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Technical Assistance Program

INSIGHTS FROM PILOT PROJECTS FOR SCALING UP SMART GRID IN INDIA

PARTNERSHIP TO ADVANCE CLEAN ENERGY DEPLOYMENT (PACE-D) TECHNICAL ASSISTANCE PROGRAM

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CONTENTS

LIST OF ABBREVIATIONS

Acronyms	Definition
ADR	Automated Demand Response
AMI	Advanced Metering Infrastructure
APDCL	Assam Power Distribution Company Ltd.
AT&C	Aggregate Technical and Commercial
BESCOM	Bangalore Electricity Supply Company
BIS	Bureau of Indian Standards
BoQ	Bill of Quantities
Capex	Capital Expenditure
CBA	Cost-Benefit Analysis
CEA	Central Electricity Authority of India
CESC, Mysore	Chamundeshwari Electricity Supply Corporation
CPRI	Central Power Research Institute
CRM	Customer Relationship Management
DDUGJY	Deen Dayal Upadhyaya Gram Jyoti Yojana
DER	Distributed Energy Resources
DG	Distributed Generation
DMS	Distribution Management System
DPR	Detailed Project Report
DR	Demand Response
DT	Distribution Transformer
EAI	Enterprise Application Integration
EESL	Energy Efficiency Services Limited
EOI	Expression of Interest
EPRI	Electric Power Research Institute
ERDA	Electrical Research and Development Association
ERP	Enterprise Resource Planning
ERTL	Electronic Regional Test Laboratories
FMS	Facility Management Services
FoR	Forum of Regulators
GIS	Geographic Information System
GoI	Government of India
GPRS	General Packet Radio Service
HPSEBL	Himachal Pradesh State Electricity Board Limited
ICT	Information and Communication Technologies
INR	Indian Rupee
IPDS	Integrated Power Development Scheme

Acronyms	Definition
IT	Information Technology
ITIA	IT Implementation Agency
JVVNL	Jaipur Vidyut Vitran Nigam Ltd.
Km	Kilometer
KPI	Key Performance Indicators
LT CT	Low Tension Current Transformer
M&V	Measurement and Verification
MDMS	Meter Data Management System
MoP	Ministry of Power
MSEDCL	Maharashtra State Electricity Distribution Company Ltd.
MW	Megawatt
NPTI	National Power Training Institute
NSGM	National Smart Grid Mission
O&M	Operation and Maintenance
OMS	Outage Management System
PACE-D TA	Partnership to Advance Clean Energy - Deployment Technical Assistance
PGRS	Public Grievances Redressal System
PII	Personally Identifiable Information
PLC	Power Line Carrier
PLM	Peak Load Management
PoPs	Points of Presence
PRIME	Powerline Intelligent Metering Evolution
R-APDRP	Restructured Accelerated Power Development and Reforms Program
RE	Renewable Energy
RF	Radio Frequency
RFP	Request for Proposal
SCADA	Supervisory Control And Data Acquisition
SLA	Service Level Agreement
ToU	Time of Use
TPDDL	Tata Power Delhi Distribution Limited
TSECL	Tripura State Electricity Corporation Ltd
UDAY	Ujwal DISCOM Assurance Yojana
USAID	United States Agency for International Development
USD	United States Dollar
US DOE	United States Department of Energy
WFM	Workforce Management
YMPL	Yadav Measurements Pvt. Limited

SECTION 1
EXECUTIVE SUMMARY

Indian power distribution sector has seen a number of initiatives and programs being undertaken by the Ministry of Power (MoP) to bring in sustainability to DISCOMs operations by enabling a secure, adaptive and digitally enabled grid ecosystem that provides reliable and quality energy for all. Globally, Smart Grid has been identified as a key tool to achieve transformation towards a more digital and consumer centric grid, by policy makers and utilities alike.

In this aspect, a number of measures have been undertaken by Government of India (GoI) to accelerate Smart Grid deployment in India. One of the key initiatives in this aspect was the sanctioning of various smart grid projects by the MoP[1]. These projects are now at various stages of execution, with some at advanced stages of implementation/completion. These pilot projects have over the years facilitated the maturation of the smart grid industry and provide a great body of knowledge which can help advance the collective thinking about the path forward.

As GoI priority shifts from pilot to scale-up, it is important that the multitude of information available about the experiences and outcomes of the Smart Grid pilot project is analyzed and shared in order to benefit other utilities and the wider stakeholder group as a whole.

A study of global implementation experience also shows how maturity of Smart Grid has been achieved over a span of 8-10 years with demonstration projects providing key insights and inputs for defining approaches for scale-up initiatives.

Therefore, in this context, the U.S. Agency for International Development (USAID), through the Partnership to Advance Clean Energy - Deployment (PACE-D) Technical Assistance (TA) Program has undertaken this activity under the guidance of National Smart Grid Mission (NSGM) to analyze the experience of select pilot projects and subsequently develop key learnings for stakeholders for scaling up of smart grid in the country.

An analytical approach was adopted for identifying the smart grid projects learnings. A data collection and analysis framework to study the different phases of project implementation viz. planning, bidding, implementation, operations and scale-up was designed. Following this,

- Review of past pilot studies and review of various project specific documents such as Detailed Project Report (DPR), tender documents, publicly documented cases etc. was undertaken
- An exhaustive set of questionnaire was developed for data collection for select pilots at advanced stages of project implementation
- Visits were undertaken to all these pilots and discussions were held with concerned officials dealing with Smart Grid project to understand their experience

[1] Fourteen (14)smart grid demonstration/ pilot projects and one (1) smart city pilot were sanctioned by MoP from 2012-14 with 50% Government of India grant amounting to ~Rs 200 Crore. Out of these smart grid pilot projects, eleven (11) are now at various stages of execution.

Besides this, insights for scaling up Smart Grid projects have been documented which would help the stakeholders in avoiding implementation bottleneck and improving project efficiency. The recommendation in this document aims to be of value in guiding scaling up at various stages—whether one is only beginning to think about it, or has already selected a model for expansion or is in the midst of scaling up.

A summary of key insights emerging from the study are provided below.

PLANNING STAGE

Defining Smart Grid Vision

Prioritize Smart Grid objectives, identify Smart Grid solutions and develop a roadmap for implementation

Area Selection Criteria

Undertake consumer mapping surveys and re-align business processes for maintaining accurate consumer indexing database

Smart Cities/ IPDS towns provides opportunities to leverage existing IT and physical infrastructure for Smart Grid implementation

Selection of area wise or feeder wise approach for accurately assessing benefit of Smart Metering system

Baselining

Capex/ Lease Model - Create detailed, high accuracy baseline at DPR stage and re-calibrate baseline post Smart Meter installation

Savings Linked Model - Create detailed, high accuracy baseline through independent third parties, and lay out governance mechanism to resolve conflicts

Business Model Selection

Select the right fit business model basis current financing and resource availability- Savings or Lease model preferable for cash-strapped utilities

Cost Benefit Analysis

Adopt standard cost-benefit methodology to establish clear business case for Smart Grid functionalities

Designing of PLM Schemes

Establish clear PLM use case and include key design characteristics at planning stages

Regulatory Readiness

Facilitation of Regulatory Investment approval

Budgeting

Adopt cost benchmarks based on discovered prices from competitive bidding

Undertake detailed BoQ assessment for the project area. Supplement the same with rate contracts to accommodate reasonable variations

BID DEVELOPMENT STAGE

Supply

Mechanism to attract proven Smart Meter providers including global vendors and mitigate supply risk

Integration

Clearly define system interface requirements with legacy system in bidding documents

IMPLEMENTATION STAGE

Testing

Scale-up testing labs and upgrade utility testing infrastructure

Create dedicated testing window for ensuring process optimization

Interoperability

Strategic guidance by policymaker for coordinated development of Interoperability standards required to avoid vendor lock-in

Capacity Building

Utility to plan and recruit for a new IT Cadre to focus on Smart Grid and other ICT initiatives

Identify and allocate multi-disciplinary team for Smart Grid

Identify employee training needs and partner with training institutes to continuously enhance employee capacity in Smart Grid

Consumer Engagement

Design comprehensive consumer engagement strategy focusing on awareness, participation and redressal

OPERATIONS & MONITORING STAGE

Communications

Build flexibility in choice of communication technology to ensure conformity to SLAs and to effectively manage peculiarities of area topology

Data Analytics

Define standard data reporting formats at bid stage

Enable provisions to include advanced analytics vendors as project partners

Data Privacy

Incorporate guidelines and practices to identify and protect personally identifiable information

Measurement and Verification

Define the approach for gauging the benefits or performance metric indicators of smart grid

Incorporate documentation and reporting through periodic report, alerts, compliance and risk report

Review and corrective actions basis M&V

Supplementing these observations, are also snippets of practices adopted by different pilots in some of these areas, the details of which are provided in this document.

The overall analysis from the study points towards a positive prospect for Smart Grid in India. The market and utilities aided by the pilot experience have now sufficiently matured to implement larger Smart Grid programs. Further, the key insights provided as part of this study/document provide the means for a more sustainable and accelerated transformation towards a Smarter Grid in India.

SECTION 2
BACKGROUND AND OBJECTIVE OF THE PROJECT

2.1 BACKGROUND

Smart Grid development has become a key priority for the Government of India (GoI) – not only to curb power transmission and distribution losses but also to improve reliability and quality of power supply, and ensure power to all. Over the years, the central government has undertaken several foundational policy, institutional and regulatory measures to support smart grid development in India.

Following are the key developments in the direction for the development of smart grid in the country:-

- Establishment of National Smart Grid Mission (NSGM) to act as an institutional mechanism for planning, monitoring and implementation of policies and programs related to Smart Grid (SG) activities
- Target of 35 million Smart Meter to be installed under Ujwal DISCOM Assurance Yojana (UDAY)
- Launch of government schemes like Integrated Power Development Scheme (IPDS), and Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) for distribution network upgradation and automation with built in or linked components to smart grid
- Model Smart Grid regulations issued by the Forum of Regulators, and later adopted by various states
- Release of Bureau of Indian Standards (BIS) Smart Meter standards and Central Electricity Authority's (CEA) Advanced Metering Infrastructure (AMI) Specifications
- Sanctioning of large scale Smart Grid projects under NSGM
- Large scale roll-out of smart metering under bilateral agreement between EESL and State(s)/Discoms

Over the last few years, several Smart Grid pilots have been initiated by the GoI. These are now at various stages of execution. The growing body of knowledge within utilities basis Smart Grid pilot projects and other deployments can thus provide vital insights into the challenges, solutions and lessons learned during the project formulation, implementation and operational stages.

As GoI accelerates Smart Grid implementation, learnings from the pilot projects would play a key role in adopting good practices and overcoming any commercial, managerial or technological barriers.

