SMART METERS

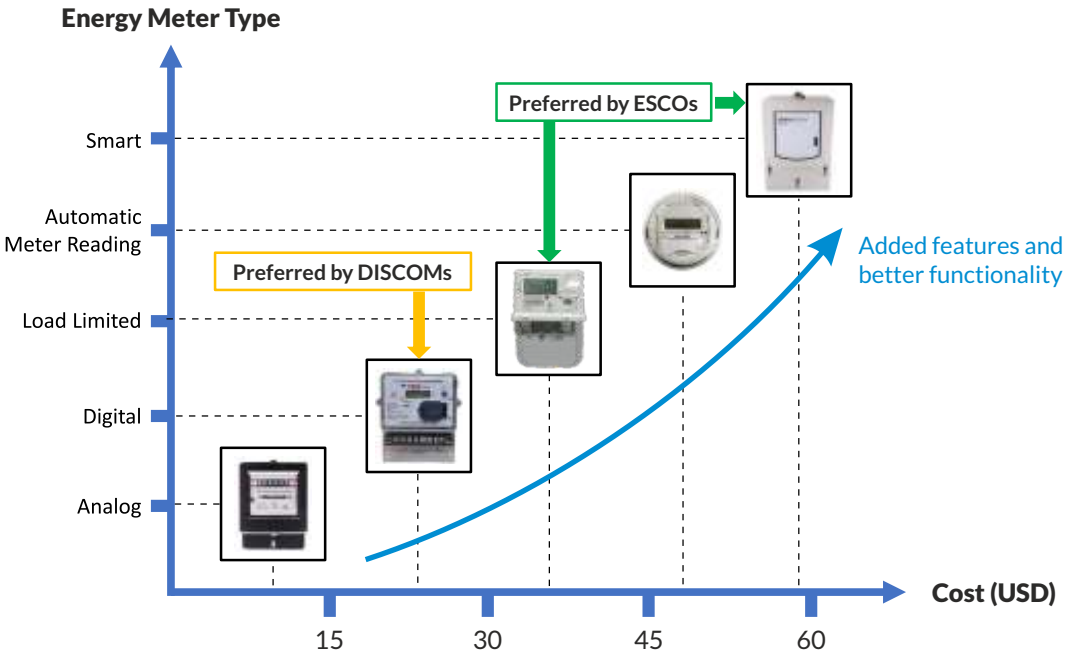
A Case for the Suitability of Smart Meters in Rural Mini-Grids

India's electricity demand is expected to triple by 2040[1], with rapid industrialization and population growth being the principal contributors to the surge. In response to this challenge, both public and private electricity service providers in India continue to develop strategies for transforming energy infrastructure with innovative technologies.

One such strategy adopted by Energy Service Companies (ESCOs[2]) has been to deploy solar mini-grids in rural areas where electricity access and reliability levels are low. However, these areas are also characterized by low and erratic customer demand, and high operational and maintenance costs. A solution that improves viability by yielding benefits to both customers and ESCOs is the need of the hour.

Smart meters can transform long-term sustainability and profitability by automating mini-grid operations, reducing operating costs and providing insight into customer behaviour and usage patterns. Next-generation smart metering combines a range of technical and customer management features designed to simplify routine tasks and expand the range of services available to customers and ESCOs. These devices have the potential for far-reaching impact on the development of smart mini-grids in emerging economies, and on the electricity sector as a whole.

Figure 1: Evolution of electricity meters



[1] "Power Sector Distortions Cost India Billions", *The World Bank*, December 2018.
[2] ESCOs are private companies with a local licence to generate and sell electricity. Another common term is "RESCO" (Renewable Energy Service Company).

Problems with Metering in Rural Mini-grids

Reading and interpreting information from conventional meters requires field agents to visit each meter and manually record the energy consumed, a time-consuming and error-prone task. Some ESCOs have taken a different strategy and equipped each connection with a “load limiter” to limit maximum usage. For such connections, the customer is billed according to the maximum power that they are allowed to draw.

This solution, however, does not account for any required variation in the cost and amount of supplying power during the day. To maximize profit and increase plant efficiency, operators want to incentivize consumption when solar energy is plentiful, and ensure that night-time demand adequately compensates the expense of battery storage and back-up diesel generators. Neither conventional energy metering nor the load-limiting approach permits such time-of-day pricing, resulting in solar mini-grids being overburdened during evening peak hours and underutilized during the day.

Moreover, without detailed information on energy consumption and dispatch during the day, it takes considerable effort to calculate the distribution network's energy losses. This is vital for identifying theft and technical inefficiencies, but is onerous to calculate when conventional metering approaches are in force.

