SMART-GRID IN ELECTRICAL AND ELECTRONICAL COMMUNICATION TECHNOLOGY

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ABSTRACT- The electric power systems (smart grid) are study intensively as a solution for energy . The important feature of the smart grid is the integration of high-speed, reliable and secure data communication networks to manage the complex power systems effectively and intelligently. The survey on the communication architectures in the power systems, including the communication network compositions, technologies, functions, requirements, and research challenges. As these communication networks are responsible for delivering power system related messages. The emerging energy crisis is a global attention on finding alternative energy resources that can sustain long-term industry development. The identified renewable energy resources include wind, small hydro, solar, tidal, geothermal, and waste.

Keyword: Smart grid, Power communications, Communication networks, Communication protocols, Grid standards

INTRODUCTION

A smart grid is a modernized electrical grid that uses analogue or digital information and communications technology to gather and act on information, such as information about the behaviors of suppliers and consumers, in an automated fashion to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity.

Smart grid policy is organized in Europe as Smart Grid European Technology Platform.Roll-out of smart grid technology also implies a fundamental re-engineering of the electricity services industry, although typical usage of the term is focused on the technical infrastructure.

In the 20th century local grids grew over time, and were eventually interconnected for economic and reliability reasons. By the 1960s, the electric grids of developed countries had become very large, mature and highly interconnected, with thousands of 'central' generation power stations delivering power to major load centers via high capacity power lines which were then branched and divided to provide power to smaller industrial and domestic users over the entire supply area. The topology of the 1960s grid was a result of the strong economies of scale: large coal-, gas- and oil-fired power stations in the 1 GW (1000 MW) to 3 GW scale are still found to be cost-effective, due to efficiency-boosting features that can be cost effective only when the stations become very large.

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.

Apart from power systems, networking technologies have gained tremendous development in the past decades as a separate industry sector. The creation of the Internet,mobile cellular networks, satellite networks, communitynetworks, wired and wireless local area and personal networks, as well as the invention of diversified networking services has enormously enhanced our capability for information exchange. However, the modern networking technologies have not been leveraged sufficiently in power systems for optimized management. When we develop the smart grid, it is critical to take advantage of the advancements in networking technologies to enable the automated and intelligent system management. Although the currently available networking technologies have greatly satisfied our personal communication needs, applying them to power systems and addressing the specific requirements for power communications are challenging by all means. We need to identify the communication scenarios and characteristics in power systems and develop practically usable network solutions. Particularly, our network infrastructuresshould be able to meet the promptness, reliability and security expectations of the power system communications.

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.

SMART GRID REFERENCE MODEL

In the smart grid, many distributed renewable energy sources will be connected into the power transmission and distribution systems as integral components. The typical renewable energy sources include wind, solar, small hydro, tidal, geothermal, and waste. These sources generate extra electricity that supplements the electricity supply from large power plants and, when the electricity generated by distributed small energy sources exceeds the local needs, the surplus is sold back to the power grid.

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.

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.

COMMUNICATION ARCHITECTURE AND FUNCTIONAL REQUIREMENTS

Network architecture

The communication infrastructure in smart grid must support the expected smart grid functionalities and meet the performance requirements. As the infrastructure connects an enormous number of electric devices and manages the complicated device communications, it is constructed in a hierarchical architecture with interconnected individual subnetworks and each taking responsibility of separate geographical regions . An illustrative example of this architecture. In general, the communication networks can be categorized into three classes:wide area networks, field area networks, and home area networks.

Wide area networks

Wide area networks form the communication backbone to connect the highly distributed smaller area networks that serve the power systems at different locations. When the control centers are located far from the substations or the end consumers, the real-time measurements taken at the electric devices are transported to the control centers through the wide area networks and, in the reverse direction, the wide area networks undertake the instruction communications from control centers to the electric devices.

Home area networks

Home area networks are needed in the customer domain to implement monitoring and control of smart devices in customer premises and to implement new functionalitie like DR and AMI. Within the customer premises, a secure two-way communication interface called ESI acts as an interface between the utility and the customer. The ESI may support different types of interfaces, including the utility secured interactive interface for secure twoway communications and the utility public broadcast interface for one-way receipt of event and price signals at the customer devices. The ESI may be linked (either be hardwired or through the home area networks) to a smart meter capable of sending metering information. This information is communicated to the utility. The ESI also receives RTP from the utility over the AMI infrastructure and provides it to the customers. The customers may use a display panel (called IHD) linked to the ESI or a web-based customer EMS (residing in the smart meter, an independent gateway, or some third party) and respond to pricing signals from the utility. The ESI and smart devices provide utility with the ability to implement its load-control programs by accessing the control-enabled devices at the customer site. Using AMI, ESI and home area networks, the demand response process can be implemented in the following ways:

DR through AMI gateway.

An AMI gateway, though generally used for automatic billing through AMR, can be used to send load control commands to the smart devices using the secure interface of the ESI. Thus, the load control algorithm may reside with the ESI.

DR through DLC.

