A

Seminar report

On

# Smart Grid

Submitted in partial fulfillment of the requirement for the award of degree
Of Computer Science

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# Preface

I have made this report file on the topic **Smart Grid**; I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to …………..who assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

# Acknowledgement

I would like to thank respected Mr…….. and Mr. ……..for giving me such a wonderful opportunity to expand my knowledge for my own branch and giving me guidelines to present a seminar report. It helped me a lot to realize of what we study for.

Secondly, I would like to thank my parents who patiently helped me as i went through my work and helped to modify and eliminate some of the irrelevant or un-necessary stuffs.

Thirdly, I would like to thank my friends who helped me to make my work more organized and well-stacked till the end.

Next, I would thank Microsoft for developing such a wonderful tool like MS Word. It helped my work a lot to remain error-free.

Last but clearly not the least,I would thank The Almighty for giving me strength to complete my report on time.

# What is Smart Grid ?

The Smart Grid is a combination of hardware, management and reporting software, built atop an intelligent communications infrastructure. In the world of the Smart Grid, consumers and utility companies alike have tools to manage, monitor and respond to energy issues.

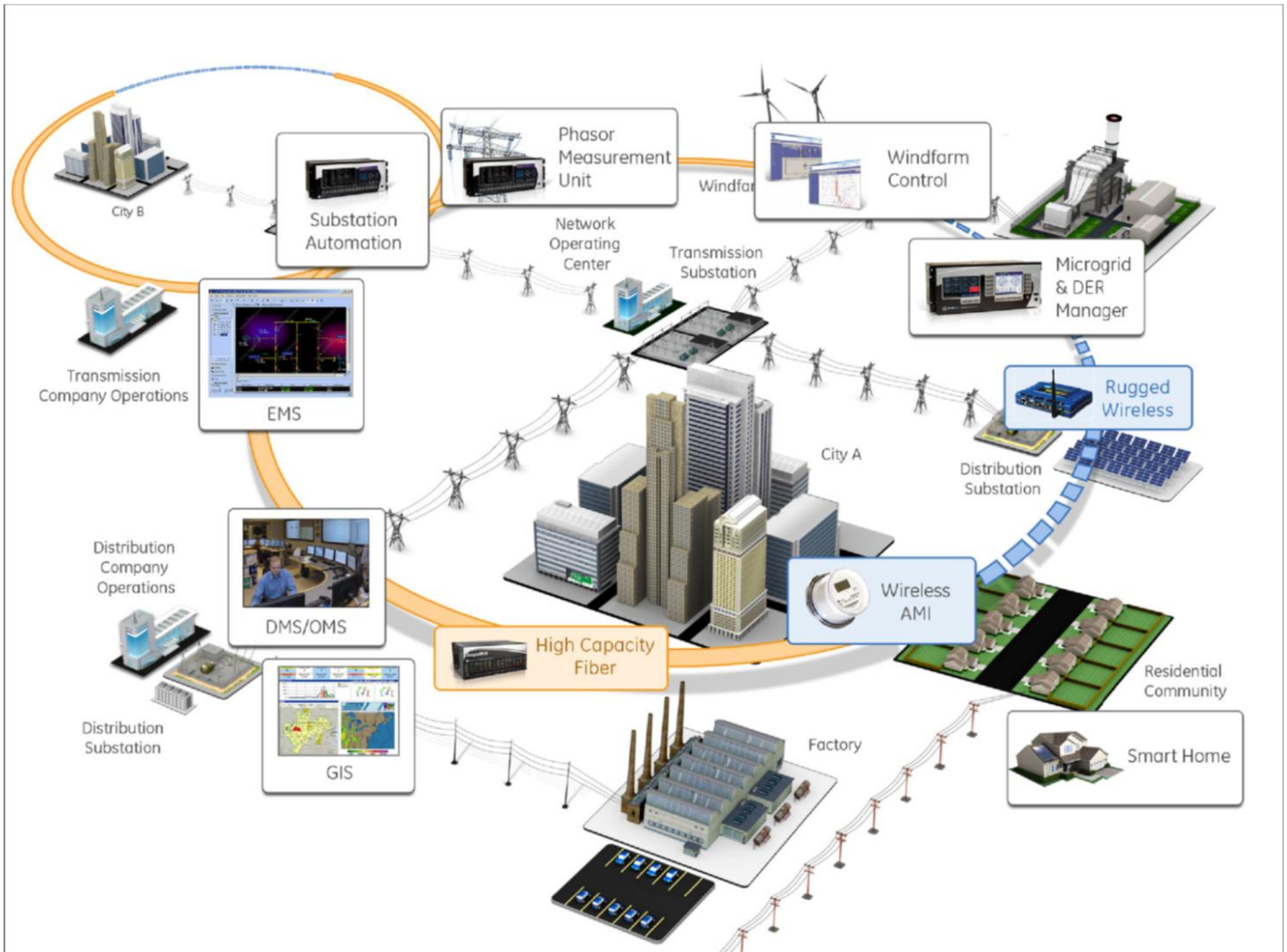
The flow of electricity from utility to consumer becomes a two-way conversation, saving consumers money, energy, delivering more transparency in terms of end-user use, and reducing carbon emissions.

