सत्यमेव जयते

National Smart Grid Mission
Ministry of Power
Government of India

NATIONAL SMART GRID MISSION IMPLEMENTATION FRAMEWORK

August 2018

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TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

LIST OF ACRONYMS

Acronyms	Definition
AD	Accelerated Depreciation
AMC	Asset Management Contract
AMI	Advanced Metering Infrastructure
AMI-I	Advanced Metering Infrastructure - Industrial Consumer
AMI-R	Advanced Metering Infrastructure - Residential Consumer
AMS	Advanced Metering Solution
APDRP	Accelerated Power Development and Reforms Program
APDCL	Assam Power Distribution Company Ltd.
AT&C	Aggregate Technical and Commercial
AVVNL	Ajmer Vidyut Vitran Nigam Ltd.
BEE	Bureau of Energy Efficiency
BESS	Battery Energy Storage System
BESCOM	Bangalore Electricity Supply Company
BIS	Bureau of Indian Standards
CAIDI	Consumer Average Interruption Duration Index
CAIFI	Consumer Average Interruption Frequency Index
CBCU	Capacity Building and Communications Unit
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CESC	Calcutta Electricity Supply Corporation Ltd.
CMDs	Chairman and Managing Directors
CMU-SEI	Carnegie Mellon University Software Engineering Institute
C&I	Commercial and Industrial
Cr	Crore
CSP	Concentrated Solar Power
DCC	Data and Communications Company
DG	Distributed Generation
DISCOM	Distribution Company
DPR	Detailed Project Report
DR	Demand Response
DRUM	Distribution Reform, Upgrades and Management
DSM	Demand Side Management
DMS	Distribution Management System
ECBC	Energy Conservation Building Code
EE	Energy Efficiency
EESL	Energy Efficiency Services Limited
EPC	Engineering, Procurement and Construction
ESCOs	Energy Service Companies
EU	European Union
EV	Electric Vehicle
FOR	Forum of Regulators
GHG	Greenhouse Gas
GIS	Geospatial Information Systems
GISS	Gas Insulated Sub-station
GW	Gigawatt
GWh	Gigawatt hour
HPSEB	Himachal Pradesh State Electricity Board
HTS	High Temperature Superconductor

Acronyms	Definition
IBM	International Business Machines Corporation
ICSU	Information and Cyber Security Unit
ICT	Information and Communications Technology
IEA	International Energy Agency
INR	Indian Rupee
IPDS	Integrated Power Development Scheme
ISGF	India Smart Grid Forum
ISGTF	India Smart Grid Task Force
IT	Information Technology
IUN	Intelligent Utility Network
JV	Joint Venture
KWh	Kilowatt hour
LED	Light-emitting diode
MAIFI	Momentary Average Interruption Frequency Index
M&E	Monitoring and Evaluation
MNRE	Ministry of New and Renewable Energy
MOP	Ministry of Power
MOU	Memorandum Of Understanding
MD	Maximum Demand
MRV	Monitoring, Review and Verification
MSEDCL	Maharashtra State Electricity Distribution Company Limited
MW	Megawatt
MWhr	Megawatt hour
NEMM	National Electric Mobility Mission
NEMMP	National Electric Mobility Mission Plan
NEP	National Electricity Policy
NIST	National Institute of Standards and Technology
NMEEE	National Mission on Enhanced Energy Efficiency
NPCL	Noida Power Company Ltd.
NPMU	NSGM Project Management Unit
NPV	Net Present Value
NSGM	National Smart Grid Mission
O&M	Operations and Maintenance
OMS	Outage Management System
OT	Operational Technologies
PACE-D	Partnership to Advance Clean Energy – Deployment
PED	Puducherry Electricity Department
PGCIL	Power Grid Corporation of India Limited
PLM	Peak Load Management
POP	Prioritized List of Programs
POPR	Prioritized List of Projects
PoS	Prioritized List of Standards
PPMU	Project Planning and Monitoring Unit
PPL	Prioritized List of Policies
PPP	Public-Private Partnership
PQ	Plant Quality
PSU	Public Sector Undertaking
PSPCL	Punjab State Power Corporation Ltd
PV	Photovoltaic
R&D	Research and Development
R-APDRP	Restructured Accelerated Power Development and Reforms

Acronyms	Definition
	Program
RD&D	Research, Development and Demonstration
RE	Renewable Energy
REC	Renewable Energy Credits
RFP	Request for Proposal
R&M	Repairs and Maintenance
ROI	Return on Investment
RPO	Renewable Portfolio Obligations
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
SDA	State Designated Agencies
SECF	State Energy Conservation Funds
SERC	State Electricity Regulatory Commission
SG	Smart Grid
SGKC	Smart Grid Knowledge Centre
SGM	Smart Grid Maturity
SGMM	Smart Grid Maturity Model
SLPMUs	State Level Project Management Units
TA	Technical Assistance
T&D	Transmission and Distribution
TOD	Time of Day
TPPDL	TATA Power Delhi Distribution Ltd.
TRANSCOs	Transmission Companies
TSU	Technology and Standards Unit
TSECL	Tripura State Electricity Corporation Ltd
TSSPDCL	Telangana State Southern Power Distribution Company Ltd
UGVCL	Uttar Gujarat Vij Company Ltd.
UHBVN	Uttar Haryana Bijli Vitran Nigam
UJALA	Unnat Jyoti by Affordable LEDs for All
USAID	United States Agency for International Development
US	United States
USD	U.S. Dollar
UT	Union Territory
WAMS	Wide Area Monitoring Systems
WBSEDCL	West Bengal State Electricity Distribution Company

National Smart Grid Mission

IMPLEMENTATION FRAMEWORK

Module 1
NSGM INSTITUTIONAL STRUCTURE

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MODULE 1: NSGM INSTITUTIONAL STRUCTURE

1. INTRODUCTION

1.1. SMARTGRID

SmartGrid involves millions of consumers, generators, a large number of service providers and a variety of energy resources with varying controllability (Figure 1). This requires a great deal of intelligence, two way communication, automation, distributed local controls, self-configuring and self-healing capabilities to be built in the grid.

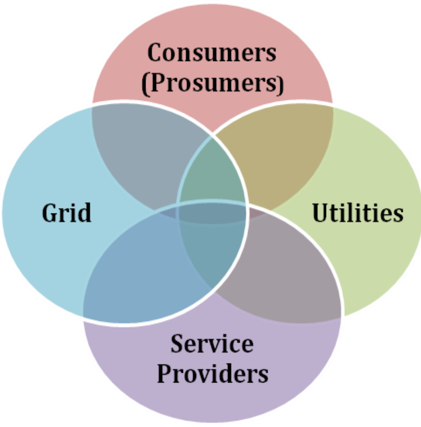

Figure 1: Key SmartGrid constituencies[1]

1.2. NATIONAL SMART GRID MISSION

Considering the need for transition of the grid into SmartGrid, a Vision and Roadmap of Smart Grid for India was approved by the Ministry of Power (MOP) in August 2013. The roadmap document envisaged the National Smart Grid Mission (NSGM) to plan, support and monitor the implementation of the SmartGrid policies and programs in the country.

The NSGM became a reality in 2015, functioning under the aegis of MOP, to plan and monitor implementation of policies and programmes related to smart grid activities in India (OM dated 27th March 2015[2]). Subsequently Guidelines for implementation of NSGM were issued vide OM dated 18th November 2015[3].

At the time of creation of NSGM, it was envisaged that a detailed 'NSGM Framework for Implementation' document will be prepared covering important areas facilitating smart grid implementation in the country. Accordingly the following recommended implementation framework has been envisaged in the present document for NSGM:

- Vision, mission, goals and institutional structure.
- Policy and standards framework.
- Business models.
- Monitoring, review and verification framework.

[1] Devices within consumer premises will become part of the smart grid in future.
[2] OM at NSGM website (http://nsgm.gov.in/sites/default/files/NSGM%20Office%20Memorandum.pdf)
[3] OM at NSGM website (http://nsgm.gov.in/sites/default/files/NSGM%20Implementation%20Guidelines.pdf)

1.3. SMARTGRID VISION AND MISSION STATEMENTS

Vision Statement

"Transform the Indian power sector into a secure, adaptive, sustainable and digitally enabled ecosystem that provides reliable and quality electricity for all with active participation of stakeholders".

Mission Statement

"Enable on-demand access and availability of affordable reliable quality power for all with optimal mix of conventional and renewable energy (RE) sources."

1.4. PRINCIPLES FOR NSGM INSTITUTIONAL STRUCTURE

Considering the SmartGrid features and aligning them with the NSGM vision and mission, the following broad principles for the NSGM institutional structure have been identified:

- Open consultation, collaboration and involvement amongst various stakeholders.
- Flexibility to create, pilot and implement new concepts, technologies and business models.
- Digitally-driven architecture for management and communication.
- Integration of expertise, experience and resources across number of institutions and programs, national as well as international to evolve appropriate standards, policies, research and development and capacity building initiatives.

Thus, the NSGM is expected to act as a catalyst to facilitate the adoption of SmartGrid technologies and standards by utilities, after initial demonstration of technologies and enabling business models to support public, private capital flows to scale-up SmartGrid deployment.

2. NSGM GOALS

The SmartGrid goals originate from the NSGM's vision and mission statements and are aligned with the national power sector priorities and commitments as communicated by different ministries.

The SmartGrid goals are related to Discoms SmartGrid rollout. These are expected to be achieved by the actions of the NSGM and other ministries and institutions. The SmartGrid goals to be achieved by 2025 (co-terminus with Finance commission) are defined as medium and long term targets to be achieved during two phases.

2.1. SMARTGRID ROLLOUT GOALS

The NSGM will plan, design and support the rollout of the SmartGrid in the country. At the state level, the NSGM will focus on establishment of State Level Project Management Units (SLPMUs), capacity building and developing preparedness for effective implementation of SmartGrid. The NSGM will facilitate formulation of state/utility specific SmartGrid roadmap, regulations and implementation plan.

At the utility level, the NSGM, through state SmartGrid cells, will engage with key stakeholders to ensure that they have the required structure and plans in place for successful implementation of SmartGrid.

The NSGM goals relating to SmartGrid rollout are distributed in two phases and are expected to be achieved by 2025 (Table 1). The goals are prescribed for the following SmartGrid aspects:

- **SLPMUs:** The NSGM will provide support for the establishment of SLPMUs and will work with the state units to develop the respective state's SmartGrid regulations and roadmaps, etc.
- **Utility Level Actions:** Apart from building the capacity of utilities (that are reflected in the utility maturity score), the NSGM will coordinate with SLPMUs to facilitate the actions at the utility level. The NSGM will ensure that the utilities establish a SmartGrid cell as per the guidelines and develop respective SmartGrid roadmaps. Further, it will also facilitate the formulation of requisite utility level policies.
- **Utility Preparedness:** Specific to SmartGrid rollout, the NSGM will focus on utility preparedness and ensure that the utility's capacities are developed to equip them technologically, and have policies and processes in place to launch and support the SmartGrid intervention. To measure the utility's maturity, a standard Smart Grid Matrix can be used[4].
- **Advanced Metering Infrastructure (AMI):** AMI is the basic building block for SmartGrid implementation as this facilitates a real time two-way communication between the consumer and the utility. This is critical for efficient flow of information between the utility and the consumer for decision making and ensuring service quality.

[4] *NSGM may develop* a maturity level framework for utilities to assess their readiness for implementing smart grid in their respective areas of operation

- **Network Mapping and Consumer Indexing:** Mapping of network and consumer indexing are important aspects of SmartGrid intervention as it supports AMI installation, energy demand forecasting and outage management, among other things.
- **Distribution Automation/Supervisory Control and Data Acquisition (SCADA):** The automation of the distribution system function includes planning, construction, operations and maintenance (O&M) of the power system and interaction with the end-users as an essential function for achieving the comprehensive benefits offered by SmartGrid. SCADA/Distribution Management System (DMS) shall be implemented along with sub-station automation in select areas for achieving comprehensive benefits associated with SmartGrid.
- **Microgrids and renewable integration:** Country-wide microgrids rollout as a strategy for increasing access to electricity and energy generation from small-scale RE projects will also be facilitated by the SmartGrid. In this regard, it is expected that all utilities will gain experience in RE microgrid projects (capacity ≤1 megawatt [MW]) within a stipulated timeframe.
- **Electric vehicle**: SmartGrid deployment encourages the adoption of EVs allowing bidirectional energy exchange between the EVs and the grid. The National Electric Mobility Mission Plan (NEMMP) works on the expansion of electric mobility by supporting recharging infrastructure and related policies. Goals related to the utilities are gaining adequate tools, experience and expertise to successfully participate in the NEMMP.

2.2. DEFINING MILESTONES FOR SMARTGRID ROLLOUT

The goals are defined considering the current status and maturity of the power sector, grid and its constituents in the country. Global benchmarks and norms for SmartGrid implementation are also considered for identifying the milestones.

Table 1: NSGM goals relating to SmartGrid rollout

Goals Relating to SmartGrid Rollout	Phase I Up to 2020	Phase II 2020-2025
1. SLPMU- actions (number, percentage of utilities taking action)		
1.1 SLPMU units	100 percent	
1.2 SmartGrid regulations	100 percent	
1.3 SmartGrid roadmap formulation		100 percent
2. SmartGrid - utility level actions (number/percentage of utilities taking action)		
2.1 SmartGrid Cell formation by utilities	100 percent	
2.2 SmartGrid Roadmap preparation by utilities		100 percent
3. Utility preparedness (Number of utilities with target maturity level, total number of utilities)		
3.1 Preparation of Maturity level framework	By 2020	
3.2 Assessment of Utilities as per Finalized Framework / self-assessment	100 Percent	
4. AMI		
4.1 Utility's having AMI experience[5]	10	100 percent

[5] AMI experience is a required condition for SmartGrid rollout.

Goals Relating to SmartGrid Rollout	Phase I Up to 2020	Phase II 2020-2025
4.2 AMI rollout in all towns[6]	25 number	100 percent
5. Network mapping and consumer indexing		
5.1 Number of utilities with network mapping and consumer indexing (live and updated)	100% (Urban)	100 percent (Rural)
6. Distribution automation		
6.1 Distribution automation (SCADA/DMS)in Urban census towns with population as per IPDS		100 percent
7. Microgrid and renewable integration		
7.1 Utilities with institutional capabilities to manage renewable integration	10	100 percent
7.2 Utilities having the technological capabilities to manage local generation and microgrid projects (at least demonstration project implementation by utilities)	10	100 percent
8. Electric Vehicles		
8.1 Utilities with technological capabilities to deploy EV Infrastructure	10	100 percent

[6] National Tariff Policy, 2016 suggests 100 % coverage of AMI for consumers with consumption of 200 units per month by 2019. 100% AMI target is prescribed to ensure that consumers benefit from SmartGrid interventions.

3. INSTITUTIONAL STRUCTURE OF NSGM

This section describes the institutional and governance mechanism of the NSGM, based on the guidelines provided by the MOP through various Office Memoranda.

3.1. NATIONAL SMARTGRID GOVERNANCE

In line with the Office Memorandum dated March 27, 2015 [7], NSGM will support implementation of the following activities.

- Assistance in SmartGrid project formulation, including project feasibility analysis, technology selection, cost benefit analysis and financial models, etc.
- Funding support to such projects, along with utilities and other financial institutions.
- Training and capacity building support of SLPMUs, utilities and other Project implementation Teams.
- Technology selection guidelines.
- Facilitation of consumer awareness.
- Project-approval to post implementation evaluation.

The Office Memorandum also describes the institutional structure for the NSGM. A modified version of the institutional structure is provided in Figure 2. The key elements of the NSGM governance structure are described below.

3.1.1. GOVERNING COUNCIL

The Governing Council is responsible for administrative and financial procedures, annual budget, review of implementation of NSGM programs and policies. Headed by the MOP, the Council will meet on a half yearly basis and will have full functional and financial autonomy. The key functions of this top body are:

- Approval of SmartGrid implementation programs and policies in the country.
- Approval of administrative procedures and financial procedures as well as the annual budget of NSGM.
- Review of implementation of NSGM's programs and policies.
- Facilitating audit process and adoption of the audited accounts.

3.1.2. EMPOWERED COMMITTEE

The Empowered Committee is the second tier body in the NSGM structure headed by the Secretary, MOP. The detailed functions of this body are:

- Providing policy inputs to the Governing Council.
- Approval of specific SmartGrid projects, guidelines and monitor their implementation.
- Approval of procedures for allocation of funds and recruitment of consultants.
- Approval of detailed structure, powers and guidelines of NSGM for its smooth functioning.

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[7] MOP. (2015). *Office Memorandum: National Smart Grid Mission (NSGM).* New Delhi: Ministry of Power, Government of India

- Approval of resource mobilization from other sources like multilateral agencies or financial institutions for meeting financial requirements over the budgetary allocation etc.

Joint Secretary (Distribution) at MoP is the Nodal Officer leading the Mission with Support of Director, NPMU and will act as a Convener and Member Secretary of the Governing Council as well as Empowered Committee

National Smart Grid Mission

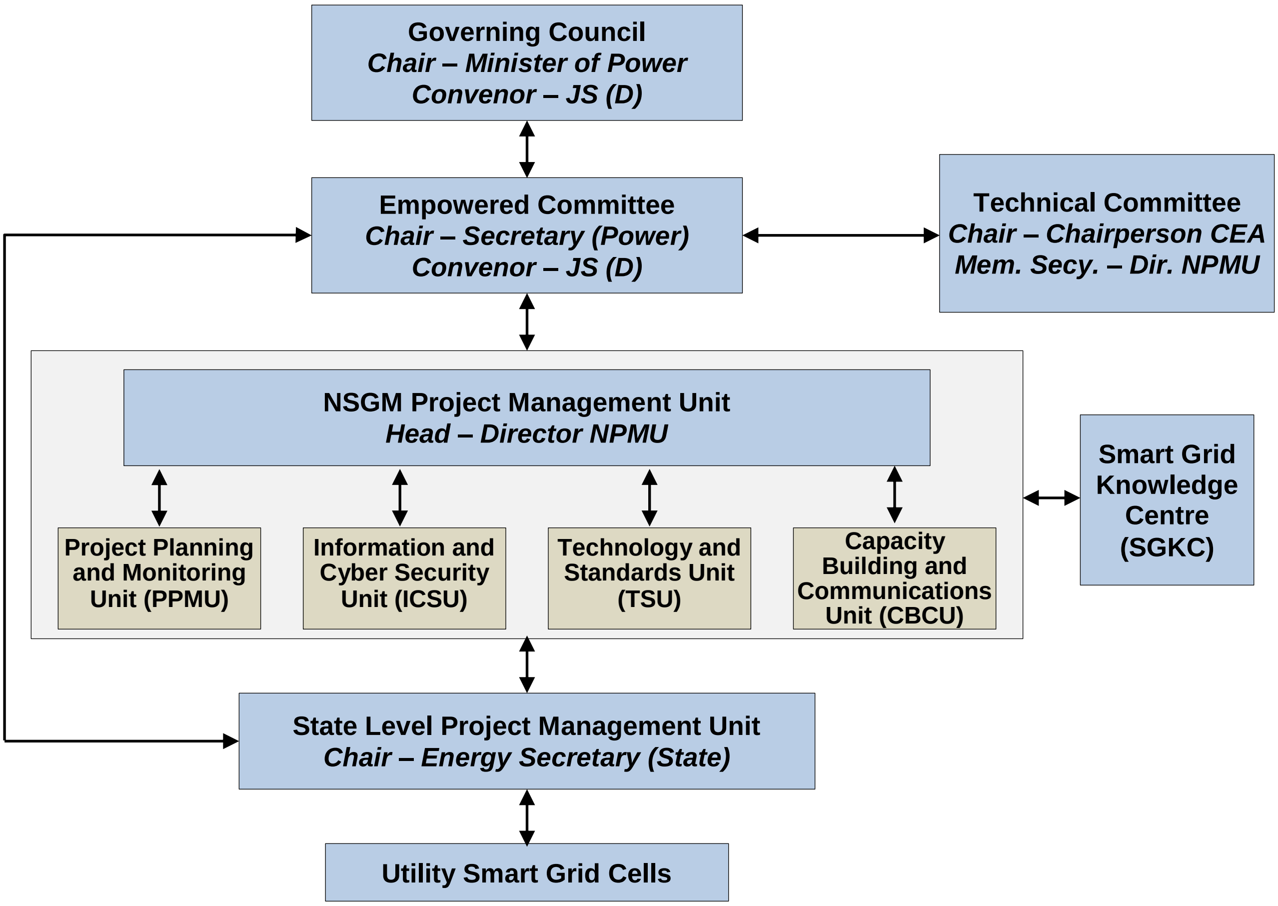

Figure 2: Proposed governance system of NSGM

3.1.3. TECHNICAL COMMITTEE

The Technical Committee is an independent body providing technical support to the empowered committee and is headed by the Chairperson, Central Electricity Authority. This committee will meet as per the requirement but at least once a month. It will provide advice and technical assistance in the following areas:

- Standards development, technology development and technology selection.
- Review of projects or documents submitted by the NSGM.
- Training and capacity building.