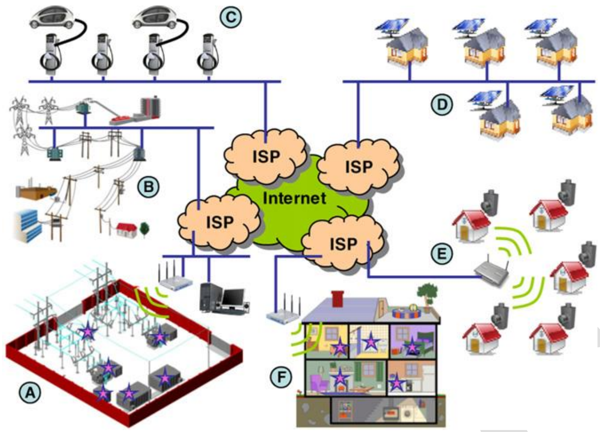
In this case, either the utility or an authorized energy service provider may directly control the smart appliances or DERs configured with such capability. The energy service provider may act as an aggregator of individual customers, negotiate RTP prices with the utility companies, and determine the demand response policy for the registered customers.

DR through BAS.

In this case, the BAS uses the RTP information available on the public channel of the ESI. A BAS has load controllers linked to security installations and building HVAC systems through wireline (e.g., ethernet) or wireless (e.g., ZigBee) communication medium and can exercise demand response.

DR through embedded control.

In this case, the smart device not only has a communication link to the home area network, but also its own load control algorithm. The smart device receives RTP information from the public ESI interface and exercises demand response. For example, a computer implements its own load control algorithm to take charge in accordance with RTP signals.



WHY WE MAKE SMART GRID

Demand for electricity continues to accelerate due to population growth and increased global reliance on electrical technologies.Simultaneously, electric grid infrastructure in the U.S. is aging. As a result,improvements in the underlying electricity infrastructureare necessary the flow of electricity from centralized power plants to the end user in the current grid system.Smooth operation of the electrical system as a whole depends on reliable performance of each one of these components. As electricity needs increase, each component must be able to handle these new demands—or the entire system becomes unreliable.

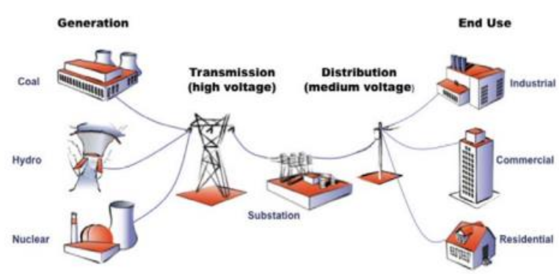


Fig: **current path of electricity generation and delivery to end users.**

IS A SMART GRID A GREEN GRID

Greater integration of renewable generation:

Smart grid technologies help gridoperators better predict daily wind and solar energy generation potential, and more easilyadjust the system for the peaks and valleys of these intermittent resources.

Dynamic pricing and demand response:

Awareness of changing prices can helpencourage consumers to reduce electricity demand during times of peak demand, therebyreducing strain on the system and overall energy consumption.

Enhanced measurement and verification capabilities:

Smart meters allow utilities andcustomers to track electricity use in real time, and to see how behaviors or energy.

SMART GRID IMPLEMENTATION

Difficulty in Measuring Benefits

Many of the benefits of a smart grid come from expected changes in consumer behavior.However, it is difficult to accurately predict how customers will react to price signals. It ispossible that customers may not change their electricity demands much, even when faced withdifferent prices at different times of the day. For example, in Connecticut, customers were given aglobe that glowed different colors based on the price of electricity. Even with this visual signal,however, customers did not change their electricity usage behavior to the extent predicted. Ifoutweigh the benefits. Putting into place proper, complementary policies (such as funding broaderprogrammatic efforts to educate and encourage customers to save energy, and adopting fair ratesand interconnection standards for distributed generation) are therefore critical for successfulimplementation of smart grid.

Cyber security and Privacy Concerns:

Installation of “smart” devices gives potential hackers new targets for exploitation. Because thesedevices monitor and collect large amounts of information, there is concern that customer privacycould be at risk. Since advanced metering infrastructure often relies on wireless technologies,hackers could infiltrate the computer systems to extract recorded information, insert malicioussoftware, identify network authentication keys, and then access other parts of the system using thegrid’s communication systems.

Message from the Assistant Secretary

The adoption of smart grid technologies varies across the nation and depends on many factorsincluding state policies, regulatory incentives, load growth, and technology experience levelswithin utilities. There is a need to share cost, benefit and performance data, as utilities andregulators work to determine the value of the technology and determine appropriateinvestment strategies. It is essential that the industry effectively shares lessons learned andbest practices along the way, especially as new challenges emerge in this transformative time.In addition, the adoption of renewable and distributed energy resources is on the rise; growinginterest in resilience and microgrids has resulted from extreme weather events; and the role ofutilities is evolving as customers also become energy producers. These future demands willrequire a faster-acting, flexible, and sophisticated grid that maintains high reliability andefficiency while integrating new capabilities. This report describes the challenges andopportunities that will shape the next several years of grid modernization

Making the Transitionto a Smart Grid

Smart grid technologies can help enable renewables,but the lack of experience and associated uncertainties—intechnology cost and performance, in costs andbenefi ts and in nontechnical issues such as privacy—make it challenging to settle on a strategy that makesbest use of these technologies.

