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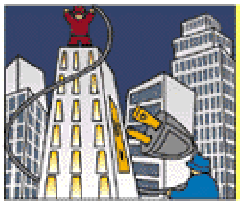
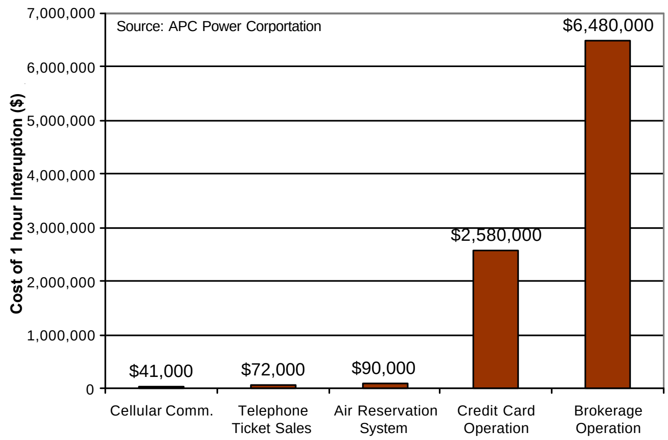


Distributed Generation MONITOR

Will DG Provide Relief to High-Tech Industry's Energy Needs?



Power outages, while inconvenient for most, are disasters for facilities with highly sensitive electronic equipment. Some electronic equipment is manufactured to withstand only milliseconds of voltage disruption, and momentary outages that to most are just a flicker of lights can cost some US businesses millions each year. Many businesses use or are building data centers in which to locate their mission-critical computer equipment and telecommunications services. These centers demand premium power which is free of interruptions, frequency variations, voltage transients, dips, and surges. To meet their stringent power needs, although they typically rely on the grid as their primary power source, many centers are outfitted with a combination of an Uninterruptible Power Supply (UPS) with distributed generation (DG) backup to protect against costly power outages. Diesel powered reciprocating engines are the DG technology most often applied because of their low capital cost. One or more engines, typically in the 500-1,500 kW size range, are combined with a UPS, and generally provide total backup capacity of approximately 750-8,000 kW, although they can go as high as 15-20 MW. Installed cost for diesel fuel reciprocating engines for backup use range from $450-700/kW, and most centers have several units to provide redundancy.

Caterpillar and other diesel recip. manufacturers *(continued on page 3)*

Solid Oxide Fuel Cell Success

Siemens Westinghouse, fresh from its record setting 100 kW Solid Oxide Fuel Cell (SOFC) demonstration in the Netherlands, has made great strides towards its goal of near-term commercialization of SOFCs and SOFC/Turbine Hybrids. The demonstration reached its scheduled end after logging 16,612 hours of operation. At project completion, in addition to setting the record for longest running high temperature fuel cell, the SOFC had experienced no output degradation and was producing electricity with an efficiency exceeding 46%.
(continued on page 3)

IEEE Nears Interconnection Standard

For the last two years a working group composed of members of the IEEE, the Institute of Electrical and Electronics Engineers, has been developing Standard 1547, Standard for Distributed Resources Interconnected with Electric Power Systems. When completed, the standard will provide consensus standard technical requirements for DG interconnection to the electric power system and for the performance, operation, testing, safety considerations, and maintenance of the interconnection. The development of this standard is an outgrowth of the evolution of the electric power industry. *(continued on page 2)*

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Resource Dynamics Corporation

To view earlier editions of the DG Monitor or to begin receiving the publication via email please visit: www.distributed-generation.com.

About the DG Monitor The DG Monitor is a bimonthly publication of the Resource Dynamics Corporation covering the many facets of the emerging Distributed Generation marketplace. Articles both report and interpret the most important items. In addition, the Monitor includes special series on DG technologies, applications, manufacturers, and issues providing the reader with a complete picture of these topics over several issues.

Comments or requests for additional information can be addressed to jab@rdcnet.com, through our website at www.distributed-generation.com, or by contacting Jeff Borek at 703/356-1300 X 214.

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Traditionally, utility electric power systems have not been designed to accommodate customer generation at the distribution level. However, electric industry restructuring has resulted in a new emphasis on DG, a fact that is forcing industry members to examine ways to integrate DG into today's electric power systems.

Many DG customers, vendors and developers cite interconnection barriers as a major obstacle to DG technology commercialization. DG manufacturers have found that utility interconnection requirements vary from state to state and system to system, making it impossible to standardize equipment. The development of an interconnection standard can lower these barriers, and is therefore a major milestone in the evolution of DG as an electric power resource.