3.1.4. NSGM-PMU DIRECTOR

The NSGM-PMU Director would lead the NSGM-Project Management Unit (NSGM-PMU) and is responsible for its day-to-day functioning and reports on all the activities to the Empowered Committee through JS (Distribution), MoP Director , NSGM-PMU will also be a

Member of Governing Council and Empowered Committee and Member Secretary of Technical Committee.

3.1.5. NSGM-PMU

The four operational units of NPMU--Project Planning and Monitoring Unit (PPMU), Information and Cyber Security Unit (ICSU), Technology and Standards Unit (TSU), and Capacity Building and Communications Unit (CBCU)--are responsible for the NSGM's day-to-day operations. These four units will ensure implementation of SmartGrid activities under the guidance of Director, the Empowered Committee and the Governing Council.

3.1.6. SMART GRID KNOWLEDGE CENTRE (SGKC)

The SGKC, being developed by Power Grid Corporation of India Limited, will be a resource centre for providing technical support to the NSGM.

3.2. STATE LEVEL GOVERNANCE ARCHITECTURE

Similar to the national level, SLPMUs are proposed to be established to deliver the NSGM goals at the state level. The state level SmartGrid functions will be delivered through a two-tier mechanism and will be led by the SLPMU, and the projects will be executed through the utilities. Utility level SmartGrid cells will be formed to assist the utilities develop and execute their respective SmartGrid plans and projects.

4. BUDGET

The NSGM budget has been developed to support mission operations for three years (coterminous with 14th Finance Commission). Post this period, budget need assessment shall be undertaken in line with EFC proposal. The costs are estimated for mission establishment and operations, consumer engagement, capacity building and SmartGrid developments.

The NSGM budget constituents include:

- **SmartGrid Projects:** NSGM will extend direct financial support to the utilities to facilitate their participation in the SmartGrid program.
- **Micro Grids:** NSGM shall facilitate development of micro grids in medium sized pockets (areas where power is not available for more than 8 hours) to balance the demand
- **Training and Capacity Building:** NSGM shall facilitate training and capacity building to utility personnel for accelerating SmartGrid deployment. Funding for SGKC is also considered
- **NSGM Establishment and O&M etc.**: The operations and maintenance of NPMU, staffing costs etc. are covered.

The NSGM will support SmartGrid projects (it is projected that the mission would support 10projects viz. 6 (incl. 4 ongoing) projects in Year 1, 2 projects in Year 2 and 2 projects in Year 3). NSGM will provide a 30 percent grant support to each of these projects.

Working with the private and public sector entities will help in providing partial financial support for time bound project/product specific R&D work of such entities. The demand for R&D requirement will be generated as the SmartGrid program matures.

A detailed annual budget (for three years) is provided in the table below. The financials of the NSGM for next three years up to FY 2019-20 is in line with the EFC proposal made coterminous with 14th Finance Commission period. The three year financial outlay for NSGM's planned activities is estimated to be INR 990 Crores with a budgetary support of INR 312 Crores.

Table 2: Budget summary of NSGM (INR Crores)

Sl.	Activity	Outlay	Budgetary Support	FY 2017-18	FY 2018-19	FY 2019-20
A.	Development of 10 Smart Grid Projects (incl. 4 Ongoing Projects)	938	281 (30% grant)	63	136	82
B	Development of Micro Grids in Medium Sized Pockets	30	9 (30% grant)	2	3	4
C	Training and Capacity Building incl. Funding to SGKC and Consumer Engagement etc.	7	7 (100% grant)	1	3	3
D	NSGM Establishment and O&M etc.	15	15 (100% grant)	3	5	7
	Total	**990**	**312**	**69**	**148**	**97**

5. NPMU OPERATIONAL UNITS

This section describes the processes and outputs of each of the NPMU operational units in order to achieve the NSGM goals. The operational units will be responsible for the day-to-day operations of NPMU. The units will have requisite manpower as well as other necessary resources for the management and operation of NPMU.

Each of four units--PPMU, ICSU, TSU, and CBCU--has specific focus and goal to be achieved during the SmartGrid implementation. To achieve this, the units will have to interact internally (within the NPMU with other units) and with entities outside the NPMU. The process steps and linked outputs for each of the units are identified and described in the following sections (Internal process details will be developed/finalised in due course).

5.1. PROJECT PLANNING AND MONITORING UNIT (PPMU)

PPMU will be responsible for SmartGrid programs and policies development and will also be entrusted with a Monitoring and Evaluation (M&E) role of the executed projects. The specific roles of the unit include:

- Develop the NSGM framework including design, goals, timelines, and utilities maturity maps.
- Undertake program-related tasks such as design of program, baseline setting, program goals, evaluation mechanism, budgetary support, financing architecture, etc.
- Provide policy development support for SmartGrid including model policy design, stakeholder consultation, draft policy review, etc.
- Manage project pipelines. Its scope includes receiving project proposals, and facilitating approval of the projects with necessary budgetary support. It will also set baselines, project goals, and project evaluation criteria.
- Carry out M&E of the project by appointment of a Third Party Independent Evaluation Agency (TPIEA) either by Nomination or by Selection under the overall guidance of Empowered Committee. The TPIEA would gather the project-related data and generate M&E reports after review and analyzing the same as per requirements.
- An impact assessment Report will also be generated by TPIEA which will act as a feedback for the Smart Grid projects and provide relevant inputs for implementing Smart Grid projects in future.
- Take responsibility for reporting. All analysis and reports on the mission progress will be developed by this unit. A dashboard will be developed and managed by this unit on the NSGM portal, with national, state, utility and program level information.

A brief on the process steps and outputs for the PPMU is provided in Table 3.

Table 3: Process steps and outputs for PPMU

Process Steps and Inputs (External Flows)	Outputs
SmartGrid Plan Rollout	• SmartGrid Roadmap (for the country and state) • NSGM Framework • State Smart Grid Annual Plans
Develop SmartGrid Programs Inputs: Technology and Standards; Information and Cyber Security; Capacity Building and Communications Unit	• Prioritized list of programs • Program baselines and design documents • Policies, standards required for Smart Grid • Program dashboard • Program finance plans • Project documentations and review reports
Policy development support	• Prioritized list of policies & priorities • Policy note inputs • Participation in Working Group Constitution
Support Rollout of State and Utility	• assessment of utilities on Maturity Matrix • Prioritized list of projects • State, utility level dashboards
Facilitate Project Implementation Inputs: Smart Grid Knowledge Centre; Information and Cyber Security	• Project proposals and approvals and consolidations • Project RFP, DPR appraisal and monitoring plans • Program dashboards • Project completion assessments and review reports
Develop Annual Plans and Budgets Inputs: Technology and Standards Unit; Information and Cyber Security; Capacity Building and Communications Unit	• Develop annual plans and budgets for planned activities

5.2. NFORMATION AND CYBER SECURITY UNIT (ICSU)

This unit will deal with software-related aspects of SmartGrid projects and provide inputs for formulating strategy for development of standards for functional interoperability and cyber security etc. to CERT-Distribution and NCIIPC. The Unit will also be responsible for the following aspects of the NPMU:

- Develop a standard information system architecture that can be used for the deployment in all utility SmartGrid programs.
- Provide design and quality assurance support for the implementation of SmartGrid systems and processes in the utilities.
- Facilitate review of operational SmartGrid systems by utilities and provide diagnosis and improvement solutions.
- Facilitate development of strategy for formation of common data center for optimization of resources as well as secure and reliable database under the guidance of Technical Committee and Empowered Committee.

A brief on the process steps and outputs for the ICSU is provided in Table 4.

Table 4: Process steps and outputs for ICSU

Process Steps and Inputs (External Flows)	Outputs
Develop Standard Smart Grid System Framework ↑ Project Planning and Monitoring Unit	• NSGM- Smart Grid system
Identify List of Smart Grid Standards	• List of information communication
Support Project Implementation ↑ Project Planning and Monitoring Unit	• Program design • Review of project proposals • Standard RFP Document • Project completion assessment report
Support Review of Smart Grid system	• System performance review reports • Revised system specifications
Provide Centralized Data	• Collect and facilitate data management at central level
Develop Annual Plans and Budgets	• Inputs to PPMU for annual plants and budgets for planned activities

5.3. TECHNOLOGY AND STANDARDS UNIT (TSU)

This unit will facilitate the development of standards, establishment of test benches, research, development and demonstration programs, and learning from experiences across the globe in collaboration with SGKC, CEA, BIS, CPRI & CBIP. It will also set up a collaborative relationship with international standard bodies, research institutions and centers of excellence.

A brief on the process steps and outputs for the TSU is provided in Table 5.

Table 5: Process steps and outputs for Technology and Standards Unit (TSU)

Process Steps and Inputs (External Flows)	Outputs
Develop Overall Technology Architecture of Smart Grid ↑ Project Planning and Monitoring Unit	• NSGM- SG Technology Architecture
Participate in development of Smart Grid standards ↑ Project Planning and Monitoring Unit	• Prioritized List of Standards • Working Group Constitution, Standards Acceptance Criteria • Publishing standards information on NSGM Website • Review of Standards (if required)
Develop Research, Development and Demonstration (RD&D) for Smart Grid Technologies ↑ Project Planning and Monitoring Unit	• Prioritized List of RD&D • Dashboard for the prioritized list of RD&D • Smart Grid RD&D Project Review Reports
Develop Facilities for Testing and Certification	• Prioritized list for testing • Test bed elements • Certification framework
Establish International Collaborations for RD&D, Testing and Standards ↑ Smart Grid Knowledge Centre	• List of institutions and programs for SG collaboration • Joint review reports with the collaborating institutions
Develop Annual Plans and Budgets	• Inputs to PPMU for annual plans and budgets for planned activities

5.4. CAPACITY BUILDING AND COMMUNICATIONS UNIT (CBCU)

This unit is aligned with the mission of the National Skills Foundation and also contributes to the promotion of green jobs in the country. The activities of this unit include:

- Design of SmartGrid curriculum and training programs, and delivery through other partner institutions, as well as online learning resources.
- Establish alliances and international collaboration for capacity building.
- Support training and certification of professionals.
- Develop programs for consumer awareness.
- Operate as an outreach arm of the NSGM through web and other media.
- Release a monthly, half-yearly and annual bulletins and magazines regarding activities carried out by NSGM and SmartGrid activities in the country.

A brief on the process steps and outputs for the CBCU is provided in Table 6.

Table 6: Process steps and outputs for CBCU

Process Steps and Inputs (External Flows)	Outputs
Develop Framework for Outreach and Communication with Stakeholders ↑ Project Planning and Monitoring Unit	• Outreach and communication plan • NSGM portal management
Develop Capacity Building Program ↑ Project Planning and Monitoring Unit	• NSGM capacity building framework • Identify potential institutions for delivery of programs, start discussions, MOUs • Smart Grid curricula, course modules etc.
Establish International Collaborations for Capacity Building	• Partnership development with institutions and programs for Smart Grid capacity building collaboration • Joint review reports with the collaborating institutions
Support Capacity Development for Utilities	• Utility level capacity building programs • NSGM portal dashboard
Develop Annual Plans and Budgets	• Inputs to PPMU for programs and annual budget

6. STAFFING PLAN FOR NPMU

For a time bound delivery of the SmartGrid goals, the NPMU will need to have in place staff with the requisite qualifications and experience. The NPMU may deploy a variety of engagement approaches to ensure that appropriately qualified resources are available. The suggested approaches include:

- Recruit officers on deputation/secondment from other Government/PSU entities, etc.
- Engage consultants on short and long term contracts.
- Assignment/deliverable-based contracts with consultants and organizations.

NPMU Director: A Director will spearhead the NSGM-PMU, which will be the implementing agency for operationalizing the smart grid activities in the country under the guidance of Governing Council and Empowered Committee.

Unit Heads: Each of the four NSGM-PMU units will be led by officials selected from the Public Sector Undertakings (PSUs) or other relevant government agencies from the power sector, on deputation basis. The unit heads will be responsible for the delivery of respective unit level goals. The unit heads, led by the Director, will work as an overall “Top Management Team” for the NSGM-PMU.

Sector Advisors: Identified experts with established expertise, experience and sector specific network will be chosen on time-based contracts or on honorary basis to shape and guide the program for each unit.

Unit Staff: The unit staff will support the unit heads for delivery of specific unit functions. Experienced officials will be brought on deputation from power sector PSUs or government ministries.

Sector Consultants: Consultants may be used for specific onetime and short term assignments and deliverables. Such tasks may require diverse or specialized set of skills, which may not require resources on a continuing basis. Demand for sector consultants will be generated by the respective unit heads.

Support Staff: A common pool of resources will be hired / contracted to support the office functions of the NSGM-PMU such as accounting, secretarial functions, IT including management of the NSGM portal, human resource management, public relations, etc.

The proposed NSGM-PMU organogram, suggested staff numbers and their qualification are shown in Figure 3. NPMU would require a total of 18 personnel during the initial phase. The staffing plan required is as per the EFC proposal and establishment OM. It should be noted that the present staffing requirement is estimated for the initial phase of the mission. As the program expands, the mission may require additional resources for delivery.

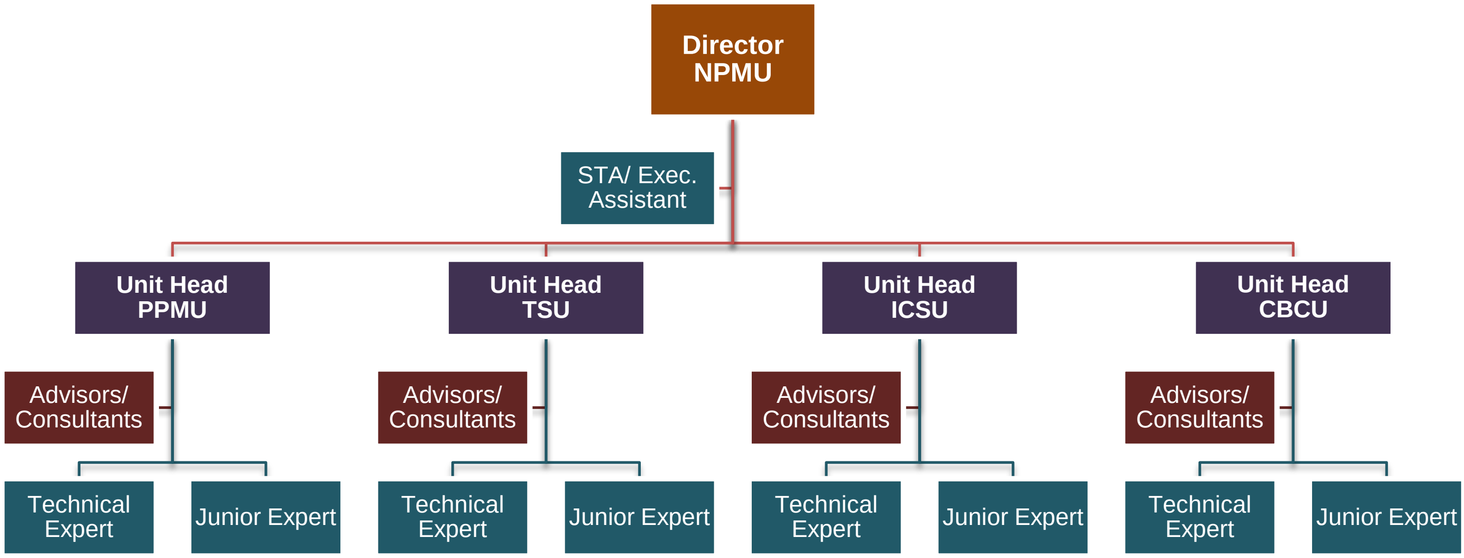

Figure 3: NPMU- Organizational hierarchy and qualification

7. STATE SMARTGRID PROGRAM IMPLEMENTATION FRAMEWORK

The SmartGrid implementation at the state level will be achieved through the SLPMUs. The SLPMUs will be the apex body for steering the state level programs and are expected to have matching roles corresponding to the NPMU.

The utilities will be the executing arm for SmartGrid projects as these utilities will design and implement the SmartGrid projects guided by the Utility SmartGrid Cells to meet the NSGM goals and objectives. These cells will also help the utilities to gradually improve their performance as measured by using the utility maturity mapping framework.

However, it should be noted that utility level SmartGrid Cell is not a prerequisite for executing SmartGrid projects, unless mandated by the state SmartGrid regulations.

7.1. CURRENT STATUS OF STATE LEVEL SMARTGRID ACTIONS

The Model Smart Grid Regulations have already been approved by the Forum of Regulators (FOR) to guide the State Electricity Regulatory Commissions (SERCs) and pave way for the development of state specific SmartGrid regulations. Draft regulations have been issued by Assam, Karnataka and Tripura SERCs and notified by Haryana (other states are also expected to notify SmartGrid regulations soon).

7.2. SLPMU

Similar to the NPMU, the state level mission units are proposed to take lead responsibility of the implementation of state SmartGrid actions.

7.2.1. FUNCTIONS OF SLPMU

The SLPMUs will be responsible for the execution of SmartGrid activities in their respective state.

The SLPMU has the following functions[8]:

- Define the vision, goals and roadmap for the state SmartGrid activities.
- Develop program proposals and submit to NSGM.
- Program review, monitoring and evaluation.
- Provide budgetary support from the state to the state level SmartGrid activities.
- Initiate implementation of National Smart Grid Policies by working with SERCs to develop state focused regulations and policies.
- Ensure that SmartGrid standards are incorporated in various SmartGrid projects undertaken in the state.
- Monitor the impact of SmartGrid activities and provide reports and data for national level integration.
- Training and capacity building for the utility personnel
- Planning and implementation of consumer engagement and awareness programs.

