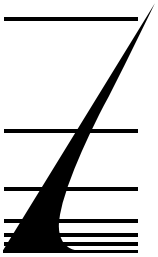
The Market for Microturbine Electrical Power Generation

Product Code #F647

A Special Focused Market Segment Analysis by:



FORECAST INTERNATIONAL

Analysis 2
The Market for Microturbine Electrical Power Generation 2009-2018

Table of Contents

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PROGRAMS

The following reports are included in this section: (**Note:** a single report may cover several programs.)

Capstone MicroTurbines
Elliott Microturbines
Ingersoll-Rand Microturbines
Turbec Microturbines

Introduction

Microturbines (very small gas turbine machines) are small combustion turbines approximately the size of a household refrigerator; they currently have outputs of 30 kW to about 250 kW. This type of power generation machine is not as new as some would believe, having evolved from automotive and truck turbochargers, auxiliary power units (APUs) onboard aircraft, and small jet engines.

Some industry followers of the small engine marketplace have split the arena into two segments: "microturbines," machines whose power outputs are in the range between 30 and 250 kW; and "miniturbines," machines whose power outputs are above 250 kW. At present, only Kawasaki (CGT302 at 300 kW) and Niigata (RGT3R at 300 kW) have worked on machines that have a power output of about 250 kW. These two efforts are now in limbo.

Gas turbine machines as a group can be classified by the physical arrangement of their component parts: single-shaft (single-spool) or twin-shaft (twin-spool), simple-cycle or recuperated, inter-cooled, or reheat. These machines generally rotate at speeds in excess of 40,000 rpm. As such, the selection of bearings, or whether the machine's manufacturer selects oil or air, is a function of the machine's use. A single-shaft design is the more common since it is less complex and less expensive to build. A twin-shaft design is needed for mechanical load drive applications where an inverter is not needed to change the frequency of the AC power.

Microturbines, which are Brayton-cycle machines, can also be classified as simple-cycle or recuperated. Recuperated units have a heat exchanger (normally made of sheet metal) that recovers (recuperates) some of the heat from the machine's exhaust flow and transfers it into the entering air flow. The preheated air is then utilized in the combustion process.

Having very low emissions and requiring low maintenance, microturbines are well suited for small-scale cogeneration schemes. The machine's exhaust can be used for hot water heating, absorption cooling, and dehumidifying. The extremely clean exhaust of many microturbines can be used directly in many industrial processes. In some instances, the machine's CO_2 generation can be utilized in greenhouses.

Several manufacturers have very small machines with few parts and relatively good efficiency, largely due to the incorporation of small recuperators that boost combustion efficiency. Some adapt the recuperative cycle further for waste heat recovery, which pushes system efficiency yet higher.

A key point in the promotion of microturbines is their versatility. Their multifuel capability, reliability, and simplicity in design can be exploited in a number of ways.

The machines are being considered for distributed generation baseload use. Electric utilities can expand their ability to offer remote power, in small increments, without having to connect to their main grids.

Because their small size affords them such mobility, microturbines are ideal for providing remote temporary power. They can also be installed permanently at remote sites, providing prime (peak) power for a variety of applications. They can also be run on low-quality gases where available.

Small gas turbines have been used for some time as standby generators. Microturbines are efficient enough to provide peak power as well as standby, particularly in combined cycles.

The costs of microturbine machines, relative to their application and competing piston and diesel engines in the same power class or higher, have long made them uneconomical. As their prices per kilowatt drop, they will find greater acceptance.

At present, a drawback of microturbines is the limited number of times the machines can be cycled on and off. Each startup and shutdown adds Equivalent Operating Hours (EOH) to the machine history, which leads to more frequent maintenance requirements. As a result, it is relatively normal practice to keep the machines running continuously once they are started. That drawback, however, is being addressed, and in the future should not prove to be an obstacle to their increasing acceptance. On a 24/7, 365-day basis, the typical useful life of a currently commercially available machine ranges from 40,000 to 80,000 hours, or up to 10 years with proper overhaul.