2.2 OBJECTIVE OF THIS STUDY

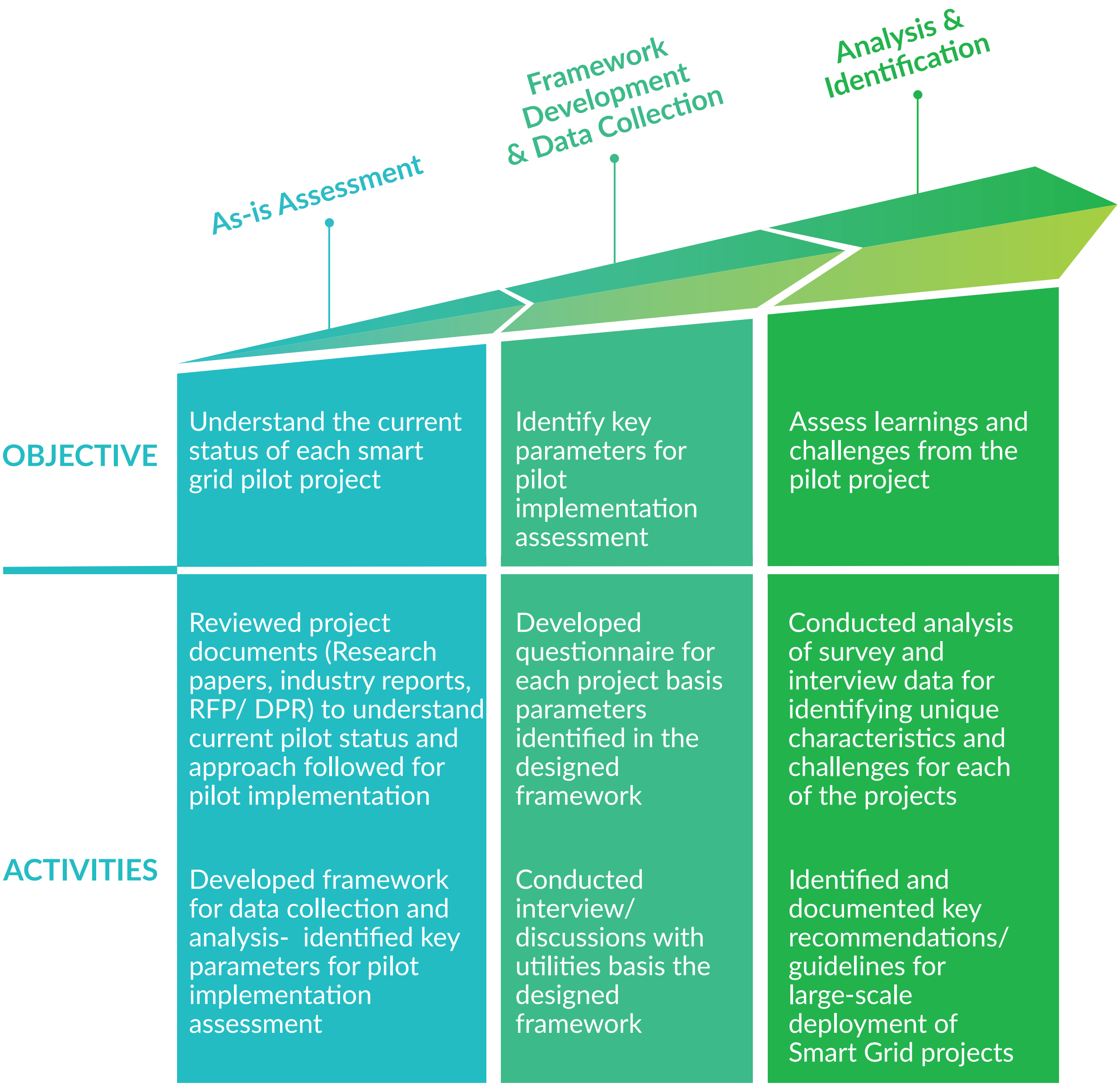
The objective of this assignment was to:

- Capture the rich and diverse experience being offered by various smart grid pilot projects right from the planning to the execution stage
- Document learnings for implementing large-scale smart grid projects

2.3 APPROACH

The overall approach adopted for the project is detailed out below.

Figure 1: Project Approach



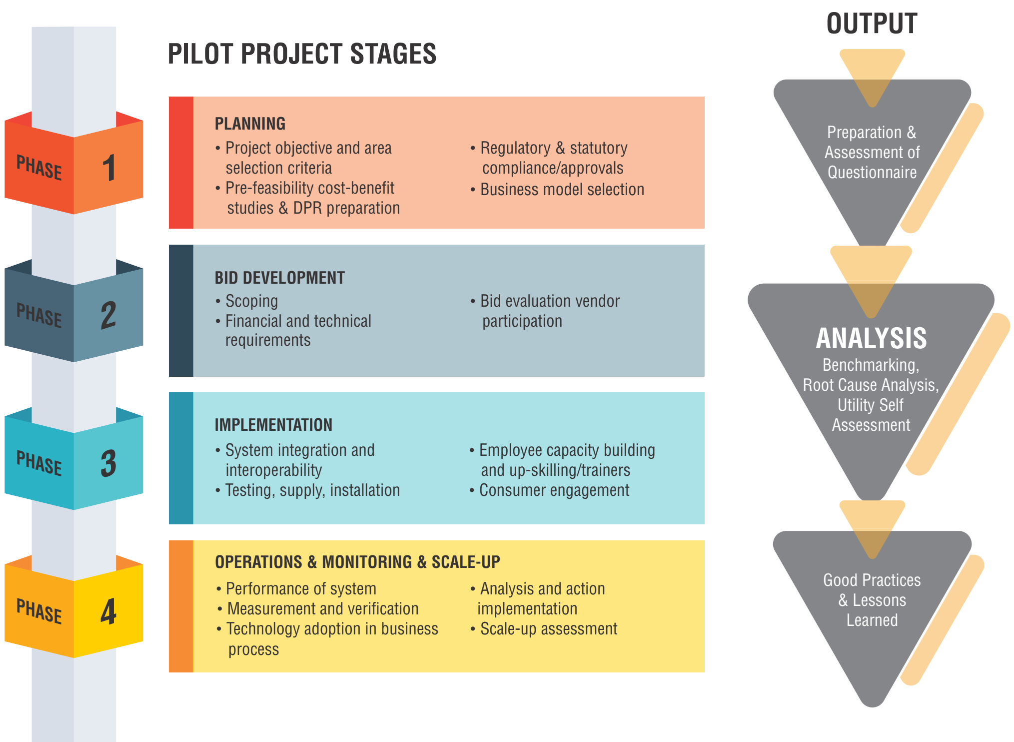
A stakeholder workshop was also conducted by NSGM to discuss on the key learnings emerging from the pilot projects. Further, site visits were also conducted to few utilities which are at advanced stages of implementation/completion of pilot projects i.e. Tripura Smart Grid pilot project implemented by Tripura State Electricity Corporation Ltd (TSECL), Mysore Smart Grid pilot project implemented by Chamundeshwari Electricity Supply Corporation (CESC) and Kala Amb Smart Grid pilot project implemented by Himachal Pradesh State Electricity Board Limited.

SECTION 3

FRAMEWORK FOR DATA COLLECTION AND ANALYSIS

In order to understand the experience of pilot projects an assessment framework was prepared. This comprised of stages of smart grid pilot project life cycle along with a list of respective activities/parameters. Refer Figure below.

Figure 2: Project Framework for Data Collection and Analysis



PHASE 1 – PLANNING

This stage covers the overall strategy and vision at organization level for the smart grid initiatives, and alignment of the same with the specific smart grid project. This stage also comprise of aspects like pre - feasibility studies for area selection, preparation of detailed project report covering selection of smart grid functionalities, baselining, business model, cost- benefit analysis, regulatory approvals etc.

PHASE 2 – BID DEVELOPMENT

This stage comprises of finalization of scope, design specifications, roles and responsibilities and procurement/bidding strategy. Planning stage covers the entire bid process management i.e. issue of Request for Proposal (RFP), pre bid meetings, evaluation of bids, selection of vendor, negotiation and award of contract.

PHASE 3 – IMPLEMENTATION

This stage covers the entire implementation of the smart grid project covering detailed design and implementation approach adopted by the vendor, receipt of equipment's to the site, effective monitoring of work, timely decision making on bottlenecks faced, ensuring the quality of work, inspection of material, testing, installation and integration with existing utility systems. This stage also comprise aspects related to employee engagement, capacity building and consumer engagement.

PHASE 4 – OPERATIONS, MONITORING AND SCALE-UP

Once the project is implemented, it is essential to evaluate whether performance guarantees and Service Level Agreement (SLA's) as specified in the RFP are achieved or not. This stage involves continuous monitoring of SLA's, training to utility personnel's for effective operation of system, handholding and institutionalization and use of analytics for undertaking appropriate actions for continuous operational improvement. This stage also covers assessment of learnings and successes from the smart grid project and scaling the project to other areas or adding new functionalities.

Based on this framework, a detailed set of questionnaire was prepared which captured the unique characteristics for each of the stages. Basis this consultations were held with the utility officials (at different level) involved in the implementation of the pilot project.

The key learnings, experience and insights emerging from the pilot projects for scaling up smart grid projects in India is detailed out in the next section.

SECTION 4

KEY INSIGHTS FOR SCALING UP SMART GRID PROJECTS

This section presents the key insights/learnings for implementation of smart grid projects. The flow of the learnings has been mapped in accordance with different stages of smart grid project.

4.1 PLANNING STAGE

4.1.1 Smart Grid Vision for aligning investments with utility objectives

The Smart Grid pilots were initiated largely with the intent of testing technology options (Smart Meter, Power Line Communication (PLC), Radio Frequency (RF), etc.) and use case functionality. As such, most pilots included multiple functionalities as part of the project including AMI, Peak Load Management (PLM), Distributed Generation (DG), Outage Management System (OMS), Workforce Management (WFM), etc.

However, on a larger scale, the transition to the Smart Grid will be driven by the objectives of the primary beneficiaries—utilities, individual consumers, and society in general. Therefore, the utilities which are now embarking on mainstreaming Smart Grid should first clearly understand the goals it wants to achieve using Smart Grid, how it can leverage legacy/existing solution for transition to a Smart Grid, and what are the new technologies/ functionalities it needs to implement.

- **Prioritize Smart Grid objectives, identify Smart Grid solutions and develop a roadmap for implementation**

Setting the right Smart Grid goals: In order to understand the readiness of the utility to move towards smart grid or to take benefit of technology implementation under other GoI schemes (IPDS, Restructured Accelerated Power Development and Reforms Programme (R-APDRP), etc.), it is necessary to understand what the benchmark is, "where does the utility need to be", including what needs to be done to make the utility financially stable and more customer oriented. Goals therefore should be defined based on business objectives, industry objectives, the current policy and regulatory requirements and the emerging sector dynamics. These goals then translate into activities and project level objectives.

Business Goals can be in terms of reducing financial losses, optimizing power procurement costs, integration of renewables, etc. which can translate into Smart Grid project level objectives of reducing Aggregate Technical and Commercial Losses (AT&C) losses, demand side management, reducing outages, and so on. Setting goals would provide focus and an indication of which smart grids initiatives could support achieving these goals. For example, the goal of reducing AT&C losses could be achieved through investment in Advanced Metering Infrastructure (AMI) which will help the utility in real time accurate energy accounting.

Gap analysis to identify required solutions: The smart grid vision defined in the desired future-state assessment should be first compared to the present-state assessment results to identify the gaps in technology, business processes, and consumer acceptance areas.

Gap analysis would help utility identify the actions/ specific solutions that would be needed to reduce or eliminate them. These solutions would include new applications, technologies, business processes, regulatory policies, consumer outreach and can be linked to the outcomes required of the smart grid project.

