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Some discussions on alternative energy resources with particular reference to smart grid technology

The electric power system is undergoing a profound change driven by a number of needs,including environmental compliance and energy conservation. Grid reliability, operational efficiencies and customer service become important with aging infrastructure.This paper includes a plan for electric utilities to make their distribution grid a modern one, a smart one, an agile one. Smart grid solutions, including distribution automation, asset management, demand side management, demand response, distributed energy management and advanced metering infrastructure, allow utilities to identify and correct a number of specific system issues through a single integrated, robust and scalable smart grid platform.The paper provides an overview of technologies being deployed and key smart grid applications being implemented.

1. Introduction

A smart grid is a modern electric system. It uses sensors for monitoring, sophisticated communications, automation and computers to improve the flexibility, security, reliability, efficiency and safety of the electricity system. It increases customer choice by allowing consumers to better control their electricity use in response to prices or other parameters as per choice. A smart grid includes diverse and distributed energy resources and it brings all elements of the electricity system i.e generation, transmission and distribution closer together to improve overall system operations for the benefit of consumers and the environment.

Energy, and more precisely, electrical energy is the key to development and sustenance of the modern Indian economy. Energy demand in India is expected to grow at an annual rate of nearly 6% over the next 10 years in tandem with projected economic growth rates of a similar scale. Finding adequate supplies of energy to satisfy this increased demand is a signicafant challenge.The Indian energy sector continues to struggle to overcome chronic energy shortages caused by a combination of low levels of domestically available fossil fuels (except coal), inefficiencies in T&D,and the high intensity of energy use particularly in the value-added industry sector.The urgent need to increase per capita electricity consumption, serious environmental problems due to power generation from conventional energy sources such as coal, naphtha and diesel fuels, the ever increasing prices of such fuels and the shortage of fuels have caused India to initiate programmes and projects for energy efficiency as well as power generation from renewable energy sources. The growth of renewable energy in the national energy scenario has been modest and much of the planned expansion in India's power sector is predicted on the use of coal, with related negative implications for emissions of both local air pollutants and greenhouse gases.

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A smart grid is an umbrella term that covers modernization of both the transmission and distribution grids. The concept of a smart grid is that of a “digital upgrade” of distribution and long distance transmission grids to both optimize current operations by reducing the losses, as well as open up new markets for alternative energy production.

Some of the benefits of such a modernized electricity network include the ability to reduce power consumption at the consumer side during peak hours, called demand side management; enabling grid connection of distributed generation power (with photovoltaic arrays, small wind turbines, micro hydro, or even combined heat power generators in buildings); incorporating grid energy storage for distributed generation load balancing; and eliminating failures such as widespread power grid cascading failures. The increased efficiency and reliability of the smart grid is expected to save consumers money and help reduce CO_2 emissions. Governments increasingly focus on energy security, investing in the smart grid could be used to reduce dependence on non-domestic energy sources. It could also make the grid more resistant to military or terrorist attacks,by physical or digital means. Smart Grid is referred to by other names including “Smart Electric Grid”, “Smart Power Grid”, “Intelligrid” and “Future Grid”.

2. Major driving forces to modernise current power grid

- Increasing reliability, efficiency and safety of the power grid;
- Enabling decentralized power generation so homes can be

both an energy client and supplier (provide consumers with interactive tool to manage energy usage);

- Flexibility of power consumption at the clients side to allow supplier selection (enables distributed generation, solar, wind, biomass);
- Increase GDP by creating more new green-collar energy jobs related to renewable energy industry manufacturing, plu-in electric vehicles, solar panel and wind turbine generation,energy consumption construction.

3. Salient features of smart grid

- Self healing: The grid has the ability to rapidly detect, analyze, respond and restore from disturbances;
- Tolerant to attack the grid should be resilient to physical and cyber security attacks;
- Provide quality power required by users;
- Accommodate various generation options, including green power;
- Allow competitive electricity markets;
- Use IT for monitoring and minimize O&M costs;
- Empower the consumer and incorporate consumer equipment and behaviour in operation and design of the grid.