Microturbines are viable for energy applications. They are ideally suited to alternate fuels, CHP applications, and remote siting, and their costs, performance, and emissions are competitive in selected applications.

Microturbines have significant expanded market potential with technology advances:

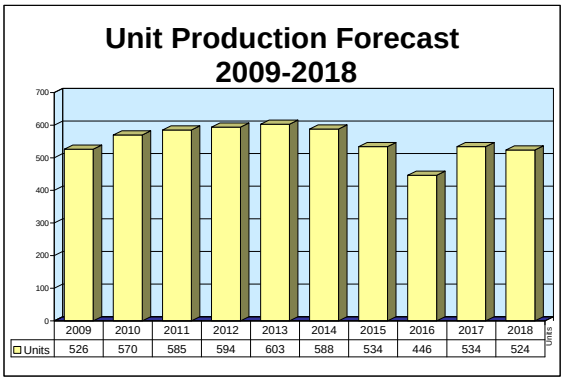
- Competitive efficiency at < 1 MW size
- Potential for low first cost
- Low emissions and broad fuel specification
- Class boundaries of 30 kW to 250 kW

Continued…

Capstone MicroTurbines

Outlook

- Packaging agreements with United Technologies and FuelCell Energy, together with distributor agreements that improve end-user satisfaction, bode well for Capstone
- Capstone projected to be *the* leader in number of microturbine machines to be manufactured in the decade
- Fuel cells and competing technologies could begin to erode the market for microturbines after 2014



Orientation

Description. The Capstone C30 and C65 MicroTurbine™ systems are compact, low-emission electrical power generators.

Sponsor. The C30 and C65 systems were privately developed by the prime contractor.

Power Class. The approximate power outputs of the Capstone MicroTurbine systems are 30 kW and 65 kW.

For comparison, a Model C30 turbine can produce enough electricity to power a small convenience store. The C60 series products can produce enough heat to provide hot water to a 100-room hotel while also providing about one-third of its electrical requirements.

Status. The 30-kW and 65-kW turbine-equipped power generators are available.

Total Produced. At the start of 2009, at least 3,888 Capstone machines of all variants had been fabricated and installed.

Application. Electrical generation, including distributed generation, cogeneration (combined heat-power/chilling solutions), resource recovery (converting oilfield and biomass waste gases into electricity), and onboard generation for hybrid electric vehicles (HEVs).

Price Range. In 2009 U.S. dollars, the C30 is estimated at $18,000-$19,500; the C65 is estimated to cost $39,000-$41,000.

Competition. The Capstone MicroTurbine system, at 30 kW, faces no serious competition. Capstone's C65 faces competition from Ingersoll-Rand's 70L system, which is rated at 70 kW.

Contractors

Prime

Capstone Turbine Corp	http://www.microturbines.com, 21211 Nordhoff St, Chatsworth, CA 91311 United States, Tel: + 1 (818) 407-3770, Fax: + 1 (818) 734-5320, Email: kfield@capstoneturbine.com, Prime
Areche Ingenieros SA de CV	Av. Gregorio Mendez, # 740, Centro, CP 86000, Villahermosa, Tabasco, Mexico, Tel: + 52 993 312 3322, Fax: + 52 993 312 6969, Dealer/Distributor