However, manufacturer, customer and utility DG activities are frequently not coordinated. IEEE is working to address this complicated issue by fostering a standards development approach that is open to all interested parties. It has been an organizational and technical challenge to reach industry consensus on issues including performance, operation and safety of the interconnection.

These standards, meant for universal adoption in the U.S., will assure system safety, reliability and performance, and can also facilitate the commercialization of DG technologies. N. Richard Friedman of the Resource Dynamics Corporation has been facilitating the deliberations of a working group of over 300 members representing utilities, vendors, and other interested parties developing the technical requirements for interconnection. As he leads this effort, Mr. Friedman brings his and RDC's extensive experience with DG technologies to the Standards discussion. In addition, through involvement in the development of the IEEE 1547 Standard, RDC is able to provide clients with a unique insight into current and future opportunities for DG applications.

The Standard is slated for completion in the Spring of 2001, with a publication target date of December 2001. Plans are currently being formulated for development of the DG Interconnection Applications Guide to facilitate the use of the 1547 Standard. ■

RDC Chairman N. Richard Friedman will be presenting at the 5th Annual DG and Onsite Power Conference being held March 21- 23 in New Orleans. The conference theme is "Installing Viable DG Systems for Improving Power Quality and Reducing Energy Costs". Two dozen presentations will provide insights into DG planning, installation, interconnection, and operation with focus on DG issues, barriers and practical ways to resolve them. For more information, see www.dist-gen.com

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have a dominant hold on the data center DG market. The systems use a battery or flywheel UPS in combination with a standby generator set to provide constant power in case of an outage. Other DG technologies, like ONSI fuel cells, are currently under testing for data center usage and have been employed in a few applications including the Bank of Omaha, but are not yet financially viable for most customers.

Cost is not the only issue when considering DG to serve a data center. Each center must have absolute confidence that the DG technology will function as it is meant to when it is needed. For this reason, reliability and quick start up time are key. In some regions environmental controls limit the use of diesel fueled units to several hundred hours annually or preclude their use in anything other than emergency applications. Lower emission natural gas units can still raise air and noise quality concerns, and regulatory issues such as local siting and zoning rules must also be factored into any DG evaluation.

Data center development activity is on the rise, and contributes to the economy's increasing demands for premium power. As computing technologies become increasingly less tolerant of outages, DG will remain a fundamental element in data center projects and in supporting the continued expansion of the high-technology industry. ■

Virginia: A Dose of Prevention

Learning lessons from energy crises across the nation, the Resource Dynamics Corporation and other forward thinking organizations like America Online and Dominion Virginia Power are part of a task force studying electric infrastructure and environmental concerns related to Virginia's booming high tech industry. The task force will first seek to identify and characterize these challenges, focusing initially on Northern Virginia's "Internet Alley." Among other issues, the task force will discuss the use of DG to mitigate the risk of power outage for mission critical facilities in an environment of tightening emission standards. The task force met for the first time in late September, and will meet three more times in the coming year to tackle these reliability, power quality and environmental questions.

For information on this task force or DG use in data centers please contact N. Richard Friedman at (703) 356-1300.

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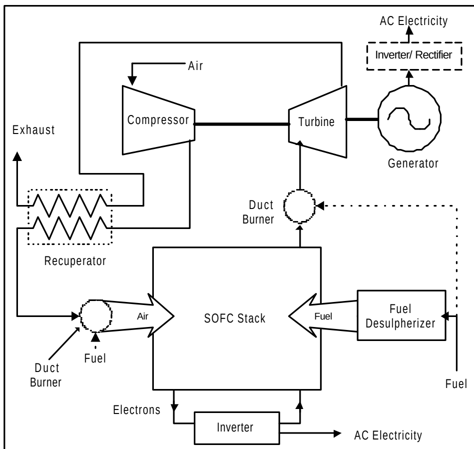
In part because of the success of this project, Siemens is expanding its R&D efforts, most notably in fuel cell/turbine hybrid systems. A 220 kW SOFC hybrid is being powered up at the University of California-Irving and a 1 MW system is set to be installed in Fort Meade, Indiana. Siemens has also recently been awarded two contracts by European utilities. The first system will be employed by RWE Power AG of Germany, and the second by Edison Spa of Italy. Both of these systems are 300 kW with a generator module that is a direct application of the record setting 100 kW project. The Cal-Irving 220 kW system is expected to reach 55% efficiency, and the European projects are expected to approach 60%, but the estimates have not been proven. Even if achieved, these efficiency levels are far below Siemen's and the National Energy Technology Laboratory's (NETL) goal of 70%+ by 2010 and DOE's Vison 21 goal of 80% by 2015 – though the latter goal is deemed highly optimistic by many industry experts. ■



