Galileo Research

Distributed Generation

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Distributed, or small generation units, typically less than 30MWs, strategically located near consumers and load centers can provide benefits to customers and support for the economic operation of the existing power distribution grid.

Over the last thirty years the cost of building and maintaining large centralized nuclear and coal fired generating facilities has become increasingly expensive and technology has improved the efficiency and cost of smaller modular power generating options, while industry restructuring is paving the way for customers to select the optimum combinations of energy resources to fit their individual needs.

Lately we are seeing a move towards on-site distributed power generation that is reversing an almost 50 year trend towards centralized generation. As deregulation and restructuring sweeps through the world's energy corridors, utilities and other energy service providers will see distributed power generation as a threat or an opportunity, and will use a range of strategies and technologies to keep old customers, find new ones, and boost revenues. Used wisely, distributed power generation technologies can improve power quality, boost system reliability, reduce energy costs, and help delay or defray utility capital investments.

Tapped Markets

Proponents of distributed generation are quick to point to the untapped market that exists among the world's two billion people that currently have no access to electricity and several hundred million more that have to rely on a limited, unreliable, or impossibly expensive supply. Despite the tremendous social, economic, health and environmental benefits of widespread access to environmentally clean electricity, many nations are unable to maintain their current limited electrical grids, let alone afford the cost of extending electrical capacity to service the majority of their citizens.

There is an upheaval taking place through the world's power grid as state-owned or highly regulated utilities hand off resources to deregulated private markets and consumers become more vocal in their desire to have greater choice in power quality, more extensive time of use pricing and provisions such as “net-metering” which give them the ability to self-generate and receive a fair price for power they sell back to the grid.

The combined influence of growing environmental concerns and the arrival of new distributed generation technologies are changing both the scale of power projects and the way utilities think about electricity.

These trends give rise to important questions regarding the future providers of electricity and what form service will take. It is becoming clear that any future electricity generating systems, on any scale, will include distributed generation services, concepts and technologies.

Killer Application

Distributed generation has been termed the latest “killer application,” with some analysts predicting it will be to electricity what personal computers were to the computer industry. The day is fast approaching they say, when you can walk into your nearest appliance store, purchase a small self contained DG “appliance,” take it home, plug in and supply all the power needed, grid free.

Distributed power generation in the form of turbine generators, internal combustion engine generators, microturbines, photovoltaic solar panels, wind turbines and fuel cells, provide electric power at a site closer to customers than central station generation and can be connected either directly to the consumer or to a utility’s transmission or distribution system.

Systems in use today provide a multitude of services to utilities and consumers, including standby generation, peak shaving capability, baseload generation or cogeneration. As technology advances, distributed power promises to provide economic and environmental benefits well into the 21st century.

“Competition,” is becoming the rallying cry for the electric power industry. That means new opportunities for electric utilities and their customers. The future of electric power lies in distributed generation - thousands of small power systems in industrial and commercial facilities, working together as "virtual power plants." In such applications, diesel and gas engine generator sets offer the benefits of low installed cost, high efficiency at full or partial load, reliability, fuel flexibility and heat recovery potential.

The Gas Technology Institute (GTI), an independent technology organization, says, “worldwide demand for stationary engines and turbines has grown substantially in the past decade.” The Institute has released figures showing engine demand has grown by 380% and turbine demand by 560% with the prime movers providing electricity or shaft power being requested by end users as well as large scale utility and independent power producers, indicating a shift away from the thermal power plant model.

Recent studies by GTI, Arthur D. Little, the giant consulting firm and others show a significant long-term opportunity for smaller scale distribution worldwide. In the U.S. alone it is predicted that the market for distribution represents over 27 GW (gigawatts) of power and $10 billion of cumulative capital equipment purchases by 2015.

Applications for Distributed Generation

A number of areas lend themselves to opportunities for distributed generation. Chief among these are:

Standby Power. For customers that cannot tolerate interruption of service, for either public health or safety reasons, or where outage costs are unacceptably high, standby generators installed at hospitals, water pumping stations and electronic dependent facilities such as server farms fill the bill.

Combined Power and Heat. Since all power generation technologies produce a great amount of heat locating a power generator near a customer's site will allow the use of combined heat and power (GHP) or cogeneration applications, significantly increasing system efficiency.

Peak Shaving. Typically power costs fluctuate hour-by-hour depending upon demand and generation availability and hourly variations are converted into seasonal and daily time-of-use rate categories such as on-peak, off-peak or shoulder rates. Customer's use of distributed generation during relatively high-cost on-peak is referred to as peak shaving. Peak shaving benefits the energy provider as well when energy costs approach energy prices.

Grid Support. The power grid is a complex, integrated network of generation, high voltage transmission, substations and local distribution. Strategic placement of distributed generation can provide system benefits and negates the need for expensive upgrades to the grid.

Stand Alone. Stand-alone distributed generation isolates the user from the grid either by choice or circumstance, as in remote locations. Such applications include users requiring tight control on the quality of the electric power delivered, as in computer chip manufacturing.

