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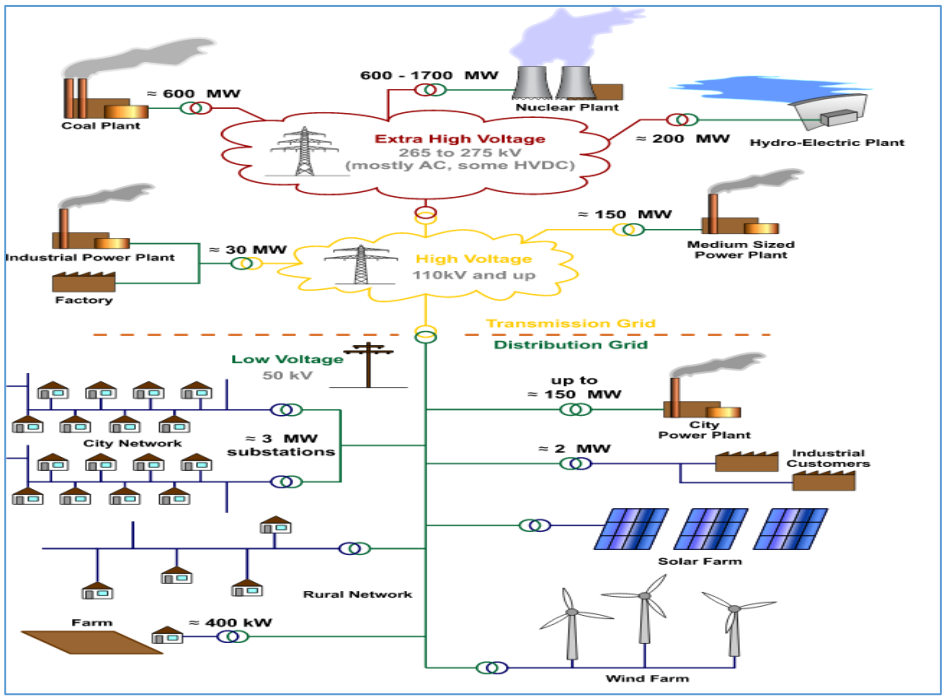
CASE STUDY - SMART GRID

WHAT IS GRID?

Grid in distributed computing architecture is nothing but large number of independent computers connected to solve a complex problem. In the grid computing model, machines utilize the same resources collectively. The grid computing usually consists of one main computer, which basically distributes the information and tasks to the group of computers that are interconnected through network for accomplishing the common goal. The grid computing is used for intricate mathematical or scientific calculations.

WORKING OF CURRENT GRID

The electrical grid is an interconnected network for delivering electricity from suppliers to consumers. The components of electrical grid are power stations that generates electrical power (coal plant, nuclear plant, etc.), transmission lines that carry power from distant sources to demand centers, and distribution lines that carry electricity to individual customer. In order to distribute the electricity to distant locations, the generated electric power is stepped up to a higher voltage and transmitted to wholesale customer via electric power transmission network. When electric power arrives at substation, electric power voltage is stepped down from transmission level voltage to a distribution level voltage. Finally, upon arrival at the service location, the power is stepped down again from the distribution voltage to the required service voltage(s)



PROBLEMS IN CURRENT GRID

Due to rapid industrialization and development in technology, grid becomes crucial part of every nation's infrastructure. But presently, the grid is facing multiple challenges which can be divided in 3 different categories.

1) **Infrastructural problems:** These type of problems occur due to the fact that grid systems are outdated and cannot keep up with increasing demands. This causes frequent network congestions and in turn blackout of extremely costly utilities. These problems spread rapidly because of lack of communication between grid and its control center.

2) **Lack of information and transparency:** Due to lack of information and transparency for customers, they are unable to make optimal decisions relevant to market, so that they can efficiently reduce their consumption in costly peak period.

3) **Inflexibility of grid:** Current grid technologies cannot support the development of renewable source of energies which are more sustainable like solar energy, wind energy, etc. The main problem with this is a grid does not disseminate information to control centers rapidly.

All of these problems can be addressed by the smart grid through improved communications technology, with numerous benefits for both the supply and demand sides.

WHAT IS SMART GRID?