4. The basic requirements of smart grid

- Dynamic, fast response to varying supply demand situations;
- Preparation of old grids to the era of alternate energy and energy efficiency;
- Constant monitoring and communication all around the electric grid;
- Establishment of dynamic energy markets and optimal revenue patterns to generators and utilities;
- Improving the overall efficiency of the network through better management of resources, thus reducing the effect on the environment;
- Improving the operational efficiency of utilities. This aspect is not to be under estimated, just changing the way utilities measure power and do billing can yield tremendous benefits;
- And last but not least, probably the foremost is to improve the stability of the electrical system under any adverse conditions.

5. Functional requirement of smart grid

- Smart grid should be able to recover itself following any grid disturbances i.e self healing and adaptive;
- Motivate consumers to actively participate in operations of the grid;
- Resilient to disruptions;
- Provide higher quality power that will save money wasted from outages;
- Accommodate all generation and storage options;
- Run more efficiently;
- Optimized to make best use of resources and equipment;
- Distributed across geographical and organizational boundaries;
- Integrated and merging the functions of monitoring, control, protection, maintenance, EMS, DMS, marketing and IT;
- Interactive with consumers and markets;
- Predictive rather than reactive to prevent emergencies;
- Self-healing and adaptive;
- More secure from physical or cyber attacks.

6. Greenhouse gas policy

Smart grid is an aggregate term for a set of related technologies on which government has invited the attention. Demand side management enabling grid connection of distributed generation, power with photovoltaic arrays, small wind turbines, micro hydros or even combined heat power generators in buildings incorporating grid energy storage for distributed generation, load balancing and eliminating or containing failures such as widespread power grid cascading failures. The increased efficiency and reliability of the smart grid is expected to save consumers money, fuel, import of conventional energy resources and help reduce CO_2 emissions.Increase GDP by creating more new green collar worker energy jobs related to renewable energy industry manufacturing, plug-in electric vehicles, solar panel and wind turbine generation, energy conservation construction.

7. Overview of smart grid technology

- Detect and address emerging problems before they impact service;
- Respond to local and system-wide inputs and know much more without broader system problems;
- Incorporate extensive measurements,rapid communications and feedback controls that quickly return the system to a stable state after interruptions or disturbances;
- Automatically adapt protective systems to accommodate changing system conditions;
- Reroute power flows,change load patterns,improve voltage profiles and take other corrective steps within seconds of detecting a problem;
- Enable loads and distributed resources to participate in operations;
- Be a grid that is self-healing and adaptive,interactive with consumers and markets, more secure from attacks,

accommodate all generation and storage options, accommodate bidirectional energy flow for net metering and predictive rather than just reacting to emergencies.

8. Steps to be taken for unification of smart grid

- Integration of new technology/new type of generation at generation level;
- Integration of new technology in transmission system;
- Smart way of managing the transmission system;
- Integration of new and smart technology at distribution level;
- Smart way of using the electricity.

9. Drivers for smart grid

The global movement towards smart grid is driven by improving operational efficiency, enhanced customer satisfaction, improvement in energy efficiency and environmental impact. These are elaborated below:

- Operational efficiency: Increase operational productivity, reduce capital and operating costs, improvement physical/ cyber security.
- Efficient energy use: Optimize usuage, meet growing demand, enhance utilization of existing assets.
- Customer satisfaction: Improve reliability matrix, empower consumer to control energy usuage, stronger communications.
- Environmental aspects: Reduce GHG emissions with utility, give more environmental options to consumer,adhere to regulatory mandates.

The key functional elements which are required to meet the challenges are described.

10. Major driving forces of smart grid technology

- Integrated communications, connecting components to open archietecture for real time information and control, allowing every part of the grid to ‘talk and listen’;
- Sensing and measurement technologies, to support faster and more accurate response such as remote monitoring,time of use pricing and demand side management;
- Advanced components to apply the latest research in super conductivity, storage, power electronics and diagnostics;
- Advanced control methods to monitor essential components,enabling rapid diagnosis and precise solutions appropriate to any event, and,
- Improved interfaces and decision support, to amplify human decision making, transforming grid operators and managers quite literally into visionaries when it comes to seeing into their systems.

