India SMART GRID Week 2016

Recommendations for Updating India Smart Grid Roadmap: 2016

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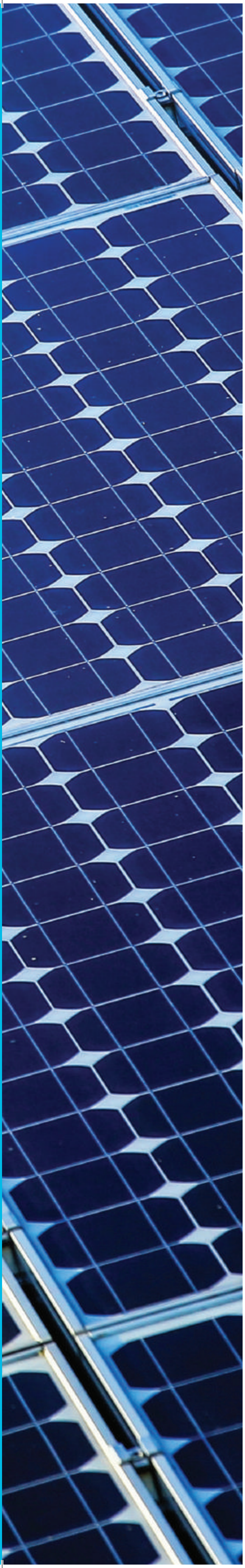

Foreword

India took its first steps towards outlining a documented vision and roadmap for ushering in smart grids in India through the Smart Grid Vision and Roadmap formulated by India Smart Grid Forum (ISGF) and issued by the Ministry of Power in August 2013, which envisaged nation-wide rollout of smart grids by 2027.

Since 2013 until now circa 2016, multiple developments across the landscape of energy and infrastructure have unfolded in India, which help to accelerate reforms in Indian power sector and thereby reinforce the need for faster, deeper and broader rollout of smart grids in India. Therefore, it is very pertinent that the said roadmap be updated now in 2016 to reflect the progress made, recognize the challenges that lie ahead, as well as factor in the new policies and programs announced by the Government of India and structural reforms that are taking place at the moment. At the same time, this Roadmap Update document ought to be transparent about the gaps identified that still persist over the years, because the path to rectifying such gaps can only start with an honest admission of their existence.

These are exciting times for India. Accenture—which has been on the forefront of smart grid developments worldwide—has now partnered with ISGF as the Knowledge Partner in the process of formulating this Roadmap Update. Accenture had earlier worked with Government of UK (Department of Climate Change) to provide inputs in helping formulate the Smart Grid Roadmap for Great Britain in circa 2009-2010. In India, Accenture has been working in India's power sector for nearly two decades, across generation and distribution sectors covering private sector as well as Government-owned Utilities, including deep hands-on work in the areas of AT&C Loss Reduction, IT Enablement, Rural Electrification using Renewable Mini-grids, and DISCOM turnaround. Thus, Accenture brings the best of global technologies juxtaposed with our local context to help ISGF update its Smart Grid Roadmap effectively.

We hope that this updated Roadmap brings together diverse stakeholders on to a common dialogue for ideating and finalizing the detailed action plans for the larger benefit of distribution sector, with particular focus on distribution segment turnaround enabled by smart grids.

Reji Kumar Pillai
President
India Smart Grid Forum

Sandeep Dutta
Managing Director
Resources Operating Group
Accenture

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1 Introduction

India, with a population of 1.221 billion[46], is the second most populous country in the world. While a majority of its population lives in villages, an ongoing migration to urban areas means that its urban population will rise from 377 million in 2011 to 600 million by 2031[15]. Accompanying this growth will be an increased demand for utilities like water and electricity. In fact, the potential demand for electricity by 2032 is expected to be 900 GW as compared to an installed capacity of 290 GW in 2016. While India is making progress in increasing capacity, having doubled its capacity from previous decade, fully meeting future demands requires a multi-pronged approach.

Much of India's electricity generation, transmission and distribution needs is served by traditional grids that burn fossil fuels like coal to produce electricity. As per ISGF-Bloomberg's Knowledge Paper[19] published in 2015, "the Power sector in India has traditionally seen a unidirectional flow of electrons, information and money. With an installed capacity of 258 GW, the Indian power system is the second largest synchronous grid in the world covering an area of over three million sq. km and about 200 million consumers. Yet, almost 79 million households in the country do not have access to electricity and the per capita consumption is one-fourth of the world's average. Transmission and Distribution losses are also relatively high, about 7% and 26% respectively. Largely dominated by Government owned utilities (both central and State), the private sector's role is about 35% in generation, less than one percent in transmission and about 5% in distribution."

While these massive infrastructures ably met demands at the beginning of 20th century, by the beginning of the 21st century, they were showing signs of limitation. The traditional grid has a few points of power generation and millions of points of power consumption. It also suffers from huge transmission losses as the power stations are located away from populated areas.

In spite of having large power generation capacity, India has low per capita consumption. Coupled with vast geography, India's AT&C losses are quite high and vary widely, ranging from "below 6%" pockets to "over 60%" pockets. In spite of a wide reach, there is very limited data regarding consumer indexing to the supply network, with only select pockets of the grid having distribution automation/distribution management/control systems. For a growing economy, a management of power grid is needed to reduce losses as well as to provide better service to customers.

Renewable energy is looked upon as an alternative to fossil fuels, which it can complement and that too under distributed generation mode, which reduces transmission loss in high voltage transmission segment as well as AT&C loss in distribution segment. The power grid that manages the flow of electrons currently is designed keeping mega structures in mind, it supplies energy as it is generated, not taking into account any variation in demand that may occur. To better serve todays energy needs, we need a grid that serves our energy when we need it, not when it is ready to give, and is efficient enough to not lose a substantial amount in transmission. It should also be versatile to incorporate renewable as well as non-renewable energy resources.

In this context, Smart Grids have proven their capability in transmitting energy from multiple sources, while reducing losses, managing peak demand, and world over, complement or upgrade traditional grids into smart grids.

1.1 Background of the 2013 Smart Grid Vision and Roadmap

In August 2013, with input from the India Smart Gird Forum, (a Public-Private Partnership initiative by the Ministry of Power) and other stakeholders, Ministry of Power released a vision document titled "**Smart Grid Vision and Roadmap for India**" that provided a roadmap for setting up smart grids in India by the year 2027. In August 2013, the India Smart Gird Forum, a public-private partnership initiative by the Ministry of Power released a vision document title "Smart Grid Vision and Roadmap for India" that provided a roadmap for setting up a smart grid in India by the year 2027. The vision document is aligned towards achieving the milestone of providing 24x7 electricity for all in a phased manner while promoting energy efficiency and technology enablement.

"Smart Grid Vision and Roadmap for India" is a visionary document that laid the groundwork for the progress that has been made in smart grids so far. It aligned Ministry of Power's policy objective of "access, availability and affordability of power for all" with the then ongoing programs such as R-APDRP and RGGVY. The disparate visions and aims of the various bodies were brought together and aligned towards the common goal of making power available for all. The document laid down a roadmap for upgrading India's antiquated electrical grid with a smart grid by 2027, that would reduce AT&C losses, improve peak load management, eliminate power cuts and dependency on diesel generators, stabilizers and inverters, bring down dependence on fossil fuels and cut pollution, and earn carbon credits.

The vision document defined a smart grid as: "A smart grid an electrical grid with automation, communication and IT systems that can monitor power flows from points of generation to points of consumption (even down to the appliances level) and control the power flow or curtail the load to match generation in real time or near real-time."[31] Smart grid reduces operational and capital costs for utility providers, improves asset utilization and revenues, reduces losses in transmission, and gives them an ability to integrate intermittent renewable resources into the grid. For consumers too, smart grids offer advantages such as reduced out-of-pocket costs due to power outage, opportunity to sell electricity back to the grid, and affecting a positive change in environment[47].

Smart grid uptake has been on the rise globally, as societies and Government take steps to move away from the monolithic and traditional power grids to one that is more efficient in distributing power, while cutting down losses and managing fluctuations in power demands.

There is a need for a system that considers the peak times when more power is required, like evenings as opposed to night times when power consumption is relatively low. The table on following page lists benefits of smart grids for all parties involved.

Smart grids, in turn, have found a relevant place in turning cities into smart cities. A smart city effectively delivers public services to citizens and businesses wherever they may be located, in an integrated and resource-efficient way while enabling innovative collaborations to improve the quality of life, reduce any detrimental impact on environment, grow the local and national economy and ensure safety and emergency compliances[15]. What is needed is a system that takes into consideration, peak times when more power is required like evening as opposed to night time when power consumption is relatively low. A smart city uses technologies that do not burden the environment, and take into account the activities of its inhabitants in order to maximize the service.

A smart city is enabled by smart grids to regulate the flow of power across the network. A smart grid does more than simply supply the power needed to operate the city. It is flexible enough to accommodate variations in demands, and is capable of ingesting power from multiple sources as opposed to

Smart Grids Benefits to Various Stakeholders:

Utilities	Customers	Government
• Reduction of AT%D losses as well as improved collection efficiency	• Expand access to electricity – "Power to all"	• Satisfied customers
• Peak load management – multiple options from direct load control to consumer pricing incentives	• Improve reliability of supply to all customers – no power cuts, no more DG sets and inverters	• Financially sound utilities
• Reduction in power purchase cost	• User-friendly and transparent interface with utilities	• Tariff-neutral system upgrade and modernization
• Better asset management	• Increased choices for consumers, including green power	• Reduction in emission intensity
• Increased grid visibility	• "Prosumer" (producer and consumer) enablement	
• Self-healing grid	• Options to save money by shifting loads from peak periods to off-peak periods	
• Renewable integration		

Table 1. (Source: Rahul Tongia: **Smart Grids, Storage and Renewables—Pillars of the Future Grid**; Blowing Hard of Shining Bright: Making Renewable Power Sustainable in India, Brookings Institution India)

the traditional grids. An important part of what makes the grid smart is smart meter.

A smart meter enables a user or utility provider to remotely measure and disconnect/ reconnect load in real time. Thus, smart meter, smart grid and smart city are part of a chain that aim to improve the life of people, while preventing wasteful use of resources.

1.2 Recap of 2013 Vision & Roadmap and Reality Check vis-à-vis Current Status

The stated policy objective of the Roadmap is "access, availability and affordability of power for all[31]."

The vision stated in the 2013 Vision document is:

"Transform the Indian power sector into a secure, adaptive, sustainable and digitally enabled ecosystem that provides reliable and quality energy for all with active participation of stakeholders"[31]

The document laid guidelines for distribution and transmission of electricity, setting up policies, standards and regulations, and other initiatives like tariff mechanisms, information exchange and research.

A recap of roadmap as laid out in 2013 is as follows:

- Access and availability of quality power to all
- Electrification of all households by 2017
- Reduction of power cuts, with minimum of eight hours of electricity supply to everyone.
- Reducing AT&C losses by 15 percent
- Advanced metering infrastructure for all by 2027 in three phases
- Deployment of Wide Areas Monitoring Systems (WAMS)
- Development of micro grids
- Generation of 30 GW energy by renewable means
- Energy efficient programs for lighting and HVAC in metros and state capitals
- Initiating Dynamic (smart) Energy Efficiency Programs, to be spread nation-wide
- Charging stations for electric vehicles
- Promoting energy storage systems
- Indigenous smart meter by 2014
- Training of at least 10 percent of utility technical personnel in smart grid technologies

In addition to these, the 2013 Roadmap also focused on finalizing the institutional framework for smart grid development, aligning the then existing schemes like R-APDRP and NOFN with smart grids, and setting up a National Smart Grid Mission.

It is pertinent to pause, look back and reflect as to what has been achieved in line with the Roadmap, what is still pending, and what needs to be modified in order to suitably reflect the changes that transpired in the Indian power sector in the last couple of years. Following sections briefly summarize these aspects.

A. Areas where progress has been satisfactory:

i. The National Smart Grid Mission is an institutional mechanism established by Government of India in 2015 as an independent body to implement the goals stated in the Smart Grid Vision and Roadmap. Its purpose is to plan and monitor implementation of smart grid policies and programs all across India. Though housed under the Ministry of Power, it also liaises with Ministries of New and Renewable Energy (MNRE), Urban Development (MOUD), Heavy Industry (MOHI) and Communications; and also with State Governments and Utilities to fulfill its goals[22].

The NSGM is a three-tiered structure, with a Governing Council headed by the Minister of Power at its apex level, an Empowered Committee headed by Secretary – Power and a Technical Committee headed by Chairperson – Central Electricity Authority. NSGM enjoys financial and functional autonomy to roll out smart grid in the country. Currently, NSGM is overseeing the 14 smart grid pilot projects in various States. In addition, it is collaborating with IIT Kanpur on a project titled, "Development of R&D Platform for Smart City Projects in the Indian Context" to evaluate the existing smart grid technologies and identify the technology, methods and algorithms needed to overcome the shortcomings of the existing techniques.

NSGM supports smart grid projects in the form of assistance in formulation of projects including funding, training and capacity building, consumer awareness initiatives etc. It is in the process of allocating another set of smart grid projects with a provision of grant funding to the tune of 30 per cent of the project cost. NSGM, with its stated goal of implementing the smart grid vision, is poised to play an important role in this space.

ii. Net Metering Policy in 25 States

Another important development is in the area of net metering policies. As on January 2016, 25 state electricity regulatory commissions (out of 29 in the country) have issued net metering policies that would empower customers to become "prosumers" as had envisioned in the smart grid roadmap. Government of India is aggressively promoting roof top PV program with a target of 40 GW from 20 million roofs by 2022 and the net metering policies in almost all big states will facilitate faster rollout of this rooftop PV program.

iii. Model Smart Grid Regulations

MoP with inputs from ISGF, USAID and other stakeholders prepared a Model Smart Grid Regulation and got it approved by the statutory body, Forum of Regulators (FOR) that comprises of Chairperson of Central Electricity Regulatory Commission (CERC) and Chairpersons of all the State Electricity Regulatory Commissions (SERC). FOR issued the Smart Grid Regulations in September 2016 and Draft Smart Grid Regulations have already been issued by SERCs in Assam, Karnataka and Tripura while several other SERCs are in the process of issuing Smart Grid Regulations. This is a significant step towards smart grid roll outs in the country.

iv. "Indigenous smart meter by 2014"[31]

The vision document mentioned spurring innovation locally, with the aspiration that India would develop its indigenous smart meters by 2014. It further said that after successful completion of pilots, they would be rolled out for consumers based on the size of connection, starting with load more than 20 KW by 2017 to all 3-phase consumers by 2022 and finally, total deployment of smart meters and necessary infrastructure for the same by 2027[31].

In a significant development, in October 2015, Bureau of Indian Standards (BIS) finalised the national standard for smart meters, IS-16444, to standardise anti-tamper measures and enable modular plug-and-play communication.[59] In March 2016, BIS issued IS 15959 (Part 2), the standards for data exchange protocols for smart meters.

Several meter manufacturers in India are expected to produce smart meters conforming to the new standards this year. Ministry of Power (MoP) is working on a framework and roadmap for smart meter rollout in the country. MoP has already announced that all customers with a monthly consumption of 200 kWh and above will be brought under smart metering regime by December 2019 and a rollout plan for the same is expected to be announced soon.

v. "Energy Efficiency Programs for lighting and HVAC in metros and state capitals"[31]

Energy efficiency programs that promote the use of appliances that use less energy has been a great success. The 2013 vision document stated that from the 12th Five Year Plan (FYP) onwards, metropolitan cities and state capitals would use lighting and HVAC tools that required less energy to work. This would later be expanded to urban areas in the 13th FYP and nationwide in the 14th FYP.

Ministry of Power, through Energy Efficiency Services Limited (EESL), started the Domestic Efficient Lighting Programme (DELP) to supply LED lights at affordable price to electricity consumers. By sourcing LED lights in bulk, DELP scheme has enabled LED lights to become affordable to a common man.

As of March 4, 2016, DELP claims to have sold 7.15 crore LED lights, saving nearly 2.52,71,498 KWh of energy per day, which is nearly 9.19 crore in savings for both, utility provider and users[55].

To further promote energy efficiency Bureau of Energy Efficiency (BEE) launched the Partial Risk Guarantee Fund for Efficient Energy (PGRFEE) in 2015 as a risk sharing mechanism for commercial banks. PGRFEE has been endowed by Government of India with ₹312 crore for providing them partial risk coverage to banks when they disburse loans for energy efficiency to Government building, municipalities SMEs as well as industries[52].

In 2015, BEE also launched the Venture Capital Fund for Energy Efficiency (VCFEE) with an approved corpus of ₹210 crore for investing in research into newer technologies, goods and services in energy efficiency[53].

B. Areas where work is in progress

i. "Reducing AT&C losses to below 15 percent by 2017[31]"

The vision document envisaged tackling the loss of electricity during transmission as well as outright theft on a war footing. It aimed to reduce AT&C losses to less than 15 percent by 2017, below 12 percent by 2022 and below 10 percent by 2027[31].

