Smart grid deployment, what we've done so far

by Edvard

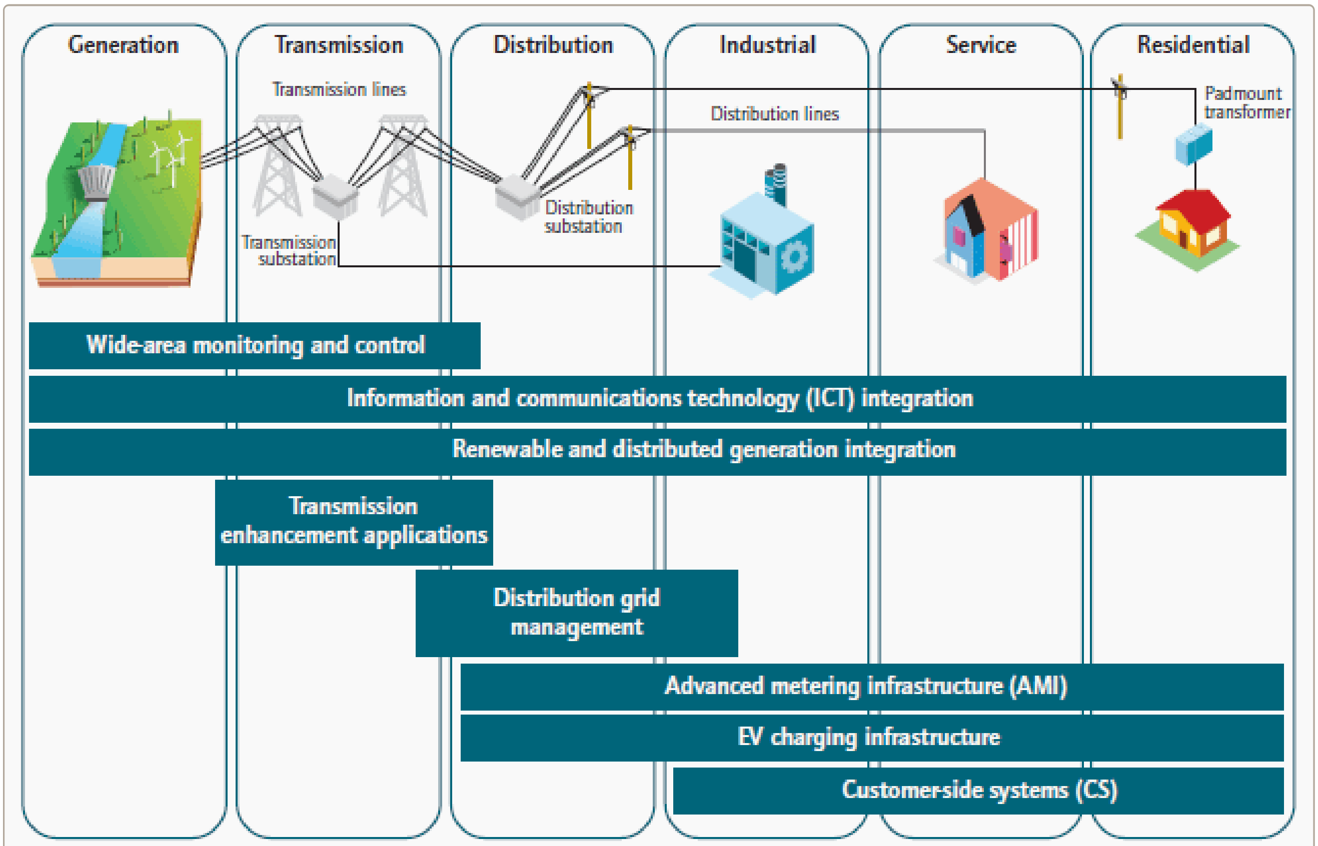

Figure 1 - Smart grid technology areas

Smart grid technologies

The many smart grid technology areas – each consisting of sets of individual technologies – span the entire grid, from generation through transmission and distribution to various types of electricity consumers. Some of the technologies are actively being deployed and are considered mature in both their development and application, while others require further development and demonstration.

KEY POINT – Smart grids encompass a variety of technologies that span the electricity system.

A fully optimised electricity system will deploy all the technology areas in ***Figure 1*** above. However, not all technology areas need to be installed to increase the "smartness" of the grid.

Wide-area monitoring and control

Real-time monitoring and display of powersystem components and performance, across interconnections and over large geographic areas, help system operators to understand and optimise power system components, behaviour and performance. Advanced system operation tools avoid blackouts and facilitate the integration ofvariable renewable energy resources.

Monitoring and control technologies along with advanced system analytics – including wide-area situational awareness (***WASA***), wide-area monitoring systems (***WAMS***), and wide-area adaptive protection, control and automation (***WAAPCA***) – generate data to inform decision making, mitigate wide-area disturbances, and improve transmission capacity and reliability.

Information and communications technology integration

Underlying smart grid communications infrastructure, whether using private utility communication networks (radio networks, meter mesh networks) or public carriers and networks (***Internet, cellular, cable or telephone***), support data transmission for deferred and real-time operation, and during outages.