11. Major challenges to be faced while designing smart grid technology

Challenges are present in system planning, policies, metering, communication etc. A few major challenges to be faced are as followes :

- System planning level: Too many decision makers, opposition to new plants and lines,lack of predictive real-time system controls,inadequate focus on supply-side reliability solutions, proper tax incentives for predictive real-time system, time-dependent controls, pricing information and tax incentives for demand side management (DSM) technologies.
- Energy selling level: Public resistance to deregulation, lack of consumer participation in DSM, environmental incentives/penalties to be addressed, consumer access to pricing information to enable DSM technology.
- Technology level: Communication bit falls for real-time management of grid, optimal power flow control, automatic meter reading, reduction in energy consumption by use of improved technology, harnessing alternate energy sources and feeding the grid from them,energy storage devices,innovation in smart sensors and automation.

12. Distributed energy resources (DER)

DER’s are small sources of generation and/or storage that are connected to the distribution system. A smart grid has the potential to have large and flexible sources of DER's to include solar photovoltaics, wind turbines, micro turbines, fuel cells and battery storage. An extension would result in an Intelligent Distributed Autonomous Power Systems (IDAPS), to include ‘normal operation’ and ‘outage mode operation’. The characteristics are :

- Intelligent: IDAPS performs DSM based on price, secures critical loads, sheds loads of low priority and allows for locally available power to be shared within a community.
- Distributed: DER’s are dispersed and communicate through a common IP protocol.
- Autonomous: IDAPS disconnects itself from the local distribution utility and operates autonomously to maintain integrity of the system.

Here, the distribution system begins to resemble a small transmission system and has to consider non-radial power flow and increased fault current duty. Thus it can be seen that the evolution of a smart grid is still a long way off, from what has been conceptualized.

13. Key steps of power sector reform which improve smart grid initiatives in India

- Unbundling the State Electricity Boards assets into separate entities for generation, transmission and distribution, with an intention of increasing private participation;

- Adding capacity in support of a projected energy growth rate of 12% coinciding with a GDP rate of roughly 8%;
- Improving metering efficiency and controlling pilferage;
- Improved billing and collection;
- Preferential tariffs for renewables;
- More transparency in auditing and accountability;
- Outsourcing a couple of functions like billing, maintenance etc.

14. Key factors that affect indian power sector

- Poorly planned distribution systems;
- Low metering and bill collection;
- Lack of adequate reactive power support resulting in poor power factor;
- Over loading of transformers and lines;
- Bureaucratic slowness etc.

15. Suggestive measures to be taken for moving forward to a smart grid

- Suggestions for DSM to selectively curtail delinquent customers/neighbourhoods;
- Improve service for consistently paying customers;
- Increased use of renewables;
- Sophisticated metering i.e smart meter;
- Introduction of availability based tariffs (ABT).

16. Desired functionalities of smart grid

- Self-healing;
- High reliability and power quality;
- Resistant to cyber attacks;
- Accommodates a wide variety of distributed generation and storage options;
- Optimizes asset utilization;
- Minimizes operations and maintenance expenses.

17. Design criteria of smart grid

- Increasing use of clean DER;
- Establishing a significant amount of DSM and demand side response capability with direct consumer communication;
- Replacing over build reliability methodologies with distribution and sub-station automation approaches;
- Maximizing utilization of the existing delivery infrastructure;
- Adding physical and IT security systems to protect critical infrastructure.

18. Salient measures to be taken for successful implementation of smart grid technology

- The need for significant and accurate simulated models representing the as-built and operational status of the delivery grid and its connected consumers;
- The need for significant levels of operational field information on a timely basis;
- self-diagnose equipment health, detect and characterize delivery "disturbances", communicate to masters and peers and make "local" decisions;
- The need for a two-way communications infrastructure supporting monitoring, automation, remote control and load manipulation;
- The need for advanced applications capable of analyzing and filtering the field information;
- The need to effectively integrate these systems and applications into efficient environments for operations and maintenance.

