Available online at www.sciencedirect.com

SciVerse ScienceDirect

Energy Procedia 17 (2012) 1524 – 1528

Energy Procedia

2012 International Conference on Future Electrical Power and Energy Systems

Architecture Design For Smart Grid

Yu Cunjiang, Zhang Huaxun, Zhao Lei

Electronics and Information Engineering College , Changchun University, Changchun, China

Abstract

This paper analyzes the current grid and point outs its disadvantages; according to the present demands from power users, presents the characteristics of smart grid and its technical components, finally puts forward smart grid architecture.

Keywords: component; smart grid; robust; compatibility; power

1. Introduction

The electric power system delivery has often been cited as the greatest and most complex machine ever built. It consists of wires, cables, towers, transformers and circuit breakers—all bolted together in some fashion, as shown in Figure 1.

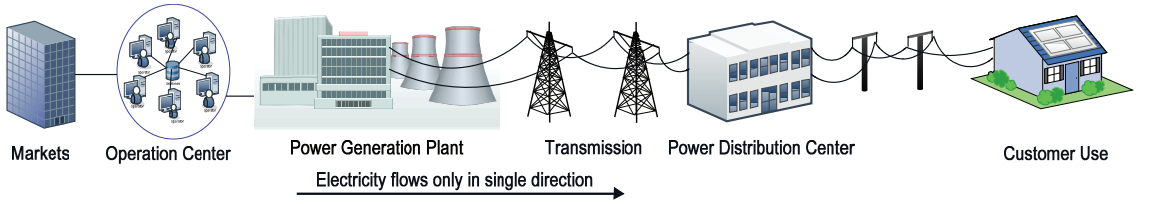

Figure 1 Electric power system

The conventional grid is a robust system, lacks of robustness to the access and departure of power and transmission of electric energy, which results in lacking of flexibility and assemblability; the multilevel control mechanism responses slowly, can not satisfy the need to construct a real-time, reconfigurable, and restructured system; its self-healing and self-restore capability completely depends on entity redundancy; simple customer services and one-way transmission lead to information islands and lacking of information

1876-6102 © 2012 Published by Elsevier Ltd. Selection and/or peer-review under responsibility of Hainan University.
doi:10.1016/j.egypro.2012.02.276

sharing. Although local automatic levels have been improving continuously, intrinsic characteristics of the conventional grid is always the same, so the infrastructure of the conventional grid is doomed to be changed.

According to the statistic figures from China Electrical Power Technology Holdings Limited (CEPT), by the end of 2007, in China, total installed capacity= 713.3 GW, while total generated = 3,256 bn kWh, as shown in figure 2.

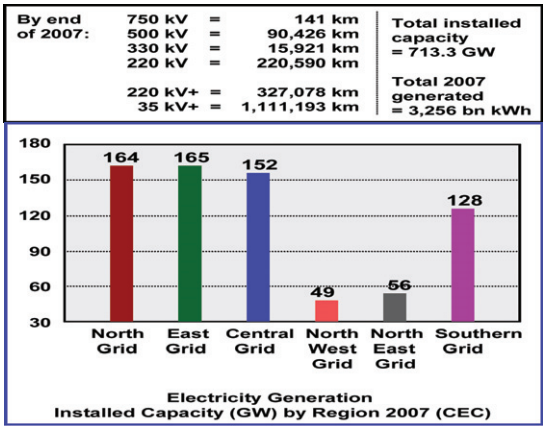

Figure 2. Statistic figures by the end of 2007 from CEPT

2. Key Characteristics of Smart Grid

Under the increasing pressure from global resources, the continuous proceeding of power-marketing and higher quality and reliability from power users, people hope that the future state grid should be more renewable, more robust, more efficient, more distributed, reconfigurable, more interactive, with faster protection and control, and higher power quality [1, 3].

Meeting these demands, smart grid integrates modern advanced sensor technology, measurement technology, communication technology, information technology, computing technology, and control technology into it, where information and electricity flow bi-directionally [7] and the smart grid can: (1) Enable active participation by customers; (2) Accommodate all generation and storage options; (3) Enable new products, services, and markets; (4) Provide power quality for the digital economy; (5) Optimize asset utilization and operate efficiently; (6) Anticipate and respond to system disturbances; (7) Operate resiliently against attacks and natural disasters [4]. Its conceptual model is shown in Figure 3.