To that end, overall AT&C loss of India has reduced from 26.51% in 2010-11 to 23.65% in 2014-15. Further some DISCOMs performed much better in loss reduction while others have stagnated or even deteriorated in performance[56]:

The following table lists the AT&C losses of DISCOMs in India:

Utility-wise Reduction in AT&C losses between 2010-11 and 2014-15					
Decrease of 10-15 percentage points	Decrease of 5-10 percentage points	Decrease of 2-5 percentage points	Decrease of 0-2 percentage points	Increase of 0-5 percentage points	Increase of 5-10 percentage points
MP Poorv, NBPDCL, TSECL	UPCL, JKPDD, SOUTHCO, MP Madhya, GESCOM, DGVCL, APDCL, PGVCL, CSPDCL, BESCOM, HESCOM, TSSPDCL, MP Pashchim	WESCO, MESCO, BRPL, TSNPDCL, BYPL, MGVCL, APEPDCL, CESU, TPDDL, PSPCL, TANGEDCO, AVVNL	KSEB, Torrent Power (Ahmedabad and Surat), DHBVN	MSEDCL, APSPDCL, JBVNL, SBPDCL, MESCOM, WBSEDCL, UGVCL, HPSEB, UHBVN	MePDCL, JdVVNL, CESCOM, JVVNL

Table 2. (Source: DISCOM finances, Power Purchase costs and Tariffs; India Infrastructure, 2015)

As is evident from the table, about 15 DISCOMS (from over 55) in India have managed to reduce their AT&C losses to below 15 percent in this period[56].

While the overall average still remains high, with time, as more grids become smart, it is expected that AT&C losses will decrease. For accelerating the pace of loss reduction, Ministry of Power launched the Ujwal DISCOM Assurance Yojana (UDAY) scheme to assist DISCOMS in their operational and financial turnaround. Under UDAY, DISCOMS are required to undertake consumer indexing and a GIS mapping to identify high loss pockets that need pin-pointed intervention. In order to reduce technical losses and minimizing outages, DISCOMs are required to upgrade their transformers, distribution lines and meters. Smart meters for all consumers consuming more than 200 kWH per month is to be completed by December 2019. This will help in granular, accurate and real time energy audit, loss measurement, and precise inputs for undertaking loss reduction interventions.

By promoting LED lighting, DISCOMS can further reduce their peak load, which will lead to high savings in cost of peak power purchase[40].

The Ministry of Power is also encouraging the DISCOMs that reduce their AT&C losses in line with UDAY target by offering more power supply[40].

ii. Technology and Standards

ISGF and Smart Grid Interoperability Panel (SGIP) signed and MOU proposing an approach to enhance the coordination between the two organisations at the SGIP conference in October 2014. The MOU focuses on sharing information for a standardization policy, smart grid projects, testing and certification, cyber security requirements and technologies, as well as policy and regulation issues[59]. Subsequently in 2015, BIS and IEEE signed an MOU facilitating BIS to adopt IEEE Standards with customization for Indian requirements. These developments are very significant towards standards for smart grid rollouts.

In January 2016, Ministry of Power updated Tariff Policy that envisages rollout of smart meters in a phased manner to enable “Time of Day” metering. With emphasis is now shifting towards smart metering, it is expected that the dream of a low cost smart meter will be realized once demand increases[38]. “Further, the industry expects the government to soon announce the wide-scale deployment of smart meters (about 100 million) in the country. Mass procurement is expected to push down the prices of smart meters to $20-30.[59]”

iii. “Micro grids in 1,000 villages by 2017”[31]

The vision roadmap document said 1000 micro-grids would be developed across villages, industrial parks and commercial hubs by 2017, making power available to remote locations, as well as those that need to be shielded against power fluctuation and grid disturbances during peak hours. Rural Electrification Corporation (REC), was tasked with lighting up the villages. REC, with its mission to “facilitate availability of electricity for accelerated growth and for enrichment of quality of life of rural and semi-urban population”, promotes and finances power generation, conservation, transmission and distribution projects.

Apart from REC’s programmes, the micro-grid “market” is now also attracting private/ non-Government players who operate solar powered mini-grids in remote villages on a self-funded model. One such example is Rockefeller Foundation’s SPRD project (refer box) where Accenture is assisting it develop a self-sustainable ecosystem of rural Energy Supply Companies (ESCO).

In 2015, REC amended its guidelines for Decentralized Distributed Generation (DDG) that supports 90 percent of a project cost till it is commissioned, and the remaining 10 percent within six months of Performance Guarantee Testing (PG Testing) for solar projects and 40 days for hydro projects. It also removed the clause mandating the project developer to submit five percent of project cost as a guarantee. The DDG amendments also change the technical criteria for a bidder to enable more participation[2]. States like UP (Uttar Pradesh) have undertaken a very progressive step of formulating a detailed mini grid policy.

Smart Power for Rural Development

Today, 1.3 billion people around the world live without reliable electricity. In India alone, more than 300 million people lack access to electricity, most of them are in rural areas.

The Government, led by Prime Minister Modi has declared 24/7 power a key part of its economic development agenda. The Rockefeller Foundation is committed to support the Prime Minister's electricity agenda with **Smart Power for Rural Development** (SPRD)—an initiative that will deliver electricity and catalyze economic development among underserved rural populations in 1,000 Indian villages. The smart power model is an innovative way to deliver electricity via decentralized renewable energy mini-grids.

SPRD model is an innovative model that goes beyond household lighting and ensure productive use and serves customers ranging from shops, businesses using power to run appliances and motors, institutions such as banks, telecom towers and households.

Government is targeting to electrify 3,449 villages through off-grid mini-grids by March 2017, of which about four percent has been completed till date; entire information is transparently made available on a web-based dashboard and a mobile app (called GARV)[62].

NSGM is expected to undertake microgrid demonstration projects in its next phase of smart grid projects.

iv. "Grid integration of renewable energy"[31]

The vision document said Renewable Energy Monitoring Centers (REMCs) and energy storage systems would be set up to facilitate the integration of renewable energy into the grid. NSGM is expected to undertake microgrid demonstration projects in its next phase of smart grid projects. Currently, excess renewable energy is fed into the main grid, irrespective of whether the grid needs it or not. Till recently, energy storage systems were not used to store renewable energy. Recently, PowerGrid Corporation has awarded energy storage demonstration project involving two 500 kWh systems in 2015 which will be installed in Pondicherry. MNRE published an Expression of Interest for energy storage demonstration projects for supporting renewable generation. This is a clear indicator of the Government's seriousness when it comes to energy storage.

v. "R&D, training and capacity building"[31]

A 2011 document titled Strategic Plan for New and Renewable Energy Sector for the Period 2011-17 by the Ministry of New and Renewable Energy recognized the fact that the renewable energy field was not well served due to a paucity of skilled personnel.

Also, the skill set of the personnel would be continually improved through suitable training37. The 2013 Roadmap also called for training at least 10 percent of utility technical personnel in smart grid technologies31. Currently, smart grid technologies are new and there are not many trained personnel. But as the grids expand, there will be a need for professionals that are training in operating them.

ISGF has launched a set of training and capacity building programs related to smart grids such as

1. Foundation course on smart grids (3 days), 2. Workshop on cyber security for power systems (3 days), 3. Smart grid bootcamp (1 day) – for C level executives as well as students, 4. Three months certificate program on smart grids. Presently, with support from Shakti Foundation, ISGF is developing a course content for a Four days training program for regulators. Many other institutions in India also conduct a variety of programs related to grid modernization and smarter systems.

NSGM has kept provision for training and capacity building for all DISCOMS. However, participation of DISCOM engineers in these programs is not encouraging.

ISGF advocate to allocate 5-10% of the cost of all smart grid projects towards training and capacity building so that engineers and operators are well trained in the new equipment and systems deployed.

vi. Smart grid pilots followed by full roll out in cities[31]

"In May 2015, the Government launched the National Smart grid Mission (NSGM) to plan, monitor and implement grid modernization policies and programs in "mission mode.[59]" At the outset, these pilots were:

- APDCL, Assam
- CESC, Mysore
- CSPDCL, Chandigarh
- HPSEB, Himachal Pradesh
- JVVNL, Rajasthan
- KESB, Kerala
- MSEDCL, Maharashtra
- PED, Puducherry
- PSPCL, Punjab
- TSECL, Tripura
- TSSPDCL, Telangana
- UHBVN, Haryana
- UGVCL, Gujarat
- WBSEDCL, West Bengal

Fifty percent of the project cost for these pilot projects were offered as grant by Ministry of Power under the then on-going program R-APDRP.

However, the outcome has been a mixed bag. Of the 14 pilots, eight have been awarded, four are still at different stages of tendering, and two have been cancelled. While even the awarded pilots are suffering from varying extent of delay in implementation, the pilots for Puducherry, Gujarat and Kerala are still under the process of award; the pilots for Maharashtra and Chhattisgarh have been cancelled; the RFP for Rajasthan pilot has not yet been released–signifying large overall delay in the smart grid pilot program.

Progress of the awarded projects is summarized below:

i. Chamundeshwari Electricity Supply Corporation Ltd. (CESC), Mysore, Karnataka

The pilot covers 21,824 residential, commercial, industrial and agricultural consumers, including 512 irrigation pump sets covering over 14 feeders and 473 distribution transformers and accounting for input energy of 151.89 MU in additional city area of Mysore. Functionalities like Agriculture DSM with community portal, consumer portal to support DSM/DR, employee portal for knowledge sharing and benefit realization, KPI based MIS and data analytics for decision support have also been added to it. Its total cost is ₹32.59 crore, with Ministry of Power contributing ₹16.30 crore. Expected Completion Date: May 2016.

ii. Uttar Haryana Bijli Vitran Nigam (UHBVN), Panipat, Haryana

This pilot is selected by NEDO (New Energy & Industrial Technology Development Organization), Japan for potential funding under Indo-Japanese international collaboration. In 2015, the pre-feasibility study was completed and it has been proposed to undertake AMI/PLM; OMS with simplified SCADA along with Renewable Integration in three feeders in Panipat, covering about 11,000 consumers.

"The Project is being executed under a grant from the Japanese Government through NEDO, which has awarded it to a consortium of Japanese companies led by Fuji Electric.[59]" Accenture is implementing key smart grid applications for this pilot, including meter data management system and outage management system. Expected Completion Date: March 2017

iii. Assam Power Distribution Company Limited (APDCL), Guwahati, Assam[59]

The pilot covers 15,000 consumers involving 90MUs of input energy. The approved cost of the project was ₹29.44 crore, of which, Government of India contributed ₹29.86 crore, with ₹14.97 crore paid through the Ministry of Power. Currently, smart meter prototype is being tested at the project, which will is expected to be completed by October 2016.

iv. Himachal Pradesh State Electricity Board Limited (HPSEB), Kala Amb, Himachal Pradesh

This pilot project covers about 1,500 consumers in Kala Amb Industrial area. It was approved at a cost of ₹19.45 crores, with Ministry of Power contributing ₹8.92 crore. "Its functionalities include AMI-I, OMS, PLM and PQ. Under the project, 1,100 smart meters have been installed and data form 300 meters is being monitored.[59]" Expected Completion Date: September 2016.

v. Punjab State Power Corporation Limited (PSPCL), Amritsar, Punjab

This pilot project area covers 2,737 customers in the Industrial Division of City circle, Amritsar with an overall consumption of 112.8 MUs per annum. It was approved at a cost of ₹10.11 crore in which, Ministry of Power contributed ₹5.06 crore. The project will incorporate advanced metering infrastructure and peak load management into its infrastructure. Expected Completion Date: October 2016.

vi. West Bengal State Electricity Distribution Company Limited (WBSEDCL), Siliguri, West Bengal

This aim of this pilot project is to convert four 11 KV feeders and convert them into smart grids, covering 5,275 consumers in Siliguri town in Darjeeling district. AMI will be used to reduce AT&C losses and manage peak loads. The total approved cost of the project is ₹7.03 crore and MoP has contributed ₹3.52 crore in it. Expected Completion Date: January 2017.

vii. Tripura State Electricity Corporation Limited (TSECL), Agartala, Tripura

This pilot project covers 42,676 consumers in Agartala. It will add AMI and peak load management to the existing infrastructure for system strengthening, which will help it reduce AT&C losses peak load consumption. "The total approved cost of the project is ₹63.43 crore of which, the Central Government has contributed ₹31.72 crore[59]." Expected Completion Date: March 2017.

viii. Telangana State Southern Power Distribution Company Limited (TSSPDCL), Telangana

The TSSPDCL pilot project focusses on 11,904 consumers in the Jeedimetla Industrial Area. It was approved at a total cost of ₹41.82 crore, with MoP contributing ₹20.91 crore. TSSPDCL will integrate AMI peak load management, outage management and power quality management into its systems to reduce AT&C losses as well the high cost of power at peak hours. Currently, the project is in its final stages of opening of bank accounts, preparation of PFMS and KPI forms etc. Expected Completion Date: March 2017.

ix. Electricity Department, Government of Puducherry

"This project will cover Division-I of Puducherry and serve 34,000 consumers. Its functionalities include AMI-Residential and AMI-Industrial. Its total approved cost is ₹23.06 crore.[59]"

1.3 Developments during 2013 – 2016: Need and Relevance for Roadmap Update

The last couple of years have been very dynamic and positively eventful for the Indian power sector. The country has witnessed a series of interventions initiated by the Central Government to revitalize power, coal and renewable energy landscape of India, with special focus on electricity distribution turnaround. As per MOP, "DISCOMs are the weakest link in providing 24x7 Power for All"[24], which has triggered the Central Government to launch its flagship program UDAY, which in a way, ties in all other reform programs together under one umbrella.

» UDAY

The Ujwal DISCOM Assurance Yojana (UDAY), a scheme for financial turnaround of state-owned DISCOMS, was announced in November 2015 by Ministry of Power[40]. The scheme seeks to improve the efficiency of state-owned DISCOMS through targeted activities like:

- Compulsory feeder metering by 2016 and distribution transformer metering 2017
- Consumer indexing and GIS mapping by 2018

- Smart metering of all consumers consuming more than 200 units/month by Dec 2019
- Demand Side Management like LED lighting, energy efficient appliances by March 2019

UDAY framework also sets up a mechanism on judging the efficiency of DISCOMs on the basis of their reduction in AT&C and reduction in gap between average cost of supply and average revenue realized[40].

The most direct linkage between UDAY and smart grids is the policy decision to install smart meters at all connections with 200+ units of monthly consumption, as well as meterization of all network points down to feeders and transformers. Though UDAY is optional, most of the large states (15+) have announced their intent to join it, signifying that a major smart meterization drive is in the offing across the nation, whose impact will be seen in near future in more ways than we can imagine.

» Tariff Policy[38]

The initiative to roll out smart meters is taken a step further by the amendments to National Tariff Policy (NTP) published in January 2016. NTP seeks to spread smart metering across all consumers in a phased manner to enable Time of Day tariff, besides also curbing commercial loss and allowing net metering to encourage rooftop solar generation.

Both UDAY and NTP will significantly accelerate country-wide deployment of smart meters, thereby mandating a major enabler of large smart grid rollout in India.

The amendments seek to encourage micro -grid for electrification of remote villages by mandating compulsory buying of electricity from these off-grid plants as and when the main grid reaches these villages.

By March 2022, solar RPO has been set at 8 percent of total consumption of electricity excluding hydel power.

» IPDS & DDUGJY

The scope of R-APDRP has been extended to another 5,000 towns under the newly launched program called Integrated Power Development Scheme (IPDS), and an amount of Rs. 32,612 crore has been allocated to modernize the electricity distribution grid in those 5,000 towns in addition to Rs 44,011 crore which was sanctioned for R-APDRP.

The scope of RGGVY has been modified under the newly launched DDUGJY to include separate feeder for villages and separate feeders for agricultural and other areas so that 24x7 can be ensured for all households and amount of Rs. 43,033 Crore has been allocated for this program in addition to Rs 39,275 crore which was sanctioned for RGGVY. Finance Minister stated in his budget speech in February 2016, “the Government is committed to achieve 100% village electrification by 1st May, 2018.”

» Smart Cities Mission[33]

Arguably the most ambitious project, in June 2015, Ministry of Urban Development released a document titled “Smart Cities Mission Statement and Guidelines”. This document talks of turning 100 cities into smart cities, and incorporating the learning from this mission to build more such cities. In August 2015, a list comprising of 98 cities was unveiled.

In January 2016, of the 98 smart cities identified, 20 have been shortlisted for development in the first phase. Additionally, the concept of smart city/township has gained currency and fired the imagination of state Government and urban local bodies – which are formulating additional smart city projects over and above these.

Global experience show that smart utilities in general, and smart grids in particular, serve as a key enabler of smart cities.

» Scale-up of Renewables

MNRE has revised upwards significantly the targets for renewable energy to 175GW by 2022, of which, 100GW is expected from solar, of which, 40GW is expected from distributed generation/rooftop.

Ministry of New and Renewable Energy (MNRE) issued guidelines for grid-connected solar rooftop program in June 2014[27]. The stated aims of this program are:

- Promote use of residential, community, institutional, industrial and commercial rooftops for installing solar panels, with any excess power being fed into the grid
- Mitigate dependence on fossil fuel based electricity generation and encourage solar power generation
- Investment in solar energy sector by private sector, State Government and the individuals
- Create a paradigm shift needed for commoditization of grid connected SPV rooftop applications

Banks have started including the cost of Rooftop Solar plants as part of the construction cost when sanctioning home loan amounts.

