
SMART METERING SCENARIO IN INDIA

A high level summary

About India Smart Grid Forum

India Smart Grid Forum (ISGF) is a public private initiative of the Ministry of Power (MoP), Government of India for accelerated development of smart grid technologies in the Indian power sector. ISGF was set up in 2010 to provide a mechanism through which academia, industry, utilities and other stakeholders could participate in the development of Indian smart grid systems and provide relevant inputs to the government's decision making.

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1.0 Introduction

From electromechanical meters to electronic meters to AMR (Automated Meter Reading) and prepaid meters to smart meters, the metering industry has embraced evolving information and communication technology for bringing along a revolution in utility operations. With the advent of an Advanced Metering Infrastructure (AMI), both consumers and the utilities would benefit. The consumers would be able to:

- a. View their consumption of electricity accurately on a regular basis
- b. Manage loads in different manners based on the design, ranging from remotely turn ON/OFF their appliances to managing total demand to allow curtailed supply instead of load-shedding
- c. Save money from Time of Use (ToU) tariffs by shifting non-priority loads
- d. Face reduced outages and downtimes, and even lower or zero load-shedding

Utilities would benefit in the following ways (which would pass on to the consumer):

- a. Financial gains by
 - i. Managing the load curve by introducing ToU/ToD tariff, demand response etc.
 - ii. Reducing equipment failure rates and maintenance costs
 - iii. Enabling faster restoration of electricity service after fault/events
 - iv. Detecting energy theft/pilferage on near real-time basis
 - v. Streamlining the billing process
 - vi. Remote meter reading which reduces human resources, human errors and time consumption for meter reads
- b. Respond to power outages and detect meter failures (with no on-site meter reading)
- c. Enhanced monitoring of the system resources that would significantly improve the reliability indices like CAIDI/CAIFI, SAIDI/SAIFI etc.
- d. Improvement in other key performance indicators

2.0 Objective

The objective of this report is to present a high level summary of the current smart metering scenario in India focussing on the adoption scenario and the preparedness of the meter manufacturers and other solution providers in India.

The main objective of ISGF Working Group 4 on Metering is to facilitate fast development of smart metering technology and help foster the roll out of smart meters in India. WG-4 also evaluates emerging technologies and best practices as well as identify gaps in existing solutions. It is pertinent to mention that R-APDRP has chosen the IEC 62056 (DLMS) as the metering protocol for 3-phase meters in 2008/09; and COSEM for 3-phase meters has been released as IS 15959. Also, ICS (Indian Companion Standards) for single phase meters (including COSEM) have been finalised and are awaiting approval.

3.0 Status of Smart Metering

3.1 Global Scenario

The following table depicts a snapshot of the smart meter deployment status in select areas around the world:

Country/Continent	Total number of meters currently deployed (in millions)	Number of <u>smart meters</u> already deployed (in millions)	Smart Meters as share of total deployment
USA	150	46	30.7 %
Europe	281	61.2	22.0 %
Australia	9.5	3	31.6 %
Canada	15	7.3	49 %
India	200	-	<<1 %

Note that global or country numbers do not convey the entire picture – there are large utilities such as Enel (Italy) that have tens of millions of smart meters deployed, for 100% penetration.

3.2 Current Scenario in India

At present, the number of smart meters deployed in India is miniscule and does not even represent a percent of the total number of meters, which is about 200 million. The smart meters that are currently deployed, exist in pilot projects only.

In June, 2013 CEA released updated specifications for single phase smart meters to be used in India. These specify the functional requirements and technical specifications of single phase smart meters. This contained 4 categories of meters which was further amended to two categories of meters vide CEA Order No. CEA/DPD/Smart Meter/2013/8916 Dated 18.02.2014 issued to all Discoms and State Electricity Regulatory Commissions.

However, there is a view amongst several stakeholders that further clarity on areas such as meter display, meter data storage, specifications of In-Home Display and Data Concentrator Unit, etc. is required.

Moreover, several other agencies are engaged in developing smart meters/standards as summarized below:

- BIS (ET 13 Panel 4) is working on modifying the CEA report with the aim of converting it to a BIS standard for smart meters.
- BIS LITD is preparing a standard on Advanced Metering Infrastructure (AMI), which will be a guideline document to the utilities explaining the actors, benefits and enablers of AMI. This work is assigned to Panel 7 of LITD 10.
- Power Grid invited tenders for appointment of consultants to design smart meters that Power Grid intends to sell.
- The Department of Telecommunications (DoT) nominated C-DOT for developing a prototype of a smart meter based on the IPv6 for advancement of M2M communications in the country.
- Central Board of Irrigation and Power (CBIP) has also decided to prepare specifications/manual for Net Metering.
- Under NaMPET program, a smart meter development project is under consideration.

