Smart Grid Processes, People and Policies

ISGAN discussion paper
Annex 4, Subtask 3.1

The IEA Implementing Agreement for a Co-Operative Programme on Smart Grids

International Smart Grid Action Network (ISGAN)

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Abstract:
Varied outcomes have been reported when the same smart grid technologies were implemented in different parts of the world. This issue brief examines the role of processes, people, and policies in smart grid outcomes, with a particular focus on the Indian context. Thisdiscussion paper extends the analysis of an earlier work presented at the Indian Electrical and Electronics Manufacturers' Association's Metering India Seminar 2013, held on 21st & 22nd February 2013 at Hotel Le Meridien, New Delhi. It also includes international examples prepared in light of conversations with collaborators from the United States. The paper aims to shed light on the non-technological dimensions of the Smart Grid that significantly determine project success. Examining these dimensions can be the first step toward project success. To illustrate the role of these dimensions, this paper identifies some example processes including optional tariffs for end consumers, frequency-based control of home appliances, inverter batteries use (both as storage and integrated with solar generation), and electric vehicle use. Finally, the paper analyzes the specifics of processes, people, and policies that may promote the success of Smart Grid.

About ISGAN discussion papers
ISGAN discussion papers are meant as input documents to the global discourse about smart grids. Each is a statement by the author(s) regarding a topic of international interest. They reflect works in progress in the development of smart grids in the different regions of the world. Their aim is not to communicate a final outcome or to advise decision-makers, rather to lay the ground work for further research and analysis.

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Introduction

The manifold advantages and benefits of implementing smart grids in the electricity sector are emerging rapidly. As analyzed in a 2012 ISGAN white paper (Williamson, 2012), realizing the benefits of smart grids – and deciding how to allocate these investment costs -- is a key public policy challenge.Varied outcomes are being reported, however, when the same technology types, especially smart metering technologies, are implemented in different parts of the world and indifferent regulatory and system environments. These variances reinforce the fact that three key dimensions—processes, people, and policies—strongly determine the outcome of smart grid projects. As a result, analysis of the ecosystems in which these projects evolve is necessary.

Processes

Smart grids hold the potential to significantlychange the implementation of a broad range of standard utility processes such asbilling, connection management, peak load management (PLM), outage management (OM), demand side management (DSM), power qualitymanagement (PQM), load forecasting, andintegration of variable renewable energy. Significantly, smart grids also hold the potential to introduce entirely new processes that will require new management protocols, such as dynamic demand response (DR), microgrids,electrical energy storage,and widespread electric vehicle (EV) integration. This paper examines a survey of processes that are emerging around the world to realize these possibilities.Designing new processes and redesigning old processes can be the first step in this direction.

People

Adoption of new technologies and processes, along withinnovation in business and operational practices by utility workforces, consumers, and related professionals from regulators to lawyers to technologists, is ultimately the key to success of the Smart Grid. Utilities and regulators around the world facevarious challenges in realizing the full benefits of smart grid systems, and many of these benefits require some level of customer acceptance and engagement. Utilities need to reach out to the consumers to understand their expectations, convey the benefits of the Smart Grid, and support themas they adopt new processes. This paper suggests how utilities can accomplish these objectives, with an aim of creating awareness and encouraging active participation of consumers to equip them in evolving from consumers to “prosumers” (a new class of customers who generate as well as consume). At the same time, utilities face a complementary challenge—training employees in new processes and technologies.

Policies

Policies and the associated regulatory framework play an integral role in the effectiveness of any technology deployed. On one hand, efficient policies can accelerate the development of a technology; on the other hand, a poor policy design can doom a promising idea.As an example of successful technology deployment with proper policy support, the Supervisory Control and Data Acquisition (SCADA) system for the transmission network in India has been implemented to monitor the grid state and ensure secure grid operations. Although the SCADA system’s control features are not automated, theAvailability Based Tariff(ABT)structure adopted via regulatory changes has helped to bring in grid discipline through incentives and disincentives that encouragegenerators and utilities to maintain grid frequency in an acceptable band.On the other hand, an attempt was made to introduce a prepaid tariff structure in the distribution sector, butthis had limited success becausedisconnection of the end consumer when the balance amount expired was not clearly stipulated in the current regulations. Similarly, open access for bulk consumers with more than 1MW of load could not be achievedbecause supporting regulatory changes were not clear enough. This clearly indicates that appropriate changes in policies and the regulatory framework are required for any technology to flourish.

Table 1 outlines the people, processes, and policies involved in various smart grid systems under consideration in India. The rest of the paper describes the Indian context and discusses various implementation issues and lessons learned.

Table 1. Smart Grid functions and associated people, processes and policies

Smart Grid Function	People	Process	Policy
Advanced Metering Infrastructure (AMI) + Demand Response	End consumers; Utility personnel	Consumers shift their load as per incentives given as part of Time of Use (ToU) or Critical Peak Price (CPP) tariff for peak load management	ToU/CPP tariff policy; Rate recovery for AMI investment
AMI + Demand-side management	End consumers; Utility personnel	Utility manages the load thru HAN with a prior agreement with end consumer for PLM or frequency-based smart devices	Remote connect/ disconnect; ToU/CPP tariff policy; Rate recovery for AMI investment
Outage Management viaSignal Transmission Messaging Unit and AMI	Utility personnel	Utility dashboards to monitor load profiles and proactive actions to reduce outages and response time	Employee incentives based on outage-based Key Performance Indicators (KPIs)
Utility-scale renewable energyintegration viaforecasting applications and AMI	Utility personnel	Wide Area Monitoring Systems, software applications and Demand Response for grid security	ToU/CPP tariff policy
Distributed renewable energy integration via AMI	Prosumers; Distribution Utility	Consumers participate in generation throughrooftopsolar power or small windmills	Feed-in tariff and remote disconnection for grid security
Power quality management via IEDs	Utility	Dashboards for power quality	Employee incentives based on utility KPI dashboards; Penal tariff for injecting harmonics