Recent Amendments to NTP has also emphasized and clarified the role of distributed generation and mini-grids with provision of power purchase as and when the grid reaches in future such villages that are currently do not have electricity.

Multiple initiatives have been launched or existing programs revitalized to enable the above targets. Spurred by the Central Government's initiatives, multiple states have launched net metering policy, made rooftop solar mandatory, announced rural mini-grid policy, and are now gearing up to meet much higher solar RPO norms to ensure compliance with the latest amendments to National Tariff Policy.

Finance Minister stated in his budget speech in February 2016, "the Government is committed to achieve 100 percent village electrification by May 1, 2018."

Certain states have taken the initiative to make rooftop solar mandatory for large premises. For example[63], Government of Haryana, through its Gazette notification dated 3rd Sept 2014, made it mandatory for all residential buildings on a plot size of 500 square yards and above falling within the limits of municipal corporations, municipal councils, HUDA and HSIIDC (the industry body), educational institutions, government buildings, hospitals, commercial establishments like malls and licensed builder colonies, to install solar rooftop power plants of minimum 1 kW or 5% of the connected load whichever is higher. The Chandigarh Renewable Energy Science and Technology Promotion Society (CREST) is also expected to notify mandatory rooftop solar very soon. Tamil Nadu Government issued orders in 2014 for mandatory rooftop PV for educational institutions, hospitals, Government buildings and other large campuses.

In 2014, Ministry of New and Renewable energy issued a notification for the implementation of "Development of Solar Cities Program" of 2011 during the 12th FYP. The program aims to promote the use of renewable energy in urban areas by supporting Municipal Corporations in the development of their cities as Solar Cities. It will enable urban local Governments to address energy challenges at a city-level. The Solar Cities program will involve many stakeholders in the planning process, and provide a framework and support to prepare a Master Plan including assessment of current energy situation, future demand and action plans. It will oversee the implementation of sustainable energy options through public - private partnerships.

The program has an initial target of 60 cities or towns, with at least one in each state. Out of the 60 target cities, eight cities will be developed as model solar cities[36].

» Amendments to DDG

Ministry of Power made specific changes to the Decentralized Distribution Generation (DDG) scheme in 2015 to promote rural electrification. The changes concern separation of farm and non-farm meters to better understand the consumption of power, changes in payment terms of projects to make them more attractive, provision for a single point contact in the state implementing agency, as well as changes in the standard bidding document and procurement guidelines[15].

Additionally, Amendments to Tariff Policy further improve the prospects of rural mini-grids by minimizing uncertainty about their future at the time grid reaches such villages that are currently not electrified.

» FAME India

The Department of Heavy Industries under the Ministry of Heavy Industries and Public Enterprises launched the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME) and issues guidelines for the same on March 13, 2015[11], further revised on April 27 2015[10].

FAME India aims to promote indigenous manufacturing of electric and hybrid vehicles, and setting up of a robust ecosystem to support electric vehicles by 2020. Under FAME India, manufacturers of hybrid or electric vehicles will receive incentives, and charging infrastructure will be built up at the same time. It has a corpus of ₹795 crore, which it will use for building technology platform, demand infrastructure, charging infrastructure, pilot projects, and IEC/operations[10].

It aims to accelerate the implementation of National Electric Mobility Mission Plan 2020 which has a target of 6-7 million electric vehicles in India by 2020. In April 2015, ISGF formulated and submitted its recommendations to MoHI, including inter alia detailed recommendations on developing charging infrastructure to boost offtake of electric vehicles[18].

» Falling Costs

Whether it is the capital cost of solar plants, or the tariff of electricity generated thereof, there has been significant drop in the market operating prices (₹50-55/KWP and ₹4.32/KWH). Coupled with fall in Li Ion batteries ($400-500/KWH)[60] and LED lights (household bulbs retail price has crashed to about 1/3 in the last couple of years especially after launch of DELP), the overall innovation in Indian power sector is poised to become far more affordable, and hence far more accessible, in near future.

Inference

Therefore, factoring not just Government initiatives but also market trends and industry dynamics, it is imperative to relook at the Roadmap with a fresh perspective at the start of 2016, so that the same vision can be pursued with renewed vigor and energy. It is important to understand and synergize the interplay between smart city, smart grid, smart meter, rooftop solar, electric vehicle and smart home. For green energy to grow and replace fossil-based energy, smart grids and integration of distributed renewable generation becomes doubly important—from the urban perspective, rooftop solar plays an important role, whereas in case of remote rural areas, mini-grids become a pragmatic enabler—thus all tributaries converge to the same river of smart grids!


H_2O
O_2

2 International Experience in Smart Grids and Smart Cities

The Dept. of Energy and Climate Change (DECC), Government of UK, was a pioneer in formulating its smart grid vision and roadmap. DECC published a document on Smart Grids Opportunity in UK in December 2009. Subsequently, an initial Routemap was published by Electricity Networks Strategy Group (ENSG) in February 2010, and subsequently a broader Roadmap was published by UK's Smart Grid Forum in February 2014.

Accenture worked closely with DECC in their smart grid endeavors. Based on Accenture's experience in UK, as also in other developed countries like USA, Continental Europe and Australia, we feel it is the opportune moment to consider how smart grid story is evolving internationally, and how can we leverage those learnings to put our own country's priorities in right perspective and plan smart grid rollout efficiently.

In this regard, let us first recap evolution of smart grid in developed countries, and then review the similarities and differences between the Indian power scenario and theirs.

2.1 Smart Grid Evolution in Developed Countries

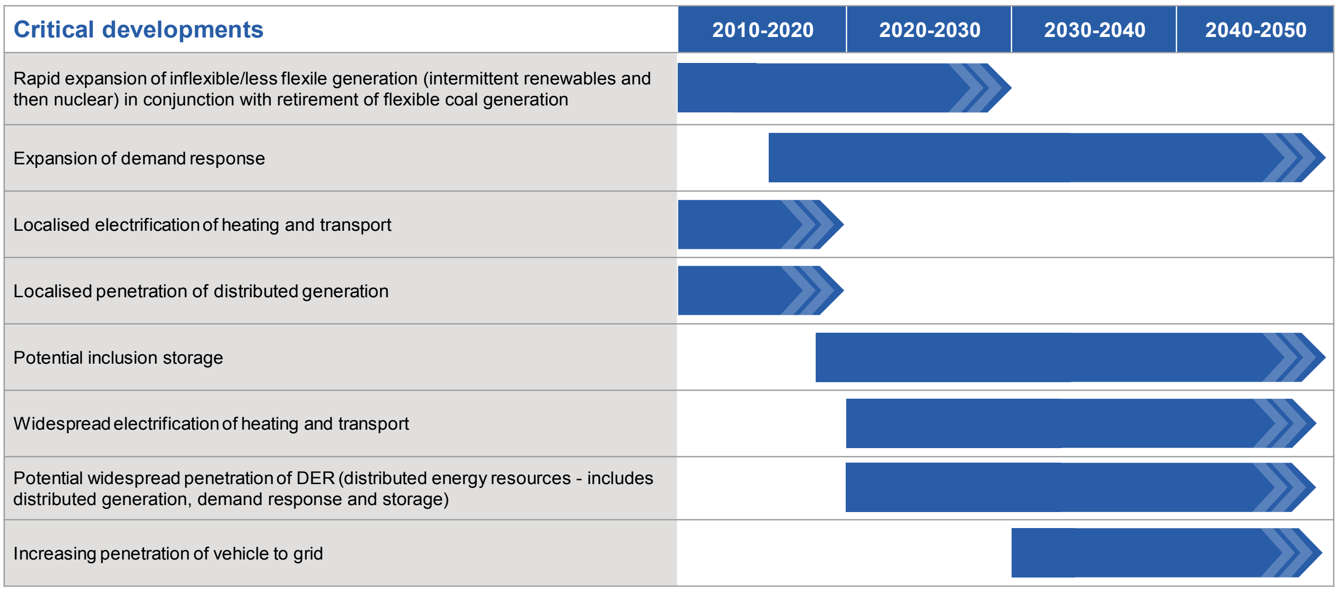
A. UK Experience:

Excerpts from the ENSG's 2010 Routemap:

"The Electricity Networks Strategy Group (ENSG) endorses 'A Smart Grid Routemap' as a high level description of the way in which a UK smart grid could be delivered to contribute to the realisation of Government carbon targets and end-customer benefits.

The UK power system will have to evolve in the next 40 years in order to accommodate a number of critical developments—a smart grid has the potential to act as a key enabler.

It is critical that the government structure supports coordination between smart



The Smart Grid Forum's Vision for a Great Britain smart grid is:

A smart electricity grid that develops to support an efficient, timely transition to a low carbon economy to help the UK meet is carbon reduction targets, ensure energy security and wider energy goals while minimising costs to consumers. In modernising our energy system, the smart grid will underpin flexible, efficient networks and create jobs, innovation and growth to 2020 and beyond. It will empower and incentivise consumers to manage their demand, adopt new technologies and minimise costs to their benefit and that to the electricity system as a whole.

grid, smart metering and other relevant government programs such as Digital Britain."

Excerpts from Smart Grid Vision and Route map (UK) dated February 2014:

Smart meters are a key enabler of a smart grid, providing information to help improve network management as well as facilitating demand shifting and supporting distributed and renewable energy generation.

The global market for smart grids is considerable. Zpryme Research 33 estimated a global market size of $220 billion by 2020 for smart grid technology, rising to $500 billion by 2030. The US Department of Energy (DOE) report, 'Economic Impact of Recovery Act Investment in the Smart Grid' states that smart grid projects in the USA funded through the American Recovery and Reinvestment Act (ARRA), created nearly $7 billion total economic output, nearly 50,000 jobs, and over $1 billion in tax revenue.

Smart appliances are a key component to the smart grid and BEAMA is already taking work forward through the BEAMA Smart Housing Association and Smart Grid Task Force, developing specifications for how the smart control within a home will operate, to ensure interoperability of systems and connection with the grid.

It is instructive to review how the smart metering and inter-operability is evolving now in UK, as also other European or American countries.

In UK market, Accenture is working closely with certain Utilities like EdF and SSE. UK market has about 30 million premises, and total 53 million electricity and gas connections. A few large energy suppliers dominate the market with large (multi-million) consumer base. The British regulator

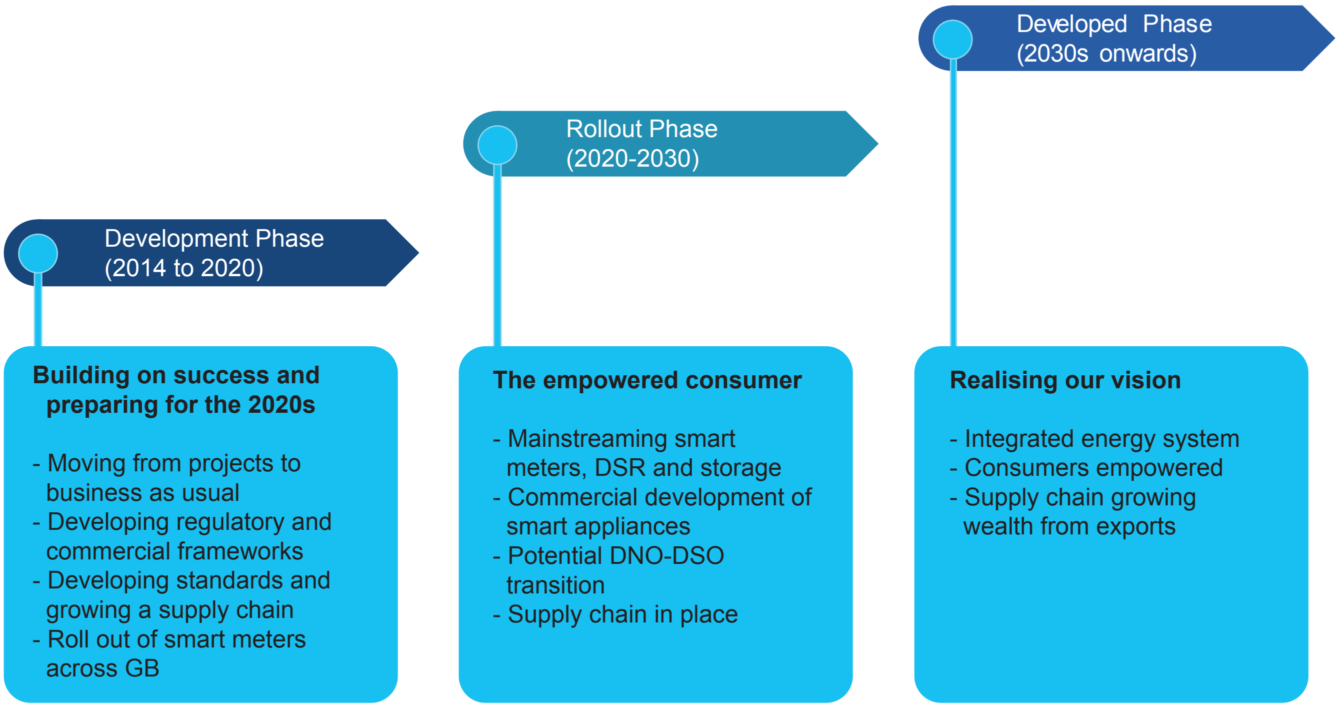
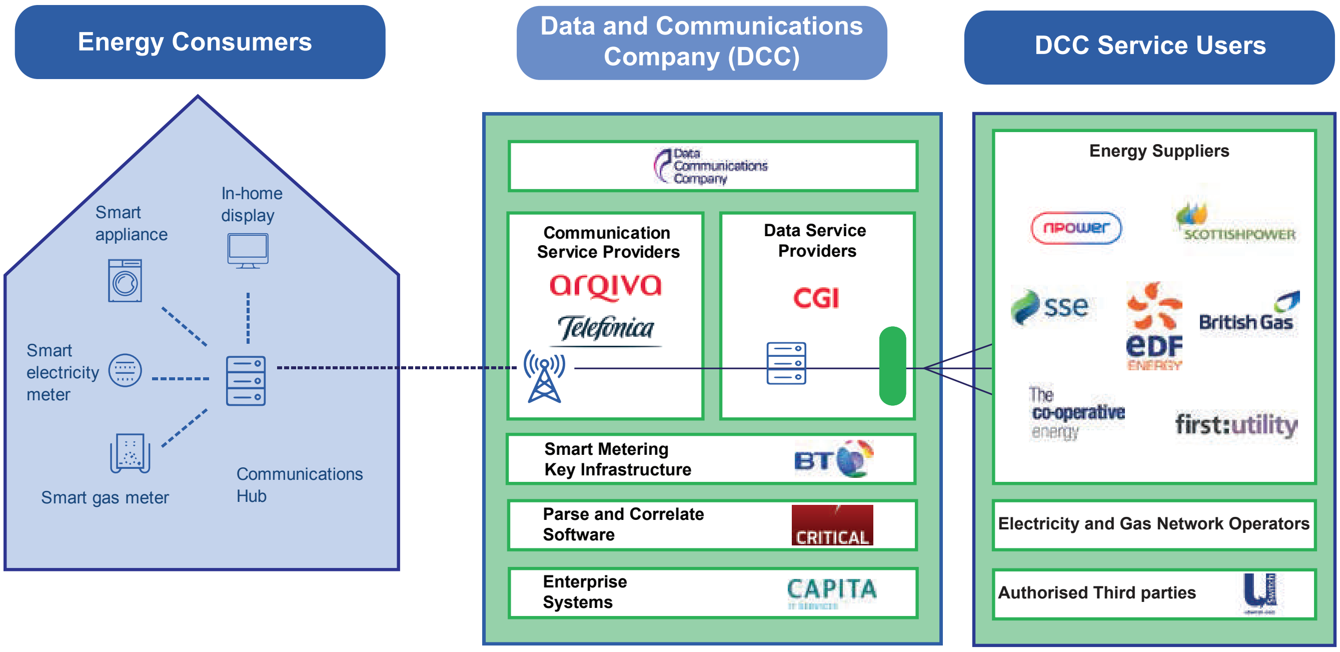


Figure 1: Key stages in the development of a smart grid

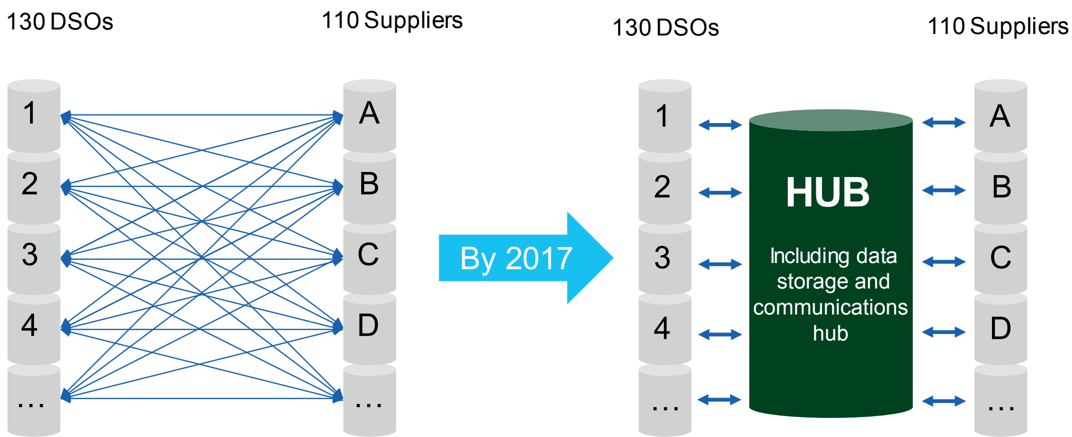


Source: www.smartdcc.co.uk

OFGEM has set up a new company—DCC (Data Communications Company)—to serve as a single common Head-end System for the country; will become operational in 2016 and roll out across UK in a phased manner, converting entire country to smart meter by 2020.