Figure 3: Gap analysis process

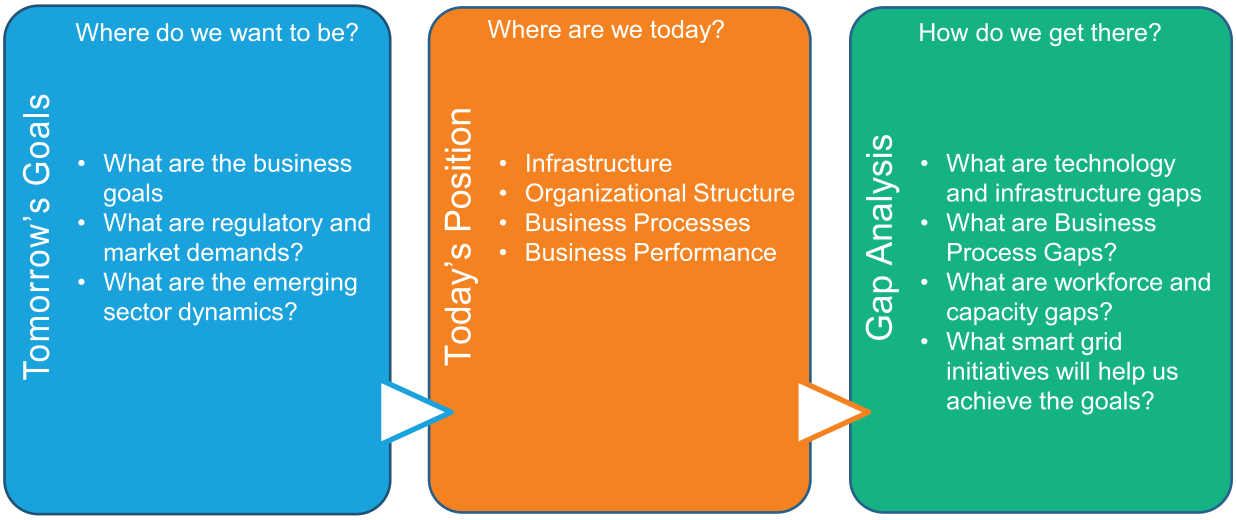


Chart the path towards Smart Grid transition: The outcome of gap analysis process is a smart grid road map, which connects the goals in the smart grid vision with the infrastructure investments needed to get there. The roadmap would indicate the stages of smart grid deployment and enable the management to clearly express its smart grid vision to employees, customer, regulators and vendors.

Figure 4: Illustrative Smart Grid Roadmap

	Phase-1	Phase-2	Phase-3	Phase-4
Technology	• Communication Infrastructure • Supervisory Control and Data Acquisition • Geographical Information System (GIS) • Automated Metering	• Distribution Management System (DMS) • Distribution Automation (DA) • Outage Management System (OMS) • CRM & Billing	• Demand Side Management • Distributed Generation (DG) • Enterprise Application Integration (EAI) • Mobile Workforce Management	• Advanced Metering Infrastructure (AMI) • Green Grid implementation • Business Analytics • Distributed Energy resources (DER) Integration
Consumer & Regulatory	• Initiation of Customer Outreach and Engagement Programs • Implementation of Dynamic Tariffs	• Mandatory Demand Response programs for larger sections of consumers • Enablement of Prosumers in select areas	• Active Participation of "Prosumers"	
Organization (People & Processes)	• Form & charter multi-disciplinary smart grid teams – State Level Project Monitoring Unit (SLPMU) expertise to be leveraged • Research & Development, Training & Capacity Building	• Link employee incentives to smart grid success. • Optimize business processes leveraging the enterprise IT architecture	• Integrate real-time analysis with integrated resource planning.	• Advanced training on modelling and simulations

4.1.2 Area Selection for Smart Grid Projects

Careful assessment of the area is a pre-requisite for timely implementation of the project. Selection of area for implementation of smart grid project depends on number of factors such as consumer mix, geographical spread, consumer density, current level of utility revenues from the area, functionality to be implemented, operational parameters, physical infrastructure, Information Technology (IT) readiness etc. Experience from the pilot projects reveals the following critical aspects for timely installation of equipment's and obtaining accurate energy accounting at all levels:

- **Updated Consumer Indexing Data -** Maintaining updated Consumer Indexing data critical for timely installation of smart meters and correct energy accounting at all levels
- **Infrastructure readiness of the area and linkages with distribution improvement schemes and wider city development goals –** The current state of physical infrastructure such as metering infrastructure, IT infra, R-APDRP, network characteristics and topology, feeder configuration, customer profile etc. Focusing on Smart Cities/ IPDS towns provides opportunities to leverage existing infrastructure being created under these schemes, and draw wider synergies
- **Ringfencing of the project -** Ease or ability to ring fence the project area, and appropriately report the findings

Each of the above aspects is detailed below:

A. Consumer indexing a pre-requisite to any Smart Meter installation

Many of the utilities selected R-APDRP town areas for pilot project implementation wherein consumer indexing and Geographic Information System (GIS) was already a part of the scope of work of R-APDRP scheme. However, experience from the pilot project reveals that in some of the cases the project area lacked updated/ accurate consumer mapping at the time of smart meter installation which led to delays.

While consumer indexing was completed as part of R-APDRP scope of work, lack of defined processes and non-availability of requisite resources for regular updation have been the key root causes for lack of accurate consumer indexing. Given the dynamic nature of the distribution grid, there are frequent changes in electrical grid which requires a continuous updating of data to reflect ground level conditions.

- **Undertake consumer mapping surveys and re-align business processes for maintaining accurate consumer indexing database**

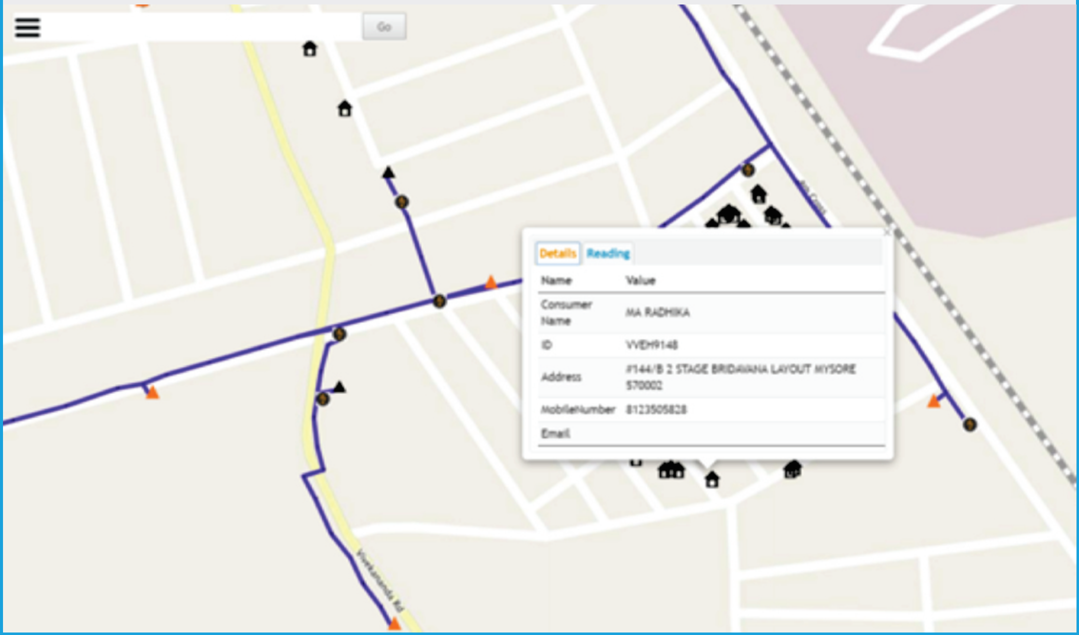
Consumer indexing of the distribution network (33KV substation down to consumer level) allows proper identification, location mapping and documentation of electrical network assets. In addition, tools like GIS can be deployed to graphically display the existing connection and consumer details on the GIS map linked to the database. Utilities thus need to:

- Undertake one-time consumer mapping survey for creating the initial data set; and

- Incorporate standardized processes/reporting formats across various business processes which necessitate updation of consumer indexing, like load growth, removal of old and faulty meters, load switching, etc. so that accuracy of consumer indexing data is maintained

Pilot Projects – Good Practice Snippet

- **CESC, Mysore** conducted consumer mapping survey for the pilot area and developed and updated GIS for the Smart Grid project area.



B. Infrastructure Readiness

Significant base work in terms of improvement of physical and IT infrastructure has been undertaken as part of implementation of R-APDRP and IPDS schemes which constitute building blocks for Smart Grid. Experience from pilot project reveals, projects which had selected R-APDRP towns for implementation of Smart Grid pilot projects found significant leverage of integrating Smart Grid data with existing base IT infrastructure like Supervisory Control and Data Acquisition System (SCADA), GIS, Enterprise Resource Planning (ERP), billing, data center, etc.

- **Smart Cities/ IPDS towns provides opportunities to leverage existing IT and physical infrastructure for Smart Grid implementation**

IPDS scheme provides for both IT enablement and strengthening of the distribution network which provides essential building blocks for smart grid. Further, utilities which are now part of GoI's Smart Cities Mission initiatives can leverage significant synergies with Smart City utility infrastructure such as GIS, SCADA, communication network and centralized control centers. This would not only enable cost efficiencies, but can enable new revenue streams for utilities to provide expanded city wide services that span beyond the traditional distribution utility boundaries.

Smart Grids Synergies with Smart Cities – The Emerging Opportunities

A.P. Fiber Grid Phase-I envisages setting up a state-wide high speed Optical Fiber Network Infrastructure across the 13 Districts of the State leveraging the assets of the Electricity Department. A 24-Core All-Dielectric Self-Supporting Optical Fiber Cable will be laid for a length of around 23000 kms over the electrical poles with its back-end electronic systems being set up at the Points of Presence (PoPs) at 2449 identified sub-stations. A state-wide control and command center for this entire network is being set up at Visakhapatnam as a Network Operations Center (NOC).[2]

CESC and Silver Spring Networks collaborated to deploy multi-application Smart Energy and Smart City network in Kolkata. The initial phase of the deployment will connect approximately 25,000 customers and automate CESC's electricity distribution grid[3].

C. Ring Fencing of the project to enable effective monitoring and quantification of benefits

It is important to ring fence the smart grid project for undertaking accurate energy accounting. Sometimes, same set of consumers are supplied electricity from multiple feeders/ Distribution Transformers (DTs) and hence ring-fencing of the project becomes essential.

Due to the nature of pilot projects, the scale of implementation was limited and the area selected was such that not all sub-stations were covered 100% with AMI infrastructure leading to complexities for accurate energy accounting.

- **Selection of area wise or feeder wise approach for accurately assessing benefit of Smart Metering system**

To ensure ring-fencing of the area it is suggested that either a geographical area approach i.e. covering entire town area similar to that covered under IPDS be adopted or at the least entire sub-station/feeder wise approach be taken to realize full potential of AMI infrastructure. These are often separate accounting/monitoring units from electricity perspective.

Further, it is also essential to ring-fence project area by identifying cut-off points and installing of boundary meters. There could be certain substations/feeders supplying power beyond town/project boundaries necessitating ring fencing of the project.

[2] http://apsfl.in/about-us/
[3] Source: http://indiasmartgrid.org/viewsnews.php?id=1992

4.1.3 Baselining of project area critical for measuring project benefits and enabling innovative business models involving third parties

Baselining of project parameters acts as an enabler not a deterrent: A number of utilities have specified baseline Key Performance Indicators (KPIs) in DPR for AT&C losses, reliability indices, peak load, etc. and subsequent project KPI targets have also been defined. However, the reliability and reproducibility of the baseline figures has historically been a challenge for the utilities.

Some of the contributing factors include:

- Lack of feeder and DT metering
- Lack of adequate processes for recording distribution network changes (shifting of feeder/ DT, DT load growth, etc.)
- Lack of consumer indexing or non-availability of updated data
- Complexity of analyzing and verifying data recorded on physical books
- Difficulty in estimating technical losses

However, even with existing infrastructure challenges, it is important that steps are taken for setting reliable baseline to the extent feasible for facilitating continuous project monitoring and for enabling implementing of innovative business model.