The Discoms implementing smart grid pilot projects (mostly under Central Government support but also otherwise) have issued different specifications in each state. The following points represent the diversity in the specifications used in the pilot projects in Puducherry, Maharashtra, Gujarat and Mysore:

- Reactive power is not measured by the meters deployed in all these projects
- The port for local communication is different in all the projects

- The power consumption of the meter is not as specified by ONE Indian Standard. Both, IS 13779 and IS 15884 are used by different utilities
- The load survey parameters are different in all of the projects
- The number of tamper events recorded by the meters deployed by each utility is different
- Different communication data rates (over the Neighbourhood Area Network) are used by the utilities
- Different communications technologies are used by the utilities
- Not all the utilities support firmware upgrade (let alone remote firmware upgrades)

Comparison of the meter specs in first 4 RfPs is given at Appendix – 1.

Smart grid regulations are being prepared by MoP and are expected to address regulatory challenges related to smart metering in India.

The proposed National Smart Grid Mission (NSGM) will give the necessary impetus to the smart meter roll out.

4.0 Global Standards Used in Smart Metering

The following table contains the partial list of standards on advanced metering infrastructure used by various countries around the world:

Standard Body	Reference	Title
IEC	IEC 61968-9	Application integration at electric utilities - System interfaces for distribution management
IEC	IEC/TS 62351	Power systems management and associated information exchange - Data and communications security
IEC	IEC 62052 -11	Electricity metering equipment (AC) - General requirements, particular requirements, tests and test conditions
IEC	IEC 62056 – 21,42,46,47,53,61,62	Electricity metering - Data exchange for meter reading, tariff and load control
IEC	IEC 62058	Electricity metering equipment (AC) - Acceptance inspection
NEMA	SG-AMI 1-2009	NEMA Smart Grid standards Publication SG-AMI 1-2009 – Requirements for Smart Meter Upgradeability
EN	EN 13321 Series	Open data communication in building automation, controls and building management — Home and building electronic system
EN	EN 13757 -1,2,3,4,5	For utility metering using M-bus and other media
EN	EN 14908 series	Information Technology – Control Network Protocol
EN	EN 50065-1	Signalling on low-voltage electrical installations in the frequency range 3KHz to 1485 KHz – General Requirements, frequency bands and electromagnetic disturbances
EN	EN 50090 -3-1,2,3	Home and Building Electronic Systems (HBES)

EN	EN 50090 -4-1,2,3	Home and Building Electronic Systems (HBES)
EN	EN 50090 -7-1	Home and Building Electronic Systems (HBES)
EN	EN 61334-4-32	Distribution Automation Using Distribution Line Carrier Systems – Data Communications Protocols
IEC	EN 61334-4-511	Distribution Automation Using Distribution Line Carrier Systems – Data Communications Protocols – Systems Management – CIASE Protocol
IEC	IEC 61334-4-512	Distribution Automation Using Distribution Line Carrier Systems – Data Communications Protocols – System Management using profile 61334-5-1 – Management Information Base
IEC	IEC 62051-1	Electricity Metering – Data Exchange for Meter Reading, Tariff and Control – Glossary of Terms
IEC	IEC 62351 (all parts)	Power Systems Management and Associated Information Exchange – Data and Communications Security
EN	EN 62056-31,42,46,47,53,61,62	Electricity Meter Data Exchange
IEEE	IEEE 1377	Utility Industry Metering Communication Protocol Application Layer (End Device Data Table)
IETF	RFC 3394	Advanced Encryption Standard (AES) key wrap algorithm (Informative)
ANSI	ANSI C12.19	Utility Industry End Device Data Tables
ANSI	ANSI C12.22	Protocol Specification for Interfacing to Data Communication Networks

Note that the above table does not include any standards on communications and cyber security for Wide Area Networks, Neighbourhood Area Networks and Home Area Networks.

