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Distributed Generation:

A Nontechnical Guide

by
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with
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and
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Distributed Generation

For Tony and Aaron
My Bubbas

--Ann Chambers

Also by Ann Chambers

Merchant Power: A Basic Guide
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Co-author of

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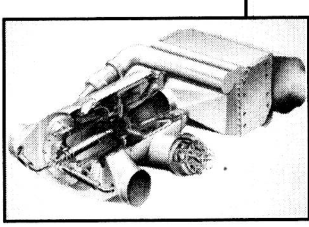
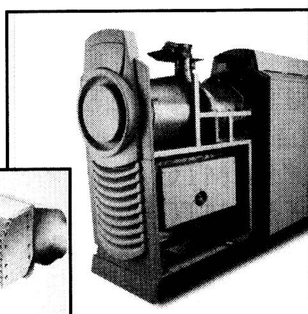
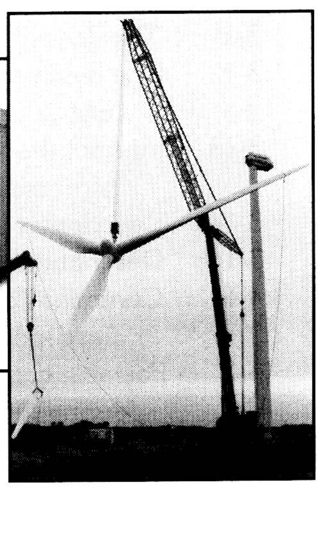

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Introduction to Distributed Generation

Today's distributed generation installations are in some ways a return to the early days of electrification. Thomas Edison's first power plants were small installations that illuminated only one or two square miles. Soon, however, Edison's dc power facilities were overshadowed by George Westinghouse's ac facilities that could transmit power over great distances, leading to the utility-scale mammoths that became the mainstay of electric power generation in the United States. The large plants offered great economies of scale and transmitted power over a massive transmission grid. This is the technology that brought affordable electric power to our nation. These facilities ran primarily on fossil fuels. Our nuclear plants are generally even larger versions of this utility-scale plant, with nuclear fuel running the steam generators.

But the changing times have brought changing technologies and economics. Over the past decade or so, the uncertainty of impending deregulation caused utilities to hold off on capital intensive construction projects. This brought narrowing margins of excess capacity as our country's energy use continued to grow. These facts have given birth to the merchant power movement, powered primarily by large-scale gas turbines. But they also have led to the inclusion of smaller technologies in our power generation mix.

Over the past decades, great strides have been made by research and development groups on a great many technologies. Fuel cells first used by NASA received government funding and industry participation for several decades. This technology is now on the verge of commercialization for transportation and stationary power generation.

Similarly, small gas turbines have benefited from the advances in large-scale turbine development, bringing this technology to recent commercial competitive standing. Diesel and gasoline-powered engines, used in transportation, are suitable for a variety of power generation uses and they have certainly made great advances in efficiencies, reliability, and emissions reduction from the transportation industry. These are becoming ever more common in the power generation world. (Fig. 1-1)

Renewable technologies such as wind power, landfill gas, solar, and geothermal are also vying for a portion of today's much needed new power generation capacity. Government assistance in research and, in some cases, tax