Notes: AMI:advanced metering infrastructure; ToU: time of use; CPP: critical peak pricing; HAN: home automation network; KPI, key performance indicators; DG: distributed generation; IED: Intelligent Electronic Devices

India Energy and Smart Grid Context

Developing economies such as India are challenged by making power available to match a large unmet demand,and further increasing the quantityand quality of power to those who do have access. India has an installed capacity of more than 210 GW, which is the world's fifth largest capacity. In the last 5-year plan period, which ended in March 2012,India added approximately68 GW of capacity. For the current plan, which covers 2012 through 2017, the target is to add approximately another 80 GW. The plan calls for India to have an installed capacity of 685 GW by 2027.The current share of renewable energy in the installed capacity is around 25 GW, which, in capacity terms, isabout 12%.The target is to increase this share to about 41 GW, or about 15%, by 2017. India has abundant natural solar and wind resources for sustainable growth. The country's share ofrenewable generation, though, needsto be enhanced by deploying advancedsmart gridtechnology and formulating suitable policy guidelines and tariff structures.

Such efforts are unfolding in a context in which around 200 million people in India do not have access to electricity. With an installed capacity of more than210GW, there is an average deficit in energy requirement of around 8.5%,which means that power is not available to all users all the time. Atpeak demand, the average deficit is around 11% (CEA, 2011-12). Averaged at the national level, electricity losses of Indian distribution companiesare around 27%, which is alarmingly high [See ISGAN White Paper on reducing non-technical losses]. Because electricity isa prime mover for economic growth, the Indian government makes improving the current power system to supply reliable and quality power to all a priority. This goal can be achieved in part throughimproved and innovative information and communication technology (ICT) interventions.

Considering the addition of ICT intopower networks to make them smarter is increasingly common. Major smart grid objectives are PLM, OM,PQM, renewable integration, load control, near-real-time dynamic pricing, EV usage, large-scale storage systems, and homeenergy controllers, among others. All these objectives contribute to the primary aims—making the power system reliable, secure, and efficient, as well as reducing the carbon footprint of the system. Initiatives have been taken in India to make the transmission sector smarter by introducing new smart grid technologies like PhasorMeasurement Units (PMU)-based wide area monitoring systems(WAMS) to improve control and monitoring capabilities. In India, the central transmission utilityPOWERGRID plans to take a lead in deploying these smart technologies, deployingone of the largest PMU networks in the world --approximately 1,750 PMUs – across the Indian transmission grid.

Steps for harmonizing and calibrating smart grid technologies in India are being taken by implementingpilot projects with the nation's utilities.The Ministry of Power has finalized awards to various state utilities across the entire country for 14 smart grid pilot projects in the distribution sector.The likely cost of these pilots willbe about $212billion USD (U.S. dollar;4,000 million Rupees [INR]) with 50% funding from the Ministry of Power and the balance to be arranged by utilities. Based on the outcomes of these pilots, the projects will be scaled up and smart grid technologies will be rolled out.

Smart grid pilots in India will aim at integrating the consumer, operations, and asset management domains of the distribution sector to bring in efficiency and enhance reliability. The pilots will also help in redefining the business processes to get maximum advantage of smart grid technology options. These smart grid pilots focus on aggregate technical and commercial (AT&C) loss reduction, DSM, OM, PQM, microgrids, and renewablesintegration.

India has initiated information technology (IT) implementation as part of the Restructured Accelerated Power Development & Reforms Program i.e. (RAPDRP). Under this program, utilities have taken up GIS-based consumer indexing, asset mapping, metering, billing applications, and energy audit applications to bring AT&C losses below 15%. Utilities from states like Gujarat, Delhi, and Karnataka have changed their processes to add monitoring of distribution transformer (DT) load profiles, which enables them to take corrective actions to minimize overloading and phase imbalances. In addition, they have put in place strict administrative actions to detect theft and incentives to motivate employees to adopt new technologies. These actions could reduce losses even before the RAPDRP project is complete.Further details are available in the ISGAN paper on reducing nontechnical losses.

Different utilities in India are at different levels of smart grid maturity. In this paper, various alternatives for the same processes are discussed. Utilities can shift to high-endprocesses to enhance their service delivery to end consumers and also improve their Smart Grid maturity level.

Table 2. Details of Pilot Proposals

Number	Utility Name	Area Proposed	Functionality Proposed	Initial Consumer Base	Input Energy (GWh)
1	CESC, Mysore, Kamataka	Mysore Additional City Area Division	AMI R, AMI I, OM, PLM, Microgrid/DG	21,824	151.89
2	APCPDCL, Andhra Pradesh	Jeedimetia Industrial Area	AMI R, AMI I, PLM, OM, PQM	11,904	146.48
3	APDCL, Assam	Guwahati Project Area	PLM, AMI R, AMI I, OM, DG, PQM	15,000	90.00
4	UGVCL, Gujarat	Naroda/Deesa	AMI R, AMI I, OM, PLM, PQM	39,422	1,700.00
5	MSEDCL, Maharashtra	Baramati, Pune	AMI R, AMI I, OM	25,629	261.60
6	UHBVN, Haryana	Panipat City Subdivision	AMI R, AMI I, PLM	30,544	131.80
7	TSECL, Tripura	Electrical Division No. 1, Agartala	AMI R, AMI I, PLM	46,071	128.63
8	HPSEB, Himachal Pradesh	ESD Kala Amb Under Electrical Division, Nahan	AMI I, OM, PLM, PQM	650	533.00
9	Puducherry	Division 1 of Puducherry	AMI R, AMI I	87,031	367
10	JVVNL, Rajasthan	VKIA Jaipur	AMI R, AMI I, PLM	2,646	374.68
11	CSPDCL, Chattisgarh	Siltara, Chattisgarh	AMI I, PLM	508	2,140.90
12	PSPCL, Punjab	Mall Mandi City Subdivision Amritsar	OM	9,000	29.90
13	KSEB, Kerala		AMI I	25,078	376
14	WBSEDCL, West Bengal	SiliguriTown, Darjeeling District	AMI R, AMI I, PLM	4,404	42

Notes:
AMI I:Advanced Metering Infrastructure for industrial consumers focusing on Demand Side Management;
AMI R:Advanced Metering Infrastructure for residential consumers focusing on Demand Response; 1 GWh=gigawatt hour = 1 million kWh

Smart Processes

Designing new processes and redesigning old processes can be quintessential steps for the success of a smart grid implementation. Depending on their state of technology adoption, utilities need to implement significant process changes associated with smart meteringto derive desired value for all stakeholders. The sections that follow describe these changes.