B. Norway Experience

Norwegian distribution sector is characterized by 2.8 million electricity connections being served by ~110 small Suppliers (Retailers) and ~130 Distribution Network Operators with very small individual consumer base that too keeps changing frequently as customers keep switching from one Supplier/Retailer to another. In this context, Statnett – the Norwegian Central Transmission Utility – is setting up a single common Data Hub for the country which will serve as the common Meter Data Management System across all DNOs (Distribution Network Operators) and Suppliers/Retailers.



- Meter Reading Data
- Customer Data
- Switching/Moving in/Moving out
- Settlement

Thus, while UK, characterized by a few suppliers with large and stable consumer base, is addressing the issue of inter-operability at meter level, Norway, characterized by multiple suppliers with small and dynamic consumer base, is addressing it inter-operability at MDM level.

C. USA Experience

By contrast, in USA, each state has separate regulators. Regulators and Government are not as prescriptive as Europe. Large private sector DISCOMS with multi-million consumer-base are themselves implementing the Smart Metering program right from the Meter installation to Application integration, involving multiple meter communication protocols and meter types. Considering large scale implementation involved and multiple meter vendor need to be integrated, US DISCOMS have opted for going through pilot phase of projects which involved taking a small portion of consumer based, but covering majority of functionality involved. Performance and Scalability is one key aspect looking at the large scale volumes these systems need to support.

D. Smart Cities Experience

As urbanization marches on, the load on cities to provide for their citizens increases. It is one of the key socio-economic trends of the coming decade. It is predicted that by 2050 about 64 percent of the developing world and 86 percent of the developed world will be urbanized. This rapid urbanization has cities at the core of the world growth agenda. Competitiveness of nations is turning into competitiveness of cities. Attractiveness of cities depends on effectiveness of city's economic, environmental and social services. With burning need to improve a nation and a city's competitiveness, many nations around the world have taken up smart cities initiatives to improve competitiveness of its cities[15].

Some of the notable smart city initiatives globally are as follows. Accenture has worked with several of these prestigious projects in Singapore, Amsterdam, and Kansas City.

Singapore

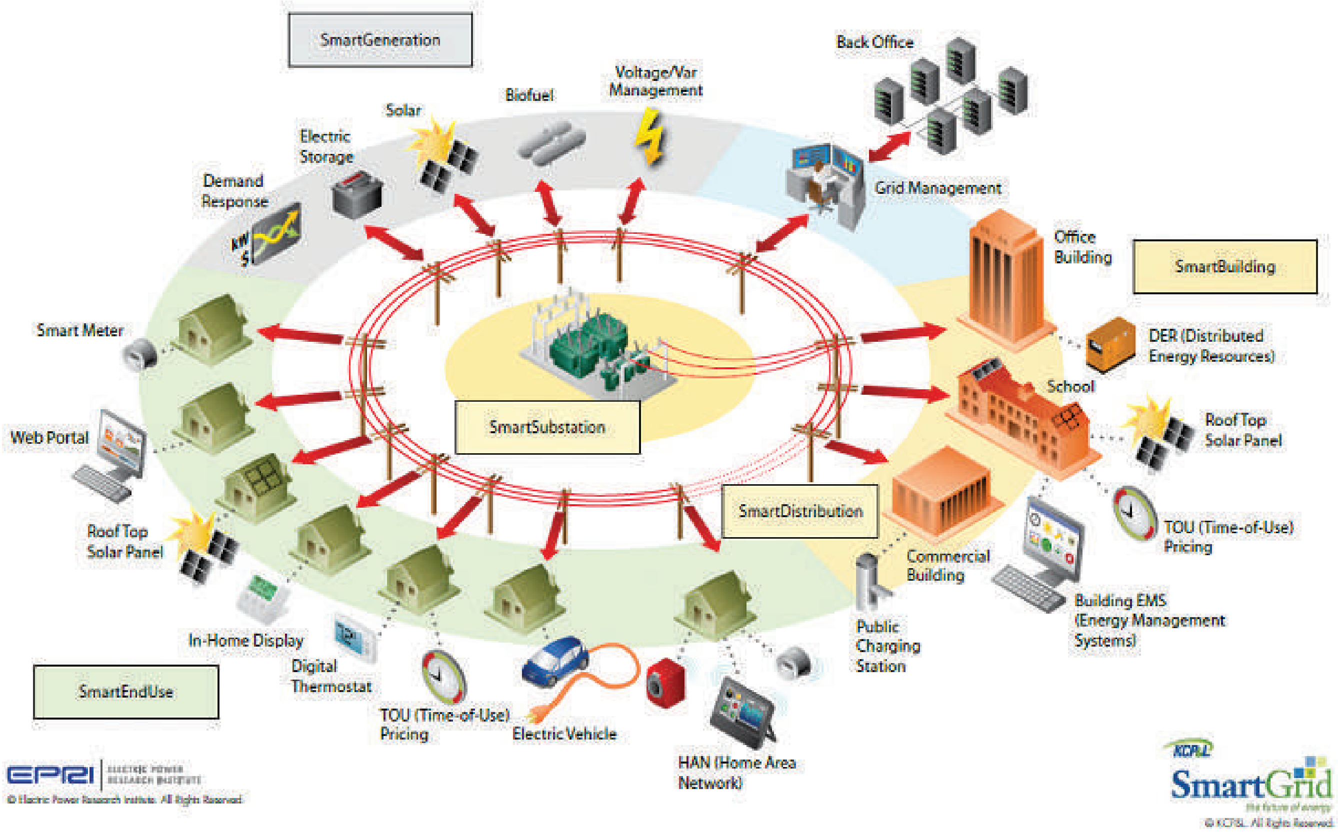
Long-term planning and strategic partnerships with leading universities and corporations, and substantial government investments in both money and manpower have enabled Singapore to transform the city into one of the most innovative, sustainable and tech-savvy cities on the planet. Every 10 years since 1971, Singapore issues a concept plan with a 40-50-year time frame. Every five years, most recently in 2008, it issued more detailed plans on smart growth. On the city's streets, a network of sensors, cameras and GPS devices embedded in taxi cabs track traffic, predict future congestion alerting all downtown drivers to alternate routes. Singapore's advanced system on congestion pricing utilizes traffic data to adjust prices in real-time and drivers' accounts are automatically deducted as they glide beneath electronic gantries. The city's water management system is among the world's most advanced, and the Government is testing a new desalination technology for seawater that would be 50 percent more energy efficient than any current method. A superfast, next-generation broadband network already reaches 95 percent of homes and businesses in Singapore[15].

Amsterdam

Amsterdam Smart City (ASC) started in 2009 as a collaboration project between Amsterdam Innovation Motor and the grid operator Liander, in close collaboration with the municipality of Amsterdam. Today, the project involves over 70 different partners. Amsterdam is focusing on the challenge of saving energy to reduce CO_2 emissions. To do this, ASC has introduced and tested a vast amount of energy saving projects, divided into four areas: sustainable public space, sustainable mobility, sustainable living and sustainable working. Some of the key projects included smart meters, energy sensors and the use of electrical vehicles[15].

Kansas City Light and Power, USA

The demonstration area under this project includes 150 inner city blocks with over 14,000 customers and the substation at its center. Very large number of systems and technologies are working together herein, with an integrated smart substation, smart



meters, demand response, distributed renewable energy, and finally smart meters—all structured into a single seamless hierarchical monitoring and control solution.

E. Empowering Consumers through Energy Portal: AGL, Australia

AGL, Australia which has taken a lead in offering value-added services to its customers—that too free of cost! Consumers get online portal and mobile app for monitoring their energy usage and charges, with tips to reduce energy consumption and thereby save money.

Additionally, if the consumer has a smart meter, then she can monitor energy consumption by the hour of day.

All consumers are encouraged and facilitated to opt for rooftop solar installation.

2.2 Similarities and Differences between International and Indian Utilities Scenario

Clearly some patterns of similarities emerge from how various phenomena unfolded in Europe, America and Australia, but on the other hand, certain structural differences between these energy markets vis-à-vis India are also quite stark—necessitating a very India-centric Roadmap.

Key structural differences between Indian power scenario vis-à-vis certain developed countries are as follows:

- Value Chain Structure: In developed countries, transmission and distribution (T&D) is often clubbed under a common player, while retail function is separate. There is competition in retail segment due to separation of carriage (wires—handled by Distribution Network Operator) and content (energy—handled by retailer). In India, traditionally, distribution and retail is clubbed under a common player (DISCOM) who runs both network and retail functions under geographic monopoly. There exist some option for open access for very large consumers, the driver for which is largely electricity cost rather than customer service.
- Energy Market: The fact that developed countries have surplus energy a vibrant energy market further adds to the dynamics of retail competition, which is currently lacking in India.

- Multi-utility vs Single Utility Structure: In certain developed countries, retailers provide single window service for electricity, gas (mostly piped gas) and water, and compete with one another for capturing customers. In India, each Utility has a complete separate existence with no overlap in their function and structure. Moreover, heating load in India is relatively low and almost entirely electrical in nature, vis-à-vis certain cooler geographies of developed countries where gas may be taking up the heating load to a great extent.
- TELCOS lead change in developed countries: Because of the above two reasons, in developed countries, the telephone companies providing fixed line phone/mobile phone/internet access to emerge as a strong contender to compete with retailers to provide energy services as well. As the basic electricity supply tends to get reduced to a commodity and innovating offerings get built around value-added service such as rooftop solar and energy efficiency. TELCOS begin to pose competition to Utilities in servicing the customer more aggressively—given their past legacy of successfully bringing in value-added data-based services and mobile apps to supplement voice-based plain vanilla offering in their quest for customer retention and profit maximization. For example, Telestra in Australia has announced its intent to enter home energy market based on rooftop solar and energy storage solutions[65].
- DISCOMS may lead change in India: This global trends lead in the direction where TELCOS tend to get in a nodal position to drive smart city initiative as the anchor player on whom other service providers and governance stakeholders can piggyback. However, in India, TELCOS don't enjoy a natural advantage, and would need to work hard to diversify into energy services or lead smart city revolution. In fact, in India, it is the electricity DISCOMS (doubling up as retailers) who have an extremely strong natural advantage for driving the smart city revolution. TELCOS may do well to form alliance with DISCOMS to enable smart metering rollout for which telecommunication would be a critical enabler. In India, the best way to propel smart city revolution is to build everything else on the back of DISCOM-Telco alliance providing the ICT Backbone for a state/city/zone.
- Smart Grid Drivers: Key factors driving smart grid interventions in developed countries include Demand Side Management (TOU tariff, automated Demand Response, etc.) and environmental concerns leading to renewable integration. By contrast, the drivers in India relate more to loss reduction, outage management, power quality, and last but not the least, renewable integration. This is because our distribution sector is characterized by high losses and significant outages; our present push towards DSM comes from energy efficient appliances rather than smart grid. Another driver for smart grids that is gaining momentum is electric vehicles that can support the grid momentarily for demand-supply imbalances as well as act as energy storage during periods of surplus generation from renewables.
- Societal Involvement: In developed countries, manpower cost is high and power theft is low—leading to automation that seeks to disintermediate manual on-site interventions and replace them with fully automated systems (such as automating meter reading). By contrast, India has higher instance of power pilferage, while cost of manpower is much lower—leading to automation that seeks to curb theft (such as detecting meter tampering).

Inference

No single "right" operating model for the future of the grid exists across the world. National level energy challenges, varying industry structures and legacy network characteristics mean that each Service Provider needs to combine smart grid technologies and solutions in a way that meets its exact needs. Smart capabilities will be increasingly built in to network assets, many consumers will demand increasing amounts of information and the costs of delivering smart solutions are likely to decrease as volumes rise in Smart cities. Smart solutions should be seen as a natural extension of the ongoing improvement of the distribution grid and Service Providers must be able to make investment choices on a particular smart grid solution as a standard part of asset investment planning processes to improve service delivery to the citizens.

Challenges do exist in the implementation smart grid energy for smart cities, however the new paradigm shift in the utility sector also opens a number of possibilities and opportunities for growth.

3 The Roadmap Ahead

Having recapped the Smart Grid Vision and Roadmap for India, and the developments between 2013 and 2016; and reviewed how smart grids have evolved globally while critically examining their relevance to India, we wish to submit following recommendations for updating the smart grid roadmap of 2013.

- Smart Grid Drivers: We believe that for any idea to find acceptance in the long run, it should be intrinsically viable, with minimal or no dependence on an external life support system such as grants or subsidies. For smart grids in India, the business case is expected to emerge from the following value levers:
    - Loss Reduction
        - Accurate and timely meter reading
        - Granular level Energy Audit in near real time, enabling precise interventions for loss reduction, such as Theft Detection, Load Curtailment, and Disconnection on Default
    - Making Lifeline Power accessible:
        - Load Limiters for rationing power supply, leading to a differentiated offering for bottom of the pyramid
    - TOU Tariff
        - Dynamic Pricing
    - Rooftop Solar
        - Shift from fossil fuels to green energy
        - Net Metering (a kind of smart meter), contributing to DISCOM's RPO fulfillment
        - Consumers' cost saving in the long run
    - Value-added Services for Smart City
        - DISCOMS to provide anchor infrastructure for smart cities, sharing:
            - Data Backbone with governance stakeholders
            - Physical and Organizational infrastructure with other service providers
        - New Business Models to make these investments self-financing
    - Value-added services for Smart Home/ Smart Premises for large customers
        - Consumers willing pay for additional services will get the option to avail special ICT-enabled facilities
- Electric Vehicle Rollout
    - EV Charging Infrastructure and its remote management
    - Vehicle to Grid (V2G) services
- Tasks that need quick resolution:
    - Metering, Data and Communication Technology Standards
        - Smart metering rollout framework for the Country
    - Policy and Regulations on new emerging subject areas
        - Energy Storage
        - Rural mini-grids
        - Anti-Theft Provisions
        - Model Regulations for Time of Use Tariff
        - Model Regulations for Demand Response
        - Government's Procurement Framework for specialized services
            - Program Management/Project Implementation Agency
            - Technical Design and Solution Architecting
            - System Integrator
    - Bulk Sourcing of Smart Meters for capitalizing on Economies of Scale

  - Standards and specs
  - Procurement Process through a designated Nodal Body
- Must-have Synergies:
  - Smart Grids (including Smart Meters) + Smart Cities (including Smart Homes) = Whole that is greater than the sum of its parts
  - PPP Model: Collaboration between Utilities on the one hand, and on the other hand, private partners offering consumer goods and customer service
  - Smart Grids with Digital Technologies for Utilities
    - Analytics
    - Mobility Solutions
    - Customer Touchpoints
    - Remote Monitoring and Remote Control Automation

Key features of some of the aforementioned points are elaborated in the following sections.

Smart Grid Driver: Loss Reduction

The most immediate value lever for any intervention in distribution business is loss reduction, as it has the potential to fetch faster and assured payback. Even for DISCOMS with low overall losses, there tend to exist pockets with high losses that get exposed when energy audit is cascaded downwards from DISCOM level to feeder level to transformer level—the more granular the audit, the more incisive the findings. But to arrive at such granular energy audit and that too in near-real time, smart metering of all network points and substantial consumer-base is a pre-requisite; on top of such metered database, automated analytics can be readily applied to extract energy accounting reports. Other pre-requisites include accurate consumer indexing to transformers and feeders, and GIS-enabled network management. These interventions were initiated in R-APDRP and have been reinforced and further expanded in IPDS, UDAY and other Government of India funded projects.

Based on loss levels, different individual customers, as well as different localities with homogeneous customer segments, can be given differential treatment, such as Loss Surcharge in high loss pockets, Reliability Surcharge for high-paying consumers with critical load, etc. One particular intervention could be to use smart metering systems in load limitation mode, which means, disconnect supply if connected load exceeds sanctioned load (or some buffer beyond the sanctioned load limit):

1. At individual consumer level, and
2. At transformer level serving a particular locality with customers of similar load and usage type (for example, a residential colony); supply could be restored remotely after the connected load has been brought back to within limits by the targeted customer cluster.

This will not only help reduce losses in high-loss pockets, but also install discipline amongst all customers to:

1. Refrain from power pilferage
2. Be energy efficient
3. In case genuinely required, proactively apply for enhancement of sanctioned load

Upon payment default, the smart meter can disconnected remotely and automatically upon expiry of disconnection notice period, and can be reconnected remotely through escalated intervention by authorized personnel upon receipt of payment. Smart meter can be operated in either Pre-paid or post-paid mode, which gives the option to increase in collection efficiency by operating in pre-paid mode in pockets where customers usually default their payments.