Capstone MicroTurbines

BPC Energy	http://www.capstone.ru, Office 602, 35 Myasnitskaya St, Moscow, 101959 Russian Federation, Tel: + 7 095 780 3165, Fax: + 7 095 780 3167, Email: skorokhodov@bpc.ru, Distributor
GTSA Engineering	http://www.gtsa-engineering.com.au, 627-635 Bickley Rd, Maddington, Perth, 6109 Western Australia, Australia, Tel: + 61 8 9251 8009, Fax: + 61 8 9452 3598, Email: gbrowne@gtsa-engineering.com.au, Distributor
Geveke Power Systems	http://www.microturbine.nl, Ketelweg 20, Papendrecht, 3356 LE Netherlands, Tel: + 31 78 6420 420, Fax: + 31 78 6517 122, Email: sven.fransen@gmo.geveke.com, Distributor
Matune Power Systems Ltd	http://www.matune.com, 39 Gloucester Rd, Wanchai, # 2507, 25/F, Harcourt House, Hong Kong, Hong Kong, Tel: + 852 2140 6100, Fax: + 852 2179 5530, Email: frankie-cheng@matune.com, Distributor
Meidensha Corp	http://www.meidensha.co.jp, 36-2 Nihonbashi Hakozakicho Chuo-ku, Riverside Bldg, Tokyo, 103-8015 Japan, Tel: + 81 3 5641 7229, Fax: + 81 3 5641 7249, Distributor
Soffimat	http://www.soffimat.com, 22 Ave de la Grande Armee, Paris, 75017 France, Tel: + 33 1 55 37 46 00, Fax: + 33 1 55 37 46 36, Email: psamaha@soffimat.com, Distributor
Sumitomo Corp	http://www.sumitomo.co.jp, 1-8-11, Harumi, Chuo-ku, Tokyo, 104-8610 Japan, Tel: + 81 3 5166 5000, Distributor
Takuma Co Ltd	http://www.takuma.co.jp, 2-2-33 Kinrakuji-cho, Amagasaki-shi, Hyogo, 660-0806 Japan, Tel: + 81 6 6483 2609, Fax: + 81 6 6483 2751, Distributor

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Contractors are invited to submit updated information to Editor, International Contractors, Forecast International, 22 Commerce Road, Newtown, CT 06470, USA; rich.pettibone@forecast1.com

Technical Data

The Capstone C30 and C65 MicroTurbine systems incorporate a compressor, combustor, turbine, and permanent magnet generator. The rotating components are mounted on a single shaft supported by patented air bearings that rotate up to 96,000 rpm (at full load power). The generator is cooled by airflow into the gas turbine, thereby eliminating the need for liquid cooling. System output is variable-frequency (50/60-Hz) 400 to 480V AC power. High-efficiency recuperated models are also available.

Note: *As used in this report, the microturbine arena consists of gas turbine machines of up to 250 kW.*

Design Features

Compressor. A single-stage centrifugal-flow compressor is standard.

Recuperator. The recuperator features a metallic, counter-flow prime-surface recuperator.

Combustor. A single, annular, reverse-flow combustor is standard. It features a dry, lean premix combustion system. Dual-fuel and lean-fuel burners are available.

Turbine. A single-stage, radial-inflow turbine is standard.

Digital Power Controller. High-frequency power produced by the rotating speed of the generator is converted to grid-quality 50 Hz/60 Hz by the digital power controller.

Bearings. The patented air bearings operate free of contact with the shaft, eliminating the need for lubrication and resulting in greater reliability and low maintenance requirements.

Optional Equipment. Optional equipment includes an automatic dual-mode controller, a fuel gas compressor, an emergency stop (E-Stop) options kit, an external filter option kit, a multipac options kit, a remote modem kit, a remote monitoring kit, a stand-alone option, and a Unifin heat exchanger.

Dimensions. Approximate dimensions and weights (under ISO conditions):

	C30 High-Pressure Natural Gas or Gaseous Propane	C30 Landfill or Digester Biogas	C30 Liquid Fuels	C30/ Model 330 HEV(a) Multi Fuels	C65 Natural Gas	C65-ICHP Natural Gas
Length/Depth	1,516 mm	1,516 mm	1,516 mm	836 mm	1,956 mm	1,956 mm
Width	762 mm	762 mm	762 mm	572 mm	762 mm	762 mm
Height	1,943 mm	1,943 mm	1,943 mm	629 mm	2,108 mm	2,387 mm
Weight	405 kg	405 kg	405 kg	102 kg	758 kg(a) 1,121 kg(b)	1,000 kg(b) 1,346 kg(c)

(a) Engine assembly dimension only (does *not* include digital power controller).
(b) Grid connect weight.
(c) Dual mode weight.