[8] NSGM OM, March 2015

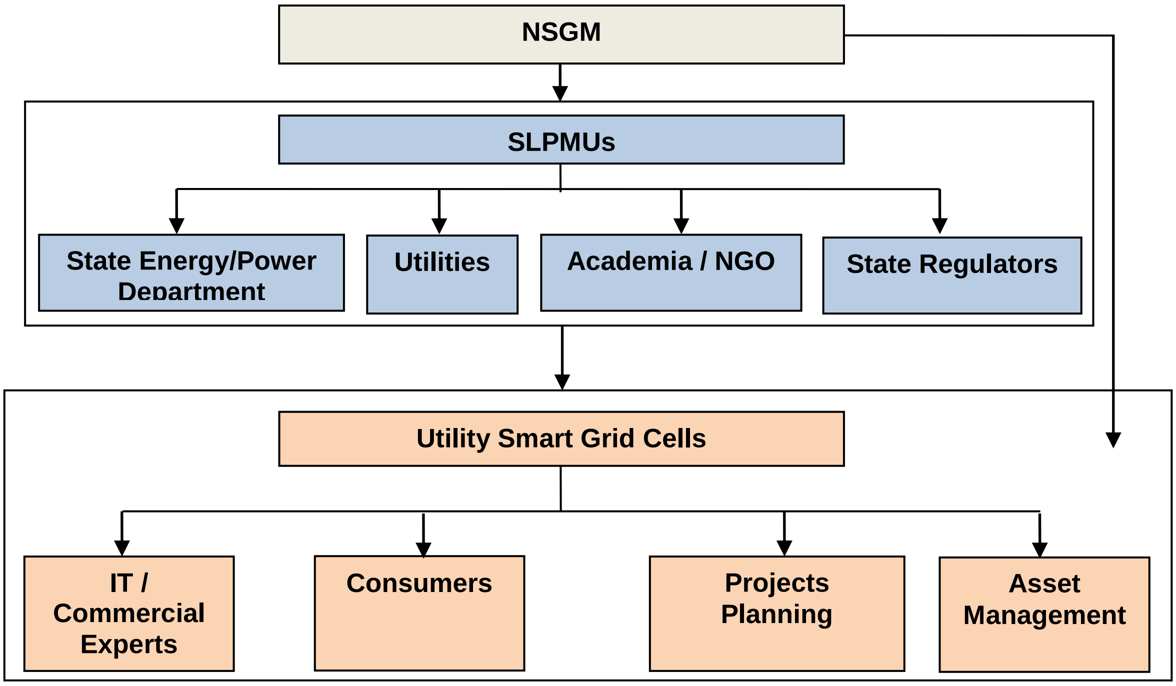

Figure 4: Governance and operational structure of SLPMU

7.2.2. CONSTITUENTS OF SLPMU

The SLPMUs will be headed by the State Power Secretary and will work to achieve the stated objectives. The SLPMU will include members from related institutions such as:

- Utilities.
- Department of Energy for the State.
- Consultants with subject expertise, technical expertise from research institutions with experience in SmartGrid areas.
- Consumer Forums.

The SLPMU will carry out implementation of SmartGrid mission activities along with the members who can be engaged on a contractual basis or on deputation from utilities for the delivery of mission. The constitution of SLPMU is depicted below:

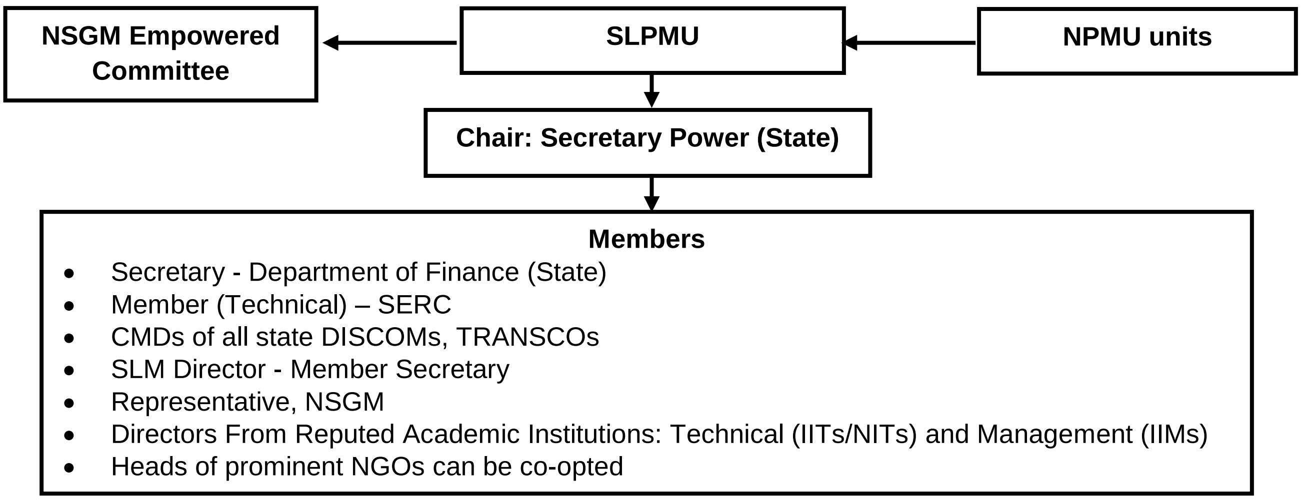

Figure 5: Constituents of SLPMU

7.2.3. RELATIONSHIP BETWEEN NSGM AND SLPMU

The NSGM will work actively with the SLPMU to ensure that the NSGM goals and objectives are achieved in a time bound manner. The relationship between NSGM and SLPMU is envisaged as following:

NSGM will provide:

1. Capacity building support to SLPMU and Utility's SmartGrid Cell.
2. Grants and technical assistance to the state/utilities linked to develop State Smart Grid Roadmap, goals, projects and programs.
3. Support to the state level procurement related to SmartGrid.

SLPMU will provide:

1. Annual plans, and program/project proposals.
2. Monitoring and evaluation reports on grid performance and SmartGrid programs/projects, etc.

7.3. UTILITY SMARTGRID CELL

The transmission and distribution utilities will play a central role in implementing SmartGrid programs. To achieve the goals of SmartGrid, utilities will need to transform:

- Systems, processes and hardware
- Customer services
- Business models

Every distribution licensee shall, constitute Smart Grid cell which shall have the authority and necessary resources so as to execute the functions assigned to it by the regulatory bodies.

Utilities have to ensure that a) the enabling infrastructure for launching SmartGrid is in place, b) the growing share of distributed power generation is accommodated, and c) consumers become active participants in energy management (usage, generation and conservation depending on the signals provided by them).

At the state level, the SLPMU, working closely with the utilities, will oversee and guide the utilities for a SmartGrid transformation in the state.

7.3.1. CONSTITUENTS OF THE UTILITY SMARTGRID CELLS

The utility SmartGrid cells should be constituted such that the cell possesses the requisite domain expertise to plan the projects, acquire and manage the assets (especially new and advanced assets) as per the technical guidelines, develop and manage the IT capabilities and proactively engage with the consumers.

In addition, it may also have suitable interface from finance, training, policy and regulation, procurement functions as well depending on the maturity of the utilities.

7.3.2. UTILITY SMARTGRID CELL'S INTERACTION WITH THE NSGM

- **Reporting:** The Utility SmartGrid Cells will submit periodic project M&E reports of the SmartGrid projects to the NSGM through respective SLPMU.

- **Capacity Building:** The NSGM will provide capacity building support to the Utility SmartGrid Cells. This includes support on:
    - Technical capacity.
    - Project/program development.
    - Procurement of systems, hardware, etc.

7.3.3. UTILITY SMARTGRID CELL INTERACTION WITH OTHER STAKEHOLDERS

Utility SmartGrid Cell will be the coordinator for all SmartGrid centric activities and it will play a key role in engaging with other stakeholders for SmartGrid activities including:

- Other utilities
- Distributed electricity generators including RE generators
- SmartGrid service providers
- Regulators such as state electricity regulators
- Customers

7.3.4. ROLES OF UTILITY SMARTGRID CELLS

The SmartGrid Cell shall be entrusted with the following roles[9]:

- Baseline study and development of data.
- Formulation of Smart Grid plans, programs and projects.
- Design and development of Smart Grid projects including cost benefit analysis, monitoring & reporting and for measurement & verification.
- Seeking necessary approvals to Smart Grid plans, programs and projects.
- Implementation of Smart Grid programs.
- Collaboration with NSGM and SLPMU for technical assistance and resources.
- Anchor programs for capacity building at the utility and for the consumers.
- Ensure progress of the utility on the SmartGrid Maturity Parameters.
- Share learning in State/National Forums and provide feedback and ideas to improve the performance of SmartGrid programs in the country.

[9] Model Smart Grid Regulations released by Forum of Regulators in August 2015

National Smart Grid Mission

IMPLEMENTATION FRAMEWORK

Module 2

POLICY AND STANDARDS SUPPORT

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MODULE 2A: NSGM POLICY SUPPORT FRAMEWORK

8. OBJECTIVES OF SMARTGRID POLICY BRIEF DEVELOPMENT

The NSGM will facilitate development of the SmartGrid policy briefs. The objectives of developing SmartGrid policy briefs are to help accelerating the SmartGrid policy development process and thus helping in achieving of SmartGrid Mission, Vision, and Goals in alignment with the GoI policies in power sector.

SmartGrid policy briefs will define the principles, rules (incentives, penalties, etc.) for ensuring 'transparent' and 'regulated' participation of a multitude of stakeholders in:

i. Building and operating SmartGrids.

ii. Realizing fair economic returns and achieve the goals set for SmartGrids.

iii. Providing affordable SmartGrid services to the consumers.

Similarly NSGM would provide inputs based on stakeholders consultation and experience gained through implementation of smart grid projects across the country which may include processes and rules for licensing, cost, quality of service, adherence to standards, reporting, checks and verification, and policy revision, etc. for formulation of smart grid regulations by Forum of Regulator/Utility Regulators (SERCs).

9. PROCESS OF POLICY BRIEF DEVELOPMENT

9.1. TYPES OF POLICY BRIEFS

The various types of policy briefs needed for SmartGrid programs would be generated by the NSGM and may include

- Broad description and design brief of policies required to enable Smart Grid for utilities.
- Sector or domain specific policy briefs which outline principles or strategy (e.g., consumers, smart meters, etc.)
- Operational policy briefs which may guide decisions and provide guidance on programs and project selection.

The SmartGrid intervention focused policy brief development process will be led by NSGM.

9.2. SMARTGRID DOMAIN WISE POLICY SCOPE

I. Distribution

Supporting increased use of renewable energy, micro-grids, energy efficiency, reliability and quality of power supply, distributed generation, demand side management, demand response, peak load shaving, electric vehicles etc.

II. Transmission

Supporting flexibility to accommodate increased penetration of renewables, ancillary market development, respective load and generation resources, and climatic conditions; ensuring high efficiency & reliability.

III. Power generation

Supporting large scale use of renewable energy power while streamlining the mechanism of forecasting and scheduling for all power generation with increased flexibility.

IV. Consumers (including electric vehicles)

Facilitation and integration of consumer owned assets with that of the grid (including EVs, batteries and solar photovoltaic devices). Providing high quality energy-services to customers and engaging them to support Smarter Grid operation.

Enabling integration of consumer behavior in decision processes across the power system and allowing consumers with information to participate in power management strategies opted by the utilities (e.g. dynamic tariff) while ensuring the integrity of consumer data and reliability of grid.

V. Energy markets

Using market instruments to manage demand-supply balance of power, allowing variety of independent service providers including demand aggregators to operate and provide grid resources and services.

VI. Research, Development and Deployment (RD&D)

Support SmartGrid related Research Development & Demonstration (RD&D).

9.3. PLANNING AND DEVELOPMENT PROCESS OF POLICY BRIEFS

The NSGM will facilitate development of policy-briefs based on the policy inputs required for execution of the SmartGrid project. This process will start by scanning the existing policy environment and identifying gaps. If the NSGM is of the view that a specific policy instrument may be required to support the SmartGrid project, it may allocate internal resources to facilitate development of policy briefs or draft-policies to be shared with the MoP for final decision and action.

MODULE 2B: SMARTGRID STANDARDS

10. ROLE OF SMARTGRID STANDARDS

10.1. SMARTGRID STANDARDS

"Standards are specifications that establish the fitness of a product for a particular use or that define the function and performance of a device or system. Standards define specifications for languages, communication protocols, data formats, linkages within and across systems, interfaces between software applications and between hardware devices, and much more". These are technical specifications that define the threshold qualifying requirements for products, production processes, services, etc.

However this document focuses on the framework for development standards for promoting the SmartGrid programs in the country and the role NSGM needs to play to effectively implement the programs.

10.2. ROLE OF SMARTGRID STANDARDS

SmartGrid standards ensure safety, reliability, environmental care along with interoperability and safety of SmartGrid systems and components. Further, the standards should:

- Ensure achievement of SmartGrid goals;
- Provide direction to public and private sector technology development;
- Facilitate innovation while adhering to the threshold criteria and interoperability concerns;
- Encourage concerted decision making and resource allocation for development of technology;
- Ensure consistency in SmartGrid management and deployment
- Promote large-scale demand aggregation (economies of scale) resulting in competitive markets for SmartGrid components and services;

In the absence of standards, there is a risk of:

- Products and equipment not being compatible with each other,
- The performance of products not matching expectation,
- Inferior quality products and premature obsolescence, and immature technologies getting implemented and
- Lack of encouragement for innovation due to un-clear demand signals.

11. SMARTGRID STANDARDS DEVELOPMENT OBJECTIVES

The SmartGrid standards will be implemented nationwide covering variety of stakeholders in the power sector. This section outlines the scope of SmartGrid standards.

11.1. SCOPE

The SmartGrid standards, notified by the relevant national authority, will apply to all Indian States and UTs.

11.2. TECHNOLOGIES (STANDARDS FOR APPLICATIONS)

The standards will cover:

- Issues relating to IT such as interoperability, security, data exchange (communication protocols and data models) etc.
- Issues relating to OT linked to generation, transmission, distribution, markets and consumption. The technical standards will shape the performance architecture of the system and integrate all grid-connected systems and subsystems.

11.3. SMARTGRID DOMAIN WISE STANDARDS

i. Power Generation

Standards to support large-scale integration of distributed and RE generation units with the grid; and standards for forecasting and scheduling for all power generation systems.

ii. Transmission

Standards to support coordination, coherence and interoperability of equipment for strong interconnected power system (to facilitate 'one-nation, one-grid principle).

iii. Distribution

Specifications to support bi-directional (electricity flow) functionalities, RE integration, Storage, automation and software interfaces etc.

iv. Consumers

Standards for appliances including EV and equipment to facilitate consumer interaction, interoperability and grid integration.

v. Energy Markets

Standards for market communication for uniform and efficient exchange of data and information in the energy market place. Allowing market instruments to manage resources and services for the grid through standards on settlements and placements of bids.

vi. Research, Development and Deployment (RD&D)

Support RD&D in the area of SmartGrid.

12. SMARTGRID STANDARD DEVELOPMENT PROCESS

SmartGrid standard development is a continuous process and evolves as the SmartGrid matures. The NSGM will be facilitating the SmartGrid standards identification in the country. In this, the NSGM will work with power sector institutions for generating list of standards required for SmartGrid implementation.

12.1. STANDARD DEVELOPMENT FRAMEWORK

- Reference architecture of SmartGrid identifying main domains and integrating systems and interfaces to be finalized.
- Adopt a set of standards based on the principles defined.
- Adopt a standard development process that is based on collaborative approach and participate in the process to introduce new standards based on gap analysis.

Standards planning and development process: NSGM role

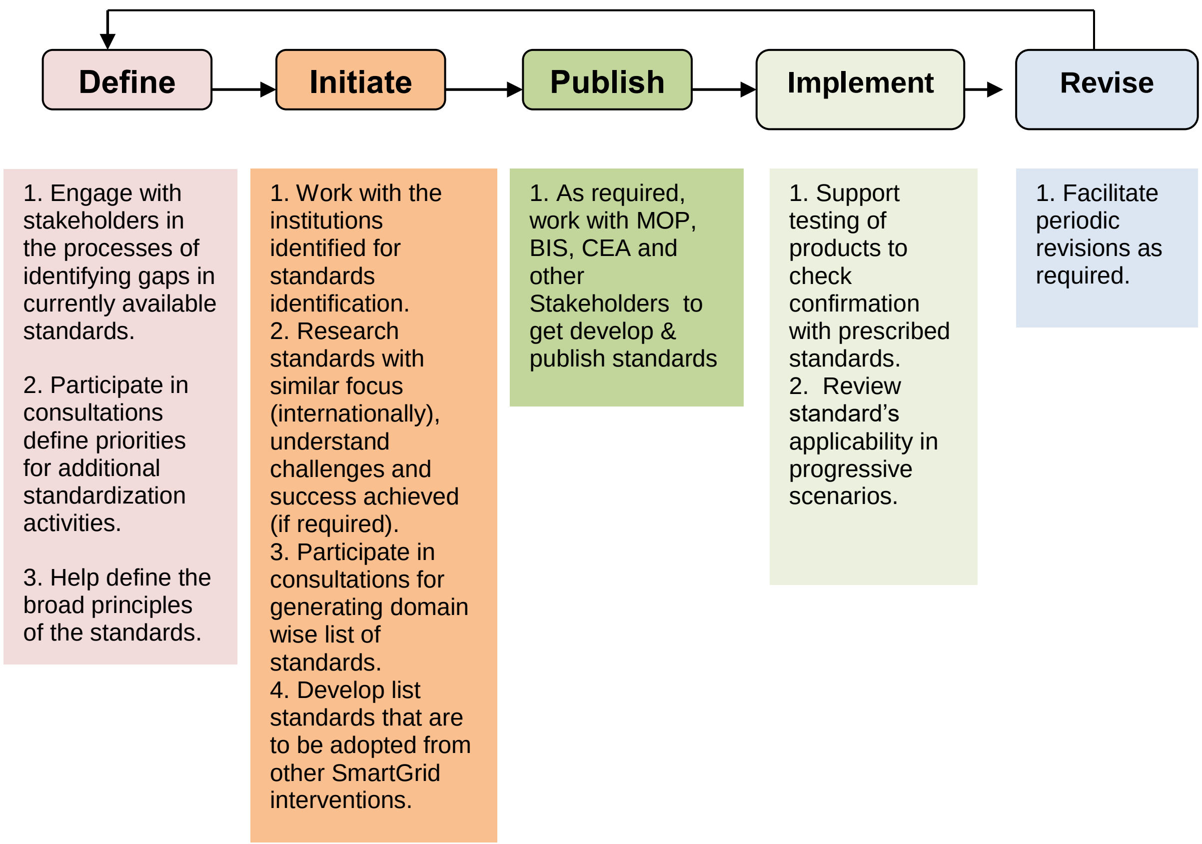

Figure 6: Standard planning and development process

The NSGM's approach to accelerate the development of standards:

i. Identify products to be mass deployed and achieve standardization for the same

ii. Identify existing standards that could be immediately applied to meet SmartGrid needs

iii. Identify gaps and establish priorities

iv. Prioritize additional needed standards to fill these gaps

v. Define a whole framework of standards and further actions to help realize the SmartGrid vision

vi. Define criteria for standards to identify:

- Standards that are to be developed domestically
- Standards that are to be adopted (with or without testing/modifications).