Distributed Generation Technologies

Reciprocating engines. The most common form of distributed generation technology available today, reciprocating internal combustion engines (IC) fueled by natural gas offer low cost, easy start up, proven reliability, good load following characteristics and heat recovery potential. Emissions from IC engines have been reduced significantly in the last several years.

Combustion Turbines. Combustion turbines (CT) are an established technology available in sizes from several hundred kilowatts to hundreds of megawatts. CTs can be set to burn natural gas or be dual-fuel fired. The combination of low maintenance and high quality waste heat make them an excellent choice for industrial and commercial applications larger than 5MW.

Fuel Cells. Fuel cells producing power electrochemically similar to a battery are coming on strong in the DG market. Several different liquid and solid media can be used to create the fuel cell's electrochemical reaction. Fuel cells are inherently quiet and extremely clean running. At the moment the high costs of fuel cells make them best suited to environmentally sensitive areas with power quality concerns. They are being aimed at small commercial and residential markets as well as industrial cogeneration applications. Hospitals are at the greatest advantage of using Fuel Cells, they may be run in one direction to produce Electric Power or reverse run to produce Oxygen for Hospital needs.

Photovoltaics. Photovoltaic power cells use solar energy to produce power and can be sited anywhere the sun shines, making them suitable in sensitive environmental areas and for remote applications. High costs make them a niche technology for now, but a lot of development wok is being done in this area, so costs are expected to decrease over the near term.

Wind Turbines.

Distributed wind generation, wind farms of just one or several wind turbines, have several advantages over traditional large wind farms:

* distributed wind, in many cases, has a lower cost to integrate into the existing grid than large wind farms,
* new turbine technology can add voltage and reactive power support to distribution feeders far from substations, improving system reliability and power quality,
* distributed wind generation, in many cases, can supply power much closer to electrical loads than conventional power plants significantly reducing electrical losses as well as lessening constraints on congested power lines,
* distributed wind generation is a way for community stake holders to control electrical generation, allowing communities to keep energy dollars local and to take control their energy future.

Wave Turbines.

An important feature of sea waves is their high energy density, which is the highest among the renewable energy sources. Among different types of ocean waves, wind generated waves have the highest energy concentration. Wind waves are derived from the winds as they blow across the oceans. This energy transfer provides a natural storage of wind energy in the water near the free surface.

Nearer the coastline the wave energy intensity decreases due to interaction with the seabed. Energy dissipation near shore can be compensated by natural phenomena as refraction or reflection, leading to energy concentration ("hot spots").

The power in a wave is proportional to the square of the amplitude and to the period of the motion. Long period (~7-10 s), large amplitude (~2 m) waves have energy fluxes commonly exceeding 40-50 kW per meter width of oncoming wave. As most forms of renewables, wave energy is unevenly distributed over the globe. Increased wave activity is found between the latitudes of ~30o and ~60o on both hemispheres, induced by the prevailing western winds (Westerlies) blowing in these regions.

It is important to appreciate the difficulties facing wave power developments, the most important of which are:

- Irregularity in wave amplitude, phase and direction; it is difficult to obtain maximum efficiency of a device over the entire range of excitation frequencies
- The structural loading in the event of extreme weather conditions, such as hurricanes, may be as high as 100 times the average loading
- The coupling of the irregular, slow motion (frequency ~0.1 Hz) of a wave to electrical generators requires typically ~500 times greater frequency.

There are now several wave energy devices with predicted costs of about 8,5 cEUR/kWh or less at 8% discount rate, if the devices achieve their anticipated performance.

Shoreline devices are fixed to or embedded in the shoreline. This has the advantage of easier installation and maintenance. In addition shoreline devices would not require deep-water moorings or long lengths of underwater electrical cable. However, they would experience a much less powerful wave regime. This could be partially compensated by natural energy concentration ("hot spots"). Furthermore, the deployment of such schemes could be limited by requirements for shoreline geology, tidal range, preservation of coastal scenery etc.

Offshore Devices This class of device exploits the more powerful wave regimes available in deep water (>40m depth). More recent designs for offshore devices concentrate on small, modular devices, yielding high power output when deployed in arrays.

http://www.cres.gr/kape/pdf/download/Wave%20Energy%20Brochure.pdf

Distributed Generation Opportunities

With worldwide electricity consumption expected to reach 22 trillion kilowatt hours by 2020, largely due to growth in developing countries without nationwide power grids, there can be no doubt about the importance of the distributed generation market.

The projected distribution generation capacity increase associated with the global market is conservatively estimated at 20 gigawatts per year over the next decade. As utility restructuring sets in, the financial burden of new capital investments will shift from consumers to energy suppliers along with capacity additions.

This favors less capital-intensive projects and shorter construction schedules. The opening up of energy markets places increased pressure on energy suppliers to increase capacity to meet growing demand and increases the probability of forced outages.

Customer concerns over reliability have escalated, particularly in the manufacturing sector. With the increased use of sensitive electronic components, the need for high quality power supplies is of paramount importance.

These factors coupled with the worldwide hunger for more electricity and the need to turn the lights on for an estimated 2 billion without access points to a bright future for distributed generation