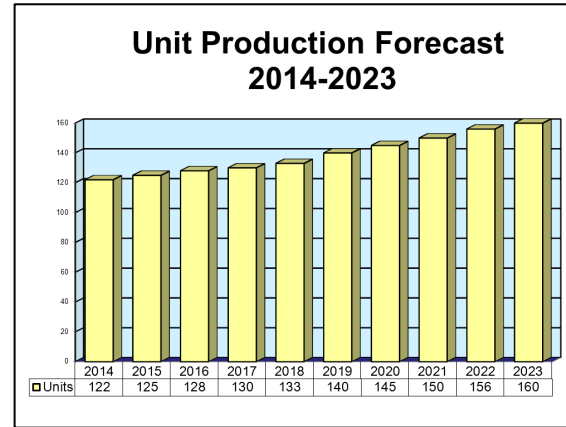


Capstone TA-100

Outlook

- The increasing popularity of distributed generation has opened opportunities for small-power-output machines
- The TA-100 100-kW Turbo Alternator in the CHP package is gaining in the Far East and Asia/Pacific Rim
- Calnetix distribution network will be an asset to Capstone for its own machines as well as the TA-100



Orientation

Description. The 100-kW Turbo Alternator (also known as TA-100 100-kW Turbo Alternator) is a small simple-cycle, electrical power-generating machine that can be melded into a CHP system.

Sponsor. The TA-100 was privately developed by Elliott Microturbines.

Power Class. The output of the TA-100 microturbine machine is 100 kW of electrical power and 172 kW of thermal exhaust power.

Status. The TA-100 is currently the sole series-production unit by Calnetix for Capstone. (The EES TA-45 and TA-80 Turbo Alternator units are no longer in production.)

Total Produced. By the beginning of 2014, nearly 1,700 TA-45, TA-80R, and TA-100 systems had been built and installed, of which at least 1,227 were the 100-kW Turbo Alternator.

Application. The standard TA-100 Monogen is packaged as a continuous-duty genset. The microturbine system is capable of producing 100 kW of electrical energy and additional exhaust energy. The exhaust energy may be captured and used in drying processes, to preheat boilers, or even to drive exhaust-gas-fired absorption chillers.

The absorption chiller-heater is a new solution for total energy utilization. Extracting exhaust gas thermal energy (280°C/536°F) from the TA-100 microturbine,

the chiller-heater can generate chilled water (7°C/45°F) for cooling mode or hot water (55°C/131°F) for heating mode. This combined system is capable of supplying not only electricity but also air conditioning for facilities such as office buildings, factories, hotels, supermarkets, and others.

The Calnetix chiller-heater developed by Elliott is a double-effect lithium bromide absorption type driven by the exhaust from the microturbine. This chiller also has a redundant gas-fired burner, allowing independent chiller operation.

The TA-100 Offshore package was designed to meet the needs of offshore oil and gas platforms, where environmental, safety, and reliability requirements must meet a higher standard. The design is intended to give flexibility to platform designers in locating the power generators. An important economic benefit of the microturbine is that a local fuel source can be used instead of shipping liquid fuel from the mainland. This is especially beneficial for unmanned platforms.

A potential application arena is the oil and gas marketplace.

Price Range. The 2013 price of a TA-100 system is estimated at \$65,000-\$67,000.

Competition. In the microturbine arena, the chief competitor to the TA-100 is the Turbec AB T100 CHP system, which has an output of approximately 105 kW.

Capstone TA-100**Contractors****Prime**

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Technical Data**Design Features**

Compressor. The compressor has a rugged stainless-steel radial-flow design; approximate pressure ratio is 4:1.

Combustor. The combustor is computer-designed and tested on a flow bench to provide low emissions of NOx and CO in the exhaust across a wide operating range, with superior on/off-load stability.

Turbine. The super-alloy turbine drives the compressor and alternator. The combusted gas expands through the turbine.