Approximate dimensions and weights (under ISO conditions):

	Stainless Steel Enclosed Models for Non-Hazardous Areas		NEC Class 1, Division 2, Groups C & D Type X for NFPA 496	
	C30	C65	C30	C65
Length/Depth	2,159 mm	2,540 mm	2,717 mm	3,175 mm
Width	889 mm	889 mm	889 mm	889 mm
Height	2,235 mm	2,362 mm	2,235 mm	2,362 mm
Weight	1,043 kg	15,87 kg	1,134 kg	1,678 kg

Performance

	C30 Non-Liquid Fuels[(a)]	C30 Liquid Fuels	C65 Natural Gas
Power	30 kW net (+ 0/-2)	29 kW net (± 1)	65 kW net
Efficiency (LHV)	26% (± 2)	25% (± 2)	29%
Heat Rate (LHV)	13,800 kJ/kWh	14,400 kJ/kWh	12,450 kJ/kWh
NOx Emissions (@ 15% O_2)	< 9 ppmv	< 35 ppmv	< 5 ppmv
Fuel (natural gas-HHV)	457,000 kJ/hr	459,000 kJ/hr	888,394 kJ/hr
Mass Flow	0.31 kg/sec	0.31 kg/sec	0.49 kg/sec
Exhaust Gas Temperature	275°C	275°C	309°C
Exhaust Energy	327,000 kJ/hr	327,000 kJ/hr	591,911 kJ/hr
Typical Sound Level	65 dBA @ 10 m	65 dBA @ 10 m	70 dBA @ 10 m

(a) Non-liquid fuels = natural gas, gaseous propane, landfill gas, digester biogas, and wellhead/flare gas.

The 65-kW Capstone C65-ICHP (Integrated Combined Heat and Power) system has the following performance parameters (ISO; fuel is natural gas):

Net Power Output	65 kW
Net Electrical Efficiency	29% LHV
Heat Rate (LHV)	12,900 kJ/kWh
Emissions (@ 15% O_2)	< 9 ppmv NOx; <130 ppmv CO
Exhaust Mass Flow Rate	0.49 kg/sec
Exhaust Temperature	309°C
Exhaust Energy Output	591,911 kJ/kWh

Capstone MicroTurbines

Variants/Upgrades

Capstone's MicroTurbine systems product offerings include a 30-kW C30 model and a 65-kW C65 model. Capstone also offers a Model 330, at 30 kW (which has been offered for truck and bus onboard power generation). The Model 330 has been referred to as the C30 HEV MicroTurbine.

Capstone has also fabricated at least four C200 units, at about 200 kW, for testing and proof-of-concept. The model has not yet been released for production.

Program Review

Background. The Capstone C30 and C65 MicroTurbine systems are adaptable, low-emissions electrical generation systems. In each system, a gas turbine-driven high-speed generator is coupled with power electronics that allow the system to operate connected either to the grid or in stand-alone modes. The MicroTurbine operates on multiple fuel sources; currently, the unit runs on high- or low-pressure natural gas. Capstone has refined the machine to enable it to burn diesel, kerosene, propane, and low-grade waste gases from landfills, oilfields, sewage treatment plants, and agricultural digesters.

In addition to producing electricity, the MicroTurbine produces usable exhaust heat. The oxygen-rich exhaust can be used directly without any "cleaning," owing to the very low levels of NOx (less than 9 ppmv for the Model 65), CO, and THC.

The patented air bearings of these systems eliminate the need for oil or other lubricants, and the air-cooled design of the entire system (engine and controller) eliminates the need for water, antifreeze, and water pumps. There are no gears, belts, or engine-driven accessories; there is only one moving part in the engine, and advanced combustion control eliminates the need for ceramics or other exotic materials, or catalytic combustion.