12.2. CURRENT ACTION ON SMARTGRID STANDARD DEVELOPMENT IN INDIA

Standards developed by BIS have sector wise committees working on standards linked to power system control and associated communications. This committee is working on a variety of SmartGrid-related standards like transmission and distribution control centers, information exchange between utilities, power system controls, etc. The scope of work of this committee includes preparing standards on:

- Power system control equipment and systems
- Distribution management system
- SCADA
- Distribution automation
- SmartGrids
- Communication used in planning and O&M of power systems

Some of these standards covering smartgrid domain are:

- **SCADA for power system applications[10]:** It provides definition and guidelines for specification, performance analysis and application of SCADA in electric utilities as well as remote operations in substation.
- **Power system communications-interoperability guidelines [11] :** It provides interoperability guidelines for utilities and their various components including generation, transmission and distribution chain as well as elements like trading, risk management, renewable generation and automation technologies.
- **Power control systems-security requirements[12]:** It provides security requirements for critical assets of utilities including monitoring, security management, physical security, incident response, recovery planning and auditing procedures.
- **Common information model for information exchange in context of electrical utilities (draft stage)[13]:** It provides specifications for information exchange between utilities and interface specifications for utilities that contribute in information exchange.
- **Data exchange for electricity meter - reading tariff and load control-companion specification[14]:** It provides specifications for secure and efficient transfer of energy related data from meter to secure host.

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[10] www.standardsbis.in/Gemini/scoperef/SR15953.pdf
[11] http://www.bis.org.in/sf/ltd/LITD10_3299.pdf
[12] http://www.bis.org.in/sf/ced/CED22(7587).pdf
[13] http://www.bis.org.in/sf/ltd/LITD_10_3296.pdf
[14] http://www.bis.org.in/sf/etd/ET13_02082016.pdf

Apart from the above set of standards, BIS has also developed specifications for smart meters (IS 16444 Part 1 and 2), providing specifications for selected category of smart meters on design architecture, communication modules and functional requirements. Also BIS has released data exchange for Electricity Meter Reading, Tariff and Load Control-Companion Specifications (IS15959 Part I, Part II and Pat III), which also provides for data exchange related to smart metering.

Standards developed by Central Electricity Authority (CEA): CEA has issued certain technical standards which give specifications for grid integration of utilities, electrical components, grid stability and connectivity conditions to ensure better grid performance.

These standards are:

- **Technical standards for connectivity to the grid, 2007[15]:** This specifies technical standards applicable to generating units, transmission lines and substations, distribution systems and bulk consumers and general conditions. These provide specifications for grid integration of power generation plant, integration with transmission and distribution utilities, integration of RE generators and grid connection of co-generation equipment.
- **Technical standards for construction of electrical plants and electric lines, 2010[16]:** This provides standards for construction of thermal generating stations, hydroelectric stations, substations, switchyards, electric lines and general requirements. Specifications for distribution substation, feeder lines, transmission lines and transmission substations are also provided.
- **Technical standards for connectivity of distributed generation resources, 2013[17]:** General connectivity conditions and specification for safety, substation grounding and metering for distributed energy resources are provided.
- **Grid standards, 2010[18]:** Grid stability management standards for O&M, operations, reporting and restoration of grid and related components are provided.
- **Functional Requirements of AMI:** It provides for minimum functionalities and performance for AMI system in India.[19].

Standards developed by Automotive India Standards

- **Electric vehicle conductive AC charging system, 2018:** This standard provides safety and protection specifications for AC charging stations for electric vehicles and hybrid electric vehicles. This standard was issued by Automotive India Standards for electricity charging stations for electric vehicles.

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15 Gazette of India Notification, February, 2007 (http://www.cea.nic.in/reports/regulation/tech_std_reg.pdf)
16 Gazette of India Notification, August 2010 (http://www.cea.nic.in/reports/regulation/tech_std_reg.pdf
17 Gazette of India Notification, Sep, 2013 (https://www.tatapowerddl.com/UploadedDocuments/CEA%20Technical%20standard%20for%20connectivity%20of%20DG%20resources.pdf)
18 Gazette of India Notification, June, 2010 (http://www.cea.nic.in/reports/regulation/grid_standards_reg.pdf)
19 http://www.cea.nic.in/reports/others/god/dpd/ami_func_req.pdf

National Smart Grid Mission

IMPLEMENTATION FRAMEWORK

Module 3
BUSINESS MODELS

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MODULE 3 - BUSINESS MODELS

13. INTRODUCTION

SmartGrid is slated to revolutionize the electricity sector, adding state-of-the-art functions and services to enhance value for the consumers and fuel economic growth. The functional expectation from SmartGrid will be set based on the current level of services offered by such interventions as experienced from similar projects internationally. Dynamic in nature, SmartGrid will evolve over time with policy-technological advancement but the basic functionalities such as increased local generation, enhanced reliability, efficiency, effective control and transparent information/data management would always be the core of the mission.

The technological interventions related to SmartGrid rollout will be large and new features will get added overtime. Such interventions can be broadly clubbed under four functions of the power system viz. generation, transmission, distribution, and consumption. The broad level interventions include wide area monitoring control, battery storage (at transmission, distribution, and residential end), smart distribution and distribution company (DISCOM) systems, and transmission and line upgradation. At the consumer end, the programs would include DSM and AMI among others as shown in Figure 7.

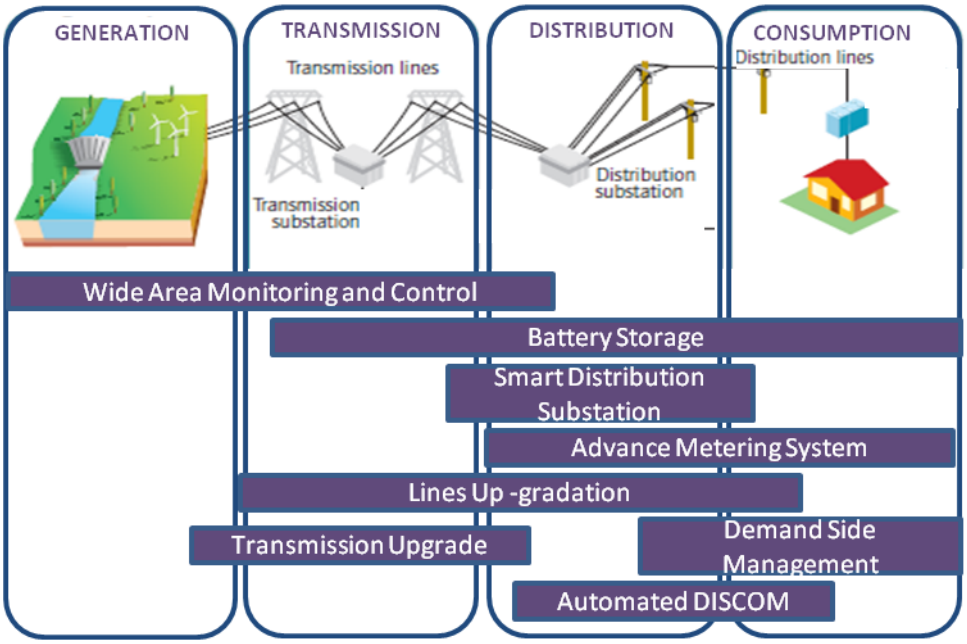

Figure 7: SmartGrid programs

Some interventions are incremental whereas, in other cases, complete technological transformation is required. The associated costs initially which can be offset by value derived from each of the interventions benefits (financial, economic, and environmental, etc.) that could justify the investments.

Since the present focus of the NSGM is on distribution, business approaches for power distribution and consumption are considered for analysis.

The actual contours of SmartGrid intervention will have to be opted by the utilities. Also, the quantum of benefits may differ if interventions are bundled. The bundling of interventions could result in minimization of costs and maximization of returns.

Utilities may not always finance the required money to execute such projects on their own. Hence, business models for defined project boundaries can be presented to potential investors to forge business partnerships.

NSGM will act as a catalyst to help form business models, achieve the partnership through workshops, MoUs and experience sharing etc. The business models can be deliberated and shared with Discoms on AMI are enclosed at Annex-I.

14. MODES OF PARTICIPATION BY THE INVESTORS

14.1. CLASSICAL OPTION – CAPEX INVESTMENT BY THE UTILITY

Utility undertakes the investment and realizes all the benefits. Presently, the Government grants capital subsidies (~30%).

The system supplier undertakes an Engineering, Procurement and Construction (EPC) contract and may also be given an Asset Management Contract (AMC) for a defined period. AMC charges may be performance linked (varied based on equipment availability, metering accuracy, mean-time-between-failures etc.).

14.2. LEASE RENTAL

The total project investment is undertaken by the system supplier, except for the investment in back-end IT integration which is done by the utility.

Utility pays lease to the system supplier. The lease is paid for a pre-agreed lease period, after which the assets are transferred to the utility at residual transfer cost if any.

The rentals may have performance linkage. The role of system supplier is to operate the assets and assure reliability, availability, and accuracy of services such as data availability etc.

The responsibility of using smart metering infrastructure and realizing savings such as reduced metering costs, reduced R&M costs, reduced T&C losses, and reduced peak period power remains with the utility.

This reduces to a method of contracting wherever technology suppliers neither have any operating role nor take any operational risks.

14.3. SAVINGS LINKED CONTRACTS

As in the earlier case, the investment is by the system supplier. Hence, the system supplier plays an operational role that may include, (*one or more* of the following areas):

- Billing
- Collections
- O&M of distribution infrastructure
- Customer service
- DSM

The system supplier gets paid out of the savings realized:

- A fixed share
- A variable share with incentives and penalties for over and under achievement of performance improvements

The performance parameters may include system availability, reliability (SAIFI, SAIDI), technical and commercial losses, peak load reduction, and reduction of float.

This is unlikely to be popular because it transfers operational risks to the system supplier, who may not have necessary authorization to operation.

Operators perceive difficulty in dealing with customers lacking control and may not easily accept the discipline demanded by smart grid, especially from a private entity.

14.4. FRANCHISE MODEL

A Franchise Contract may be used to bring in a private operator to use the existing infrastructure of utility, pay utility an assured return/share, manage all the operations and make necessary investments.

The contract may define minimum performance targets for the franchisee. A detailed baseline is required before handing over the operations and assets.

A Franchisee leaves the assets after the Franchise Period to the original owner, with laid out terms on compensation for additional investments made during the interim period and residual life of such assets.

These contracts have been used by several utilities in India and the contract structure is well established.

14.5. JOINT VENTURE (JV)

A JV between the utility and the system integrator makes an investment.

The JV may enter into lease or savings and share the contract with the utility.

This structure allows alignment of interest between the utility and the system supplier. Also, it makes financing feasible for large projects.

However, it is unlikely to be the preferred choice in most cases because managing operations and exit from JVs have operational and contractual complexities.

The proposed SmartGrid interventions and the various business opportunities associated with these SmartGrid initiatives have been described and analysed in the Annex-I for suitable deliberation by Utilities and stakeholders

National Smart Grid Mission

IMPLEMENTATION FRAMEWORK

Module 4

MEASUREMENT, REPORTING AND VERIFICATION

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MODULE 4: MEASUREMENT, REPORTING, AND VERIFICATION

15. MRV FOR NSGM

MRV is a process through which the performance of an entity or intervention is measured, and results are verified based on pre-defined targets or goals. It captures and communicates the progress to enable tracking of achieving the goal in the timeframe envisaged.

MRV for the NSGM consists of:

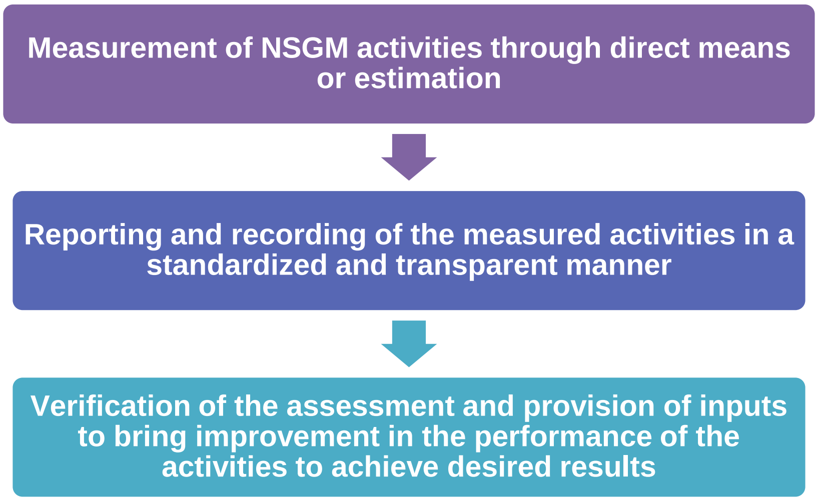

Figure 8: MRV for the NSGM

This MRV document is useful to track the progress of Smart Grid Projects in achieving the goals of SmartGrid rollout.

This process and subsequent analysis can be used to support:

- Achievement of goals related to SmartGrid rollout by monitoring and coordinating the activities done by states and utilities, tracking the performance, reviewing the results and giving inputs to concerned entities.
- Comparison of technologies, assessment of application-technology fit and identification of areas for further improvement through R&D.
- Development of programs for SmartGrid applications.
- Understanding of the economic value from the use of SmartGrid business models to enable project financing for SmartGrid projects.
- Identification of policy and regulatory measures for scaling up of SmartGrid applications.
- Facilitation of standards development for SmartGrid activities.

The scope of the detailed MRV does not extend to individual SmartGrid applications. Outcome level MRV parameters for SmartGrid applications are defined (example MRV for AMI at Annex-III) and the project specific MRV will have to be designed depending on the project design and its intended objective.

16. MRV FRAMEWORK

The MRV plan for the NSGM would focus on MRV related to SmartGrid rollout and Impact Assessment of the smart grid implementation.

This section deals with MRV of all the activities related to SmartGrid rollout goals.

Table 7: MRV Related to SmartGrid Rollout

SN	Goals related to SmartGrid Rollout	MRV indicator of the outcome	
1	**Plan roll out of Smart Grid**		
		i.	Number of consultations held at national level and state level for development of SmartGrid Roadmap and its roll out
		ii.	Submission of SmartGrid roadmap document to MOP
2	**State Level Project Management Unit Actions**		
		i.	Model state SmartGrid roadmap document developed/updated
		ii.	Model state level SmartGrid monitoring document developed/ updated
		iii.	Number of capacity building programs for State Level Project Management Units (SLPMUs) on SmartGrid /roadmap/ monitoring plan
		iv.	Periodically updated SmartGrid state level progress review report on:
			• Number of states with SLPMU units (or under process)
			• Number of states having SmartGrid regulations notified
			• Number of states with SmartGrid roadmap.
3	**Utility preparedness**		
		i.	Roadmap for 'utility maturity approach' finalized in consultation with the utilities
		ii.	Utility maturity linked incentive mechanism developed
		iii.	Utility SmartGrid participation criteria developed
		iv.	Development of utility rating model framework
		v.	Utility rating agencies identified and a list accredited agencies prepared and published
		vi.	Number of workshops and capacity building programs for utilities
4	**SmartGrid implementation**		
		Periodic reports compiled from the information generated by the utilities, Ministry of New and Renewable Energy (MNRE), MOP, etc. reports on SmartGrid Rollout (parameters defined in NSGM Institutional Framework)	

SN	Goals related to SmartGrid Rollout	MRV indicator of the outcome
		i. Annual reports of state wise and national level AT&C losses compiled and mapped as per commitments made by states[20] ii. Nationwide RE deployment compiled on: (i) rooftop solar, (ii) ground-mounted solar, (iii) wind, (iv) biomass, and (v) others.
		iii. SLPMU actions (number, percentage of utilities taking action)
		iv. SmartGrid - utility level actions (number/percentage of utilities taking action) v. Utility preparedness for target maturity level vi. AMI rollout - number of utilities having AMI experience, number of towns/ cities with AMI coverage, number of smart cities with AMI coverage vii. Microgrid - number of utilities with microgrid experience, and total capacity of microgrids in utilities viii. Distribution automation - number of transformer / feeder / consumers / MW covered

[20] For state commitments refer to contract between states & MOP (http://powermin.nic.in/content/power-all)

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National Smart Grid Mission

IMPLEMENTATION FRAMEWORK

ANNEXURES

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ANNEX-I: BUSINESS MODELS DESCRIPTION

1.1. SMART METER IMPLEMENTATION

1.1.1. SMART METER

Integral to the AMI of the SmartGrid system, smart meters are electricity measurement and communication devices for real time integration of the consumers with utility functions. Smart meters support all communications linked to service billing (consumer to utility and vice versa) and can provide information and control to the utilities on electric systems at consumers' premises.

The smart metering devices come with varying features and degree of advancement depending upon the maturity level of the SmartGrid. The major features of such meters include net metering, in-home displays, and energy usage control systems, etc. (the evolution of smart meter functionality is provided in Annex-II).

1.1.2. SMART METER PROGRAM FEATURES

Smart meters with base features, as prescribed by the utility/regulator, would be installed at the consumers' premises. Add-on features may be available that can be selected by the consumers (depending on maturity status of the utility). An IT enabled interface facilitates a two-way real-time communication between the utilities and the metering device. The real-time power consumption information of the consumer can be accessed by the utilities. Further such devices can also be used to control the power usage at the consumption end (depending on the utility's maturity and its service contract with the consumer).

The consumer too can communicate with the utilities through a web portal linked to the meter.

1.1.3. VALUES DERIVED WITH SMART METER

Smart meters vary in features and so are the benefits associated with the meters. The benefits associated with full feature loaded smart meter are listed in the following table.

Table 8: Benefits of smart meter devices

Entity	Benefits
DISCOM	• Reduced cost of meter reading • Reduced billing errors • Shortened billing cycle and revenue collection • Reduced direct consumer interaction with the utility • Real time monitoring and quick detection of meter tempering and power thefts • Quick and automated access to consumer data and its collection • Quick and easy outage detection and reduced response time • Accurately designed DSM programs (equipped with accurate consumer information)
Customers	• Better access to data on energy use • Accurate billing that can be verified by the consumer • Improved rate options (applicable for dynamic pricing scenario) • Quick response to outages • Access to power quality data
Transmission	• Improved power system load management as accurate power

Entity	Benefits
Companies	consumption data is available • Improved data for efficient grid system design • Power quality data
Society	• Improved environmental benefits • Support for the SmartGrid initiatives

1.1.4. BUSINESS CASE FOR SMART METER PROGRAM

Compared to the conventional meters installed at consumers' premises in India, smart meters emanate the features that can be used by the utilities (and the consumers) to launch programs that could result in tangible and non-tangible benefits to the stakeholders. Some of the key benefits favoring smart meter installation are:

- **Operational efficiencies:** Smart meter results in more efficient use of distribution assets and streamlining of business processes, thereby reducing operational and future capital expenses.
- **Energy savings:** Usage of less electricity through improved distribution system control, efficiencies, and reduced consumption by customers.
- **Consumer participating in energy markets:** With a more modern electricity system, customers investing in energy generation (e.g., solar) through different sources of electricity, can sell excess power back to the grid.
- **Revenue protection:** This includes both recovery of revenue and prevention of future potential revenue loss through reduced theft.
- **Capacity savings:** Lesser electricity use at certain key periods, which reduces peak demand and capacity constraints. If customers take advantage of the conservation tools offered through the program, the overall benefits increase significantly.

