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Distributed Generation MONITOR

Exploiting Synergies in the DG Market

Several DG companies have recently revealed that their commercialization strategies will rely heavily on coordinated, global operation with one another. Through a series of world-wide joint ventures, joint development and marketing agreements, and mergers and acquisitions, these companies hope to exploit each others strengths to overcome the hurdles of the emerging DG market. For example, companies can cut costs through joint billing, maintenance, and marketing, and potentially make greater strides by combining their expertise and capital for joint product development. Furthermore, when a new, unproven company partners with a more established one, it may gain the advantage of lower costs of capital and thus access to critical investment funds.

Many of these newly announced DG agreements are marketing and distribution based. It is expensive to establish marketing and distribution networks, and emerging DG companies often find they can keep cost down by working within established infrastructures. In exchange, their partners gain access to new technologies. In a press release this month, G. Paul Horst, president of DTE Energy Technologies, said "As we prepare for the commercial launch of many of our new distributed generation products and services, we have been actively pursuing strategic relationships…around the world." One of those efforts will be a joint venture, called energy|now(TM) Korea, with Samsung Techwin, an international firm focusing on high-technology industries.

(continued on Page 2)

Green Energy

Two large global companies are betting that renewable, or 'green' energy will be one of the highest growth areas in the energy market. Merrill Lynch Asset Management, a big name in global fund management, has started up its own 'New Energy Technology Fund' to capitalize on the growing strength of the green energy market. The Royal Dutch/Shell Group of Companies announced it plans to invest between $500 million and $1 billion in renewables over the next five years. These two companies may be harbingers of growing large scale investment in green energy.

Interest in the renewable energy field has been piqued in part by recent changes in energy policy. In the last two months alone, Illinois, Minnesota, New York and Nevada have called for increased reliance on renewable energy sources. In Illinois, on May 31, the Legislature passed a law that sets a goal for 5 percent of the state's energy production to be from renewable energy sources by 2010 and 15 percent by 2020. On May 7, the Minnesota Senate voted unanimously for SF 722, which requires all utilities in the state to supply their customers with electricity produced from renewable energy. In addition, the legislature has several renewable energy mandates in place that will result in about 825 MW of wind energy and 125 MW of biomass power for the state. New York Governor George Pataki issued an executive order June 10 that requires state facilities to purchase at least 10 percent of

(continued on Page 3)

IN THIS ISSUE

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 bi-monthly 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 DGMonitor@rdcnet.com, through our website at www.distributed-generation.com, or by contacting Jean Connors at 703/356-1300 x 208.

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Exploiting Synergies from page 1

DTE will contribute its DG technologies and expertise and, in exchange, gain access to Samsung's customer base and sales and marketing infrastructure.

Similarly, Marubeni, one of Japan's leading general trading houses, will provide the infrastructure to launch FuelCell Energy's Direct FuelCell® in Asia as part of a strategic alliance the two companies entered into this June. They also anticipate forming a manufacturing joint venture in the future. Shell Hydrogen U.S. and International Fuel Cells will sell fuel processors and fuel cell power plants through a 50-50 joint venture called HydrogenSource LLC. In addition, by integrating their development and manufacturing efforts, the two hope to further reduce costs.

Proton Energy Systems, Inc. and global communications provider Marconi also have this goal, and will jointly develop concepts, designs and products incorporating Proton's UNIGEN® regenerative fuel cell technology for potential application to Marconi's product lines. Texaco Energy Systems Inc. (TESI) and Reliant Energy Power System will work together to develop and integrate TESI's proprietary multi-fuel processor and Reliant's PEM fuel cell system. Sustainable Energy Technologies Ltd. and Nuvera Fuel Cells will collaborate on the development of power conditioning for a fuel cell system that will integrate Sustainable Energy's power management module with Nuvera's PEM fuel cell stacks.