5.0 Challenges and Action Items

5.1 Challenges in India

In the present scenario, the following are the challenges for AMI rollout in India:

1. Limitations in various last mile connectivity solutions
2. Availability of limited RF spectrum
3. End-to-End interoperability standards to integrate AMI systems
4. Latency in the reception of signals
5. Coverage of the communications network not 100%
6. Consensus on specifications of low cost single phase smart meters by all stakeholders
7. Industry readiness for manufacturing of smart meters
8. Utilities lack clarity on functional requirements and business models
9. Security concerns especially balancing firmware upgradability with usability
10. Manpower limitations for deployment, usage, and management - both in the Discoms as well as in the industry

Amongst the above, last mile connectivity is most crucial for following reasons:

- Existing electricity distribution network is considered not very suitable for stable PLC solution
- Freely available RF spectrum is 865-867 MHz which is too weak to penetrate the double-brick walls of buildings in India; and also too small a slice to optimize for collision avoidance
- Zigbee (2.4 GHz) results have not been very encouraging in most field trials
- GPRS/CDMA experience in R-APDRP and other AMR/Smart Metering trials are also not very encouraging

Several countries that embarked large rollouts of AMI have gone through these experiences and finally converged on certain suitable solutions. Appendix-2 describes last mile connectivity solutions adopted in various countries/utilities including the experiences in India.

5.2 Action Items

The following are the action items that need to be done on a priority basis:

S. No.	Action Item	Responsible parties
1.	Finalising standards of low cost single phase smart meters	CEA + CPRI + BIS (ET 13, Panel 4 + LITD 10, Panel 7) + MoP
2.	Preparing smart meter regulations (as part or independent of the smart grid regulations)	MoP/CEA + CERC + SERCs
3.	Assessing the communications technology of the 14 pilots to select the best communications technology or technologies	ISGF + DoT
4.	Testing the reliability of the smart grid architecture – setting up of smart grid interoperability lab/s	CPRI + ISGF
5.	Improving the coverage of the communications technology	Network providers + DoT
6.	Improving the signal characteristics such as SNR, latency, etc.	Industry
7.	Adopting/developing standards that lead to interoperability and security	CPRI + BIS + ISGF
8.	Consumer awareness	ISGF + 14 utilities (involved in pilot projects)
9.	Capacity building	Development partners of the NSGM + CPRI + ISGF/SGDC
10.	Developing roadmaps for smart meter deployments	Utilities (starting with 14 utilities undergoing pilots) + ISGF/SGDC
11.	Developing business models to encourage private players to invest in the deployment of smart meters	Appropriate body under NSGM + ISGF + CEA/CERC/SERCs

5.2.1 On the functional requirements of low cost single phase smart meters (partly applicable for 3-phase smart meters also)

1. What all functionalities of AMI can be transferred to the Head End System (HES)?
2. What all parameters will be stored at the meter, DCU and HES?

3. What are the functionalities that will be offered by the In Home Display (IHD)?
4. What communications technologies will be used in different parts of India? Different geographic areas pose different limitations.
5. What will be the specifications of the Data Concentrator Unit (DCU)?
6. Preparation of functional requirements and technical specifications of THREE PHASE smart meters.
7. What intelligence, logic, and functionality is to be located at which node(s)?
8. At what level(s) will interoperability be available?
9. What is the expected lifespan of such systems?
10. How much of firmware upgradability will be required and in what manner?
11. How will security be handled, which extends to firmware, key management, etc., in addition to usability?

5.2.2 On Regulations

1. Who will pay for the smart meter? Utilities, consumers or third party solution providers??
2. Is In Home Display (IHD) mandatory?
3. If IHD is mandatory, can the meter be outside the premises of the consumer?
4. At present, there are no regulations regarding operation testing and maintenance
5. Data privacy - who all will have access to the meter data?
6. What are the norms for data access and usage, including but not limited to privacy?
7. Are there any options for "opt-out"? There should not be, but this needs to be clarified.

5.2.3 On the Standards used in AMI

1. Since all smart meters will now have a remote connect/disconnect facility, IS 13779 will not be applicable except for metrology. As of now, IS 15884 is more suitable for smart meters. Need to deliberate and include the relevant standard in the specifications released by CEA.
2. COSEM for single phase smart meters needs to be approved on fast track.
3. The design of the communication ports shall be standardised.
4. The meter should support modular plug-in type communications module (as suggested by CEA). The design, including the pin configurations and the physical size should be standardised so that any smart meter can be plugged with any other make of communications module/ communications technology and sealed separately.