- **Capex/ Lease Model - Create estimated baseline at DPR stage and re-calibrate baseline post Smart Meter installation**

In case of capex/ lease based model where project benefits are not shared among the participants, utilities can assess existing data records (billing system, SCADA, outage records, etc.) to establish a best-case estimate of the baseline scenario.

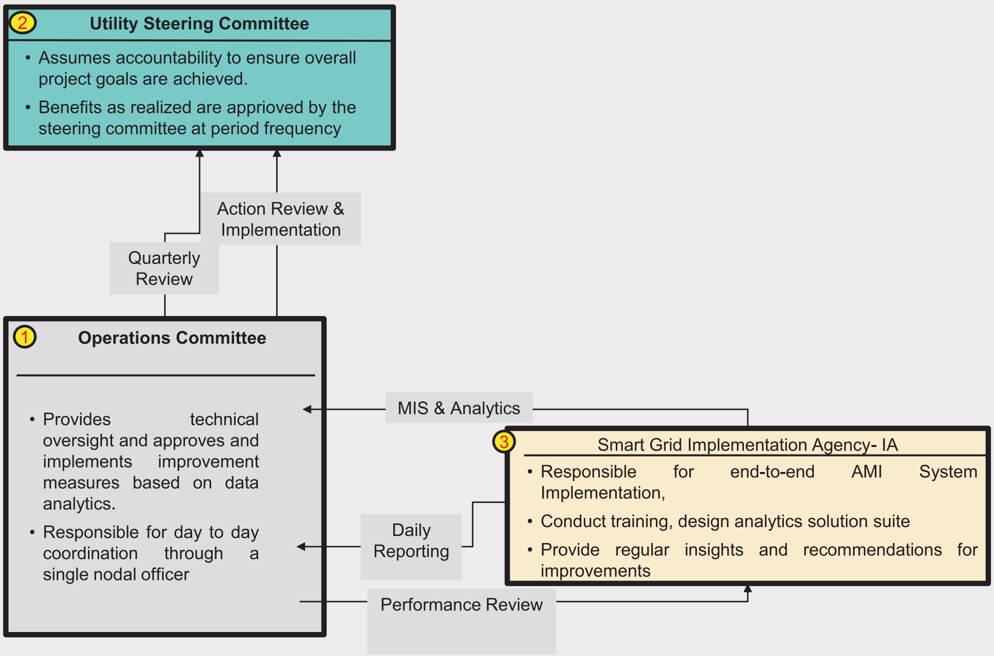
Post project installation and operationalization, a revised/re-calibrated baseline basis Smart Meter data may be developed which would help the utility in accurately measuring and verifying project KPIs.

- **Savings Linked Model - Create detailed, high accuracy baseline through independent third parties, and lay out governance mechanism to resolve conflicts**

However, for enabling savings linked business models and encouraging private investments, utilities need to establish a detailed and high accuracy baseline as prerequisite to support contractual sharing of project benefits with the stakeholders. In order to develop the baseline besides existing data records, physical assessment of infrastructure may also be needed. Utility can also get this developed through independent and competent third parties. In structuring such models, a clear governance mechanism for resolving issues and conflicts also is desirable.

Illustrative Governance Structure for Smart Grid Project Management

A two-tiered possible governance structure (primarily for savings model, but can be adapted for any business model) is presented below.



4.1.4 Innovative Business Model key for investment in Smart Grid Project

In case of pilot projects, the MoP contributed 50% of the capex as grant to the utilities while remaining 50% were to be contributed by the utilities from their own funds. Different business models were observed in case of pilot projects with respect to the 50% share contribution by the states. Some of the cases are highlighted below.

Pilot Utility	Model	Funding Contribution
CESC, Mysore	Equity Contribution	• 50% GoI Grant • 25% CESC • 25% Vendor
Electricity Department, Govt. of Puducherry (PED)	EMI model	• 50% GoI Grant • 50% Vendor - paid in installments over a period of 5 years (60 EMIs)
Tripura State Electricity Corporation Ltd. (TSECL)	State grant to utility	• 50% GoI Grant • 50% Grant by state govt.
HPSEBL and others	Capex Model	• 50% GoI Grant • 50% Utility

With the utilities graduating from pilot projects to implementation of large scale smart grid projects, upfront capex to invest in such project remains a key challenge for the utilities.

It is thus essential to develop innovative business models which can enable large scale implementation of such projects.

- **Select the right fit business model basis current financing and resource availability - Savings or Lease model preferable for cash-strapped utilities**

Various business models can be adopted by utilities going forward, each having its own risks and considerations. These are discussed below.

Business Model	Model Description	Considerations
Capex Model	• A part of the payment made on the supply of material • Remaining amount structure over the project deployment and operations, generally in equal monthly installments	• Payment terms linked to implementation milestone and pre-defined Service Level Agreements (SLAs) • Detailed Bills of Quantity (BOQ) to be determined at tender stage
Savings Model	• Minimal/ Zero upfront payment by utility • Payment based on realization of benefits [recovery capped at return expectations of the funding agency]	• Payment terms linked to meeting agreed project saving KPIs • Requires creation of utility governance structure with nominated officials for decision making and monitoring of project • Payment terms to consider timely installation • Should have clearly defined and agreed baseline and M&V methodology
Lease Model	• Payment over a specified tenure on a per consumer per month basis • Features of the lease model can also be structure with capex, and/or saving models to bring elements of other models also. As an example, for the recent Smart Meter procurement by EESL, its investment recovery from utilities in UP and Haryana is in form of lease payments over the project lifecycle (10 years)	• Payment terms to consider timely installation and meeting of defined equipment SLAs • Detailed BOQ may not be required for tendering however need to be specified for reference and use

Utilities may decide to adopt aforementioned models basis their own unique characteristics, financial and risk appetite.

4.1.5 Cost-Benefit Analysis provides a clear basis of evaluating business and consumer benefits

Model Smart Grid regulations issued by the Forum of Regulators (FOR) with technical support from USAID PACE-D TA Program, states that a comprehensive cost benefit assessment of smart grid projects is pre-requisite for regulatory approvals. This provides a clear basis of taking up such projects, and helps build confidence among stakeholders (both private and public) on the usefulness of the investments.

- **Adopt standard cost-benefit methodology to establish clear business case for Smart Grid functionalities**

With experience of pilot projects, it is now important to establish a standardized cost-benefit methodology that can model in different technologies, business model assumptions, benefit areas and existing area conditions to provide a detailed economic assessment to provide clear understanding of the benefits to the utility, consumers, regulators and investors alike. Insights provided by the analysis can therefore be used to justify smart grid investment. In this context, the model developed by International Smart Grid Action Network (ISGAN), as shared by NSGM Project Management Unit (NPMU) team can be a good beginning point for initial set of Smart Grid projects.

Further more, a standard methodology can enable a national level assessment of the cumulative impact of Smart Grid investments and help policy makers refine the strategy with respect to encouraging investment in smart grid technologies in India.

CBA- International Good Practice

In many parts of the world, particularly in US and Europe, policy makers/regulators have developed standard Smart Grid cost benefit assessment methodology. These methodologies/ tools have been used by individual utilities and countries alike to assess the financial and economic impact of different Smart Grid technologies and undertake business decisions based on the assessment results.

In 2011, Electric Power Research Institute (EPRI, USA)[4] released a report (titled "Guidebook for Cost/Benefit Analysis of Smart Grid Demonstration Projects" in 2011, and Revision 1 in 2012) on step-by-step process for estimating the costs and benefits associated with smart grid demonstration projects. The report consisted of a 24-step procedure that established an experimental demonstration framework for impact measurement followed by methodologies for monetizing impacts to support the benefit side of a Cost-benefit analysis.

In 2011, the Joint Research Center (JRC, European Commission) carried out the first comprehensive collection of smart grid projects in Europe to perform a qualitative and quantitative analysis of past and currently active projects to extract results, trends and lessons learned. To complement this work, a comprehensive assessment framework of smart grid projects centered on a cost-benefit analysis (CBA) was proposed under the publication

[4] Source: 'Guidebook for cost/benefit analysis on Smart Grid demonstration project', EPRI, 2012

CBA- International Good Practice

"Guidelines for conducting a cost benefit analysis of smart grid projects", released in 2012. Moreover, this CBA methodology was tested on "InovGrid", a Smart grid project implemented by Portuguese distribution operator.

JRC's CBA framework consists of ten guidelines covering four main macro-steps namely tailoring to local conditions, Cost-benefit analysis, Sensitivity analysis and Qualitative Impact analysis. The first step concerns with definition of assumptions, critical variables and boundary conditions tailored to the specific geographical/regulatory context. Afterwards Cost-benefit analysis is performed which entails baselining, identification and monetization of benefits, quantification of costs etc. Sensitivity analysis is performed next in order to analyze the influences of key variables on the CBA. Lastly, CBA is integrated with qualitative assessment of the merit of the deployment, externalities and social impact.

4.1.6 Comprehensive design of Peak Load Management and customer participatory schemes to ensure commercial success and customer buy-in

Projects required a clearer objective and a definite plan for PLM implementation: The existing Smart Grid pilots have envisaged significant benefits from Demand Response programmes. For example- Demand Response (DR) comprises of majority share of benefits to the tune of 85% and 87% in a couple of smart grid pilots. However, most of these projects have not formulated a comprehensive PLM/Demand response scheme for implementation in project area. The regulatory filings remain to be completed.
Specifically, some key factors for the lack of progress on PLM implementation include:

- Lack of detailed consumer load studies to identify PLM opportunities and schemes
- Changing peak requirements (states now moving from power deficit to power surplus state) has meant that utilities no longer envisage PLM related benefits as estimated at DPR stage
- Demand response programmes are currently perceived as a tool for load reduction and not as a tool for better load management and flattening of load curves. Demand Response programmes are, however, beneficial for both power deficit and surplus situations and can be designed accordingly to ward off capital investment or flatten load curves

Without implementation of such schemes large portion of benefits envisaged from the implementation of smart grid projects may not be achieved.

- **Establish clear PLM use case and include key design characteristics at planning stage**

With experience from the pilots, it is now imperative that future projects establish a clear use case and action plan for implementing the PLM scheme of choice at the DPR stage itself. In this context, some key program design characteristics that utilities should consider at planning stage includes:

- **Target customer:** Before implementing the DR program, the utility must decide on the customer category where it wants to implement the DR program, i.e. residential, commercial or industrial category. Selection of target customers depends on the potential savings, ease of managing the program and the load profile of customers
- **Assessment of load profile of different utility area:** This includes assessment of load contribution by target customer category and local balancing needs of the selected area
- **Identifying hours of need:** Identify time periods when a DR event can be implemented would involve identifying the level and periods of overdrawal by the state utility and study of local project area demand conditions
- **Cost-Benefit assessment** of the PLM scheme

CBA- International Good Practice

Tata Power Delhi Distribution Ltd. (TPDDL)[5] implemented utility-level Automated Demand Response (ADR) with smart meters for its high end commercial and industrial consumers in the year 2014 as part of its Smart Grid project. The objective of the DR program was to manage peak demand and to manage grid stress situation and thus ensure better reliability of power supply to the customers.

