alchemy

Opportunities in Smart Grid Technologies in Indian Power Distribution

2015

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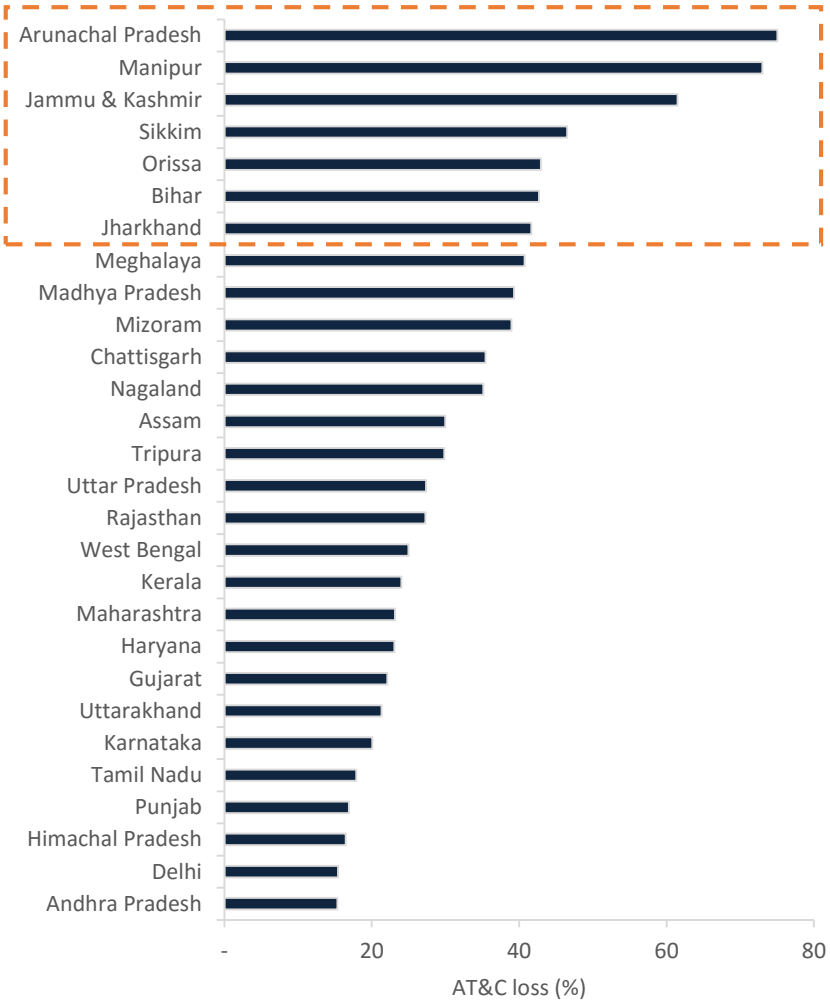
Plugging leakages in network – a major focus area for power distribution utilities

Aggregate Technical and Commercial loss (%)



Source: Planning Commission of India

- Network losses (referred to as aggregate technical and commercial (AT&C) losses) are considerably high in India's power distribution segment
  - ✓ While technical losses arise due to the physical infrastructure, it is the commercial component that is a concern, as it is driven by inefficient energy monitoring, accounting and billing
- Average network losses on a pan-India basis is about 27-28%, varying widely from as high as over 70% in the north-eastern states to about 15% in others
- Such leakage in network imposes high cost for power distribution operations, especially when tariff realisation is also weak
  - ✓ An estimated $17 billion could be attributed to the total power supply lost to network leakages

Key areas of focus for utilities to reduce network losses

- Revamp of energy accounting and monitoring systems
  - ✓ Comprehensive metering coverage at the consumer, feeder and transformer levels to ensure accurate accounting
  - ✓ Automated metering and billing systems to reduce errors and discrepancies and minimise human interface in operations
  - ✓ Real-time monitoring and tracking of asset and consumer base to ensure loss reduction
- Re-align business processes
  - ✓ Streamline business processes so as to ensure technology adoption is in sync with objectives
  - ✓ Capacity building and organisational transition to best practices

