following end to end business processes:

- Connection MGMT
- Meter reading -billing- collection
- Energy Audit
- Energy Accounting
- Asset lifecycle management
- Consumer lifecycle management – similar to Bank KYC and Bank Customer

Smart Grid aims for continuous improvement thru application of ICT and Business processes and increased participation of stakeholders.

However, before going ahead with the implementation of Smart Grid, it is extremely important to first gauge the current technology adoption levels in the utilities. Since the Indian Power Sector has a huge diversity on this front, enormous differences in the interpretation and implementation of a process or technology may exist.

To bridge this gap, a smart grid maturity assessment for the Indian Power System needs to be done for the development of a Smart Grid Maturity Model, followed by a “Technology Map” in order to reach the next level of maturity.

7.0 TO-BE Picture

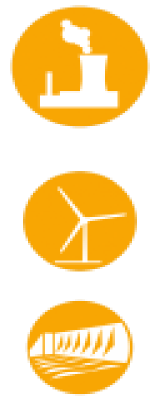
Proposed Vision for the Indian Power Sector is Secure, Affordable, Sustainable and Adaptive Electricity for All.

TO-BE Business Use Cases (to be populated as per priority BUCs).

Listed below are typical business applications across the electricity value chain. A stakeholder organization may need a few or all of these applications depending upon the prevailing business environment that they operate in. This is governed to a large extent by the policy and regulatory framework. Certain processes may not be mature enough to warrant establishing of IT systems immediately. This can vary from utility to utility. Example- electric storage and processes for handling Electric Vehicle charging.

7.1 Generation:

Generation Management System
Plant Control System - SCADA
Fuel Management System
Operations –Generation scheduling
Market Operations – PPASs/Trading
Asset Management
Generation Forecasting



7.2 Transmission

Transmission capacity is determined by system studies triggered in RPC meetings (Regional Planning Committee) where any new generation plant needs are articulated. Currently, Powergrid as the sole CTU publishes the Day ahead or week ahead spare transmission capacity. This capacity is usable for short term power evacuation- through power exchanges as well as OA. How dynamic is this going to be?

The transmission grid will be synchronous, and the backbone will be ultra- high-voltage that will include 1200 kV. Inter-regional transfer capacity will grow enormously which is important since supply sources (both coal and renewables) are region-specific. New technologies such as Flexible AC Transmission Systems (FACTS) are expected to mature. Deployment of Synchro-Phasor Measurement Units (PMUs) to enable Wide Area Measurement System, or WAMS is planned that can help improve the transmission system stability as well as its transfer capacity.

Transmission Operations – ABT scheduling /wheeling

WAMS
SCADA - EMS
SSA
Transmission Operations – ABT scheduling /wheeling
Grid stability – Protection & HVDC etc
Market Operations – Complex Billing/Point of Connection Charges
Metering
Asset Management

7.3 Distribution

SCADA – DMS
DSM
OMS
Load Forecasting
Market Operations – Complex
Billing
Tariff schemes – TOU etc.
CRM
Power quality and reliability
Connection Management
Meter to Cash
Asset Management
Work Force Management

RAPDRP and Smart Grid with PLM/PQM/OMS/DR/TOU-CPP Billing covering up-to residential consumers.

RAPDRP to ERP linkage.

Extension of ABT based scheduling, billing and settlements into Distribution segment (DT as a profit centre).

Network Analysis for facilitating smarter operation of DT and downstream system (based on DT load and temperature profile)?

Asset has engineering, operational, financial and lifecycle (maintenance) management aspects. How should assets be treated in the above 4 planes? How should field force activities related to asset management be integrated.

How to ensure data quality and integrity (with fall back data incase primary data is not available (VEE and States of data).

Locating an asset or point has electrical coordinates and GIS coordinates. Levels of maturity can be defined for implementing Outage Management Systems.

Distribution Grid Management

7.4 Operations

SCADA
Generation and Load Scheduling
Market Operations – Complex Billing/Point of Connection Charges
Open Access

Operational Planning Studies: Load Flow, Transient Analysis, Short Circuit Studies etc.

Synchronized view of Network Model between SCADA, DMS and Outage Management systems.

Collaborative System modeling in EMS,SCADA, DMS systems.

Offline system studies, Metering Applications, Open Access Applications.