- For the project, TPDDL enrolled 161 Commercial and Industrial (C&I) consumers. These consumers entered in agreement with TPDDL for enrolment after detail auditing of their connected loads and business process
- The enrolled consumers are intimated four hours in advance through SMS or email for participation in DR event called with option of opt out through return SMS or email reply
- Only an aggregated pool of non-critical resources identified at consumer end is shaved or usage time of non-critical load is shifted through DR event created by utility operator and the balance supply of consumer is not affected
- As for program results, maximum load shifting/shaving of 7.2 MVA and average of 5.09 MVA was achieved against a sanctioned load of 63 MW through 17 DR events conducted in FY 2014-2015 which demonstrated significant benefits of implementing DR at the utility level

Jaipur Vidyut Vitran Nigam Ltd. (JVVNL)[6] undertook a DR program to showcase the benefits for scaling up such projects across Rajasthan and the country. The stages under the DR program included:

- **Pre-DR:** activities included industry survey, customer enrollment, baseline methodology, DR event decision and lastly infrastructure development
- **During DR:** activities included DR bidding and trigger activities
- **Post-DR:** activities were composed of M&V of program performance and customer's incentives calculation

[5] BEE, 'TPDDL ADR & AMI Project'. [Online]. Available: https://beeindia.gov.in/sites/default/files/ctools/G%20Ganesh%20DasWorkshop.pdf

[6] BEE, 'Demand response pilot project for JVVNL Discom, Jaipur, India'

4.1.7 Regulatory Readiness for Smart Grid implementation

Regulatory decisions impact the overall savings and improvements due to Smart Grid investments, recovery of these investments through different modes, provision of incentives and penalties to promote adoption of new and innovative use cases by the utilities and protection of consumer interest. Dynamic and flexible regulation is hence needed to evolve Smart Grid.

- **Facilitation of Regulatory Investment Approval**

  Regulatory facilitations can come in various forms for example:

  - Supportive tariff structure such as Time of Day (ToD), Time of Use (ToU), etc.
  - Procedures for specific applications such as remote disconnect and brownout

Haryana Electricity Regulatory Commission Order on Remote Disconnect and Brownout[7]

The Haryana Electricity Regulatory Commission (HERC) has passed an order based on the petition received by it for seeking approval for Peak Load Management (PLM) through remote disconnection and through brown out concept through advanced Smart Grid technology on pilot basis in Panipat sub-division.

The final regulatory order allowed remote disconnection and connection for load violation only for feeders where quality of supply disruptions (voltage drop by 6 percent) is expected. The details of the regulatory provisions include:

- If maximum demand > the sanctioned load, then an alarm will be sent on consumer mobile/in home display system
- If the maximum demand is > 10 percent of sanctioned load, supply to be automatically disconnected for 5 minutes interval and thereafter reconnected automatically
- This will work for three instances of violation. For further violations, meter lock out period shall be 15 minutes for 4th and 5th instance and 30 minutes after the 5th instance

The functionality shall be evoked only on those feeders on which a consumer faces voltage drop of 6 percent or more in order to maintain the reliability and quality of supply as per the voltage regulation (± 6 percent) defined in the standard of performance.

The order allows for implementation of brown out in cases of overloading/partial availability of supply for preventing blackouts. The order also calls for adequate awareness of consumers is required as part of implementing the functionality.

  - Requiring utilities to include consumer engagement and participation initiatives: emphasize the need for having a clear strategy for consumer involvement as part of Smart Grid program proposal

[7] Final Order, HERC/PRO-58 of 2014, 16-Dec-2015

To facilitate timely approval of Smart Grid investments, the following could be considered:

- Including clear cost benefit analysis covering all stakeholders including consumers and prosumers in the DPRs
- Aligning of Smart Grid investment approval process with the current existing capex approval project through development of a Multi-year smart grid plan. These plans could be evaluated on the basis of the objective that the national and state level roadmaps have set to achieve for themselves
- Outlining specific aspects and areas where regulatory approval is required. In some cases, advance announcement of specific schemes or procedures could also be considered

In order to provide regulatory impetus to Smart Grid investments, model Smart Grid regulations have been approved by the Forum of Regulators in 2015. These model regulations provide a framework for SERCs to support smart grid investments in the state. Several of the SERCs have already adopted these regulations.

4.1.7 Detailed Budgeting for minimizing variances between expected/approved price and market discovered price

Large variances between approved cost and bid cost observed in pilot projects: In a number of pilot projects it was observed that there was significant cost variation in financial bids vis-à-vis approved budgets, which led to delays in awarding of the project. The range of variation in some of the projects varied from 70% to > 200%. Some of the suggestions in this regard include:

- **Adopt cost benchmarks based on discovered prices from competitive bidding**
- There was significant variation in unit rate of Smart Meters and Software assumed in DPR and actual bids.

Meter	Total Sanctioned Cost (Rs./Meter)	Range for Cost of Meter (Rs./Meter)[8]	Range of Variation
Single Phase Meter[9]	3500	5000-6000	43%-70%
AMI Three Phase whole current smart meter[9]	7000	10000-12000	43%-70%
AMI Three phase LT CT meters with/without control[9]	7000	12000-15000	70%-115%

- **Similarly, conservative estimate for Smart Grid Data Centre software was another reason** for high financial bids

Smart Grid Data Centre	Budget Estimated in DPR	Range Of Actual Estimated Budget
Software[9]	2-3 Crores was the estimated cost for softwares in some of the DPR's with minimal magnitude of difference with respect to functionalities	Ranges from Rs. 6 Crores – Rs. 20 Crores depending upon the functionalities

[8] PACE-D TA program market analysis

[9] However, the price discovered recently through competitive bidding of large quantity of Smart Meter for the EESL tender has substantially reduced and has even been lower than the sanctioned cost. For example, Single phase Smart Meter prices have now come down to ~ INR 2500/ meter

This variation was primarily driven by the fact that Smart Grid being a new/emerging domain at the time of pilot conceptualization, appropriate market benchmark rates were not available.

Nevertheless, with the maturity of the current market, benchmarking exercise must be undertaken for finalizing the budget and it should be based on current market prices (identified through price discovery from recent competitive bidding or through market surveys) and not on expectation of outcomes.

- **Undertake detailed Bill of Quantity (BoQ) assessment for the project area and supplement the same with rate contracts to accommodate reasonable variations**
- All required hardware, software and services may fully be accounted for while preparing for the budget. **Some of the services were to be provided for separately by the utilities and were not fully reflected in DPR** accounted for ~ 15% of the total cost of the pilots. This included the following:

Project Cost Heads	Additional cost as % of project cost[10]	Remarks
Project Management/System Integration	5%-7%	Depending on the scale of pilot
FMS	5%-6%	Depending on the no. of years required
Training	1%-2%	Depends on the quantity required and man hour rates
Bandwidth Charges/Communication Expenses	4%-5%	

Therefore, contingency cost must account for such variations[11] and the budgeting exercise should incorporate detailed BoQ assessment covering all hardware, software and service requirements to minimize variation of discovered price vis-a-vis budgeted price. Additionally, the provision of inclusion of rate contracts for legitimate and reasonable variations, especially in view of load growth etc. must be accommodated.

4.2 BID STAGE

4.2.1 Supplier capability/manufacturing capacity to cater to domestic smart meter market needs to be assessed

Many of the pilot projects were either delayed or had to be cancelled due to delays in manufacturing or supply of Smart Meters by vendors as per requisite specifications. A number of factors contributed to this delay, including:

[10] PACE-D TA Program Market Analysis.

[11] As part of NSGM projects, a 15% provision Project Management and Consultancy is being provided.

- Unavailability of Smart Meter conforming to specified technical standards – leading to testing failures, re-design/ customizations and in some cases changing of meter vendor

With expected scale up of smart meter deployment, the existing capabilities of the smart meter suppliers needs to be assessed for supplying the expected volumes in the desired timeframe.

- **Mechanism to attract proven Smart Meter providers including global vendors and mitigate supply risk**

Apart from national vendor assessment, states can intervene by adopting enabling provisions in contracts so that vendors with proven capability are selected. With growth in Smart Metering market in India and globally, the new tenders can enable a stronger financial and experience requirement for critical areas of AMI infrastructure, including allowing experienced global players to participate.

Innovative procurement methodologies may be adopted to hedge the risk of supply failure/delays. For e.g. in the recent EESL Smart Meter tender, procurement policy included awarding proportional order quantity for L1, L2 and L3 level bidders at the agreed L1 cost.

4.2.2 System integration with the legacy systems key to avoid cost overruns

Commercial considerations and process deficiencies of legacy system a key challenge for Smart Grid integration: The smart grid pilot projects which are at advanced stages of implementation have faced challenges in integrating Smart Metering data with R-APDRP billing systems. Further, there have been additional challenges in updation of legacy system to enable mass updation of system data with replaced Smart Meter data. Some of the challenges have been due to:

- Contractual commercial challenges with existing R-APDRP vendors
- Additionally, the meter installation and replacement process requires system to be updated with new data. The current legacy system is designed such that batch updation of new data takes far longer to complete than it takes to replace meters on ground. This significantly delays the time for using Smart Meter data for billing

- **Clearly define system interface requirements with legacy system in bidding documents**

To avoid this going forward, a number of steps should be taken by the utility at the planning stage:

- **RFP should clearly define the interface requirement** for both sides of the system (Smart Grid and legacy system) to enable transparency and clarity for integration process
- **Changes in integration/ legacy system processes should be identified in planning stage** and should be included in the RFP. This will enable vendors to plan and prepare/ customize systems to enable smooth integration
- **Separate BoQ item for any additional system requirement for integration of new and legacy systems** should be included as part of the contract document to avoid commercial issues at the implementation stage

4.3 PROJECT IMPLEMENTATION

4.3.1 Testing facilities for smart meters needs to be scaled up for improving operational efficiencies

Delay in type testing of smart meters has been one of the key reasons for extension of the overall meter installation timelines for the pilot projects. This delay can be attributed to:

- Lack of clear standards at the time of pilot inception and
- Limitations of labs facilities in handling multiple requests

In some cases, time expended in completion of type testing of smart meters at labs was more than 6 months of duration.

Going forward, Smart Meters are expected to be deployed at much larger scale which could significantly increase the time for testing with capacity constraints of existing labs.

- **Scale-up of testing labs in India, upgradation of utility metering testing infrastructure and creation of dedicated testing window for vendors can optimize the entire testing process**

There is a need to increase smart metering testing infrastructure in the country. Although the current landscape has improved significantly with clarity on Smart Meter standards and consequent approval of new labs for Smart Meter testing, further scaling up of such facilities is essential. Currently, Smart Meter testing facilities are available at 8 locations at Central Power Research Institute (CPRI), Electronic Regional Test Laboratories (ERTL), Electrical Research and Development Association (ERDA) and Yadav Measurements Pvt. Limited (YMPL). Some of the other initiatives which could be initiated include:

- **Upgradation of in-house testing labs of utilities:** With the increased emphasis on large scale deployment of smart meters, utilities are required to upgrade their meter testing facilities for testing of smart meters
- **Creation of dedicated testing window:** The new labs can be utilized to create dedicated Smart Meter testing windows during which every vendor would be required to submit Smart Meters for type test. This will provide much needed clarity of schedules and resource requirement to labs and would ensure vendor readiness before project implementation

4.3.2 Interoperability

End-to-end interoperability is one of the key missing link in the AMI system definition and lack of clarity on interoperability has been a key concern cited by utilities in implementation of large scale AMI projects.

Interoperability is crucial to prevent vendor lock-in of any distributed system. Successful outcomes from development of interoperable standards can accelerate technology adoption by reducing costs and investment risk. On the other hand, lack of interoperability could hinder investment, restrict synergies, cause expensive redesigns and thus limit the eventual benefits of the Smart Grid.