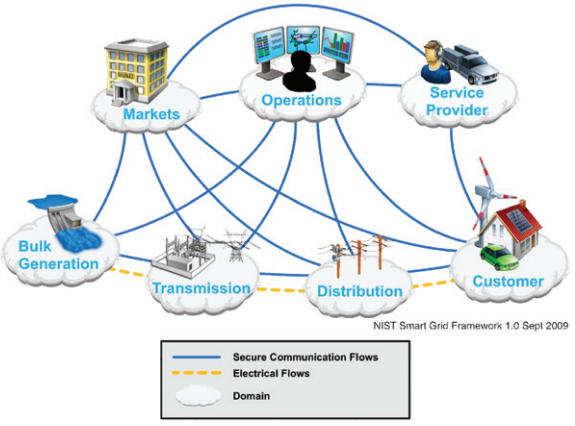

Figure 3 Smart grid conceptual model by NIST

A. Internal Communications Among Subsystems And Basic Systems In The Conceptual Model

- Bulk generation system converts bulk energy into electrical energy and usually directly connects to the transmission system and provides smart applications.
- Transmission system transmits electrical energy from generation over longer distances. The transmission system is typically remotely controlled and supervised by a transmission system operator. This system includes the transmission of metering information and equipment condition information for asset management applications.
- Distribution system distributes the electric energy delivered by transmission system to power consumers. In order to reduce fault clearing times by faster fault identification, small transformer substations need to be automized. The distribution system is typically remotely controlled and supervised by a distribution system operator. This system transmits metering information and equipment condition information for asset management applications.
- Customers refer to power consumers, such as industries, which apply process automation to control and supervise manufacturing process and energy consumption or generation.
- The service system offers potential for a wide range of new service developments. New business models may emerge due to the opportunities of the future Smart Grid. Therefore the service system will have and depend on various interfaces to other systems.
- The operation system includes the network control centers for energy management (EMS) and distribution management systems (DMS). It can also be used for scheduling and trading purposes, information about the availability of power (transfer power, operating reserve) or order information is transmitted to or from the market system.
- Market system distributes market and price online and within a far shorter time period to a larger extent and to participants in the system which do not today receive price and market information. The information about the availability of power (transfer power, operating reserve) is transmitted from the bulk generation system.

B. Characteristics of Smart Grid:

As analyzed above, smart grid has the following characteristics:

- Robustness

The grid can continuously provide power against disturbances (in extreme climate conditions and disasters) without outage over large area, and can ensure information security against attacks.

- Self-healing Capability

The grid can on-line and real-time monitor and evaluate the current state of itself, has strong risk warning systems to provide preventive control capabilities, automatically provides fault diagnosis, fault isolation and self-restoration [8].

- Compatibility

It can support the access of renewable resources, adopt the access of distributed generation and micro-grid, improve the management functions from users, efficiently realize interactions with users.

- Ecnomics

It can operate normally in combination with hydropower and thermal power, providing clean and high quality power, reduce the power loss and improve the utility efficiency of power, lowering investment and operation costs [6].

- Integratability

By using unified platform and model, smart grid can highly integrate the grid information and provide sharing, give a guarantee to the standard, normal and fine grid management.

- Interoperability

Figure 4 depicts the “layers” of an interoperability framework identified by GWAC along with issues that cut across the layers.

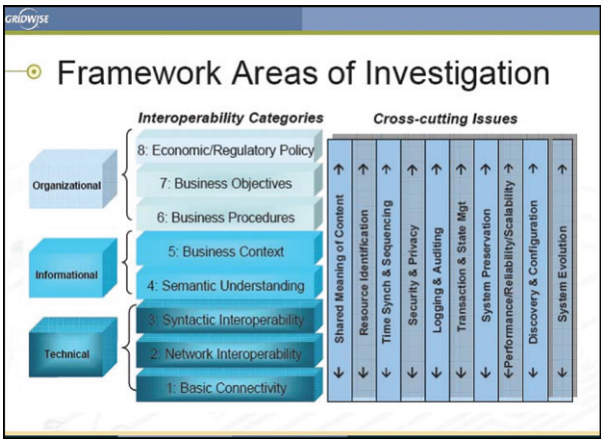

Figure 4. Smart Grid interoperability framework and cross-cutting issues.
Source: The Gridwise TM Architecture Council, 2008 (GWAC-1)

This "interoperability framework" expends the entire power supply chain and provides a logical organization of the standards needed to ensure interoperability between components operating on the Smart Grid [2,5]. It also provides architecture to identify areas of interest and their interdependencies that would need to be addressed and would improve smart grid vision and contribute to the widespread implementation of Smart Grid.

3. Architecture of Smart Grid

One key characteristics of the Smart Grid is a completely two-way communication network between the energy suppliers and their customers. This communication network will be constructed to enable this energy concept.

Figure 5 depicts the smart grid architecture, and shows network connections that can be traced from the customer's premises to collector nodes, then to the utility control center and to transmission and distribution substations where the electronic controllers are located that control the generation and flow of electrical power. the HAN communication devices may control power sources as well as power consuming equipment. All the HAN devices are connected to a network such as Zigbee or mesh wireless by a smart controller/meter, which connects the HAN to a collector node also through a network such as Zigbee or mesh wireless. Collector nodes communicate with the utility through common communication mechanisms including the Internet.

