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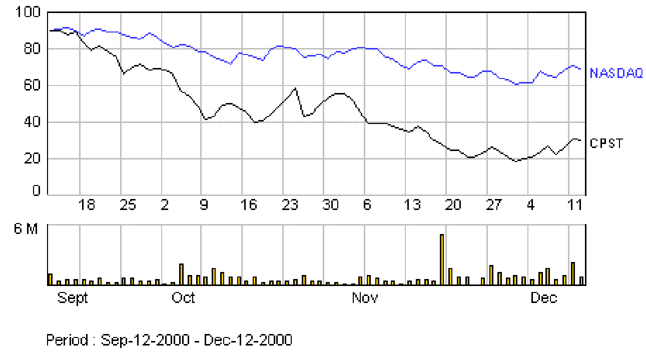
Distributed Generation MONITOR

Capstone Turbine Sales Increase: Will Profits Follow?

California based Capstone Turbine began commercial sales of their MicroTurbine™ power systems in 1998 but in the past year they have announced a flurry of orders, including the shipment of their 1000th microturbine unit on November 27th. On October 11th Capstone announced a two-year, 126-unit order for its systems from American Energy Savings Inc. On August 21st, they announced a 52-unit order from Cincinnati-based Cinergy Corp. In addition, Capstone has arranged with Alliant Energy, New Energy Ventures and Kohler Power Systems to jointly distribute and market the Capstone MicroTurbine™. Capstone began by broadly targeting the distributed generation market, but acknowledged that they must focus on reducing unit costs to reach full market penetration. Additional Capstone research continues on the



application of their technology in hybrid electric vehicles, onboard generation, resource recovery (i.e. converting oilfield and biomass waste gases into electricity), and micro-cogeneration.

Capstone has gained a (*continued on page 2)*

GE Expands DG Presence

General Electric (GE) has made a big splash in the DG industry with its recently announced plans to acquire Honeywell. Combined, the two companies will offer a wide range of traditional engines with aircraft, industrial and energy applications. As a bonus, GE will also acquire the Honeywell microturbine program.

The question, then, is in what fashion and to what extent GE will alter its position in the DG market with the addition of the Honeywell Parallon 75 microturbine to its existing line of Nuovo Pignone and GE turbines and Plug Power-produced GE HomeGen 7000 residential fuel cells. GE, through subsidiary GE Power Systems, has distribution *(continued on page 2)*

Fuel Cells Move Towards Commercialization

For decades, great interest has been expressed in the development and potential of fuel cell technology. However only recently, steps by fuel cell manufacturers to reduce costs and facilitate marketing and distribution are making commercialization look like a reality. Several companies have been in recent headlines as proactive participants in this new market.

Ballard Power Systems hopes to launch its first commercial proton exchange membrane (PEM) fuel cell system in 2001, and has concentrated its efforts on actively pursuing relationships with strategic value in the development and distribution of its products. In addition to existing ties with partners GPU International, Alstom and Ebara, in October *(continued on page 3)*

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Resource Dynamics Corporation

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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.

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reputation as one of the hot new energy IPOs, but recent stock news reflects investor uncertainty about this "seems too good to be true" organization. In November, Capstone issued a secondary offering of its stock, but though the company hoped to float 7 million shares at over $50 each, they cut this back to offering 5 million shares at $30 a share.

The fact that Capstone's stock has fallen significantly, even when the overall market downturn is taken into account, is most likely due to questions about ultimate profitability. Revenues have increased but have been offset by an increase in selling, general, and administrative expense. Capstone expects to report losses at least through 2001, which has made some investors uneasy.

Still, Capstone has had success both in selling their units and establishing distribution and marketing channels and projected growth for the microturbine market remains high. Additionally Capstone has recently shipped its first 60 kW unit and has entered into an agreement to develop systems for hybrid electric cars. The company's outlook remains positive, believing the milestones reached recently will translate into company growth and long-term profitability. ■

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agreements with Jenbacher and Elliott Energy Systems, and efforts to market the Parallon aggressively may be to the detriment of these existing relationships especially considering the similarity of Honeywell's and 75-80 kW products (see table below).