Billing

Most of the meters currently deployed in India are electromechanical, with meter readers taking readings once a month. Many utilities have started deploying automated meter reading (AMR), in which data are transmitted to a handheld device or a drive-through vehicle. This reduces manual reading errors and makesthe dataresistant to manipulations. The next step is moving from mere measurement and monitoring to controlling load for optimal asset utilization.The latest technology, smart metering,facilitates two-way exchange of information that can be based on the global system for mobile communications/general packet radio service (GSM/GPRS), power line communications, or fiber optics. This also enables real-time monitoring and, as appropriate,consumption control along with time stamped metering information. All the meter readings can be read regularly (per programmable time periods) and remotely and the data can be logged on a central server where the informationcan be used for billing that can be based on ToU. The utility can benefit froman increase in revenue based on ToU pricing as well as improved billing efficiency (the national billing efficiency in India's power distribution sector currently ranges from 70% to 80%). Becausethe utility can monitor the meters in real time, it can receive on-the-spot tampering information and also eliminate losses resulting from faulty readings. (See Figures 1 and 2) (Sodha, Wadhwa, Megha, 2013)

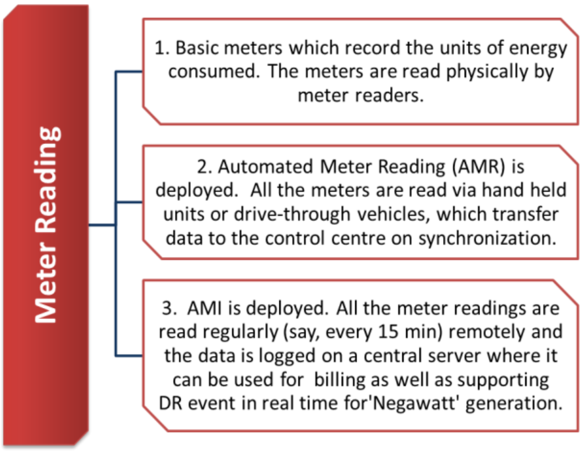

Figure 1. Process options for meter reading

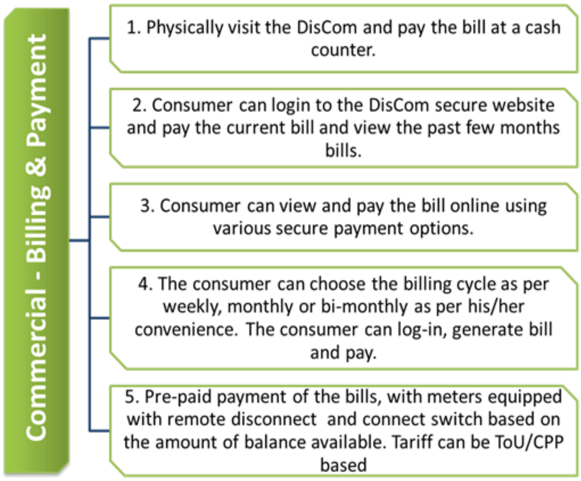

Figure 2. Process options for billing and payment

Such opportunities are not without challenges in the form of implementing entirely new processes. Various utilities in the US report significant challenges with collecting, storing, and analyzing all of this new meter data in a cost effective manner. Nonetheless, utilities are innovating new solutions. One utility reported starting to build a meter data management system, but realized that they had no data architecture that could do analytics.So they asked their vendors to explain their analytics and realized that the available meter data management systems did not have the analytical capabilities that the utility wanted. So they decided to build their own. The result was a system that could look at meters in any number of ways, especially both physical and financial grouping of meters, and opened up new possibilities, such as allowingthe utility to do predictive analytics around their asset base, and focus resources on prevention instead of repair.

Similarly,paper bills are being increasingly replaced by online bills. After visiting the websites of approximately 30 distribution utilities (of about 60 utilities), the paper authors observed that 20 utilities have made online bill payment available through utility portal. Thisnumber is expected to rise as more and more utilities undergo IT implementation under RAPDRP. In the US, online portals are also impacting customer service, especially in cases of bill disputes. Utilities report that customer service representatives, aided with online usage data, are better able to resolve many of these disputes. With appropriate meter data management system, Utilities can also deliverother value-added services viaan online portalExamples include viewing and paying current and past bills; choosing a weekly, monthly, or bimonthlybilling cycle according to consumer preference;and accessing consumption pattern analysis and comparison of consumption with benchmarks. In the US, various utilities with AMI networks nowoffer “projected bills” that estimate monthly cost at current rates of usage. Some of these utilities also allow customers to elect a “preferred due date,” which has been found to reduce defaults. These new services and options can enhance consumer satisfaction and motivate end users to regulate their consumption. (See Figure 2)

Apart from improving processes and practices with advanced technologies, offering consumers incentives for timely or advanced bill payment can be rewarding. For example, utilities can classify consumers as priority consumers if they pay their bills on time, and these consumers can receive benefits like service priority and discounts, among others.At the same time, the utility can usethe remote connect–disconnect feature of smart metering todisconnect or give a minimum lifeline supply to consumers defaulting on bill payments. Utilities in Italy also leverage AMI systems to provide a minimum amount of electricity to defaulting customers.