High-Speed Alternator. The electric power is generated through a permanent magnet alternator rotating within an oil-cooled stator assembly. The stator assembly acts as a motor during initial startup, reducing the need for auxiliary starting hardware.

Heat Exchanger. The heat exchanger is an air-to-liquid, tube and fin counter, current-flow design fired by the exhaust gas. The tube and fin materials

have been selected to provide long life and maximum thermal energy recovery; they also allow for potable liquid applications. The outlet liquid temperature is dependent upon inlet liquid temperature and liquid flow.

Control System. The control system provides automatic control of the rectifier, inverter, and grid protection features.

Rectifier. The rectifier converts the high-frequency alternator output to VDC for input to the inverter.

Inverter. The inverter converts the VDC to the required 50-Hz or 60-Hz cycle, 400 or 480 AC voltage.

Standard Equipment. Standard equipment includes a four-pole permanent magnet generator, manual output contactor, automatic voltage regulator, 24-VDC electrical system, battery charger, single-stage dry-type air filter, corrosion-resistant hardware, and digital liquid crystal display (LCD). System protection includes under-and-over voltage, under-and-over frequency, and over current.

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Dimensions. The TA-100 100-kW CHP Turbo Alternator has the following dimensions and weight:

	TA-100 100-kW CHP TURBO ALTERNATOR	
	Metric Units	U.S. Units
Length	3.25 m	128.1 in
Width	0.85 m	33.5 in
Height	2.25 m	88.6 in
Weight (with enclosure)		
Indoor	1,860 kg	4,100 lb
Outdoor	2,041 kg	4,500 lb

Performance. The TA-100 100-kW Turbo Alternator in a CHP microturbine system for electrical generation has the following performance specifications:

	ELECTRICAL GENERATION	
	Metric Units	U.S. Units
Power Output (60 Hz/50 Hz)	100 kW @ 0.8PF at 15°C	134 shp @ 0.8PF at 59°F
Voltage Regulation	+/- 2%	+/- 2%
Heat Rate	13,035 kJ/kWh	12,355 Btu/kWh
Fuel Consumption (NG)	0.62 m3/min	22 SCFM
Efficiency	29% (+/-1) LHV	29% (+/-1) LHV
Outdoor Noise	< 62 dBA @ 10 m	< 62 dBA @ 32.81 ft
Indoor Noise	< 75 dBA @ 1 m	< 75 dBA @ 3.281 ft
Compression Ratio	4:1	4:1
EGT (heat recovery mode)	82°C	180°F
EGT (Full HRU) Bypass	293°C	560°F
Fuel Supply (pressure required)	15-350 mbar	0.5-5 psig
Oil Capacity	19 liters	5 U.S. gal
Thermal Output (hot water)		
Water Inlet Temperature	49°C	120°F
Water Outlet Temperature	60°C	140°F
Flow	227 liters/min	60 U.S. gal/min
Total System Efficiency (a)	> 75%	>75%
Emissions (natural gas fuel)		
CO	25 ppm @ 15% O2	25 ppm @ 15% O2
NOx	24 ppm @ 15% O2	24 ppm @ 15% O2

(a) Not including gas compressor.

Variants/Upgrades

Elliott Energy Systems and Calnetix have worked on other microturbine systems in addition to the TA-100, including the TA-80R and TA-45. Capstone continues to maintain and support those field-installed units.

Program Review

Background. Elliott Energy Systems Inc (EES), a wholly owned subsidiary of Ebara Corporation (Tokyo, Japan), was the primary manufacturer of the TA-100 100-kW Turbo Alternator CHP system. EES was formerly known as Universal Turbine Energy Systems (UTES) Corporation. Calnetix purchased the company's Stuart, Florida, assets and is continuing production now that Capstone has taken ownership of the line.

Apart from its more publicized work on the TA-45 and TA-80R, Elliott evolved a microturbine capable of

developing 100 kW of electrical power and 172 kW of thermal exhaust power. The TA-100 CHP is packaged as an efficient CHP genset. The TA-100 Turbo Alternator has the same core as the TA-80, but with a different recuperator in a microturbine package.