The Capstone MicroTurbine subassemblies include a turbogenerator, a fuel system, and a digital power controller. All are enclosed in a weather-resistant package. To support integration with other distributed generation devices, the Capstone MicroTurbine communicates through an "open architecture," supporting the concept of a virtual power plant.

The Capstone MicroTurbine generates electricity by drawing air in through the generator cooling fins before it flows to the compressor inlet. This cools the machine and eliminates the need for any liquid cooling. Air from the generator then flows into the compressor, where it is pressurized and forced into the cold side of the recuperator. Here, exhaust heat is used to preheat the air to about 1,110°F (600°C) before it enters the combustion chamber, reducing fuel consumption by more than 50 percent. The combustion chamber then mixes the heated air with fuel and burns it. This mixture expands through the turbine, which drives the compressor and generator at up to 96,000 rpm. Since the generator is mounted on the same shaft as the turbine, it rotates at the same speed. The exhaust gas is then routed through the recuperator before being discharged at the exhaust outlet.

The high-speed generator delivers power at up to 1,600 Hz. The power controller converts the power to useful 50/60 Hz at 400-480V AC. Additional output options (including 0-400V DC) are under development.

Capstone 65 Power System. In September 2000, Capstone introduced its first commercial 60-kW C60 microturbine power system. The 60-kW C60 unit was also referred to by the manufacturer as the Capstone 60 (or Model 60). The C60 designation has been superseded in favor of the C65 designation, reflecting the increase in power output to 65 kW.

The Capstone C65 model is an addition to Capstone's C30 model. It develops twice the amount of electricity, but does so with the same unique characteristics of the company's C30 model: only one moving assembly, no oil or other liquid lubricants, no liquid coolants, and NOx emissions of 9 ppmv, even though it is not equipped with post-combustion pollution controls.

This first natural gas-powered system produced was shipped to one of Capstone's Midwest distributors, Interstate Power Systems, headquartered in Minneapolis, Minnesota. The unit was shipped for installation at a propane and liquefied natural gas storage facility of Reliant Energy Minnegasco, where it is used as a supplement and backup to the local utility grid.

The exhaust heat of the Capstone C65 unit is ported through an absorption chiller that can deliver refrigerated air, which is also used for cooling. Reliant

Energy Minnegasco was already equipped with one of Capstone's 30-kW Model 330 systems to provide load-following and standby energy to the facility's control center. The exhaust from the current system passes through a Unifin heat exchanger for space heating at the facility.

The refrigerator-sized Capstone C65 has about the same height and width as Capstone's continuing line of 30-kW models.

New C200 Unit. In April 2004, Capstone Turbine shipped the first beta unit C200 to the University of California, Irvine. It was fully installed in May 2004.

The 200-kW natural gas-fueled power system has many of the unique features of Capstone's 30-kW and 60-kW products: a single moving part, no lubricants or other hazardous fluids, and extremely low emissions even though it is not equipped with any exhaust cleanup devices or chemicals.

Since 2000, Capstone has been working with the U.S. Department of Energy on the C200 under a Cooperative Agreement on the "Advanced Microturbine System" and has received from the DoE a portion of the development costs. Four beta units are being tested and are reported to be performing well. The commercial launch of the C200 product is dependent upon the successful completion of beta and qualification testing and market demand.

Sales and Distribution Channel. Capstone's previous sales strategy of selling large volumes of product through distributors did not meet its expectations, and some distributors refocused their efforts on opportunities other than microturbines. As a result, several end-users began working directly with Capstone.

Capstone's strategic plan calls for building a direct sales channel for select vertical markets to augment sales channel efforts in the Americas. The company expects that its distributors will continue to provide a majority of its business. It is continuing to develop and strengthen key distributors while moving other distributors into dealer or manufacturer representative-type arrangements. These efforts have required the termination of some existing agreements to the extent permitted by the applicable contracts, and the launch of new agreements. Additionally, the company has been adding new distributors and representatives that are experienced in its target markets. The company believes that this combined approach can leverage the best of what its distributors and Capstone have to bring to their customers and that it will make it more responsive to its customers' needs.