Deploying IT-based monitoring systems – spearheaded by a government-funded scheme

The Scheme

- Officially known as the Restructured Accelerated Power Development and Reforms Programme (R-APDRP)
- This central government sponsored scheme aims at reducing network losses of state-owned power distribution utilities by funding projects in IT-based energy systems as well as physical network overhaul
- The scheme also provides for funding utilities' initiatives in technology adoption such as smart grid pilot projects

Funding Structure

Part-A category

- This category pertained to projects related to IT-based energy accounting and monitoring systems as well as baseline network data
- Over 1,400 towns were identified in this regard. Within these, select towns were identified for SCADA
- Total budgeted outlay for this was about USD 1.7 billion, to be released as upfront grants for utilities

Part-B category

- In this category, utilities were expected to undertake projects related to network and system strengthening – essentially involving physical infrastructure
- This covers about 1,260 towns for implementation of key projects in utilities' power distribution network
- Total budgeted outlay for this was about USD 7 billion, to be released based on milestones

Major Initiatives

- Establishment of baseline data
- Consumer Indexing
- GIS-based mapping of network assets
- Feeder and Distribution Transformer metering
- Supervisory Control and Data Acquisition (SCADA)
- Automated Meter Reading and Billing/Collection

SMART GRID

Funding status of R-APDRP projects

Category	Sanctioned (USD million)	Disbursed (USD million)
Part-A	912	446
Part-A (SCADA)	259	72
Part-B	5,369	755

Completion of the various initiatives under R-APDRP would lead to the establishment of a smart grid network that would optimise losses

Source: Ministry of Power

The case for smart grids – leapfrogging utilities' technology profile

Concept

- Defined as an interconnected system of information, communication technologies and control systems used to interact with automation and business processes across the entire power sector value chain
- Through technology, the aim is to make the entire grid efficient – by minimising human errors, encouraging active interactions between demand and supply sides and setting appropriate incentives for the value chain

Context

- In the Indian context, the need for smart grid is being driven by rising complexity in overall power sector transactions
  - ✓ There is a synchronous operation of bulk power transmission that needs to be coordinated and balanced
  - ✓ Power generation is increasingly diversified, thus making it difficult to plan and schedule power flow
  - ✓ Rising consumer base and its requirements entail appropriate business models
  - ✓ As cost of power rises, the network losses in distribution need to be minimised

Emerging requirements of power utilities across the value chain

Generation

- Emergence of multiple distributed generation sources (as a shift from traditional centralised generation)
- Stress on maintaining plant availability in the grid
- Setting up dedicated capacities for peak demand in power network

Transmission

- World's largest synchronous grid operational in India – requiring coordination from multiple players
- Regulating grid discipline – automated controls required for pre-emptive steps
- Intelligent controls and analytics for integrating renewable energy

Distribution

- Long identified as the weakest link in power system value chain – strong need to cut losses in network
- Need for demand response systems to reflect market forces in power market
- Analytics and forecasting capabilities to ensure optimal resource planning in power procurement

Source: Alchemy Analysis

Advanced Metering Infrastructure (AMI) – critical element for smart grid in power distribution

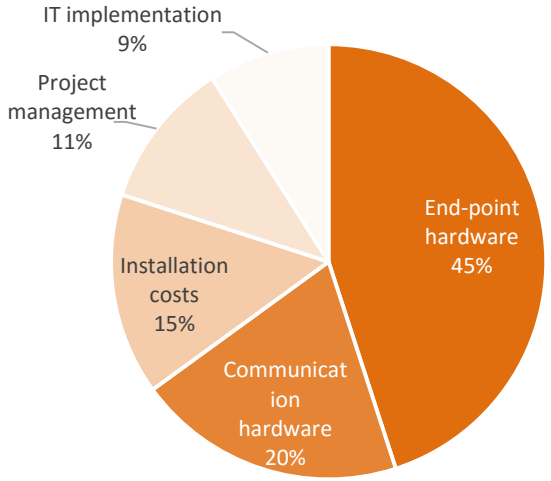
Technology

- AMI constitutes the whole integrated infrastructure set up to enable transfer of real-time energy usage information and undertake two-way communication between the utility and its consumers in the former's network
- Typically, these systems entail state-of-the-art electronic hardware and software, robust communication systems and data reception and management systems
- Globally, AMI has been implemented across various service providers such as electricity, water and gas. In the Indian context, it is the power distribution sector which is at the forefront of adopting AMI

