Distributed Generation:A Future Solution for Power

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***Abstract*—Distributed generation (DG) is expected to become more important in the future generation system. This paper discusses the relevant issues and aims at providing a general definition for distributed power generation in competitive electricity markets. In general, DG can be defined as electric power generation within distribution networks or on the customer side of the network.**

Keywords:DistributedGeneration,theopportunity,benefits,regula-tion,economics,applications,challenges,technologies.

I. INTRODUCTION

Distributed generation (or DG) generally refers to small-scale (typically 1 kW – 50 MW) electric power generators that produce electricity at a site close to customers or that are tied to an electric distribution system. Distributed generators include, but are not limited to synchronous generators, induction generators, reciprocating engines, microturbines (combustion turbines that run on high energy fossil fuels such as oil, propane, natural gas, gasoline or diesel), combustion gas turbines, fuel cells, solar photovoltaics, and wind turbines.

There are many reasons a customer may choose to install a distributed generator. DG can be used to generate a customer's entire electricity supply; for peak shaving (generating a portion of a customer's electricity onsite to reduce the amount of electricity purchased during peak price periods); for standby or emergency generation (as a backup to Wires Owner's power supply); as a green power source (using renewable technology); or for increased reliability. In some remote locations, DG can be less costly as it eliminates the need for expensive construction of distribution and/or transmission lines.

II. BENEFITS OF DISTRIBUTED GENERATING SYSTEMS

Distributed Generation:

- Has a lower capital cost because of the small size of the DG (although the investment cost per kVA of a DG can be much higher than that of a large power plant).
- May reduce the need for large infrastructure construction or upgrades because the DG can be constructed at the load location.
- If the DG provides power for local use, it may reduce pressure on distribution and transmission lines.
- With some technologies, produces zero or near-zero pollutant emissions over its useful life (not taking into consideration pollutant emissions over the entire product lifecycle ie. pollution produced during the manufacturing, or after decommissioning of the DG system).
- With some technologies such as solar or wind, it is a form of renewable energy.
- Can increase power reliability as back-up or stand-by power to customers.
- Offers customers a choice in meeting their energy needs.

III. THE OPPORTUNITY

The importance of distributed generation is reflected in the size of the estimated market.Domestically, new demand combined with plant retirements is projected to require as much as 1.7 trillion kilowatthours of additional electric power by 2020, almost twice the growth of the last 20 years. Over the next decade, the domestic distributed generation market, in terms of installed capacity to meet the demand, is estimated to be 5–6 gigawatts per year.

Worldwide forecasts show electricity consumption increasing from 12 trillion kilowatt hours in 1996 to 22 trillion kilowatt hours in 2020, largely due to growth in developing countries without nationwide power grids. The projected distributed generation capacity increase associated with the global market is conservatively estimated at 20 gigawatts per year over the next decade.The projected surge in the distributed generation market is attributable to a number of factors. Under utility restructuring, energy suppliers, not the customer, must shoulder the financial risk of the capital investments associated with capacity additions. This favors less capital-intensive projects and shorter construction schedules. Also, while opening up the energy market, utility