19. Fixed devices required for implementation of smart grid technology

The smart grid has a lot to do with decentralization i.e distributed generation and storage, distribution system automation and optimization,customer involvement and interaction, plug in hybrid electric vehicles (PHEV) and even micro grids.That means that it will be necessary to have more intelligence and control beyond generation and transmission throughout the distribution grid and all the way to the retail consumer's side of the meter. This will involve few fixed devices like :

- Supervisory control and data acquisition (SCADA) devices and distribution automation (DA) devices;
- Automatic meter reading (AMR) devices and smart meters;
- Retail premises monitoring and control systems and energy management systems (EMS) and
- Emerging technologies for monitoring and control, both for electric utilities and for consumers.

20. Smart grid functions are as follows

- Be able to heal itself;
- Motivate consumers to actively participate in operations of the grid;
- Resist attack;
- Provide higher quality power that will save money wasted from outages;

* Accommodate all generation and storage options;

- Enable electricity markets to flourish;
- Run more efficiently.

Table 1 gives energy gap in India based on yearly basis.

21. Operational philosophy of smart grid

- The electric utility or home energy monitor does an 'audit' of the supply points and detects idle energy, the home then either qualifies or is disqualifies for efficiency credits

Table 1: Energy gap in India at 8% & 9% growth projections

Year	Required (MW, 8% growth)	Gap (MW)	Required (MW, 9% growth)	Gap (MW)
2006-07	140000		140000	
2011-12	206000	66000	215000	75000
2016-17	303000	97000	331000	116000
2021-22	445000	142000	510000	179000
2026-27	655000	210000	785000	275000
2031-32	962000	307000	1207000	422000

or gets a chance to respond;

- At times of peak load, the utility command center broadcasts a message to all household units to go below 2 kW in their drawal. Home monitors respond by local control of their loads, say stalling a washing machine and acknowledging back;
- A power plant downtime is expected that the utility broadcasts a message to all industrial loads allowing them to schedule accordingly;
- On a very hot day, when demand is peaking, the utility increases both the tariff and the 'feed-on' tariff. A home with a solar PV installed decides to curtail their consumption and opt to 'feed-in' more of their PV output to the grid,hence raising their revenue on it;
- An outage in a home or a sub-area is immediately reported (Without the need for customers to call) and tested in network to isolate the problem. This is very similar to how communication networks operate today.
- One can envisage many such situations. In every case, the utility needs to develop very smart protocols and unambiguous, fail safe communication to make this happen. Local, regional and seasonal variations abound; the industry will need some extremely sophisticated simulators and analytical tools for this purpose. Fortunately on a micro-scale, these issues have been solved on IC design problems. It can now extend the same tools and analytical techniques to model and analyze smart grid projects.

22. Alternative energy sources

(a) Solar power

As a parallel to curbing energy consumption, there is an immense thrust all over the world in producing more energy especially in clean and renewable forms. Among the various alternate sources possible solar photo voltaic (PV) is one of the biggest trends and possibly the one that will impact the semiconductor industry. Solar PV generation of energy is one of the primary responses to the energy gap. Especially in places where electrification itself is absent. Solar PV has a much shorter commission cycle,ranging from weeks to months for systems ranging from 3 kW to 5 MW. Even larger solar PV 'farms' can be installed and commissioned in a matter of months. Solar energy is harvested by PV cells to release charge/ current, which is aggregated and used to supply loads.Note that generation is in DC and an Inverter is used to convert the output to AC. Cost is the primary inhibiting factor for solar PV at this moment, though prices of solar PV modules have fallen almost by 40-50% in recent past. Overall grid parity without any subsidies etc is expected in 2011-12 time frame. Currently, many larger installations achieve close to grid parity with subsidies and tax benefits.Note that grid parity is very local in nature in the absence of electrification or frequent blackouts, grid parity is obtained at higher costs, but affordability in these areas is a key barrier. There are three primary trends in the market for solar PV realizations: (i) Residential solar PV: 1-5 kW systems; (ii) Commercial rooftop: 10-250 kW systems (typical,though this goes up to 2 MW sometimes); (iii) Solar PV farms: 250 kW-50 MW, some planned up to 2 GW.