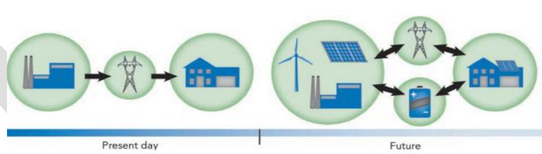


Fig: Smart Grid Transition

Purpose, process andstructure of the roadmap

To provide guidance to government and industrystakeholders on the technology pathways neededto achieve energy security, economic growth andenvironmental goals, the IEA is developing a seriesof global low-carbon energy roadmaps covering arange of technologies. The roadmaps are guidedby the IEA Energy Technology Perspectives BLUE MapScenario, which aims to achieve a 50% reductionin energy-related CO_2 emissions by 2050. Eachroadmap represents international consensus onmilestones for technology development, legal andregulatory needs, investment requirements, publicengagement and outreach, and internationalcollaboration.

THE SMART GRID ROADMAP AIMS TO:

1 Increase understanding among a range ofstakeholders of the nature, function, costs andbenefits of smart grids.

2 Identify the most important actions required todevelop smart grid technologies and policies thathelp to attain global energy and climate goals.

3 Develop pathways to follow and milestones totarget based on regional conditions.

Smart grid technologies

The many smart grid technology areas – eachconsisting of sets of individual technologies –span the entire grid, from generation throughtransmission and distribution to various types ofelectricity consumers. Some of the technologiesare actively being deployed and are consideredmature in both their development and application,while others require further development anddemonstration. A fully optimised electricity systemwill deploy all the technology areas.However, not all technology areas need to beinstalled to increase the “smartness” of the grid.

Wide-area monitoringand control

Real-time monitoring and display of powersystemcomponents and performance, acrossinterconnections and over large geographic areas,help system operators to understand and optimisepower system components, behaviour andperformance. Advanced system operation toolsavoid blackouts and facilitate the integration ofvariable renewable energy resources. Monitoringand control technologies along with advancedsystem analytics – including wide-area situationalawareness (WASA), wide-area monitoring systems(WAMS), and wide-area adaptive protection,control and automation (WAAPCA) – generate datato inform decision making, mitigate wide-areadisturbances, and improve transmission capacityand reliability.

Information and communicationstechnology integration

Underlying communications infrastructure,whether using private utility communicationnetworks (radio networks, meter mesh networks)or public carriers and networks (Internet, cellular, cable or telephone), support data transmissionfor deferred and real-time operation, and duringoutages. Along with communication devices,significant computing, system control softwareand enterprise resource planning software supportthe two-way exchange of information betweenstakeholders, and enable more efficient use andmanagement of the grid.

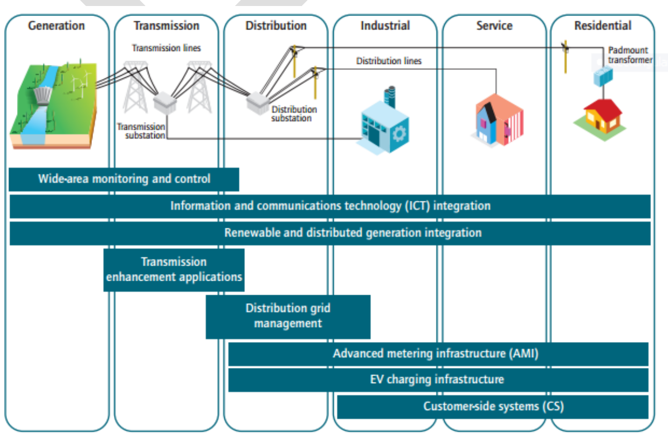


Fig:Smart Grid Technology Areas

Renewable and distributedgeneration integration

Integration of renewable and distributedenergy resources – encompassing large scaleat the transmission level, medium scale at thedistribution level and small scale on commercialor residential building – can present chalengesresources and for operation of the electricitysystem. Energy storage systems, both electricallyand for themally based, can alleviate suchproblems by decoupling the production anddelivery of energy. Smart grids can help throughautomation of control of generation and demand(in addition to other forms of demand response) toensure balancing of supply and demand.

Conclusion

Although there are notable exceptions within some agencies, the federal government hasgenerally failed to provide needed leadership and vision. Congress and high level policymakersseem to be committed more to protecting established industrial and financial interests than toplotting a viable course for the future. At the state level, PUCs and other public officials are tiedto large corporate interests in carbon, to lobbyists, and to political careers. Too often, ratepayers,citizens, and communities are abandoned to their own resources. It is left to the people to"occupy" the grid and transform it to shape a sustainable clean energy. Reliability and securityare thus very challenging problems in the communicationnetwork. Fourth, preliminary experiments indicate that acommunication network must be planned carefully in orderto meet the performance requirement in energy management.Our survey summarizes the current research status on communication networks in the next generationpower systems. Many research efforts are still required before the communication infrastructure can be implementedfor intelligent energy management.

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