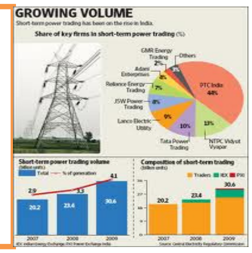
Interoperability profiles of automation equipment – meters, TVMs, RTUs, Data concentrators, FPIs etc.

Collaboration between SCADA/EMS/DMS and OMS/GIS/Metering Applications, historian/Web system/scheduling system/Power Exchange/Open Access System

7.5 Markets

Online consumption –generation – capacity trends and forecasting

Market Operations – Complex Billing



Bilateral Trade – Long term and short term/spot trading

Point of Connection Charges

Market Operations – PPASs/Trading

Pricing Models

7.6 Consumer Behavior and Participation

Web Self Service
Pre-payment
End use efficiency
Energy Storage
Electrification

End consumers would like to self-monitor their consumption patterns – probably in real-time. Refer AMI recommended specifications (smart meter - In-Home-Display/In-Home-Controller –Utility Self Service portal). Meter reading data needs to be in a universal common format. Interface of this data with End Consumers' Energy Management Systems.

TOU on fixed time slots makes sense if the load curve is static but if weather conditions and consumption profiles are dynamic then would the utility like to offer real time TOU tariff?

How to take care of consumers who have in-elastic consumption patterns – like medical cases/old people.

Load research analysis to facilitate informed policy making on Demand Side Management and Energy Efficiency programs. Consumer segmentation should be part of load research. End consumer meter reading consumption profiles.

Demand Response schemes appropriate to Indian Context.

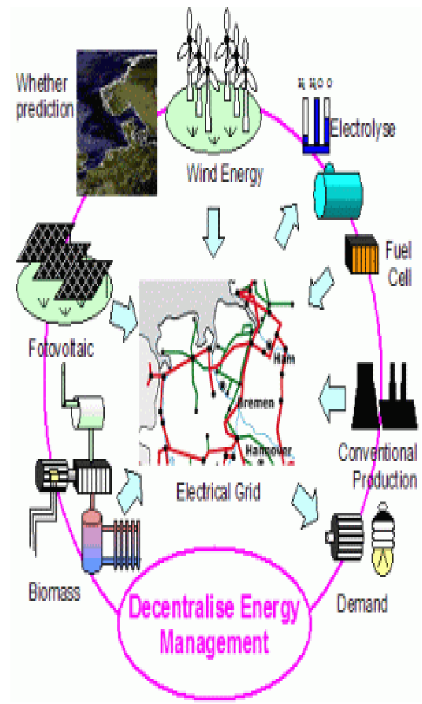
Open Access.

PEVs/PHEVs – pricing (subsidized or not), charging pattern – regulations/policies for charging and charging currents? Premise management/Control systems required to control PEV/PHEV charging.

Electricity Charging stations- how will they charge to the EV owner –since resale of electricity is not allowed.

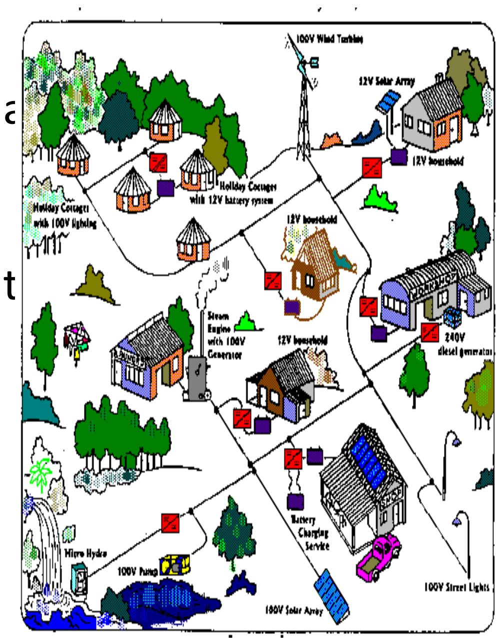
7.7 Distributed Generation

Generation Forecasting?
Captive Power Generation capacity utilization
Market Operations – Complex Billing
Tariff schemes
Power quality and reliability
Connection Management
Generation Control – remote by utility or local by owner
DSM with DG
Local generation-demand balancing-near off-grid?