Table 3. Meters and associatedprocesses

Meter Type	Features	Process
Electromechanical	Metering and anti-tamper features with manual reading option	Mainly manual system for meter to cash i.e meter reading, billing and realisation of bills.
AMR	Load profile, time-stamped metering and anti-tamper features with an option of remote reading	Partly automated system for billing and energy audit process
Smart	Load profile, two-way communication, time-stamped metering with an option of remote reading as well as remote connect–disconnect	Mostly automated system for meter to cash that can be highly effective if supported by appropriate tariff design policy

Peak Load Management

PLM is one of the key functionalities of smart grid tools like AMI or smart metering. At the distribution level, PLM can be achieved by reducing/shifting load from peak to off-peak times. PLM encompasses DR, DSM, and energy efficiency options.

Demand Response—Communication to Consumers

Some utilities have implemented time-of-day (ToD)-based DR for bulk consumers, announcing higher prices during peak hours and lower prices during off-peak hours. This encouragesthose consumersto shift their load to off-peak hours. Seventeen utilities in India have implemented ToD-based DR for bulk consumers and are reaping its limited benefits. In Karnataka, an optional ToD tariff was introduced in fiscal year (FY) 2005–2006, for consumers under LT and HT industrial categories and HT water supply (Pricewaterhouse Coopers India Private Limited, p.15) (see Table 4). Under this ToD tariff, different categories of bulk consumers were charged higher tariffs during evening peak hours and lower tariffs during the night when electricity demand was lower. It is difficult, though, to determine thebenefits of ToD-based DR for these utilities because of insufficient baseline usage data.

Smart meters with a robust communications backbone can further extend the DR to end consumers. The real-time usage information can be collected from the smart meter at the consumer's premises and processed by the meter as well as at the control center. In this way, a pricing signal is obtained. That signal can then be sent back to the smart meter, which displays pricing information on a mobile phone, an in-home display,or an online portal. Consumers can check their usage patterns and change themaccording to the electricity pricing wherever possible.

In addition, the effect of load shifting on prices can be considered and used for overall optimization. A full-fledged DR system for the entire distribution grid, integrated to the SCADA and DSM system,should also identify the most optimal source of DR to be used for stable and reliable grid operation.(See Figure 3)

Table 4. Details of ToD tariff applicable in Karnataka for Bulk Consumers

Particulars	**LT(supply at 415 V) 5(b) Consumer Category**	**HT(Supply at 11KV or 33KV) 1 Water Supply and Sewage**	**HT(Supply at 11KV or 33KV)2a (i) & (ii)consumer category**
Applicable energy charges		3.50 Rs./unit	4.30–4.60 Rs./unit
For the first 500 units	3.30 Rs./unit		
For the next 500 units	3.90 Rs./unit		
For the balance of units	4.25 Rs./unit		
ToD			
22.00 h to 06.00 h	–0.80 Rs./unit	–0.60 Rs./unit	–0.80 Rs./unit
06.00 h to 18.00 h	0	0	0
18.00 h to 22.00 h	+0.80 Rs./unit	+0.60 Rs./unit	+0.80 Rs./unit

Source: Tariff Order FY 2010; USD 1 = INR 54

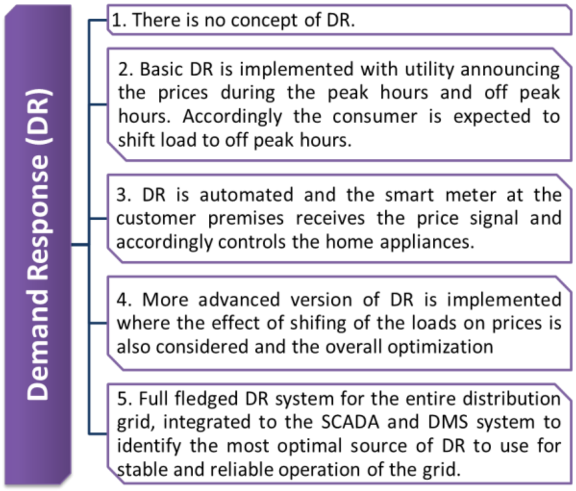

Figure 3. Process options for DR

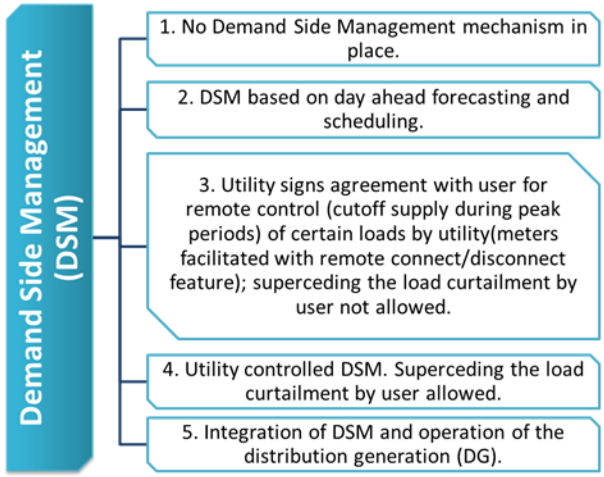

Figure 4. Process options for DSM

Demand Side Management—Control of Consumer Loads

In India, the current practice for meeting electricity supply shortages is load shedding, in which a complete feeder (or feeders) is switched off and the whole area is deprived of electricity for some hours of the day (local blackouts).Consumers have their own back-up supplies in the form of small DG sets or inverters with batteries that are charged when grid supply is available anddischarged during the load shedding period. One of the objectives of the Smart Grid is to supply partial load during periods of shortages throughsmart meters, leading to brownoutsinstead of blackouts. This form of DSM,thru Smart Meter with theadditional feature of remote connect–disconnect, will allow utilitiesto disconnect non critical loads like air conditioners or water pumps in case of shortages. Utilities can further stagger switching of these devices to reduce peak demand in an area. In the US, various utilities offer a bill discount for direct load control. One utility reports offering a 2.5% discount for control of electric heat, 2.5% for electric water heating, and 1% for air conditioning, and this level of discount makes the program quite popular. Another utility reports an even simpler approach that has proven popular, offering a voucher for a local electronics store in exchange for enrollment in the DSM program.