In many parts of the world, particularly in US and Europe, Smart Grid interoperability has seen extensive research and different approaches have been taken to design Smart Grid interoperability standards. In many of such cases, utilities and a pool of vendors have formed alliances to develop open interoperable standards which prevent vendor lock-in and address a global market for Smart Metering.

- **Strategic guidance by policymaker for coordinated development of Interoperability standards required to avoid vendor lock-in**

In view of this consideration, a systemic intervention is required at the policy level for identification of gaps in currently available standards and development of roadmaps/ approaches which can serve as guiding documents for utilities.

Global Models for Achieving Interoperability

Interoperability in the European model has been achieved by development of in-house standards by utilities and creating an ecosystem of manufacturers who conform to the standards. For example, this ecosystem in Spain is created through the PRIME alliance by Iberdrola. Achieving interoperability at all levels, i.e., System, Meter and Data Concentrator level has been a key factor in bringing down cost of Smart Meter. Prices of Smart Meters have fallen more than 50 percent from their 2010 levels with different meter vendors fighting for the share in a competitive market.

In U.S., the National Institute of Standards and Technology (NIST) has the primary responsibility to coordinate development of a framework that includes protocols and model standards to achieve interoperability of smart grid devices and systems[12]. In May 2009, NIST released the initial set of 16 interoperability standards, which addressed a wide range of subjects, including smart meters, distributed generation components, and cybersecurity.

4.3.3 Continued Capacity Building of Utility Personnel

Lack of dedicated and skilled manpower, particularly in IT domain a key challenge for project sustenance and operations: The power sector in India is set for transformational changes with increased digitization and automation leading the change. There is paradigm shift in the focus of traditional utilities from only electrical systems to managing of IT and communication systems. Currently, with Smart Grid being a new domain, multiple pilot projects have a lack of dedicated/ skilled manpower available to manage and maintain such specialized areas. This may lead to delays in implementation of the technology.

The experience from pilots illustrates various contributing factors which necessitate the organization changes. Some of these factors are:

- **Lack of full time multi-disciplinary team:** Utilities have generally appointed nodal officers within the existing organizational structure resulting in additional responsibilities for staff. As most team members are involved part-time, project governance at time becomes a concern. Also, in some of the pilots, nodal officers/team is assigned with responsibilities which require a multi-disciplinary team with specific skills for greater coordination and better decision making
- **Unavailability of full time resources for control center operations:** In order to gain maximum benefits of the system post successful commissioning, dedicated personnel

[12] Source: http://smartgrid.gov/recovery_act/overview/standard_interoperability.html

both at control center and at level of sub-division/ sectional officer are required to continuously monitor and analyze Smart Grid data and take actions accordingly. However, in the current utility scenario, with limited manpower and multiple projects, allocation of dedicated personnel becomes difficult. To address this, some of the utilities have contracted out the O&M services for 1-5 years to the vendor. While this is good to kick start the project, institutionalization of knowledge remains a key challenge

In this context, a multi-pronged approach is necessitated to build the requisite capabilities at utility level to improve efficiency and effectiveness of a Smart Grid system.

- **Utility to plan and recruit for a new IT Cadre to focus on Smart Grid and other ICT initiatives**

Utilities should create a new cadre for Information & Communication Technology (ICT) and Smart Grid departments with separate seniority and line of promotion. This step will help in attracting eligible, dedicated and highly motivated officials, enabling institutionalization of smart grid knowledge within the department. As an example, BESCOM has already created a separate cadre for ICT and Smart Grid in 2015.

IT Cadre in BESCOM[13]

The BESCOM Board approved the creation of a New ICT and Smart Grid Cadre for BESCOM in 2015.

The new cadre focuses on the ICT and Smart grid areas which are strategic to BESCOM's Growth Initiatives. As part of the new ICT & Smart Grid cadre structure, various new positions like DGM (EE)/AGM (AEE)/Manager (AE) have been created.

BESCOM has implemented major ICT initiatives like R-APDRP, MIS, Ganga Kalyana, Enumeration of IP sets, Public Grievances Redressal System (PGRS) – consumer empowerment and Smart Grid Pilot projects. To meet the existing and new upcoming business objectives of the organization, major ICT and Smart Grid initiatives will be taken up by BESCOM in near future. The New ICT and Smart Grid Cadre formed will help BESCOM meet this strategic business goals.

The High level structure includes creation of three Wings headed by CGM (Digital).The three wings are

1. ICT wing (Information and Communication Technologies)
2. Smart Grid Wing
3. Planning and CISO(Chief information Security officer)

- **Identify and allocate multi-disciplinary team for Smart Grid before project implementation**

Utilities should establish a multi-disciplinary team of personnel with complementing skillset for management and operation of smart grid initiatives. This could include team comprising skill set relating to IT, electrical and protection systems, metering and regulatory know-how.

[13]Source: https://bescom.org/wp-content/uploads/2015/09/notification.pdf

Model Smart Grid regulations also mandates the institution of a Smart Grid cell in this respect. Up-scaling of smart grid projects requires creation of dedicated smart grid cells within the utility with the aforementioned multi-disciplinary team.

- **Identify employee training needs and partner with training institutes to continuously enhance employee capacity in Smart Grid**

Apart from project specific trainings, covered as part of the vendor's scope, utility should leverage other avenues of capacity building as well. NSGM in collaboration with USAID has developed a 3-day basic Smart Grid training program for utility professionals. The purpose of the course is to provide professionals with foundational knowledge on Smart Grid technology, planning and implementation. Institutes such as CPRI, NPTI etc. also provides training in the domain of Smart Grid.

4.3.4 Consumer Engagement

Consumer engagement key to unlocking full Smart Grid benefits: One of the key objectives of deployment of smart grid infrastructure is to empower customers and actively engage them in electricity ecosystem. The aim of these applications is to make customers more informed, aware of energy usage and participate in utility programs for mutual benefits.

Many applications of Smart Grid have direct impact on customers. The aim of these applications is to make customers more informed, aware of energy usage and participate in utility programs for mutual benefits.

Smart Grid Application	Customer involvement and benefit
Interval meter data recording	All types of customers whether residential, commercial, industrial receive benefits from this data. Customers can avail the facilities of energy management tools which import usage data to analyze and provide actionable insights. These insights include usage optimization and energy saving tips leading to a value for money scenario for customers.
Remote power connect, disconnect	Customers can choose energy packages according to their needs and utility can manage the connection remotely.
DR/ADR System	Customers will have convenient and multiple options to register for such programs. Customers receive benefits for their participation.
Prepaid Metering	Customers gain control over their energy consumption.
Distributed Generation	Customers can avail benefits of gross or net metering
Customer portal	Customers can avail the benefit of online profile management by getting an accurate near real time view of its usage.

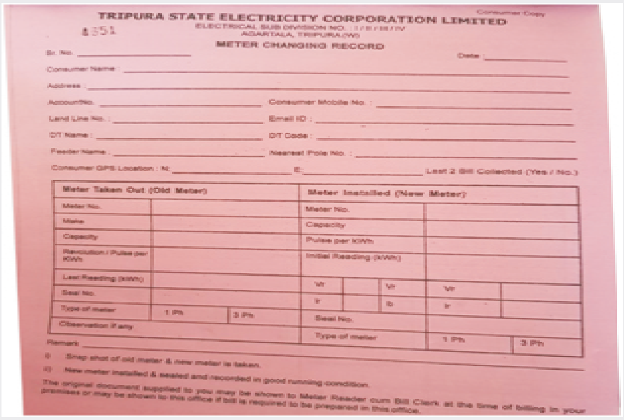
Smart Grid technologies and applications thus have direct influences on customer through various action points namely energy consumption, billing, grievances redressal, power outages etc. Hence, for success of Smart Grid project, effective engagement of consumers is important. Lack of customer involvement may even lead to low participation or decreasing participation over time, leading to failure of Smart Grid project.

Consumer engagement strategies to be strengthened for greater acceptability of smart metering systems: Experience from pilot projects indicates that although no major consumer resistance was observed, a higher level of consumer engagement still needs to be adopted to improve consumer satisfaction and avoid any potential resistance in case of larger roll-out.

Pilot utilities have been able to actively engage consumers in smart metering process and some of these practices are illustrated in the box below.

Pilot Projects – Snippets of Good Practices

- **TSECL-** Apart from following the metering guidelines for installation, TSECL has developed standard formats and templates for smart meter replacement to ensure uniformity and overall monitoring of replacement process. For each installation, 3 copies are taken, one for TSECL, one provided to consumer and the other to the vendor.



TRIPURA STATE ELECTRICITY CORPORATION LIMITED

METER CHANGING RECORD

Sr. No. ______ Date: ______

Consumer Name: ______

Address: ______

Account No. ______ Consumer Mobile No.: ______

Land Line No.: ______ Email ID: ______

DT Name: ______ DT Code: ______

Feeder Name: ______ Nearest Pole No.: ______

Consumer GPS Location: N: ______ E: ______ Last 2 Bill Collected (Yes / No.)

Meter Taken Out (Old Meter)			Meter Installed (New Meter)	
Meter No.			Meter No.	
Make			Capacity	
Capacity			Pulse per kWh	
Revolution / Pulse per KWh			Initial Reading (kWh)	
Last Reading (kWh)			Vr Vr Vr	
Seal No.			Ir Ib Ir	
Type of meter	1 Ph	3 Ph	Seal No.	
Observation if any			Type of meter	1 Ph 3 Ph

Remark ______

i) Snap shot of old meter & new meter is taken.

ii) New meter installed & sealed and recorded in good running condition.

The original document supplied to you may be shown to Meter Reader cum Bill Clerk at the time of billing in your premises or may be shown to this office if bill is required to be prepared in this office.

  TSECL also optimizes installation time at consumer premises by pre-fabricating meter along with the boxes at their facility. This has helped TSECL reduce installation time at consumer premise from 30 minutes to 5/10 minutes.

- **HPSEBL-** Apprehensions were raised by industrial consumers that Smart Meters would result in higher billing. To gain trust of consumers, HPSEBL installed Smart Meters in electrical series with existing meters. Readings from both meters would be compared and once consumer confidence is gained, old/existing meters would be removed.

- **Assam Power Distribution Company Ltd. (APDCL)**[14] has undertaken various consumer engagement activities. These include:
  - o Circulating a notice on Smart Grid Pilot Project and its benefits to consumers on APDCL's website.
  - o Distributing leaflets on various aspects of the project, including its benefits, along with the monthly energy bills to all the consumers of the project

[14] 'Challanges faced in APDCL Smart Grid Pilot project', Anuj Goswami, AGM-APDCL

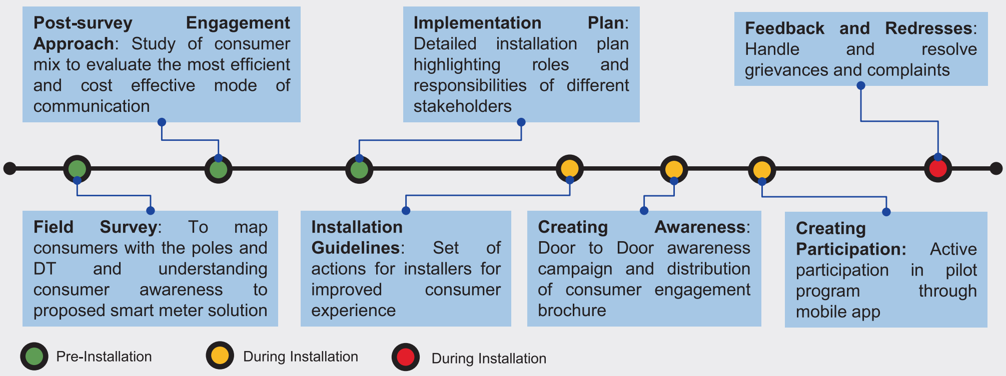
Pilot Projects – Snippets of Good Practices

- o Articles on Smart Grid were published in journals and newspapers in and outside the State
- o Held meetings with consumer groups during meter installation to remove any doubts about Smart meters and Smart Grid among consumers

- **CESC, Mysore-** Consumer engagement programmes have been initiated before roll out of smart meters using pamphlets and public advertisements (in English and local language). A mobile application for consumers has also been developed.