7.8 Micro Grids

Generation and Load Forecasting a
scheduling
Energy Storage
Tariff schemes – @ local communit
level
Power quality and reliability
System Asset management
System Operations
Network Management



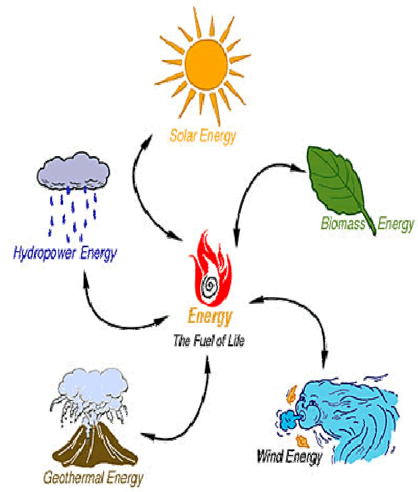
7.9 Renewables:

Generation Forecasting and scheduling for Wind, Solar and others

Integration of Bulk and Distributed Renewable Generation – Network Stability

Energy Storage

Tariff schemes – Generation based and beyond



7.10 Electric Vehicles:

Charging for PEVs and PHEVs - new category of “consumption”
Tariff and Billing structure

7.11 **Electric Storage**

- Small and large storage; static and mobile; interconnections of storage
- Can DMS influence storage charging/discharging? By pricing signals OR direct control? There are so many CPPs and inverters and backup supply systems in India.

What is the recommended way to exchange data (especially large volume) between business applications spanning multiple stakeholder organizations for collaborative operations (example ABT schedule related exchange between Transcos and SLDCs).

Unified portal linked to utility portals for monitoring operational and performance (ex. AT&C losses, RI) metrics.

Utility needs to provide following data on its portal: Business Analytics; Web-Self-Service and Extranet Services (market, supplier and partners etc.). Should this require 3 different “portals” or a universal portal with adequate segmentation and unification to ensure same base data set is used.

SG roadmap as per business value versus effort (quick wins and long term) all tied to the same vision.

8 COMMON ISSUES

8.1 Time Synchronization

8.2 Common Semantics Model

8.3 Communications for the interconnected systems

8.4 Security for the interconnected system

8.5 Interaction with the systems at the Protection and Electrical Stability planes

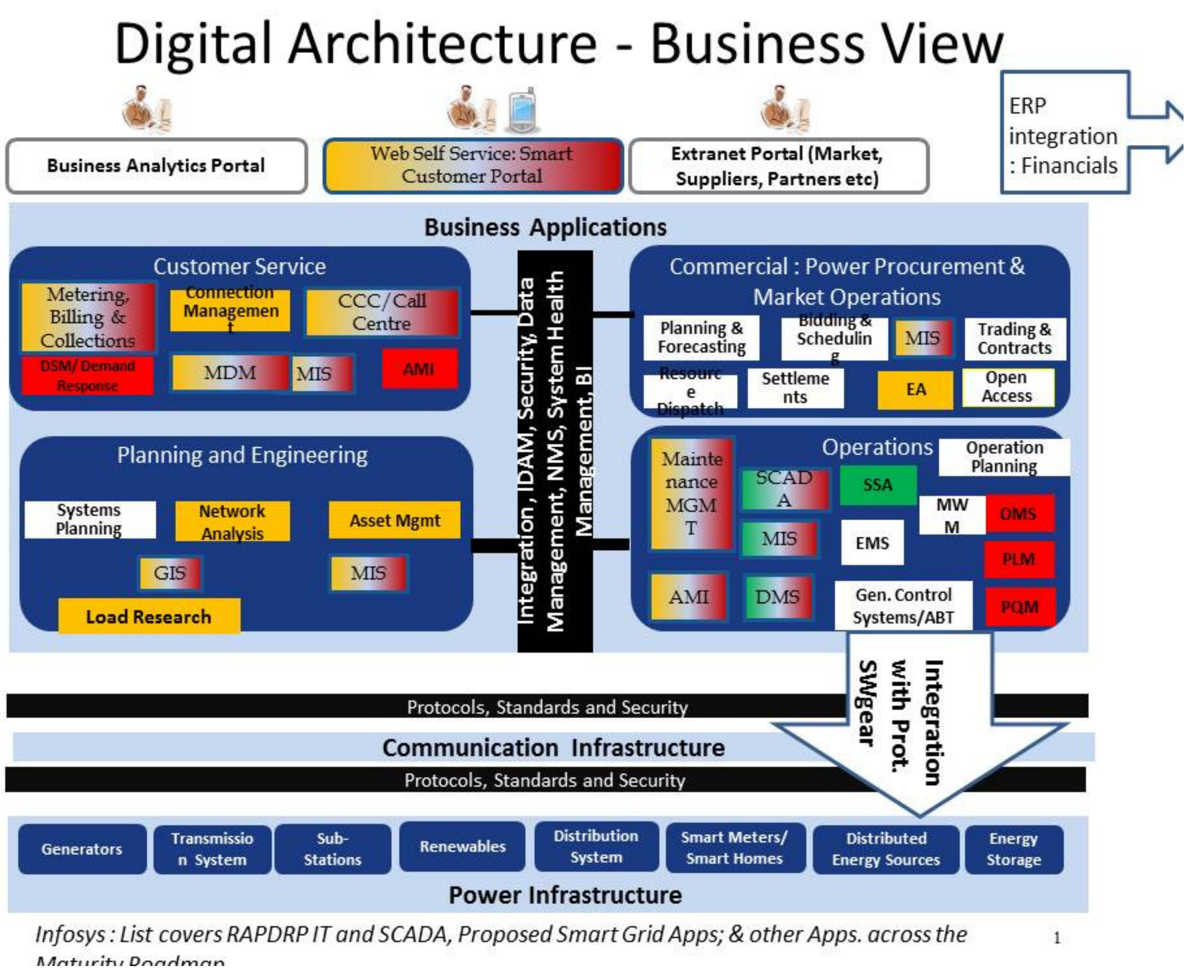
8.6 Data Collection granularity/Quality/Intergrity