Basic components/blocks of an AMI system

Smart meters	• Advanced meter devices equipped to receive and collect data at specific intervals for the utility
Communication	• Strong communication system that can enable two-way information flow between meters and utility
Meter Data Acquisition	• Software on control centre hardware and data concentrator units to acquire data from meters
Meter Data Management	• The host system that is supposed to receive, store and analyse the metering information

Typical AMI cost breakup



Key issues

- Being capital intensive, utilities are wary of committing large scale investment in such systems. From the utilities' perspective, getting the regulators and consumers to agree on costs of such projects is a difficult proposition
- Cost issues aside, there are technical challenges to circumvent. AMI is a complex system, that has to be integrated with varied IT systems in utility operations. This is not easy, considering the high dependence on legacy systems
- Implementation of AMI also requires having interoperability of technical standards across individual components

Source: India Smart Grid Forum, EPRI

Emerging AMI-based smart grid framework in India – a roadmap formulated

Policy

- In August 2013, the government notified its smart grid roadmap, laying out the broad contours for a future smart grid rollout in the country. To be sure, an inter-ministerial task force (India Smart Grid Task Force) has been working as a co-ordination agency since 2010 in this direction
- The stated policy is to address the issues of efficiency and management in power transmission and distribution network and in the process achieve the objective of "access, availability and affordability of power for all"

Initiative

- The most important initiative towards smart grids has been the allocation of 14 pilot projects, in which government is sharing 50% project cost
- Notably, select private utilities have initiated pilot projects on their own

Estimated capex of $60-65 million for 14 pilot projects

AMI for industrial and residential consumers to be tested

AMI-based Smart Grid pilot projects to establish feasibility – results of the technology trials to determine the future course of implementation

IT-based backbone in 1,400 towns nearing completion – these are ripe for AMI capabilities

Modern IT infrastructure created in select urban towns to be leveraged for AMI-based projects

Focus major urban areas where infrastructure has been upgraded for smart grid tech

100 smart cities to based on large-scale smart metering

AMI-based smart grid in power to be key

Digital assets of smart grid to be leveraged for objectives of smart cities being planned

Make available a low-cost smart meter so as to enable widespread adoption across utilities and consumers

