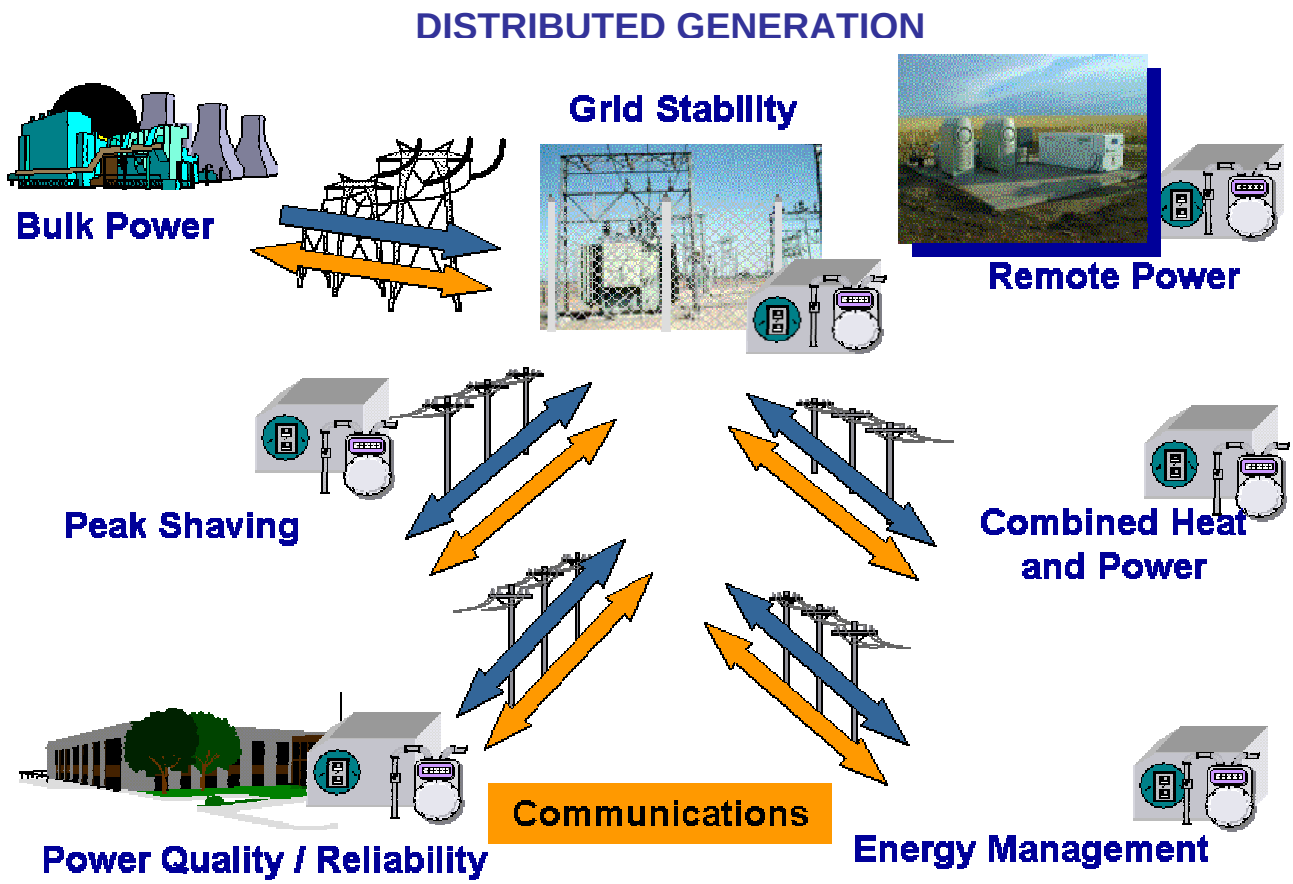
1.3.3 DISTRIBUTED GENERATION AND COMBINED HEAT AND POWER

Technology Description



Distributed generation, including combined heat and power (CHP), can be distinguished from central energy resources in several respects. These distributed energy resources are small, modular, and come in a range of capacities from kilowatts to megawatts. They comprise a portfolio of technologies that can be located onsite or nearby the location where the energy is used. They provide the consumer with a greater choice, local control, and more efficient waste utilization to boost efficiency and lower emissions.

System Concepts

- The portfolio of distributed generation technologies includes, for example, photovoltaic systems, fuel cells, natural gas engines, industrial turbines, microturbines, energy-storage devices, wind turbines, and concentrating solar power collectors. These technologies can meet a variety of consumer energy needs including continuous power, backup power, remote power, and peak shaving. They can be installed directly on the consumer's premise or located nearby in district energy systems, power parks, and mini-grids.
- CHP technologies have the potential to take all of the distributed generation technologies one step further in pollution prevention by utilizing the waste heat from the generation of electricity for the making of steam, heating of water, or for the production of cooling energy. The average power plant in the United States converts approximately one-third of the input energy into output electricity and then discards the remaining two-thirds of the energy as waste heat. Integrated DG systems with CHP similarly produce electricity at 30% to 45% efficiency, but then capture much of the waste heat to make steam, heat, or cool water – or meet other thermal needs and increase the overall efficiency of the system to greater than 70%.