Potential Solutions with Smart Metering

Advanced metering technology has the potential to provide benefits to all key stakeholders along the electricity generation-distribution-consumption chain, including end customers, field agents, and plant managers. Functionalities include:

Automated billing	Automatic upload of energy consumption to cloud servers ensures accurate and timely bill generation
Time-of-day tariff	Recording energy use on an hourly or sub-hourly interval allows for time-of-day tariffs which reflect the cost of supply
Time-of-day supply & load limit	Time-sensitive connection parameters allow for customised packages which meet the customer’s needs while ensuring the plant does not get overloaded
Customer management	Automated severing of non-paying connections, instantaneous package updates, ability to pinpoint theft, improvement in financial performance and customer service
Robust communication	Intelligent networked communication technology ensures that data are not lost during wireless transmission
Real-time data analysis	Real-time monitoring of parameters besides energy consumption, such as line voltage and power factor, allows speedy identification of network problems
Remote monitoring and control	Remote access to all requisite data provided to the mini-grid central office and ground teams, enabling them to deliver high-class customer service

Smart Metering Pilot by Smart Power India

Smart meters developed by SparkMeter, a US-based company specializing in metering solutions for utilities operating in remote, underserved areas (refer Box 1), were installed at 8 mini-grid sites in Uttar Pradesh and Bihar. Each meter cost ~USD 30 (FOB USA) and the landed cost is ~USD 60 after logistics, custom duty, and other taxes. Replacement of conventional meters at each mini-grid site and configuration with the base station and server back-end was achieved within a day.

Through pilot projects, SPI discerned that the key to unlocking smart meters' full potential is to integrate their output with mini-grid operators' existing digital data platforms (if they exist). The process of collecting and combining real-time data into a cloud-based platform enables automated analysis of critical performance parameters (refer Figure 3), raising of alerts, and instant remote management of meters and customer accounts.

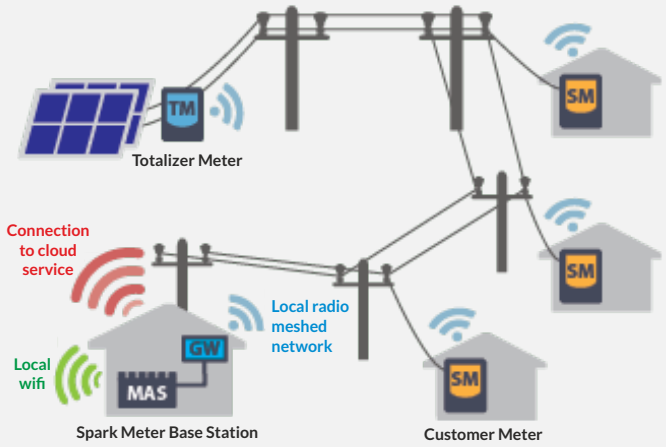
Naturally, the benefits of deploying smart meters must be greater than the cost to justify the purchase of the technology. Although the initial capital expenditure is almost twice that of conventional meters, customers benefit from a more efficient and convenient service and ESCOs from long-term cost savings and reduced theft. ESCOs across India and Africa are now designing new mini-grid plants with smart meters in mind, as well as retrofitting them onto existing sites.

Box 1: Technology Insight – SparkMeter

SparkMeter's smart meters are developed taking into account the challenging operating conditions of rural mini-grids; their capabilities include resistance to water and dust (they are graded IP65), and even resilience in the face of a mobile network interruption.

Once installed, the meters collectively establish a radio-frequency network through which they communicate with one another and with a base station housed in the plant control room. The base station collects metering and power quality data from the meters at 15-minute intervals, stores it in memory, and sends it via a mobile phone network to a cloud server.

Two-way communication allows plant managers and field operatives to access the server database through their mobile devices, and send messages to re-configure individual meters: for instance, to change electricity plans, disconnect or reconnect customers, and add account credit.



Schematic of Spark meter setup in a mini-grid

'SparkMeter was founded to help utilities in underserved markets connect more people to affordable, clean, and reliable electricity. We saw smart metering as a crucial tool for these utilities to improve operations and reduce their OpEx, but realized that the existing paradigm of smart metering – known as Advanced Metering Infrastructure (AMI) – was out of reach due to its cost and complexity. We set out to develop an alternative to AMI that would be low-cost and plug-and-play, precluding the need for IT consultants and the integrations necessary for AMI.'

– Dan Schnitzer, Co-Founder and CEO, SparkMeter

Figure 2: Cumulative cost for a single mini-grid site equipped with smart meters versus load-limited conventional meters (see Table 1 for details).