Consumers can enter into an agreement with the utility on the noncritical timings and devices on which they want the utility to execute control to manage peak loads. This agreement, once in place, will allowthe consumer to avoid discomfort. For example, one US utility reports that water heater shutoffs typically happen for 2-3 hours during peak periods, and the utility has observed no complaints. In India,it is proposed that utilities can offer an option in which consumers can use a manual override option for controlto opt out of the program in case of an emergency. The utility might charge a higher price for the manual override option. An even more automated form of DSM can befrequency-based control of home appliances. These can be typical appliances controlled by external frequency based relays or control switches or smart appliances with integrated frequency-based control features.(See Figure 4)

Connection Management

To apply for a new connection or change in existing connection agreement, a consumer must visit the utility office. That process can be improved by offeringapplication forms online, which can then be submitted online or physically at the utility office. In the US, various utilities now have remote connection and disconnection utilizing AMI meters. This saves time for the customer and travel of a service technician to the site.

In India, consumerstypically have no choice of service provider because there is only one service provider in an area. Creating a parallel infrastructure to give consumers open access is not economically feasible. As a result, there is a need to segregate the "wire" and "electricity service" business to give consumers options for choosing a service provider. In this "retail competition" scenario, one central utility can manage and own the infrastructure and many service providers and retailers can give the consumer open access. First, the consumer can submit a connection requestonline. Next, the utility takes preliminary steps like working out the consumer requirements in terms of capacity and system requirements for that capacity. Once the utility has granted clearance, theconsumer can submit a service request to multiple service providers in that area, and accept the proposal from the service providerthat best suits his needs. (See Figure 5).This classification of distribution asset owner and service provider willcreate a competitive market and give consumers better services and options.Such a system is in place in Texas, with more than 90 "retail electricity providers" offering their services through a centrally-managed marketplace (Texas Electric Choice Education Program).

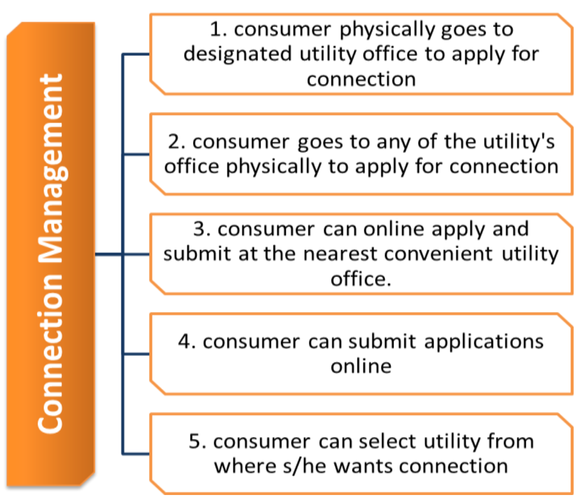

Figure5. Process options for connection management

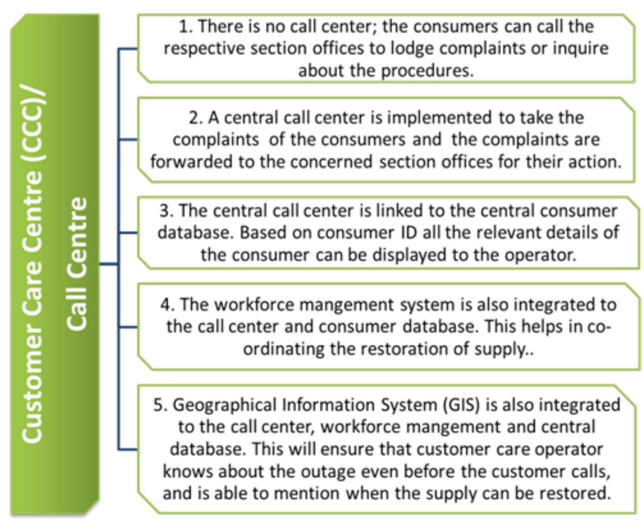

Figure 6. Process options for customer care/call center

Customer Care/Call Center

For most of the utilities, the major source of outage information is currently the customer care/call center. To improve the existing OM process, a responsive and efficient customer call service is necessary. Bringing in new processes for outage detection via smart meter implementations can, however, further improve the mechanism for outage detection, as long as the smart meter includes the feature of communicating a no-supply alarm to the control center in real time when power supply fails.

In the US, customer care centers have experienced two divergent trends. On the one hand, customer service representatives are increasingly expected to know and understand how AMI, ToU, and online-portal features work. This requires greater training of these personnel. On the other hand, more and more customers are using "social media" (e.g. Twitter or Facebook) to interface with their utility. Indeed, an increasing number of US utilities post outage and system status messages, and respond to customer complaints, through social media. This trend has reduced call center traffic. (See Figure 6)

Tariff Structure

In India today, mostresidential consumers pay a flat average rate for electricity. Even if the infrastructure necessary to execute dynamic pricing is put in place, the right tariff structure(s) that suits consumers according to segmentation of the market is necessary to successfully implement the technology. Different tariff structures can be designed to reduce peak loads to save on generation and transmission capacity addition for peaks, to supply quality power at a premium price, to reduce consumer bills, and to enhance revenue generated by the utility. These tariff structures couldbe similar to the telecom servicetariff plans in India, which give consumers different options that suit their budgets or the premium service requirements. Consumers that need to reduce their total power bill can receive tariff signals from the power company and use those signals tochoose whether to switch their consumption to different time periods with lower rates. Another class of consumer might be willing to pay premiums for enhanced availability and a higher quality power supply, both of which can be facilitated through smart meters. The strategy should be to selectively introduce consumersto more flexible and beneficial options through smart meters.

The tariff structure can be based on a mix of the following components:

- Settingdifferent rates for different time periodsof the day during a month of a season based on historical data
- Including a variation in the duration of the time period or the rate of the periodor both on day-ahead basis.
- Informing consumers in real time (i.e., hourly or bihourly) about the change in rates in case a critical loading situation is to be managed (this is the most dynamic form of tariff). (See Figure 7).