9.0 TO-BE ARCHITECTURE[13]

(This will also include the Sample Solution design covering the architecture details as mentioned in the section along-with Benefits and Roadmap)

TO- BE Picture

9.1 Business Architecture Framework



9.2 Information and Data Architecture

Transmission transfer capacity to be known in real-time to Distribution Systems and C&I customers?

Common Semantics Model

- **Meteorological and Geospatial**
- **Scheduling**
- Assets?
- Consumers?
- Meter reading – standard meter reading data profiles – one step below DLMS?
- Monitoring Data –MODBUS etc.
- Control data
- Configuration data
- Others-? Derive from business information exchange

Implications of an interconnected System of Systems on Data Architecture:

Separation of Operational and Analytical Data

In an interconnected system agile decision making is the norm to optimize revenues and in some cases to ensure stability of the system. Example: emergency scheduling; lots of distributed end consumers suddenly change their loads reflecting in tangible change at supply side; wind/solar – weather dependent generation or load fluctuations. This requires availability of data in appropriate formats. Data for Operational use and for Analytics needs to be segregated. Using operational data for analytics and decision making impacts business operations as well as impedes decision making.

Data Exchange Standards:

Utility companies need to open up new interaction channels to exchange information with other entities in the energy supply chain – generation companies, retail companies, energy markets, and meter reading service providers, independent system operators, energy traders and distribution companies and now end consumers. This requires specific formats for storage as well as exchange.

Data Ownership – Primary custodian and entry/updation/propagation mechanisms across the concerned consuming entities.

Data type integrity: meter reading instantaneous/billing/Load Profile /SCADA data?
Data acquired on schedule basis can be complete – versus specific data acquired for a selective parameter on on-demand.
Standard meter reading parameters – DLMS/MIOS/MODBUS/SCADA.

Audit & Security:

Audit and access control mechanisms need to be enforced for obvious reasons and also to comply with regulatory and other statutory requirements.

Disaster Recovery:

Data is very critical to business operations and hence there is a greater need to ensure data is protected and retrievable in case of exigencies.

9.3 Application and Technology Architecture

Rules for Workflows spanning multiple "Actors" (GENCO/ TRANSCO/ DISCOM/ LDC etc.) to be recommended.

We need to recommend standards for information exchange across the Actors boundaries (covering: **Who, What , Where, Why, When**, and How);

and "specify" relevant features of the participating system tools to accomplish the workflows in desired process timelines.

The above processes can span multiple utilities (example to finalize Scheduled generation requires coordination of LDC with multiple GENCOs) and/or multiple actor segments (LDC, Gencos, Transcos, DISCOMs).

Documenting the How piece can be restricted to good architecture practices including interoperability and security aspects.

Operations to Enterprise Level Application integration

Event driven Integration across Applications

Meter reading protocols should be standardized so that meter of any make can be read by any head-end. Protect and secure Meter reading data from tampering perspective. Access to relevant meter reading data – can be IDAM based. Address integration aspects of meter reading data from various sources and meter makes.

