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Distributed Generation MONITOR

Heavy Hitters Move into Fuel Cells

Well known company names are appearing with increasing frequency in fuel cell news and in new areas of the fuel cell market. Automotive heavy weights like GM, Toyota, Ford, BMW and DaimlerChrysler are exploring stationary as well as automotive fuel cell applications. Energy companies such as Exxon Mobil, Sanyo Electric Co. and Osaka Gas Co. have begun to move into and expand their presence in the fuel cell sector. Collectively, these heavy hitters have signaled their belief in the future of the fuel cell market.

The potentially lucrative nature of the stationary markets likely sparked the interest of Sanyo Electric Co. and Osaka Gas Co., a natural gas utility serving more than 6 million customers in Japan. These two entered relatively new territory when they announced in late August that

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GM Stationary Fuel Cell

Waste Gas Utilization Increases

Until recently, few facilities have found biogas usage to be economical and instead the gas has been flared. However, growing concerns about energy supplies and the environment, and advancing technologies have changed the economics of biogas usage and led an increasing number of facilities to explore harnessing this fuel. The unutilized portion of this resource is substantial. According to Capstone, over 4 trillion cubic feet of energy-containing gas is flared worldwide.

Facilities generally choose to flare the gas because it is too expensive to use it. Large installations use specially modified turbines or internal combustion engines that can

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California Launches Advanced Reciprocating Engine Program

Faced with potential electricity shortages during peak periods, California has been exploring many options to increase its power supply and reduce demand. Over 1,200 MW of new central station plants have been added in California during 2001. However, a large electricity source already in place is emergency and standby reciprocating engines. A just completed survey found there are about 3,000 MW of these units in California.

In recent months, interest in reciprocating engines has been strong. Since January, GE Distributed Power has secured contracts to supply 131 MW total of midrange

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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 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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be quite costly. As a result, many smaller sites have found biogas recovery to be uneconomical. Technological change has produced new, more cost-effective alternatives for these smaller sites. Power generation units like those from Caterpillar and GE Distributed Power have been designed to burn a wide variety of gaseous fuels and, in addition, to be switched from one to the other. In 1999, microturbines emerged as an option for biogas usage when AlliedSignal Power Systems Inc. demonstrated its Parallon™ 75 running on landfill gas in Albuquerque, New Mexico. Since then, further technological advances and the search for new energy sources have made microturbines even more attractive. In July of this year, Capstone provided the fifty 30 kW microturbines run exclusively off landfill gas used at the Los Angeles Department of Water and Power's Lopez Canyon Landfill site. The company's microturbines will also be used by the Inland Empire Utilities Agency (IEUA), a wastewater treatment and wholesale water agency in San Bernardino County California, to burn excess methane gas produced from the manure of approximately 3,750 dairy cows.

Biogas has also been used with another emerging technology, fuel cells, though this application is still in the trial stages. Ballard's fifth 250 kW stationary PEM fuel cell power system is to be field tested at the Nishimachi Sewage Treatment Center in Tomakomai, Japan, and will operate on anaerobic digester gas. King County and FuelCell Energy, Inc.'s demonstration program at the county's South Wastewater Treatment Plant wastewater treatment facility in Renton will use digester gas to fuel a 1 MW fuel cell power plant using carbonate technology.

These new installations will be closely watched, as the technological and situational problems of biogas usage are still being ironed out. For example, special filters must be designed to remove compounds that can be present in some biogas and, if left unfiltered, could potentially damage and shorten the life of generation equipment. Also, biogas makeup at each site is different, and units may have to be custom-tailored to meet the needs of the site and application. Once solution for these and other problems are found and tested, the true economics of installations can be better approximated.

Even with these uncertainties, biogas usage has both economic and environmental benefits, and with advances in microturbine and other technologies, is increasingly cost-effective. Though landfills, sewage plants and agricultural facilities are the most visible opportunities for biogas usage, the solutions found for these facilities will have other applications, such as in the usage of sweet or sour (i.e., high sulfur content) wellhead gas from oil and natural gas wells and of coalbed methane.

