SMART GRID

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***Abstract*—**

This paper describes the concept of how to utilise the electric power efficiently with increased reliability, quality, quantity, sustainability of the production and distribution of electricity by normal power grid into smart grid.

***Keywords*—** Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Demand Response, Self-healing, network protocol, smart meter

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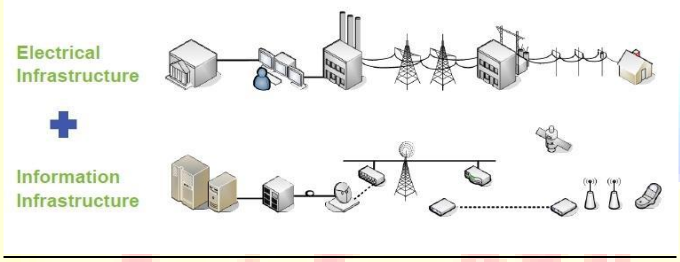
I. INTRODUCTION

Current days many countries have awareness to reduce the carbon footprint produced during electric power generation. They think many ways to reduce the carbon footprint; the common think is to reduce carbon footprint by increasing renewable energy resources, decreasing fossil fuel usage, eliminating conventional vehicle by electric vehicle, reduce energy loss in grid managing greater total demand enabling more customer control of both demand and supply. The above can be achieved by “SMART GRID”

In the early of 21st century so many developments take place in the field of Power Electronics, Telecommunication and Computing Technology. Due to this technology development, we can convert our power grid into smart grid. This technology is a combination of electrical infrastructure with collection of devices, communication infrastructure and the data manage system that supports the information. The electrical infrastructure consists of transmission and distribution system with normal power grid, the collection of devices consists of sensors, meters etc., and in the communication infrastructure consists of modern communication technology to transmit and receive data.



II.ORGIN OT THE TERM “SMART GRID”

The term smart grid has been in use since at least 2005, when it appeared in the article "Toward A Smart Grid" by Amin and Wollenberg. The term had been used previously and may date as far back as 1998. There are many smart grid

definitions, some functional, some technological, and some benefits-oriented. A common element to most definitions is the application of digital processing and communications to the power grid, making data flow and information management central to the smart grid.

To achieve a Smart Grid, the industry must merge copper and steel (electricity generation and delivery infrastructure) with silicon and glass (computation and communication infrastructure). And by Smart grid we can provides two way power flow and information between power plant and consumer. We can make instantaneous Demand balance by real time monitoring.

III.REASON TO CREATE NATIONAL SMART GRID

There are two reasons to create a national smart grid. First, today's grid needs to be upgraded because it is aging, inadequate, and out-dated in many respects investment is needed to improve its material condition, ensuring adequate capacity exists, and enable it to address the 21st-century power supply challenges. Second is to overcome the following challenges such as inadequate access to electricity, supply shortfalls (peak and energy), huge network losses, poor quality and reliability and rampant theft.

IV.SMART GRIDS BENEFITS

- Improved operating efficiencies of delivery companies and electricity suppliers will reduce their operating, maintenance and capital costs, keeping downward pressure on electricity prices for all consumers.
- Self-healing from power disturbance events.
- Enabling active participation by consumers in demand response.
- Better match of demand with supply of energy and grid congestion.
- Improved Grid Usage, flexibility and power quality as per the need of 21st century economy.
- Reduced losses to society from power outages and power quality issues.
- Increased access to renewable energy resources by micro power plant (like solar and wind).
- Power theft is eliminated and Economic Growth in improved.
- Lowered carbon footprint and reduced emissions.

- We can replace the fossil fuel transportation by Electric Vehicle (EV).

V.THE SMART GRID'S FIVE CAPABILITIES

A.Demand Response

Demand response provides an opportunity for consumers to play a significant role in the operation of the electric grid by reducing or shifting their electricity usage during peak periods in response to time-based rates or other forms of financial incentives. This also provides the capacity of the user or operator to adjust the demand for electricity at a given moment, using real-time data. Demand response can take the form of active customer behaviour in response to various signals, generally the price of electricity at the meter, or it can be automated through the integration of smart appliances and customer devices which respond to signals sent from the utility based on system stability and load parameters. For example, a residential hot water heater could be turned OFF by a utility experiencing high electricity loads on a hot day, or could be programmed by its owner to only turn ON at off-peak times. Active demand management can help smooth load curves, which in turn can reduce the required reserve margins maintained by electricity generators.