1.1.5. BUSINESS MODELS (FLOW OF REVENUE)

Based on the revenue realization potential, business models are identified in following table.

Table 9: Business logic of smart meter program implementation — Revenue sources

Entity	Economic/Financial Benefits by Participating in AMI Program	Direct Revenue Realization Potential	Potential Revenue Option
DISCOM	• Billing efficiency improvement • Consumer handling cost reduction	✓	
	Improved tariffs — Reliability charges for consumers		✓
Customers	Procurement of peak load reduction — Payment from utility		✓

1.2. DSM

DSM implies that electricity demand is adapted to the electricity production and availability in the grid. It refers to load shifts by reducing electricity demand and avoiding load peaks during congestion in the grid.

SmartGrid deployment will reduce costs and introduce functions that would enable utilities to rollout a bouquet of DSM programs in a cost effective manner. Smart meter will enable prosumers to interact with the utilities, provide accurate information to utilities on power consumption patterns (demographically, temporally) to design, launch, measure, and verify the elements of the DSM and quickly adjust to ensure optimum value from such intervention.

DSM strategies may include three approaches:

- Peak load management
- EE procurement
- Rooftop RE procurement (solar photovoltaic [PV])

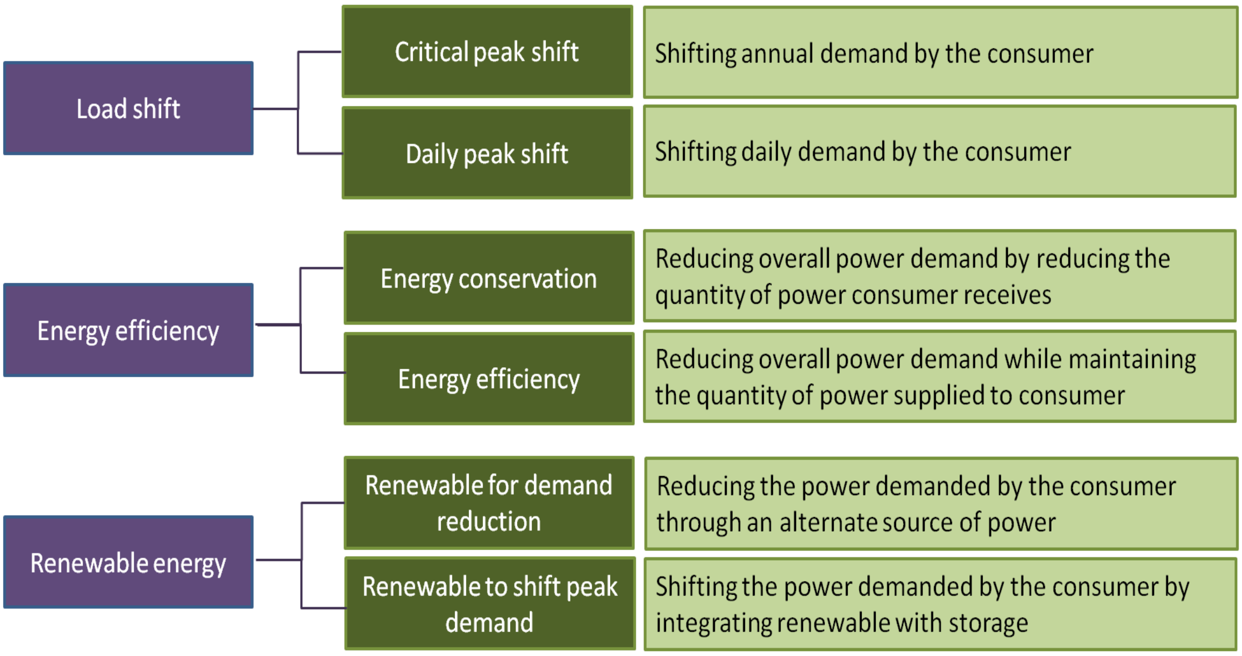

Figure 9: DSM approaches

1.2.1. VALUES DERIVED FROM DSM

DSM programs result in a stream of quantifiable and non-quantifiable benefits to the stakeholders. These include:

- **Avoided capacity expansion costs:** DSM can result in a shift in peak power demand, thus capacity upgradation and associated O&M costs can be deferred.
- **Avoided T&D costs:** The strain on T&D system is lower as system components carry loads close to the near-design-capacity. Therefore, the result is that equipment degradation and maintenance frequency is less.
- **Environmental benefits:** DSM may result in reducing energy use leading to reduced greenhouse gas emission (GHG) and other pollutants associated with fossil fuel burning.
- **Power cost reduction:** DSM efforts in the context of integrated resource planning can reduce total costs of meeting energy demand.
- **Reliability and network issues:** Averting problems in the electricity network through decreasing demand in ways which help in maintaining the system reliability in the immediate term and over the longer term defers the need for network augmentation.

1.2.2. PEAK LOAD MANAGEMENT

The electricity prices depend on both production of power and its demand at that instance (true for utilities; however, may not completely apply to the entire consumers in India). Peak load management can be achieved by exposing consumes to the power price fluctuations and simultaneously, incentivizing them to change their electricity consumption patterns.

The incentive approach can work in two ways:

- Shift the power demand
- Reduce the power demand

In this section, the shift in power demand has been discussed. Reduction in power demand is covered in the EE procurement section of the chapter.

1.2.3. PEAK LOAD MANAGEMENT — PROGRAM FEATURES

The most common approach by utilities for peak load management is to communicate power prices to consumers indicating a need to reduce the peak demand. Equipped with information on price fluctuations (which follows a trend depending on the peak load and base load pattern), the consumers are motivated to respond by adjusting their power consumption.

The higher order peak load management programs allow utilities to automatically reduce the consumer’s power consumption when supply is scarce. Smart meter at the consumer’s premises provide communication interface necessary to facilitate such action by the utilities.

Based on the above mentioned extremes (ranging between purely price indication versus consumption control), various approaches to achieve peak load management include:

- **Differential pricing:** Various versions of real time pricing exist; the more common version (also applied in Indian context) allows the consumers to pay a fixed rate for part of the consumption. Any consumption beyond the prescribed consumption limit attracts higher rate for electricity.
- **ToD tariff:** Electricity prices are fixed for predefined periods of the day, the periods falling under on-peak and off-peak categories, with the latter offering lower prices to the consumers.
- **Dynamic pricing**: As an advanced form of ToD tariff, real time communication with the consumer (through smart meter) provides information on the current electricity price and feedback on its demand load.
- **Demand response for large industrial consumers:** Purely based on the financial benefits to consumers, demand response is managed by compensating the consumers for foregoing their power consumption:
    - During contingencies in the power system, consumer loads are turned off by the utilities and in turn are compensated by the utilities (applicable to consumers with high load and ability to shift the timing of the power utilization without compromising its welfare).

1.2.4. BENEFITS OF PEAK LOAD MANAGEMENT PROGRAMS

DSM benefits have been discussed in Annex 1.2.1.

1.2.5. BUSINESS CASE LOGIC FOR PEAK LOAD MANAGEMENT PROGRAMS

1. **Quantifiable Benefits:**

- **Peak load procurement:** The shift in peak demand ensures that utilities need not purchase high cost power during the peak hours. In dynamic/ToD electricity pricing environment, same benefit is enjoyed by the consumers as their peak period consumption is lowered.

  In contrary, if consumers defer their consumption (applicable to high load consumers), they can be compensated by the utility.

- **Delayed electricity system upgrades:** The reduced power demand and load shift results in deferring upgradation of the electricity networks (including low voltage and high voltage transmission).

- **Savings on generation capacities:** The load shift and shaving off peak load helps save costs of maintaining or operating power plants.

2. **Non-Quantifiable Benefits:**

- **Environmental benefits:** Here, the power demand is shifted, not reduced. Hence, peak generating units (running on fossil fuel) are less utilized. However, the net power withdrawn from other sources may rise which may be coming from relatively cleaner sources.

- **Grid management costs:** The load on power system and the requirement to fire peak load plants are low. Hence, the maintenance demanded by power grid system is also low. Clear linkage of the impacts of DSM on reduced maintenance costs is difficult. Simultaneously, it is also difficult to quantify the reduction in maintenance costs.

1.2.6. BUSINESS MODELS (FLOW OF REVENUE)

Based on the revenue realization potential, business models are identified in following table.

Table 10: Business logic of peak load management — Revenue sources

Entity	Economic/Financial Benefits by Participating in AMI Program	Direct Revenue Realization Potential	Potential Revenue Option
DISCOM	• Peak load management — Reduced power procurement • Reduced capacity upgrade cost • Grid management costs — Reduced ancillary service/contingent capacity procurement	✓	
	• Peak load management — Reduced stress on distribution equipment • Grid management costs — Reduced UI charges		✓
Customers	• Savings (fixed, variable) due to peak power and load reduction • Procurement of Peak Load Reduction — Payment from DISCOM	✓	
Transmission Companies	Grid Management costs — Reduced ancillary service/contingent capacity procurement		✓

Entity	Economic/Financial Benefits by Participating in AMI Program	Direct Revenue Realization Potential	Potential Revenue Option
Society	• Reduced GHG emissions • Reduced SOx and NOx particulates		✓

1.3. EE PROCUREMENT

The EE improvements allow for a reduction in energy consumption when the appliance or equipment is in use.

Under the EE procurement approach, buyers make offers to the consumers for delivery of the EE resulting from technology adoption at the consumption end. The EE procurement programs also offer direct financial benefits to the consumer in the form of savings in the energy bill.

1.3.1. APPROACH

Utility anchored programs offer performance-based incentives to customers to achieve large scale power savings. Based on the result based mechanism, consumers are paid fixed amount for achieving power savings by installing energy saving equipment.

Two such mechanisms include:

- **'Standard Offer'-** In this mechanism, the consumers are offered a technology option matching with the prescribed or qualifying program. Energy service companies (ESCOs) offering standard services (matching with the utility goals) tie-up with the consumers for project execution. The energy saving estimations is carried out using baseline information and accordingly, consumers are passed on the benefits (in cases where ESCOs act as intermediary service providers, financial benefit arrangement may differ).
- **'EE Feed-in-Tariff'** provides a revenue stream for projects that can demonstrate measured electricity savings. The payments depend on the quantum of savings achieved.

1.3.2. BENEFITS

DSM benefits are discussed in Annex 1.2.1.

1.3.3. BUSINESS DRIVER

1. **Quantifiable Benefits:**

- **Peak load procurement:** The shift in peak demand ensures that utilities need not purchase high cost power during the peak hours.
- The same benefit is enjoyed by consumers as their peak period consumption is low.
- If consumers defer their consumption (applicable to high load consumers) they can be compensated by the utility for helping utilities save on power procurement costs.
- **Deferred electricity system upgrades:** The reduced power demand and load shift results in deferring up gradation of electricity networks (including low voltage and high voltage transmission).
- **System quality improvement:** Integration of RE improves quality and reliability of electricity supply.

- **Savings on generation capacities:** The load shift, shaving of peak load and RE integration helps save costs of maintaining or operating power plants at full capacity.
- **Environmental benefits:** The International Energy Agency (IEA) calculations establish that EE measures are not only always cheaper but also cleaner than energy capacity addition.

2. **Non-Quantifiable Benefits:**

- Improved EE (of electric appliances or infrastructures) reduces the cost of energy services and release resources that may be spent on a greater use of that appliance (direct effect) or on other electricity consuming goods and services (indirect effect). The other challenges to quantify benefits include:
    - **Environmental benefits:** The power demand is shifted, but not reduced. Hence, the peak generating units (running on fossil fuel) are less utilized. Simultaneously, in low energy consumption scenario, the percentage of fossil fuel based power production can be reduced, thus, increasing the share of power from relatively cleaner sources.
    - **Grid management costs:** Less power flowing through the power system reduces the upkeep cost; however, it is difficult to quantify such benefits to link it to DSM intervention.

1.3.4. BUSINESS MODELS (FLOW OF REVENUE)

Based on the revenue realization potential, business models are identified in following table.

Table 11: Business logic of EE procurement program — Revenue sources

Entity	Economic/Financial Benefits by Participating in AMI Program	Direct Revenue Realization Potential	Potential Revenue Option
Generators	Reduced energy upgrade cost	✓	
	Improved ability to meet EE targets		✓
Customers	EE procurement — Payment from DISCOM (standard offer approach)	✓	
	Savings (fixed, variable) due to peak power and load reduction		✓
Society	• Reduced GHG emissions • Reduced SOx and NOx particulates	✓	

1.4. RE INTEGRATION

Implementation of SmartGrid provides the power system with the ability to ensure smooth integration of large number of RE sources of varying capacity. Thus, the intermittent production of renewable power is harmonized.

SmartGrid will help connect prosumers and mid-sized projects and feed power into the grid. The role of RE integration is to ensure efficient (i) demand forecasting; (ii) supply balancing; and (iii) billing and metering.

1.4.1. APPROACH

In SmartGrid scenario, the AMI interface will help consumers to connect their RE facilities with the grid and communicate with the utilities. Similarly, small RE projects can be connected to the grid as the system is able to forecast demand, and hence, ensure demand-supply balancing.

The issues linked to intermittent power generation (supply generation) and interaction with multitude of generators makes it difficult to achieve RE integration.

Further, RE with storage option can be deployed for optimum returns. The storage allows to match the power generation with that of demand, and there is flexibility to the RE power generator to sell power at a chosen ToD to maximize the return on investment (applicable in case of dynamic tariff regime).

1.4.2. BUSINESS CASE LOGIC FOR RE PROCUREMENT

1. **Quantifiable Benefits (for All Stakeholders):**

    - **Financial benefits to consumers:** The prosumers will receive payment for excess renewable power at the utilities going rate for electricity. Also, prosumers net power demand goes down as part of the consumption is met through captive sources. Theoretically, the consumers can be energy positive, i.e., deliver more power than derived from the grid.
    - **Battery system cost can be avoided:** Unlike conventional solar PV system, in the grid tied system, the battery bank can be avoided as power can be directly sold to the grid.
    - **Avoid peak load procurement:** The shift in peak demand ensures that utilities do not have to purchase relatively costlier power during the peak hours. The same benefit is enjoyed by consumers as their peak period consumption is low.

      In contrary, if consumers defer their consumption (applicable to high load consumers) the same can be compensated by the utility.
    - **Delay in electricity system upgrades:** The reduced power demand and load shift results in deferring upgradation of electricity networks (including low voltage and high voltage transmission).
    - **System quality improvement:** Integration of RE improves quality and reliability of electricity supplies.
    - **Savings on generation capacities:** The load shift, shaving of peak load, and RE integration helps save costs of maintaining or operating power plants.

2. **Non-Quantifiable Benefits:**

    - **Grid management costs:** Maintenance costs are difficult to estimate. Also, linking it to the DSM is much more challenging.
    - **Reduced costs on ancillary services:** The cost of contingent power procurement or power demand for cold-start is reduced as utility can draw power from the prosumers at prices lower than ancillary service providers.
    - **Environmental benefits:** As the number of electricity producers grows, the energy production may undergo significant shift, greening the power production.

      As the power demand is shifted, and not reduced, peak generating units (running on fossil fuel) are less utilized.

- **System quality improvement:** Integration of a high number of RE improves quality and reliability of electricity supply. This is due to normalization of the production from producers distributed across the geography.

1.4.3. BUSINESS MODELS (FLOW OF REVENUE)

Based on the revenue realization potential, business models are identified in below table.

Table 12: Business logic of rooftop (solar PV) procurement program — Revenue sources

Entity	Economic/Financial Benefits by Participating in AMI Program	Direct Revenue Realization Potential	Potential Revenue Option
DISCOM	• Reduced capacity upgrade cost • Improved ability to meet Renewable Portfolio Obligations (RPO) compliance	✓	
	Peak load management — Reduced stress on distribution equipment		✓
Customers	Savings (fixed, variable) due to peak power and load reduction	✓	
Transmission Companies	Grid management costs — Reduced ancillary service/contingent capacity procurement		✓
Society	• Reduced GHG emissions • Reduced SOx and NOx particulates		✓

1.5. ENERGY STORAGE: DISTRIBUTION GRIDS

The power demand during off-peak hours can be stored at the distribution grid to avoid purchase of power during the peak load period.

Energy storage at distribution grids can help DISCOMs to manage their power procurement timings allowing utilities to procure more power when prices are low and store it or store power when demand is low, and releasing it when demand is high or when power prices are high.

1.5.1. TECHNOLOGY FEATURES

Multiple energy storage technology choices are available to the distribution grid, including battery energy storage, flow batteries, fuel cells, and flywheels. All these technology options provide flexibility to DISCOM to maintain power rating and discharge time.

1.5.2. VALUES DERIVED

- **Benefits from DISCOM perspective:** Storage at the distribution grid helps utility to ensure that the power is procured at a reasonable price. The power stored with DISCOM offers flexibility and ability to provide power to the system when demand is high. Also, when the system is under stress, power can be sold back to the grid to maintain frequency and demand (in such case DISCOM becomes the provider of ancillary services).
- **Benefits for consumers:** The power quality supplied to the consumers improves as the utility has a backup mechanism to provide power when supply is low. Further, since DISCOM can manage the power procurement timings, the cost of power can be reduced resulting in low cost of power for the consumers.

Also, consumers can be isolated from any power supply problem as the stored power can be made available to them by DISCOM.

- **Environmental benefits:** The power stored by the utilities during off-peak hours helps the system to meet the demand during peak-load hours. Further, the demand to run the peaking power stations reduces.
- **Benefits to power system:** The storage facility reduces the need for peak generation plants, as energy storage could help reduce peak load and also lower the load of transmission and distribution system.

1.5.3. BUSINESS CASE LOGIC

Quantifiable Financial Benefits (for All Stakeholders):

- **Availability of cheap power:** The flexibility of power procurement timing will help DISCOM to procure and provide power at cheaper costs.
- **Power quality:** The additional source of power (storage device) can act as power backup mechanism which helps to restore power, maintain power supply standards and quality. Thus, premium can be charged to the consumers for quality service provisioning.
- **Defer investments in peak power:** The energy storage will reduce the peak power demand by the power system as on demand buffer is available.
- **Defer investments in transmission and distribution lines and substations:** Peak load reductions and demand smoothening will help defer the T&D line and substation capacity enhancement.
- **Ancillary service offerings:** The power storage facility helps to provide ancillary grid services such as frequency regulation and demand response.