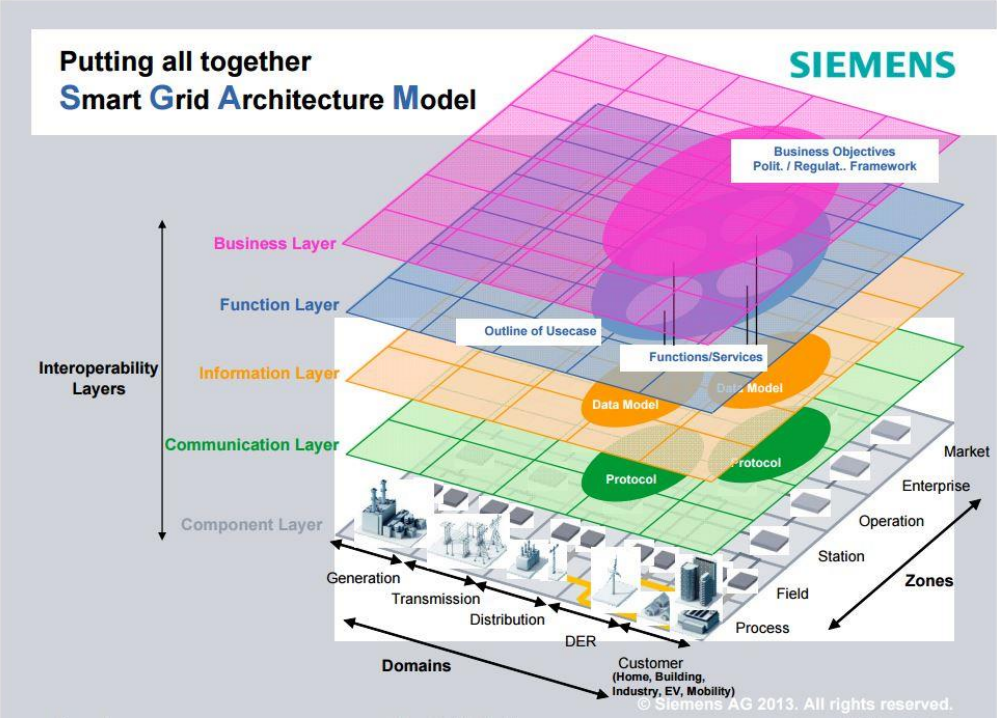
Smart Grid which is intelligent grid or modern grid that uses new technologies to reduce the environmental impact of grid, increasing efficiency, energy conservation, renewable energy utilization. The majority of traditional electricity grids are not designed to comply with climate changes, latest ways of energy-efficiency nor use the latest technologies.

Smart Grid focuses to fulfil increasing demand for electricity, by providing reliability, efficiency and sustainability. Grid which is self-healing, self-balancing and self-optimizing long distance transmission, and automated monitoring and analysis tools based on real-time data about weather, outage history, etc.

Using smart grid, we can create a system, which will exchange electricity and information between utility and its customers, so that we can make grid more efficient, reliable, secure and greener. Smart grid also enables us to integrate other sources of energy like wind, solar, etc. So, smart grid can help us rebuild overall structure of grid system and efficient use of energy resources.

This system can manage demand response actions either by decreasing demand through reduced voltage on the distribution network or regulators can ask consumers to change their electricity consumption patterns when supply is short.

ARCHITECTURE:



1) **Business Layer:** The business layer describes standards related to information exchange concerning smart grid applications. This layer maps several market and economic structures with business models, portfolios of different stakeholders involved in application. This layer helps in decision making while implementing new smart grid applications.

2) **Function Layer:** functional layer illustrates the relationship between different functions and architectural viewpoints. Function description must not be dependent on actual implementation of various system components.

3) **Information Layer:** A smart grid works on exchanging information between different components. To exchange information effectively a specific information data model is used which describes common semantics used in information exchange. The information layer describes these data models and required semantics.

4) **Communication Layer:** Data models described in information layer are used by functional components of the system. But in order to transfer data over network we need specific protocols that can be used by specific functions or services. Communication layer deals with the protocols and various mechanisms to exchange messages between heterogeneous data models or interoperable system components.

5) **Component Layer:** This layer describes all the physical components participating in smart grid. This can range from power system equipment or network equipment to controlling devices or computing devices connected to network.

TECHNOLOGY AREAS:

Major technology areas that facilitate development of smart grid application are as follows:

A. Advance components and control methods:

To develop and deploy a smart grid application we need new improvised electrical components that are capable of handling distributed application. These components include grid friendly cables, semiconductors and appliances capable of processing and transmitting data. Apart from this we need specialized devices to monitor the grid and react or transmit information based on specific events.

B. Integrated communication:

We need new communication channels that can allow transfer of information and power. This must be a two way communication in order to facilitate information exchange, power distribution and fault location.