It is important to note that demand response and energy conservation are not one and the same. Successful demand response smoothest out consumption levels over a 24-hour period, but does not encourage decreased consumption. Smart grid technologies that promote a reduction in the use of electricity include the Advanced Metering Infrastructure (AMI) and the Home Area Network (HAN), both of which allow for increased customer control over their energy use.

B.Facilitation of Distributed Generation:

As demand response is the management of system outputs, the facilitation of distributed generation is the management of system inputs. Some in the industry refer to the combined optimal management of both to be the "Achievement of Flow Balance." Traditionally, the grid has been a centralized system with one way electron flows from the generator, along transmission wires, to distribution wires, to end customers. One component of the smart grid allows for both movement and measurement in both directions, allowing small localized generators to push their unused locally generated power back to the grid and also to get accurately paid for it. The wind and the sun however, generate energy according to their own schedule, not to the needs of the system. The smart grid is meant to manage intermittency of renewable generation through advanced and localized monitoring, dispatch and storage.

In addition to intermittency challenges, distributed generation can cause instances of "islanding" in which sections of the grid are electrified even though electricity from the utility is not present. Islanding can be very dangerous for utility workers who may not know that certain wires have remained live during a power outage. Ideally, real time information will allow islanded customers to remain in service, while posing no risk to utility workers. Again, the automation afforded by the smart grid offers a means to this end.

C. Facilitation of Electric Vehicles:

We already know that conventional vehicle used by people all over the world produce high carbon emission and the usage of this is increased rapidly. To minimize the usage of conventional vehicle with the increased usage of Electrical Vehicles (EVs) this lead to eliminate the carbon footage to lower level. Electrical Vehicle uses electrical power for their traction. They store power in battery for running so it needs charging rapidly. In normal grid by using Electrical Vehicles will mostly increase the power demand to little higher. So this time the smart grid shows its other beneficial technologies as well. Most notably, it can support advanced loading and pricing schemes for fuelling Electric Vehicles (EVs). Advanced Metering Infrastructure would allow customers to recharge at off-peak hours based on expected prices and car use patterns, while bidirectional metering could create the option for selling back stored power during on-peak hours.

Although significant EV penetration is still a medium to long-term projection, some cities and regions have started experiments and the existence of a smart grid is essential to their uptake. The area of the smart grid provides an illustrative example of the potential risk to utilities of getting caught in the middle. Many policy makers and car manufacturers correctly point out that widespread charging infrastructure may help incest customers to switch to electric vehicles. While this is true, we must recognize that charging infrastructure alone may not be enough to change customer behaviour; until a breakthrough technology is discovered by the automotive industry, electric vehicles will still have relatively high price tags and limited range. As such, prudence dictates that utility investments in EV infrastructure ought to respond to the automotive purchasing patterns of their customers rather than laying the groundwork for a fuel switch that is still largely dependent on technological breakthroughs. If utilities invest in infrastructure now, and the EV market takes longer than promised to develop, customers may not feel well served.

D. Optimization of Asset Use:

Monitoring throughout the full system has the potential to reduce energy losses, improve dispatch, enhance stability, and extend infrastructure lifespan. For example, monitoring enables timely maintenance, more efficient matching of supply and demand from economic, operational and environmental perspectives, and overload detection of transformers and conductors. In addition, network enhancements and in particular, improved visualization and monitoring will enable "operators to observe the voltage and current waveforms of the bulk power system at very high levels of detail." This capability will in turn provide deeper insight into the real-time stability of the power system, and the effects of generator dispatch and operation and thereby enable operators to optimize individual generators, and groups of generators, to improve grid stability during conditions of high system stress.

Or as Miles Keogh, Director of Grants and Research at the National Association of Regulatory Utility Commissioners in the US, argues in a recent paper, system optimization an occur "Through transformer and conductor overload detection, volt/var control, phase balancing, abnormal switch identification, and a host of ways to improve peak load management." Thus, as he concludes, "while the smart meter may have become the 'poster child' for the smart grid, advanced sensors, synchro-phasors, and distribution automation systems are examples of equipment that are likely to be even more important in harnessing the value of smart grid."