Prosumers

With the emergence of a new class of consumers called prosumers, who generate as well as consume, a provision of bidirectional metering in the tariff structure should be made a priority. One optioncan be net metering, which bills consumers for the net electricity theyconsume (i.e.,electricity consumed from the grid minus the electricity supplied to it). Another option, which has been deployed in Germany,has a different tariff for the electricity the grid supplies to the consumer and the electricity the consumer injects into the grid.In this case,a unit generated by the consumer has significantly lower losses and associated carbon emissions associatedcompared to a unit of electricity supplied by the grid. To encourage consumers to use theirown sources of electricity, they should be paid back more per unit to manage increase in demand, especially during peak power-use times. If violations occur—such asusagehigherthan the sanctioned load or harmonic injections beyond permissible limits—consumers can be charged a penalty tariff to ensure proper grid management.

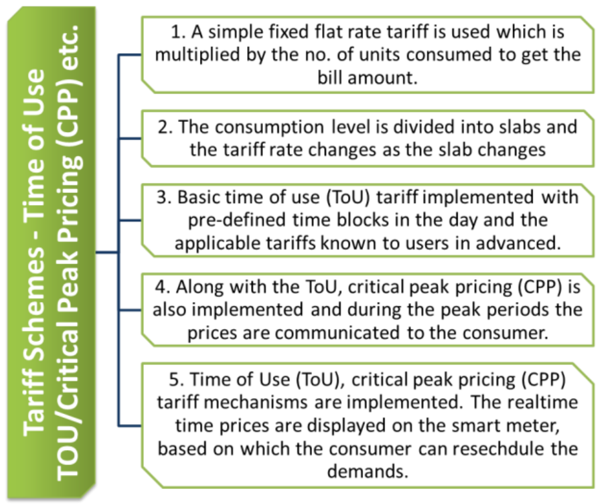

Figure 7.Process options for tariff schemes

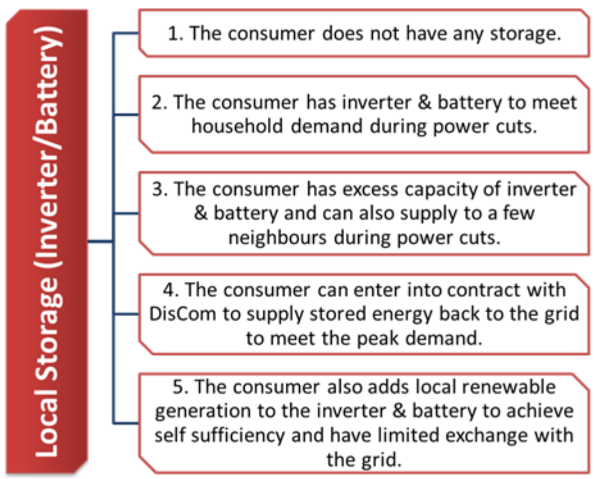

Figure 8. Process options for storage

Electric Vehicles

EVs are emerging as an important option for energy system planners and operatorsto consider. But concerns like battery performance and cost, access to charging infrastructures, and charging times are posing bottlenecks to the widespread adoptionof EVs. Using EVs at specific times and places, however, can help the power system in some cases. Electric scooters or taxis, or both, can be introduced at places like universities and marketplaces where user density is quite high, allowing a limited charging infrastructure to cater to a significant numberof people. In addition, charging strips can be deployed within the parking spaces foroffices, malls, and various stations-railways, airports, metro etc. so that the vehicles can be charged at the most suitable off-peak time of the day.

Inverter Batteries for Storing Electricity

As previously mentioned, Indian consumers have installed inverters on their premises to meet emergency loads during load shedding or other outages. It is estimated that there are more than 50 million inverters in India (Internet PPT-Power Losses - Save Today Survive Tomorrow)**.** Worldwide pilots are being conducted for experimenting V2G concept wherein it is proposed that batteries of Electric Vehicles may act as a distributed storage option that can supply back to grid, to manage peak loads. However, it may take time for EVs to settle in as a storage medium for off-peak grid power and use the same during peak load period. A more ready-to-use setup for electricity storage in India, however, would be to use existing power inverter batteries as storage media for the power generated by rooftop solar panels during off-peak times and then use the solar power stored in inverter batteries during peak hours. This strategy can result in additional savings. Because the efficiency of most of the inverters is around 50% (i.e., for every 1 unit supplied by an inverter, 2 units are drawn from the grid), therefore, consumers must be encouraged to deploy rooftop solar panels by suitable policy provisions.(See Figure 8).

Utilities can mandate using rooftop solar panels with inverters, offer subsidized rooftop panels to consumers (Ministry of New and Renewable Energy (MNRE) currently furnishes a 30% subsidy on rooftop solar), or lease rooftop solar panels. The initial investment in these panels might seem to be high. A number of factors, however, such as future increases in the cost of grid-supplied power, reductions in distribution losses, diminished use of costly back-up sources like DG, enhanced consumer satisfaction, and the ability to provide electricity to areas without access to power will improve the return on investment numbers for rooftop solar panels.

Cyber Security

With development of the Smart Grid and the associated increased integration of power system covering generation, transmission,and distribution, India'spower system is becoming more vulnerable to large-scale cyber-attacks. Moreover, integrating renewable sources and moving to open standards such as Ethernet, TCP/IP, and Web technologies lead to improvements and increased vulnerabilities simultaneously, making cybersecurity an even more critical priority. Proactive measures should be taken to make the system more robust. Identification and classification of cyber threats can be the first step, followed by appropriate and up-to-date electronic and physical security measures. Security reviews and audits should be made a part of the routine.

Smart People

Capacity Building

Because the successful operation of a project is the ultimate aim, utilities should take up capacity building as an important aspect in the initial stages of a project. Project planning should notbe confined to scope and schedule planning only; resource planning should also form an integral part of the process.Skilled laborshould be acquired or created well in advance, not as a follow-up to the implementation phase. Utilities should hireexperts to train the workforcein concert with implementation. In addition, conducting workshops, seminars, national and international events, demonstrations, and employee training at beginner and advanced levels should be priorities. Motivating employees to encourage their wholehearted participation will be another important factor in the successful rollout of a Smart Grid in India.