As shown in the figure to the left, a fuel cell/turbine hybrid consists of a SOFC stack (Molten Carbonate cells, MCFC, can also be used in different configurations) and a turbine and compressor similar to those used for microturbines (for current sub 1 MW units). SOFCs and MCFCs are chosen because of their high operating temperatures. The components (rectifier/inverter, recuperator, and duct burners) illustrated with dotted lines are optional and usage will depend on exact configuration and intended use of the hybrid unit. Although this schematic shows the compressor, turbine, and generator all on one shaft, actual units may have multiple turbine sections and a split shaft design. Currently, Siemens Westinghouse Power Corp., Allison, Solar Turbines, FuelCell Energy, McDermott Technology Inc., and National Fuel Cell Research Center are working on the development of hybrids in projects partially sponsored by NETL.

DG APPLICATION SERIES: PEAKING POWER

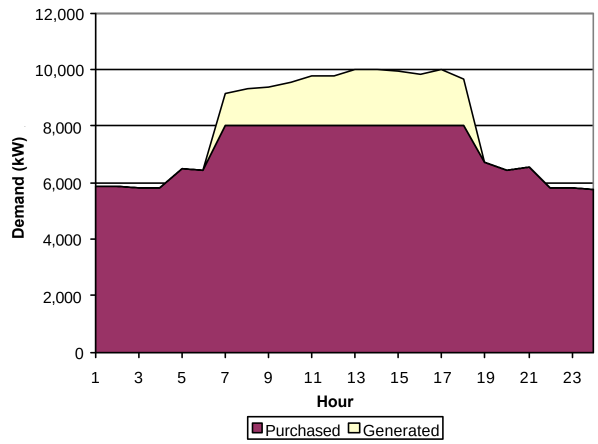
Peaking power applications, where DG is operated for a limited number of hours per year to reduce overall electricity costs, can be cost effective for many sites. Units can be operated to reduce demand charges, to defer buying electricity during high-price periods, or to allow for lower rates from power providers by smoothing site demand.

In general, sites with a high total charge per kWh, caused by high demand charges or from being forced to buy power during peak price periods, have the most potential benefit from adding a peaking unit. However, the nature of peaking power applications ties their economics closely to the underlying strategy motivating their implementation. For example, the profitability of a unit employed to be dispatchable (able to be called into service when a power provider chooses) is primarily determined by the price the power provider pays for such an option.

Peaking power applications are generally only operated for short duration at various times in the year. Units may be sized to meet certain portions of a site's load, entire site load, or may be sized much larger than site electric demand with the intention of selling most of the power back to the grid. Important DG characteristics for peaking power units include: low installed cost, quick startup, and low fixed maintenance costs. Factors such as unit efficiency and fuel price are less important here than in continuous power applications.

Reducing Site Peak. Applications designed to reduce the site peak should be sized at the level of desired peak reduction and operated when the site load is larger than "base" load (the peak load minus the desired peak reduction). For example, if a site has a relatively flat portion of their load up to 8 MW and a "peaky" portion of the load that fluctuates between 8 and 10 MW, it may have high demand charges based on 10 MW even though most of its energy is required at demands of 8 MW or less. In this case it may be possible to size a unit that peaks at 2 MW and operate it any time site demand is above 8 MW. This concept is illustrated in the accompanying figure (above, right).

The customer's load duration curve will dictate what peak reduction can be obtained for a given number of operation hours, and a peaking unit should be sized no larger than the maximum possible reduction. Since any capacity above the maximum peak reduction could not be used to reduce demand charges, it is unlikely that the incremental expense of a larger unit could be justified.