Modernization of the electricity delivery system so that it monitors, protects and automatically optimizes the operation of its interconnected elements – from the central and distributed generator through the high-voltage network and distribution system, to industrial users and building automation systems, to energy storage installations and to end-use consumers and their thermostats, electric vehicles, appliances and other household devices.The Smart Grid in large, sits at the intersection of Energy, IT and Telecommunication Technologies.

## "Smart Grid"

There are many smart grid definitions, some functional, some technological, and some benefits-oriented. The term smart grid to describe an electric grid, has been in use since at least October 1997, when the article Grids get smart protection and control, by Khoi Vu, Miroslav M. Begovic, and Damir Novosel, was published in the journal "IEEE Computer Applications in Power".
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.

Various capabilities result from the deeply integrated use of digital technology with power grids, and integration of the new grid information flows into utility processes and systems is one of the key issues in the design of smart grids. Electric utilities now find themselves making three classes of transformations: improvement of infrastructure, called the strong grid in China; addition of the digital layer, which is the essence of the smart grid; and business process transformation, necessary to capitalize on the investments in smart technology. Much of the modernization work that has been going on in electric grid modernization, especially substation and distribution automation, is now included in the general concept of the smart grid, but additional capabilities are evolving as well.
*Source: wikipedia*


City B
Substation Automation
Phasor Measurement Unit
Windfarm Control
Network Operating Center
Transmission Substation
Microgrid & DER Manager
Transmission Company Operations
EMS
Rugged Wireless
City A
Distribution Substation
Distribution Company Operations
DMS/OMS
Wireless AMI
High Capacity Fiber
Residential Community
Distribution Substation
GIS
Factory
Smart Home

# Why is it important?

Smart Grid refers to an improved electricity supply chain that runs from a major power plant all the way inside your home. In short, there are thousands of power plants throughout the United States that generate electricity using wind energy, nuclear energy, coal, hydro, natural gas, and a variety of other resources.These generating stations produce electricity at a certain electrical voltage.This voltage is then “stepped-up” (increased) to very high voltages, such as 500,000 volts, to increase the efficiency of power transmission over long distances.

Once this electrical power gets near your town or city, the electrical voltage is “stepped-down” (decreased) in a utility substation to a lower voltage for distribution around your town or city. As this electrical power gets closer to your home, it is stepped-down by another transformer to the voltage you use in your home. This power enters your home through your electrical meter. The voltage in your home is typically 110-120 volts for most appliances, but may also be 220-240 volts for an electric range, clothes dryer, or air conditioner.

In many areas of the United States, the electricity delivery system described above is getting old and worn out. In addition, population growth in some areas has caused the entire transmission system to be over used and fragile. At the same time, you have probably added more electronic devices to your home, such as computers, high-definition TV’s, microwave ovens, wireless telephones, and even electronic controls on refrigerators, ovens, and dishwashers.

These new appliances are more sensitive to variations in electric voltage than old appliances, motors, and incandescent light bulbs. Unfortunately, the entire electrical grid is becoming more fragile at the same time the appliances in your home are getting more sensitive to electrical variations. In short, the reliability of electrical power in the United States will decline unless we do something about it now.

Adding new transmission lines will help the utilities get more power from the power plants to your home. However, many communities don’t want new power lines in their areas. In addition, adding new capacity, although needed, will not increase the reliability of all the old electrical equipment reaching the end of its useful life. What is needed is a new approach that significantly increases the efficiency of the entire electrical delivery system. This approach will not only increase reliability, but will also reduce energy in the delivery process and thereby reduce greenhouse house emissions. We call this new approach Smart Grid.