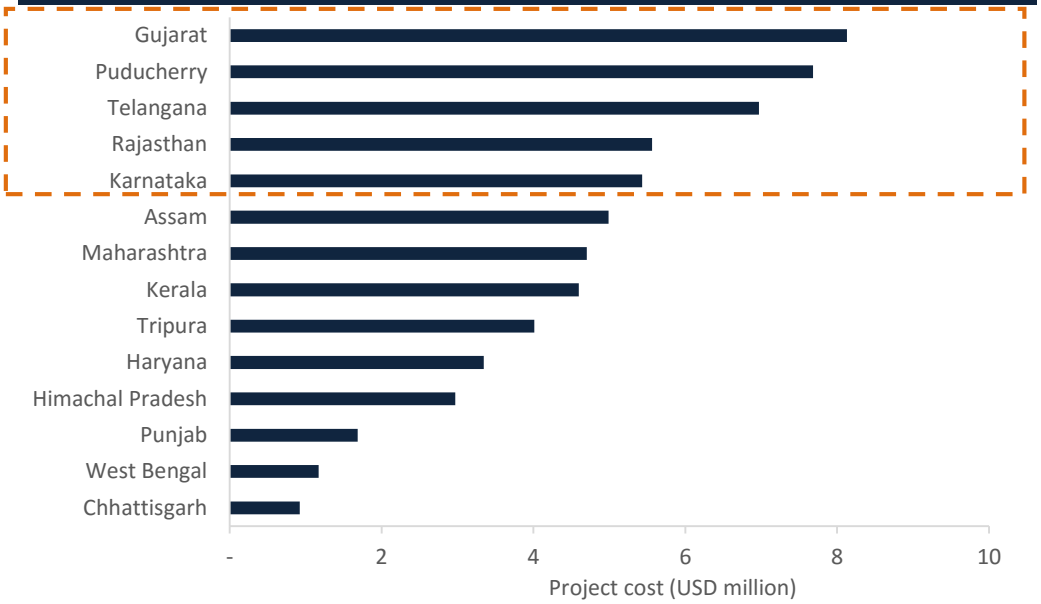
Source: India Smart Grid Forum

Technology demonstration – pilot projects as the first step to establish feasibility

Pilot projects selected by government

- The government shortlisted a number of pilot projects to be implemented by state-owned power distribution utilities
- **There are 14 pilot projects that are presently under various stages of implementation**
  - ✓ 50% of project cost is government funded. The rest has to be borne by utility and technology providers
  - ✓ Almost all the projects are testing AMI for industrial and residential consumers in the designated project locations
  - ✓ Puducherry's project has already completed the first phase of implementation and the early results obtained indicate encouraging results for loss reduction and demand response

Project cost of sanctioned pilot projects part-funded by government



Other pilot projects under way

Smart grid test bed

- The U.S. Trade and Development Agency has provided a $692,0000 grant to Central Power Research Institute for setting up a smart grid test bed at Bengaluru in India. The proposed test bed will comprise an integrated interoperability laboratory and a smart grid technology demonstration centre

Indiranagar, Bangalore

- Bangalore Electricity Supply Company is implementing a pilot project at Indiranagar, Bengaluru with a consumer base of 63,058. The project involves testing and evaluation of AMI, integration of solar rooftop systems and peak load management systems. Smart meters are to be installed for 20,000 consumers

Mumbai

- Tata Power recently initiated a pilot AMI deployment project for its Mumbai distribution circle in the state of Maharashtra. In the first phase, this project involves installation of 5,000 smart meters

Source: India Smart Grid Forum

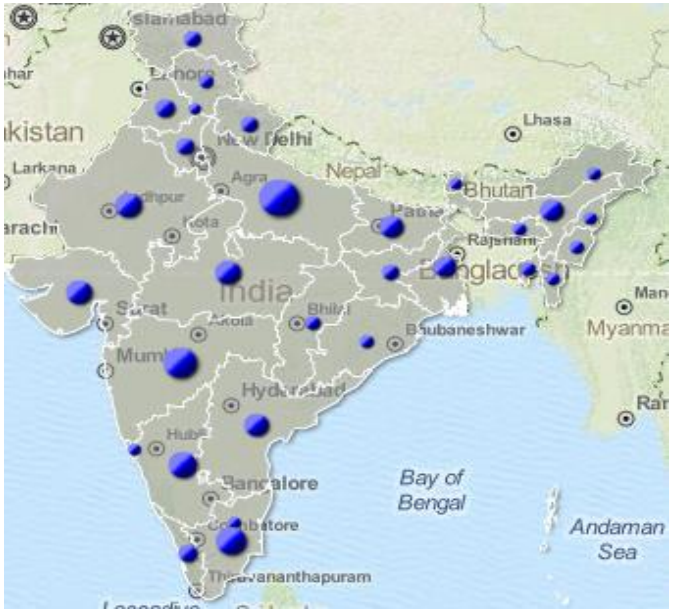
The leverage for scaling up – ongoing modernisation sets the foundation for AMI

Critical asset infrastructure build-up under R-APDRP across the country

Building Blocks under R-APDRP

- GIS-based consumer indexing
- SCADA and ERP-based MIS systems
- Metering, Billing and Collection systems
- Asset Management Systems
- Data centres

- Govt sponsored initiative to revamp power distribution – upfront grants to establish IT-enabled energy systems
- $8-9 billion outlay for IT and physical infrastructure
- Roughly $1.5-2.0 billion allocated for IT-based systems
- Over 1,400 towns (mostly urban) across 50 utilities
- The proposed systems are being set up for the first time in the country at this scale
- These systems are pre-requisites for undertaking any smart grid related project in the power system