System Components

- Advanced industrial turbines and microturbines – combustion turbines are a class of electric-generation devices that produce high temperature, high-pressure gas to induce shaft rotation by impingement of the gas on a series of specially designed blades. Simple cycle efficiencies range from 21% to 40%. Turbines produce high-quality heat and can be used for CHP production. Microturbines are small combustion turbines with outputs of 25-1,000 kW. Microturbines evolved from automotive and truck turbochargers.
- Energy-storage systems – the combination of an energy-storage device (e.g., a battery or a flywheel) and a power-conversion system to connect the storage device with the local grid.
- Concentrating solar power – concentrating solar power systems use suntracking mirrors to reflect and concentrate sunlight into receivers where it is converted to high-temperature thermal energy, which can then be used to drive turbines to generate electricity.
- Fuel cells – power is produced in fuel cells electrochemically by passing a hydrogen-rich fuel over an anode and air over a cathode and separating the two by an electrolyte in producing electricity. The only byproducts are heat, water, and carbon dioxide.
- Natural Gas Engines – the reciprocating engine is widespread and well-known technology. Spark ignition gas-fired units (the focus here) typically use natural gas or propane. Capacities are typically in the 0.5- to 5-megawatt range.
- Photovoltaic Systems – photovoltaic systems use semiconductor-based cells to convert sunlight directly to electricity.
- Hybrid Systems – hybrid systems consist of two or more types of distributed energy technologies.
- Wind Energy Systems – wind turbines convert the kinetic energy of wind into electricity.

Technology Status/Applications

- Industrial gas turbines and natural gas reciprocating engines are existing technologies that are being utilized and have a great deal of potential.
- Microturbines, concentrating solar power, fuel cells, wind energy, photovoltaic systems, and hybrid systems are currently under development.
- CHP is a proven technology, responsible for 8% of U.S. electricity generation. The potential for expanding the use of CHP in the United States is enormous – the Department of Energy and the Environmental Protection Agency have a goal of doubling CHP capacity to 92 GW by 2010.

Current Research, Development, and Demonstration

RD&D Goals

- Research is needed to increase the efficiency and reduce the emissions from microturbines, reciprocating engines, and industrial gas turbines to allow them to be sited anywhere, even in nonattainment areas.
- Research is needed to increase the efficiency of waste-heat-driven absorption chillers and desiccant systems to overall efficiencies well above 80%
- The overall research goal of the Distributed Energy Program is to develop and make available, by 2015, a diverse array of high-efficiency, integrated distributed generation and thermal energy technologies, at market-competitive prices, enabling and facilitating widespread adoption and use by homes, businesses, industry, communities, and electricity companies that may elect to use them.
- If successful, these technologies will enable the achievement of a 20% increase in a building's energy utilization (when compared to a building built to ASHRAE 90.1 standards), using load management, CHP, and energy-storage technologies that are replicable to other localities.

RD&D Challenges

- Provide lower cost and more efficient systems.
- Improve the reliability.
- Solve the institutional and regulatory barriers such as a lack of widely used technical interconnection standards.
- Enhance the implementation of CHP with technologies such as microturbines, fuel cells, gas turbines and reciprocating engines.

RD&D Activities

- Direct and coordinate a diverse portfolio of research development and demonstration investments in distributed natural gas technologies.
- Conduct supporting RD&D and enabling technologies.
- Direct and coordinate a diverse portfolio of RD&D energy generation and delivery systems architecture for distributed energy.
- Coordinate activities with RD&D and renewable energy technologies.
- Conduct system integration, implementation, and outreach activities aimed at addressing infrastructure, institutional, and regulatory needs.

Recent Progress

- DOE's advanced turbine system program has developed an industrial gas turbine with Solar Turbines, Inc., for a 48%-efficient simple-cycle machine. CHP is currently at 50 GW of installed capacity.
- Wind energy generation is experiencing rapid growth in various western and eastern United States locations.
- Microturbines have achieved more than 10,000 hours of operations and preliminary tests.
- The Southern Company accepted a SAFT/SatCon LiIon System developed by the DOE ESS program that provided three times the 100kW/1 minute rated performance. Southern agreed to test the battery system at no cost, because it can supplement a distributed energy resource (in this case a microturbine) and provide load-following capability.

Commercialization and Deployment Activities

- Advanced industrial gas turbines in the range of 1 to 50 MW are starting to be deployed.
- Natural gas reciprocating engines of 0.5-5 MW with efficiencies of 30%-40% are now being deployed.
- The DOE and EPA CHP programs are cooperating to actively promote the use of CHP to add about 46 GW of new CHP capacity by 2010.

Markets

- Distributed generation, including CHP, is currently helping the U.S. economy and has the potential to enhance the electric infrastructure. These technologies could produce more than 100 GW of generated capacity for the U.S. electric system.