A typical solar PV farm has many similarities to the IC design process, with of course, many subtle differences.In many ways, an IC is a vast 'array' of standard cells consuming electricity, connected to a trunk/grid that itself is supplied by a step down DC power supply which in turn is connected to AC mains. In solar PV farms,the process reverses, cells generate DC electricity, connect to local trunks which in turn gets inverted and scaled up to AC. Solar PV is a game changer and a new paradigm in many ways. It will see a shift from remote AC generation and HVAC distribution to local, direct DC generation and distribution. Grid characteristics fundamentally change with solar PV and will need a 'democratization' of the grid i.e multiple local small generators interspersed with loads will now connect to a 'smart grid' that is capable of managing this supply and demand dynamically.

There are other ways to generate solar based electricity that are emerging such as solar thermal. These are still nascent and need to be watched to determine if there is opportunity.

(b) Fuel cells

A fuel cell works by catalysis, separating the component electrons and protons of the reactant fuel, and forcing the electrons to travel through a circuit, hence converting them to electrical power. The catalyst typically comprises a platinum group metal or alloy. Another catalytic process puts the electrons back in,combining them with the protons and oxidant to form waste products like water and carbon dioxide. A typical fuel cell produces a voltage from 0.6 to 0.7 Volts at full rated load.To deliver the desired amount of energy, the fuel cells can be combined in series and parallel circuits,where series yield higher voltage,and parallel allows a stronger current to be drawn.Such a design is called a fuel cell stack.

These fuel cell stacks are used to get the planned amount of voltage in a micro grid depending upon the load requirement.

The attraction of fuel cells is their potential for highly efficient conversion to electrical power likely 35 to 55% without recovery. The ability of a fuel cell to change load levels is dictated by its ability to produce more voltage through consumption of additional fuel. They show great promise for use in micro grids because they combine high efficiency, high reliability and quiet operation. Their biggest drawback is high cost.

(c) Photo voltaic (PV) cells

PV devices rely on sun light to produce DC voltage at cell terminals.The amount of voltage and current that PV systems use can produce depend on the intensity of sun light and the design of the cell. PV systems use arrays that are either fixed or track the sun to capture additional energy using micro controllers. Because solar energy is a diffuse takes a large area of PV cells to produce significant power. To reduce the number of costly PV devices used, mirrors or lenses can be used to concentrate sun light on to the cells. This increases the PV cell output but requires tracking devices to ensure that the array is aligned with the sun light. While the sun shines, PV systems operate with high reliably, quietly and with no emissions.

(d) Wind turbines

A wind turbine is a rotating machine which converts the kinetic energy in wind into mechanical energy. If the mechanical energy is then converted to electricity, the machine is called a wind generator, wind turbine, wind power unit (WPU), wind energy converter (WEC), or aero generator. The generator component, which is approximately 34% of the wind turbine cost, includes the electrical generator, the control electronics, and most likely a gearbox component for converting the low speed incoming rotation to high speed rotation suitable for generating electricity. Wind turbines may also be used in conjunction with a large vertical solar updraft tower to extract the energy due to air heated by the sun.

(e) Biodiesel generator

B20 is a blend of 20% by volume bio diesel with 80% by volume petrol diesel. B20 is methyl or ethyl ester of fatty acid of made from virgin or used vegetable oils and animal fats. Jatrophanol + methanol (CH_3OH) + KOH – bio diesel + glycerine. Key products are bio diesel, bio fertilizer (seed cake) and glycerine. Its advantages are low sulpher dioxide emissions, high flash point around 150 degrees centrigrade compared to 77 degrees for petroleum diesel. No special engine design is needed. B100 reduces CO_2 emissions by more than 75% over petroleum diesel and use of blend of 20% bio diesel reduces CO_2 by 15% and fewer particulate matters.