In some cases, the synergies between companies can be best exploited through mergers and acquisitions. In June, Ballard Power Systems Inc. acquired Textron System's carbon products business unit, and the accompanying intellectual property. However, the M&A process is not always a smooth one. In a high profile example, the General Electric Co. (GE) is having difficulty obtaining the go ahead from European regulators for its proposed merger with Honeywell (see December-January issue, *GE Expands DG Presence)*. On June 14, GE submitted a final offer of concessions to the European Commission (EC), but the company and the EC remain far apart from each other in their positions.

As the DG market develops, companies will continue to explore collaborations and strategic alliances as they seek to benefit from acting together. The agreements that develop will range in form and in scope, but will have significance for the commercialization of DG technologies.

Green Energy from Page 1

their energy needs from renewable sources by 2005, and 20 percent by 2010. Nevada Governor Kenny Guinn signed SB 372 on June 8, enacting legislation that requires utilities Nevada Power Company and Sierra Pacific Power Company to generate 5 percent of their power from renewables by 2003 and 15 percent by 2013.

In order to obtain financing, renewable energy projects need a secure and predictable revenue stream. These mandates, or portfolio standards, have been hailed as a critical step for creating more stable markets for renewable energy sources by encouraging long-term sales contracts. Gov. Guinn said "…I believe [SB372] will substantially boost the use of renewable energy sources..." and many industry members agree with him. However, obtaining a long term contract, even with the mandates in place, will be difficult. For example, in Nevada, the future of load serving entities is uncertain. Potential new entrants, like Shell, are in a holding pattern as they wait to see whether they will be allowed to enter into the market or not and under what conditions. The utilities are no more secure- with recent law making, it is not certain that they will even be around for the duration of a long term contract. Requiring new entities to honor contracts made by the utilities could be disastrous, as a contract to purchase at, say 13 cents, when the market is actually for 8 cents, will result in stranded costs, and repercussions potentially like, or even worse then those in California. The situation is similar in the other states.

Portfolio standards may indeed mean that a market for renewables develops, but much depends on emerging market conditions. Recent conditions in California have increased the risks for electric service providers (ESPs) offering 'green power' products, but concurrently, high overall electricity prices have made green power more cost-competitive. In Nevada, it was agreed that a utility could be exempted from the portfolio requirement if the price of renewable energy was determined by Public Service Commission not to be 'just and reasonable.' However, even with market uncertainty, green energy tech stocks are surging as investors bet that technological advances will decrease costs enough to make the renewable requirements stick. In the photovoltaic (PV) arena, Duke Solar Energy LLC has a solar system that integrates Concentrated Solar Power (CSP) technologies. Evergreen Solar, Inc., whose stock has increased in value by 33 percent since March, has a new 51-watt panel, the EC-51, that uses a wider 3.2-inch ribbon representing a productivity increase of more than 40 percent in the wafer fabrication process. Kyocera Solar (KSI) has a new full line of standardized, rooftop-mounted solar energy systems that convert sunlight into utility-quality AC power which can be used or automatically sold back to the grid. Projects such as these, that increase availability and decrease costs, will remain important indicators for the future of renewable energy.

Wind Turbines provide one renewable energy option

CONFERENCES:

IEEC Integrated Energy Efficiency Congress (Contact: www.aeecenter.org), 29 Aug. – 3 September, 2001, Cleveland, OH

NASEO Annual Meeting (Contact: www.naseo.org/events/annual/default.htm), 16-19 September, 2001, Portland, ME