The basic concept of Smart Grid is to add monitoring, analysis, control, and communication capabilities to the national electrical delivery system to maximize the throughput of the system while reducing the energy consumption. The Smart Grid will allow utilities to move electricity around the system as efficiency and economically as possible. It will also allow the homeowner and business to useelectricity as economically as possible. You may want to keep your house set at 75 degrees F in the summer time when prices are low, but you may be willing to increase your thermostat to 78 degrees F if prices are high. Similarly, you may want to dry your clothes for 5 cents per kilowatt-hour at 9:00 pm in stead of 15 cents per kilowatt-hour at 2:00 pm in the afternoon. You will have the choice and flexibility to manage your electrical use while minimizing your costs.

Smart Grid builds on many of the technologies already used by electric utilities but adds communication and control capabilities that will optimize the operation of the entire electrical grid. Smart Grid is also positioned to take advantage of new technologies, such as plug-in hybrid electric vehicles, various forms of distributed generation, solar energy, smart metering, lighting management systems, distribution automation, and many more.

# Components of the Smart Grid

**Most of the Smart Grid technologies are currently ready to be deployed on existing network to make them more efficient at better costs.**

Alstom Grid is a key player to supply Utilities with the technology to adjust and balance energy consumption to energy production with a real-time two-way management of electricity and information.

Our solutions allow the integration of renewable energies and a more efficient electrical transmission and distribution across the whole energy grid.

Alstom's Smart Grid components and engineered solutions give the capacity to analyse, monitor and control Utilities electrical assets and devices at all times, 24/7, including load factor and other grid conditions with digital elements and simultaneous communications technologies installed throughout their electrical network.

This combined subset of interconnections and communication devices added to software permits Utilities to better react to incidents.

At the heart of the Smart Grid revolution, these solutions also provide immediate benefits in many eco-city projects, thus enabling end-consumers to benefit from better energy consumption and sharing, at the heart of the smart cities.

By adding automation, information and communication expertise to the existing power grid infrastructure, Alstom Grid's state-of-the-art integrated technologies – **Substation Automation Solutions**, **Network Management System** and **Smart Power Electronics** - offer grid operators, governments, consumers and all energy chain stakeholders, a set of strategic solutions to churn existing grids into a more sustainable, flexible and efficient electrical network system; allowing:

- A better management of electricity consumption and improved density management during peaks
- A healthier environment by integrating renewable energy sources to the grid and by integrating energy storage solutions for a cleaner, reliable power
- An improved customer service by enabling :
  - Real time pricing to customers, with less errors on bills and more transparency
  - New services like the ability to endorse local green energy consumption and optimisation

- Real-time assessment of system conditions and anomalies caused by bad weather conditions, catastrophes,…
- Quick network repair by anticipation and isolation enabling a rapid restoration of current with adaptive reconfigurations.
- An increased end-users involvement converting “customers” into “prosumers”. Measuring and controlling consumption leads to better usage adjustments and cost management, influencing how and when energy is consumed. Local production and storage can completely change the consumer role.

Alstom Grid’s interoperable and IEC 61850 compliant solutions allow achieving high level availability and reliability of the network.

It also permits full integration with the control room network monitoring and Smart Grid applications such as stability, wide area protection plans, and online condition monitoring.

Moreover, using the IEEE P1547.8 Standard to build the grid establishes a common technical platform where distributed resources and interconnected applications proffer an interoperable Smart Grid and an optimised execution of the network.

# Features of the Smart Grid

The smart grid represents the full suite of current and proposed responses to the challenges of electricity supply. Because of the diverse range of factors there are numerous competing taxonomies and no agreement on a universal definition. Nevertheless, one possible categorisation is given here.

## Reliability

The smart grid will make use of technologies, such as state estimation, that improve **fault detection** and allow **self-healing** of the network without the intervention of technicians. This will ensure more reliable supply of electricity, and reduced vulnerability to natural disasters or attack.

Although multiple routes are touted as a feature of the smart grid, the old grid also featured multiple routes. Initial power lines in the grid were built using a radial model, later connectivity was guaranteed via multiple routes, referred to as a network structure. However, this created a new problem: if the current flow or related effects across the network exceed the limits of any particular network element, it could fail, and the current would be shunted to other network elements, which eventually may fail also, causing a domino effect. See power outage. A technique to prevent this is load shedding by rolling blackout or voltage reduction (brownout).

The economic impact of improved grid reliability and resilience is the subject of a number of studies and can be calculated using a US DOE funded methodology for US locations using at least one calculation tool.