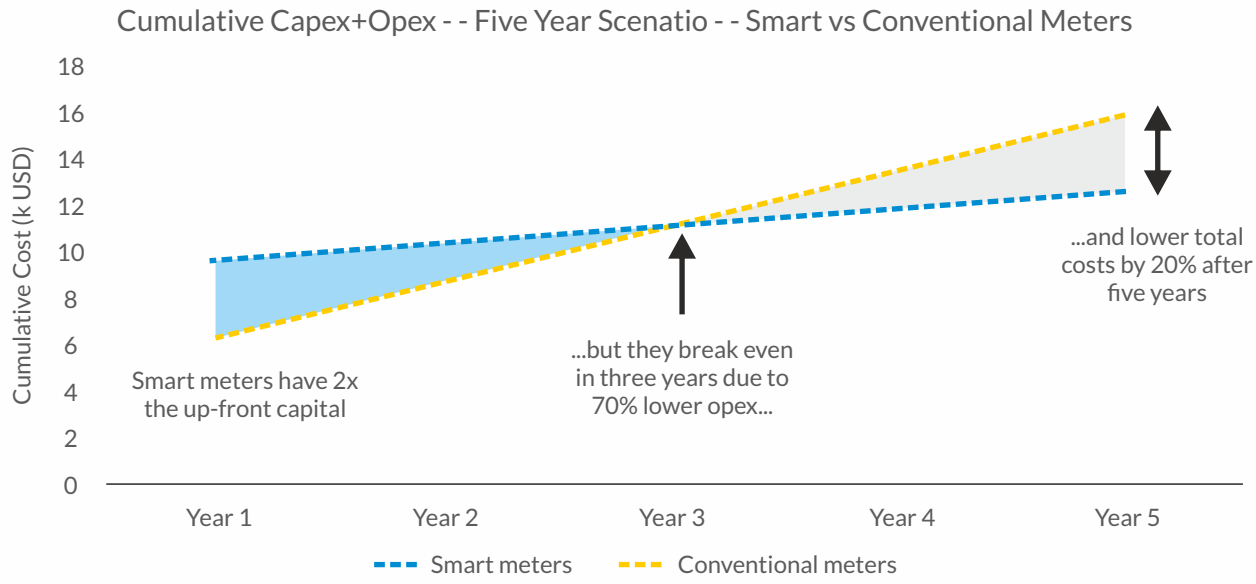


Table 1: Assumptions for the lifetime cost-comparison model for the mini-grid site from Figure 4.

Parameter	Unit	Smart Meter	Conventional Meter
Number of customers	#	150	150
Plant revenue	USD / month	1,100	1,100
Meter lifetime	years	5	5
Meter cost	USD	60	26
Manpower cost	USD / month	17	86
Software support	USD / month	43	0
Theft	%	0%	10%

The above model is based on actual data and projected lifetime costs of installing smart and conventional meters at a Smart Power supported mini-grid site in Bihar, India. Following are the assumptions for the calculations:

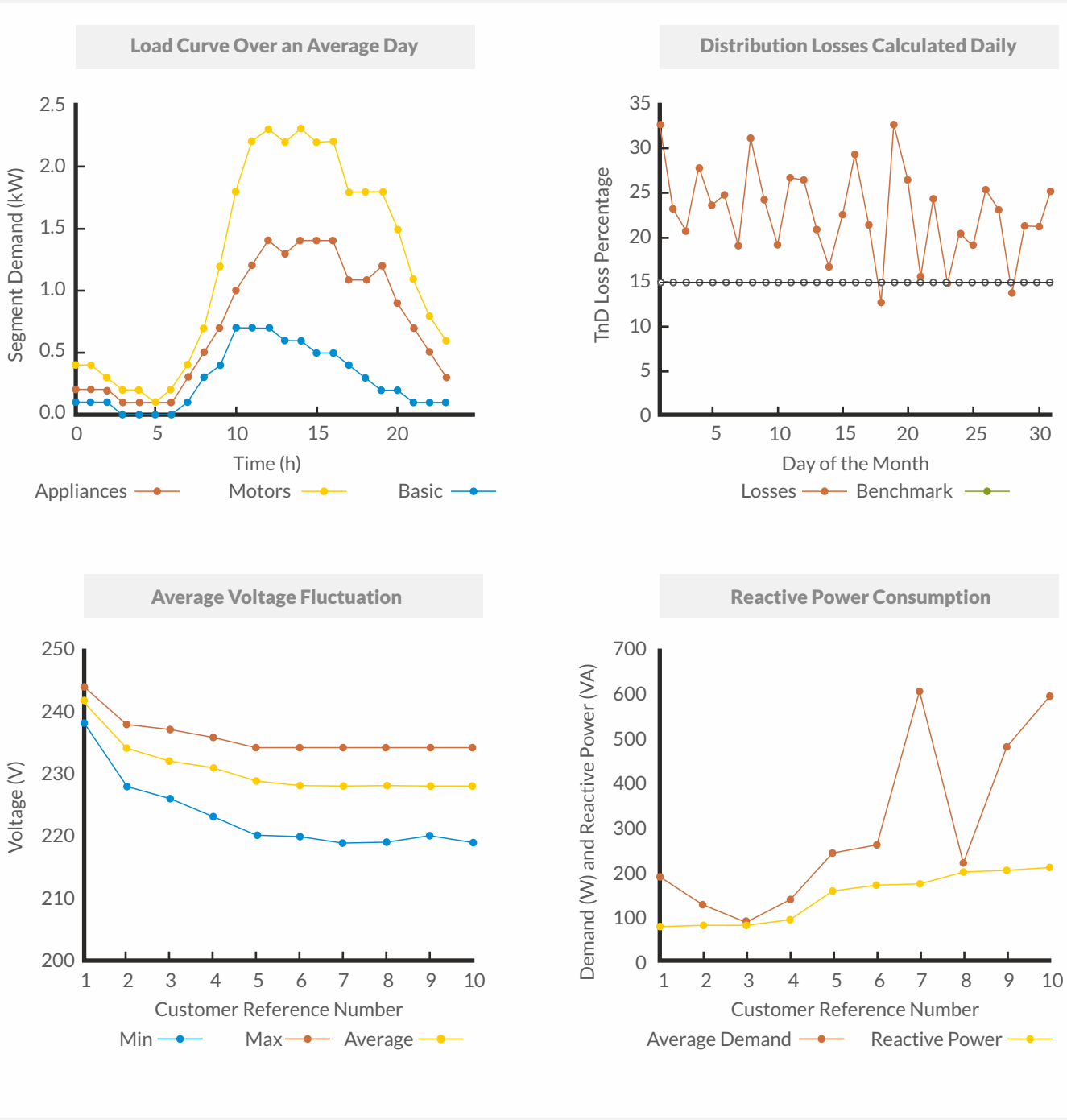
- The mini-grid serves 150 customers, including households, shops and commercial institutions
- Plant revenue is same for both metering technologies
- Metering technologies are distinguished by their initial capital and operating cost requirements
- "Meter cost" is the landed cost at the site for each type of meter
- "Manpower cost" is the salary for a customer service agent responsible for meter reading, load limit adjustment, technical interventions, and customer complaint resolution
    - For conventional meters, a single agent can typically manage only two sites, whereas smart meters' remote management functionalities extend this to 10-12 sites
- ICT, database, and hardware support fees ("SaaS fees") apply to smart meters only; these are typically charged by the smart meter provider
- Elimination of theft and instant disconnection of non-paying customers is possible with smart meters, whereas with conventional meters cumbersome levels of manual vigilance & control is required