Implementing a Smart Grid will require traditional utility "human resource" policies to change to "strategic human resource management" that nurtures human resources for optimal performance. Components in this type of management include adequate compensation packages, performance-linked incentives, and transparency in promotions and transfers, among others. Team performance can also be rewarded by introducing concepts like "DT as profit center"and KPI improvements, including, for example, voltage profiles, numberand duration of outages, and numberof consumerhours not served in the area. Acknowledging good work by publishing data for areas with minimum losses or rewarding the team that achieves maximum reduction in losses in their areascan also motivate others to follow.

Beyond the training of individual employees, smart grid projects also change the internal organization of utilities. Before smart grid rollout, an increased focus on updating technician training and streamlining back-office functions is the key to success.

Customer Engagement

Bringing consumers onboard and encouraging participation inDR initiatives are additionalbig challengesfacing utilities. To gain consumer faith in the concept, utilities need to reach out to consumers with goals of understanding their expectations, conveying the benefits of the Smart Grid, and giving them timely support.Steps that can encourage high levels of participation include the following:

- **Awareness to create willingness:**Utilities can conductawareness programs, hold expositions and seminars, and disseminate newsletters, text messages, and emails to encourage consumers to actively participate in the Smart Grid. Moreover, if the consumers are to evolve into prosumers, an additional level of awareness about the norms of two-way power flow is needed.Pilot demonstrations can show consumers that “it does what it says it does,” which will help to gain their faith in the smart metering technology and by extension, the Smart Grid.
- **Incentives to promote participation:**Incentives are necessary to initially catalyze consumer participation. For example, CESC, a utility in West Bengal started a voluntary advance payment scheme(CESC Limited) involvingincentives forprepayment in the form of interest throughpre-paid meteringthat was highly successful.

  Similar schemes for incentivizing customers in monetory form for ‘Negawatt Generation’, in the form of voluntary load reductionas signaled by utility, can help to manage the system more effectively.

  Alsotie up with OEMs for lucrative buy back prices for replacing existing inefficient air conditioners, refrigerators, washing machines, televisions, pump sets etc. with energy efficient equipment can help to reduce losses. Such pricing programs or incentivesshouldbe designed with scientific rigor by conducting simulations to correlateprice elasticity with consumer demographics, designing and administering pre- and post-launch surveys, and continuously improving the program based on feedback.
- **Training to support new systems and processes:**A recent survey revealed that childrenare major influencers for adoption of any new technology(McVay New Media). With this in mind, designing anappropriate training program on the Smart Grid for schoolchildrenwould be prudent. Workshops, seminars, demonstrations, and online courses can also be helpful. A numberof U.S. utilities have changed their customer outreach methods in relation to new smart grid processes. One large urban distribution utility in the UShas conducted significant outreach to low-income customers through community colleges. The local community college is a trusted community resource, and helps the utility provide outreach and education about smart metering programs to reach diverse groups. The plan was so successful that it is now being rolled out to all community colleges in the area. The utility and community college co-developed an energy curriculum to teach consumers how to use the in-home

energy dashboard and manage their energy. They also jointly hosted regular consumer expos to introduce the equipment and the program to the community.

- **Complexity reduction:**Other utilities in the United States have aimed to dramatically reduce the technical complexity of in-home devices. One utility worked with a vendor to develop a Web portal through which consumerscan program their thermostat, water heater, and pool pump, among others.The system is easy to use and the consumer can "setitandforgetit."The utility conducteda 100-consumer pilot, with a sample comprisinga highly computer literate group: 75% hada college degree and only 7% described themselves as"computer illiterate."These consumerssaved 6.5% of their consumption compared to similar users in the service territory.

  Other utilities work to achieve DR directly through direct load control. Various utilities in the United States are coordinating pilot projects to implement direct load control of hot water heaters to shave peak load. The technical implications include much more data collected for analysis, along with system and device integration. The technology is new, so utilities do extensive beta testing on data collectionand device communication.

Optimization can also be done on selection of the consumers. The right processes for the right consumers at the right time can help utilities avoidhuge investments and lessen consumer confusion.For example, a research project done in Carnegie Mellon's Electricity Industry Center(M. Granger Morgan, 2009)has shown that in most systems for Time-of-day and time-of-use meters, only about 20% of the larger and more flexible consumersneed to be switched from conventional meters to real-time meters. This 20% switch is enough to give everyone in the service territory as much as 80% of the benefits that would accrue if all consumerswere on real-time meters.

Smart Policies

Before a decision is made on smart grid implementation, a supportive regulatory framework needs to be built and the right government policies must be in place.The sections that follow describe key areas in which policy plays a defining role.

Security

The policies to be designed for the new smart grid ecosystem must ensure consumer safety (because consumer data will be shared with the utilities) and comfort (in terms of better services). Given the amount of automation and digitization, along with a new consumer segment being added to the system, a sea change in cybersecurity policies willbe required. The policies must ensure cyber justice and security forconsumersand providers, ensuring a robust, yet flexible system.

Tariff Structure

The significant modifications in energy laws resulting from the Electricity Act of 2003 and the National Electricity Policy of 2005 have brought new urgency to implementing the existing provisions.The National Tariff Policy, 2006 already has provisions for implementingsmart metering. The relevant provisions of the National Tariff Policy, which define the tariff components and their applicability, read as follows:

8. *4 Definition of tariff components and their applicability 1. Two-part tariffs featuring separate fixed and variable charges and Time differentiated tariff shall be introduced on priority for large consumers (say, consumers with demand exceeding 1 MW) within one year. This would also help in flattening the peak and implementing various energy conservation measures.(National Tariff Policy, p.18, 2006)*

Tariff structure is a critical aspect of the regulatory framework that needs modifications. The current tariff is not cost reflective and is based on a limited number of parameters.