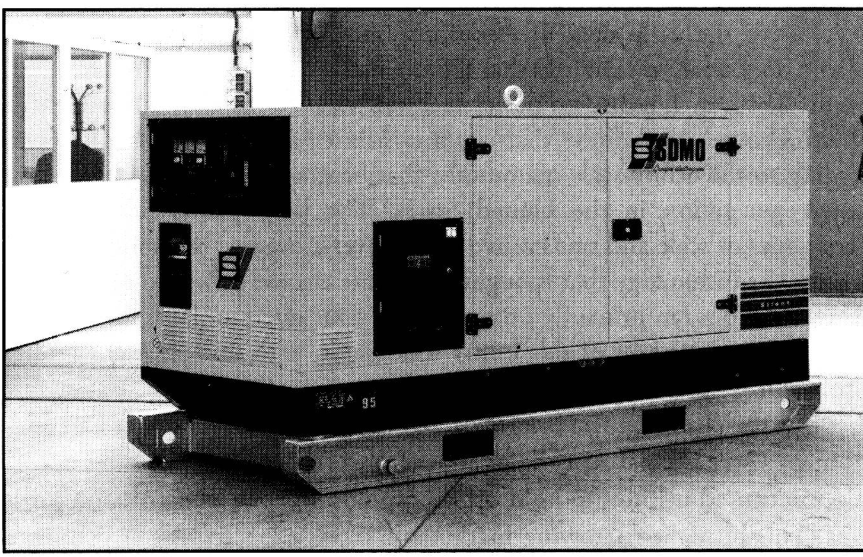

Fig. 1-1 *Small modular units need little space and take very little time to install. This JS 100 Euro Silent generation package is equipped with a John Deere 4045 HF 157 Powertech engine. It generates 100 kWe with relatively little noise – 70 dBA at 23 feet.*

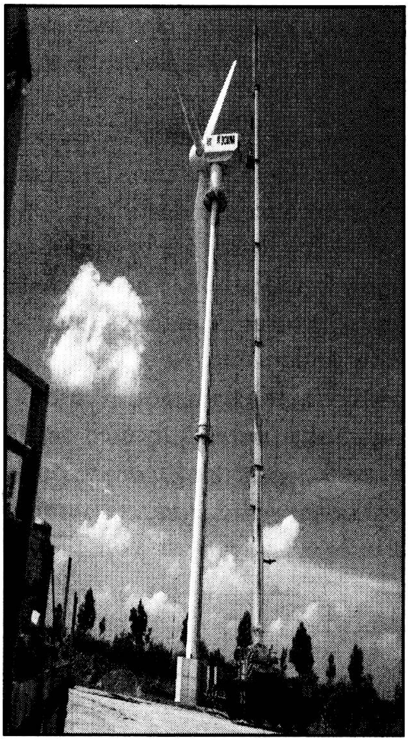

Fig. 1-2 Completion of a NedWind 500 kW wind turbine generator. The plant is expected to generate 2.6 million kWh annually, enough to meet the annual electricity demand of more than 800 households. Wind generation is particularly popular in rural areas, because it can allow farmers to generate additional income from grazing lands while still using the land for farming. The wind turbines use only a tiny fraction of the land they are sited on. Today's wind turbine models are far quieter than previous generations.

credits or other incentives, help make these technologies more viable.

With the national grid showing its age, and with new transmission lines almost non-existent, distributed generation receives a great boon. These small, generally quiet facilities can be placed next to or near to the customer or customers needing their power. (Fig. 1-2)

Restructuring and Deregulation

Utility restructuring, technology evolution, environmental policies, and an expanding power market are providing the impetus for distributed generation's growth into an important energy option. Utility restructuring opens energy markets, allowing the customer to choose an energy provider, method of delivery, and ancillary services. The market forces favor small, modular power technologies that can be installed quickly in response to market signals. This restructuring comes at a time when the demand for electricity is escalating both domestically and internationally. Impressive gains have been made in the cost and performance of small, modular distributed generation technologies. Regional and global environmental concerns have placed a premium on efficiency and environmental performance. Concerns are growing regarding the reliability and quality of electric power.

A portfolio of small gas-fired power systems is coming onto the market with the potential to revolutionize that market. Their size and clean performance allow them to be sited at or near customer sites for distributed generation applications. These systems often allow fuel flexibility by operating on natural gas, propane, or fuel gas from any hydrocarbon. These include coal, biomass and waste from an assortment of sources including refineries, municipalities, and the forestry and agricultural industries.

Technologies such as gas turbines and reciprocating engines are already making a contribution and they have more to offer through focused development efforts. Fuel cells are entering the market, but need more research and development to see widespread deployment. Also, fuel cell/turbine hybrid systems and upcoming generation fuel cells offer even more potential. (Table 1-1)

Distributed Generation Defined

Distributed generation generally applies to relatively small generating units of 30 MW or less sited at or near customer sites to meet specific customer needs, to support economic operation of the existing distribution grid, or both. Reliability of service and power quality are enhanced by the proximity to the customer, and efficiency is often boosted in on-site applications by using the heat from power generation.