No matter GE's ultimate decision, the company's actions bear watching as they are likely to impact and help define the microturbine market in the future.

The tax-free merger, valued at $45 billion, is expected to be completed in early 2001. ■

	Honeywell Parallon 75	**Elliott** TA-80R
Output	75 kW	80 kW
Efficiency	27-30%	23-30%
Weight	2850 lbs	1890 lbs
Gas Pressure	75-85 psig	>75 psig
NOx Emissions	50 ppm	<30 ppm
Single-Shaft	Yes	Yes
Inverter	Yes	Yes

Source: manufacturer websites and published reports

Fuel Cells from page 1

alone Ballard announced agreements with Millennium Cell and with QuestAir Tech to jointly develop and commercialize their technologies using Ballard's fuel cells. Through these steps Ballard hopes to both reduce its high production and research related costs and gain access to established distribution networks.

Houston based Enron, who has already achieving top billing in the natural gas and energy wholesale markets, recently made inroads into the fuel cell business as well. This October Enron invested $5 million in FuelCell Energy, and made an equity investment in Dais-Analytic. FuelCell Energy's proprietary solid oxide "Direct Fuel Cell" is multi-fuel capable, and although the company will not take commercial orders until the second half of 2001, tests of prototype systems have been promising. Enron's investment in Dais-Analytic Corporation (DAC) will help fund product development and marketing and distribution costs for their PEM fuel cell power systems and membrane-based humidity control products. Both organizations have successfully developed prototype fuel cell systems and have carried out extensive testing and field trials, but require outside assistance in product development and marketing.

International Fuel Cells (IFC), a subsidiary of United Technologies Corporation, is perhaps most famous for supplying the fuel cells used on all the Space Shuttle flights. However, in recent news, IFC has moved, though a series of projects and alliances, to consolidate its role as the only company in the world producing commercial stationary fuel cell systems. IFC gained attention for supplying the largest commercial fuel cell system in the nation, which was installed last month at the Anchorage Mail Processing Center in Alaska. The company announced joint ventures with Shell Hydrogen US and with Toshiba, an equity owner of IFC, early in October to develop, produce, and market fuel cell technologies in the US and Japanese markets.

DaimlerChrysler's Fuel Cell Powered NECAR 4

In addition to targeting power markets, these companies, like most other fuel cell manufacturers and developers, are working to develop fuel cells for automobile usage. This application may be key to fuel cell viability as a DG option, as many industry observers believe transportation applications may lead to the economies of scale necessary to reduce fuel cell prices to competitive levels. Ballard, Ford and DaimlerChrysler have joined up in this pursuit, and this quarter alone, orders have been placed with Ballard for their fuel cell systems by Honda, GM, Nissan, and Volkswagen. IFC is also working to develop fuel cells for automobiles in partnership with the Department of Energy and as a member of the California Fuel Cell Partnership.

Financial indicators remain mixed for these fuel cell manufacturers. Increased revenues are offset by corresponding increases in research and development costs. Still, market interest is strong, if cautious. Investors are counting on narrowing losses turning to profits in the long term, and value the potential of the emerging fuel cell market. ■

DG NOTES

IMPCO Technologies, Inc. announced that its Advanced Technology Center located in Irvine, California, has been awarded an additional contract by the US Department of Energy (11/8)

Nuvera Fuel Cells Inc., a designer and developer of fuel processors, PEM fuel stacks, and integrated fuel cell systems for stationary and transportation applications, filed to go public. (11/8)