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they will jointly research and develop a fuel-cell-based co-generation system for household use. Caterpillar Inc, in conjunction with Nuvera Fuel Cells and Williams Bio-Energy, is also developing a 13 kW PEM stationary fuel cell system, and was awarded $2.5 million in June by The U.S. Department of Energy (DOE) to fund their work.

Even so, much of the new interest in stationary applications has come from automotive companies. For years, these companies have funded research into fuel cell transportation applications. Moving in a new direction, Toyota announced it intends to develop fuel cells for residential energy generation. In early August, General Motors (GM) unveiled a stationary fuel cell generator to be used either as a backup generator or as a primary source for electricity in individual homes. The GM generator is based on the technology developed for the company's experimental fuel cell vehicles. These stationary applications have a side benefit for automotive companies; the work the automakers do in developing stationary generators can lead to breakthroughs in their area of primary focus, transportation applications.

Automakers have also tackled a major hurdle to fuel cell commercialization: finding safe and effective hydrogen production and storage methods. Many of these companies have entered into research collaborations that can save money and accelerate the development process. Amongst other projects, BMW is working with United Arab Emirate member state Dubai on a hydrogen production feasibility study. GM acquired equity in QUANTUM Technologies, a company which works on automotive hydrogen storage. Other companies with processor technology experience have also entered the market. Exxon Mobil recently joined the California Fuel Cell Partnership, looking to adapt its gasoline processor technology for use in fuel cell vehicles. The company also announced that it has decided to merge its fuel cell fuels-related research with that of GM and Toyota. The three companies will share resources and results in an effort focused particularly on developing and testing fuel processing technologies.

Other new market entrants have announced plans to support the emerging fuel cell market. Early this year, DuPont, stating that it expects the fuel cell market to be as much as $10 billion by the year 2010, revealed it has formed a fuel cell business unit and intends to become the leading supplier of materials and components to the PEM fuel cell market. The company has also forged agreements with other fuel cell industry companies. In August, DuPont announced that it has entered into a partnership with Mechanical Technology Inc. to develop fuel cell components, based on DuPont technology, for use in Mechanical Technology's micro fuel cells. H Power Corp., a fuel cell development company, announced in the first week of September that it has also partnered with DuPont to develop direct methanol fuel cells (DMFC) for portable and mobile applications.

Whether these heavy hitters will end up obtaining a large share of the fuel cell market remains to be seen. Much of the research and development work is still carried out by smaller fuel cell companies that are themselves growing in size and influence. However, as large companies seek to capitalize on the potentially large fuel cell market, they can help push fuel cells over the final technical and practical hurdles to commercialization.

CONFERENCES:

Fall Meeting, General Session, U.S. Fuel Cell Council, September 2001, Washington, DC

Distributed Generation: Opportunities and Obstacles (Contact: 858-794-7355), 1-2 November 2001, San Diego, CA

Distributed Energy Resources and the Power Technologies Revolution. Has the Summer of 2001 Accelerated Customer Interest: (Contact NAESCO: 202-822-0954), 6 November 2001, The Biltmore Hotel, Coral Gables, FL

EPRI's 7th Distributed Resources Conference and Exhibition (Contact: lgoldie@epri.com), 17-21 March, 2002, Dallas, TX USA

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(300 kW - 2.8 MW) power generation equipment for installations in California and the Pacific Northwest, including several of GE's new 1 MW Power in a Box(TM) systems as well as a series of stationary, natural gas fired 1 and 2 MW reciprocating engines. Part of the interest is driven by lead time. Dan Kabel, General Manager of GE Distributed Power, said in a recent news release that the Power in a Box unit "can go from order to delivery, installation and operation in less than 30 days, and is ready to produce power the day it arrives on a customer site."

However, there are many restrictions on the operation of stationary reciprocating engines. Depending on the applicable Air Quality Management District rules, most recips are permitted to operate only during actual power interruptions, must not supply power to a serving utility for distribution via the grid only, may operate for maintenance purposes at most 100 hours/year, and must limit operation for both maintenance and power interruptions a maximum of 200 hours/year.