Types of meters: Energy, SCADA, ABT, Control Room Panel meters.

Meter data processing : pair checking, Validation with SCADA, historian.

9.4 Communication Architecture

Communication latency wrt

- data acquisition;

  example – how "late" can meter reading data be received at a Head –end? Schedule based and on-demand? SCAN and refresh rate?

- system monitoring

  SCAN rate (normal/fast /slow scan)

- alert notifications;
- work order notification
- command control

Typical Communication Architecture for the Sector (later)

IP communication based needs
Radio communications – connectivity, security and bandwidth reserving issues: licensed OR unlicensed forSG?
Communication system backup and fast restoration in the event of major event or disaster-

9.5 **Security Aspects**

Security WG to cover this aspect.

1. Architecture enablement of Defense in Depth
    a. Information model sensitized to security
    b. Security to be Device Dependent or Application Driven
    c. Security level supported by Devices/Application
    d. Standards of Operational preparedness for Security breach

Adequate Anti virus capabilities should be there in the systems.
Appropriate Policies and procedures need to be put in place to ensure security and there should be awareness/training drives amongst the stakeholder community. The usage and administering work instructions must cover “security” aspects.
Appropriate methods to detect and prevent Denial of Service and intrusion type of attacks.

It is recommended that the organization should have suitable processes for ensuring cyber security- with identified and continuously monitored metrics, and conducting periodic security audits. The organization can target Compliance to proven security standards.

10.0 ROADMAP FOR TRANSFORMATION

To be based on India Specific SGMM. SGMM is being developed – based on Questionnaire to be administered in the workshop.

RAPDRP is the first step towards standardizing IT Architecture across the Distribution segment.

Experience of implementing similar such standard frameworks in other segments- example LDC level needs to be obtained to derive best practices and learnings.

BIG BANG implementation like RAPDRP – absorb the new system and then take the next step?

AMI and a good communications infrastructure (spanning end consumer to bulk generation) is the minimal investment requirement. Automation (especially at meters /sensors/controllers and below) can be future ready.

Time Synchronization: PMUs need millisecond level time sync. Will Communications networks and protocols support this?

Automation Roadmap

- Sensing (metering/sensors/
- Automation (controllers/Protection/monitoring)
- Communication options and range at all levels
- Central Systems

Policy and Regulatory and Organization maturity roadmap

Policy and Regulations across the entire value chain will play a key role in our journey of Smart Grids.

Architecture adoption maturity readiness in terms of workforce skills and organization structure and standardization of information and workflows across the enterprise (example Meter reading data flow across the organization departments and how it is used). Categorize Utilities/Distribution Licensees /Franchisees/Electricity Cooperatives on the above criteria.

11.0 STANDARDS

Standardization gaps as of now –indicative are listed below. Standards for India specific scenario need to be developed as per priority areas. As long as the basic architecture principles of Interoperability, Standard data models, and extendibility are adhered, standards can be evolved as based on small commercialization implementation experiences in the short term.

- Data format in S/S and in Control Centres – format translation?
- S/S toS/S protective relaying and other communication can use IEC61850 protocol?
- Distributed Generation: DR signals interaction with DER equipment – see adequacy of Standards for DER which currently cover wind, PV, fuel cells, DG sets, batteries and CHP from India Perspective.
- Demand Response: adopt OpenADR as a standard? Wholesale and Retail Price data available to all in a standard format.
- Transmission: CIM for transmission (IEC 61970) does not specify messaging strings. Shd we use Multispeak? OR extend CIM to cover this gap?
- PMUs – are there standards for calibration?
- Coexistence of DNP3 and IEC61850 in the transition period
- Do we need common information exchange formats for interface between Transmission and Distribution systems
- Transmission EMS and DMS and Market Operations Systems need to exchange information in real-time for price driven behavior. Overlap between EMS and DMS also needs to be evaluated.
- Standardizing of protective relay settings and other field component management functions- diagnostic to ensure completeness of configurations.
- Bulk Generation Plant modeling in IEC61850 required in India?

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APPENDIX A: SAMPLE CASE FOR ARCHITECTURE DEFINITION– DT AS A PROFIT CENTRE

Value proposition:

Recently, DLMS/MIOS meters have been installed on DTs with Modems to facilitate RAMR under RAPDRP scheme- with a mandate for collecting meter reading data daily. It is proposed to exploit this infrastructure fully to realize maximum benefits for the utility as well as end customers.