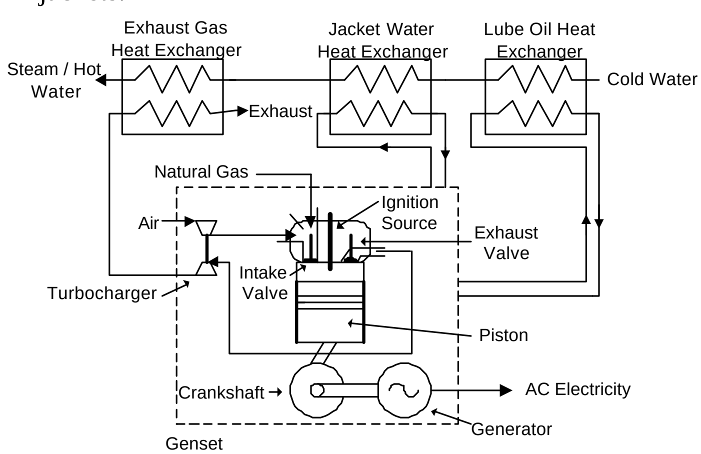
A **Siemens-Westinghouse Power Corp.** fuel cell-gas turbine hybrid system will be installed in an EPA laboratory, powering the facility beginning in 2002. The proposed plant will be the largest of its type in the world. (10/26)

In a Class Action Lawsuit filed in the U.S. District Court for the Eastern District of New York, **Plug Power, Inc** is charged with misleading investors. The suit alleges that company insiders delayed the release of harmful news to keep stock prices up, and then dumped shares before releasing the information to the public. (9/28)

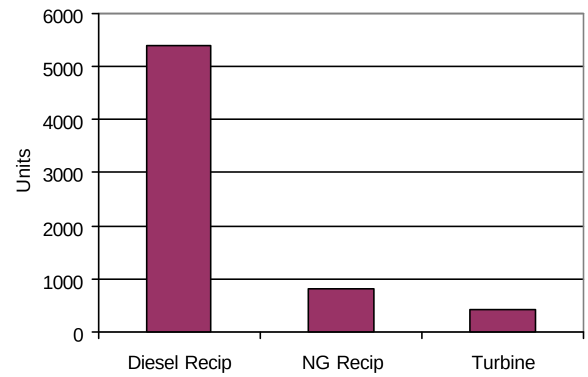
DG TECHNOLOGY SERIES: RECIPROCATING ENGINES

Reciprocating engines, developed more than 100 years ago, were the first among DG technologies. Both Otto (spark ignition) and Diesel cycle (compression ignition) engines have gained widespread acceptance in almost every sector of the economy. Smaller engines are primarily designed for transportation and are converted to power generation, usually with little modification. Larger engines are designed primarily for power generation, mechanical drive, or marine propulsion. Engines (mostly diesel) have historically dominated global sales of mid-sized (1-10MW) power applications and continue to receive a lion's share of orders as illustrated in the chart to the right. For the time period, engines accounted for 94% of unit sales and 88% of capacity.

Almost all engines used for power generation are four-stroke and operate in four cycles (intake, compression, combustion, and exhaust). The process begins with fuel and air being mixed. In turbocharged applications, the air is compressed before mixing with fuel. The fuel/air mixture is introduced into the combustion cylinder. The mixture is then compressed as the piston moves toward the top of the cylinder. For diesel units, the air and fuel are introduced separately with fuel being injected after the air is compressed. A spark is produced that ignites the mixture (in most diesel engines, the mixture is ignited by the compression alone). Dual fuel engines use a small amount of diesel pilot fuel in lieu of a spark to initiate combustion of the primarily natural gas fuel. The pressure of the hot, combusted gases drives the piston down the cylinder. Energy in the moving piston is translated to rotational energy by a crankshaft. Cogeneration configurations are available with heat recovery from the gaseous exhaust and water and oil jackets.



Schematic of a NG Engine with Cogeneration

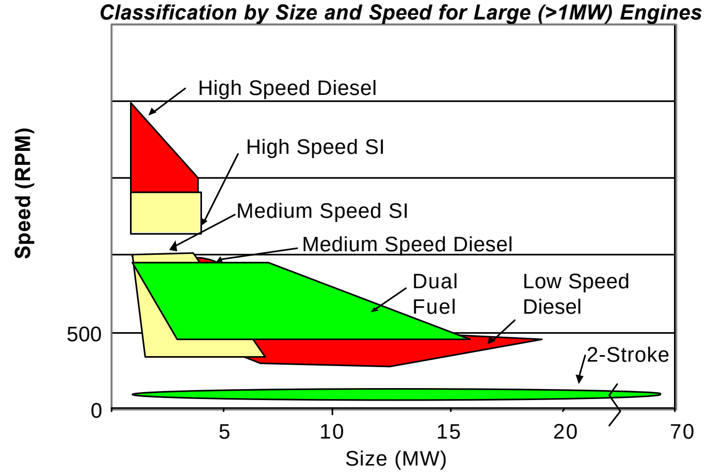


1-10 MW Prime Mover Orders (June 1999 - May 2000)
Source: Diesel & Gas Turbine Worldwide, Oct. 2000