Bio diesel generator is the combination of a diesel engine with an electrical generator (often called an alternator) to generate electric energy. A conventional diesel engine without modifications can be used for electricity production using B20. Diesel generating sets are used in places without connection to the power grid or as emergency power supply if the grid fails. Small portable diesel generators range from about 1 to 10 kVA may be used as power supplies on construction sites or as auxiliary power for vehicles such as mobile homes.

(f) Micro turbine

The capstone micro turbine generator is composed of a fuel system, a turbo generator and a digital power controller (DPC). It operates on high pressure natural gas or low pressure gas with optional gas compressor.Fuel flow is controlled by the position of the smart proportional valve (SPV). Fuel flow for the low pressure unit is controlled by a variable speed gas compressor. The turbo generator includes a compressor, recuperator, combustor, turbine and generator. The output of the generator is variable voltage, variable frequency AC power. The shaft rotates at up to 96,000 RPM. During the micro turbine's start up, the generator is used as the starter motor. The DPC converts the variable frequency power from the generator into grid quality power at 400-480 volts, three phase AC and 50/60 Hz.

23. Standards of smart grid technology

In absence of standards, Bureau of Indian Standards, Central Electricity Authority, manufactures and other government agencies have to take lead and collaborate with other working groups world wide, those who are actively participating in formulating the standards and the standard specifications.

IEC TC57 has created a family of international standards that can be used as part of the smart grid. These standards include IEC61850 which is architecture for substation automation and IEC61970/61968 – the common information model (CIM). The CIM provides for common semantics to be used for turning data into information.

Some of the experts believe that the lack of industry standards for security, reliability, data sharing and privacy could result in government money waste on proprietary smart grid technologies that are not inter operable with each other and may be becoming obsolete within a short while, however it can go slow and should not stop.

24. Standardization of energy meter parameters

The present day electronic meter goes beyond metering and provides relevant and meaningful data. The range of data covers billing quantities,electrical parameters, tamper details and historical data. There are also high end meters capable of meeting the needs of import/export category, ABT and power quality measurements. Most of the distribution setups have resorted to electronic meters,thanks to the sufficient production base in the country which has been rising to the needs of quality meters, by their clients with support of country wide test houses like CPRI, ET and DC, ERDA and other laboratories.

The industry is also supporting the reading of meter data through HHUs or remotely. The distribution companies in their quest for improving the MBC process started adopting various degree of automation which centered on IT systems for delivering the desired outputs. Under this scenario the retrieval of meter data was found to be challenging due to plethora of proprietary protocols, with which data are structured by each of the manufacturers. The irony was that in a cosmopolitan type of network, information about those structures is reported to be not freely available there by choking the process of automation. This misery was traced to the lack of a common (open) meter data reading protocol not only in India but in other countries as well and the issue was deliberated at various national forums.

The IT empowerment of power distribution is round the corner through Part-A of the APDRP programme which aims at establishment of base line data creation for ultimate objective of 15% AT and C loss level. Some of the activities are consumer indexing, asset mapping, GIS mapping, integrated MBC, energy account and auditing and AMR on DT and feeders. In other words a modern metering system capable of interfacing with IT infrastructure to facilitate communication directly with the AMR systems and transforming in to an AMI is needed. The common open metering protocol forms an important ingredient for realizing the full capabilities of an AMI system.

The common protocol often referred to as “O Protocol” exists in the form of standards.The various parts of IEC 62056 standards address all aspects of protocol. The standard was evolved by DLMS UA and subsequently adopted by the IEC in 2002. This standard enables a structural approach for exchange of meter data. The system and semantics for this open protocol are well documented. Most of the meter parameters defined as objects. This protocol is independent of communication medium and supports interoperability.

In an attempt to introduce interoperability standardization of energy meter parameters in India, a committee was formed under the chairmanship of Director General, CPRI to standardize the parameters. The general guideline adopted in this process is that the data required for the envisaged applications like energy accounting, billing, energy auditing system analysis etc, shall have prime importance and other data considered useful in the IT empowered scenario shall also be included in the list. The meters shall be able to provide identified data for designated usage at the host computer.