Metered DTs can be treated as the lowest level profit centres. Utility can target AT&C loss reduction, improve Reliability Indices, and perform Load profiling, and manage network health.

Background:

Metering at DTs has been done only recently –DLMS/MIOS meters installation with GPRS modems under the RAPDRP scheme. Energy consumption, power quality and supply durations patterns can be monitored at DT level now. These meters are not "SMART" enough to initiate communication with other entities and/or execute connect/disconnect actions. However, since the investment is in these meters is quite recent, it is a good idea to extract maximum utilization from the available infrastructure.

Functional Architecture:

ASIS System[14]**:**

DLMS meters with Modems installed at DTs. All Meters are time synchronized with GPS clock (ensure this at the time of commissioning the meters). Meters are polled at-least once every day for all reading data (LS, events, billing energy registers).

It is assumed that Feeder to DT and HT Consumers mapping is available. Information of all Consumers connected to DT is available. Consumers connected to meter can be categorized into residential/commercial etc.

Target TOBE System – The IT side business context

Use the reading data for following Analyses:

- Load profiling at DT level – daily load and load duration trends.
- MD profiling at DT level[15].

- Peak load profiling at DT level- provided meters capture peak load spikes (lasting atleast 10 seconds? or more).
- The above can be analysed as a % of total Sanctioned demand of all downstream loads and also % of DT loading.
- Load profiling of DTs serving similar category of end consumers mix – to get a sense of demand patterns of end consumers.
- Voltage profiling at DT level.
- Frequency profiling at DT level.
- Supply pattern- mapping interruptions to upstream, local. For momentary interruptions(check min. interruption duration recognizable by meters).
- Forecasting load profiles –use the loading patterns to build a forecasting model at DT level.
- Help in Designing TOU tariffs for LT consumers.
- EA at DT level: correlate energy billed at LT consumer level to Energy measured at DT level.
- Harmonics measurement (Does DLMS protocol support this?)
- Ripple measurement (Does DLMS protocol support this?)

Target TO-BE system: Communications and Automation side:

Can Modems installed on the DT meters poll data from the meter constantly – near online – and trigger notification to remote head-end on predefined events?

DT monitoring: DT Oil level, Oil temp., Winding Temperature, parameters monitoring. In next phase, install a Data concentrator on the DT – which collects this data from suitable transducers installed at DT as well as collect data from smart meters installed at end consumer premise on DLC/Radio mesh. This DCU can also poll meter regularly (almost online) and trigger notification to head-end on occurrence of predefined events.

Option #1: modem acts as a HUB for DCU and meter. Modem is intelligent and has DLMS API embedded to be able to communicate with slave meter.

Option #2: DCU becomes master of meter and has DLMS API embedded. DCU can have load connect/disconnect switches also –for controlling downstream loads. Challenge: Security of DCU –from malafide dismantling as well as corruption of firmware. Current standards for DCU communication- do these have adequate standard security protocols?

DCU/Modems should be able to detect power off/on events and notify the same reliably.

Communication backbone needs to support high throughput on secure channels. Can DT end meter/DCU be addressable and hence reachable?

Install Smart meters at end consumer premises.

Intercept between DT meters/DCUs and TMUs.

DMS perspective:

Implementing a full feature SCADA (with transducers etc.)for DT and below for achieving Peak Load Management can be avoided. We can acquire half-hourly meter readings from tail-end and if possible aggregate it at DT level (after due reconciliation based on the RAPDPR –GIS based asset/consumer mapping). The data so obtained can be displayed on the Network drawing (Achieve SCADA through meters). Overloaded nodes, nodes predicted to be overloaded (based on rate of rise of load), and impending load-shedding DT nodes (instead of consumer nodes); load curtailment (by pre-notifying affected consumers) and if allowed (pre-agreed) curtail loads remotely.

Inputs from each solution area for CIM, Interoperability, security, DMS/PMU – as applicable to be provided to the respective BIS WG.