Box 2: Quote from the Field

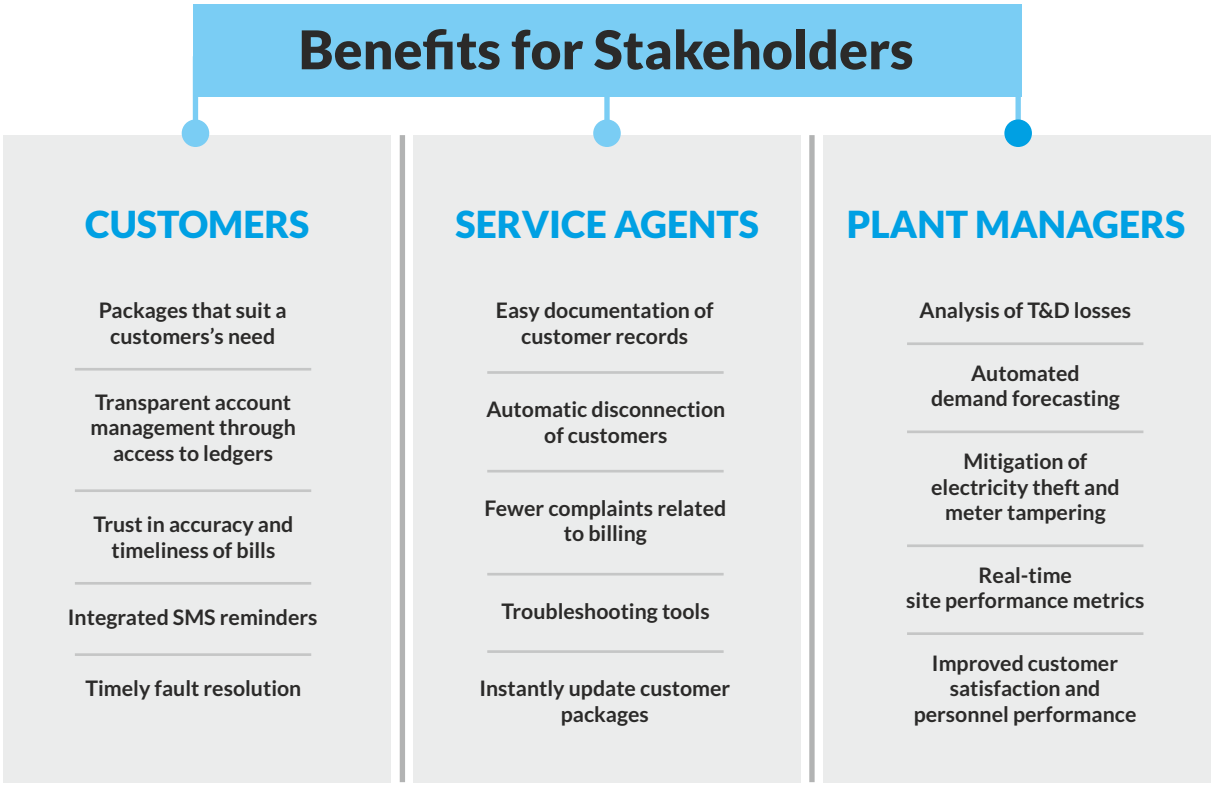
'We used to spend a lot of time on complaints from customers that their meter readings had been incorrectly registered. Now, everyone has confidence that bills will be correct.'

– Vikas Saxena, Tara Urja, Uttar Pradesh State in-charge

Figure 3: Data analysis through smart meters.



Benefits of Smart Metering



Key Implementation Challenges of Smart Meters

The market for smart meters is presently in a growth stage; however, there are few off-the-shelf options appropriate for the mini-grid context. Most existing technologies tend to be immoderately priced, and some technical and operational issues remain. Key among these are:

- Resilience of data retention and transfer during blackouts and mobile network disruptions
- Integration with existing data management systems to present a comprehensive user-friendly interface for customers and field agents
- Creation of standard data analytics packages to deliver maximum information leverage to mini-grid developers
- Compliance with international and national standards, to enhance market appeal, facilitate international importing protocols, and minimize customs duties
- Development of vendor and distribution networks for meters to penetrate to target markets

Future Outlook

Adoption of smart meters, in both off-grid and on-grid contexts, will grow in tandem with falling costs and expanding awareness. More quantitative impact evaluation on business profitability and customer satisfaction will hasten appreciation of smart meters' capabilities.

Recognizing the potential of smart meters, the Government of India is implementing a number of initiatives:

- In April 2019, spurred by the Smart Cities Mission, the Indian Government took its first step towards replacing all conventional electricity meters with smart prepaid meters by 2022.
- The Uttar Pradesh Power Corporation Ltd. Is targeting 4 million consumers currently catered to by 5 DISCOMs across the state.
- More recently, the Energy Efficiency Services Limited (EESL) entered into a joint agreement with the North Bihar Power Distribution Company Limited (NBPDCL) and South Bihar Power Distribution Company Limited (SBPDCL) to deploy smart meters covering 1.8 million consumers.
- Previously EESL, assisted by the Asian Development Bank (ADB) conducted a pilot with 5000 smart meters in Varanasi, India. Following this, the partnership announced a rapid scaling up to cover other states of India.

The sector is evolving towards increasingly integrated equipment and services. The interaction of meters and server-based customer databases is fast becoming streamlined; standards are being adopted for backend data analyses and automatic error flagging; and mini-grid developers are embracing the dynamism afforded by responsive communication between customer meters and generation infrastructure.

About Smart Power India

Smart Power India (SPI), a subsidiary of the Rockefeller Foundation, is the key agency for implementing the Smart Power initiative of the Foundation. SPI extends power to those without sufficient access to end energy-poverty and transform the livelihoods of the under-served. It is working towards building and nurturing ecosystems to promote sustainable and scalable models to deliver electricity access.

The Demand and Innovation vertical of SPI works with technology developers and electricity service providers to pilot and scale innovations that make mini-grids' operations more efficient and responsive to changing rural demand scenarios.

Authors:

Umang Maheshwari : Associate Director – Innovations, Smart Power India
Cato Sandford : Fellow, Smart Power India