Since March 31, 2004, Capstone has terminated, or served notice of termination or non-renewal on, many of its distributors worldwide. Despite that significant change, about 55 percent of its product revenues in the third quarter of FY05, and 75 percent year-to-date, were generated by its distributors. The company expects to access direct sales opportunities in the market both through its own sales force and through sales representative relationships. It is also in the process of negotiating with several potential new distributors and dealers in key focused markets and has already signed new dealer agreements.

The C65: A Nice Improvement

On December 6, 2005, Capstone announced at the Power-Gen International trade show that it would begin shipping an enhanced line of 65-kW microturbine models that would replace its popular C60 series of power and heat generators.

"Reflective of our commitment to continuously improve our product performance, I'm very pleased to announce that effective January 2006, the Capstone C60 MicroTurbine will be replaced by the C65, with an installed output of 65 kW, a 29 percent electrical efficiency, and NOx emissions of less than 5 ppmv," said Capstone CEO John R. Tucker. "This approximate 8.5 percent increase in electrical output, 4 percent increase in efficiency, and 45 percent reduction in NOx output is reflective of our continuing engineering effort to provide our customers with the best distributed generation product available."

The new natural gas-fueled C65 and C65-ICHP (with factory-integrated heat recovery) are intended to deliver higher electrical and thermal output without any change to the product's weight and dimensions, allowing flexibility in indoor, outdoor, and rooftop siting.

Capstone also stated that it would introduce a variation of the 65-kW machine that uses waste flare gases from landfills or sewage treatment plants as fuel to create renewable energy. The new CR65 – the "R" for renewable – would be available with an optional stainless-steel integrated heat exchanger.

Affiliates. In addition to the firms in the **Contractors** section above, the following firms are or have been affiliated with Capstone on its MicroTurbine systems:

- Active Power Corporation; Tokyo, Japan
- Aquatec-Maxcon; Leichhardt, QLD, Australia
- CE Energy; Bangkok, Thailand
- Cyclect; Singapore, Republic of Singapore
- Fores Engineering SrL; Forli (FC), Italy

Capstone MicroTurbines

- General Systems Design (GSD); Maltepe, Istanbul, Turkey
- Integrated Building Technologies; Villorba, Treviso, Italy
- Samsung Corporation; Seoul, Korea (ROK)
- Totalsupport Ltd; Rumuogba, Nigeria
- Verdesis; Wavre, Belgium
- WESCO Distribution Inc; Pittsburgh, Pa., USA

Related News

Capstone MicroTurbine Fleet Surpasses 15 Million Operating Hours – President and Chief Executive Officer Darren R. Jamison recently confirmed that the installed fleet of the company's Capstone MicroTurbine energy systems has surpassed the 15-million-hour mark in documented runtime operation.

The company recently shipped its 4,000th unit and also has achieved significant mean time between failures (MTBF) reliability criteria, as follows: MTBF of greater than 8,000 hours for the C60 series, and MTBF of greater than 15,000 hours for the C30.

Fifteen million hours is equivalent to approximately 1,710 years worth of continuous operation. Each Capstone MicroTurbine system has integrated power electronics that maintain a log of runtime hours and operational performance data. "The 15-million-hour figure represents the total documented operation of installed units with which we have contact or dial-in permission," said Shelby Ahmann, Capstone's senior vice president of customer service. (Capstone, 5/07)

Funding

No U.S. government funding for the Capstone C30 or the C60 MicroTurbine systems has been identified.

It should be noted here that the U.S. Department of Energy, through its Office of Fossil Energy, has funded testing of the high-energy Direct FuelCell/Turbine power plant. That effort involves FuelCell Energy Inc (Danbury, Connecticut) and Capstone Turbine Corporation.