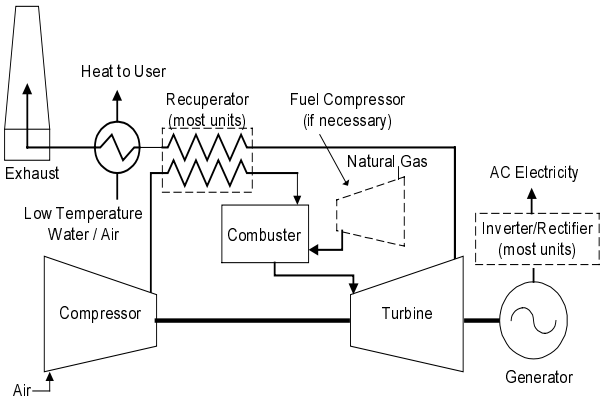
Distributed Generation (Presented By: The Center for Business Intelligence), 24 September, 2001, Denver, CO

Powering the Future—New Strategies and Solutions for Deploying Distributed Power in the Marketplace (Contact: www.intertechusa.com), 24-26 September, 2001, Chicago, IL

World Energy Engineering Congress (Contact: www.agcc.org (includes CHP Expo www.aeecenter.org)), 24-26 September, 2001, Atlanta, GA

DG TECHNOLOGY SERIES: MICROTURBINES

With changes in the electricity industry and growing concerns about electricity reliability and quality, microturbines have garnered recent attention as a strong potential technology for DG applications. Promised benefits include electrical efficiency levels of about 30 percent, high reliability, relatively low emissions, ease of maintenance, short lead times, and siting close to load. Several manufacturers are already marketing production models, and more units are slated to enter the market in 2001 and 2002. So far, the response has been steady, with sales, distribution, and alliances developing worldwide.



Microturbine Schematic

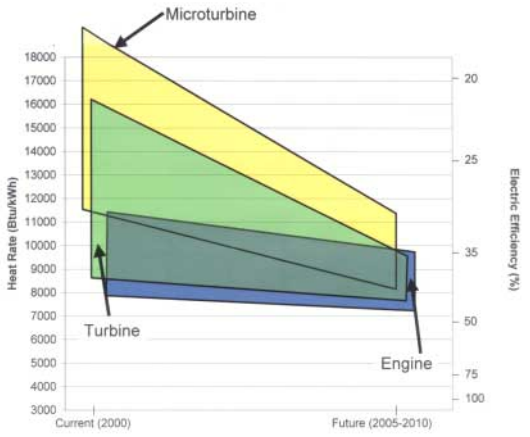
Technology. Microturbines are essentially a packaged automotive turbocharger combined with elements of aircraft, diesel and automotive designs. Typically within the 30 kW to 500 kW size range, they are often thought of as a "new" technology, even though microturbine development dates back to the 1950s. Most designs are single-shaft and use a high-speed permanent magnet generator that produces variable voltage, variable frequency alternating current (AC) power. An inverter then converts this high frequency power to 60 Hz AC power. Another design incorporates a split shaft with a reduction gearbox, and a 2-pole, 3600 rpm induction generator to produce 60 Hz power directly without an inverter. The single-shaft design is simpler, but the split shaft design can also work for mechanical drive applications.

Because most microturbines operate at high speeds (40,000+ rpm), they require highly reliable bearing systems. Air bearings eliminate the need for an oil lubricant, resulting in less maintenance and eliminating the parasitic oil pump load. However, oil bearings generally last longer and may be less prone to catastrophic failure, especially when turbine power is ramped up and down frequently. Recuperators—air-to-air heat exchangers that use the hot gases produced by the microturbine to preheat the combuster inlet air after it has been compressed—increase the efficiency of the units from a range of 15-22 percent (unrecuperated) to 26-30 percent.

The question now is whether microturbine manufacturers can meet cost and efficiency goals to reach full market potential. Early test results indicate that microturbines can be a cost-effective alternative to conventional generation. However, these reports may not account for the suboptimal conditions of real world operation. For example, efficiency and maximum output degrades at high ambient temperatures and when high pressure gas (50-60 psig) is not available. Gasifiers that produce gaseous fuel from solids (such as coal and biomass) provide microturbines with valuable fuel flexibility, but require expensive fuel treatment systems and gas cleanup that can compromise efficiency and increase initial costs.

