Advance Innovations, Thoughts & Ideas

Liao, Int J Adv Innovat Thoughts Ideas 2013, 2:4
http://dx.doi.org/10.4172/2277-1891.1000149

Editorial

Open Access

# Transformation of Electric Power Grid into Smart Grid

**Yuan Liao***

*Department of Electrical and Computer Engineering, University of Kentucky, Lexington, KY 40506, USA*

Smart grid is the future trend of the development of electric power grids. This editorial presents challenges and possible solutions for operation, protection and control of future electric power systems. The need for research and development to realize the smart grid is discussed.

Electric power industry faces many challenges: depleting resources (fossil fuels and water), regulatory and public pressure to reduce pollution, growing load, increasing demand on higher reliability and power quality for a digital economy, and aging infrastructure. On the other hand, there are virtually unlimited, clean renewable energy resources including solar and wind energy waiting to be harnessed. Aimed to utilize more renewable resources and ensure reliability of power systems, the current power industry is under a wave of modernization to transform the current grid into the so called "smart grid". Taking advantage of the latest technologies in computer and networking, communications, signal processing, control, sensing, manufacturing, power engineering, etc., the future power grid will be more resilient, self-healing, more environmentally friendly, and more efficient, accommodate all kinds of generation, provide higher power quality, and provide more choices for customers [1,2].

Power grid comprises the high voltage network, normally 69 kV and above, namely the transmission system, and the low voltage network, below 69 kV, namely the distribution system. The transmission system is already equipped with advanced Supervisory Control and Data Acquisition (SCADA) and Network Management System (NMS). SCADA is a telemetry system that collects real time information from the network, transmits the information to the control center, and passes the command to the field. NMS is a collection of applications such as power flow, contingency analysis, stability analysis, fault analysis, outage management system, economic dispatch, unit commitment, long term resource scheduling, and so on. There are other types of monitoring devices such as digital fault recorders, disturbance recorders, power quality meters, phasor measurement units, and the like. In the future, more Phasor Measurement Units (PMU) will be installed across the transmission grid for enhanced situational awareness, operation and control. Integration of large scale wind and solar generation at transmission level is a challenge due to undispatchability of wind and solar resources. Effective solutions to deal with power angle and voltage stability due to wind and solar power variations are needed. One possible solution is to employ utility scale energy storage techniques such as thermal storage systems (two-tank direct system, two-tank indirect system, or single-tank thermocline system). Practical techniques to optimize and control the grid considering the characteristics of energy storage systems and intermittent energy sources will need to be developed. Schemes for wide area protection and control of transmission networks to reduce cascading faults are needed.

Distribution systems have limited SCADA functionality, limited metering and communication infrastructure. Advanced metering infrastructure is being deployed in distribution grids, which will provide two-way communication between customers and utilities. Consumer load data at a desired time interval, say 15 minutes, will be available to control room for improved operation, control and protection purposes. Applications that benefit from the load data may include voltage and var control and optimization, optimal power flow, asset management, and adaptive protection. Consumers will receive electricity pricing information from utilities, based on which consumers can better manage their own usage of electricity. In demand side management programs, consumer load is controlled by utilities to reduce peak load and consumers get financial benefits in return. Load leveling can greatly improve system reliability and also reduce utility generation capacity. Another important application that is under deployment is integrated voltage and var optimization, where the settings of tap changer transformers, voltage regulators, and capacitor banks are calculated based on the load level and network data to reach the goal of minimizing the system loss or system demand depending on the business need. Solar or wind generation integration is also a great challenge due to power output variability. Fast cloud passing can cause drastic voltage fluctuations at a time resolution of seconds. Trying to chase the fast transients will only lead to excessive wear and tear of mechanical controllers, and has little efficacy due to their large time constants. Tapping the ability of power electronics based smart inverters to quickly change their reactive power output to counter the real power output is a promising way to solve the problem. In a two level control scheme, the mechanical controllers and power electronics devices take care of the longer term system variations (global control) and the power electronics devices cope with the fast changing transients (local control). The global control will provide the base operating point, and smart inverters can act autonomously. In another possible variant scheme, smart inverters can communication with each other and work together, thus resulting in a sub-global control of inverters, where all inverters are optimized to control transient voltages. A short term and long term solar power production method based on real time weather and cloud data will enhance the operation and planning of the power system. Energy storage systems can also be harnessed to compensate for generation variability. Opportunities arise to develop optimization techniques to achieve optimal operation of the entire system.

Advanced outage management system, protection and restoration of distribution systems are other important areas that deserve deliberation. Future distribution grids will no longer be radial and will contain an increasing number of distributed generations. Coordination among substation relays, reclosers and feeder fuses becomes increasingly complex and difficult. In a possible solution, a distribution network is partitioned into zones based on load and

***Corresponding author:** Yuan Liao, Department of Electrical and Computer Engineering, University of Kentucky, Lexington, KY 40506, USA, Tel: 859-257-6064; E-mail: yliao@engr.uky.edu

**Received** September 09, 2013; **Accepted** September 10, 2013; **Published** September 16, 2013

**Citation:** Liao Y (2013) Transformation of Electric Power Grid into Smart Grid. Int J Adv Innovat Thoughts Ideas 2: 149. doi: 10.4172/2277-1891.1000149

generation distribution, which are connected through circuit breakers controlled by relays. When a fault occurs, intelligent algorithms will promptly determine the fault location, and the faulted zone will be quickly isolated from the remaining network through breaker operations. The remaining network will continue to operate with possible re-dispatch of generations and shedding of controllable loads. Increased use of breakers and monitoring devices will increase the cost of protection system and a tradeoff between protection reliability and selectivity and economics needs to be made. Another development is an increased emergence of microgrid. It is a network of loads and generations (e.g. gas turbine, photovoltaic (PV) system, energy storage system, controllable load), which can operate connected to the power grid, or islanded. A microgrid may cover only one resident/consumer (load, PV and battery system), or a community of consumers like a residential community or university campus or industrial park, or an entire distribution system (including all of its loads and distributed generations). Effective methods for protecting and controlling microgrids and the grid are needed [1]. Development of robust hardware including diverse types of smart switches, relays, energy storage systems, and inverters will be indispensable for successful implementation of microgrids. When appropriately operated and controlled, microgrids will be able to reduce outage to critical loads, and provide power and voltage support to transmission grid as well.

Centralized and distributed control will coexist in future grids, robust control is mandatory to ensure reliable operation of the system. Simulation and modeling techniques and tools considering all types of components including physical power networks, various types of generators and loads, controllers, protection devices, communication systems, and various control and protection algorithms need to be developed and verified. Impacts of communication system delays, failures, and throughputs will need to be thoroughly studied and considered.

Ensuring cyber security and consumer privacy is also essential for successful smart grid technology deployment. Appropriate regulatory policies such as electricity rate structure, responsibility of investments and distribution of returns on investment, and renewable energy portfolios will also have great impacts on smart grid development.

In summary, smart grid technologies offer potential solutions to many challenging problems facing the electric power industry. Technological, political, regulatory and societal factors need to be considered when deploying smart grid projects.

## References

1. The Modern Grid Strategy: A Vision for the Smart Grid (2009) U.S. Department of Energy, National Energy Technology Laboratory.
2. The Smart Grid (2009) US Department of Energy.

**Citation:** Liao Y (2013) Transformation of Electric Power Grid into Smart Grid. Int J Adv Innovat Thoughts Ideas 2: 149. doi: 10.4172/2277-1891.1000149