- Post completion of R-APDRP (i.e. by 2017/2018), there will be at least 1,400 towns completely equipped with a modern IT-based energy accounting and monitoring system – providing the best scope of setting up AMI-based projects for the utilities and technology suppliers

Estimated customer base covered in R-APDRP

31 million

Average capital cost per customer in AMI systems

$280

Potential investment in AMI at R-APDRP sites by 2020

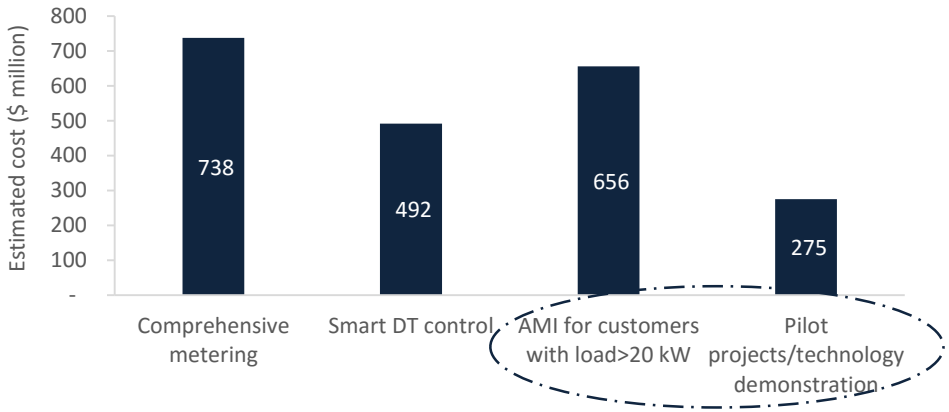
$7.11 billion

Source: India Smart Grid Forum, Ministry of Power

Long-term plan – staggered deployment beginning with industrial loads

- The government smart grid roadmap draws up a plan for achieving full scale smart grid deployment – one that encompasses transmission and generation
  - ✓ In this context, cost of such implementation was worked out at about $30-40 billion
  - ✓ Power distribution segment finds a particular emphasis in the roadmap due to the vast scope involved
- Though standardised cost estimation is generally not feasible in such cases, indicative cost estimation done by India Smart Grid Forum (a PPP venture between govt and industry) suggest an almost $1 billion of capital expenditure in projects related to AMI

Indicative cost of major smart grid projects in power distribution



Planned rollout of AMI

2017
- Customers with connected load over 20 kW
- Full rollout of pilot projects based on results

2022
- Roll out AMI for all three-phase connections
- Domestic/residential consumers to be key

2027
- Full scale nationwide roll out of AMI-based smart grid

- The government roadmap refers to AMI-based solutions for utility customers with connected load above 20 kW –
  - ✓ these are typically the industrial loads where willingness to pay may not be an impeding factor
  - ✓ All consumers in this segment are 100% metered, thus obviating the need to undertake specific metering investments
  - ✓ Considering that these consumers account for major share of utility earnings, the potential benefits (e.g. reliable supply) will be tangible for utilities to justify costs
- Rolling out the AMI for residential/domestic consumers is the most significant milestone for utilities
  - ✓ These consumers are highly cross-subsidised and need to be taken on board for potential cost implications of AMI deployment
  - ✓ Significant customisation may be in order for this consumer segment

Source: India Smart Grid Forum

Transition from AMR to AMI – the opportunity in industrial consumer segment

The scope

- Industrial consumer segment accounts for roughly 45% of total energy sale in a given year. This segment holds considerable significance in utilities' revenue
  - ✓ Over the years, utilities have been losing industrial consumers to captive power, due to lack of reliability (load-shedding, poor quality) and high tariffs (cross subsidisation for domestic and agriculture)
  - ✓ Industrial consumers are willing to pay premium for reliability – this particularly holds true for functionalities such as demand response (time-of-day tariffs), peak load management, etc. which smart grid systems enable