Efficiency Levels. Microturbine efficiency levels are currently the lowest among micropower (<1 MW) options, but improved recuperation and other design improvements can help improve this picture. Advances in high temperature recuperator materials, such as ceramics, can also improve efficiency by allowing microturbines to operate at higher temperatures. Figure 1 shows that the "efficiency gap" between microturbines and other

Figure 1
Expectations of Current and Future Heat Rates



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Market Acceptance for Microturbines

After years of testing and speculation, market acceptance of microturbines is growing. Units already commercially available have now been operating long enough to convince many buyers that the new technology can provide reliable generation of electricity.

Capstone Turbine Corporation, the company that has delivered the most units, has logged cumulatively about 650,000 hours on over 500 units it tracks, according to Capstone's Kevin Duggan. He adds that some of the company's 30 kW units are close to logging 20,000 hours of operation.

Honeywell Power Systems, meanwhile, claims that it has managed to save up to $113,000 a day in energy costs at its Torrance, California site as a direct result of installing 13 of its units at its own facility. The savings represent what the company would have paid in "penalty rates" as an interruptible customer during an eighteen-hour Stage 3 Alert. Last May Honeywell delivered 40 units to Mercury Electric Corporation in Alberta, for delivery to customers in Western Canada.

Manufacturer	Model	Notes
Capstone Turbine Corporation	MicroTurbine power systems	Shipped its 1,400th 28 kW microturbine unit in January and completed its first stand-alone 60 kW unit in June.
Honeywell Power Systems	Parallon 75 microturbine	Thirteen 75 kW units online at Honeywell's Torrance, CA facility. EU has prohibited a pending merger with GE.
Elliot Energy Systems	45, 60 & 80 kW units.	Models commercially available since 1997. 200 kW unit in development.
Ingersoll-Rand	PowerWorks 70 kW microturbine	Currently several 70 kW units undergoing alpha testing in the New York City, Boston and Los Angeles areas.
Turbec	Cogeneration package	Shipping a unit that produces 100 kW electricity, 167 kW thermal in Europe, looking to enter the U.S. market.

In addition, consumers will soon have a wide range of microturbine types and sizes to choose from, delivered by a growing number of manufacturing companies. Elliott Energy Systems is now delivering microturbines in 45, 60 and 80 kW sizes, while a 200 kW system is under development. Elliott is providing microturbines to Bowman Power Systems, a British company that has developed a cogeneration package. Bowman is marketing its microgeneration system in Europe, and has opened an office in Southern California.

Ingersoll-Rand Energy Services, formerly Northern Research Engineering Corporation, has designed a 70 kW "PowerWorks" unit, now being tested in the field. Turbec, a joint venture between ABB and Volvo, is already marketing a cogeneration package in Europe that produces 100 kW of electricity and 167 kW of thermal energy, and is now sending representatives to scout the U.S. market.

DTE Energy Technologies is developing a 400 kW miniturbine slated for testing this year. In May, DTE acquired Alliance Energy Companies Ltd. of Minneapolis, a DG product and services distributor. DTE's energy | now™ mini-turbine unit combines a Pratt & Whitney gas turbine and a high-speed electric generator provided by Turbo Genset, and boasts emissions of less than 10 ppm of NO_x and net energy efficiencies of 29 percent.

Solo Energy Corporation of Alameda, CA, is developing a 90 kW Wireless Energy™ Microturbine that it hopes to use to provide electricity to industrial customers under fixed-term contracts. Solo Energy says it will combine on-site generating capacity with internet-based remote control to give its customers cost effective power, better reliability, price certainty and superior power quality.

Whatever the market strategy, customers will have plenty to choose from within the next 18 months, as most companies not already providing commercial units plan to offer their wares sometime this year or next.