1.5.4. BUSINESS MODELS (FLOW OF REVENUE)

Table 13: Business logic of energy storage at distribution grids — Revenue sources

Entity	Economic/Financial Benefits by Participating in AMI Program	Direct Revenue Realization Potential	Potential Revenue Option
DISCOM	Reduced technical losses		✓
	• Reduced peak power procurement — Peak load management • Peak load management — Reduced stress on distribution equipment • Improved outage management: - Better compliance with customer supply standards - Reduced down time - Reduced equipment failure, degradation/ damage to assets (e.g., DT) - Reduced man hours - Reduced service time • Reduced capacity upgrade costs • Grid management costs: - Reduced UI charges - Reduced ancillary service/contingent	✓	

Entity	Economic/Financial Benefits by Participating in AMI Program	Direct Revenue Realization Potential	Potential Revenue Option
	capacity procurement • Improved tariff — Reliability charges for consumers		
Customers	Improved power quality and availability: - Reduced equipment failure costs - Improved productivity		✓
Transmission Companies	Grid management costs — Reduced ancillary service/contingent capacity procurement		✓
Generators	Revenue from ancillary services to the grid	✓	
	Improved grid availability and higher plant availability		✓
Society	• Reduced GHG emissions • Reduced SOx and NOx particulates		✓

1.6. STORAGE AT CONSUMER END

Energy storage has been used by the consumers in India for several years to negate power supply disturbances. The behind the meter electricity storage capacity is slated to go up as consumers install solar PV systems, and combine it with storage (to improve the economic performance of the installation). Also, increase in the deployment of electric vehicles (EV) will enhance the customer side energy storage capacity.

1.6.1. TECHNICAL FEATURES

A residential electric storage unit might range from 1.5-20 kWh, while a commercial electric storage system would typically reach a multi-megawatt capacity (US DoE, 2013).

1.6.2. VALUES DERIVED

Increasingly, deployment of new technologies on the customer side of the meter is changing the nature of power use and consumption requirements. Also, the evolution of 'SmartGrid' is enabling customers to shape their requirements to improve electricity use and utilization; simultaneously, contributing to improved grid reliability, performance, and economics. These developments will help create opportunities for customer storage to play an increasing role in grid services.

- **Benefits to consumers:** Using behind the batter storage option, consumers get the flexibility to choose the timing of power drawn from the grid. In terms of benefits, they can reduce cost of power by offsetting the consumption of costly power by shifting power usage to non-peak hours. Therefore, consumers' specific electricity service needs are met (power quality and reliability purposes). Consumers are able to increase the value of solar PV by smoothening fluctuation in power production.
- **Benefits from utility perspective:**
  - Defer major investments in transmission and distribution lines and substations in constrained areas of the grid via peak load reductions.
  - Reduce the need for peak generation plants and spinning reserves by providing a "buffer" of on-demand energy storage at customer sites.

- Buffer grid imbalance: Storage helps stabilize the grid, enabling more intermittent users and suppliers of electricity (e.g., EVs, solar PV, etc.) to connect safely.
- Provide ancillary grid services such as frequency regulation and demand response.
- Achieve compliance with mandatory energy storage targets (in MW).
- New products and incentives targeted towards consumers with battery storage facilities can be deployed to manage the power system load.
- Consumer energy use can be altered by introducing ToD and dynamic tariffs as consumers can store electricity for future without compromising on service quality when the prices are relatively higher.

1.6.3. BUSINESS CASE LOGIC

Quantifiable Financial Benefits

The behind the meter storage payback periods depend on the storage device costs and returns from the solar PV (if deployed). With fast dropping storage costs, the payback period is ever decreasing.

- **Defer investments in peak power:** Addition of energy storage (if solar PV is discounted) will reduce the peak power demand as on-demand buffer is available.
- **Defer investments in T&D lines and substations:** Peak load reductions and demand smoothening will help defer the T&D line and substation capacity enhancement.
- **Extension of network storage to behind the meter storage:** Substations could theoretically dispatch as well receive electricity from storage devices sitting at consumers' place. Thus, effectively expanding the network storage potential and utilizing it at a higher efficiency.
- **Ancillary services:** Provide ancillary grid services such as frequency regulation and demand response to achieve compliance with mandatory energy storage targets (if any).

1.6.4. BUSINESS MODELS (FLOW OF REVENUE)

Table 14: Business logic of energy storage at consumer end — Revenue sources

Entity	Economic/Financial Benefits By Participating In AMI Program	Direct Revenue Realization Potential	Potential Revenue Option
DISCOM	• Reduced peak power procurement — Peak load management • Improved ability to meet mandates — RPO compliance	✓	
	• Peak load management — Reduced stress on distribution equipment • Improved outage management — Reduced equipment failure and degradation/damage to assets (e.g., DT) • Reduced capacity upgrade costs		✓
Customers	• Savings (fixed, variable) due to peak power/load reduction: - Procurement of peak load reduction — Payment from DISCOM - Revenue from ancillary services to the grid	✓	

Entity	Economic/Financial Benefits By Participating In AMI Program	Direct Revenue Realization Potential	Potential Revenue Option
	• Improved power quality and availability: - Reduced equipment failure costs - Improved productivity		
Transmission Companies	Grid management costs — Reduced ancillary service/contingent capacity procurement		✓
Generators	Improved power evacuation		✓
Society	• Reduced GHG emissions • Reduced SOx and NOx particulates		✓

1.7. SMART DISTRIBUTION SUBSTATION

Smart substation is an integral part of SmartGrid. Smart substation deploys advanced technology as compared to SCADA and has provisions to apply for IT to improve O&M, increasing efficiency (both system and human resources) and optimized capacity utilization[21].

1.7.1. FEATURES OF SMART DISTRIBUTION SUBSTATION

Smart distribution substation will have to abide with the operational standards prescribed for SmartGrid including the aspects on protection, automation, and control of power systems.

Depending on the utility level of maturity achieved, the distribution substation should be able to offer the following features (Heckel, 2009)[22]:

- High order automation of power system operations.
- Automated supervision of all security features and response triggers.
- Integrated monitoring, diagnosis, and reporting for all levels.
- Predictive maintenance at all levels.
- Automated decision making to support predictive avoidance of system problems.

Since, SmartGrid is a dynamic intervention; the distribution substation should regularly add new features and functions as the power system matures. This will ensure that the substation and its feeders operate in a fully integrated and automatic manner in normal as well as in emergency situations.

1.7.2. BENEFITS OF SMART DISTRIBUTION SUBSTATION

Distribution automation can provide a balance of both quantitative and qualitative benefits. Also, utilities are considering higher order of distribution automation to address challenges faced by the industry, including:

- Increased saturation of existing distribution networks.
- Greater sensitivity to consumer service.

[21] The SmartGrid applications, include integrated voltage and VAR control (IVVC), fault detection isolation and restoration (FDIR) in distribution automation (DA), and AMI, as well as the demand response (DR) (Fan, Toit, and Backscheider, 2009).

[22] The applications that may be opted by the distribution substation may include remote access to intelligent electronic devices (IED)/relay configuration ports, waveforms, event data, diagnostic information, camera based equipment status or security assessment, metering, switching, volt/VAR management, and others (PSE, 2016).

- High RE deployment.

Smart distribution automation has answers to the above challenges along with other benefits, including:

- **Loss reduction:** Automatic voltage management at substation and down line results in improved line throughput and reduces line losses.
- **Power quality:** The power quality parameters are under continuous monitoring; the auto-detection and correction features ensure that the power problems are addressed before they occur.
- **Deferred capital expenditure:** Utilities are able to operate closer to the physical limits of their systems. Distribution automation makes this possible by providing increased availability of better data for planning, engineering, and maintenance.

  Also, using a preventive maintenance algorithm may improve utility's ability to schedule maintenance, reduce labor costs, optimize equipment use, and extend equipment life.
- **Improved reliability:** On the qualitative side, improved reliability adds perceived value for customer and reduces the number of complaints. Distribution automation features providing interruption and customer service related benefits include load shedding and other automatic control functions.
- **Lowering of operations cost:** Operating cost reductions[23] are achieved through improved voltage profiles, controlled VAR flow, repairs and maintenance (R&M) savings, reduced substation transformer load losses, reduced feeder primary and distribution transformer losses, load management, and reduced spinning reserve requirements.

1.7.3. REVENUE MODELS FOR SMART DISTRIBUTION SUBSTATION

The potential revenue models for smart distribution substation and for energy storage at distribution grid are summarized in the following tables.

Table 15: Potential benefits of smart distribution substation — Revenue sources

Entity	Benefits
DISCOM	• Substation peak load can be manipulated and reduced • Reduced purchase of expensive peak power • Efficient utilization of network • Efficient utilization of skilled resources
Customers	• Quality and reliable power supply
	• Reduction in outages
Transmission Companies	• Peak load can be manipulated and reduced
Generators	• Peak load can be manipulated and reduced
Society	• Savings on power consumption
	• Less dependency for peak power from less efficient power plants

Table 16: Business logic of energy storage at distribution grids — Revenue sources

Entity	Economic/Financial Benefits by Participating in AMI Program	Direct Revenue Realization Potential	Potential Revenue Option

[23] In addition, data acquisition and processing and remote metering functions play a huge role in reducing operating costs.

Entity	Economic/Financial Benefits by Participating in AMI Program	Direct Revenue Realization Potential	Potential Revenue Option
DISCOM	• Improved outage management: - Better compliance with customer supply standards - Reduced down time - Reduced equipment failure, degradation/damage to assets (e.g., DT) - Reduced man hours • Reduced technical losses • Improved tariff — Reliability charges for consumers • Grid management costs — Reduced UI charges	✓	
Customers	Revenue from ancillary services to the grid	✓	
	Improved power quality and availability: - Reduced equipment failure costs - Improved productivity		✓
Transmission Companies	Grid management costs — Reduced ancillary service/contingent capacity procurement		✓
Generators	• Improved grid and higher plant availability • Improved power evacuation		✓
Society	• Reduced GHG emissions • Reduced SOx and NOx particulates		✓

1.8. NETWORK / DISTRIBUTION UPGRADATION

Network modernization focused SmartGrid projects commonly involve feeder and transmission network upgradation as a means to advancement. It would involve replacement of the existing wires to high performance options (e.g., high temperature superconducting lines). Integrated with telecommunications and operational (sense and control) technologies, such arrangement would also improve delivery performance of the power distribution system and lead to the formation of a modern and self-healing grid.

1.8.1. NETWORK UPGRADATION OPTIONS AND LINKED SERVICES

There are various options for network modernization. Depending on the resources available with the utilities and network upgradation, priorities can be decided as follows:

- **High temperature superconductor (HTS) wires:** HTS wires enable power transmission and distribution cables with three to five times the capacity of conventional underground AC cables.

  HTCs are able to withstand higher operating temperatures and can therefore carry a higher amount of power compared to conventional conductors, thereby increasing the capacity of transmission lines.

- **Transmission and distribution intelligent electronic devices:** Such devices monitor the network's hardware performance and help communicate with operators, automatically respond to problems, and help integrate renewable resources with grid.

- **New sensor and control technologies:** Combined with distributed intelligence, sensor and control technology options helps to report and resolve grid issues in real time (adding to self-healing properties of the grid).
- **Upgradation to accommodate renewable integration (high voltage direct current transmission):** RE projects isolated from the point of consumption require long distance power transmission. High voltage direct current transmission proves to be the best transmission method for such projects as it minimizes the transmission losses.
- **Underground cabling:** Below surface power distribution is relatively safer and also makes precious urban land available for alternate use.

1.8.2. REVENUE POTENTIAL AND BUSINESS MODEL

The upgraded transmission and distribution network results in quantifiable as well as non-quantifiable benefits but significant benefits to the stakeholders. The potential revenue models for both the benefits are listed in following table.

Table 17: Business logic of line upgradation program — Revenue sources

Entity	Economic/Financial Benefits by Participating in AMI Program	Direct Revenue Realization Potential	Potential Revenue Option
DISCOM	• Reduced capacity upgrade cost • Improved outage management: - Better compliance with customer supply standards - Reduced down time - Reduced equipment failure, degradation/ damage to assets (e.g., DT) - Reduced man hours • Reduced technical losses • Improved tariff — Reliability charges for consumers	✓	
	• Improved outage management — Better compliance with customer supply standards • Improved tariff — Reliability charges for consumers		✓
Customers	Improved power quality and availability: - Reduced equipment failure costs - Improved productivity		✓
Transmission Companies	• Improved throughput of transmission assets • Reduced power loss in the grid		✓
Generators	Improved grid availability and higher plant availability		✓
Society	• Reduced GHG emissions • Reduced SOx and NOx particulates		✓

1.9. AUTOMATED DISCOM PROCESSES

DISCOMs automation optimize the operations of the utilities and improves the system performance and its reliability.

1.9.1. REVENUE POTENTIAL AND BUSINESS MODEL

Advanced distribution automation is a real-time adjustment to changing loads, generation, and failure conditions of the distribution system, usually without operator intervention. This is facilitated through an automated decision making.

Other important feature of automated DISCOM is real-time communication with utilities and other power systems (linked to DISCOM) including users. SmartGrid enabled DISCOM automation facilitates AMI to comunicate with the consumers and manage power consumption using DSM approaches. Futher, the distributed generation is linked to DISCOM and managed through net metering approaches.

The automated DISCOM ensures that distribution loads are managed by sensing power system overloads at the distribution feeders, thus, increasing the possibility to shift the loads to other feeders by reducing stress in the system. The automated DISCOM also helps preempt, promptly respond to system problems and reroute power to consumers through an alternate route. Hence, the duration of outages can be reduced or avoided. The ability of a DISCOM to automatically isolate stress sectors and outages helps in containing the problems, thus, avoiding system level failures.

The automated response triggered by the detected system problems ends when the system is restored to normal levels of operations.

At a monitoring level, the automated DISCOM keeps detailed logs of the system level events and gives feedback to the system managers.

1.9.2. BUSINESS DRIVERS

Quantifiable Financial Benefits (for All Stakeholders)

The quantiafiable benefits associated with the automated DISCOM include:

- **Utility perspective:**
  - Disruptions are minimal and system restoration is quick.
  - Automated system requires less human resources.
  - Power quality is high.
  - Equipment performance is high and system strain is less, resulting in low maintenance.
  - Reduced times for service provisioning to consumers.
- **Benefits to consumers:**
  - Consumers offer paid services to DISCOM, i.e., energy storage and DSM helps in managing power quality.

1.9.3. BENEFITS OF DISCOM AUTOMATION

Applications having huge potential are operations and efficiency management of peak loads via predictive technologies and communications for equipment, and system restoration technologies.

- **Automated accurate decision making:** Automated DISCOM allows accurate modeling of distribution operations and supports quick real-time decision making at the control center and in the field.
- **Utilization of available infrastructure:** By applying automated DISCOM to support power infrastructure, the system can be managed more efficiently, and the voltage profiles can be managed to maximize energy throughput of the system.
- **Complete information on the power system:** Automated DISCOM can facilitate real-time data acquisition and communication with utility databases and other automated systems.
- **AMI/Smart meter:** For details, refer Chapter 2 of the report.
- **Introduction of demand response:** See Chapter 3 for detailed discussion.
- **System reliability:** Distribution automation along with new technology introduction (e.g., transformer upgradation[24]) helps to achieve system reliability.
- **Integration of distributed generation**: RE integration support local power grids in the presence of blackouts and ease the load on long distance transmission lines.
- **Self-healing features:** In autmated DISCOM, outage time is eliminated/reduced through control systems embedded in the distribution system.

1.9.4. REVENUE MODELS FOR AUTOMATED DISCOMs

The potential revenue models for automated DISCOMs are summarized in following table.

Table 18: Business logic of automated DISCOM processes — Revenue sources

Entity	Economic/Financial Benefits by Participating in AMI Program	Direct Revenue Realization Potential	Potential Revenue Option
DISCOM	• Improved outage management: - Better compliance with customer supply standards - Reduced down time - Reduced equipment failure and degradation/damage to assets (e.g., DT) - Reduced man hours • Commercial loss reduction — Billing cost reduction	✓	
	• Peak load management — Reduced stress on distribution equipment • Grid management costs — Reduced UI charges • Commercial loss reduction: - Billing efficiency improvement - Collection efficiency improvement • Grid management costs — Reduced UI charges • Improved tariff — Reliability charges for consumers		✓

[24] Technologies that are less prone to damage and theft and that can reduce power losses during the step-up and step-down voltage conversion.

Entity	Economic/Financial Benefits by Participating in AMI Program	Direct Revenue Realization Potential	Potential Revenue Option
Customers	Revenue from ancillary services to the grid	✓	
	• Savings (fixed, variable) due to peak power/ load reduction • EE procurement (standard offer) payment from DISCOM • Procurement of peak load reduction — Payment from DISCOM • Revenue from ancillary services to the grid		✓
Transmission Companies	Grid management costs — Reduced ancillary service/contingent capacity procurement		✓
Generators	• Improved grid and higher plant availability • Improved power evacuation		✓

1.10. CASE OF ENERGY SAVINGS USING AMI

In a dynamic pricing environment, energy savings can be achieved by communicating pricing information to the consumers resulting in altered power consumption behaviour and patterns. The percentage of energy savings achieved by providing consumers with the pricing information in a dynamic pricing scenario is illustrated in following figure.

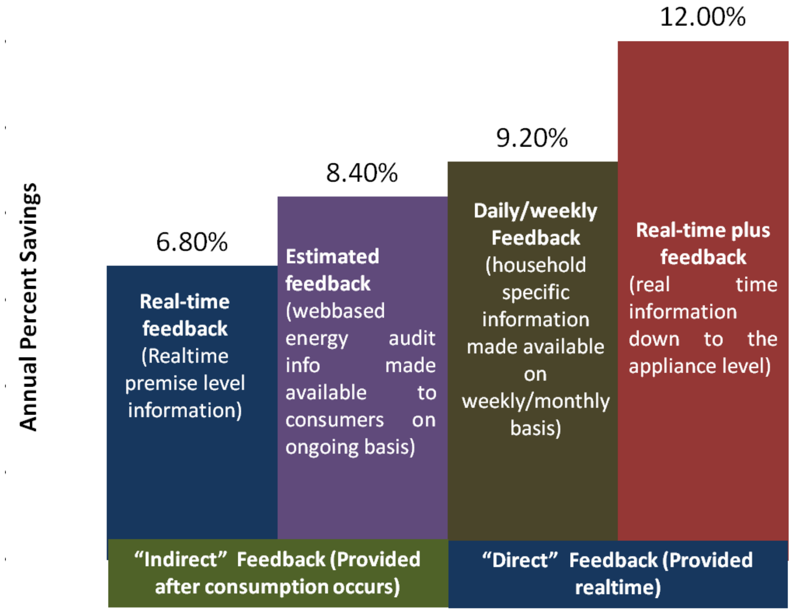

Figure 10: Aggregate household electricity savings by feedback type

Several studies have established the quantum of savings that can be achieved by providing price feedback to the consumers. The benefits are highest when real-time information is available to the consumers (only possible through AMI intervention).

1.11. CASE ON AMI ROLLOUT: AJMER SMART METER PILOT

The case on AMI rollout implemented in Ajmer (Rajasthan) with the consumers of Ajmer Vidyut Vitran Nigam Limited (AVVNL) is designed to establish the AMI linked benefits and rollout strategies. The main functionalities proposed for the pilot are AMI installation and loss reduction analytics. The project is being implemented applying pay for service approach (entire implementation is treated as a service and no direct payment for advance meters are required).