Opportunity

- The industrial consumer segment is presently covered by automated meter reading (AMR) systems – these can be gradually shifted to an AMI-based system
  - ✓ In absolute terms, the number of industrial consumers is about 11% of total consumer base – this translates to about 40 million customers in India based on the estimated consumer base in 2013-14
- Assuming average capex per consumer of $300 (based on global AMI projects and ongoing Indian pilot projects), just 20% of industrial consumers shifting to AMI each year works to investments worth $2.5-3.0 billion

Market opportunity of AMI deployed for industrial and commercial consumers

	Estimated number of consumers (million)	Number of industrial consumers (approx. 11% share) (million)	Assuming 20% consumers are shifted to AMI system	Potential capital expenditure involved ($ million)
2013-14	334	40	8.02	2,405
2014-15	357	43	8.57	2,571
2015-16	382	46	9.16	2,748
2016-17	408	49	9.79	2,938
2017-18	436	52	10.47	3,141
2018-19	466	56	11.19	3,358
2019-20	499	60	11.97	3,590
2020-21	533	64	12.79	3,838

Source: India Smart Grid Forum, Power Line, industry reports

Demand for smart metering – expected to grow from present negligible levels

Smart metering in India vs rest of world

Country/region	Share of smart meters in network (%)
USA	30.7
Europe	22.0
Australia	31.6
Canada	49.0
India	< 1

- India's installed metering base (200-220 million) varies from electromechanical to automated meter reading (AMR) systems
  - ✓ Electromechanical meters are part of the legacy metering systems in utilities' network
  - ✓ AMRs have been installed mostly for industrial consumer segment (being high-value customers)
- Comprehensive metering is yet to be achieved
  - ✓ Significant share of rural consumers remain unmetered
  - ✓ Most of the installed distribution transformers (DT) are unmetered
- Cost is an important criteria
  - ✓ Cost of new metering systems deters utilities/consumers
  - ✓ The cost of smart meters could be thrice (or more) depending on functionalities chosen

Key factors expected to drive smart meter adoption in India

Indigenous low cost smart meter

- Indigenous smart meter costing $15-25 in the works
- Several technology suppliers in the fray for developing/customising
- Bulk ordering of the indigenous smart meter could follow soon

Loss reduction initiatives

- Government funded 'feeder segregation" project could help push automated metering
- Ongoing government projects offer upfront grants for smart metering initiatives by utilities

Smart grid pilot projects

- Bulk ordering of smart metering to be undertaken under ongoing pilots
- Several technology suppliers have come forward with competitive pricing to build market demand

Source: India Smart Grid Forum (report on smart metering), Power Line magazine and industry reports

Distribution Transformer metering – an untapped opportunity for AMI smart meters

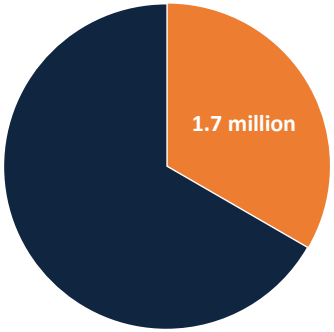
Scenario

- Despite policy initiatives, DT metering in India has been abysmal
  - ✓ It is estimated that less than 20% of the DTs are metered
  - ✓ Automated meter reading is negligible among the ones metered
- Utilities also suffer from a high transformer failure rate (11-12%) arising out of poor asset tracking and zero condition monitoring capabilities – factors enabled in smart DT control systems

Importance

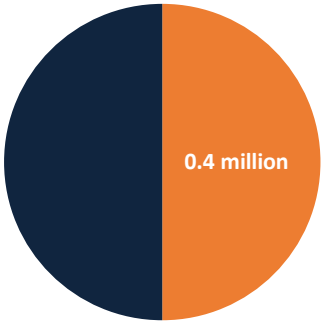
- Comprehensive DT metering is one of the key pre-requisites that the Indian utilities must fulfil to achieve the overall objective of a full scale smart grid rollout (aimed by 2022 as per government policy roadmap)
- Considering the timelines laid out in policy documents, DT metering should be completed in the next 2-3 years

Potential investment in metering one-third of existing DTs



- Estimated cost of smart metering $850 million
  - ✓ This is based on an estimated installed base of 5 million distribution transformers as of end-2013
  - ✓ Average cost of USD 500 per transformer to implement smart metering