E. Problem Detection and Mitigation:

Intelligent monitoring on a smarter grid allows for early and localized detection of problems so that individual events can be isolated, and mitigating measures introduced, to minimize the impact on the rest of the system. The current system we used to monitor the system is supervisory control and data acquisition (SCADA). While SCADA and other energy management systems have long been used to monitor transmission systems, visibility into the distribution system has been limited. As the grid is increasingly asked to deliver the above four capabilities, however, dispatchers will require a real-time model of the distribution network capable of delivering three things: 1) real-time monitoring (of voltage, currents, critical infrastructure) and reaction (refining response to monitored events); 2) anticipation (or what some industry specialists call “fast look-ahead simulation”); and 3) isolation where failures do occur (to prevent cascade tripping).

Intelligent monitoring on a smarter grid allows for early and localized detection of problems so that individual events can be isolated, and mitigating measures introduced, to minimize the impact on the rest of the system. The current system of SCADA, much of it developed decades ago, has done a reasonably good job of monitoring and response. But it has its limits: it does not sense or monitor enough of the grid; the process of coordination among utilities in the event of an emergency is extremely sluggish; and utilities often use incompatible control protocols—i.e. their protocols are not interoperable—with those of their neighbours.

A more reliable grid is also a safer grid. First, as discussed previously, smart grid technology allows for “anti-islanding” when needed. Detection technology can ensure that distributed generators detect islanding and immediately stop producing power. Second, power failures can leave vulnerable segments of the population, such as the sick or elderly, exposed to the elements or without power required by vital medical equipment. Third, safety is also enhanced through electricity theft reductions.

VI. FIVE FUNDAMENTAL TECHNOLOGIES THAT WILL DRIVE THE SMART GRID

- Integrated communications, connecting components to open architecture for real-time information and control, allowing every part of the grid to both ‘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 superconductivity, storage, Power Electronics and diagnostics
- Advanced control methods, to monitor essential components, enabling rapid diagnosis and precise solutions appropriate to any event
- 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

VII.DEVICE AND TECHNOLOGY USED TO IMPLEMENT SMART GRID

The five capabilities just reviewed are demand response, facilitation of distributed generation, facilitation of electric vehicles, optimization of asset use, and problem detection and mitigation have excited considerable interest in policy discussions about the smart grid. To assess the merits of each, however, we ought to bear in mind that their value is derived from their ability to contribute towards the three ultimate objectives of increased resilience, improved environmental performance, and operational efficiencies.

In other words, we need to consider their contribution in practical terms. This question of practicality gives rise to a consideration of the building blocks needed to implement the various capabilities. Implementation of a smart grid will require investments and changes in tangible infrastructure complemented by investments and changes in soft infrastructure. A detailed understanding of the benefits and challenges for both of these categories is required when assessing the business case for the various capabilities of the smart grid.

A) Hardware Infrastructure

Key investments and changes in tangible infrastructure to deliver smart grid capabilities are the following:

1) Advanced Metering Infrastructure (AMI)

AMIis an approach to integrating consumers based upon the development of open standards. It provides consumers with the ability to use electricity more efficiently and provides utilities with the ability to detect problems on their systems and operate them more efficiently. AMI enables consumer-friendly efficiency concepts like “Prices to Devices” to work like this: Assuming that energy is priced on what it costs in near real-time a Smart Grid imperative price signals are relayed to “smart” home controllers or end consumer devices like thermostats, washer/dryers and refrigerators the home’s major energy-users. AMI can also enable net-metering which allows for the flow of electricity onto the grid from residential or commercial distributed power generation. The devices, in turn, process the information based on consumers learned wishes and power accordingly. The house or office responds to the occupants, rather than vice versa. Because this interaction occurs largely “in the background,” with minimal human intervention, there’s a dramatic savings on energy that would otherwise be consumed.

This type of program has been tried in the past, but without Smart Grid tools such as enabling technologies, interoperability based on standards, and low-cost communication and electronics, it possessed none of the potential that it does today.

2) Visualization technology.