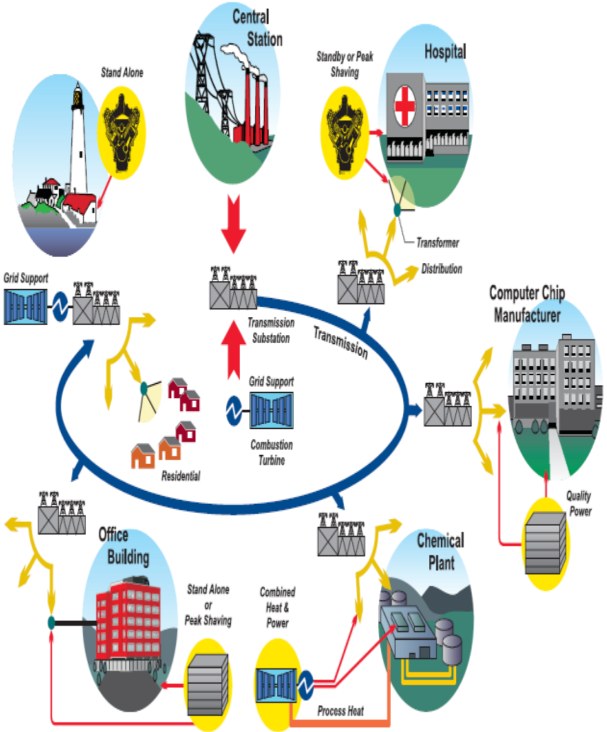

Fig 1. Distributed Generation Cycle

restructuring places pressure on reserve margins, as energy suppliers increase capacity factors on existing plants to meet growing demand rather than install new capacity. This also increases the probability of forced outages. As a result, customer concerns over reliability have escalated, particularly those in the manufacturing industry. With the increased use of sensitive electronic components, the need for reliable, high-quality power supplies is paramount for most industries. The cost of power outages, or poor quality power, can be ruinous to industries with continuous processing and pinpointquality specifications. Studies indicate that nationwide, power fluctuations cause annual losses of $12–26 billion. As the power market opens up, the pressure for enhanced environmental performance increases.For e.g. in many regions in the U.S. there is near-zero tolerance for additional pollutant emissions as the regions strive to bring existing capacity into compliance. Public policy, reflecting concerns over global climate change, is providing incentives for capacity additions that offer high efficiency and use of renewables. Overseas, the utility sector is undergoing change as well, with market forces displacing government controls and public pressure forcing more stringent environmental standards. Electricity demand worldwide is forecasted to nearly double. Moreover, there is an increasing effort to bring commercial power to an estimated 2 billion people in rural areas currently without access to a power grid.

IV. Regulation of Distributed Generation

For remote areas not connected to an electricity grid, there is no reason to apply an regulatory framework apart from safety issues. However in a networked grid system, issues of quality of supply and competition with the bulk providers of electricity do arise. These issues are viewed as being complex and, until a suitable framework is achieved, development of distributed generation will be limited.

V. ECONOMICS OF DISTRIBUTED GENERATION

Apart from “premium power” locations where grid connection is not available,distributed generators will need to be able to produce electricity at price levels that equal the lowest cost producer - brown and black coal. In this environment, distributed generators would need to be able to produce power at around $32/kW. However, other factors work for distributed generation.

These are the reliability of user managed power at the site and risk of power outages on revenue. Additionally, there is the expected move to have end-user costs reflect the loss incurred in transmission. As will be shown in the following chapter, when gas powered microturbines are used in a co-generation configuration, it can lead to a substantial increase in efficiencies. While not likely to be evident in the time frame set for this project, advances in manufacturing processes are leading to improvements in efficiencies in photovoltaics. This may lead to this energy option providing for an increasing part of energy production. See Figure 2 – Estimated Electricity Costs.

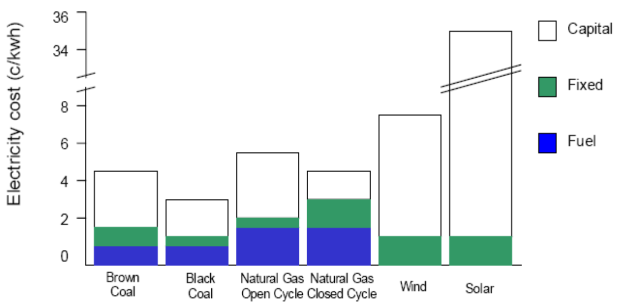

Fig 2. Estimated Electricity Costs

VI. APPLICATIONS

There are a number of basic applications, outlined below, that represent typical patterns of services and benefits derived from distributed generation.

A. Standby Power

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 electronicdependent manufacturing facilities.

B. Combined Heat and Power

Power generation technologies create a large amount of heat in converting fuel to electricity. If located at or near a customer's site, heat from the power generator can be used by the customer in what are called combined heat and power (CHP) or cogeneration applications. CHP significantly increases system efficiency when applied to mid- to high-thermal use customers such as process industries, large office buildings, and hospitals.

C. Peak Shaving

Power costs fluctuate hour by hour depending upon 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.

D. Grid Support

The power grid is an integrated network of generation, high voltage transmission, substations, and local distribution. Strategic placement of distributed generation can provide system benefits and precludes the need for expensive upgrades.

E. Stand Alone

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

VII.THE CHALLENGE

Although growing, distributed generation is still in its infancy. Ultimately, the market will be shaped by crucial product development and economic, institutional, and regulatory issues.

Market penetration will depend on how well manufacturers of distributed generation systems do in meeting product pricing and performance targets. Many of the more promising technologies have not yet achieved market entry pricing or risk levels, while others simply have not reached their market potential.

Customers—utilities, energy service companies, and end users—have yet to define and quantify distributed generation attributes such as transmission and distribution upgrade cost avoidance, improved grid stability, or enhanced power reliability.