Acquisition by Capstone. In February 2012, Calnetix Power Solutions (CPS) sold its TA100 microturbine product line to Capstone Turbine Corporation.

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Capstone and CPS also entered into a three-year Original Equipment Manufacturer agreement under which CPS will supply its 125-kW waste heat recovery generator system. In exchange for certain minimum purchase requirements, Capstone will have exclusive rights to sell the zero-emissions waste heat generator for all microturbine applications and for applications below 500 kW in which the source of heat is the exhaust of a reciprocating engine used in a landfill application.

Under the purchase agreement, CPS sold substantially all of the rights and assets related to the manufacture and sale of its TA100 100-kW microturbine generator. Under a separate agreement, CPS and Capstone also entered into a manufacturing subcontract arrangement under which CPS will continue to manufacture the TA100 turbines for Capstone from existing CPS TA100 backlog and select new orders received.

Funding

No government funding from the U.S., U.K., or Canada for the EES TA-45, TA-80R, or TA-100 CHP Turbo Alternator systems has been reported.

Contracts/Orders & Options

No major U.S. or Canadian government military contracts for production of the EES TA-45, TA-80R, or TA-100 Turbo Alternator units have been awarded in the recent past.

Timetable

<u>Month</u>	<u>Year</u>	<u>Major Development</u>
	1997	Elliott begins designing microturbine-based systems
May	1998	GE announces that it will sell/service EES microturbines
1Q-2Q	1999	TA-45 begins running continuously at EES' Florida facilities
Jul	1999	EES announces shipment of about 50 machines
Feb	2000	Secure Power Systems installs first TA-45 in Canada at Carrot Creek gas plant
Mar	2000	Ebara Corporation acquires full ownership of Elliott Turbomachinery
By 4Q	2004	Production of TA-100 100-kW microturbine machine begins
Mar	2006	Elliott, Northern Power sign agreement
Apr	2006	Elliott signs agreement with Fine-tec Century of Korea
Nov	2007	Calnetix acquires Elliott Energy Systems
Feb	2012	Capstone acquires TA-100 from CPS, CPS continues to manufacture units per subcontract
Thru	2023	Continued production of Calnetix TA-100 microturbine line

Worldwide Distribution/Inventories

At the beginning of 2014, nearly 1,700 TA-45, TA-80R, and TA-100 Turbo Alternator systems had been manufactured and delivered, with 1,227 being the TA-100 model. The machines are known to be operational in **Canada**, the **U.K.**, and the **U.S.**

Forecast Rationale

Capstone's TA-100 100-kW Turbo Alternator is the newest member in a successful group of microturbine machines with power outputs ranging from 35-1000 kW.

The TA-100 is well sized for applications in oil and gas recovery, moderate industrial applications, and large building HVAC systems, as well as distributed generation. Capstone is sure to benefit from both the CPS waste heat recovery generator and the Elliott

lithium bromide absorption chiller and heater for HVAC applications.

We are convinced that use of distributed generation (DG) will grow in the coming decade, especially with regard to cogeneration and CHP schemes. We are also convinced that Capstone is well positioned to continue manufacturing a majority share of that arena, especially given its plans for units in the overall power range of 35-1,000 kW (even before ganging them for larger

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power outputs). Its TA-100 has a robust and efficient design, is readily available, and has low maintenance costs. The machine currently enjoys a reputation for being a very good product. The emissions profile makes the machine well suited for even the most heavily regulated regions.

Ten-Year Outlook

ESTIMATED CALENDAR YEAR UNIT PRODUCTION												
Designation or Program		High Confidence				Good Confidence			Speculative			
	Thru 2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total
Capstone Turbine Corp												
TA-100 <> MW < 0.2 <> Industrial Power Generation												
	1,227	122	125	128	130	133	140	145	150	156	160	1,389
Total	1,227	122	125	128	130	133	140	145	150	156	160	1,389