The following energy meters are recommended to be brought under the ambit of standardization of parameters:

(a) Energy accounting and audit meters: The energy accounting and audit meters are identified for use at sub-station feeders and distribution transformer centres. These meters would record energy flow in one direction.

(b) Interface meters: The interface meters are identified for use at meter banks, network boundaries, for ABT based metering and wherever consumer is drawing/injecting from/to the grid and

(c) Consumer meters: The consumer meter is identified for HT PT and CT operated and LT CT operated consumer meters who import energy.

In line with the above, the parameters have been identified and it is expected that the recommendations will be adopted by the government in order to bring in the much needed standardization in energy metering. This would also enhance the prospects of establishment of smart grid by achieving interoperability of energy meters and advanced metering infrastructure.

25. Conclusions

So, it can be concluded that:

- The evolution of smart grid is still in its nascent stage.The entire power society is busy now in understanding and developing smart power grid system which is no longer a theme of future.
- Some of the utilities are progressive and have come forward to implement new technologies in their network for getting hands on experience and would like to be the first to use latest technology, where as many utilities are still looking forward to share the experiences gained by the others before implementing the new devices/ technologies in their networks (deferred risk and higher development costs).
- Some of the technologies may be improving the system reliability and increasing the life of the equipment/system, however not providing the direct monitory benefit to the utility,do not get much attention as a mind set.
- Off-setting the peak demand by renewable generation, plugging hybrid vehicles for charging during off-peak load duration.
- With smart communication between end user and the service/power provider,power consumption can be optimized. The customer is ignorant about the status of grid overloading,cost of the power at any instant of time in order to schedule its consumption to optimal use.
- At the moment it is difficult to access or predict the contribution of smart grid technology to the Nations's energy efficiency applicable for the present grid and there may be other variables too.
- In the coming years,many distribution systems will not resemble the distribution systems of today. These systems will have advanced metering, robust communications capability, extensive automation and distributed generation. Through the integrated use of these technologies, smart grids will be able to operate, provide high degree of reliability and power quality.

- There will also be muti-directional power flow possible, increased equipment utilization and more importantly, the customers will be offered a variety of services possibly at lower costs.
- Intelligent or smart grids,the vision unfolded,would soon becomes a reality in a couple of years.Increasing energy demands, depletion of natural resources, effect of carbon emissions, need for a sustainable environment together with changing life styles requiring increased automation, make smart grids an inevitable option of the future.
- The only viable way to realize an extensive smart grid is to develop a vision for the ultimate design of a smart grid and then make short term decisions that incrementally transform existing distribution systems into this future vision.Within a utility culture of annual budget cycles and hard-to-change standards,this is a tall order. What is needed now is an effort to develop an integrated vision for smart grid, and strong leadership to ingrain this vision on the people who are ultimately responsible to make it happen.
- We are at the genesis of a worldwide overhaul in the way electric power is generated, distributed and consumed.It will take a decade or two for this whole transition to take place,but the seeds are being sown now. Hence, this market represents many opportunities to penetrate the ecosystem both by exploiting adjacencies as well as exploring new areas.Fundamental to this revolution is an understanding of how to measure and control voltage, current, power, energy – whether on the load side, generation side or in distribution. An understanding of alternate energy (especially solar PV), which is very closely tied to energy efficiency markets is essential.
- The industry will need very sophisticated analytical tools to ensure that coming generations of grid design are safe. These are available in other domains and need to be retargeted to the electrical world.
- The major power quality events which are delineating the electrical transmission efficiency can be eliminated using micro grid as a perfect solution. Even voltages and frequencies can be uniformed by adding power electronic interfaces to each component of a micro grid. Micro grid with its unique features is the only alternative to large UPS, SMPS systems used as a solution for sensitive load problem in the IT, electronic component manufacturing industries.Micro grid also can be a well established approach to provide electricity to remote areas of our country.

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