As per the model, the vendor provides equipment including meters and supporting software, along with a remuneration of monthly service charge. The charges are fixed to cover the capital expenditure of the vendor for a period of four to five years.

The USAID Partnership to Advance Clean Energy - Deployment (PACE-D) Technical Assistance (TA) Program supported payments to the vendor for the first six months of the project. The major findings from the project are depicted in following table.

Table 19: Ajmer smart meter pilot project particulars

Parameter	Particulars
Satguru Feeder Electricity Consumption for 1,000 Consumers	17,64,500 Kilowatt Hour (kWh)/Year
Average Tariff	INR 5.5/kWh
Total Cost of Project	INR 30 Lakhs
No. of Consumers in the Pilot Area	1,000
AT&C Loss	17 Percent
Savings Due to Smart Installations (arising from 5 percent reduction of AT&C losses)	INR 4.85 Lakh/Year

1.12. BUSINESS MODEL — SMART METER CASE

Smart meter projects typically involve the following:

- Installation of smart meters at the customer premises and transformer, and line monitoring units in the distribution infrastructure.
- Setting up a two-way communication infrastructure connecting smart meters and monitoring units of distribution infrastructure to the IT systems of utility, which covers customer data management, billing, load forecasting and management, collection, service, asset management, and outage management.

1.12.1. BENEFITS OF SMART METERING

Use of smart meters can result in significant benefits such as:

- Improved reliability, quality, and availability of services
- Reduction of costs
- Reduced capital required to serve customers; postponement of future capacity:
  - Improved throughput of distribution assets
  - Reduced float (between metering and collection)
- Ability to respond to customers promptly
- Assisting customers to manage their energy costs

As a result, this leads to improved customer and employee satisfaction. The benefits of smart meters are outlined below.

Table 20: Benefits of smart meters

Sr. No.	Smart Meter Feature	Impact	Benefit
1	Automated Metering	• Eliminate manual meter reading	• Reduce metering costs

Sr. No.	Smart Meter Feature	Impact	Benefit
	and Billing	• Reduce metering errors • Improve metering frequency (e.g., move from bi-monthly to monthly billing; prepayment option)	• Reduce float • Reduce customer service costs
2	Ability to Remotely Connect/Disconnect Services, and Identify Tempering	• Reduce number of customers who do not pay or tamper metering • Prompt response to dead/faulty meters	• Reduce commercial losses • Reduce energy procurement costs
3	Ability to Forecast Loads; Provide Signals to Manage Demand/ Control Customer's Load (DSM Program)	• With an access to dynamic customer load data, utilities can help reduce peak loads (with DSM program), and overdraw power • Improve load forecasting and scheduling of procured power. Lesser network down time due to power shortage • Dynamic/Online feedback to customers on peak loads, energy consumption, and effect of EE measures	• Reduce premium paid on energy procured during peak hours • Reduce stress on distribution and metering assets • Reduce regulatory costs (UI charges, penalties) due to overdraw of power • Customers are able to improve energy costs and engage in EE measures
4	Ability to Quickly Identify Assets/Areas Where Load Is Imbalanced, Power Quality Is Poor, Including Ability to Predict and Take Counter Measures	• Reduce downtime of DT infrastructure due to overloading/burning • Undertake upgrade of capacity in time to improve overall throughput • Predictive maintenance, reducing down time, and maintaining health of assets • Identification of points of power loss; system energy audits	• Reduce R&M costs • In the long run, reduce investment in operating assets for a given level of energy flow • Reduce instances of DT, line burning; hence, downtime • Reduced technical losses • Improve reliability, availability (SAIFI and SAIDI) • Improve power quality
5	Ability to Quickly Identify Points Where Network Is Down	• Reduced turnaround time for repairs	• Improve SAIFI and SAIDI • Improve productivity of asset maintenance, outage management, and customer service teams

1.12.2. TYPICAL INVESTMENT LEVELS

The current cost estimates of metering and communication infrastructure is in the range of INR 4,000-7,000/meter.

This capital investment can be justified by savings in recurring costs and capital as brought out in our analysis later.

1.12.3. BUSINESS MODELS FOR SMART METERING

A business model defines the following for a proposed investment:

- Benefits:
    - Revenue model
    - Savings model
- Cost model:
    - Capital costs
    - Operating costs
- Investment model:
    - Investment sharing (e.g., utilities, system supplier, and investors)
    - Framework for risk-reward sharing across investors/operators

The paragraphs below outline how a business model can be constructed for smart meter investments.

1.12.4. BENEFITS

No revenue stream is proposed for smart meter projects, although, with improved customer service, power quality, reliability and availability of service, and choices for customers to optimize their energy costs, it is possible to earn a premium on energy tariff[25].

Therefore, this note focuses only on the savings from smart meter projects. Such savings are of two types:

- Recurring cost savings
- Savings on capital employed (reduced investment/kWh or investment/meter, or postponement of future investments because surplus capacity is made available):
    - In Working Capital
    - In Network Assets

1. Recurring Cost Savings

The following areas can be analyzed for recurring cost savings:

- Category – 1 savings resulting directly from the smart meter program, aided only by strong management processes and controls and no supplementary capital investments include:
    - Reduced metering costs
    - Reduced peak load and power consumption during peak hours
    - Reduced commercial losses (billing loss and commercial loss)
- Category – 2 savings are realized with small complementary infrastructure investments. These are difficult to measure compared to Category – 1 savings:
    - Lower R&M costs
    - Reduction of technical loss

[25] Some utilities have attempted to charge reliability and quality premium for 24/7, high quality power supply. Though, it is not common.

- Category – 3 savings is related to productivity improvements. These are difficult to measure and are normally achieved over time as surplus capacity realized is utilized for expanding the network and improving throughput.
    - Improved employee productivity for people employed in:
        - Customer service
        - Billing
        - Outage management
        - Asset management
    - Employee rationalization is not expected, but employees would be retrained and used elsewhere as capacity expands.

2. Capital Savings

Smart meters can help save capital investments in the following areas:

- Category – 1: Reduction of float money locked up between the date of metering and collection:
    - Meter reading and billing can be completed, practically any time when needed, rather than carrying out over time (manual metering).
    - If customers do not pay the bill on time, after alerts and warnings, disconnection can be carried out online and the services can be resumed once payments are received.
- Category – 2: With load balancing and peak load management, existing distribution infrastructure can be used to meet higher demand. Therefore, average loading of transformers and lines improve. This allows postponement of capacity expansion investments.

3. Cost Streams

Smart meter investments create additional cost streams:

- O&M of smart metering infrastructure
- Communication costs for communication between smart meters, field monitoring units, and the utility
- Capital costs – such as interest, depreciation, and equity returns required for the new investment

1.13. CASE STUDY – UTILITY

This section outlines the case of a utility and presents potential financial feasibility for smart meter investment under a Lease Rental Model.

Background

Consider a utility which covers the distribution for an area of around 500 square kilometer (Sq km) with an annual turnover of INR 1,900 Crore (financial year [FY] 2015-16) and has 24x7 power supply.

With improving availability, the demand in the utility area is rapidly growing and in the last three years, it has grown at a rate of 22 percent per annum. Utility has completed APDRP programs and has invested strongly in 'customer service'.

- Around 15 percent of customers are served with online alerts such as service breakdown, complaint resolution, and energy consumption
- It has identified priority customers who pay regularly, do not carry out theft or overload the system, etc. Such customers get priority in service; need not stand in queue, etc.

Utility has planned investments of INR 315 Crore in smart metering infrastructure.

Operating Conditions

Table 21: Utility operating profile[26]

Parameter	Value	Unit
Consumption (FY 2015-16)		
Total Electricity Billed	2,904.5	MU/a, FY 2016-17
Total Customer billing	2,028.6	INR Cr/a FY 2016-17
Total Collections	1,991.7	INR Cr/a
Peak Load	650	MW
Connect Load	1,300	MVA
Transmission and Distribution (FY 2015-16)		
Total Power Procured	3,557.05	MU/a
T&D Losses	19.8	Percent
Transmission and Distribution (FY 2015-16)		
Technical Losses	12	Percent
Commercial Losses	7.8	Percent
Meters — Tariffs (Aggregate Revenue Requirement [ARR] FY 2016-17)		
Average Procurement Rate of Power	4.21	INR/kWh
Transmission Charges	0.20	INR/kWh
Short Term Procurement of Power	6.6	INR/kWh
Operations (2016)		
Average Cost of Metering	8	INR/Metering
Billing Frequency	1	Monthly/Bi-monthly
Average No. of Days of Receivables	60	Days
Peak Load Hours	5	Hours
Expenses (FY 2015-16)		
Employee Expense	118.77	Cr
A&G Expenses	61.33	Cr
R&M Expenses	53.05	Cr
Depreciation Costs	64.9	Cr
Total Expenses	298.05	Cr
Existing Investments (FY 2015-16)		
Gross Fixed Assets	747.29	Cr
Plant and Machinery	212.41	Cr
Lines, Cables, and Network	476.65	Cr
Others	58.23	Cr

[26] Considered utility is KESCO. Data is from ARR for FY 2016-17 as well as DPR prepared by KESCO for smart meter investments.

Parameter	Value	Unit
Less: Total Capitalized Expenses	31.38	Cr
Net GFA	715.91	Cr
Net GFA	1,3282	INR/Meter
Grants and Consumer Contribution	164.37	Cr

It is expected that energy demand/meter will increase @ 2 percent per annum and the number of meters will grow @13 percent per annum for the next three years and thereafter @3 percent per annum. This is consistent with the expectation that there is still significant unspent demand in the utility.

Improvements Expected From Smart Metering Implementation

The impact in the utility after implementation of smart metering is as follows:

- No manual metering – All metering would be done online, as all meters are likely to be replaced by smart meters.
- The productivity of employees is likely to be improved:
    - Faster identification of areas where service/network is down
    - Quicker resolution of problems – Less man effort of customer service and outage management teams
    - Reduced frequency of failure of DT infrastructure. Less number of outages to be handled
    - Reduced billing errors
    - Reduced manual intervention in collection.
- The productivity of asset (increase in energy transmitted and distributed through the same infrastructure, without fresh capacity:
    - Less asset downtime and number of breakdowns
    - Less load imbalance
    - Faster identification of bottlenecks and improve capacity at these points
    - Improved scheduling and therefore, reduce 'no power' downtime
- Reduced R&M expenses because of less frequent failures in distribution infrastructure
- Less number of days between metering and collection - Reduced float and increased cash with the utility
- Reduced T&C losses:
    - Reduced technical losses because of better load balancing, reduced frequency of failures, reduced down time, improved energy audit, and control of losses
    - Improved identification of areas where theft happens or meters are tampered and immediate action is taken resulting in reduced commercial loss.
- Reduced peak load (MW, megawatt hour [MWh]):
    - Peak load is reduced by working with customers and providing those incentives and/or regulation for limiting loads during peak periods, voluntarily or on demand.

In addition, customers of utility may receive the following benefits:

- Improved service reliability, power quality, and availability
- Faster response and resolution of complaints
- Lower power costs (peak load reduction and EE) as well as navigate some utility benefits

However, these benefits are not being valued in the proposed business model. The improvement targets are based on the understanding of current baselines (wherever data is available) as outlined below.

Table 22: Impact of smart meter program

	Unit	Current	Post SM Program
Manual Metering	Percent	100	0
Improvement in Employee Productivity (Billing, Collections, Outage Management, Asset Management, and Load Management)	Percent	-	20
Reduction of DT and Line Failures	Percent	-	20
Asset Throughput Improvement	Percent	-	30
Average Float	Days	60	30
Commercial Loss	Percent	7.8	1.80
Technical Loss Reduction	Percent	12	9
Reduction of Peak Load and Peak Period Energy Consumed	Percent	-	10

Investments Required

The estimates of DPR are outlined below.

Table 23: Estimates for the model

AMI Program	
Planned AMI Installation No.	
1 Phase — Low Tension (LT) (Load <4 kW)	4,51,108
3 Phase — LT (5 kW+)	74,890
CT Operated 3 Phase High Tension (HT)	13,002
Total	5,39,000
Nos.	
DCUs	5,390
Meters/DCU	100
Investment INR Cr	
Total AMI HW Cost	241.4
IT System	15.7
Field Equipment for DT Monitoring	9.7
SI (Design, Supply, Construction and Installation) Costs	40.0
FMS – One Year (Facility Management Service)	8.0
Total	314.8

The same estimates are used in developing the business model.

Leasing Model and Estimation of Lease Rental

A cash flow analysis would be carried out for a system supplier who invests in smart meter, field metering and communication infrastructure.

- 539,000 meters, 5390 DCUs, 1,600 transformed monitoring units and related equipment.
- Investment required INR 291.1 Crore
- 10-year lease period.

An annual lease rental of **INR 1,061 per meter** would provide adequate recovery of cost of capital for the supplier (estimated at 10.1 percent per annum). *This will have 4 percent per annum annual escalation.*

No capital or revenue subsidy is assumed here.

Free Cash Flow to the Utility

Utility pays the lease to smart metering infrastructure and using this infrastructure derives various benefits - 'saving of recurring costs' as well as 'saving of float and capital costs'.

Based on the assumptions made about the impact of the program, the cash flow forecast for the utility is outlined below. The cash flow is estimated for three categories, with increasing difficulty of realization.

Table 24: Financial analysis for AMI Program

Savings in Costs Versus Baseline	Year 0	Year 1	Year 2	(INR Cr) Year 3	Year 4	Year 5	Year 10
Category – 1: Direct, With Managerial Oversight and Process Changes							
Metering Costs		6	7	8	9	10	14
Peak Load Reduction		10	25	30	32	35	55
Commercial Loss Reduction		55	127	151	165	180	279
Total Recurring Savings		71	158	190	207	225	348
Recurring Savings Post Tax		47	105	125	136	149	229
Float Reduction Change Versus Baseline Figure		100	140	48	27	29	45
Total Category – 1 Savings Cash Flow		**147**	**244**	**173**	**163**	**178**	**275**
Add: (Category – 2)							
Category – 2: Those Which Will Require Some Investments in Asset Upgrade							
Technical Loss Reduction		50	110	132	144	157	243
R&M Cost Reduction		6	11	12	12	13	16
Total Recurring Savings		55	122	144	156	170	259
Recurring savings post tax		36	80	95	103	112	171
Total Category – 2 Savings Cash Flow		**36**	**80**	**95**	**103**	**112**	**171**
Add: (Category – 3)							
Category – 3: Productivity Related							
Effect of Employee Productivity		11	21	22	23	24	29
Post Tax Recurring Savings (Category – 3)		7	14	15	15	16	19
Saved Investments in Distribution Infrastructure		61	51	0	0	0	0
Total Category – 3 Savings Cash Flow		**68**	**65**	**15**	**15**	**16**	**19**
Less: Annual Lease Rentals and Additional Investments							
Annual Lease Rentals		65	76	89	96	102	144
Post Tax Value of Lease Rentals		43	50	59	63	68	95
Additional Investments							
IT and Backend	16						
Upgrade/Balancing Investments		69	0	0	0	0	0

Savings in Costs Versus				(INR Cr)			
Total Cash Outflow	**16**	**112**	**50**	**59**	**63**	**68**	**95**
Tax Savings on Depreciation on Additional Investments		2	2	2	2	2	2
Net FCF	-16	142	341	225	220	240	371
Per Meter Savings	-292	2,627	5,603	3,274	2,833	2,998	3,999

This cash flow model assumes:

- 4 percent inflation in costs, including lease rental payouts.
- Tax rate of 34 percent for the utility - This could be lower for utilities with accumulated losses etc.
- The savings require one year to realize and are fully taken into account in the second year of the program.
- Demand grows allowing surplus capacity in assets and employees (Category – 3 saving areas) to be used over time.

Therefore, the utility is likely to save INR 2,600-4,000 annum per meter (INR 140-370 Crore/a), which are substantial and can be passed on to consumers in terms of cost reduction.

The utility should make an investment of INR 290-300 per meter in the first year and the balance investment will be by the system supplier.

The effect of various parameters is pictorially represented in figure below.

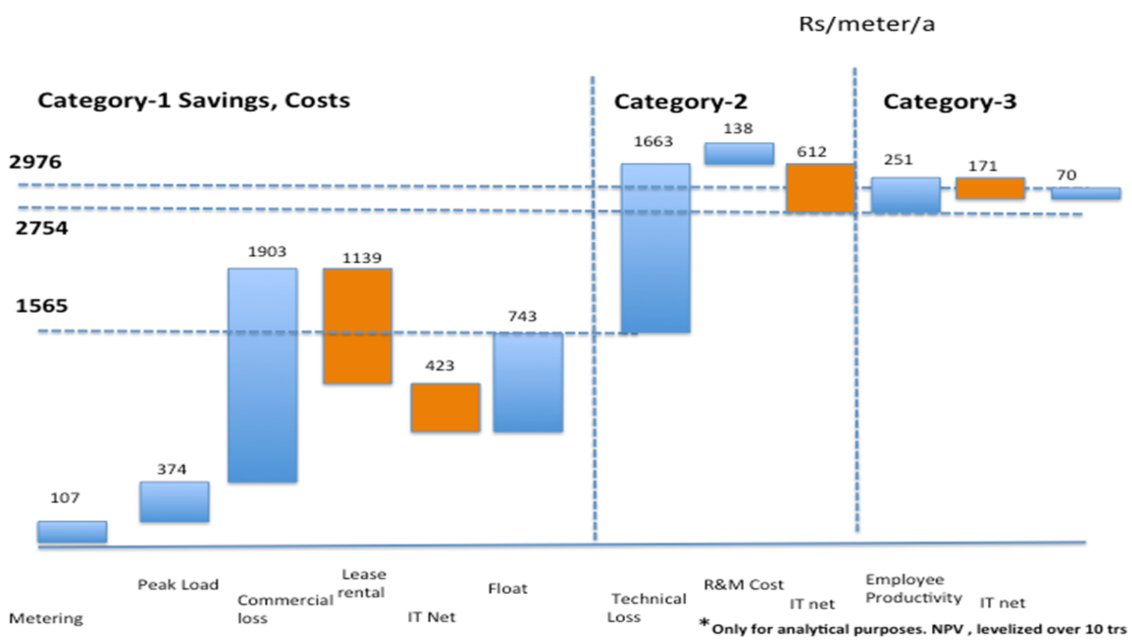

Figure 11: Smart meter business case — Utility

Category – 1 factors are likely to be most important and directly controllable by the utility to ensure viability of smart meter investments.

Scenario Analysis

Category – 1 savings which are direct results of smart meter investments can almost support the entire investments and lease rental payouts.

The sensitivity analysis in Table 28 highlights that with float reduction of above 15 days and commercial loss reduction of over 3 percent, the programs do not require any other type of savings to justify investments. There is a high probability that this can be achieved.

It is to be noted that the analysis does not assume any capital subsidy.

Table 25: Scenario analysis

NPV	Category – 1: Cash Flow Balance Float No. of Days (After Smart Meter Is Implemented)					
	647	15	30	40	45	60
Commercial Loss Reduction	1 Percent	230	40	-87	-151	-341
	2 Percent	351	160	33	-31	-221
	3 Percent	469	278	151	87	-103
	4 Percent	584	393	266	203	12
	5 Percent	697	507	380	316	126
	6 Percent	808	618	491	427	236
	7 Percent	917	726	599	536	345

With 30 percent capital subsidy, Category – 1 savings are sufficient for almost the entire range of variables.