6.0 Recommendations by ISGF

Since different organisations are working in independent silos, ISGF recommends the following:

- 1) MoP may advise BIS to finalize and issue single phase smart meter standards on fast track (within 3 months) including DLMS/COSEM – Action by CPRI/BIS
- 2) MoP may advise all utilities to strictly abide by the BIS standards
- 3) MoP may advise all other players not to indulge in developing new standards
- 4) MoP may advise the metering industry to prepare a readiness roadmap for roll out of both single phase and 3-phase smart meters complying with new standards

Further all communication technologies used (whether RF or PLC) may be IPv6 compliant as per directions of the Department of Telecom; and data exchange between meter and DCUs should tunnel the DLMS ICS frames whether in "Protocol Aware" or "Protocol Unaware" modes. Also, until

acceptable standards are evolved on HAN technologies and protocols, the demand response and consumer interface may be provided through web interface with the Discom's server.

Ministry of Consumer Affairs have issued a list of Indian Standards under mandatory certification for various industries and in this list for electricity measurement and billing, IS 13779 and IS 14697 have been made mandatory. MoP may request Ministry of Consumer Affairs to amend this list with the inclusion of new smart metering standards that will be issued by BIS on fast-track. Till such time a waiver for compliance under this mandatory list may be sought so that installation of smart meters under the pilot projects can progress uninterrupted.

Most importantly, all new meters must not only be digital/static, but smart ready even if they are not smart meters. This simply ensures that data formats/structures/APIs, and the communications ports/protocols are standardized. This will allow a modular pathway for upgrading to a smart meter where not deployed for business/regulatory approval reasons in the next 1-2 years. This is not in conflict with smart meters, which shall be fast-tracked in parallel.

MoP may appoint an empowered committee that may look in to issues described in Section 5.0 of this document; and issue clarifications on fast track (60 days). The empowered committee may have representation from CEA, CPRI, BIS, IEEMA and ISGF.

APPENDIX – 1: Comparison of Smart Meter Specifications in First 4 Smart Grid Pilot Project RfPs

S.No	Particulars	Specifications CEA (Category II (Meter for consumers with load more than 1 kW with connect/disconnect switch))	Specifications PGCIL Single Phase	Specifications MSEDCL Single Phase	Specifications UGVCL Single Phase	Specifications Chamundeshwari, Mysore Single Phase
1	Measuring Parameters a. Reactive Energy b. Reactive Power	X	X	Reactive Energy - kvarh-lag Reactive Energy - kvarh-lead Reactive Power	X	X
2	Communication Optical/LPR / PLC/ GPRS	The port for local communication and baud rate shall be as per IS 15959 (once the single phase specification is defined). In addition to this the meter will have a provision for an 'integral	The port for local communication and baud rate shall be as per IS 15959. In addition to this the meter will have a provision for	Isolated RS 232 / RS 485 for local communication RF Mesh technology for upstream communication	Meter Communication: Meter should have Optical & RS232 (RJ45) port for local reading and configuration. This port should be physically accessible for authorized person only with adequate	Optical port & RS 232 will be provided for local communication. The port for local communication and baud rate shall be as per IS 15959(once the single phase specification is defined). In addition to this the meter will

		modular plug in type' OR 'built in type' Communication Module for NAN . This Communication Module could operate on Low Power Radio / RF with Mesh/PLC/GPRS (directly up to HES). The communication module option can be decided at the time of actual implementation by the utilities. Different communication technologies shall follow relevant National or International standard as applicable.	an 'integral modular plug in type' OR 'built in type' Communication Module for NAN. This Communication Module could operate on Low Power Radio / RF with Mesh/PLC. Different communication technologies shall follow relevant National or International standard as applicable		sealing provision. Pin details for RS232 (RJ45) is as under 1 - +5V 2 - CD 3 - DTR 4 - GND 5 - RX 6 - TX 7 - CTS 8 - RTS Meter should be able to support inbuilt communication modems (RF/PLC).	have a provision for an „integral modular plug in type“ OR „built in type“ Communication Module for NAN (Neighbourhood Area Network) i.e. from Meter to Data Concentrator or directly for WAN (Wide Area Network). This Communication Module could operate on Low Power Radio / RF with Mesh/ PLC/GPRS (directly up to HES). The communication module option can be decided at the time of actual implementation by the utilities. Different communication technologies shall follow relevant National or International standard as applicable.
3	Power Consumption	Power consumption of Meter As per CE Regulations on Installation and Operation of meters and its amendments.	As per IS 15884	1Watt 4 VA (excluding communication module / connect – disconnect switch) since the power supply is SMPS.	As per IS-13779	As per IS – 13779(1999).
4	MD Integration	Maximum Demand register for kW and kVA with integration period 30 minutes.	Maximum Demand registers kW and kVA with integration period 15 minutes	KW & KVA, 30 minutes	MD in (KW) for 15 minutes integration period The system shall support interval lengths of 15 / 30/ 60 minutes.	MDKW, 15 minutes
5	LS days	35 days data with 30min integration	35 (Power ON) days data to be recorded with 30 minutes integration period / 17 days data to be recorded with 15 minutes	35 days of data 15 minute	Load Survey Data: (For 45 days with 15 minutes integration period) The system shall support interval lengths of 15 / 30/ 60 minutes.	62 (Power ON) days data to be recorded with 15 minutes integration

