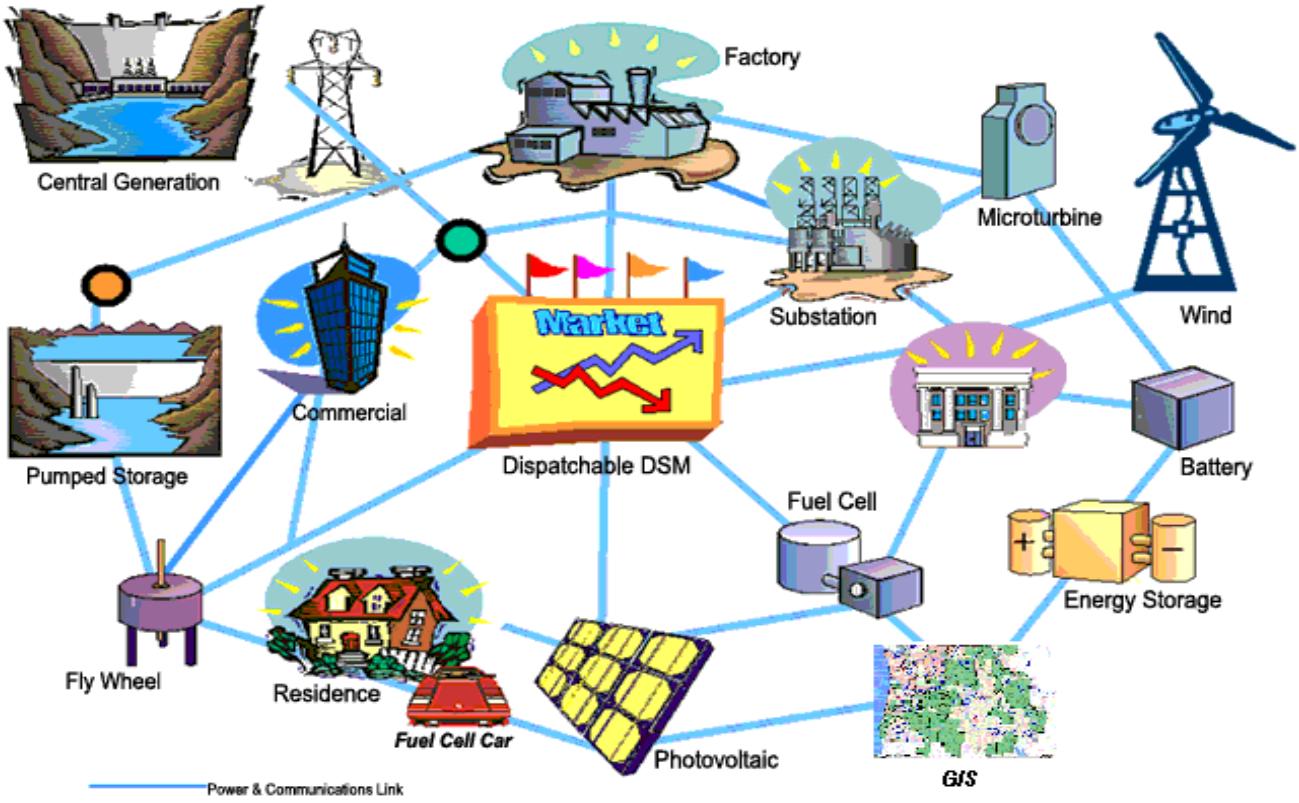
1.3.5 SENSORS, CONTROLS, AND COMMUNICATIONS

Technology Description



Improved sensors and controls, as part of the next-generation electricity transmission and distribution system, could significantly increase the efficiency of electricity generation and delivery, thereby reducing the greenhouse gas emissions intensity associated with the electric grid. Sensors and controls can play a key role in the development of the nation's next-generation electric T&D system. In the grid of the future, distributed energy resources can be fully integrated into grid operations, providing a robust energy infrastructure enhanced by local protection and control measures. The communication and control challenges associated with this evolution are significant. Local system conditions can be sensed, and local intelligent agents can process the data and communicate decision commands to local controllers for problem rectification and performance optimization. These local sensors and distributed software agents can assess adequacy and security with only high-level oversight from the central control authority. Distribution system and transmission grid reliability can be significantly improved by higher levels of local distributed energy generation using power electronics to control and manage two-way power flow as directed by local sensors and intelligent agents. Research on sensors, controls, and communications focuses on developing distributed intelligent systems to diagnose local faults and coordinate with power electronics and other existing, conventional protection schemes that will provide autonomous control and protection at the local level. This hierarchy will enable isolation and mitigation of faults before they cascade through the system. The work will also help users and electric power-system operators achieve optimized control of a large, complex network of systems; and will provide remote detection, protection, control, and contingency measures for the electric system.