NPV	Category – 1: Cash Flow Balance 30 Percent Capital Subsidy Float No. of Days (After Smart Meter Is Implemented)					
	841	15	30	40	45	60
Commercial Loss Reduction	1 Percent	425	234	107	44	-147
	2 Percent	545	355	227	164	-27
	3 Percent	663	472	345	282	91
	4 Percent	779	588	461	397	207
	5 Percent	892	701	574	511	320
	6 Percent	1,003	812	685	622	431
	7 Percent	1,111	921	794	730	540

If Category – 2 savings are added instead of capital subsidy, the NPV of cash flow becomes positive across the wide range of scenarios.

NPV	Category – 1 + Category – 2: Cash Flow Balance Float No. of Days (After Smart Meter Is Implemented)					
	1,251	15	30	40	45	60
Commercial Loss Reduction	1 Percent	701	510	383	320	129
	2 Percent	848	658	531	467	277
	3 Percent	993	802	675	611	421
	4 Percent	1134	943	816	752	562
	5 Percent	1,271	1,081	954	890	700
	6 Percent	1,406	1,216	1,089	1,025	835
	7 Percent	1,538	1,348	1,221	1,157	967

Key inferences:

- Category – 1 benefits should be more accurately assessed for designing the programs:
  - Metering costs
  - Commercial loss
  - Float

- Even small savings in commercial loss reduction are sufficient to keep the cash flow NPV positive. Thus, even in efficient utilities where T&C loss reduction opportunity may be relatively low, smart metering is likely to be viable.
- Smart utilities (with necessary management processes and intelligence) can significantly reduce the operating costs and enhance customer satisfaction by smart grid initiatives. Hence, the entire investment can be recovered in a period of one to two years.
- Category – 3 savings arising from 'employee productivity' or 'asset productivity' improvement are not required to justify investments. Thus, the fear that Smart Grid initiatives would result in retrenchment of people is not justified. Future requirements can be met through retraining and repositioning of staff to enhance efficiency and customer service levels.
- Migration to 'no state support' would be possible when:
    - Initial smart meter implementations prove the 'savings' potential
    - Scale up reduces the cost of equipment. Experiences of programs such as National Solar Mission and UJALA (LED bulb program by EESL) have shown that costs fall rapidly as scale up happens and market participants gain confidence.

Future Directions

Precise understanding of 'savings' and 'cost streams' for a utility can be developed by deeper analysis of the following:

- Current asset performance (availability, downtimes, frequencies of failures, etc.)
- Current float levels, billing frequency, causes of float, and possibilities of reducing float. This may include pre-payment and online payment options and ways of encouraging customers to opt for them.
- Cost structure linked to staff and overheads costs of people employed in metering, billing, collections, asset management, outage management, and customer service processes increase as the network and energy throughput grows. Understanding of these factors drive the volume of work in each of these processes.
- Asset utilization, loading, opportunities for peak load improvement.

Implementation of SmartGrid projects by large utilities can help understand equipment pricing. To attract strong and active participation from private sector players the following needs to be in place:

- Appropriate (fair, balanced) contract structure for leasing.
- Strong payment protection provisions.

ANNEX-II: SMART METER AND ENERGY STORAGE EVOLUTION

2.1. SMART METER EVOLUTION

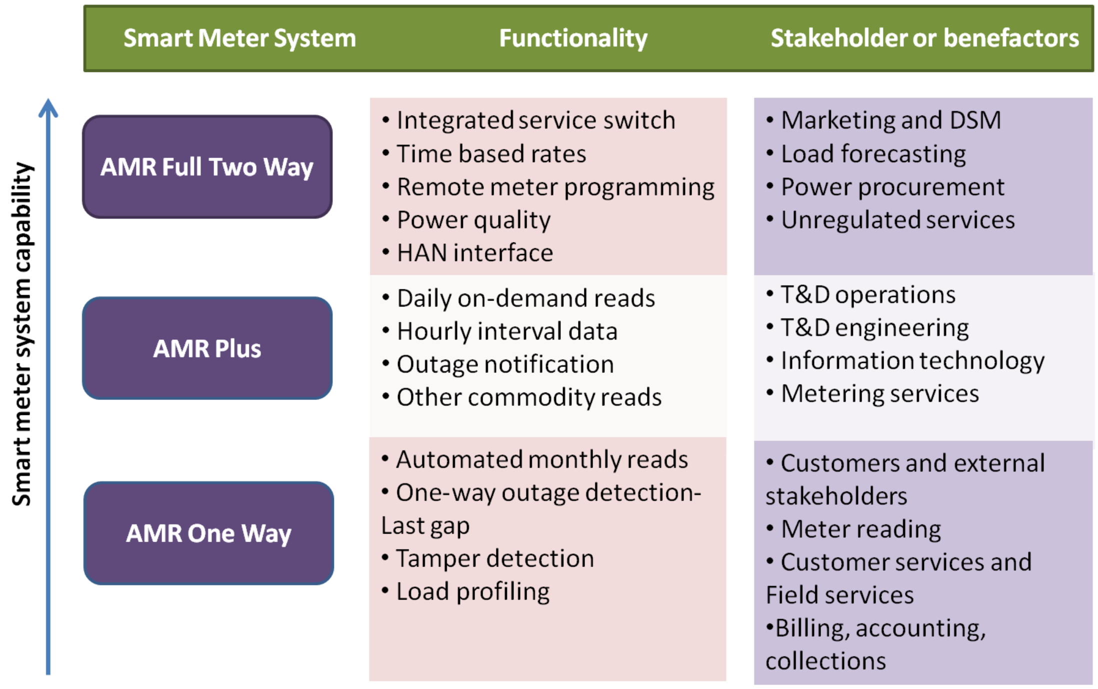

Figure 12: Smart meter evolution

2.2. ENERGY STORAGE TECHNOLOGIES

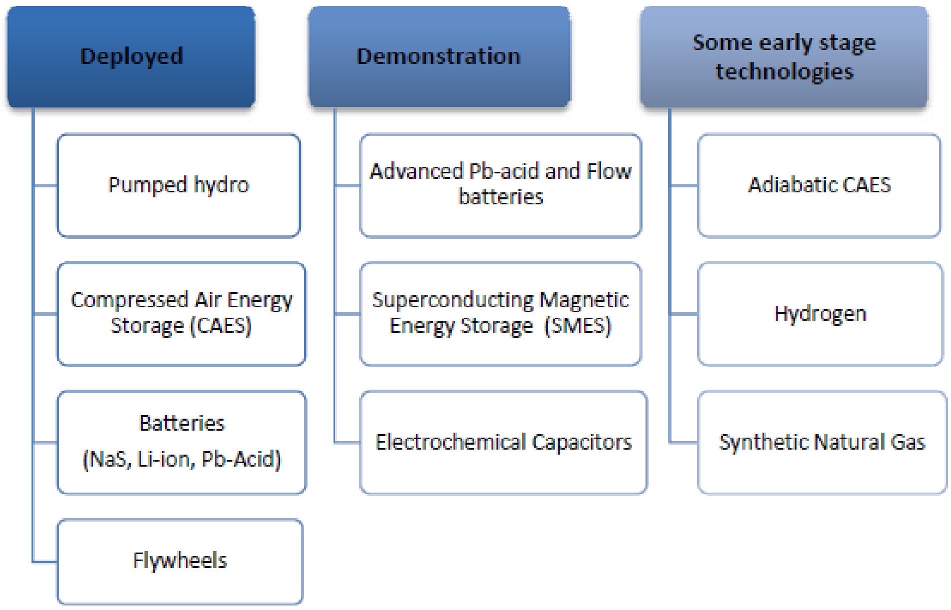

Figure 13: Maturity of energy storage technologies

ANNEX-III: DETAILED MRV FOR AN AMI PROJECT

In this section, a detailed MRV for an AMI project is presented. The MRV plan for AMI has the following types of parameters:

1. **Metering and billing:** The changes in the metering and billing are captured through operational data related to meter reading, reduced meter operations costs and reduced float.
2. **Improved service and reliability:** The reduced interaction with consumer for resolving complaints and service quality linked revenue collection.
3. **Peak load management:** Peak load shifting and reduced load variations linked benefits to the utilities.
4. **Optimized asset management:** Reduced maintenance and breakdown costs of assets
5. **Output parameters:** Some examples are reduced AT&C losses, and improved collection efficiency.
6. **Impact of the AMI on the grid/application:** Outcome parameters which are related to the energy level or system level outcome.
7. **Community impacts:** Impact parameters which are related to the overall impact of the ESS for various applications.

A list of indicative parameters is given below[27]. However, these parameters may vary depending on the application and design goals of the program. Also, not all the parameters would be required for each project and will have to be tailored as per the project requirements and application.

3.1. METERING AND BILLING IMPROVEMENT

A. Reduced Meter Reading Costs

In the baseline scenario, meters are read by meter readers who visit each consumer premise. In certain cases, for example due to locked premises, the meter readings have to be estimated by using average of previous billed consumption. Post meter reading, in certain cases (where hand held devices are not used for meter reading), utility personnel have to enter the meter readings manually into the IT system.

In the post roll-out scenario, smart meter would automatically record meter readings at regular intervals which would be made available to utility for the billing purpose. This would result in savings under the following components:

a. **Workforce costs**: A large number of personnel are needed for completing meter reading and data entry tasks. Due to automation of meter reading, this task will be completed remotely. These personnel can be re-deployed on other utility activities.

b. **Transportation costs**: Visits by utility personnel for meter reading are avoided. This leads to reduction in vehicle and fuel cost expenses.

[27] As developed under PACE-D for Tripura State Electricity Corporation Limited (TSECL) Smart Meter Implementation pilot project

Quantification Formula

a. Saving in personnel related costs

Annual Saving (INR) = (Number of personnel engaged for meter reading and data entry) x (Average percentage time dedicated by personnel for meter reading and data entry work) x (Average personnel cost to company per annum) x (1- Communication Failure Rate of Smart Meter)

b. Savings in Transportation costs

Annual Saving (INR) = (Annual Travel distance (in km) from base location to site for meter reading) x (Average vehicle fuel cost per km) x (1- Communication Failure Rate of Smart Meter[28])

B. Reduced meter operation costs

A number of tasks are involved in disconnecting and re-connecting of meters to ensure smooth functioning of the metering system. In a baseline scenario, this task is performed by the personnel visiting the customers' premises. Whereas in post roll-out scenario, the remote control capability of smart meters will be utilized by the utility personnel, thus completely eliminating the manual intervention. This functionality results in savings under the following components:

a. Transportation costs: Visits by utility personnel for this activity will be completely avoided leading to reduced expenditure on vehicle and fuel costs.

b. Skilled man hours: The personnel hours will be saved due to avoided visits. These saved man-hours can be utilized in other activities of the utility operations.

There is also the added benefit of the consumer not having to make any number of trips to follow-up on re-connection of their meters.

Quantification Formula

a. Transportation costs saving

Annual Saving (INR) = (Annual Travel distance (in km) from base location to site for meter operation activity [reconnect/disconnect]) x (Average vehicle fuel cost per km) x (1- Communication Failure Rate of Smart Meter)

b. Personnel costs saving

Annual Saving (INR) = (Number of personnel engaged for meter reconnect/disconnect activity) x (Average percentage time dedicated by personnel for the activity) x (Average personnel cost to company per annum) x (1- Communication Failure Rate of Smart Meter)

C. Reduced Float between Meter Reading and Customer Billing

In baseline scenario, due to manual operations, there is a significant delay between readings of meter data to generation of bill for consumers.

In the post roll-out scenario, delays are avoided because of real time, automatic transfer of consumption data to utility billing system. This would improve cash flows for the utility and reduce working capital requirements leading to savings in interest expense.

[28] Some of these costs may be incurred due to communication failure of smart meter and manual readings may be required for cross-checking in some cases, until the system stabilizes

Quantification Formula

Days Saved for Bill Generation = Minimum days (working and non-working) required for generating consumer bill $_{baseline}$- Minimum days (working and non-working) required for generating consumer bill $_{post\ roll\text{-}out}$

Annual Savings (INR) = (Days saved for bill generation) x (Average billing amount per billing cycle) x (daily interest rate for government securities[29]) x (number of billing cycle per year)

3.2. OPTIMIZED ASSET MANAGEMENT

A. Reduced maintenance and breakdown costs of assets

Data from a smart meter at the DT and Feeder level can be analyzed for determining the asset condition and utilization, for assets across the network (e.g. transformer loading, over and under voltage). Outcome of this data analysis can help set up efficient, condition-based asset maintenance strategies instead of the existing reactive maintenance approach.

Real-time monitoring would enable utilities to take pro-active mitigation through preventive actions which would result in lower maintenance cost, lower equipment failure and improved equipment life.

Quantification Formula

a. Reduction in maintenance costs

Annual Savings (INR) = (Direct cost per maintenance activity, labor & replacement

cost included x No. of maintenance activity performed) $_{baseline}$ – (Direct cost per maintenance activity, labor & replacement cost included x No. of maintenance activity performed)$_{post\ roll\text{-}out}$

b. Reduction in Equipment Failures

Annual Savings (INR) = (Annual number of equipment breakdown $_{baseline}$– Annual number of equipment breakdown $_{post\ roll\text{-}out}$) X (Average cost of unit replacement i.e. Capex)

These savings are expected to increase in cases where asset health monitoring and condition-based monitoring tools are also deployed along with AMI. In addition, this also provides other benefits like better asset planning and management, better capex and expansion planning which help in improving both the DISCOM operations and financial discipline.

3.3. REDUCED AT&C LOSSES

A. Reduction of commercial losses

Theft Detection

Smart meters continuously monitor meter data. Any abnormality in the energy usage pattern can thus be detected by analyzing this data. Also, smart meters generate alarm signals in case tampering of meter (mis-wiring or bypassing) is detected. These functionalities were not possible in traditional meters. Reduction of commercial losses will result in saving of electricity which was lost due to thefts. Additional savings may result from decrease in expenses on the inspection team, hotline gangs downsizing (if applicable) and transportation expenses.

[29] This can also be considered as per current interest rate of working capital loan of the utility

Accurate Billing

In traditional metering scenario, manual collection of meter readings and entering them into the system has the potential for errors. Further, in a manual system, certain amount of bills may need to be estimated due to lack of access of meter reading (e.g. locked premises). With the help of smart meters these inaccuracies and estimation can be brought down significantly.

> **Quantification Formula**
>
> **Annual Savings (INR) =** ((Billing Efficiency Percentage)$_{post\ roll\text{-}out}$ – (Billing Efficiency Percentage)$_{baseline}$) x Average retail tariff x Annual Energy Input to the Project Area in MU

B. Improved Collection Efficiency

In post, roll-out scenario, implementation of remote disconnect for defaulting customers would allow the utility to reduce the overall amount owed by consumers as well as the number of consumers defaulting on bill payments. This would improve cash flows for the utility and reduce working capital requirements leading to savings in interest expense. Further, this would also reduce the size of bad debts[30].

> **Quantification Formula**
>
> **Annual Savings (INR)$_{interest\ saving}$ =** ((Average Collection Efficiency Percentage per billing cycle)$_{post\ roll\text{-}out}$ – (Average Collection Efficiency Percentage per billing cycle)$_{baseline}$) x Average Billed Amount for the billing cycle (INR) x (interest rate for government securities[31]) x (number of billing cycle per year)
>
> **Annual Savings (INR)$_{bad\ debt\ saving}$=** ((Bad Debt Percentage)$_{post\ roll\text{-}out}$ – (Bad debt Percentage)$_{baseline}$) x Annual Billed Amount for the Project Area in INR,
>
> *Where, bad debt percentage = (Annual bad debt recorded)/ (Annual billed amount)*

3.3.1. IMPROVED SERVICE AND RELIABILITY

A. Reduced call-center and customer care center costs

Customer care centers are specialized centers which are established to address customer concerns, queries, complaints, etc. A satisfied customer is less likely to use this feature than an unsatisfied customer. AMI functionalities improve satisfaction level among customer thus reducing call-inflow of customer care center. Accurate billings, less power restoration time, automated outage reporting, etc. are the enabling factors for higher satisfaction levels among customers. As a result, customer care centers with lower capacity will be able to accommodate the reduced call-inflow. The savings achieved by reduced customer care centers costs can be calculated by following formula:

> **Quantification Formula**
>
> **Annual Savings (INR)** = (Percentage of annual call duration on billing, meter, outage and reconnection queries) $_{baseline}$– (Percentage of annual call duration on billing, meter, outage and reconnection queries) $_{post\ roll\text{-}out}$ x Annual cost of call center operation

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[30] When customers are unable or refuse to honor their billing commitments, utility must eventually recognize this unpaid usage as a bad debt and it is charged-off.

[31] This can also be considered as per current interest rate of working capital loan of the utility. Interest rate here would be taken for the period of billing cycle. For e.g. monthly billing would mean monthly interest rate used for the formula

B. Recovered revenue due to reduced outages

Smart meters will enable advanced monitoring and real-time network information. Therefore, any outages at the customer side will be duly detected and recorded. Based on this insight, can take prompt repair actions which would decrease the outage time and thereby improving revenue for the utility.

> **Quantification Formula**
>
> **Annual Savings (INR) =** (Total energy billed annually (INR) / Minutes per year) x Annual energy non-supplied minutes $_{baseline}$ x Percentage decrease in outage $_{post\ roll\text{-}out}$

Apart from outage reduction, “OK on Arrival” field trips will be virtually eliminated, thereby leading to cost savings. In “OK on Arrival” calls, utilities receive outage reports that are not their responsibility to fix, such as when a home’s circuit breaker has tripped. With smart meter, a utility can instantly and remotely determine if an individual meter has power and help the customer restore power without having to send an employee to investigate.

> **Quantification Formula**
>
> **Annual Savings (INR) =** (Average “OK on Arrival” Calls Annually) $_{baseline}$ x Cost per Trip (labor + transport) x (1 – Communication Failure Rate of Smart Meter)

3.4. PEAK LOAD MANAGEMENT

A. Cost saving through peak load shifting

The smart metering roll-out encourages consumers not only to reduce the total consumption of electricity, but to also shift part of the loads from peak periods when the electricity is most expensive to off-peak periods when it is cheaper. Peak load management includes concepts such as Demand Response, Dynamic Pricing, etc. Savings would depend on the type of intervention introduced and how the scheme is designed. In more generic terms, savings would be due to reduction of peak load.

> **Annual Savings (INR) =** (Consumption at peak duration per day – Average consumption per day) $_{baseline}$ x percentage shift in peak load $_{post\ roll\text{-}out}$ x (cost of supply at peak load – average cost of supply) x 365 – Operational cost of managing a PLM program (includes event management cost, incentive if any, etc.)

B. Increased Revenue from Reduced Load Violations

With smart meters it is possible to monitor situations where maximum demand (MD) of the consumer is higher than the sanctioned load limit. In such cases, an increase in sanctioned load might be initiated, which would result in additional funds to the utility. These additional funds would be due to increase in security deposit or due to tariff structures related to fixed charge portion of tariff.

> **Annual Savings (INR) =** (Percentage of Consumers with load violation) $_{post\text{-}roll\ out}$ x Average Increased revenue realized with increase in sanctioned load x Total number of consumers in the project area

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