The reason behind these restrictions is that most existing internal combustion engines produce relatively high levels of nitrogen oxides, hydrocarbons, carbon monoxide and particulate matter, compared with either existing air regulations or with emissions produced by central station power sources. Thus, the dilemma is how to utilize the 3,000 MW of existing capacity and still meet the requirements of the Clean Air Act.

This spring, Governor Davis temporarily relaxed the restrictions on the total number of peak hours during which emergency generators can be operated. Also, on July 10, the California Energy Commission (CEC) launched an Advanced Reciprocating Internal Combustion Engine (ARICE) program during a collaborative workshop. Representatives from the major engine manufacturers, energy companies, five of the National Laboratories, fuel supply companies and other interested parties discussed how California might apply nascent R&D efforts to substantially lower emissions from reciprocating engines, especially DG units.

According to the project director Avtar Bining, ARICE's goal is "to take a leadership role in facilitating the R&D of advanced reciprocating internal combustion engine systems that are super-efficient and ultra-clean for distributed, mobile, emergency and other power generation and stationary applications throughout California." While this goal is similar to that of the DOE's existing Advanced Natural Gas Reciprocating Engine Program (ARES), the focus is more short-term and could include non-gas engines. The plan is for ARICE to complement ARES and build on each other's efforts. The CEC expects to conduct its research via public/private partnerships. While the results should serve California consumers, they may effect the future of all reciprocating engines in the DG industry.

An RFP requesting ideas for R&D that will achieve ARICE's goal will be issued during September. The RFP could be for total projects of around $15 million per year over the next several years. More information, including a draft action plan, may be obtained from Avtar Bining at the CEC. Contact him at Abining@energy.state.ca.us or 916-657-2002.

Your Thoughts About Distributed Generation?

The Resource Dynamics Corporation would like to know your thoughts about DG, its prospects, and what you might use it for. Your response will be anonymously compiled with other respondent's views and will be used to help shape the future of the DG industry. To complete the 60-second survey, please go to www.distributed-generation.com/survey.htm. We will publish the results to date in the next edition of *DG Monitor*. We appreciate your input!

RDC DG NEWS

"DG Interconnection Standards" - N. Richard Friedman, at the Fall Meeting, General Session, US Fuel Cell Council, Washington, DC, Sept. 25.

"Enabling Technologies: Aggregation, Dispatch, & Control" and "DG Markets: Realizing Opportunities and Overcoming Barriers" - N. Richard Friedman, at Distributed Generation: Opportunities and Obstacles, San Diego, CA, Nov. 1-2.

The California Self Generation Incentive Program

In California, efforts are underway to reduce demand by 1,700 MW via $230 million of conservation programs including energy-efficient appliance, high-efficiency lighting, HVAC peak shaving, time of use meters, and other peak load reduction programs. An additional $10 million was spent this spring on a public awareness campaign designed to reduce demand by 1,000 MW. California has also allocated $240 million in assistance for low-income customers including weatherization programs, cash assistance and discounts.

The California Self Generation Incentive Program was adopted on March 27, 2001 in an effort to reduce electric load on the grid by encouraging on-site power generation. The statewide, $125 million per year program was developed by the California Public Utilities Commission (CPUC) and the state's investor-owned utilities--Pacific Gas and Electric (PG&E), Southern California Edison (Edison), San Diego Gas & Electric (SDG&E) and Southern California Gas Company (SoCalGas)--and runs through December 31, 2004. It provides monetary incentives to those who install grid-connected on-site power-generation systems to supply all or a portion of their own energy needs. Higher incentives are tied to the use of renewable or super-clean generation technologies. No incentives are provided for diesel-powered or back-up generation.

The following table describes the program incentive payments and project requirements. In addition, qualifying projects are eligible to apply for retroactive incentive funding or retroactive incentives.