  Workshops with section-wise consumers are also proposed to be conducted at the end of roll out phase to educate consumers on benefits and various aspects of demand response programs.

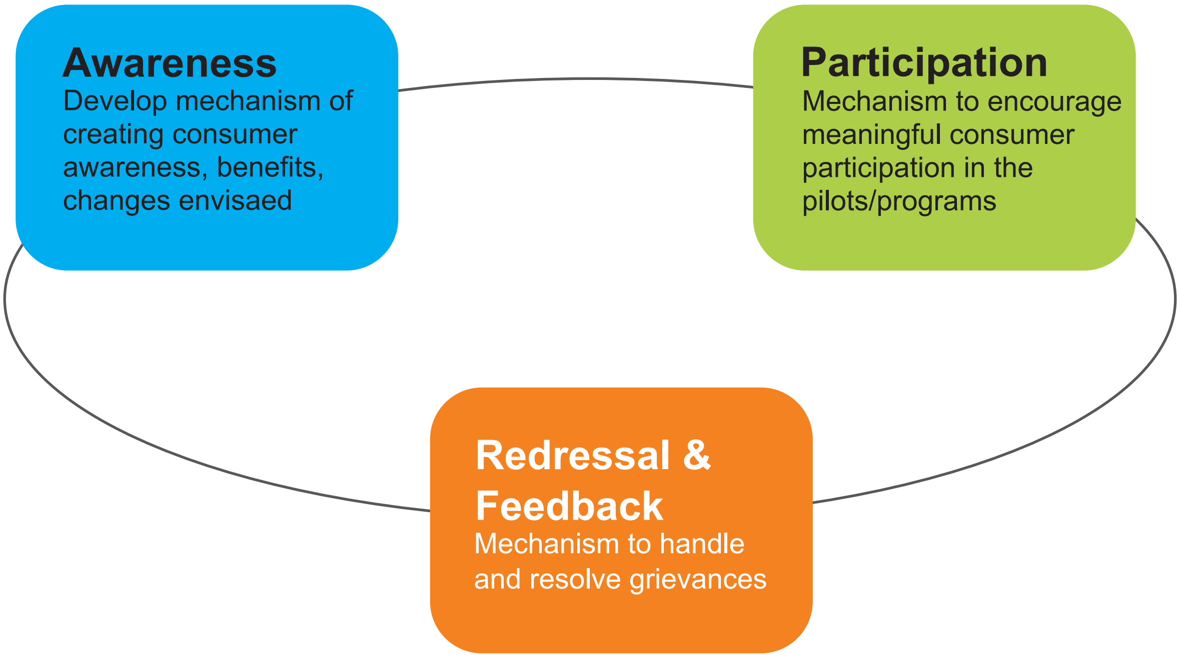
- **AVVNL-** To create a positive consumer experience at all stages of Smart Grid technology deployment, a phase wise consumer engagement strategy adopted. Snapshot of Consumer Engagement strategy was adopted during the pilot project is provided below.



- **Design comprehensive consumer engagement strategy focusing on awareness, participation and redressal**

In many of these consumer engagement activities, the primary objective has been to facilitate smooth installation. However, going forward a more robust and scalable consumer engagement strategy will be required to make customers active participants in the energy system and derive maximum benefits of Smart Grid.

To develop a comprehensive consumer engagement strategy following key elements are identified, which could form the basis of the consumer engagement plan:



Awareness – Creating and disseminating project information to build consumer understanding for the product: Awareness implies providing the right information to consumers at the right time and developing programs and services that provide value to consumers. From the utility's perspective, it means investing time and resources in marketing and education, to ensure that consumers understand and take advantage of the opportunities to participate in the Smart Grid. Some of the key tools and awareness mediums that can be adopted by the utilities include dissemination of educational material in print, computerized calls to customers providing Smart Grid information, social media channels such as Facebook, Twitter, and LinkedIn, publications of white papers, newsletter, etc.

Participation – Involving customers actively in demand side management programs: Full potential of Smart Grid technologies can only be realized if customers effectively participate in programs designed for such purposes. Utilities can incorporate activities in their customer engagement program to increase customer participation for programs such as DR, brownout implementation, net metering, etc., where customer action is required for success of the program. Some of these activities include revamping of utility website, Smart Grid project specific website, organizing meetings with consumer groups/ local community associations, creating energy saving contests, online customer account management, digital communication etc.

Redressal and Feedback- Building trust for efficient implementation: Smart Grid deployment and operation may involve situations like customers dissent to smart meter installation, unsatisfactory service, concerns on privacy and information access, poor complaint resolution and response. It is important to resolve customer concerns especially during the early stages of project, as this could negatively affect the credibility of Smart Grid efforts.
Some of the measures that can be adopted to minimize customer dissent include trained customer service representative, personalized attention to dissented customers groups, strengthening utility framework for complaint redressal etc.

4.4 PROJECT OPERATIONS, MONITORING AND SCALE UP

4.4.1 Selection of Communication technology basis peculiarities of the area selected

Selection of communication technology depends on number of factors such as density of consumers, cost (both upfront and over the life), area surroundings, placement of smart meter etc. The peculiarity of field conditions could be such that not all consumers may get covered by a single communication technology. A number of pilots have faced challenges where some pockets of area have not communicated on selected technology and had to adopt other options. Also, pilot experience reveals requirement of a stabilization period of around 3-4 months post installation to assess and ensure reliable coverage and communication of field data with Meter Data Management Services (MDMS) in line with the defined Service Level Agreement (SLA) requirements.

- **Build flexibility in choice of communication technology to ensure conformity to SLAs and to effectively manage peculiarities of area topology**

Bid documents can incorporate flexibility to include hybrid (mix of communication technology) for the project area. In case of GPRS technology, it is being suggested to keep sufficient flexibility in the bid documents to select any/all of the GPRS provider during project execution depending on the cost, signal and data communication considerations.

In this context, documentation of experience with communication technologies under the existing pilots could be also taken up to understand the performance of different technologies.

4.4.2 Data Analytics

Data analytics and reporting a key capability in Smart Grid value realization: With the adoption of Smart Grid, a number of new data sources are being added into the system that have the potential to provide distinct opportunities to drive increased operational efficiency and reliability, improved customer service, and greatly enhanced customer relationships for the utilities.

While currently most utilities analyse data, mostly historical, on an ad hoc basis through manual entries, spreadsheets and business intelligence reports, Smart Grid data analytics can enable utilities to move to a more pro-active analysis (both descriptive and diagnostic) by incorporating a much higher volume of historical data along with real time data, with more complexity, and analysing it much more quickly. Also, with historical and real-time data at hand, utilities can now look to predictive and prescriptive analytics for building real value to mitigate potential problems before they arise.

Table: Analytical model categories for Smart Grid

Analytics Model	Description
Descriptive	What happened or what is happening now?
Diagnostic	Why did it happen or why is it happening now?
Predictive	What will happen next? What will happen under various conditions?
Prescriptive	What are the options to create the most optimal or high-value outcome?

Some of the key value opportunities that exist with implementing smart analytics capabilities include:

- **Improved revenue optimization and operational efficiency:** Insights on thefts, reduction in billing errors, accurate energy accounting, timely detection of faults and control, better system-wide resource planning etc.
- **Improved grid reliability and load management:** Insights (including predictive analytics) on demand, weather, outage location, etc. lead to better grid operations management, including reduced outages and reduced faster recovery from grid outages
- **Asset Management (Repair, maintenance and replacement):** Advanced analytics, including predictive maintenance strategies can be employed to improve uptimes, performance and availability of crucial assets while reducing the amount of unscheduled maintenance to minimize maintenance-related costs and disruptions of the operation
- **Improved customer satisfaction through segmentation and personalization:** Data analytics will enable the utility to provide its customers with information about their usage patterns and target them with more effective demand response and demand-side management programs that enable energy cost savings for the customer.
  Personalized services and marketing campaigns for consumers as well as analysis of credit history of consumers to improve collections can also be enabled
- **Integration of renewable and distributed generation:** Data analytics in a distributed generation environment enables improved forecasting of load and consequent impact on the grid thereby enabling better renewable energy integration with grid operations

For building advanced analytics solutions and dashboard one of the key elements that the utilities now need to focus on is bringing in organization focus on data analytics and build capabilities in areas of data science/ advanced statistical techniques.
Further, another foundational block of bringing in smart analytics is of defining reporting structure for data capturing from the perspective of information adequacy/ visibility across departments and user interface creation. In many of the pilots, it has been observed that these reporting requirements were generally lacking and only planned for at the start of operationalization, which required additional time considerations and customizations at the time of implementation.

Therefore, to capitalize on the benefits that result from Smart Grid, utilities must address the lack of analytical talent present in organizations today and the barriers to data sharing and reporting across silos.

- **Define basic data reporting formats at bid stage**

A minimum set of data report formats and dashboards may be included as part of bid requirement covering the basic reporting requirements.

- **Enable provisions to include advanced analytics vendors as project partners**

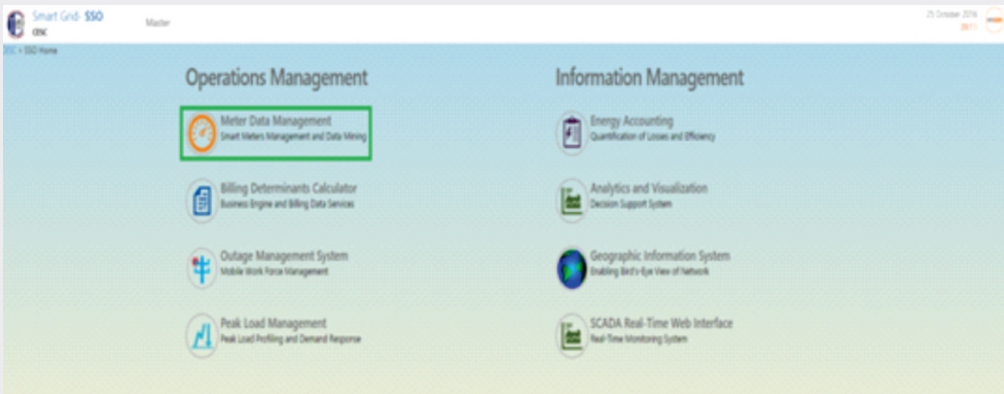
Further, utilities need to leverage specialized firms, which are expert in data mining and data sciences to generate meaningful insights- including predictive and prescriptive analytics, forecasting and optimization - from the vast amount of project data and assist the utility managers to facilitate improvement/ savings on a regular basis. For long term, however, utilities may consider establishing an analytic center of excellence

Pilot Projects – Snippets of Good Practices

- **TSECL-** Apart from customizing the analytical dashboard, TSECL with support from USAID also defined a set of 21 standard analytical reports at the time of project implementation for incorporation by the vendors