Consider grid visualization and the tools associated with it. Already used for real-time load monitoring and load-growth planning at the utility level, such tools generally lack the ability to integrate information from a variety of sources or display different views to different users. The result: Limited situational awareness. This condition will grow even more acute as customer-focused efficiency and demand-response programs increase, requiring significantly more data as well as the ability to understand and act on that data.

3)Phasor Measurement Units.

Popularly referred to as the power system's "health meter".Phasor Measurement Units (PMU) samples voltage and current many times a second at a given location, providing an "MRI" of the power system compared to the "X-Ray" quality available from earlier SCADA technology. Offering wide-area situational awareness, phasors work to ease congestion and bottlenecks and mitigate or even prevent blackouts.

Typically, measurements are taken once every 2 or 4 seconds offering a steady state view into the power system behaviour. Equipped with Smart Grid communications technologies, measurements taken are precisely time-synchronized and taken many times a second (i.e.,30 samples/second) offering dynamic visibility into the power system.

4) Network devices and enhancements

Grid enhancements will be required to integrate additional renewable and distributed generation into the grid. These enhancements will include enhancement of monitoring systems more locations, with better visualisations and improved simulations, as well as improved data processing across the entire grid. They will also include advanced voltage control, increased fault detection, digitization, and automatic system protection practices. These improvements have the potential to limit losses, optimize integration of distributed resources and electric vehicles, and enhance the resilience of the system. The distribution grid in particular, as opposed to the already quite "smart" transmission system, could gain significantly from centralized optimization through remote monitoring and control.

5) Distributed energy storage

Distributed energy storage has the potential to optimize the stability of the power supply resulting in reduced grid losses, reduced power outages and improved power quality. Local storage will also enable increased penetration of renewable resources and ensure their integration will not reduce the stability and reliability of energy supply. The main obstacle for employing additional "Flexible storage solutions such as batteries, or pumped storage, are their relatively high cost. Plug-in electric vehicles could provide distributed storage, but significant penetration is still many years out and it is not yet clear how substantial the storage contribution from electric vehicles will prove to be.

6) Household appliances

To get the full value from the smart grid, customers will require appliances to communicate with a HAN that will optimize electricity use depending on market signals (and within limits set by the customers). The magnitude of the replacements or retrofits required a change that will be dispersed across millions of households poses some clear challenges at the interplay of technology, standardization among suppliers, and customer behaviour.

B. Soft Infrastructure

Soft infrastructure required includes the following issues:

1) Interoperable communication standards and protocols

The smart grid must have robust protocols and standards to ensure interoperability of smart grid devices and systems. The National Institute of Standards and Technology (NIST), the federal entity tasked with developing smart grid standards in the US context, provides four good arguments. First, without standards there is a risk that “The diverse smart grid technologies that are the objects of these mounting investments will become prematurely obsolete”. Second, and worse “They could be implemented without adequate security measures” to elaborate on the security point, if the technology is proprietary and only well understood by its proponents, it could contain vulnerabilities to hackers or even terrorists.Third, a “Lack of standards may also impede future innovation and the realization of promising applications” .Then the fourth is, on a related note, “standards enable economies of scale and scope that help to create competitive markets” A lack of standards may encourage monopolistic and rent-seeking behaviour. There is also a fifth argument: protection of customer privacy. This issue does not receive enough attention because it has been called the “sleeper issue” of the smart grid but it is now being addressed, for instance by the Privacy Commissioner of Ontario, who has proposed a set of principles to support smart grid development.

2) Cyber security standards

As previously noted in this paper, the addition of communications capabilities to the grid network creates countless additional points of entry into both the utility billing systems and the grid control systems. Cyber security standards are being developed at both the NIST and the IEC levels, but protocols will need to be continually re-assessed and updated. There are two ways to think about this issue. The first is that there are now millions of new hack able points on the electricity grid network. Power supplies might be shut off to critical services such as first responders or hospitals; voltage control devices could be altered, frying equipment and devices attached to the network and co-ordinated attacks could take an entire city offline. It is important to recognize that most power outages today are caused by damage to power lines and poles equipment that is abundant and easy to quickly replace. An attack that requires systematic diagnostic testing and the replacement of equipment that is generally built to order could take weeks or even months.