6	LS Parameters	Active Energy, Average Voltage, Average Current	Active Energy, Average Voltage, Average Current	Active energy - kWh Reactive Energy - kvarh-lag Reactive Energy - kvarh-lead Apparent Energy - kVAh Average current Average voltage.	1.Date and Time 2.Average Voltage 3.Average Current 4.Average Power factor 5.Energy (KWH) : Current cumulative absolute total energy (KWH) reading 6.Average Maximum Demand in KW	stamping for Active Energy Reading, Average Voltage, Average Current., average PF, Average KW
7	TOU	Should support 4 tariff registers / 6 time zones per day	4 Time of day tariff registers with programmable time zones and storage of billing parameters	4 Tariff registers / 6 Time Zones per day	Total Energy (KWH) & KW MD Meter shall have facility for 8 nos. of programmable TOD Zone. Presently it shall be clubbed in three zone i.e. Peak, Night & other as under: 1: Peak Hours: 6.00 to 11.00 & 18.00 to 22.00 2: Night Hours : 22.00 to 6.00 (next day morning) 3: Other : 11.00 to 8.00	Four Tariff register and eight time zones
8	Power Quality Events	Logging of quality of supply events like power on/off, over/under voltage, (50 events)	Logging of quality of supply events like power on/off, over/under voltage and (50 events) Setting of Under/Over Voltage shall be decided by utility	Power quality parameters: voltage sag and swell, monitoring of current harmonics, monitoring of load unbalance, abnormal events	Power Quality: Power Quality information should be stored in meter and should communicate to HES as per AMI requirement. Following parameters are required. (1)Power on/off (2)Over Voltage (3) Under Voltage	Power Quality Information; Logging of quality of supply events like power on/off, over/under voltage, (20 events /EACH). Setting of Under/Over Voltage shall be decided by utility
9	Tamper Events	50 events Snapshot of kWh, V and I	last 50 events Snapshot of kWh, V and I	100 Occur/Restore events Snapshot of active energy-kWh and currents	20 nos. of each event Snap Shots: Numerical values of voltage, Current, Power Factor, Energy (kWh), Date and Time of logging of the occurrence and restoration of tamper events.	20 nos. of event. No Snapshots
10	Communication Data rate NAN	X	64 kbps	250 Kbps		X

11	HAN technology requirement	The meter communication module shall include HAN capability to support IHDD.	Home Display device (IHDD)/different controllable devices over Zigbee/RF/Wi-fi/any other suitable communication mode.	Direct display/SMS/consumer web portal/HAN etc	Notification of DR events would be on a 24hrs basis and UGVCL would be able to communicate introduction / Removal of DR programs through the web interface via the portal, Email and SMS	X
12	Reading Frequency	The reading frequency proposed is once in 24 hours automatically.	X	15min Tamper detection (30/60 Minutes & 24 Hour Interval)	X	X
13	Communication protocol	The present IS 15959 is not applicable for single phase meters which would be developed by BIS committee. Meanwhile, Meter manufacturers will share their protocol and memory map with the Utility.	DLMS/COSEM/ IS15959	Zigbee	Communication protocol should be according to IEEE 802.15.4G/6LoWPAN or any other standard protocol. Meter manufacturer shall provide API with documentation for downloading the data from the MRI.	The present IS 15959 is not applicable for single phase meters which would be developed by BIS committee. Meanwhile, Meter manufacturers will share their protocol and memory map with the Utility
14	Remote Meter Firmware upgrade	X	√	√	X	X
15	Prepaid to Postpaid Vice-versa	√	X	√	√	√

APPENDIX 2: Last Mile Connectivity Solutions Deployed in Various Countries/Utilities

Europe

Enel, the Italian utility has installed its AMI solution 'Telegestore' globally for over 40 million customers. Enel uses PLC technology to create a reliable and cost effective network for last mile

connectivity combined with aggregated mobile/cellular data communications (at a concentrator level).