## Flexibility in network topology

Next-generation transmission and distribution infrastructure will be better able to handle possible **bidirection energy flows**, allowing for **distributed generation** such as from photovoltaic panels on building roofs, but also the use of fuel cells, charging to/from the batteries of electric cars, wind turbines, pumped hydroelectric power, and other sources.

Classic grids were designed for one-way flow of electricity, but if a local sub-network generates more power than it is consuming, the reverse flow can raise safety and reliability issues. A smart grid aims to manage these situations.

## Efficiency

Numerous contributions to overall improvement of the efficiency of energy infrastructure are anticipated from the deployment of smart grid technology, in particular including **demand-side management**, for example turning off air conditioners during short-term spikes in electricity price, reducing the voltage when possible on distribution lines through Voltage/VAR Optimization (VVO), eliminating truck-rolls for meter reading, and reducing truck-rolls by improved outage management using data from Advanced Metering Infrastructure systems. The overall effect is less redundancy in transmission and distribution lines, and greater utilization of generators, leading to lower power prices.

**Load adjustment/Load balancing**

The total load connected to the power grid can vary significantly over time. Although the total load is the sum of many individual choices of the clients, the overall load is not a stable, slow varying, increment of the load if a popular television program starts and millions of televisions will draw current instantly. Traditionally, to respond to a rapid increase in power consumption, faster than the start-up time of a large generator, some spare generators are put on a dissipative standby mode. A smart grid may warn all individual television sets, or another larger customer, to reduce the load temporarily (to allow time to start up a larger generator) or continuously (in the case of limited resources). Using mathematical prediction algorithms it is possible to predict how many standby generators need to be used, to reach a certain failure rate. In the traditional grid, the failure rate can only be reduced at the cost of more standby generators. In a smart grid, the load reduction by even a small portion of the clients may eliminate the problem.

**Peak curtailment/leveling and time of use pricing**

To reduce demand during the high cost peak usage periods, communications and metering technologies inform smart devices in the home and business when energy demand is high and track how much electricity is used and when it is used. It also gives utility companies the ability to reduce consumption by communicating to devices directly in order to prevent system overloads. Examples would be a utility reducing the usage of a group of electric vehicle charging stations or shifting temperature set points of air conditioners in a city.

To motivate them to cut back use and perform what is called **peak curtailment** or **peak leveling**, prices of electricity are increased during high demand periods, and decreased during low demand periods. It is thought that consumers and businesses will tend to consume less during high demand periods if it is possible for consumers and consumer devices to be aware of the high price premium for using electricity at peak periods. This could mean making trade-offs such as cycling on/off air conditioners or running dishes at 9 pm instead of 5 pm. When businesses and consumers see a direct economic benefit of using energy at off-peak times, the theory is that they will include energy cost of operation into their consumer device and building construction decisions and hence become more energy efficient. *See Time of day metering and demand response.*

According to proponents of smart grid plans,[*who?*] this will reduce the amount of spinning reserve that electric utilities have to keep on stand-by, as the load curve will level itself through a combination of "invisible hand" free-market capitalism and central control of a large number of devices by power management services that pay consumers a portion of the peak power saved by turning their device off.

## Sustainability

The improved flexibility of the smart grid permits greater penetration of highly variable renewable energy sources such as solar power and wind power, even without the addition of energy storage. Current network infrastructure is not built to allow for many distributed feed-in points, and typically even if some feed-in is allowed at the local (distribution) level, the transmission-level infrastructure cannot accommodate it. Rapid fluctuations in distributed generation, such as due to cloudy or gusty weather, present significant challenges to power engineers who need to ensure stable power levels through varying the output of the more controllable generators such as gas turbines and hydroelectric generators. Smart grid technology is a necessary condition for very large amounts of renewable electricity on the grid for this reason.

## Market-enabling

The smart grid allows for systematic communication between suppliers (their energy price) and consumers (their willingness-to-pay), and permits both the suppliers and the consumers to be more flexible and sophisticated in their operational strategies. Only the critical loads will need to pay the peak energy prices, and consumers will be able to be more strategic in when they use energy. Generators with greater flexibility will be able to sell energy strategically for maximum profit, whereas inflexible generators such as base-load steam turbines and wind turbines will receive a varying tariff based on the level of demand and the status of the other generators currently operating.

The overall effect is a signal that awards energy efficiency, and energy consumption that is sensitive to the time-varying limitations of the supply. At the domestic level, appliances with a degree of energy storage or thermal mass (such as refrigerators, heat banks, and heat pumps) will be well placed to 'play' the market and seek to minimise energy cost by adapting demand to the lower-cost energy support periods. This is an extension of the dual-tariff energy pricing mentioned above.