A major institutional issue, regarding customer interconnection with the distribution grid, currently stands in the way of distributed generation. Utility specifications for connection with the grid are complex and lack clarity and consistency. The results are high costs and project delays, or termination.Clearly, interconnect requirements are needed for safety, reliability, and power quality purposes. This strongly suggests the development of transparent national interconnect standards. Also needing to be addressed are the historical use charges, back-up charges, insurance charges, and other utility fees associated with those choosing to selfgenerate while remaining connected to the grid. Moreover, there is the matter of high liability insurance coverage for mis-operations of the distributed generator, needed to protect the utility.

Regulatory issues arise as well. For example, unless changes are made, distributed generation units may not get credit for avoided pollutant emissions. These emission credits are normally dealt with during the utility resource planing process, not during operation.

To realize the potential of distributed generation, the technical, economic, institutional, and regulatory issues must be dealt with effectively. This task will require cooperation between the public and private sectors. In doing so, a new industry can emerge benefitting the economy through jobs and revenues.

VIII.TECHNOLOGY OPTIONS

Some distributed power components, such as diesel generators and lead-acid batteries, have been around since almost the dawn of the power industry. However, improvements in these technologies and the development of advanced technologies promise to make the widespread deployment of distributed power systems a reality. This overview of specific distributed technologies will discuss conventional generating technologies, advanced generating technologies using conventional fuels, renewable generation, and technologies that do not generate power from primary energy sources, but support the efficient utilization of this power.

A. Advanced fossil technologies

Over the past decade, two new fossil-fuel generation technologies have been developed to the point of commercialization or near commercialization: the micro-turbine and the fuel cell. A micro-turbine is a scaled-down version of the brayton cycle gas turbine used in large-scale central generation. Although primarily designed to use natural gas, these systems also can be designed to use a variety of gaseous and liquid fuels. As with diesel engines, micro-turbine costs are shared with the transportation industry, through development of the engines for small planes, helicopters, and tanks. Fuel cells rely on electrochemical rather than thermodynamic energy conversion. Although they ultimately require hydrogen, the source of this hydrogen can be virtually any hydrocarbon fuel (natural gas or propane preferred) or even hydrogen electrolyzed from water using renewable energy or off-peak generation. Fuel cells have been developed at a small, sub-kilowatt scale for use in space exploration, but have only recently begun scaling-up for stationary power applications.

B. RENEWABLE TECHNOLOGY

Hydro electric is the only renewable energy resource to be used on a wide-spread basis for central-station power. Small-scale, run-of-river hydro projects have the potential to provide a sort of distributed generation to remote areas with appropriate resources. However, photovoltaics (PV), solar thermal technologies, and wind turbines offer more modular and easily deployable options for renewable distributed generation. The primary limitation on these renewable resources is their lack of “dispatchability”; that is, the power is not available on-demand, but rather when the river is flowing, sun shining, or wind blowing. This is less of an issue when the technology is used to support an existing large grid, but for use in an expanding village grid, renewable energy resources require energy storage and/or redundant dispatchable capacity, both of which add substantial cost to already capital-intensive capacity.

C. EFFICIENT TECHNOLOGIES

Energy storage, co-generation (combined heat and power), and load-control technologies can all improve the utilization of primary generation sources on any grid, especially on a small grid or grid with high-penetration renewable capacity.Energy storage technologies range from traditional lead-acid and nickel cadmium batteries, to advanced electrochemical systems (rechargeable lithium batteries, zincbromide batteries, and reversible fuel cells), composite flywheels, and superconducting magnets. Batteries (that is, electrochemical systems) can cover a wider range of needs, from several megawatts provided over several hours to a few kilowatts provided with a few seconds notice. Flywheels tend to have less energy capacity, but relatively good response time. Superconducting magnets can provide very high power for a very short period of time, but with extremely fast response time. Co-generation utilizes waste heat from a variety of generation sources (including combustion turbines, diesel generators, and even some fuel cell systems) to provide hot water, space heating, or thermal energy for industrial processes. This increases the overall efficiency of energy use in the cogenerating facility or village. Utilities on well-developed grids have used customer load control devices to reduce peak loads such as air conditioning for the past decade.

Such controls could help smaller-scale grid operators adjust the dispatch of deferrable system loads to level the load on a base-load generator or match the output of a renewable resource.

IX. SUMMARY

In developing and rural areas, distributed resources will form the core of the grid, allowing for flexible, incremental grid expansion with reduced environmental impacts and reasonable operating costs. Before these models become reality, however, key participants in the potential markets, including government planners/regulators, utility decision-makers, and end-users, must be made aware of the benefits of these technologies and their impacts on electric power systems, economic development, and environmental quality.

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