Lastly, the meter reading obtained electronically would be more reliable than manual reading. Thus, from reading, to theft, to collections of rightful dues, the AMI/Smart Metering interventions at transformer level and consumer level can contribute in multi-pronged ways towards loss reduction.

Smart Grid Drivers: Making Lifeline Power Accessible

Using Load Limitation functionality of smart metering/AMI, lifeline electricity could be provided to all underprivileged consumers as the following thought experiment suggests (see box).

The moot point being that smart grids can, on the one hand, enable more equitable

> "It's important to recognize that Smart Grids are only a means to an end, an enabling infrastructure. Instead of feeder-level load-shedding, using smart meters, one could provide all homes 50-100 watts (or 300 watts) as "lifeline" if one wished."
>
> (Source: Rahul Tongia: **Smart Grids, Storage and Renewables – Pillars of the Future Grid**; Blowing Hard of Shining Bright: Making Renewable Power Sustainable in India, Brookings Institution India)

distribution of electricity to small consumers (through load limitation for example), and on the other hand, enable more market-driven supply of electricity (say, with Reliability Surcharge and TOU Tariff) to high-paying consumers or consumers with critical load vis-à-vis non-critical load. Thus, the commodity called electricity can evolve into a variety of "offerings" satisfying different customer segments. As the rural mini-grid developments are demonstrating to us now, there is a lot of market potential in the Lifeline customer segment at the bottom of the pyramid, waiting to be tapped.

Smart Grid Drivers: TOU Tariff—Dynamic Pricing based on Peak Demand and Peak Supply

While this is a well understood and oft repeated concept, our belief is that in India, ToU based peak pricing will contribute less towards peak-demand reduction, and more towards generating better revenues for the DISCOM—reason being, electricity demand is mostly inelastic, meaning, consumers will continue to use power at a time slot of their requirement and pay more for the facility, than shift their demand pattern to save on energy spend. Either ways, DISCOMS will gain either through higher peak-time revenue, or through lower peak-time power purchase.

> "As a though experiment, if we take all the homes that don't have electricity (either at a wire level or at meaningful supply levels), and we give them minimum lifeline supply of, say, 100 watts, the total extra capacity we'd need even from the centralized grid, with technical losses, would only be on the order of 15 GW of capacity. This is less than India has added in a single year. The catch is we have no means today of either limiting usage to 100 watts or of ensuring supply goes to such users (electricity flows like water based on voltage differentials, so new capacity is shared across the grid based on physics). Smart Grid technologies now exist to enable such curtailment through smart meters."
>
> (Source: Rahul Tongia: **Smart Grids, Storage and Renewables – Pillars of the Future Grid**; Blowing Hard of Shining Bright: Making Renewable Power Sustainable in India, Brookings Institution India)

Smart Grid Drivers: Rooftop Solar

Smart meter with net metering functionality can measure energy from two sources (or multiple sources), and in both directions. The Net Meter market is poised to grow on the back of rooftop solar market, which in turn is poised for hyper-growth given the strong support to solar power provided by Government Expansion of rooftop solar will convert consumers into prosumers, and necessarily compel Utilities to make their grids smarter, commensurate with the expansion of rooftop solar amongst their consumers. Most consumers realize that opting for solar energy is a "good cause" and the upfront investment does pay back with savings in the long run; however, they are skeptical of the workmanship and prices of solar service providers. The Rooftop Solar market will grow as soon as it attracts professional and trusted service providers who can provide end-to-end customer service within reasonable price—similar to where the mobile telephony market was 10 years ago or DTH TV Market was 5 years ago. PE investors would do well to bet on some new-age start-ups in this sphere.

Smart Grid Drivers: Electric Vehicle Rollouts

Electrification of transportation is the evolving trend towards low carbon development and polluted Indian cities are expected to introduce electric vehicles for both public and private transportation in the near term. The NMEM plan with a target of 6-7 million EVs in India by 2020 would require substantial support from the electricity distribution grid through smart systems for charging the vehicles. The evolving electric vehicle supply equipment (EVSE) technologies facilitate remotely managing the distributed charging stations and variety of payment settlement options.

Large number of EVs connected to the grid can support the grid in times of demand-supply imbalances for shorter durations as virtual power plants. Also when the generation in the grid is more than the demand, particularly when all renewable energy resources are in full generation mode, the surplus energy can be stored in the EVs connected to the grid. Building a network of EVSE and its management require smart grids.

Smart Grid Drivers: Interplay of Smart Grids with Smart Cities

All Indian DISCOMS are sitting on a wealth of data that captures vital information about every property which has an electricity connection, and its occupant household or organization. In urban areas where almost every premises has an electricity connection, this translates to owning an exhaustive "census" of city's population and property. Add to it the identity and location of each customer, load, usage, etc. and you get a relatively most exhaustive encyclopedia of a city's residents. No other utility—water, gas or telephone can boast of such rich data availability.

Now enters consumer indexing on GIS as mandated by R-APDRP and UDAY, which will transform this rich database into an even more valuable asset—a comprehensive Data Backbone—that all other services providers can piggyback on to convert a city into a smart city. Simply put, smart grids provide the anchor infrastructure for smart cities.

Therefore, all the push that the Government has been putting on smart cities—especially the first 20 shortlisted ones as also other cities preparing for the "smart transformation"—will actually rub off on smart grid take-off also in these cities. What's more, this fusion of "Smarts"—"grids & meters" with "cities and homes"—will give rise to new business models funded by a whole new breed of investors who will pay to "googlize" the data for benefit of consumers as well as government stakeholders.

Smart Grid Drivers: Value-added Services for Smart Home/Smart Building/Smart Premises

Imagine a consumer at whose premises, the Utility replaces normal meter with smart meter. Most likely, the premises already have a water connection, phone/internet connections, and various electrical and electronic appliances, in many cases a piped gas connection, and in some cases power backup sources (battery or diesel) run by self or a local operator. Even if not all of the above conditions are true, it is likely that the consumer wishes to monitor her energy consumption, control appliances remotely, pay bills online, explore installing rooftop solar if it saves money in the long run, expect high quality customer service from a single vendor to handle all needs without intruding every other day in her premises, and possibly contribute to environment by being energy efficient. Needless to add, she demands uninterrupted power supply as a given, expecting DISCOM to forecast her energy requirement in advance, and doesn't mind paying extra for something "really cool."

The leap of faith that DISCOMS (or their business partners) need to consider is to move from outside the consumer's premises to inside. In case of large industrial/commercial consumers, this may also mean sub-metering at appliance level or sub-premises level. In fact, across residential, industrial and commercial consumers, automation inside the premises will be the next wave of technology enabled intervention, bringing together IT/ICT, IOT and OT to converge. Sooner than we realize, consumers will demand, and get, the facility to monitor and operate their appliances and premises remotely. A revolution similar to mobile telephony is under way in the realm of smart devices, wherein a luxury of yesterday has become a basic need of today. The DISCOMS have the potential to be at the forefront of riding this wave, provided they tie up with right private sector partners who specialize in capitalizing on technology to create and capture markets.

3.1 Suggested Policy Interventions

» Metering, Data and Technology Standards

As summarized in Section 2, different countries have taken different approaches to shape their distribution landscape and industry structure—and the subject is still evolving! No one right answer has emerged as a default option, and that may not happen too soon either.

Given the federal structure of our distribution landscape, with multiplicity of OEMs/ Vendors, it is proving challenging to forge an interoperable platform. Options include interoperability at either meter level, or meter data acquisition level, or meter data management level.

What adds to the complexity is that different terrains are best served by different telecommunication technologies—be it fiber optic, RF, GPRS, or others. Eventually the combination of data measurement, acquisition and management together need to gel seamlessly for smart grids to be fully operational and effective. In this confusing landscape, DISCOMS tend to be cautious about whether all pieces of jigsaw are fitting together or not, and what if after all the "implementations" are completed by respective vendors as per their respective "scope", ultimately the system as a whole is not functional?

While it will not be prudent to prescribe one panacea solution to this issue, but certainly what can be said at this point of time with reasonable confidence is following:

- If there was ever a more opportune moment to accelerate a policy framework for standardization and interoperability, it is now, with UDAY, National Tariff Policy and Rooftop Solar together pushing the case of smart metering in different shapes and forms.
- Different Utilities have different priorities, and many requirements are being met currently with meters that have some partial functionality (such as load curve needed for TOU billing) while not others (like remote disconnection). A net meter can also be labeled as a type of smart meter but with additional functionality of dual source energy and bidirectional flow. Industrial consumers (and therefore DISCOMS with HT consumers) are interested in sub-metering level AMI so that they can optimize energy spend.
- Most Utilities would avoid becoming the "guinea pig" and are possibly waiting for a first end-to-end successful smart grid implementation at a somewhat significant scale; then whichever model or technology emerges as effective and functional would become a benchmark that all Utilities would like to emulate.
- Government think tanks should deliberate and arrive towards a common set of specifications and data sharing protocol, which will not only enable interoperability but also facilitate bulk procurement of smart meter through a nodal agency.

Considering the situation in India, we advocate for interoperability at MDM level.

» Policy considerations for Integrating DRE Mini-Grids/Micro-Grids

With DDG Scheme, off-grid mini-grid (using the term mini-grid and micro-grid interchangeably for the purpose of this discussion) with distributed generation represent a real option for rural electrification. However, the narrative around mini grids in India has so far focused mostly on projects based on grant, subsidy or CSR funding. These mini-grids were serving home-lighting needs only, with no impact on livelihood and revenue generation. However, we believe that rural electrification must focus on provisioning electricity to meet productive load such as commercial/rural enterprise. With this objective in mind, we propose the following policy imperatives for the Government to consider.

First and foremost, the definition of mini-grids may need encompass the various services it enables and the types of customers it serves. In this regard, cross functional dialogue between MNRE, Ministry of Rural Development, and existing mini-grid operators could help formulate a holistic definition of mini-grid on which the policy framework would rest.

Sometimes the mini-grids are perceived as an interim solution till such time as the grid reaches a particular village. However, policy framework should enable easy conversion of the microgrid into smart microgrids that can be integrated with the mainstream grid and can be operated in islanded mode when required.

Accordingly, mini-grids (inter alia with all its components including generation, storage, distribution network, in-home wiring, and appliances) should be recognized as "infrastructure", which should be eligible for various financing options and models prevalent as per Indian laws.

Technical specifications and safety standards to be followed in setting up mini grid plants may be clearly laid out, as also the specifications for grid interactivity anticipated for future convergence. Adherence to these standards may be on the basis of self-certification by the mini grid developers on a prescribed CEA framework.

Operations of mini-grids should be explicitly exempt from Service Tax.

Mini-grids should be explicitly included in the list of activities for which funding support by companies would qualify under the definition of CSR, as per the CSR definition adopted in the Corporate Affairs guidelines for CSR compliance.

Together all of the above policy interventions will go a long way in speeding up rural electrification "from the tail end" and still be future-compatible with the mainstream grid. It is pertinent to mention here that the 2013 Roadmap envisaged creation of 31,000 microgrids in India.

» Policy Considerations for Electric Vehicle Infrastructure

Per present laws sale of electricity by third party is not permissible, which means parking lot operators, fuel stations, hotels, shopping malls, commercial complexes etc cannot install charging stations and sell electricity to EV owners. Discoms (perhaps except few private ones) have no bandwidth in terms of finances or technical manpower to install and operate the charging infrastructure. Either through changes in the Electricity Act or through state level regulations, appropriate changes may be introduced to promote private investment in EV charging infrastructure in the country which otherwise would be the single most obstacle in realizing the goals of NMEM Plan.

Many days in the year there are long durations of power surpluses on the grid which we wre likely to witness more often in the coming years with huge proliferation of renewable resources. EVs are emerging as a viable option to store the surplus power in the grid at such periods of surpluses particularly from renewables. Similarly, EVs can support the grid by supplying the stored electricity to the grid when there are short durations of shortages on the grid – a phenomena we are going to experience frequently with increasing share of distributed renewable resources on the grid. So EVs can play a significant role in grid balancing and V2G technologies are in the commercialization phase. Enabling policies and tariff structures that could promote EVs and help the grid are required. In August 2015, ISGF formulated and submitted its recommendations to MoHI, including inter alia detailed recommendations on developing charging infrastructure to boost offtake of electric vehicles1

We recommend:

1. to formalize standards for EVSE on fast track so that whole country adopt common standard
2. Submit a Model Regulations on Electric Vehicles Rollout to Forum of Regulators and get that approved on fast track so that state regulatory commissions can issue state specific tariffs and policies

» Policy Considerations for Grid Scale Energy Storage (GSES)

Need for Grid Scale Energy Storage

Renewable energy sources, such as wind and solar, have vast potential to reduce dependence on fossil fuels and greenhouse gas emissions in the electricity sector. However, both solar and wind have variable and uncertain output that has led to concerns regarding the reliability of an electricity grid that derives a large fraction of its energy from these sources.

Currently, electricity supply – demand matching is done in real time through peaking generation assets (such as gas based power plants, reservoir based hydro plants) that are costly as they get utilized only during the peak periods. Additionally, with a globally increasing focus on renewables that are intermittent sources of power, the need for a cost-effective mechanism for balancing demand and supply in the electricity grid has acquired much higher significance.

Grid Scale Energy Storage (GSES) technology has started emerging as a promising solution in the recent years with storage costs coming down progressively.

GSES is even more crucial to India's electricity grid for two reasons – 1) Country's installed generation capacity comprises largely of coal fired thermal stations that have technical limitations in responding to peaking loads and pollute the environment due to carbon emissions, 2) It would be a challenge to integrate India's target of 175 MW of renewable energy, including 100 GW of solar, by 2022 into the electricity grid without a grid balancing mechanism. Energy Storage Systems can address the issues with the timing, transmission, and dispatch of electricity, while also regulating the quality and reliability of the power generated by traditional and renewable sources of energy.

It is in this context that GSES technology needs to be supported and encouraged through appropriate policy measures to accelerate its financial viability thereby paving the path for a wide scale adoption.

Current status

With the advancements in energy storage technology the cost to store energy has come down progressively. For example, the cost of lithium-ion based storage has reduced from around $3,200/KWh[74] in 1995 to around $400[75] in 2015. Analysts estimate that this cost is likely to reduce to around $200/KWh by 2020 and further to $100/KWh by 2025.

However, the price of power electronics has not come down in the same proportion as battery prices have declined. The average cost of power electronics is around $400/kW. This will reduce to below $100/kW provided domestic manufacturing is encouraged.

Objectives

The GSES Policy should aim to achieve the following objectives:

- To create an initial demand for Demonstration cum learning opportunities that not only sensitize people to storage technologies but also help industry, Government and other stakeholders gain valuable technical, economic and policy insights for a larger scale deployment at a later stage
- To follow up the initial demand creation phase with subsequent phases that target to bring the GSES technology to a stage where it becomes commercially exploitable without the need for government subsidy
- To provide a level playing field to all storage technologies through a technology-neutral selection framework
- To encourage optimum deployment of GSES, that is, 'behind-the-meter' or 'in-front-of-the-meter'[76], whatever is most suited to the requirements.
- To ensure that the electricity grid operation standards and protocols are amended to allow for seamless embedding of GSES in the grid infrastructure.

Measures for encouraging grid-scale energy storage

Demand Creation

Globally, the market for GSES (other than pump storage) is nascent but rising fast. According to latest estimates of US DoE, global deployment of large-scale batteries reached 2313 MW, while thermal energy storage capacity surged to 3614 and electro-mechanical storage has increased to 2611 MW.

Several National governments have been supporting storage technologies through policies that include funding for demonstration projects, subsidies and mandatory storage requirements for utilities as it is expected that such demand creation will fuel the necessary R&D efforts and financial investments required to bring about the desired cost reductions.

In the same spirit, the Indian Government should create a market for GSES through installation of targeted quantum of storage capacity, commensurate with the renewable capacity targets and off-grid rural electrification targets.

To ease the burden of the incremental cost of such capacity installations (until economic viability is achieved), viability-gap funding could be provided by the Government to the state distribution utilities that utilize this capacity.

Technology Neutrality

Currently, multiple storage technologies such as Li-ion, Flow batteries, NaS, fly-wheel, and thermal storage etc are competing with one another, and different technologies may emerge dominant over various phases of evolution.

Given that this competition is healthy, the subsidy support should be technology neutral. As long as the technology meets the technical and operational criteria and environmental concerns, the support decision should only be guided by the end result desired, namely the lowest Levelized Cost of Energy (LCOE) achieved.

Optimal Deployment

Embedding of GSES in the grid infrastructure has different utilities depending upon the point where it is embedded. For instance, GSES at generation point or an intermediate point (a grid sub-station for example) may result in better infrastructure utilization and frequency response etc while GSES at consumption point may result in better reliability at customer end and reduced investments in transmission and distribution infrastructure.

While storage may be encouraged at generation point or intermediate points during initial phases to benefit from the economies of scale, as time progresses, policy provisions should be made such that optimal deployment of storage is encouraged irrespective of the point of storage.

Technical enablement

GSES technologies can provide several benefits to the electricity grid such as ‘time shift,’ ‘grid stabilization,’ ‘peak shaving of demand,’ ‘improved generation efficiency’ and ‘improved transmission capacity utilization.’