Other than the earlier Enel deployment, most new deployments keep in mind the regulatory push towards renewables and support for Electric Vehicles. While these don't mandate smart meters per se, utilities see smart meters as inevitable entities for meeting such regulatory requirements.

In **France**, in the pilot project Linky, conducted by Electricite Reseau Distribution France (ERDF), 300,000 smart meters were deployed successfully in France by 2011. PLC technology was used for providing last mile connectivity up to an aggregation point. The French government has approved 35 million smart meters to be deployed by 2018. The deployment commenced in 2013.

Sweden has completed the smart metering for 100% consumers. They have successfully deployed 6LowPAN technology on wireless mesh network in Stockholm and other regions.

In the **UK**, the Department of Energy and Climate Change (DECC) has initiated the Smart Metering Implementation Programme (SGIP) that aims to roll out 53 million smart meters by 2020. The government is working with the regulator and industry to put in place the legislative, commercial and delivery framework. The Central Delivery Body (CDB), formed in June 2013 supports the consumer engagement activities of energy suppliers. The Data Communications Company (DCC), formed in September 2013, is responsible for providing communications services between the smart meters and utilities. The new, Smart Energy Code (SEC) came into force under the DCC licence in September 2013.

A range of communications technologies have been proposed for providing last mile connectivity namely, cellular, mesh radio and long range radio. DECC has stated that whichever technology is chosen, the relevant provider will be required to provide at least 97.5% coverage. The market share in the UK's gas and electric market is divided as:

British Gas	E. On	Scottish Power	EDF Energy	RWE npower	SSE
32%	16%	11%	11%	14%	16%

USA

In 2009, under the ARRA Act, USD 7.9 billion were allocated to 99 pilot projects in the United States of America. The target was to install 15.5 million smart meters. In nearly 50% of the projects, RF mesh is used to provide last mile connectivity. PLC usage is limited in the US due to specifics of the US grid architecture (only 4-7 homes per transformer, and less in some areas).

The Pacific Gas and Electric Company uses RF mesh technology to provide last mile connectivity to over 10 million smart meters. Better coverage, performance and cost effective are the reasons that RF technology outweighed other communications technologies.

Duke Energy, serves approximately 7.2 million U.S. customers and uses PLC for providing last mile connectivity to almost all of its customers.

San Diego Gas and Electric Company, serves 3.4 million people and uses RF mesh technology for providing last mile connectivity.

Southern California Edison, one of the largest utilities in the United States, also uses RF mesh technology for providing last mile connectivity.

In Texas, there are utilities using Fiber Optics for connectivity, and there are other deployments on different solutions as well.

Centre Point Energy in Huston, Texas deployed a combination of RF and BPL for last mile connectivity.

Majority of the Electric Cooperatives that deployed AMI, also chose RF Mesh in licensed spectrum (as public spectrum had too much interferences).

Australia

In general, the current major smart meter rollouts use RF mesh technology (75%), followed by WiMAX (20%). The remainder use 3G/LTE point to point. There have been trials of other technologies (PLC and radio) but no large rollouts. The distributor that used WiMAX in Victoria has now stated that their further rollouts will use 3G.

It is expected that any further deployments will use 3G/LTE for the last mile connection. The two main factors that PLC and RF may not be used in Australia are:

1. Economics is now attractive for capital costs based on deployment densities. But 3G/LTE requires good coverage by the service provider and creates recurring costs which are high.
2. Rollout structure - The current arrangements in the National Electricity Market (NEM) are for market led rollouts, which will be more piecemeal rather than bulk rollouts. This favours point to point communications technology (in this case, 3G/LTE) to be used.

New Zealand

Vector, the New Zealand market leader in smart metering, has deployed around a million smart meters that communicate using GPRS technology. The reliability of the meter reading was around 98 %. This was an expected result taking into account the small population and good coverage of the GPRS network in New Zealand.