### Demand response support

Demand response support allows generators and loads to interact in an automated fashion in real time, coordinating demand to flatten spikes. Eliminating the fraction of demand that occurs in these spikes eliminates the cost of adding reserve generators, cuts wear and tear and extends the life of equipment, and allows users to cut their energy bills by telling low priority devices to use energy only when it is cheapest.

Currently, power grid systems have varying degrees of communication within control systems for their high value assets, such as in generating plants, transmission lines, substations and major energy users. In general information flows one way, from the users and the loads they control back to the utilities. The utilities attempt to meet the demand and succeed or fail to varying degrees (brownout, rolling blackout, uncontrolled blackout). The total amount of power demand by the users can have a very wide probability distribution which requires spare generating plants in standby mode to respond to the rapidly changing power usage. This one-way flow of information is expensive; the last 10% of generating capacity may be required as little as 1% of the time, and brownouts and outages can be costly to consumers.

Latency of the data flow is a major concern, with some early smart meter architectures allowing actually as long as 24 hours delay in receiving the data, preventing any possible reaction by either supplying or demanding devices.

**Platform for advanced services**

As with other industries, use of robust two-way communications, advanced sensors, and distributed computing technology will improve the efficiency, reliability and safety of power delivery and use. It also opens up the potential for entirely new services or improvements on existing ones, such as fire monitoring and alarms that can shut off power, make phone calls to emergency services, etc.

**Provision megabits, control power with kilobits, sell the rest**

The amount of data required to perform monitoring and switching one's appliances off automatically is very small compared with that already reaching even remote homes to support voice, security, Internet and TV services. Many smart grid bandwidth upgrades are paid for by over-provisioning to also support consumer services, and subsidizing the communications with energy-related services or subsidizing the energy-related services, such as higher rates during peak hours, with communications. This is particularly true where governments run both sets of services as a public monopoly.

Because power and communications companies are generally separate commercial enterprises in North America and Europe, it has required considerable government and large-vendor effort to encourage various enterprises to cooperate. Some, like Cisco, see opportunity in providing devices to consumers very similar to those they have long been providing to industry. Others, such as Silver Spring Networks or Google, are data integrators rather than vendors of equipment. While the AC power control standards suggest powerline networking would be the primary means of communication among smart grid and home devices, the bits may not reach the home via Broadband over Power Lines (BPL) initially but by fixed wireless.

# Advantages of Smart Grid

- **Economic Development** : The manufacture, installation, operation and maintenance of the smart grid and its components will create new jobs within the state. o Innovation: Smart grid innovation will enable the growth of business while rewarding customers with valuable new products.
- **Lower Costs**: Costs rise over time and energy is no exception, but the smart grid should provide less costly energy than otherwise would be possible. As such, it will save customers money which can be invested or consumed as they choose.
- **Higher Customer Satisfaction**: The combination of lower costs, improved reliability and better customer control will raise satisfaction among all types of customers.
- **Improved Reliability**: Smart grid will reduce and shorten outages and improve the quality of power.
- **Customer Energy/Cost Savings**: As pricing becomes more transparent and is aligned with the underlying economics of generation and distribution, customers' decisions to save money will benefit society as well.

# Disadvantages of Smart Grid

- Biggest concern: Privacy and Security
- Some types of meters can be hacked
- Hackers
  - May gain control of thousands, even millions, of meters
  - Increase or decrease the demand for power
- Not simply a single component
- Various technology components: - software, the power generators, system integrators, etc.
- Expensive in terms of installation

# Conclusion

Smart Grid is a concept designed to provide electricity in more efficient way by better allocating electricity according to consumer's wants. It integrated multiple energy sources and avoid over-generation as well. In foreign countries, namely the UK and USA, started to implement as they see it as a solution of energy and environment pressure in their own country.

In Hong Kong, despite the fact that pilot scheme is running, electricity companies are not very active in promoting Smart Grid in Hong Kong. They are still thinking of the question "**Should Hong Kong implement "smart grid" technology?**" By analyzing arguments for and against Smart Grid deployment, we concluded that Smart Grid is worth doing because of the benefits of energy saving, positive environmental impact and long-term economic outcome. Yet, we also discovered the drawbacks of huge expenses in short-term and the difficulties of lack of funding, public support, problem of privacy and effectiveness. Hence, suggestion on government, companies and citizen levels to settle the foreseeable problem to help the successful implementation of Smart Grid.

# REFERENCES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