However, these benefits are possible only when GSES is efficiently embedded in the electricity grid infrastructure. This would require appropriate modifications to the grid code and other regulations, including the ABT mechanism, that define the grid operating standards in a manner such that the operating characteristics of GSES can be accommodated by the grid.

Research and Development

Given the benefit that GSES technology can provide to our country, Indian companies and institutions would need to take global leadership position in the R&D efforts.

Government could consider creating R&D Fund for energy storage (or club it under an existing renewable energy funding and institutional framework) that selects promising technologies/proof-of-concepts through a transparent funding mechanism and makes further investments based on the milestones/results achieved so as to allocate funds for R&D in the most optimal manner.

» Policy Considerations for Anti-theft Measures

The current provisions of the Electricity Act 2003 provide for long drawn procedures for prosecuting electricity theft and payment default, entailing serving of notice periods and imposing penal charges, wherein the eventuality of disconnecting a dishonest consumer can materialize only after prolonged proceedings. Ultimately, what transpires in most cases is settlement by dishonest consumer through payment of penal rates.

It is recommended that while the aforementioned proceedings should continue, but additionally, Government should incorporate concurrent provision to disconnect power supply with immediate effect while the proceedings are under progress, so that once the theft is detected red-handed, the illegal load is immediately removed from the distribution network and consumer is deprived of electricity during hearing procedure—we believe such deprivation of power would be a much more compelling and effective deterrent imposed in conjunction with the current provisions of legal proceedings and penalties.

Such effective disconnection (and subsequent reconnection) can be instantly effected using smart meters in remote mode, producing instant impact without the dependence of manual intervention. Thus, the larger objective of loss reduction can be further enhanced using smart meters if the legislative basis of such provisions are incorporated of the Electricity Act. Further, in case as consumer disconnected through remote disconnection of smart meter restores power supply in an unauthorized manner (say, by bypassing meter), then a second offence of tampering with network apparatus shall attract even stricter punitive measures (like minimum imprisonment), which can be suitably incorporated in the Act.

Once again, the deterrence against payment default can be far more effective using smart meters through which disconnection due to non-payment can be effected remotely, immediately upon expiry of 15 day notice period in case of post-paid connections, and exhaustion of money charged in case of pre-paid connections. This can be done for all consumers where smart meters get progressively installed as per the time-bound plans of UDAY and/or implementation of TOU tariff.

Similarly, in order to enhance deterrence against default of electricity bill payments, we strongly recommend that details of such consumers be published in a government forum so that the poor creditworthiness of such defaulters is exposed to the world at large; in particular, the forum of CIBIL must be used to publish defaulters' data so that banks factor this information while assessing loan eligibility of such people or organisations, similar to default on loans or credit card repayments. To keep this intervention realistic and practical, this step should be enforced only above a certain default amount and ageing of overdue debt – the threshold limits for various customer segments (commercial, industrial, domestic, and government) can be suitably determined by the Government. To operationalize this concept, suitable amendments should be made in the Act and CIBIL rules such that PAN becomes a mandatory document for obtaining electricity connections above a certain threshold of load and/or for certain tariff categories.

Together both the provisions of disconnection and CIBIL disclosure would compel consumers to restraint from defaulting on their bills, which is a menace that jeopardizes cash-flows of DISCOMS very adversely.

Act should provide for load limitation for individual connections as well as transformers, i.e., power supply should automatically disconnect in case connected load exceeds sanctioned load by a certain tolerance factor (and reconnect upon withdrawal of surplus load). This will compel consumers to either manage better energy efficiency, or proactively apply for enhancement of sanctioned load. Similarly, for a transformer feeding a homogeneous set of neighboring consumers, the transformer could be set to trip supply in case its drawal load exceeds the cumulative sanctioned load of all connected consumers. This will ensure peer pressure amongst the consumers to refrain from overdrawing or power theft as the case may be.

» Government's Procurement Framework for Specialized Services

Traditionally procurement by government offices including DISCOMS and/or Public Sector Enterprises relies on prescribed rules and guidelines with mandate lowest price bidding, which in turn is predicated on competitive price discovery presuming a mature market of commoditized services. Services related to smart metering and smart grids do not fall under this category and require different approach for procurement. Moreover, the legal and commercial terms and conditions of procurement and contracting are based almost entirely on the concept of procurement of products/goods/materials, and not services, especially specialized services.

However, the market reality is starkly different. The procurement and contracting process that was created for product procurement is fundamentally unsuitable for purchasing services. The problem is further exacerbated by applying the purchase process of commoditized services to the sphere of specialized services for which the market in India is not mature yet. The last straw on the proverbial camel's back is that the budgetary estimate prepared by DISCOMS or approved by the Government are well below the realistic cost estimates, as evidenced by the fact that in multiple smart grid pilots, even the L1 price bid was much higher than the budgets.

Thus, we strongly recommend that procurement of certain foundational services which are based on quality of expertise based and not quantum of labor should be carved out from the general rules of procurement and vigilance guidelines, and given special provision for discretionary procurement based on recommendations of expert panel set up by the Government for this purpose. Furthermore, the pricing of such procurement shall be based on direct negotiations and not L1 bidding. While the aforementioned concept is true for all walks of life and should be adopted for all specialized services, but with reference to smart grid projects in India, we recommend the following services be put under this category:

- Technical Design/Solution Architecting
- Program Management/Project Implementation Support
- System Integration

It is not out of place to recap the recommendations made by ISGF in its Knowledge Paper on Smart Grids in India, published in 2015, which have not been undertaken for implementation to date:

"Some of the Challenges faced in RAPDRP and Smart Grid Pilot Projects:

a. Conditions of Contract

The terms and conditions in the General Conditions of Contracts (GCC) that is in use in most utilities is very old and were framed during 1950s with primary focus on civil and mechanical works. These GCCs have clauses on "defect liabilities," "intellectual property rights," "confidential information," "limitation of liabilities" et cetera that are not relevant for contracts involving IT equipment, software and IT services. Despite frequent cries from several quarters, utilities have not changed these contract clauses. Although an internationally reputed agency was engaged to prepare the R-APDRP framework and Model RFP, these old clauses found their way in to the Model RFP.

Even for bidding as consortiums, R-APDRP Model RFP insisted on a clause that states that all partners in a consortium should be "jointly and severally" responsible, which is not acceptable to most international firms. In a contract that requires multiple domain expertise such as GIS, AMR, Communication Systems, IT Hardware and other Software Systems for Billing and Customer Care et cetera, there is no company that meets all criteria meaning that a consortium is necessary. When a consortium is formed no responsible agencies will agree to sign an agreement with a "jointly and severally responsible" clause as a GIS company will not have any expertise on AMR or Billing Systems and vice versa.

The above issues precluded all international agencies from participating in the tendering process of R-APDRP Part-A. All System Integration contracts went to local firms as no MNCs submitted bids. This should be a key lesson for new programs.

Payment Terms

The payment terms in R-APDRP are not supportive of smooth project execution. According to the Model RFP there will be negative cash flow for six quarters (18 months) for the best performing agency if everything is done on schedule by both the contractor and the purchaser.

Smart Grid Pilot Projects

Most of the above issues are equally applicable to the Smart Grid Pilot projects.

Here also a Model RFP was issued by India Smart Grid Task Force (ISGTF) which had all the derogatory contract clauses as in the Model RFP of R-APDRP.

Pilot projects are basically technology trials and world over the practice is to allot such trials on the basis of proposals received and evaluated. New technologies cannot be piloted on an L1 procurement basis. The Smart Cities projects in Japan, Smart Grid Test Bed in Jeju Island in South Korea, the ARRA Projects in the USA; and the EC projects in Europe are all undertaken in public-private partnership modes in which utilities, research labs and technology companies jointly apply for grants. Based on the project merits full or part grant is allotted by the Government and part of the money invested by the industry and the utility.

India should explore more pragmatic approaches to undertake “smart” technology projects rather than L1 bidding route with GCCs of 1950s!”

» **Bulk Sourcing of Smart Meters for Economies of Scale**

Similar to LED prices crashing due to bulk procurement by the Government, there is similar potential to spur R&D, reduce cost, encourage indigenous design and Make in India manufacturing of smart meters, if Government decides to buy smart meters on behalf of all DISCOMS combined. However, the similarity ends here. Smart Meters are more complex products than lights, requiring detailed specifications which need to be standardized and subjected to rigorous testing and certifications in order to ensure consistency of product quality, warranty, performance, as well as inter-operability of data acquisition and telecommunication.

Having said that, these tasks are anyways pre-requisites for large scale smart meter rollout in India, and the case for bulk procurement further reinforces the need to speed up such standardization. Government should leverage CEA, BIS and CPRI to speed up this set of activities in a time-bound manner.

The nodal body for procurement could be designated as a central PSU.

3.2 Evolution the “Smart” Industry – Cities, Grids, Meters, Homes

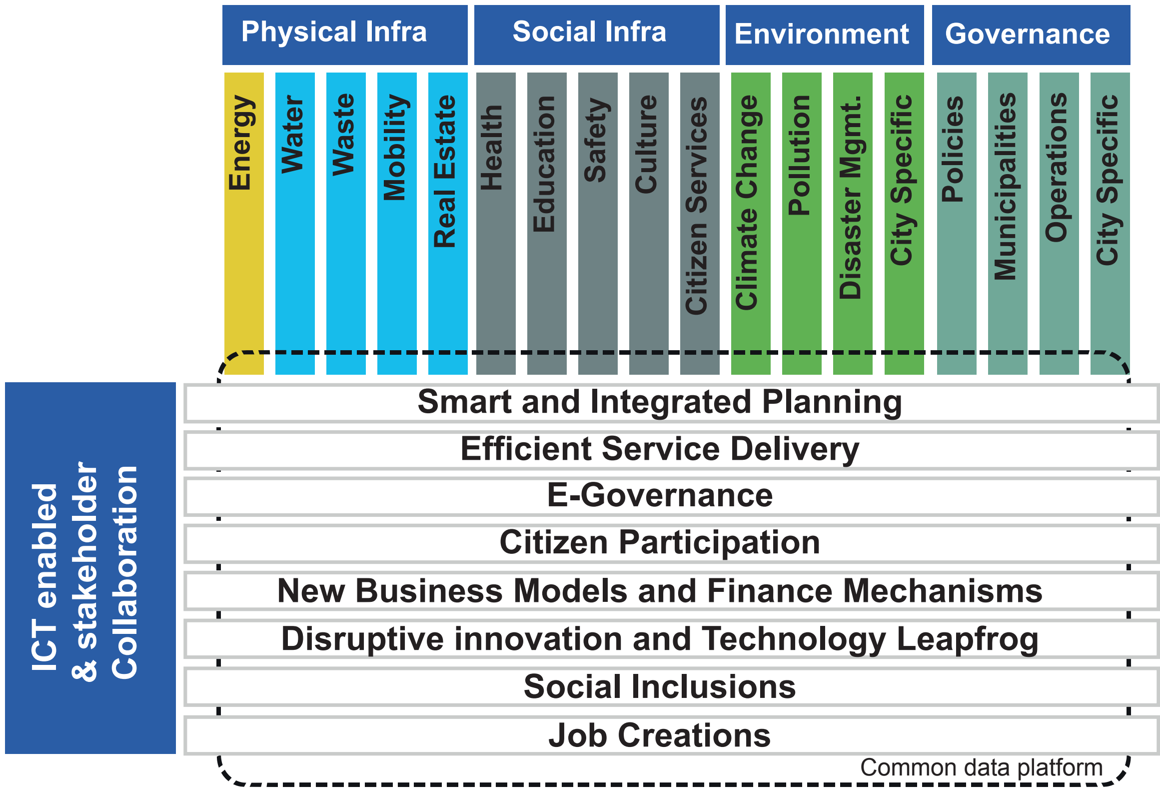
Enabling Smart City through Smart Grids

Government of India’s prestigious Smart Cities Mission is taking shape with the announcement of first 20 Cities out of the proposed 100 Smart Cities. The total population of these proposed Smart Cities is about 12 crore accounting for 35 percent[67] of country’s total urban population as per the 2011 census. The shortlisted first 20 cities alone account for 3.54 crore people.

When one of the objectives of the Government is to promote cities that provide core infrastructure and give a decent quality of life to its citizens, concerns on the accessibility to sustainable and robust infrastructure arises. Improving the quality of life of citizens by providing sustainable and robust infrastructure requires comprehensive development of physical, institutional, social and economic infrastructure.

With the onset of Smart City initiatives and other factors, the Indian cities will witness a surge in the number of city dwellers in the coming years and it will profoundly change the fundamentals of Utilities that serve them. More people in cities means more relevance of Smart Grids. Electricity and other utilities have to be strengthened for a Smart City to be deemed successful

For creating Smart Cities in India, India needs balanced focus in terms of modernizing city infrastructure and leveraging technology to improve efficiency and capacity of city services. In terms of city infrastructure, investments are required to modernize city services like water, energy, public transportation, roads and sewerage. In the ICT framework developed by Accenture[15] for smart cities, one of the key pillars in Physical Infrastructure is Energy.



Smart Cities will need investment to the tune of several billions of dollars, while government's funding support will be limited to a small fraction of that. It is widely accepted that the scalable business model of smart cities can emerge largely through PPP model. Which brings us to two fundamental questions:

1. Which is/are the Public Player(s) most suited to anchor the PPP venture for smart cities?
2. How will the Private Player, from whom the bulk of capital infusion may come, earn return on his investment?

In smart cities, "somebody" needs to own the "Data Backbone" of the city and thereby serve as the nervous system on which all other applications piggyback. Globally, this role has been played by Telco/ISP vendors. In India, we believe that the nodal role can be best played by Electricity DISCOMS.

Just as a journey of a thousand miles starts with a single step, similarly, we believe that the journey of a hundred Smart Cities will start with a hundred smart utilities. Further, amongst the various existing Utilities (gas/ water), we recommend to use **Electric Utilities** as the anchor utility for driving smart city initiatives. In case of PPP, we recommend that the Private Player should tie up with the DISCOM as the Public Player to create the nodal body driving the overall smart city program.

It is reasonable to assume that **all** premises in urban areas, especially in cities shortlisted for smart city program, would have electricity connections. Water, Gas and Phone connections would be subsets of electricity connections.

At this juncture, let us place a smart Utility in the perspective of a continuum of evolving level of maturity.

A Basic Utility is expected to have fully functional Billing & Customer Care Solution,

Additionally, a Mature Utility is expected to have all urban consumers and entire network mapped into GIS down to DT level, seamlessly integrated with ERP/Billing Solution, and monthly electronic meter reading at all urban consumers

Additionally, an Advanced Utility is expected to have smart metering at most consumers and all network points, energy audit at DT level, network mapped into GIS down to LT pole/feeder pillar level; preferably along with Renewables, Distribution Automation/ DMS/SCADA/OMS; demand forecasting for optimal power procurement

BASIC → MATURE → ADVANCED

Smart Electric Utility can serve as the foundation of a Smart City by enriching and sharing its Data Backbone, as explained below:

- **Metering:** Exact location of each plot of land, building on plot, and floors/portions of buildings as individual **premises** using GIS database. I.e., **Premises = Property**

- **Billing:** Identification of each **property** with its occupant **person** or **organisation**. I.e., **Consumer = Citizen**

- **Collection**
  - Bill Amount trend = proxy for **income** level
  - Bill Payment track record = **Creditworthiness** of each household or organisation

- **DISCOM's Billing Database is the only pre-existing database that exhaustively links for entire cities:**

  Property → Citizen → Income → Creditworthiness

DISCOM's Database can serve as the Data Backbone of a smart city, on which other entities can piggyback for administering their own functions

- "Consumers" such as Streetlights, Traffic Lights, Toll Plaza, Railway/Metro Rail lines & stations, Mobile Towers, Petrol Pumps, etc. enable DISCOM to map key civil infrastructure in their database as well as on GIS.

- Similarly, list of Institutional "Consumers" like Police Stations, Fire Stations, Hospitals, Schools, Parks, Borewells, Monuments, Advertising Hoardings, Public Toilets, etc. provide a readmade encyclopaedia of city's social infrastructure

- Similarly, Institutional "Consumers" like Industries, Malls, Hotels, etc. provide a ready reckoner of city's economic infrastructure

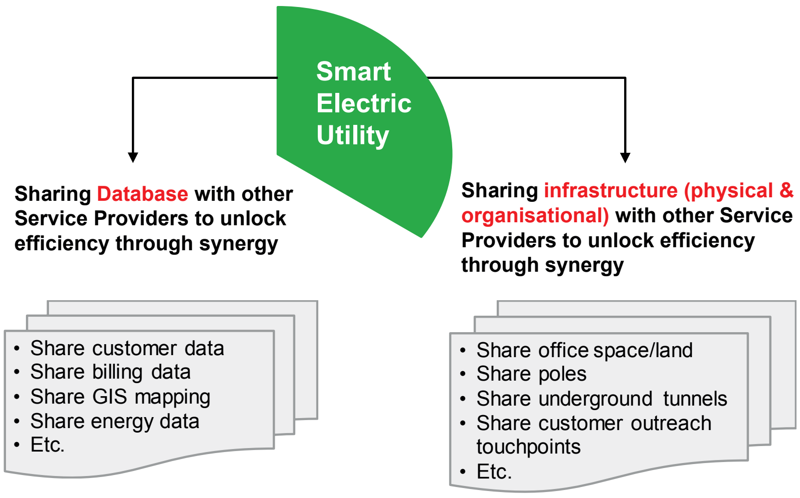
DISCOM's Billing Database is the only pre-existing database that exhaustively captures a city's most major infrastructure: Civic, Social & Economic

DISCOM's Database can serve as the Data Backbone of a smart city, on which other entities can piggyback for administering their own functions

Though there are certain caveats also to bear in mind:

Limitations wrt Citizen Data	Limitations wrt Infrastructure Data
• DISCOM can capture citizen data only up to household level, not down to individual person level • Registered consumer might be the Karta/Chief Wage Earner of the household or Land Lord of the property • Property Owner may be different from Premises Occupant • DISCOMs can't cover data wrt Vehicles, Bank Accounts, etc.	• DISCOM can't cover data wrt water pipelines, gas pipelines, optic fibre cables, sewerage pipelines, drainages, etc.