South Africa

Eskom uses PLC to provide last mile connectivity to over 40,000 homes. A range of 1 km is achieved using PLC technology without the use of any repeaters.

Korea

In the Smart Grid Demonstration Project in Jeju Island, PLC is used to provide last mile connectivity.

Japan

Tokyo Electric Power Company, serving over 27 million customers has selected 6LoWPAN on RF mesh for smart meters after 2 years of technology trials. Government also released a spectrum slice of 9 MHz (920 – 928 MHz) for utility applications.

China

China has installed over 250 million smart meters. PLC is mostly used to provide last mile connectivity in rural areas while RF technology is used in urban areas. China is also looking forward to other options such as cellular and Passive Optical Networking (PON) technology that uses optical fibres. Though the latter would be much more expensive than cellular technology and the increased bandwidth would be an overkill, the State Grid Corporation of China (the world's largest utility) might provide internet over the same lines.

India – Issues, challenges and description of some deployments

India is a country that has different requirements and constraints. In the pilot projects currently under execution, different technologies are proposed to provide last mile connectivity. We need to wait until the results of some of these projects are released. At present, all the options such as PLC, RF, GPRS,

optical fibre are open. One notable issue with GPRS is the lack of a robust data network in many parts of India.

The experience with R-APDRP using GPRS/CDMA has been poor and a reliability of 50-60 % was observed across the states.

Some examples of last mile connectivity in India:

1. Experience at Puducherry with different technologies (Information provided by PGCIL): Around 1500 smart meters are deployed in the project. The following communications technologies are used for providing last mile connectivity:
 - a. Narrowband PLC
 - b. Broadband PLC
 - c. RF mesh at 2.4 GHz
 - d. RF mesh at 865 MHz
 - e. GPRS [no Data Concentrator Unit (DCU) used]

All the above technologies are working satisfactorily. For large scale deployment, selection of the communication technology shall be done as per the requirements of a particular area.

2. Experience at MSEDCL with Zigbee (Information provided by MSEDCL): Around 6,31,000 smart meters are deployed in dense urban areas with the aim to remove human intervention. IEEE 802.15.4 standard with ZIGBEE at the network layer is used for Automatic Meter Reading (AMR). MSEDCL has modified the protocol and is available free of cost. Any meter within 30 metres of the Hand Held Unit (HHU) is capable of being read. Mandatory parameters such as meter number, energy consumption, maximum demand, date and time, and optional parameters such as history of tamper events and load profile can be read from the HHU. The next phase of this project will be to install DCUs for data collection.
In rural areas, MSEDCL has deployed around 2.8 million smart meters using Infrared technology for AMR. Any meter in the line of sight of the HHU (up to 1.5 metres) is capable of being read.

These meters have been provided by 17 manufacturers and a single HHU is capable of reading meter data from any of these meters.

3. Experience at Reliance with 6LoWPAN (Information provided by Reliance): Reliance has deployed around 100 6LoWPAN meter nodes that communicate using the 865-867 MHz band. This band provides greater penetration than the 2.4-2.485 GHz band. This architecture has proven to be highly flexible, reliable, secure and scalable. The adoption of IPv6 based networking allows all devices involved to be managed through a single network view. All devices and the relationships between them at the IP level can be defined in the network management application and the impact of a failure of communication to any given device can be instantly evaluated and displayed.
4. Experience at TNEB with RF Mesh (865-867 MHz) (Information provided by the vendor M/s Cyan Technology): 2000 smart meters were deployed for the proof of concept. RF mesh technology using the 865-867 MHz band was used to provide last mile connectivity. Range in typical urban environment was demonstrated to be over 100 metres and at least 60 metres in more dense environments. The meters were read efficiently and the download times to the

meter reading instrument was observed to be between 3 seconds and 10 seconds. A DCU could read meters of different makes.

5. Experience at MESCOM with PLC (Information provided by the agency that executed this pilot): This was an older demonstration for almost hundred consumers undertaken almost 4 years ago, which has since been shelved for various reasons. The solution was deployed across 2-3 DTs and included load-curtailement and street-light control. The architecture was similar to Enel (PLC with concentrator on GPRS). Static meters were used with updated protocols for the communications port, and were connected to a smart node that was sealed inside a polycarb box. The node added connect/disconnect, communications, logic, and memory. The maximum distance was 500 metres and PLC worked well with no re-wiring (only last segment crimps were cleaned up during installation). GPRS on the other hand created issues in terms of coverage and reliability.