That is the worst case. The second way to look at the issue is to look to the other industries for which cyber security is critical—banking, wireless communications, government networks, etc. While each of these sectors must remain vigilant of their systems, and attacks do regularly occur, containment protocols have been developed to ensure that hacking attempts can be isolated and dealt with.

3) Customer engagement

We have to create awareness the advantage of smart grid among the people. It will be important for customers to have a much better understanding of the benefits of smart grids, if they are to be introduced effectively and sustainably. Since the high cost of smart grid implementation will, directly or indirectly, be shared by customers, if they are not convinced by claims regarding current and future benefits, they are likely to resist and challenge those costs over time.

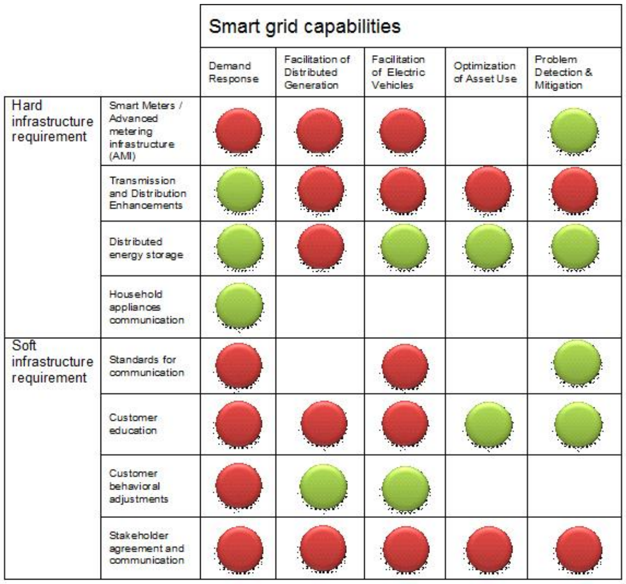
Customers must be made aware that the grid infrastructure is aging and needs to be replaced, and is concurrently being upgraded to take advantage of the latest technologies. Utilities, vendors and policy-makers must deliver on the promised functionality without expecting an immediate reorienting of the typical electric utility customer from passive market participant to active energy manager.

4) Changes in customer behaviour

Complicating this need for customer buy-in is the fact that the value of the smart grid system is intrinsically tied to their willingness to use the tools made available to them to manage their electricity use. It is important to note that households already have an array of options for reducing energy use and saving money that go untapped (e.g., isolation of heating and cooling, better insulation, lighting changes). Thus history shows that even where energy savings have a short-term! Financial pay-off, it may not be enough to convince the customer to act. Customer education will likely need to be combined with regulatory incentives and disincentives before full participation can be realized.

VIII.SUMMARY MAP OF BUILDING BLOCKS

The table below illustrates conceptually the strongest relationships between the various infrastructure requirements or building blocks and the various smart grid capabilities. In other words, there could be relationships other than those identified but these are meant to focus attention on the most important.



		Smart grid capabilities				
		Demand Response	Facilitation of Distributed Generation	Facilitation of Electric Vehicles	Optimization of Asset Use	Problem Detection & Mitigation
Hard infrastructure requirement	Smart Meters / Advanced metering infrastructure (AMI)	🔴	🔴	🔴		🟢
	Transmission and Distribution Enhancements	🟢	🔴	🔴	🔴	🔴
	Distributed energy storage	🟢	🔴	🟢	🟢	🟢
	Household appliances communication	🟢				
Soft infrastructure requirement	Standards for communication	🔴		🔴		🟢
	Customer education	🔴	🔴	🔴	🟢	🟢
	Customer behavioral adjustments	🔴	🟢	🟢		
	Stakeholder agreement and communication	🔴	🔴	🔴	🔴	🔴

🔴 = Necessary requirement

🟢 = Supporting requirement

IX. CONCLUSIONS

This paper has presented the overview of technologies used to upgrade power grid into smart grid. It has been demonstrated that the conventional grids do not provide preferable utility and also the transmission losses in that grid is normally high. Smart grid with SCADA and DAS has proven to be a viable method for converting conventional grid into smart grid making reliable and usable. This system will also reduce losses in the grid by real time demand management.

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