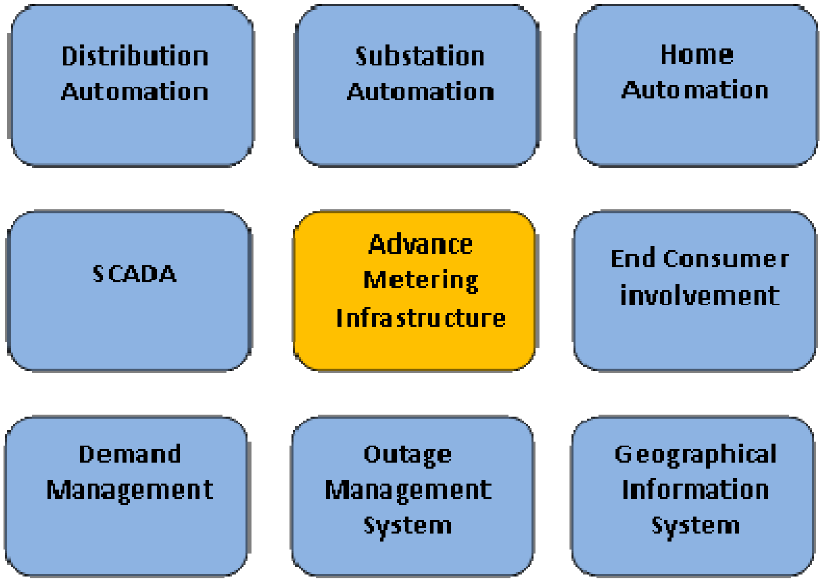
Architecture Dimension	**ASIS system**	**TOBE System**	
Business Process Model	Utility staff responsible for revenue, supply quality, load management and install/maintenance are different teams.	Utility staff organized /accountable at DT level revenue(EA), customer satisfaction (RI) and load management and system maintenance. DT level performance based Incentives for the above metrics.	
Actors and Domain			
IT System		Extend MDM to BI for features listed above.	
Infrastructure	AMR meters	DCUs at DTs and eventually Smart Meters at end customer locations.	

		DT meters- TMUs –Load switches at DT HT/LT side – modems – DCUs for connecting downstream meters.	
Workforce Skills		Analytics team may need skilling up on usage of BI tools.	
Interfaces with other tools	CRM system	Appropriate systems for capturing end-consumer details and network hierarchy.	
Standards availability		DLMS Protocol DCU- head end communication protocol	
Communications, Collaboration and Interoperability needs	*Data transfer once every day*	Strong Collaboration reqd between consumer and network mapping tools with the MDA-MDM-BI application – especially for electrical network change management. Meter-modem-DCU –head end interoperability required. Interoperability WG recommendations to be referred.	
Information and Data Model		Data exchange between these entities –to follow CIM? *Change management processes across all applications to ensure reflection of accurate field*	