Both diesel (compression ignition) and natural gas (spark ignition) engines are in widespread use for stationary applications. It is, however, becoming increasingly hard to site diesel generators other than for emergency uses, especially in larger sizes, due to emissions regulations. Most installed natural gas units are stoichiometric, though newer units, especially in larger sizes, focus on lean-burn technology which allows for increased efficiency and lower emissions from the combustion chamber. Manufacturers have developed dual fuel engines to take advantage of natural gas emissions, economics, and convenience while keeping the efficiency and reliability benefits of compression ignition technology. Dual fuel engines are typically more efficient and have lower NO_x and particulate emissions than diesels.

Engines are characterized by a number of factors such as size, rotational speed, fuel type, and end use application. As the figure below illustrates, engine

Classification by Size and Speed for Large (>1MW) Engines



sizes range up to 18 MW for 4-stoke engines and up to 65 MW for 2-stoke engines although most DG applications are smaller.

2-stroke units normally have an operating speed of approximately 125 rpm where 4-stroke units can range from 300 to 3600 rpm. For a given unit, the higher the rpm, the higher the power output. Therefore, virtually all backup units are high speed (>1500 RPM) diesels with higher power to size and cost ratios than their lower speed counterparts. However there generally is a trade off between high rpm and durability, longevity, and frequency of maintenance. Therefore most continuous duty units are medium to low speed (<1200 RPM). Lower speed units allow more time for burning of fuel and therefore can be run on lower grade fuels than higher speed units. For this reason heavy fuel oil is often an option for many low speed diesel and 2-stroke engines.

The following table summarizes some of the development issues that are currently a focus of major engine manufacturers. The developments all center around meeting the main goals of lower costs, increased efficiency and lower NO_x emissions and most are slated for natural gas units. ■

Technology	Lower Costs	Improved Efficiency	Lower Emissions
Enhanced lean burn		Primary	Primary
Improved combustion chamber design		Secondary	Primary
Improved fuel injection		Primary	Primary
Better cylinder head/valves	Secondary	Primary	Primary
More durable components	Primary	Secondary	
Increased pressure ratio	Secondary	Primary	
Advanced sensors and controls	Secondary	Primary	Primary
Improved ignition		Primary	Primary

= Primary Benefit = Secondary Benefit

Engine Development Efforts and Effects

RDC DG NEWS

Presentations

"Serving the Internet Economy" - N. Richard Friedman, at Distributed Generation: Reaching the Market, San Diego CA, Nov 9-10 2000

"Microturbine Technology and Business Developments" - N. Richard Friedman, at the World Energy Engineering Conference, Atlanta GA, Oct 26 2000

"Increasing Power Reliability Via Distributed Generation" - E.J. Honton, A presentation describing how evolving DG technologies can and are being used to increase both customer and grid reliability, presented at Power Quality 2000, Boston MA, Oct 5 2000

"The Market for Distributed Resources" - N. Richard Friedman, at the EPRI Distributed Resources Week, Tucson AZ, Oct 4-6 2000

"Overview of Distributed Power" - N. Richard Friedman, at the Intertech Distributed Power Conference, Washington DC, Sept 25-26 2000

"Combined Heat and Power for Distributed Power: Markets and Prospects" - Paul Lemar Jr, at the Intertech Distributed Power Conference, Washington DC, Sept 25-26 2000

Contracts

Maine Public Utilities Commission - Examination of the Operational and Economic Characteristics, Viability, and Likely Regional Penetration of Distributed Generation, November 2000

National Rural Electric Cooperative Association – Application Guide for DG Interconnection, December 2000

Industrial Center, Inc. – Distributed Generation Improvements in Industrial Applications, December 2000