4. Conclusions

The implementation of smart grid will greatly improve the robustness, self-healing capability, compatibility, integratability and interoperability of the grid, it is cost effective. At the same time, the current cyber vulnerabilities in the legacy power grid should be taken into account.

Since to develop the relevant supporting technologies is a step-by-step process, full smart gird will be implemented in the future.

References

[1] Anderson, Roger, et al. Smart Electric Grid of the Future: A National "Distributed Store-Gen" Test Bed, Smart Grid White Paper. New York: Columbia University, n.d. (Anderson-1)

[2] Butler, Jim. “Achieving Interoperability using BACnet.” Grid Interop 2007 Forum Proceedings. Richland, WA: GWAC, December 2007. (Butler-1)

[3] Congressional Research Service. Smart Grid Provisions in H.R. 6, 110th Congress. Washington, DC: December 20, 2007. (CRS-1)

[4] DOE. Metrics for Measuring Progress toward Implementation of the Smart Grid. Washington, DC: DOE, Office of Electricity Delivery and Energy Reliability, July 31, 2008. (DOE-7)

[5] Hammerstron, Don, et al. Part II: Grid Friendly™ Appliance Project of the Pacific Northwest GridWise™ Testbed Demonstration Projects. (PNNL-17079). Richland, WA: DOE, PNNL, Gridwise™ , October 2007. (Hammerstron-1)

[6] Electricity Advisory Committee, “Smart Grid: Enabler of the New Energy Economy,” A Report by the Electricity Advisory Committee, December 2008

[7] Lightner, Eric. “Evolution and Progress of Smart Grid Development at the Department of Energy.”DOE presentation at FERC-NARUC Smart Grid Collaborative Workshop, Washington, DC, July 23, 2008. (Lightner-1)

[8] Platt, Glenn. “The Decentralised Control of Electricity Networks—Intelligent and Self-Healing Systems.” Grid Interop 2007 Forum Proceedings. Richland, WA: GWAC, December 2007.(Platt-1)

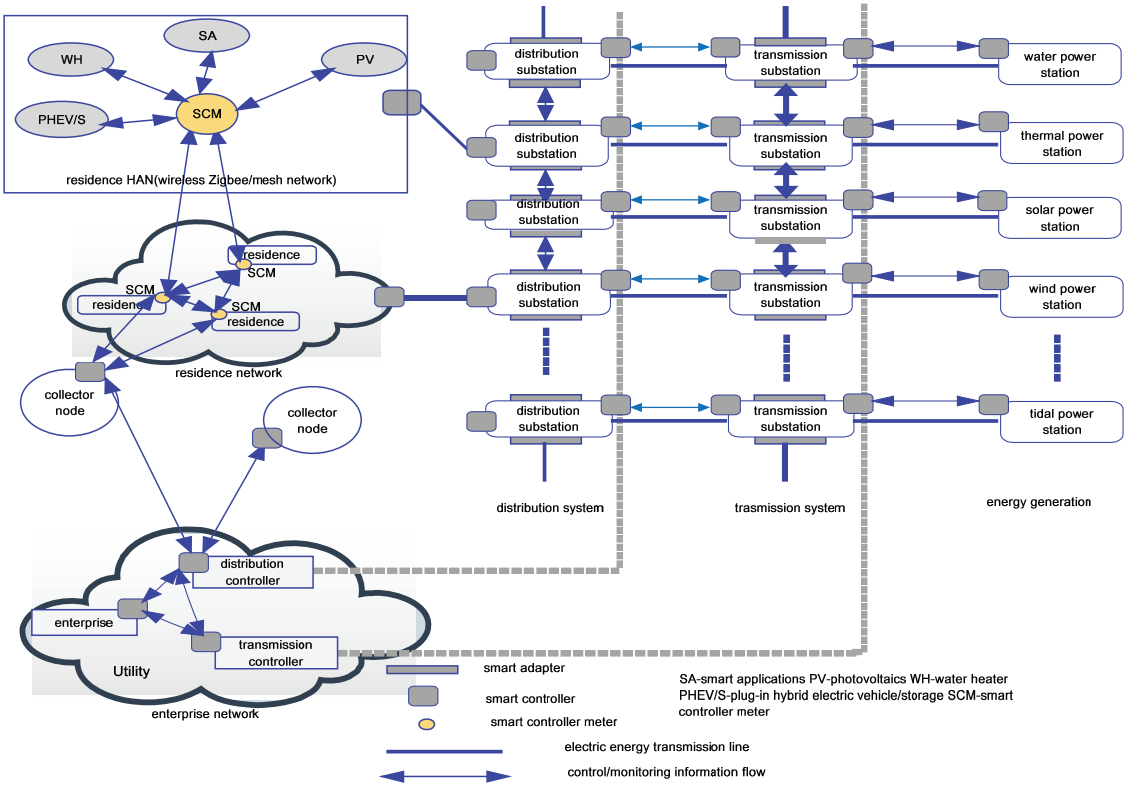

Figure 5 Smart grid architechture