Daily profile of a peaking power application in a New York City hospital

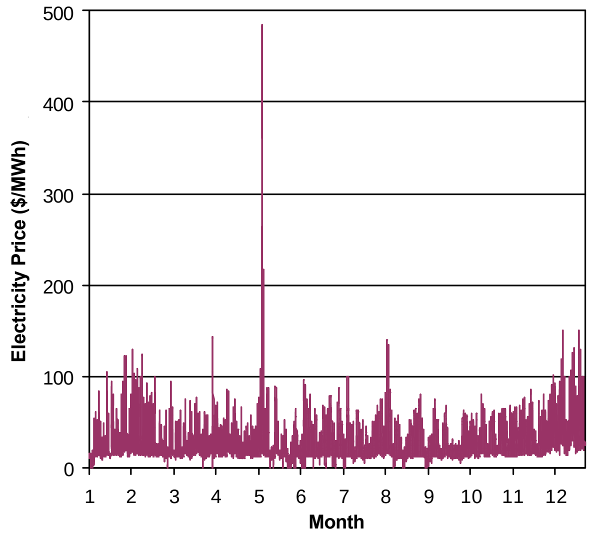
Profitability for these projects usually requires high demand charges, and demand ratchets can help. A demand ratchet is a characteristic of many rate schedules in which demand is billed based on the highest demand of that month *and past months*. Some rate schedules calculate demand charges (or at least a portion of demand charges) based on the highest total demand during the last 12 months. Other ratchets base demand charges on the demand of previous months of the same season. It is important to assess exactly how operation of a DG unit will effect site demand and how changes in demand each hour affect the total bill from the power provider. This is not always an easy task and may require applying the rate schedule to the 8,760-hour yearly profile of the site, with and without DG generated power, and analyzing the difference.

Increasing the Flexibility of Power Providers. Some utilities may offer customers a discount on electricity if they maintain dispatchable units. These applications are likely in areas of the country experiencing transmission or distribution constraints. Dispatchable applications may employ existing backup units eliminating most of the capital requirements. The units are generally contracted to operate when the power provider requests, during periods of high power prices and/or high demand in the region. The units can also provide backup power for the site in the event of loss of grid power. Alternatively, units may be installed so a site can switch to lower priced interruptible rates from a power provider and not risk having to shut down during an interruption. As with backup units, these units are not likely to be operated often and their value depends on allowing critical operations to continue when power is shut off. Other units might be installed to flatten load profiles in order to negotiate better rates from electricity retailers.

The operation of these units will vary based on the desired peak reduction and load duration curve of the site.

Profiting on the Spark Spread. Projects designed to take advantage of variations in power and fuel price may operate a unit during periods when the spread between electricity and natural gas price (spark spread) is high. High electricity cost periods may be a certain time during the day or a certain day/week/season during the year. Year 2000 prices for the PJM interchange are displayed in the figure to the right and illustrate the volatility in the wholesale electricity market which leads to potential peak shaving profits. Once a unit has been installed, operation makes economic sense anytime the electricity price is higher than the variable costs to generate (mostly fuel expense). When determining whether to purchase a unit, it is important to assess how many hours a year the electricity price will be high enough to warrant unit operation and if the cost savings from the displaced charges will be sufficient to recover capital and other fixed costs.

Selling Excess Power. Peaking power applications are designed to take advantage of occasional opportunities provided by the market to make a profit by generating electricity. For the most part, the applications are utilized such that all generated electricity is consumed onsite. However if during periods where conditions make generating electricity attractive the on-site DG capacity is greater than site demand, it may make sense to sell to the wholesale market provided that the proper interconnection equipment is in place and the market/utility allows for this type of transaction. As mentioned before, operation will be economical only if the variable costs to generate additional power are lower than the price received for that power on the market.



2000 PJM Interchange Day Ahead Wholesale Electricity Prices

DG NOTES

Due to **power shortages in the Western U.S.,** utilities in Idaho, Washington and Oregon began using DG units in February to supplement their supplies. This is expected to continue at least through 2001. (2/6)

Celerity Energy is creating the largest independent power project in the western US using existing DG assets such as standby generators in commercial and industrial facilities. The project, scheduled for completion in time for the summer peaking system, will provide 25 MW of dispatchable peaking capacity for the **Public Service Company of New Mexico** and will use a communications network provide by **Sixth Dimension.** (2/5).

Honeywell stockholders approved the $37 billion takeover by **General Electric**. The companies have applied for European approval of the merger. (1/15)

Enron, **Kawasaki** and **Catalytica** recently signed contracts for three 1.4 MW turbines to be installed in a government healthcare facility. The project will be the first commercial installation of Catalytica's Xonon Cool Combustion System. (12/20)

Ballard commissioned its initial fuel cell manufacturing facility, Plant 1, intended to allow the company to introduce commercial products starting in 2001. (12/20)

RDC DG NEWS

Presentations

"Distributed Generation: The Future of Power?" – Jeffrey Price, National Economists Club, Washington DC, Jan 17, 2001.

"Update on IEEE Standard P1547, Standard for Distributed Resources Interconnected with Electric Power Systems" – N. Richard Friedman, Annual Distributed Power Program Review Meeting, Office of Power Technologies, DOE, Washington DC, Jan 16-19, 2001.