Potential investment in metering half of upcoming DTs



- Estimated cost of smart metering $200 million
  - ✓ About 850,000 DTs planned for installation between 2012-2017 as part of network augmentation projects
  - ✓ Average cost of USD 500 per transformer to implement smart metering

Source: India Smart Grid Forum (report on smart metering), Power Line magazine and industry reports

Prepaid energy meters – rising demand to help boost smart metering penetration

Existing base

- While prepaid metering has been around for quite some time in India, its implementation has been limited to select pockets of consumer base (e.g. government buildings, rented households, etc.)
  - ✓ Till recently, prepaid meters were regarded to be in contravention to Indian laws on electricity (requiring prior notice and extension before disconnection). This was addressed subsequently, at policy and regulatory level

Demand driver

- Lately, demand for prepaid meters has shown a pick up. Some of the key factors at play in this regard are as follows
  - ✓ Performance-based grants for loss reduction by state-owned utilities
  - ✓ Private franchises granted by government utilities in high-loss areas
  - ✓ Consumers gaining in terms of rebates (utilities pass on the benefits of lower collection costs)

Recent initiatives in prepaid meter deployment by states to improve billing and collection

State	Number of prepaid smart meters planned/under implementation
Mizoram	60,000
Punjab	45,000
Arunachal Pradesh	32,000
Maharashtra	25,000
Uttar Pradesh	8,000
Assam	3,500

- At an average cost of USD 100 for prepaid meter, the ongoing initiatives aggregate to over USD 17 million in investment outlay for procuring prepaid meters
- The proposed prepaid meters are amenable to additional functionalities in line with smart metering requirements under AMI
  - ✓ Prepaid meters can be configured for implementing demand response in residential consumer segments

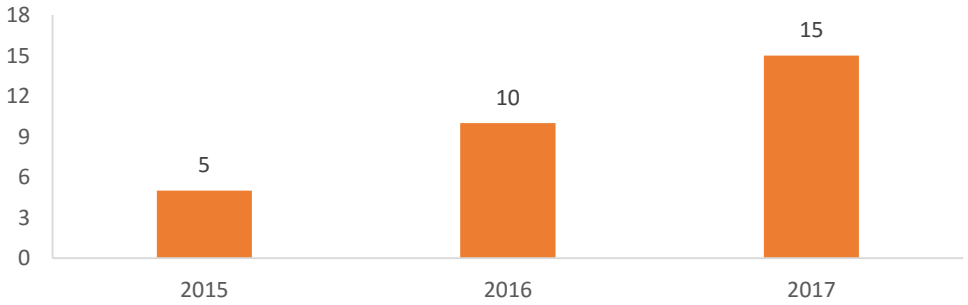
Source: India Smart Grid Forum (report on smart metering), Power Line magazine and industry reports

Upcoming smart cities to build upon the assets created in AMI/smart grid projects

Smart cities as an extension to the smart grid in power networks

- The digital assets established under smart grid projects will make way for their wider scale of application in the proposed smart cities project
  - ✓ AMI-based projects for power utilities can be extended towards other utility services such as in water supply, gas, etc
  - ✓ From the policy perspective, the general understanding is that the extension of smart grid assets/systems can be achieved at a marginal cost for upcoming smart cities
  - ✓ Under National Smart Grid Mission, it was proposed that 30 smart cities be established based on the achievements in smart grid projects – the union government took this further by announcing 100 smart cities

Proposed number of smart cities under national smart grid mission



Planned 100 smart cities in India

Investments requirement

- As per estimates of Ministry of Urban Development, development of smart cities could entail an annual investment requirement of about USD5.5 billion over a 20-year period
  - ✓ The estimates were drawn based on assumption of an average 1 million population in the 100 identified towns
  - ✓ The estimates cover water supply, sanitation, sewerage transportation infrastructure

Funding

- Recently the union government allocated a budget of USD 1.1 billion towards promoting smart city projects
- Private sector is expected to play a key role, with government role limited to providing viability gap funding

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