Incentive category	Incentive offered	Maximum percentage of project cost	Minimum system size	Maximum system size	Eligible Technologies
Level 1	$4.50/W	50%	30 kW	1 MW	Photovoltaics, Fuel cells operating on renewable fuel, Wind turbines
Level 2	$2.50/W	40%	None	1 MW	Fuel cells operating on nonrenewable fuel and utilizing sufficient waste heat recovery
Level 3	$1.00/W	30%	None	1 MW	Microturbines, internal combustion engines and small gas turbines utilizing sufficient waste heat recovery and meeting reliability criteria as outlined in Public Utility Code 218.5

The program is administered by the utilities PG&E, SCE, and SoCalGas in their service territories, and by the San Diego Regional Energy Office in SDG&E's service territory. Customers can contact these entities for more information on the program. CONTACT: PG&E, Ph: 415-973-6436, Email: selfgen@pge.com; San Diego Regional Energy Office (administrator for SDG&E), Ph: 619-595-5634, Email: selfgen@sdenergy.org; Edison, Ph: 1-800-736-4777, Email: greenh@sce.com; SoCalGas, Ph:1-800-GAS-2000, Email: selfgeneration@socalgas.com.

DG APPLICATION SERIES: DG FUELED WITH WASTE GASES

Distributed generation applications can be fueled with waste gases from landfills, wastewater treatment plants, and other sources. DG technologies that can use waste gases include reciprocating engines, microturbines, turbines, and fuel cells. In most cases, modifications need to be made to the DG prime-mover or fuel cell. Modifications can include special filters, desulphurisers, buffer tanks, gas analyzers, larger gas compressors, and changes to engine operating parameters. Many DG equipment suppliers manufacture modified units that are specifically designed to use waste gases.

Waste gases that can be used in DG applications include:

- Anaerobic digester gas from wastewater treatment plants,
- Landfill gas,
- Organic waste digester gases,
- Oil-field/gas-field wellhead gas (low Btu casing gas),
- Coal-bed methane, and
- Volatile organic compounds from industrial processes.

Waste fuels with energy content as low as 350 Btu/scf can be used. In many cases, before the installation of the DG equipment, the waste gas was flared, or burned as it was released. The following case study examples summarize each of these potential fuel sources:

Anaerobic digester gas from wastewater treatment plants

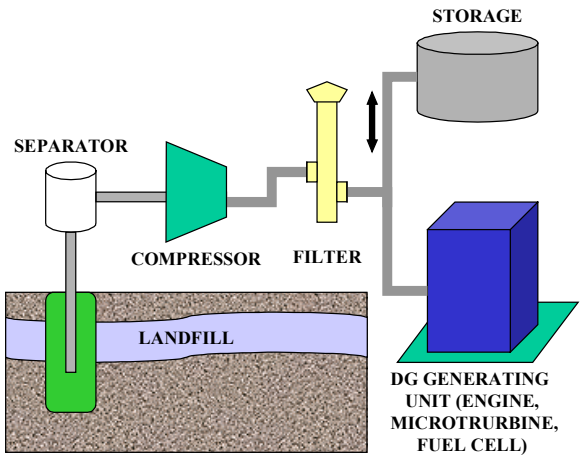
Many wastewater treatment plants use anaerobic digestion to reduce the volume of the biomass solids in sewage and produce biogas containing 60-70% methane. Most wastewater treatment plants that use anaerobic digesters burn the gas to maintain digester temperatures and to heat building space. Unused gas is usually flared as waste, but can be used as a DG fuel.

A fuel cell at the Columbia Boulevard Wastewater Treatment Plant in Portland, Oregon, converts digester gas into electricity. The fuel cell began producing power in July 1999, and will produce an estimated 1,500,000 kWh of electricity each year.

Landfill gas

The anaerobic digestion process occurs naturally underground in landfills. The biogas released from landfills is typically made up of 50% methane, 45% carbon dioxide and 5% other gases. The digestion occurring in landfills is an uncontrolled process of biomass decay. The efficiency of the process depends on the waste composition and moisture content of the landfill, cover material, temperature and other factors. Many landfills flare their waste gas, but it can be used to fuel DG technologies that produce both electricity and heat.

The Burbank Landfill Gas Microturbine Power Plant began producing nearly 300 kW of electricity for the City of Burbank, California in 2001. The landfill gas used to produce the power generated by ten 30 kW microturbines was previously flared. The South Coast Air Quality Management District issued permits to alter the existing landfill gas control system to incorporate the installation of the microturbines. Because the landfill gas is low quality, a number of critical design issues were addressed for the first time to make this project possible. For example, project engineers designed a carbon filter to remove compounds within the gas that would have significantly shortened the operating life of the microturbines.