Contracts/Orders & Options

Note that no major military contracts for the Capstone C30 and the C60/C65 MicroTurbine systems have been identified. Recent non-military contracts include the following:

Contractor	Award ($ millions)	Date/Description
Capstone Turbine Corp	N/A	Jan 2007 – A follow-on order from Capstone's distributor in Russia (Banking Production Center) amounting to approximately $1.6 million in C65 MicroTurbine systems.
Capstone Turbine Corp	N/A	Aug 2005 – Order for more than 1.5 MW of propane-fueled microturbine systems from Areche Ingenieros SA de CV in Mexico, for installation in three government buildings in Mexico City.
Capstone Turbine Corp	N/A	Jul 2005 – Follow-on order from BPC Energy in the Russian Federation for a total of 1.7 MW of 30-kW and 60-kW microturbine products for installation at four sites, including a shopping center and a telecommunications facility.
Capstone Turbine Corp	N/A	May 2005 – Follow-on order from Soffimat in France for 2.8 MW of its 30-kW biogas-fueled microturbine products, for use at four landfills in France.

Contractor	Award ($ millions)	Date/Description
Capstone Turbine Corp	N/A	Apr 2005 – Order from BPC Energy in the Russian Federation for 2.3 MW of 60-kW microturbine products to provide heat and power (0.5 MW) at a hotel in Moscow, and to generate power and heat (1.8 MW) at a ski resort near St. Petersburg.

Timetable

Month	Year	Major Development
Jan	1998	MicroTurbine unit installed at Battle River, Alberta, Canada, for testing
May	1998	Capstone MicroTurbine completes solution gas field tests
Dec	1998	Capstone MicroTurbine becomes commercially available
Jan	1999	Capstone and Williams Distributed Power Services sign agreement
Nov	1999	Capstone unveils its innovative SimpleCycle microturbine generator
Jan	2000	Mariah Energy Corporation and Capstone sign agreement
Feb	2000	Meidensha, Sumitomo become distributors/packagers; both make equity investments in Capstone Turbine Corporation
1Q	2000	Capstone's innovative SimpleCycle microturbine generator becomes commercially available
Apr	2000	Mitsubishi Corporation becomes distributor in Japan
Sep	2000	60-kW microturbine unveiled
Nov	2000	Capstone ships 1,000th production-standard microturbine
Dec	2000	ECO announces relationship with Capstone for 30-kW systems
Feb	2001	Advantica becomes distributor, places order for 250 microturbines; Capstone certified to ISO 9001 by UL
Mar	2001	Conuar, part of the Perez Company's Pecom Energia, becomes distributor Totalsupport Ltd becomes distributor in Nigeria; first shipments to African continent EnSource becomes distributor in Western Saskatchewan, Alberta, and Northeastern British Columbia LADWP orders 141 Capstone machines
Apr	2001	Meidensha, Sumitomo order 100 additional microturbines Cummins and Capstone announce agreement for Cummins to be major distributor SCAQMD announces intent to buy 30-kW and 60-kW units Takuma of Japan orders 250 microturbines
Jun	2001	Capstone completes its first stand-alone 60-kW microturbine power system Electrical efficiency of 60-kW machine raised from 26% ±2 to 28% ±2
3Q	2001	Takuma makes TCP-30AR available
Nov	2001	UL certifies 60-kW microturbine to 2200 Generator and 1741 Utility Interconnect standards
Mar	2002	Capstone turbines begin operation at St. Vincent Hospital in Santa Fe, New Mexico
Apr	2002	FuelCell Energy receives U.S. patent for its combined-cycle Direct FuelCell/Turbine power plant
Aug	2002	Samsung of Korea signs distribution agreement with Capstone for South Korea Testing begins of a C60 powered by propane fuel
Oct	2002	UTC Corp signs agreement with Capstone, takes a 4.9 percent stake in Capstone
Apr	2003	Greenvironment Oy becomes Finland's Capstone MicroTurbine distributor
Oct	2003	U.S. EPA verifies the performance of the C60 CHP system
Apr	2004	Capstone ships the first 200-kW MicroTurbine to University of California at Irvine
	2005	Capstone announces sale and shipment of 3,000th MicroTurbine system
Apr	2005	Capstone gets order from its Russian distributor for 2.3 MW of 60-kW products
Jan	2006	C65 replaces C60 in Capstone's portfolio Capstone-branded products receive U.S. GSA approval
Mar	2006	UL certifies Capstone MicroTurbines for renewable energy generation and national grid interconnection
Nov	2006	Capstone Turbine announces Service Agreement with ITS/PEMEX
Thru	2018	Continued production of C30 and C65 MicroTurbine systems; continued aftermarket support of C60