Along with communication devices, significant computing, system control software and enterprise resource planning software support the two-way exchange of information between stakeholders, and enable more efficient use and management of the grid.

Renewable and distributed generation integration

Integration of renewable and distributed energy resources – encompassing large scale at the transmission level, medium scale at the distribution level and small scale on commercial or residential building – can present chalenges for the dispatchability and controllability of these resources and for operation of the electricity system.

Energy storage systems, both electrically and for themally based, can alleviate such problems by decoupling the production and delivery of energy. Smart grids can help through ***automation of control*** of generation and demand (in addition to other forms of demand response) to ensure balancing of supply and demand.

Transmission enhancement applications

There are a number of technologies and applications for the transmission system.

Flexible AC transmission systems (FACTS) are used to enhance the controllability of transmission networks and maximise power transfer capability. The deployment of this technology on existing lines can improve efficiency and defer the need of additional investment.

High voltage DC (HVDC) technologies are used to connect offshore wind and solar farms to large power areas, with decreased system losses and enhanced system controllability, allowing efficient use of energy sources remote from load centres.

Dynamic line rating (DLR), which uses sensors to identify the current carrying capability of a section of network in real time, can optimise utilisation of existing transmission assets, without the risk of causing overloads.

High-temperature superconductors (HTS) can significantly reduce transmission losses and enable economical fault-current limiting with higher performance, though there is a debate over the market readiness of the technology.

Distribution grid management

Distribution and sub-station sensing and automation can reduce outage and repair time, maintain voltage level and improve asset management. Advanced distribution automation processes real-time information from sensors and meters for fault location, automatic reconfiguration of feeders, voltage and reactive power optimisation, or to control distributed generation.

Sensor technologies can enable condition and performance-based ***maintenance of network components***, optimising equipment performance and hence effective utilisation of assets.

Advanced metering infrastructure

Advanced metering infrastructure (AMI) involves the deployment of a number of technologies – in addition to advanced or smart meters that enable two-way flow of information, providing customers and utilities with data on electricity price and consumption, including the time and amount of electricity consumed.

AMI will provide a wide range of functionalities:

1. Remote consumer price signals, which can provide time-of-use pricing information.
2. Ability to collect, store and report customer energy consumption data for any required time intervals or near real time.
3. Improved energy diagnostics from more detailed load profiles.
4. Ability to identify location and extent of outages remotely via a metering function that sends a signal when the meter goes out and when power is restored.
5. Remote connection and disconnection.
6. Losses and theft detection.
7. Ability for a retail energy service provider to manage its revenues through more effective cash collection and debt management.

Electric vehicle charging infrastructure

Electric vehicle charging infrastructure handles billing, scheduling and other intelligent features for smart charging (***grid-to-vehicle***) during low energy demand. In the long run, it is envisioned that large charging installation will provide power system ancillary services such as capacity reserve, peak load shaving and vehicle-to-grid regulation.

This will include interaction with both AMI and customer-side systems.

Customer-side systems

Customer-side systems, which are used to help manage electricity consumption at the industrial, service and residential levels, include energy management systems, energy storage devices, smart appliances and distributed generation.

Energy efficiency gains and peak demand reduction can be accelerated with in-home displays/energy dashboards, smart appliances and local storage.

Demand response includes both manual customer response and automated, price-responsive appliances and thermostats that are connected to an energy management system or controlled with a signal from the utility or system operator.

Summary

Technology area	Hardware	Systems and software

Wide-area monitoring and control	Phasor measurement units (PMU) and other sensor equipment	Supervisory control and data acquisition (SCADA), wide-area monitoring systems (WAMS), wide-area adaptive protection, control and automation (WAAPCA), widearea situational awareness (WASA)
Information and communication technology integration	Communication equipment (Power line carrier, WIMAX, LTE, RF mesh network, cellular), routers, relays, switches, gateway, computers (servers)	Enterprise resource planning software (ERP), customer information system (CIS)
Renewable and distributed generation integration	Power conditioning equipment for bulk power and grid support, communication and control hardware for generation and enabling storage technology	Energy management system (EMS), distribution management system (DMS), SCADA, geographic Information system (GIS)
Transmission enhancement	Superconductors, FACTS, HVDC	Network stability analysis, automatic recovery systems
Distribution grid management	Automated re-closers, switches and capacitors, remote controlled distributed generation and storage, transformer sensors, wire and cable sensors	Geographic information system (GIS), distribution management system (DMS), outage management system (OMS), workforce management system (WMS)
Advanced metering infrastructure	Smart meter, in-home displays, servers, relays	Meter data management system (MDMS)
Electric vehicle charging infrastructure	Charging infrastructure, batteries, inverters	Energy billing, smart grid-to-vehicle charging (G2V) and discharging vehicle-to-grid (V2G) methodologies
Customer-side systems	Smart appliances, routers, in-home display, building automation systems, thermal accumulators, smart thermostat	Energy dashboards, energy management systems, energy applications for smart phones and tablets

Resource: *Technology Roadmap – Smart Grids (iea International Energy Agency)*

Source: http://electrical-engineering-portal.com/smart-grid-deployment-what-weve-done-so-far