While central power systems remain critical to the nation's energy supply, their flexibility is limited. Large power generation facilities are capital-intensive undertakings that require an immense transmission and distribution grid to move the power.

Distributed generation complements central power by providing a relatively low capital cost response to incremental jumps in power demand. It avoids transmission and distribution capacity upgrades by siting the power where it is most needed and by having the flexibility to send power back into the grid when needed.

	Combustion Turbines	Diesels, Internal Combustion	Fuel Cells	Microturbines	Fuel Cell Hybrids
Applications	On/off grid	On/off grid	On/off grid	On/off grid	On/off grid
Capacity	1-250 MW	50 kW-10 MW	2 kW-2 MW	25-500 kW	250 kW-3 MW
Operating life	40,000 hr	40,000 hr	10,000 hr	40,000 hr	40,000 hr
Capital cost ($)	400-600/kW	500-800/kW	3,000/kW	550/kW	1,500/kW*
O&M cost	5-10 mills/kWh	10-15 mills/kWh	5-15 mills/kWh	5-10 mills/kWh	5-10 mills/kWh
Heat rate (Btu/kWh)	8,000-10,500	9,000-11,000	9,500	12,500	6,000

Source: Edison International
**projected at maturity*

***Table 1-1** Distributed Generation Technology Statistics*

Technological advances through decades of research have yielded major improvements in the economic, operational, and environmental performance of small, modular power generation options.

This emerging group of distributed generation choices is changing the way energy service companies, independent power producers, and customers view energy.

Applications

The main applications for distributed generation so far tend to fall into five main categories:

- Standby power
- Combined heat and power
- Peak shaving
- Grid support
- Stand alone

Standby power is used for customers that cannot tolerate interruption of service for either public health and safety reasons, or where outage costs are unacceptably high. Since most outages occur as a result of storm or accident related T&D system breakdown, on-site standby generators are installed at locations such as hospitals, water pumping stations, and electronic dependent manufacturing facilities.

Combined heat and power applications make use of the heat from the process of generating electricity, increasing the efficiency of the fuel use. Most power generation technologies create a great deal of heat. If the generating facility is located at or near a customer's site, that heat can be used for combined heat and power (CHP) or cogeneration applications. CHP significantly boosts system efficiency when it is applied to mid- to high-thermal use customers such as process industries, large office buildings, and hospitals.

Power costs can fluctuate hour to hour depending on demand and generation availability. These hourly variations are converted into seasonal and daily time-of-use rate categories such as on-peak, off-peak, or shoulder rates. Customer use of distributed generation during relatively high-cost on-peak periods is called peak shaving. Peak shaving benefits the energy supplier as well, when energy costs approach energy prices.

The transmission and distribution grid is an integrated network of generation, high voltage transmission, substations, and lower-voltage local distribution. Placing distributed generation at strategic points on the grid—grid support—can assure the grid's performance and eliminate the need for expensive upgrades.

Stand-alone distributed generation serves the customer but is not connected to the grid, either by choice or by circumstance. Some of these applications are in remote areas where the cost of connecting to the grid is cost prohibitive. Such applications include users that require stringent control of the quality of their electric power, such as computer chip manufacturers.

Customer Benefits

Distributed generation ensures reliability of the energy supply, which is increasingly critical to business and industry. Reliability is essential to some industries where interruption of service creates extremely expensive problems by suddenly shutting down machinery or in industries where health and safety is endangered by sudden outages.

Distributed generation is also able to provide the quality power needed in many industrial applications that are dependent on sensitive electronic instrumentation and controls that cannot withstand power dips or surges.

It can also offer efficiency gains for on-site applications by avoiding line losses and by using both the electricity and heat produced in power generation for industrial processes, heating, or air conditioning.