Thus, any electric Utility—even more so a smart Utility—is relatively best suited to serve as the anchor for enabling smart city, as explained below:



Following are a few illustrations of use cases enabled by using electric Utility as the anchor for smart city.

Illustration: How can a Basic Electric Utility enable tighter Governance through Shared Database

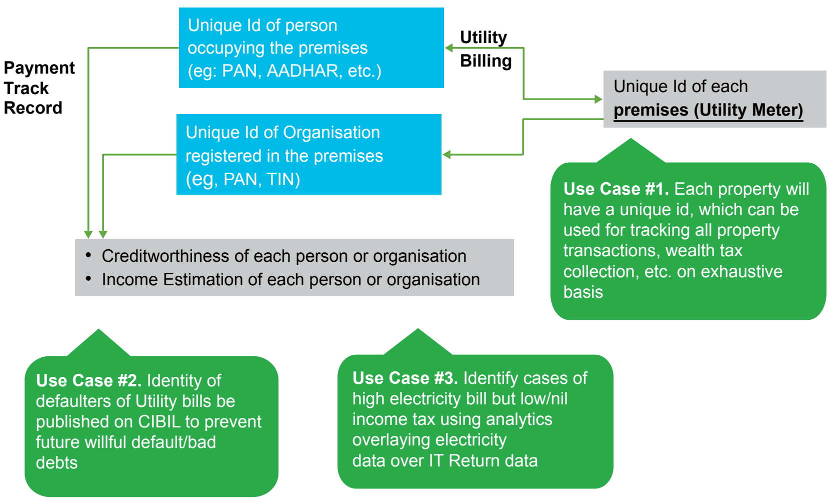
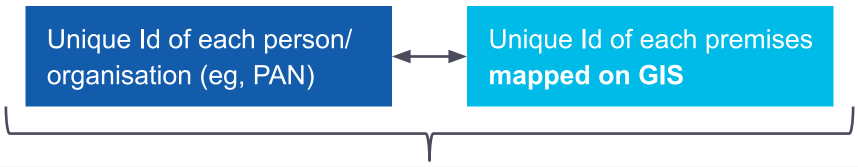


Illustration: How can a Mature Electric Utility enable better Governance through Shared Database



- Citizen Services: Quick verification enabling better discharge of duties by Govt depts., e.g.:
  – Use Case #1. Accurate Voter Listing for each Constituency at Central/State/Local levels using GIS mapping
  – Use Case #2. Transparent identification of Police jurisdiction in case of any untoward incident

Illustration: How can an Advanced Electric Utility enable better infrastructure planning through Shared Database

GIS Mapped, Smart Meterized, Network Infrastructure from feeder down to transformer level ↔ GIS Mapped, Smart Meterized, Consumer Premises indexed to transformer and pole ↔ Network Switching through GIS tool, Energy Audit at feeder/ transformer level

- Macroeconomic Planning of City's Infrastructure & Energy Requirements:
  - Direct correlation with growth rate of electricity connections, per capital power consumption, Load of various user segments such as industrial/agriculture/etc.

Illustration: How can a Basic Electric Utility unlock cost-effectiveness through Shared Organizational Infrastructure

	Piped Gas Utility	Water Utility	Telephone/Internet
Electric Utility can provide Shared Services to other Utilities with little/nil incremental cost, using its existing wherewithal	Meter Reading	Meter Reading	
	Bill Processing	Bill Processing	
	Bill Printing	Bill Printing	
	Bill Delivery	Bill Delivery	Bill Delivery
	Bill Payment Collection	Bill Payment Collection	Bill Payment Collection

Including on-site as well as on-line options

There is significant scope to remove duplicacy in commoditized functions and create a win-win model where multiple service providers save on non-core cost elements, while consumers get the benefit of handling a single touchpoint for various services.

Need for Smart Grid

Gartner estimates that 3.3 billion connected things will be used by smart cities in 2018. Some of the multitude of connected devices that shall enable "smartness" in smart cities are sensors, smart TVs, smart bulbs and various home automation tools such as smart thermostats, home security systems and kitchen appliances, smart meters, traffic lights, and security cameras.

However, to enable the myriad possibilities of Intelligent Infrastructure using Internet of Things (IoT), Machine to-Machine (M2M) communications and continuous network connectivity running, a sustainable power supply is of principal importance.

Illustration: How can an Advanced Utility help unlock efficiency through Shared Physical Infrastructure

LT Pole
Of DISCOM

Streetlight Pole
Of Municipal Corporation, Highway Authorities

Either Pole can be used to serve the function of the other entity, as both run almost parallel throughout the geography in case of overhead distribution network

- An Advanced Utility would have each pole mapped on GIS, with real time remote monitoring of whether any electrical equipment (such as those listed below) installed on the pole are functioning or not.
- Moreover, such poles can go "green" by installing solar panel, LED light and Li-Ion battery operating on automated (time/brightness based) control system, instead of using conventional light and power operating on manual switching on-off.
- Other functions that can be served by such "smart" poles include installation of:
  - Cameras for video surveillance at certain locations for security and traffic management
  - Traffic lights at certain locations
  - Telecom equipment such as wi-fi or miniature BST to create hot-spots or enhance mobile network – saving expensive real estate cost
  - Generate superior revenue through smart advertising, ie, instead of conventional hoardings, use LED screens to display contextual advertisements depending on location, time of day, day of week, etc. Content can be managed remotely by the Discom provided the revenue optimization is handled by specialized media agencies.

CITY OF SAN JOSE
CAPITAL OF SILICON VALLEY

The San José City Council recently approved a pilot allowing the Philips Corporation to install 50 Smart Poles on a trial basis. For every Smart Pole installed, Philips will also be upgrading 15 streetlights in the surrounding neighborhood to modern LED streetlights.

How businesses have benefitted from smart cities

Though smart cities are a social experiment involving user analytics and behavior, the engine that runs this experiment is commercial. The large scale solutions needed to make the smart cities work are commercial applications provided by businesses. In all the successful smart city and smart grid experiments listed

An interesting example from Silicon Valley

Smart Pole—one of the innovative concept of 'Smart Pole' could be leveraged to install streetlights fitted with CCTV cameras, and to provide telecommunications technology, feature lighting, traffic signals, signage and pedestrian signals. This sharing of road side Infrastructure reduces streetscape clutter by accommodating a range of pole mounted accessories onto a single pole system. This enables an alternative deployment methodology for 4G broadband services which streamlines, standardizes and broadens the capacity for Internet of Things (IoT) connectivity and allows for increased innovation in Smart City technology to benefit the citizens.

amsmarterdam city

Smart meters that measure the energy consumption and that can be connected to devices were installed in more than 500 houses that helped residents to save energy. Some houses were also provided with an additional energy display that gives feedback on the energy consumption and personal suggestions for saving energy based on the information provided by the smart meter above, businesses like IT services and infrastructure tool builders etc. have played a vital role. Apart from supplying the building blocks for building the projects, businesses also provide the technical knowhow and intellectual backbone to make smart cities a reality. A few ways businesses can benefit from smart cities are[63]:

- As Integrators: Smart city integrators are project integrators that bring together various sectors of the smart city through pre-packaged platforms thereby providing a unified, holistic and end-to-end integration of multiple sectors.
- As network service providers: Smart city network providers offer collaborative networks, data analytics and enterprise working solutions that connect people, assets, systems and products by leveraging on their networking and M2M capabilities.
- Managed service providers: Smart city managed service providers offer round-the-clock monitoring, complete management, compliance monitoring, and on-site consulting. These services are provided either in-house, co-managed, or are completely outsourced (third party providers).

Pure play product vendors: Smart city product vendors provide “hard assets” like smart meters and distribution devices (such as automated switches, controllers for capacitor banks and voltage regulators) that operate as the main nodes of connectivity.

How global experiences translate to India

Worldwide, there have been successful smart city implementations that India can look to imbibe as it modernizes its first 100 cities. Smart cities employ IT infrastructures that are responsive to user needs, multiple points for user and utility contact, and inclusivity as an underlying theme as all citizens within the city actively participate to make it a success.

When India launched its 100 smart city mission, it had ready examples of successes in other parts of the world to emulate. There are a lot of experiences to be emulated from global projects to the Indian context. A few of them are[15]:

1. Smart Physical infrastructure
   A smart physical infrastructure comprises of
   I. Smart energy
   II. Smart water
   III. Smart mobility
   IV. Smart waste management
   V. Smart urban planning
2. Smart Social Infrastructure
   Smart social infrastructure consists of
   I. Smart healthcare
   II. Smart education
   III. Safe city
   IV. Smart citizen services
3. Smart environmental management
4. Smart city governance and operations

PPP Model: Collaboration between Utilities on the one hand, and on the other hand, private partners offering consumer goods and customer service.

Globally, TELCOS have taken the lead to serve as the nodal agency driving the smart city business.

In case of India, we believe that electricity DISCOMS are much better suited to serve as the nodal agency as they have the anchor infrastructure and data backbone pre-existing with them based on its level of maturity.

However, diversification into value added services such as multi-utility billing, and retail sales requires a very different set of capabilities from the classical electricity business.

Hence, we strongly recommend that DISCOMS should consider entering PPP based Joint Venture or other alliance based/ inorganic business models wherein the DISCOM as the Public Partner shares its database and infrastructure, while the Private Partner raises capital and uses its business acumen to incubate profitable win-win businesses.

Following is an illustration of exactly how a sample set of alliance partners can come together to collaborate and create a new business model that is profitable in the long run. The diagram below is meant to be only broad and directional, not prescriptive or precise.

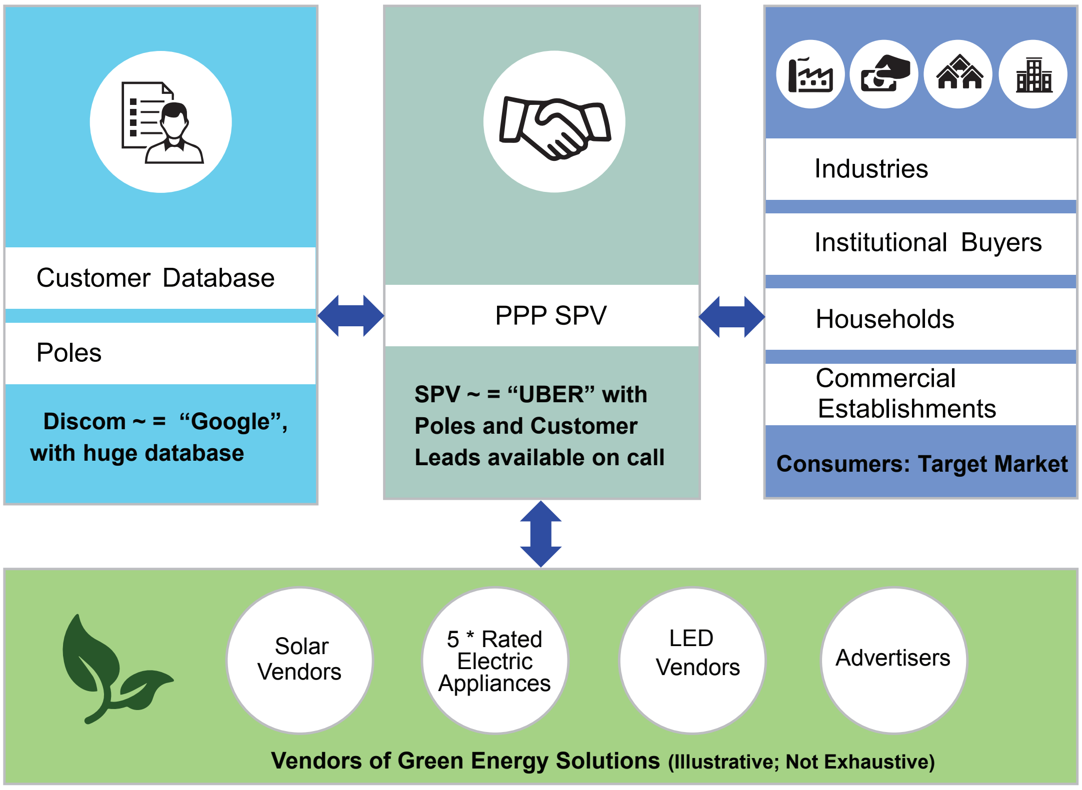


Illustration: How can a Basic Utility help create financially viable business model through Shared Database

- Target-marketing of eco-friendly energy products and solutions using electricity customer database
  - Increase penetration of renewable energy through distributed generation (example, rooftop solar) in net metering mode
  - Increase penetration of energy efficient devices such as LED and BEE 4-5 star rated appliances.
  - To enable the above, DISCOM's Customer database can be analyzed along the following attributes to craft a customized contextual sales strategy:

Parameter in DISCOM's Customer Database	Proxy/Indicator for:
Sanctioned Load	Size & Nature of Premises
Tariff Category	Nature of Usage
Name/Type of consumer	Individual vis-à-vis Institutional Government vis-à-vis Private
Address	Locality and nature of premises
Monthly Consumption	Quantum of connected load
Monthly Bill and Payment	Income
Payment and Arrears	Creditworthiness

The above information can be converted into an e-commerce platform for cross-selling solutions that save cost of energy to the end consumers.

Illustration: How can an Advanced Utility help create financially viable business model through Shared Infrastructure and Database

- Target-marketing of Smart Home (or Smart Building/Smart Township) solutions using electricity customer database and smart meters deployed at consumer premises.
  – Increase penetration of demand response for peak load reduction through demand side management.

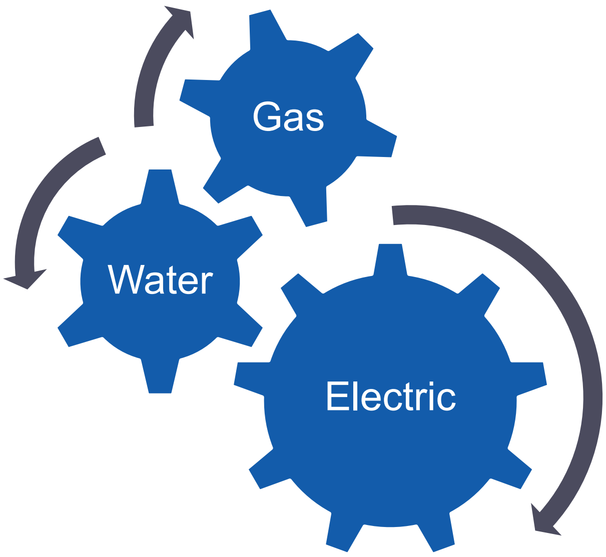
Improve lifestyle quotient of consumers willing to pay separate additional charges for smart premises solutions, for example:

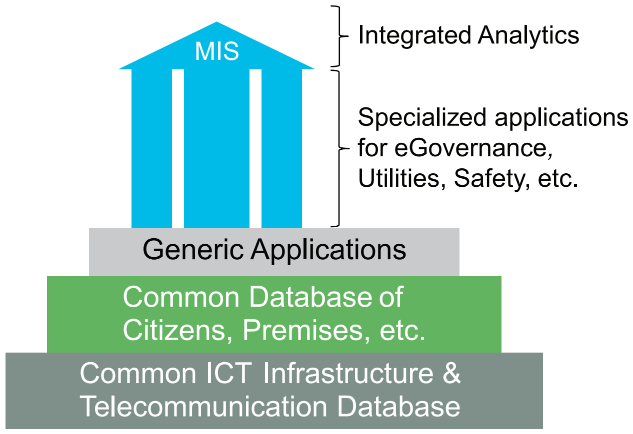
Parameter in DISCOM's Customer Database	Indicator for:
Time of Day consumption trend across week-day, calendar month, etc.	Potential for DR intervention
Monthly Bill and Payment/Arrears trend	Income & Creditworthiness, as proxy for spending capacity and intent

The above information can be converted into an e-commerce platform for cross-selling solutions that save cost of energy to the end consumers.

3.3 Technology

This brings us to the final moot point: How will all this get operationalized. We suggest the following big-picture to put everything in perspective.