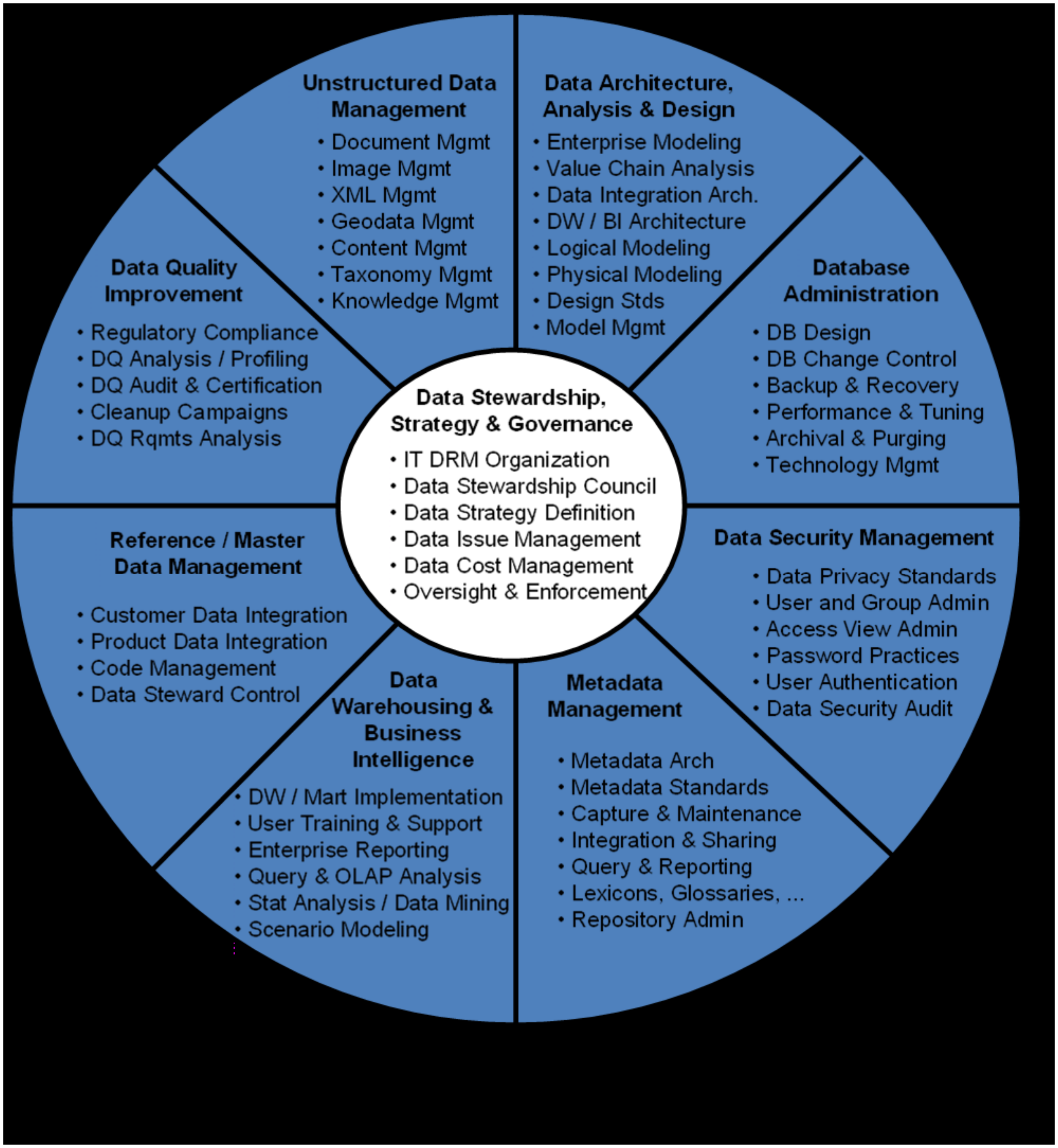
		information in all systems at all times. Single source of truth should be there. Data collection from DT meters can be daily for normal monitoring. It can be hourly for select set of DTs belonging to a SS/feeder Or administrative area- for closer monitoring. No. of DTs being monitored at hourly frequency can be restricted to 10% so as to minimize communication. Load. May need more efficient (secure and short communication messages between meters –DCUs-head end for notifications. CIM WG recommendations to be referred.	
Security needs	*Data Integrity to be ensured*	Exchange of data and configuration commands should be secure. Security WG recommendations to be referred.	

Evolution Roadmap Dimensions	
Technology maturity – Power Infrastructure	DTs are not expected to change much in near future. OLTC at remote DTs? Safe and secure Switches at DT LT End?

Technology maturity – Communications	GPRS - > 4G Standardise alert messages between meters/DCUS/head end to make these short. Online monitoring and strong diagnostics of communication layer needs to be introduced.
IT Platforms maturity	Tools available. SOA compliance essential.
Policy Maturity	Tariffs likely to evolve – TOU/Reliability assurance based tariffs likely. Regulations for voltage/frequency/availability/flicker likely to get stronger- requiring more agile and responsive practices at utility end. Proposed TOBE will help in this. Remote Load connect/disconnect – at DT /end consumer regime.
Regulatory and commercial dependencies	
Disruptive innovations likely	With open access in retail electricity supply- ownership of DT and its monitoring - multiple stakeholders needs : DT infra, electricity retailer needs will be different.
portability/scalability/robustness/evolvability/stability/sustainability	Yes on all these criteria.
Stakeholder - workforce and end consumers learnability	
Ownership/Investment models	End consumers may want to see their feeding DT load profiles- on the utility website. Retail suppliers may want to sponsor DT monitoring.


Distribution Automation
Substation Automation
Home Automation
SCADA
Advance Metering Infrastructure
End Consumer involvement
Demand Management
Outage Management System
Geographical Information System

Appendix B: Enterprise Data Management Functions



APPENDIX C – BUSINESS PROCESS MAPPING TO STAKEHOLDERS

Business Process mapping to Stakeholders

APPENDIX D: QUESTIONNAIRE FOR ELICITING USER RESPONSES

APPENDIX E: ISSUES TO BE TAKEN LATER

To ensure success implementation and usage of an IT system- it is important to have participation and ownership from the business team. This can be done by incentivizing implementation and adoption of the new system. This may need upgrades in HR practices also.