Microturbines from Page 4

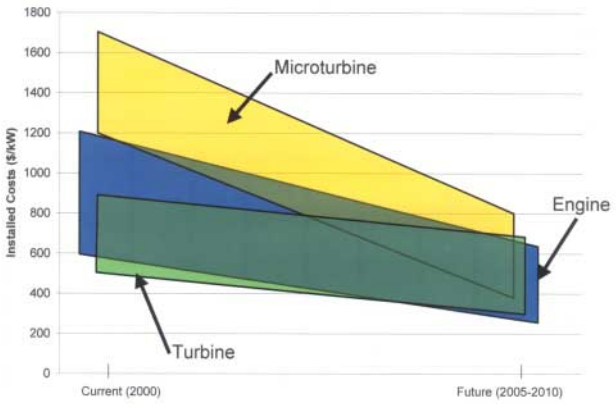
technologies like engines is expected to narrow over the next ten years. In addition, the range of efficiencies between different microturbines is also expected to decrease as improvements are applied across the board.

Emissions. Any combustion process will produce nitrogen oxides (referred to as NO_x), carbon monoxide (CO) and hydrocarbons (THC). NO_x levels drop as operating temperature declines, but low combustion temperatures result in higher levels of CO and THC, as the fuel is not completely burned. For microturbines, injectors can be developed to balance air-to-fuel ratios and air-fuel mixtures to ensure that combustion occurs at the lowest temperatures possible to limit NO_x emissions. At the same time, the injector ensures that the fuel is combusted as completely as possible by allowing the air-fuel mixture to remain in the combustion chamber for a relatively long period of time.

Several manufacturers use advanced combustion technologies to reduce emissions. When operated at high output ranges, these units can achieve emission levels that are comparable with those of larger turbines. Greenhouse gas levels, including carbon dioxide (CO_2), vary depending on the type of fuel used, and decrease as unit efficiency increases. NO_x levels are reported as <9 ppm for the Capstone MicroTurbine (30 kW) and 50 ppm for the Honeywell Parallon 75 (75 kW). Anecdotal evidence suggests that NO_x levels increase when the unit operates at part load.

Costs. Currently, microturbine installed costs are higher, on average, than competing reciprocating engine units, but these costs are expected to decrease. Figure 2 illustrates the expected path of microturbine installed costs over the next ten years. These costs, based on technical literature and manufacturer input, are projected to decrease substantially and narrow in range. The standardization of interconnection requirements, for example, can reduce the installed costs of microturbines substantially. With simple designs and fewer moving parts, maintenance costs for microturbines promise to be lower than for engines, but these claims cannot be substantiated until components have been fully proven.

Figure 2
Expectations of Current and Future Installed Costs



Challenges. Many technology challenges need to be addressed in the development of microturbines. Concerns include the reliability of equipment rotating at high speed, the feasibility of relatively unattended operation, the use of advanced, high-temperature material, and the need to track environmental performance and power quality. Microturbine manufacturers may be forced to make trade-offs in order to both address these concerns and reduce costs. For example, a single-shaft design is simpler and less costly to produce, but it requires an inverter to convert unit output to standard AC power, which can be expensive.

In spite of the potential hurdles, manufacturers are confident they can meet the needs of a growing market for on-site power generation. Microturbines remain potentially attractive for a wide variety of applications, and the development of interconnection standards, deregulation, and increasing reliability concerns may accelerate that interest.

DG Notes

July 25, 2001 - **Ballard Power Systems, Shell Hydrogen and Westcoast Energy** announced the creation of **Chrysalix Energy Limited Partnership** (Chrysalix). This private capital joint venture will provide companies with early-stage funding and other support. They will target companies with high growth potential in the fuel cell sector, including manufacturers of fuel cells and related systems, hydrogen infrastructure, maintenance and support.