Step 1. Use Electric Utility to serve as the first Smart Utility

Step 2. Use water as the add-on Smart Utilities, to reuse the people-&-property database created for electric Utility

Step 3. Piggyback CGD on top of electricity applications

Layer 1. Common Foundation:
i. Infrastructure
ii. Database
iii. Generic Applications

Layer 2. Specialized Applications for specific services

Layer 3. Integrated Analytics

The technology pieces that need to fit together from the perspective of smart grid marrying digital are as follows:

- Analytics for Demand Forecasting
- Analytics for Energy Auditing
- Analytics for fraud detection and loss reduction
- Analytics for forecasting renewable generation
- Mobility Solutions for field workforce
- Mobility Solutions for customers
- Remote Monitoring, Control and Operations

In any utility, and a smart utility in particular, the aforementioned pieces of technology will play a vital role in deriving benefit out of the technology interventions meaningful in the day to day operations of a Utility. Demand Forecasting (load forecasting + price forecasting) will help a DISCOM plan its power purchase accurately well in advance, across the time horizons of day-ahead, short term, medium term and long term power purchase. The tendency for UI drawal and over/under planned PPA will minimize, thus not only saving money to the DISCOMS but also providing predictability to the grid. In fact, since over 70-90 percent of DISCOMS' expenditure is on account power purchase, accurate demand forecasting is a fundamental (and currently most ignored!) tool for optimization of power portfolio—and this long overdue wrong must be set right by Utilities urgently.

Energy Auditing has to quickly move "down" from DISCOM level to granular levels of feeder-level and transformer-level energy accounting and loss measurement. This alone can enable targeted loss reduction interventions in high loss pockets with surgical precision. Accenture has been working with BSES Delhi DISCOMS in its journey for loss reduction from "above 50 percent" to "below 15 percent" from 2002-03 to 2015-16. One of the key trends in this evolution has been the "zooming down" of loss reduction strategies from city or region level to feeder and transformer level.

Another key trend that has supported our journey of loss reduction in BSES is using analytics as a tool for generating customer leads suspected to indulge in theft/fraud. In this case, it is necessary but not sufficient to apply analytics only on meter data files such as tamper events or load curve; it is equally important to develop and apply heuristics on customer billing data to detect patterns of suspicious behavior with regards to meter reading and consumption drop.

As the thrust on renewable grows, particularly solar energy will become most pervasive through its two-pronged proliferation of grid-scale plants on the one hand and distributed generation on the other. In this context, DISCOMS as well as TRANSCOs will need forecast regarding generation from renewables for better T&D capacity planning as well as power purchase optimization.

As all connections and network gets mapped on to GIS, the question arises—what practical value can be realized out of this beyond loss containment. One of the areas of customer delight is to use this data for expediting O&M actions such as fault repair and power supply restoration in case of unplanned outage. While distribution automation and fault passage detection tools will help identify fault locations quickly, what often tends to get ignored is the need to optimally allocate field workforce to address any on-site intervention needed in real time. For this purpose, mobility solutions leveraging GIS data can help expedite fault resolution, leading to customer delight and higher revenues for the DISCOM emanating from outage minimization.

With customers becoming increasingly tech savvy and permanently online thanks to smart phones, there is no reason why smart grids should not benefit from their omnipresence. All customer touchpoints from new connection application to billing, payment, communication, etc. can be shifted to paperless online modes, and customized to each consumer. As an example, BSES has launched mobile apps to register complaints, and has invited citizens of certain high loss divisions to report theft in their community using WhatsApp.

Eventually, convergence of IT/ICT and OT is leading to distribution automation down to LT level. Ten years back when SCADA was the new thing in Indian DISCOMS, unmanning of grid substations was a sensitive topic. Now it is only a matter of time before Smart Substations and Smart DTs will become the de facto norm, where most routine operations and disconnection/reconnection etc. shall be effected remotely by a small team in a Control Room, instead of an army of field operators. On the tap of a smartphone, Network Engineers and DISCOM management will know exact status and parameters of any feeder, transformer and consumer—including LT side, any time anywhere.

Such is the future that is waiting to happen.

However, it is also throws up challenges, not the least because of sheer complexity it imposes and confusion it evokes in the minds of more orthodox stakeholders. One simple way to comprehend and navigate this journey holistically is to use an assessment tool "before" and "after" smart grid interventions.

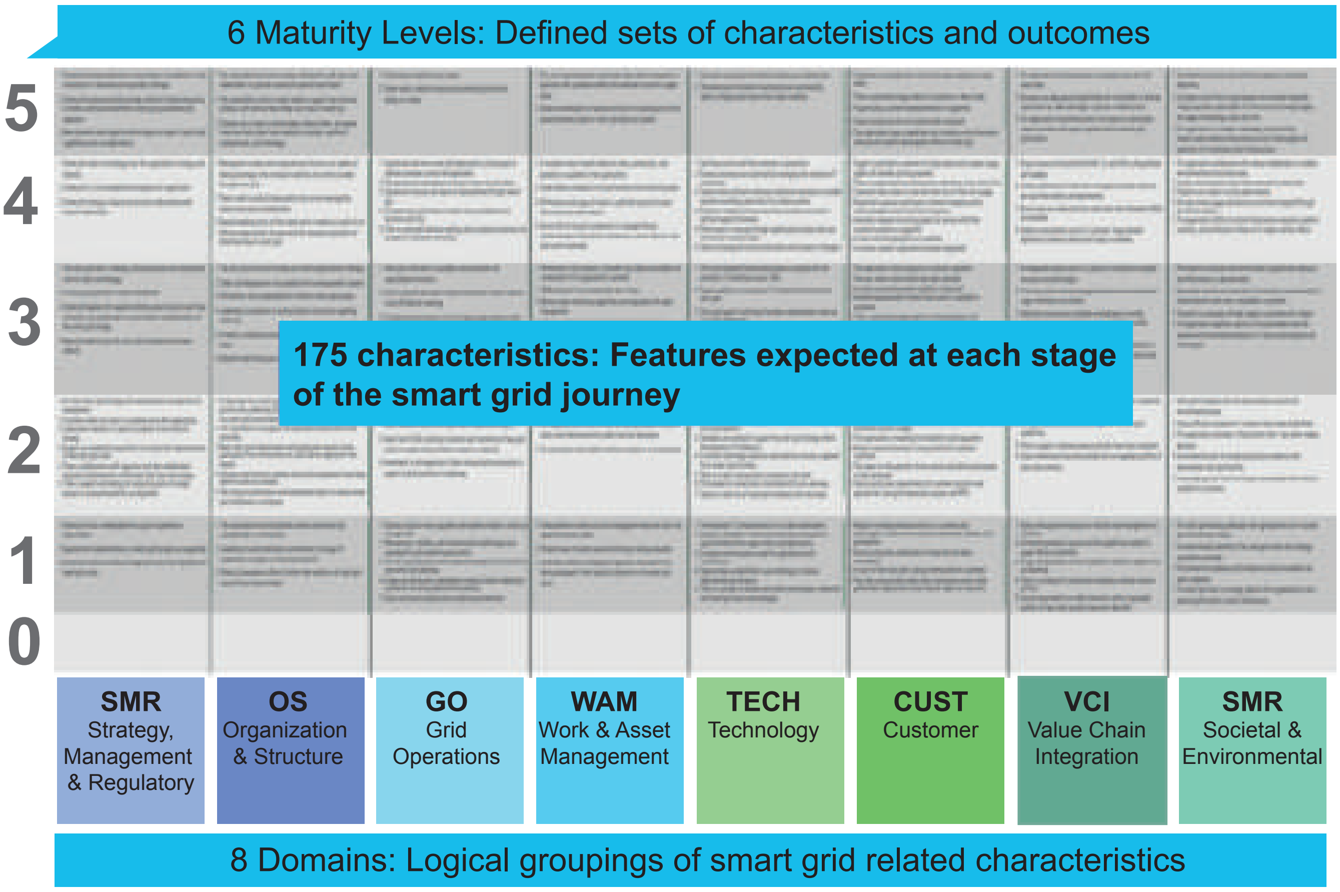
Smart Grid Maturity Model

Utilities in India are taking initial steps towards implementation of Smart Grids. Towards this end, it will be useful to have a common language and framework for defining key elements of smart grid transformation and help utilities develop a programmatic approach to track their progress. Smart Grid Maturity Model developed by Carnegie Mellon University's Software Engineering Institute, USA is a tool which has been leveraged by over 130 utilities worldwide including ~10+ utilities in India for this purpose.

Key features of Smart Grid Maturity Model:

- Consultative and participative approach to identify and prioritize initiatives.
- Benchmark against utilities worldwide across specific areas.
- Flexibility to focus on specific areas (Strategy, Technology, Organization and structure, Customer, Grid Operations, Value Chain integration, work and asset management and Societal and environmental) that are of interest to the utility in question.

The entire exercise encompasses two full day workshops with participation of all departments of the utility—first workshop



looks at the current state assessment while the concluding workshop is aimed at setting targets and priorities for 3-5 years. The workshops are conducted by Carnegie Mellon University certified assessors and the actual report and calibration is certified by the Software Engineering Institute at Carnegie Mellon University (CMU) who are the custodians of the SGMM tool.

Figure below illustrates the steps required for SGMM navigation:

Some of the utilities in India that have undergone SGMM assessment to identify and prioritize initiatives for their smart grid journey include: APCPDCL, BESCOM, BRPL, BYPL, CESC Mysore, NDPL, NPCL, MSEDCL, Tata Power and UGVCL. BESCOM has recently appointed ISGF to conduct the SGMM study and develop a smart grid roadmap.

Acronyms and Glossary

AGL	Australian Gas Light Company
AMI	Advanced Metering Infrastructure
AT&C	Aggregate Technical and Commercial
BEE	Bureau of Energy Efficiency
BIS	Bureau of Indian Standards
CEA	Central Electricity Authority
CIBIL	Credit Information Bureau Limited
CSR	Corporate Social Responsibility
DDG	Decentralized Distributed Generation
DELP	Domestic Efficient Lighting Programme
DISCOM	Distribution Company
DMS	Distribution Management Systems
DR	Demand Response
DSM	Demand Side Management
EESL	Energy Efficiency Services Limited
ENSG	Electricity Networks Strategy Group
ESCO	Energy Supply Companies
EV	Electric Vehicle
FAME	Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India
FIT	Feed-In-Tariff
GSES	Grid Scale Energy Storage
GIS	Geographic Information Systems
GOI	Government of India
GW	Gigawatts
HVAC	Heating, Ventilation, and Air Conditioning
ICT	Information and Communications Technology
IEC	International Electrotechnical Commission
IOT	Internet of Things
IPDS	Integrated Power Development Scheme
ISGF	India Smart Grid Forum
ISGTF	India Smart Grid Task Force
IT	Information Technology
KW	Kilowatts
KWH	Kilowatts per hour
LCOE	Levelized Cost of Energy
LED	Light emitting diode
M2M	Machine-to-Machine
MDMS	Meter Data Management Systems
MNRE	Ministry of New and Renewable Energy
MOHI	Ministry of Heavy Industry
MoP	Ministry of Power
MOUD	Ministry of Urban Development
MW	Megawatts
NaS	Network attached storage
NSGM	National Smart Grid Mission
PGRFEE	Partial Risk Guarantee Fund for Efficient Energy
Prosumer	Producer and Consumer
PPP	Public Private Partnership
R&D	Research and Development

R-APDRP	Restructured-Accelerated Power Development and Reforms Program
RE	Renewable Energy
REC	Rural Electrification Corporation
REMC	Renewable Energy Monitoring Centre
RGGVY	Rajiv Gandhi Grameen Vidyutikaran Yojana
SCADA	Supervisory Control and Data Acquisition Systems
SGIP	Smart Grid Interoperability Panel
SME	Small and medium enterprise
SNLP	Streetlight National Programme
SPRD	Smart Power for Rural Development
T&D	Transmission and Distribution
TOU	Time of Use
UDAY	Ujwal Discom Assurance Yojana
VCFEE	Venture Capital Fund for Energy Efficiency

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- Vishal Sharma, Principal with Accenture, leads Smart Cities engagements with the government for Accenture in India. He has been involved in many Strategic consulting assignments of national importance with various governments. His expertise includes Digital Strategy, Organizational Strategy, Innovative PPP Models and Program Management enterprise wide projects. He has Bachelors in Electronics Engineering and MTech in Radars and Control System and is an alumnus of IIM Ahmedabad with over 20 years of work experience.
- Anurag Johri, Principal with Accenture, specializes in the Utilities sector. He has over 12 years of experience working with clients on Strategy, Operations improvement and large scale Program Management. He has worked in multiple countries including India, Indonesia, Bahrain, Ethiopia, UAE and the UK. Anurag is a certified SGMM navigator and also holds a PMP certificate from PMI, USA.
- Peeyush Mohit, Principal with Accenture, has 13 years of industry and consulting experience in energy, utilities and renewables sectors. He has advised several solar companies in the areas of entry strategy, bid advisory, commercial due-diligence and process excellence, and has published thought papers on solar sector in India.
- Swapnil Pandit, Principal with Accenture, works in Accenture's Utilities India Delivery Center. Swapnil has 19 years' experience in delivering IT solutions. Swapnil is part of Accenture Smart Grid Services group at the India Delivery Center, providing support on Solution and Technical Architecture in smart grids and smart meter area. He has served as the lead Solution Architect for multiple smart grid assignments globally.
- Akshay Ahuja works as Sr. Smart Grid Specialist at India Smart Grid Forum. He is working closely with three working groups namely "Policy and Regulation", "Pilots and Business Models" and "Renewable & Microgrids. He was also part of modelling team working with Planning Commission of India on energy scenario exercise. Akshay is MBA in Power Management from National Power Training Institute (NPTI), and B.Tech in Electrical and Electronics Engineering from Lingaya's Institute of Management and Technology.
- Dr. Rahul Tongia is Fellow, Brookings India, a leading not-for-profit Think Tank in India focusing on policy analysis and multi-stakeholder engagement for improved policy outcomes, where he leads work on Energy and Sustainability. He is Advisor, ISGF, and helped found the India Smart Grid Task Force, Govt. of India, for which he was the Tech. Advisor. He is also an Adjunct Professor at Carnegie Mellon. He has led a number of IT roadmaps and analysis and pilot deployments in India, working both top-down on policy and bottom-up with utilities. Over a decade ago, he was on the Technology Advisory Board for Southern California Edison's SmartConnect, the award-winning Smart Grid rollout.

About the Authors

Shalabh Srivastava is a Principal with Accenture focusing largely on Utilities sector in India and developing countries, including renewables and smart grids. Shalabh has over 16 years of experience, wherein he has advised multiple Utilities clients on strategy, operations, technology and organizational matters. Shalabh has been instrumental in ushering operational turnaround at Utilities clients, helping DISCOMs reduce their AT&C loss, support rural electrification using solar mini-grids, advising Utilities in developing countries wrt strategy roadmap, smart grid pilots in India, among other engagements that he has handled. He holds B.Tech. from IIT Kharagpur and MBA from IIM Lucknow.

Reji is the President of India Smart Grid Forum (www.indiasmartgrid.org) and an internationally renowned expert with over three decades of experience in the electricity sector in diverse functions covering the entire value chain and across continents. He is spearheading a mission to leverage technology to transform the electric grid in India and light every home at affordable cost through sustainable developmental models. Reji played the pivotal role in formulation of the Smart Grid Vision & Roadmap for India (August 2013) and the launch of a National Smart Grid Mission (March 2015) by Government of India, issue of Model Smart Grid Regulations (June 2015) by Forum of Regulators; and issue of Standards for Smart Meters (IS 16444 and IS 15959) by Bureau of Indian Standards. He is presently advocating for a "Right to Electricity Act" that will ensure lifeline supply of electricity to all households in the country. His current areas of research include: leveraging smart grid assets as anchor infrastructure for building smarter cities at marginal cost, demonstration of smart microgrids that can participate in demand response market, and appropriate electric vehicle infrastructure solutions for India.

About ISGF

India Smart Grid Forum (ISGF) is a Public Private Partnership initiative of Ministry of Power (MoP), Government of India for accelerated development of smart grid technologies in the Indian power sector.

The main objectives of ISGF are:

- To help the Indian power sector deploy smart grid technologies in an efficient, cost effective, innovative and scalable manner by bringing together all key stakeholders and enabling technologies.
- To create a platform for public and private stakeholder members, research institutions and power utilities to exchange ideas and information on smart grids and develop use case scenarios for India.
- To bring together experts from regulation, policy, and the corporate sector to build support for smart grid policies.
- To conduct research on the capabilities of smart grids in the Indian context through case studies, cost-benefit analysis, study of technical advancements in renewable energy sources and other ancillary activities.
- To make recommendations to the Government, Regulators, Utilities and Consumers through reports, white papers, technical seminars, etc.

Mandate of ISGF is to advise government on policies and programs for promotion of Smart Grids in India, work with national and international agencies in standards development and to help utilities, regulators and the Industry in technology selection, training and capacity building.

ISGF has over 200 members covering ministries, government institutions, regulators, utilities, technology companies, non-profit organisations, educational and research institutions and students from renowned institutes. ISGF has 10 working groups focussed on different aspects of smart grid such as: WG1: Advanced Transmission; WG2: Advanced Distribution; WG3: Communications for Smart Grids; WG4: Metering; WG5: Consumption and Load Control; WG6: Policy and Regulations; WG7: Architecture and Design; WG8: Pilots and Business Models; WG9: Renewables and Microgrids; and WG - 10: Cyber Security.

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