Capstone MicroTurbines

Worldwide Distribution/Inventories

At the start of 2009, almost 4,800 Capstone C30 and C60/C65 MicroTurbine systems had been installed. The majority of the units are operating in **Argentina**, **Canada**, **China**, **Ireland**, **Japan**, **New Zealand**, **Nigeria**, the **U.K.**, and the **U.S.** (The countries listed include those operating hybrid electric buses.)

Forecast Rationale

In the microturbine arena, Capstone Turbine Corporation has had many "firsts," and its list of C30, C60, C65, and C200 machine distributors is indeed impressive, as are the quantities that Capstone's distributors worldwide have purchased or pledged to purchase.

In today's microturbine marketplace, there are no comparably sized commercial machines that can match the near-zero emissions performance of the Capstone 30-kW or 65-kW models. The near-zero emissions capabilities have attracted considerable attention worldwide, as these small turbines are used in hybrid electric (gas turbine/battery-powered) buses in China, Italy, New Zealand, and the U.S.

The microturbine marketplace had been growing dramatically for several years to about 2001, and then tapered off for a few years as customers and financial firms reassessed their needs – that pattern paralleling the overall electrical generation market.

Based on our findings, we believe that total machine production in the decade will be weak compared to earlier years. At present, some potential customers appear to be taking a wait-and-see approach to microturbines, but that hesitancy will quickly fade as the need for electrical generation becomes more acute.

We project that Capstone Turbine will, in the decade extending through 2018, build 5,504 MicroTurbines – including units for electrical generation (including CHP installations) and for use in hybrid electric duty. The production of its 30-kW and 65-kW systems is projected to account for just over 60 percent of all microturbine systems.

The rebound in the overall power generation arena worldwide means that Capstone should continue to sign dealers and distributors. With the increasing number of fuel types that the Capstone line can burn – including propane and landfill/digester biogas – the machines should become even more appealing.

Without question, with the microturbines commercially available, Capstone's products continue to dominate market sales and activity – and we believe this situation will last through 2016. Fuel cell production totals should not seriously begin to affect microturbine production totals before 2014.

Capstone's largest machine, the C200, fills the gap in the microturbine arena between the 105-kW Turbec AB machine and the 300-kW machines from Kawasaki and Niigata (with the Kawasaki and Niigat a machines not likely to attain production status in the near term).

With Kawasaki and Niigata deemed to be "out of the race" for the foreseeable future, the microturbine arena is now occupied by Capstone, Ingersoll-Rand, and Elliott. Turbec may become a more serious participant sometime in the future when its business organization and marketing issues have been laid to rest.

Owing to the non-production status of the C200, we are refraining from issuing a forecast for that model at this time.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR UNIT PRODUCTION												
Designation or Program		**High Confidence**				**Good Confidence**			**Speculative**			
	Thru 2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Total**
Capstone Turbine Corp												
C30 <> MW < 0.2 <> Industrial Power Generation												
	4,065	412	447	450	450	480	450	385	327	420	410	4,231
C65 <> MW < 0.2 <> Industrial Power Generation												
	725	114	123	135	144	123	138	149	119	114	114	1,273
Subtotal	4,790	526	570	585	594	603	588	534	446	534	524	5,504
Total	4,790	526	570	585	594	603	588	534	446	534	524	5,504

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DVD	$50	$95
Binder & DVD	$410	$775
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	U.S.	World
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Binder & DVD	$590	$1,115
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