System Concepts

- In the future, there must be a rapid, widespread measurement and control system that enables distributed energy generation to provide highly reliable services under all disturbance scenarios. Local control of such highly reliable services will improve local power quality and improve the efficiency of the distribution

system. This will be done with local sensors and "intelligent agents" that monitor local conditions and provide local responses.
- Conventional utility sensors, while robust and reliable, are quite expensive. Low-cost, reliable and robust sensors must be developed that can monitor current flow, voltage, and phase angle throughout the distribution system. These sensors would provide the intelligent agents with the information they need to make rapid, correct decisions.

Representative Technologies

- Low-cost physical sensors will be used to measure voltage, current, temperature, phase angle, and for other electric distribution and grid system characterization applications.
- The system architecture will be dependent on the ability of intelligent agents to diagnose and forecast local faults. This will involve placing a number of sensors, intelligent agents, and controllers at strategic locations.
- The sensing, communication, and information analysis required for intelligent decision making must happen in real time or near real time (in seconds), sufficiently faster than the time required to affect coordination, control, and protection schemes.
- Communications must take place to advise the central controller of the local system status, perform critical nonrepudiating functions to manage the electricity commerce, and enable real-time markets for energy and ancillary services.

Technology Status/Applications

- The variety of transduction methods and the capability to fabricate small, rugged sensor devices has advanced tremendously during the past five years. Modern techniques for fabricating electronic devices allow unprecedented miniaturization of sensors and electronic controls.
- Rapid analysis of sensor data and feedback control is also advancing, often enabled by microprocessor technology.
- Rapid, low-cost communications methods are also undergoing fast-paced advancement in wireless and fiber-optic technologies.

Current Research, Development, and Demonstration

RD&D Goals

- The initial research program goals for sensors, controls, and communications will be to develop, validate, and test computer-simulation models of the distribution system to assess the alternative situations. Once the models have been validated on a sufficiently large scale, the functional requirements and architecture specifications can be completed. Then, more specific technology solutions can be explored that would conform to the established architecture.

RD&D Challenges

- A challenge will be the development of cost-effective fault detection and control systems that can be readily implemented in the nation's power grid. The electricity market with an ever-increasing demand for highly reliable services is a key factor in the development of the new control system.
- In response to market communications, distributed energy generation must be capable of supplying the highly reliable services presently provided by large turbine generators, such as spinning reserves, reactive power supply, and voltage and frequency regulation. The entire control scheme is now based on the response of the large generation stations to supply these services. Traditionally, it has been considered to be too difficult to use distributed energy generation to supply these services because there are simply too many units to control reliably and quickly.

RD&D Activities

- Within DOE, sensor and control programs are being developed to focus on issues related to system architecture, distributed intelligence, interconnection technologies and standards, simulation and modeling of the distribution system, load/demand management, and aggregation testing and control of a suite of distributed energy resources.
- Workshops have been held with utilities; energy service companies; and providers of communications, sensor, control, and information technologies to plan strategies and develop roadmaps.

Recent Progress
• A Grid-Friendly™ appliance controller, based on the gate array chip, is being developed to monitor the power grid while controlling on-off operations of household appliances (refrigerators, air conditioners, water heaters, etc.) in response to power grid overload. This device has been tested in a laboratory environment and will be tested in a demonstration in the Pacific Northwest, using 200 grid-connected household clothes washer/dryer pairs. • A wireless end-device controller is installed at more than 200 facilities in southwest Connecticut, with the goal of controlling 2-3 megawatts of electricity on a real-time dispatchable basis. The controller collects real-time energy-use information and controls end-use loads (lighting, vending machines, etc.) to manage system peak demand.
Commercialization and Deployment Activities
• There are more than 4,200 sensor and control companies in the United States. Commercialization of sensor technology depends on demonstrating economic viability at a level commensurate with the risks small businesses can assume. **Market Context** • The market for improved sensors and controls cuts across all industrial and transportation sectors. Nuclear, fossil, and end-use efficiency technologies would all benefit.