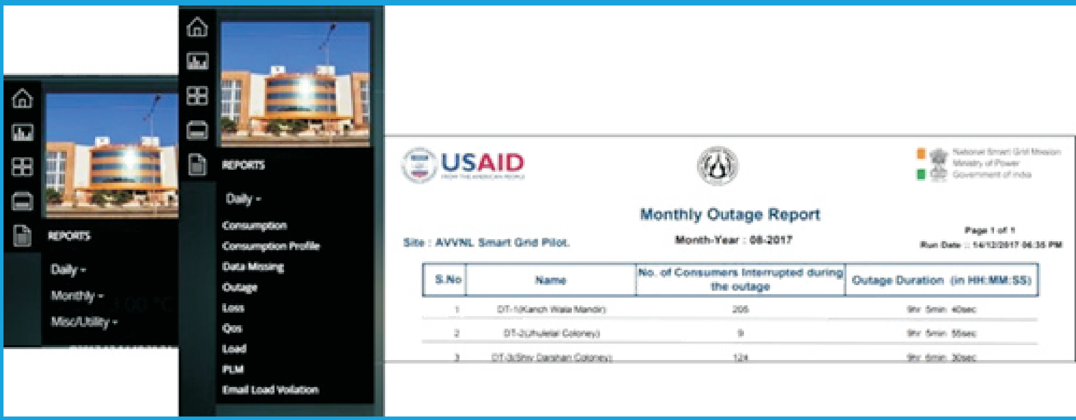
Report No.	Report
1	Daily Loss Report - DT Level
2	Daily Loss Report - Feeder Level
3	Daily Loss Report - Substation Level
4	Daily Loss Report Summary - Subdivision level
5	Daily Energy Account Report - Division Level
6	Daily Loss Exception Report - Subdivision level
7	Daily Communication Failure Report - Subdivision Level
8	Daily Meter Abnormality Monitoring Report - Subdivision Level
9	Monthly Meter Abnormality Monitoring Report - Subdivision Level
10	Daily Supply Abnormality Report - Consumer Level
11	Daily Outage Report - DT Level
12	Daily DT Load Status Report - Subdivision Level
13	Monthly DT Load Status Summary Report - Subdivision Level
14	Daily DT Peak Load Report - Subdivision Level
15	Monthly Consumer Peak Load Violation Report - Subdivision Level
16	Monthly Consumption Profile Report - Consumer Level
17	Management Summary Report - Loss Reduction
18	Management Summary Report - Loss Exception
19	Management Summary Report - DT and Feeder Overload
20	Management Summary Report - Outage Monitoring
21	Management Summary Report - Monthly Supply Abnormality

- **CESC, Mysore-** CESC has implemented detailed dashboards with features like load forecasting, consumer profiling, consumption pattern analysis, and theft detection analysis using smart meter & Transformer Monitoring Unit (TMU) data.



- **AVVNL -** In order to provide real-time data and exception reporting on a user friendly interface, an online web-based dashboard and set of standardized smart meter data report formats were prepared. The dashboard was designed to monitor critical parameters like low power factor, phase imbalance, load exceeding by consumers and provide instant health check of the entire distribution system for optimizing, improving and near future planning

Pilot Projects – Snippets of Good Practices



An Emerging Area :
Data Analytics Innovation- providing authorized access to third parties

The power sector consists of multiple participants comprising generation, transmission and distribution utilities, and system and market operators. In order to ensure effective functioning of the sector, these entities have to communicate with each other to maintain information flow, scheduling data flow, operational data flow, commercial data flow etc. At the distribution level, smart meters will provide huge volumes of data that will need to be analyzed and processed for meaningful decision making. This includes:

- Energy accounting analysis including analysis of consumption patterns, identifying anomalies in trends
- Customer behavior analysis
- Analysis of DT loading
- Analysis of outage location and magnitude of an outage
- Power demand analysis
- Analysis of quality and reliability of supply including voltage fluctuations, surges

Several of the above analysis is today increasingly possible through more efficient methods and techniques. Some of these are listed below:

- **Robotics Process Automation (RPA):** RPA mimics how a user would interact with an application utilizing the same User Interface (UI) as a human. These bots are able to execute high volumes of standardized, rules-based, repetitive tasks. For utilities there are some clear areas of automation that RPA can improve – meter reading, billing analysis, processing customer payments, other back office tasks, etc.

Further, with new Smart Grid software, RPA can also help bridge the gap between old and new systems. RPA can handle the data management aspect including receiving and sending all of that information to where it needs to go.

Data Analytics Innovation- providing authorized access to third parties

- **Artificial Intelligence (AI) and Advanced Statistical Methods:** Advanced Statistical Methods including AI techniques can be employed by utilities companies are implementing AI technologies around, predictive or prescriptive analytics and machine learning. As one example, AI offers a solution to demand management problem by using predictive algorithms to decide when to store or release energy to balance grids and to accurately estimate the production and consumption of small- scale producer-consumers.

4.4.3 Data Privacy

Data privacy concerns with Smart Grid: The real time data captured through Smart Grid technologies has the potential to improve efficiencies and drive down losses, but also transform the way consumers use electricity. The granular level, near real time consumer data can be utilized to provide innovative products and services which can enable energy savings. However, with this level of customer energy data combined with personally identifiable information available with utility, sharing and processing of such information needs to consider the growing issue customer privacy.

Balancing innovation with data privacy: However, it is also important that while protecting data privacy, utilities do not adopt a no-access/ sharing policy, which would in turn thwart innovations and forgo the many benefits that are likely to be ensue to customers, businesses and operators of the electricity grid. The grid must encourage innovation and make electricity usage available to customers and businesses all while respecting consumers' personal privacy and security. Methods to anonymize personal data from electricity usage data already exist. Utilities can anonymize or aggregate the data, possibly over several users to be large enough to ensure privacy and make it highly improbable to link the data to an identifiable individual

- **Incorporate guidelines and practices to identify and protect personally identifiable information**

The key for protecting privacy of information is determining whether data is or is not personally identifiable information (PII). Classification of consumer data can be done at two levels:

1. **PII**, which consists of consumer names, addresses, numbers, and other information that specifically identifies the person or entity to which it applies; and
2. **Consumer-Specific Energy Usage Data (CEUD)**, which, in most cases, does not identify an individual consumer but includes detailed information about the utility service provided to the consumer

Based on this classification, the utilities can set guidelines that can protect PII. Solutions include aggregation, encryption and steganography.

Smart Grid Privacy Guideline – U.S. Experience[15]

A number of Smart Grid privacy guidelines have now been developed around the globe as well. As a good practice, a U.S. DOE report on protecting consumer privacy prescribes the following principles for data privacy protection

- **Privacy by design:** Utilities should incorporate substantive privacy protections into their practices, such as data security, reasonable collection limits, sound retention and disposal practices, and data accuracy.
- **Data minimization and limited retention:** Utilities should limit data collection to that which is consistent with the context of a particular transaction or the consumer's relationship with the business, or as required or specifically authorized by law. In addition, personal information should be kept only as long as is necessary to fulfil the purposes for which it was collected. When no longer necessary, consistent with data retention and destruction requirements, the data and information should be irreversibly destroyed.
- **Data security:** Utilities should maintain comprehensive data management procedures throughout the life cycle of their products and services.
- **Simplified choice:** For practices requiring choice, companies should offer the choice at a time and in a context in which the consumer is making a decision about his or her data. Companies should obtain affirmative express consent before using consumer data in a materially different manner than claimed when the data was collected; or collecting sensitive data for certain purposes.
- **Transparency (Notice and Access):** Privacy notices should be clearer, shorter, and more standardized to enable better comprehension and comparison of privacy practices. The notice should provide a detailed description of all purposes for which consumer data will be used, including any purposes for which affiliates and third parties will use the data, and how long the data will be maintained.

4.4.4 Measurement and Verification (M&V)

Continuous monitoring of project essential to track project benefits and take corrective actions: M&V process entails documenting and measuring the parameters effecting the performance of the project, and subsequently understanding the basis of these effects and identifying ways to improve project performance.

With proper coordination and planning, M&V activities provide operational verification, i.e., confirmation that the smart grid functionalities are operating as intended during the performance period and allows fine-tuning of measures throughout the year based on operational feedback, and avoids surprises at the end of the year.

[15] 'Protecting consumer privacy in an era rapid change', FTC, U.S. 2012

The role of M&V is all the more important in Smart Grid projects which are capital intensive and stakeholders are intrinsically motivated to determine their return on investments. The main purposes why M&V is particularly to:

- Demonstrate and capture the value of smart grid and investments by providing a framework for calculating the benefits before and after the implementation of projects
- Improve the project by encouraging continuous monitoring of performance
- Provide indicators and tools to assess the project's replicability and scalability
- Increase the project benefits due to accurate determination of savings by valuable feedback on the project operation and facility

Although, a number of utilities had defined Key Performance Indices (KPIs) based targets and baseline aligned with the goals of pilot in the project DPR, no plan for continuous monitoring of project parameters was developed. Post defining of baseline and KPIs, utilities need to develop a comprehensive M&V plan.

- **Define the approach for gauging the benefits or performance metric indicators of Smart Grid**

The M&V plan should lay out the evaluation resource allocation, benefit parameters, methodology for benefit evaluation and periodicity of the exercise.

- **Incorporate documentation and reporting through periodic report, alerts, compliance and risk report**

The M&V process will provide feedback and corrective recommendations to project implementers in time for the project to benefit from those recommendations. Structured periodic reports should support project progress tracking and highlight issues identified during M&V activities.

- **Review and Rectify basis data from M&V**

Based on the documented information and data from M&V, decide whether the project is on track or course-correction measures are required through a collective decision by the key stakeholders.

SECTION 5
CONCLUSION

Smart Grid is transforming existing distribution grids to become more efficient, greener, self-healing, reliable and less constrained. Effective execution of Smart Grid requires meticulous planning from the beginning of the project. The smart grid project life cycle can be categorized into planning, bid development, implementation and operations, monitoring and scale up.

Planning stage includes prioritizing of Smart Grid objectives and functionalities and drawing up of a smart grid roadmap detailing a phased wise approach. Once the roadmap is defined at the utility level, careful selection of area, effective baselining and ring fencing of project area becomes important. Smart Cities/IPDS towns provide opportunities to leverage existing IT and physical infrastructure for Smart Grid implementation. As utilities graduate from pilot projects to large scale implementation of Smart Grid projects, use of innovative business models such as lease model, saving models etc. becomes key for obviating the need for upfront capex by utilities. Detailed cost-benefit analysis is another aspect that not only provides for establishing clear business case but also facilitates necessary regulatory approvals.

Bid development stage requires incorporating adequate mechanisms to attract proven smart meter providers both at national and global level to mitigate supply risk and consequent delays due to vendor capacity constraints. Upfront identification of system interface requirements with the legacy system can aid scope clarity to both existing and prospective vendor and avoiding cost over runs at the implementation stage.

Implementation stage involves installation of smart meters at consumer premises and hence development of consumer engagement strategies focusing on awareness creation, participation and redressal mechanisms becomes key to unleash full smart grid benefits. Delay in type testing of smart meters has been one of the key reasons for extension of the overall smart meter installation and requires adequate focus in terms of simultaneous scale up of such lab infrastructure vis-à-vis increased deployment.

Operations, Monitoring and Scale up stage involve continuous monitoring of project benefits/metric indicators to track project benefits and mid-course correction. Data Analytics and reporting are expected to provide numerous insights to utilities for improving operational and financial efficiencies. Creation of dedicated team with multi-disciplinary skills for undertaking large scale deployment of smart grid by the utilities is an over-arching requirement.

In summary, these insights gathered from the experience of various pilot projects provide immense value to all stakeholders for scaling up smart grid projects in the country. Specifically, utilities planning for large-scale Smart Grid initiatives may consider these learnings as a checklist while designing and implementing projects.

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