LandFill Gas Utilization

Organic waste digester gas

High-moisture organic materials, such as animal manure and food-processing wastes, are suitable for producing biogas using anaerobic digester technology. For individual farms, small-scale digesters of simple design can produce biogas for on-site electricity and heat generation by using digester gas to fuel an engine-generator.

In January 1997, the Craven Farms Dairy finished construction of a digester designed to process the manure from a herd of 1000 dairy cows. The digester produced

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11 million cubic feet of biogas during the first year of operation. The dairy used the gas to generate 383,000 kW/hrs of electricity that year.

Oil-field/gas-field wellhead gas (low Btu casing gas)
Small amounts of natural gas can generally be found around significant oil deposits. Most wellhead gas is currently being flared as it is not economical to use. This wellhead gas, sometimes known as casing gas, can contain significant amounts of sulfur.

At a remote PanCanadian Petroleum oilfield in Alberta, three microturbine power systems power the operation's four-well production equipment by converting waste gas into onsite electricity.

Coal-bed methane
Methane is a by-product of coal mining. This gas, a hazard in underground coal mining, is normally vented into the atmosphere or is flared. Coal bed methane is a wasted energy resource and a potent greenhouse gas.

In 1995, Illawarra Coal, located in Unanderra, Australia, installed 94 reciprocating engine gensets at their Appin and Tower coal mines that were fueled with coal-bed methane. The gas is drawn by vacuum from boreholes, sent to gas draining plants at the top of each mine, and then fed to the engines.

Volatile organic compounds from industrial processes
Many industrial processes, such as paint spraying, generated significant amounts of volatile organic compounds (VOCs). VOC-laden air is a low Btu gas and can be burned. Small turbine systems have been developed that can burn this gas and produce electricity and steam. Metal coating and painting processes have been identified as good candidates for these systems.

DG Notes

Sept. 20, 2001 - **Ford Motor Co**. and fuel cell producer **Ballard Power Systems Inc.** announced a $22 million deal under which Ballard will supply Ford with its Mark 900 Series fuel cell modules and engineering support.

Sept. 13, 2001 - **American Electric Power** and **G.A.S. Capital Inc**. have formed a joint venture company, **AEP Gas Power Systems**, to manufacture and market the Innovator(SM), a 1.2 MW gas turbine generator powered by a Lycoming Turbine, for use in co-generation, remote site, supplemental generation and backup applications. The Innovator(SM) has more than 50 million hours of operation, is fuel flexible, and designed to meet the proposed IEEE 1547 standard for interconnections.

Sept. 10, 2001 - **RealEnergy LLC** will deploy, at its own cost, additional photovoltaic (solar) panels at several sites in California where it is now installing co-generation power systems to further enhance the reliability and availability of electricity.

Sept. 6, 2001 - **PJM Interconnection, L.L.C.,** a wholesale energy market administrator, and **Comverge Technologies**, a data communications company, have formed a partnership to create systems for direct communication of real time and revenue information from small energy producers (100KW to 10MW) using wireless cellular technology.

Sept. 4, 2001 - **International Fuel Cells**, a unit of United Technologies Corp., sold a200 kW PC25 fuel cell system that will power a recreational center in Woking, England and be the first commercial fuel cell operating in the United Kingdom.

Aug. 21, 2001 - **Siemens Westinghouse** signed a contract with **BP** to install a 250 kW solid oxide fuel cell (SOFC) at BP's gas-to-liquids test facility in Nikiski, Alaska.

Aug. 16, 2001 - **FuelCell Energy, Inc.** commencing operations of a DFC/T (TM) power plant based on a 250 kW Direct FuelCell® (DFC®) integrated with a **Capstone Turbine Corporation** modified Model 330 Microturbine. The power plant is designed to operate in a dual mode: as a standalone fuel cell system or in combination with the microturbine, which is driven by heat generated by the fuel cell.

Aug. 1, 2001 - The House of Representatives approved a broad-ranging energy package that contained a 5-year extension of the wind energy Production Tax Credit (PTC).