C. Sensing and measurement

As efficiency of the grid depend largely on fast transmission of data between nodes and deriving information from the data fetched. We need special sensing and measurement devices for converting data to information and evaluate "health" of grid. These devices enable detecting congestion or faults in grid and effective measures can be taken in such cases.

D. Improved interfaces and decision support

The grid should provide better interface for the users to interact. This will make using smart grid smooth and improve decision making via users feedback.

COMPARISON BETWEEN TRADITIONAL AND SMART GRIDS:

TRADITIONAL GRID	SMART GRID
Centralized Generation	Distributed Generation
Electromechanical	Digital
Manual	Restoration Self-healing
One way Communication	Two way communication
No energy Storage	Energy Storage
Total control by Utility	Increased customer participation
Failures and Blackouts	Adaptive and Islanding
Lack of real time monitoring	Extensive real time monitoring
Slow Reaction time	Extremely quick reaction time

SMART GRID FEATURES:

1. Reliability

Improving fault detection and allow self-healing of the network without the human intervention. This will ensure reliable supply of electricity, and reduced vulnerability to natural disasters or attack.

2. Flexibility in network topology

Handling bidirectional energy flows, allowing for distributed generation such as from photovoltaic panels on building roofs, charging to/from the batteries of electric cars, use of fuel cells, wind turbines, hydroelectric power, and other sources.

3. Efficiency

Improvement in energy efficiency by demand-side management, for example turning off heavy gadgets during less energy transmission or short term hikes in electricity prices, reducing the voltage when possible on distribution lines. The overall effect is and greater utilization of generators, less redundancy in transmission and distribution lines, leading to lower power prices.

4. Load adjustment/Load balancing

The total load on power grid varies significantly over time. The overall load is slow varying, increment of the load if millions of televisions will draw current instantly for popular TV show. Using prediction algorithms it is possible to predict number of standby generators needed, to reach a certain failure rate.

5. Sustainability

With smart grid, we are moving towards more sustainable renewable energy sources such as solar power and wind power, etc.

6. Demand response support

With Demand response support, whole infrastructure with generators and loads can interact in an automated fashion in real time, fulfilling demand per sector, allowing users to cut their energy bills by telling low priority devices to use energy only when it is cheapest. Demand forecasting can be done to prepare infrastructure for upcoming requests.

7. Platform for advanced services

Use of robust two-way communications, distributed computing technology will improve the efficiency, reliability of power delivery and use. It also augments the platform for entirely new services such as fire monitoring, automatic alarms to shut off power, calling emergency services, etc.

8. Market-enabling

The smart grid provides platform for suppliers and consumers for communication on prices and consumer's willingness to pay. Suppliers and consumers can be more flexible and come up with their own strategies which kind of suits both parties.

LIMITATIONS:

Following are major barriers in successful implementation and deployment of smart grids:

1. Lack of Standardization:

This is one of the major challenge in developing a smart grid application. As smart grid is a new computational model that involves processing and communicating data between set of nodes we need formal standards that specify protocols and semantics for communication and data models.

2. Government Support:

As smart grid applications require new set of hardware platforms to run, industry or businesses may not have the required financial capability. They will need huge financial support from government and other bodies. As many consumers are not aware of smart grid applications and their benefits amount of investment required are particularly huge.

3. Compatible Equipment:

As existing hardware is incapable of operating in smart grid environment we would need to change equipment to enable use of smart grid applications. This will affect consumers as well as vendors.

4. Security:

Various components of smart grid technology will be communicating between each other to pass information. But this new communication can increase the possibility of security attacks on such systems. To address this developers need to be aware of such threats and make grid capable of reacting to such attacks.

IMPROVEMENTS:

Smart grid with distribution intelligence can be effective in

1. Outage detection and response management activities
2. Identifying and locating faults in grids and quick service restoration
3. Loss minimization with operations planning and analysis
4. Load balancing with advanced switch planning
5. Managing demand response actions – Either by decreasing demand through reduced voltage on the distribution network or regulators can ask consumers to change their electricity consumption patterns when supply is short.

FOCUS AREA FOR THIS PROJECT:

Designing and simulating a distributed intelligence for smart grid system which can provide real-time outage detection, faults locating and handling facilities.

Outage Detection & Fault Handling:

The smart grid can detect the outage of electricity, when we are facing issue like falling of tree on line, lightning strike, or short circuit by using “Distributed Automation” which sense the problem and reroutes the power around it.

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