July 20, 2001 - The DG and energy services arm of **PPL EnergyPlus** will install five 60 kW Capstone microturbines at the Masonic Homes retirement community in Elizabethtown, PA as part of PPL's GenSelect(SM) program. The on-site generation plant will be powered by natural gas, and the heat generated by the microturbines will be used to pre-heat the water in new gas-fired boilers. The project, expected to be completed in July 2002, is projected to result in more than $13 million in energy savings for Masonic Homes over the next 30 years.

July 19, 2001 - **Sustainable Energy Technologies Ltd**. will ship its 5 kW universal power inverter to the fuel cell and solar electric industry for initial evaluations. Michael Carten, President and CEO commented that as one of only a handful of inverter suppliers at this power rating, Sustainable is well positioned to compete in the rapidly growing solar energy market. Sustainable has also received requests for evaluation units from European and North American electrical and telecommunications companies.

July 9, 2001 - U.S. Rep. J.C. Watts (R-Okla.) introduced legislation HR 2322 to provide a 30% investment tax credit for residential wind generators.

July 9, 2001 - California and a group of power generators failed to reach an agreement in settlement talks over the state's demand for $8.9 billion in refunds for alleged wholesale electricity overcharges.

June 27, 2001 - The Department of Energy, through the Bonneville Power Administration (BPA), will sign pre-development agreements for seven wind power projects that will provide an additional 830 MW of generating capability during periods of high winds in the electricity-strapped Western region.

June 27, 2001 - **Avista Labs** will integrate **Maxwell Technologies'** PowerCache® ultracapacitors with its modular PEM fuel cell components and systems. PowerCache® can deliver rapid bursts of power for start-up and peak load buffering, allowing components and systems to be made across a range of voltage applications with significant reductions in size and cost.

June 27, 2001 - **Plug Power, Inc**. entered into one non-binding Memorandum of Understanding (MOU) with **GE Fuel Cell Systems, L.L.C**., **GE MicroGen, Inc.,** and **GEPS Equities Inc**., and another with **DTE Energy Technologies, Inc**., to distribute Plug Power's PEM fuel cell systems and invest new cash equity in Plug Power. Separately, DTE Energy subsidiary **Edison Development Corporation** will purchase $5 million worth of additional Plug Power common stock shares.

June 26, 2001 - As part of the five year, $170 million Clean Energy Initiative (CEI), Long Island Power Authority (LIPA) will connect 75 **Plug Power Inc** fuel cells to its electric grid at its West Babylon substation to study fuel cells operating in parallel with their electrical grid system.

June 2001 - **Capstone Turbine Corp**. combined aspects of their air bearing technology and compact rotary flow compressor (RFC) to create what they believe is the first lubricant-free compressor that can boost very low pressure natural gas to a compressed state required by microturbine systems. The new foil-bearing RFC extends operating range to as low as 0.2 psig inlet pressure, is vibration-free, and is expected to extend compressor life and reduce maintenance. Capstone has also begun producing commercial quantities of recuperator cores in a strategic move to eliminate possible availability restrictions. In addition, the company completed its first stand-alone Capstone 60 microturbine power system. This unit will be one of a 6-pack of stand-alone Capstone 60s installed by UK distribution partner Advantica at a hotel development in a combined heat-and-power (CHP) application.

June 14, 2001 - **Pepco Technologies, LLC's** GenerLink(TM) interconnection device, which is meant to be installed behind a residential electric meter, received certification from Underwriters Laboratories Inc. (UL) under the 1008 standard.

Jun 11, 2001 - New York governor George E. Pataki approved a mandate requiring state buildings and quasi-independent agencies to use 10 percent of renewable electric power by 2005 and 20 percent by 2010.

June, 2001 - The White House report on climate change recognized Federal programs that promote greenhouse gas reductions, specifically mentioning the Combined Heat and Power (CHP) Challenge and its goal of doubling U.S. CHP power capacity by 2010. It also discussed the government's support of renewable energy sources such as solar, wind, geothermal, hydropower, biopower, and hydrogen, and mentioned technologies including geothermal power plants and fuel cells.