The tariff could be based on cost of generation and transmission, service cost to discom, Unscheduled Interchange UI charges that are frequency linked charges for real time deviations in the planned generation and drawal schedule intimated to Regional Load Centers, reactive power, subsidies, ToD, ToU/CPP, power supply quality, voltage level, sanctioned load, frequency, and penalties on exceeding sanctioned load and harmonic injection limits.(Figure 9)

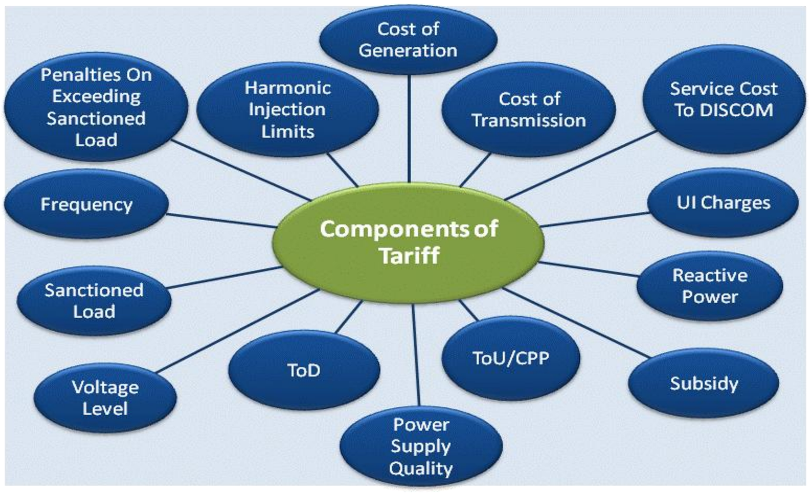

Figure 9. Possible components of tariff structure

Implementation Timeline

The timeline forimplementation also plays a major role in the contribution of a policy. The trade-offs between "doing it fast" and "doing it right" must be carefully considered. With the right government policies and a supportive regulatory framework in place, the Smart Grid can be implemented before it becomes stale.

The Road Ahead

Much is happening around the world in the smart grid field.Smart Grid is an evolving field and various national and international standardizing bodies are working toward smart grid standards development. To address India's specific needs, the corresponding entities in India must participate in these efforts.

India is not far from new and large-scale implementations in the field. WAMS are being installed, smart cities are being developed, knowledge centers and test beds are being built, low-costsmart meters are being designed, and smart grid pilots are being conducted in the distribution sector. But the smart grid concept cannot be limited to transforming infrastructure. It also encompasses process design and redesign, appropriate policymaking, and utility and consumer support.The technologies have already been tested at many places aroundthe world. Now, the real challenge is in undertaking the tangible changes to training, education, policy, and processes that will result in utilities and consumers adopting the concept.

At this point, utilities need to analyze their current state of technology adoption and implement new technologies and processesaccordingly. The existing system must be made smart grid ready, which requires not only infrastructure upgrades, butchanges in current practices and the regulatory framework. The regulatory environment must be supportive of a competitive market and dynamic processes.

To ease the stress on today's infrastructure, renewables, DG, microgrids, and peak load reduction measures need to be added.Given the enormous scale of implementation in India, takeaways from pilots and implementations need to be analyzed thoroughly to avoid pitfalls and to benefit from experience.To fully implement the Smart Grid in India, all stakeholders must work in synergy to develop a unified power ecosystem.

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Glossary

Abbreviation	Expansion
ABT	Availability Based Tariff
AMI	Advanced Metering Infrastructure
AMI I	Advanced Metering Infrastructure For Industrial Consumers
AMI R	Advanced Metering Infrastructure For Residential Consumers
APCPDCL, Andhra Pradesh	Central Power Distribution Company Of ApAndhra Pradesh Limited
APDCL, Assam	Assam Power Distribution Company Limited
AT&C	Aggregate Technical And Commercial Losses
CEA	Central Electricity Authority
CESC, Mysore, Kamataka	Chamundeshwari Electricity Supply Corporation Limited
CESC, West Bengal	Calcutta Electric Supply Corporation
CPP	Critical Peak Pricing
CSPDCL, Chattisgarh	Chhattisgarh State Power Distribution Company Limited
DG	Distributed Generation
Discom	Distribution Company
DR	Demand Response
DSM	Demand Side Management
DT	Distribution Transformer
EV	Electric Vehicle
GoI	Government of India
GPRS	General Packet Radio Service
GSM	Global System for Mobile communications
HAN	Home Area Network
HPSEB, Himachal Pradesh	Himachal Pradesh State Electricity Board
HT	High Tension supply at 11KV or 33KV
ICT	Information And Communication Technology
IEA	International Energy Agency
IED	Intelligent Electronic Devices
ISGAN	International Smart Grid Action Network
JVVNL,	Jaipur Vidyut Vitran Nigam Limited

Rajasthan	
KPI	Key Performance Indicator
KSEB, Kerala	Kerala State Electricity Board
LT	Low Tension supply at 415V or 220 V
MNRE	Ministry of New and Renewable Energy
MSEDCL, Maharashtra	Maharashtra State Electricity Distribution Company Limited
MU	Million Units
OEM	Original Equipment Manufacturer
OM	Outage Management
PLM	Peak Load Management
PMU	Phasor Measurement Unit
POWERGRID	Power Grid Corporation of India Limited
PQM	Power Quality Management
PSPCL, Punjab	Punjab State Power Corporation Limited
RAPDRP	Restructured Accelerated Power Development & Reforms Program
SCADA	Supervisory Control And Data Acquisition
ToD	Time of Day
ToU	Time of Use
TSECL, Tripura	Tripura State Electricity Corporation Limited
UGVCL, Gujarat	Uttar Gujarat Vij Company Limited
UHBVN, Haryana	Uttar Haryana Bijli Vitran Nigam
UI	Unscheduled Interchange
WAMS	Wide Area Monitoring System
WBSEDCL, West Bengal	West Bengal State Electricity Distribution Company Limited