



Combined Heat and Power Use in Data Centers

September 2009

Douglas Demaret
Capstone Turbine Corp





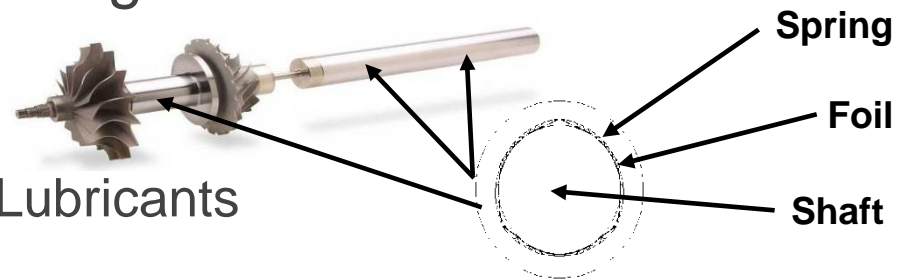
Topics to be Covered

- **Capstone Overview**
- **Microturbine Introduction**
- **Data Center Challenges**
- **Generating Technology Comparison**
- **Reliability Solutions**
- **Hybrid UPS Secure Power Solution**
- **SU Green Data Center Project**
- **Contacting Capstone**

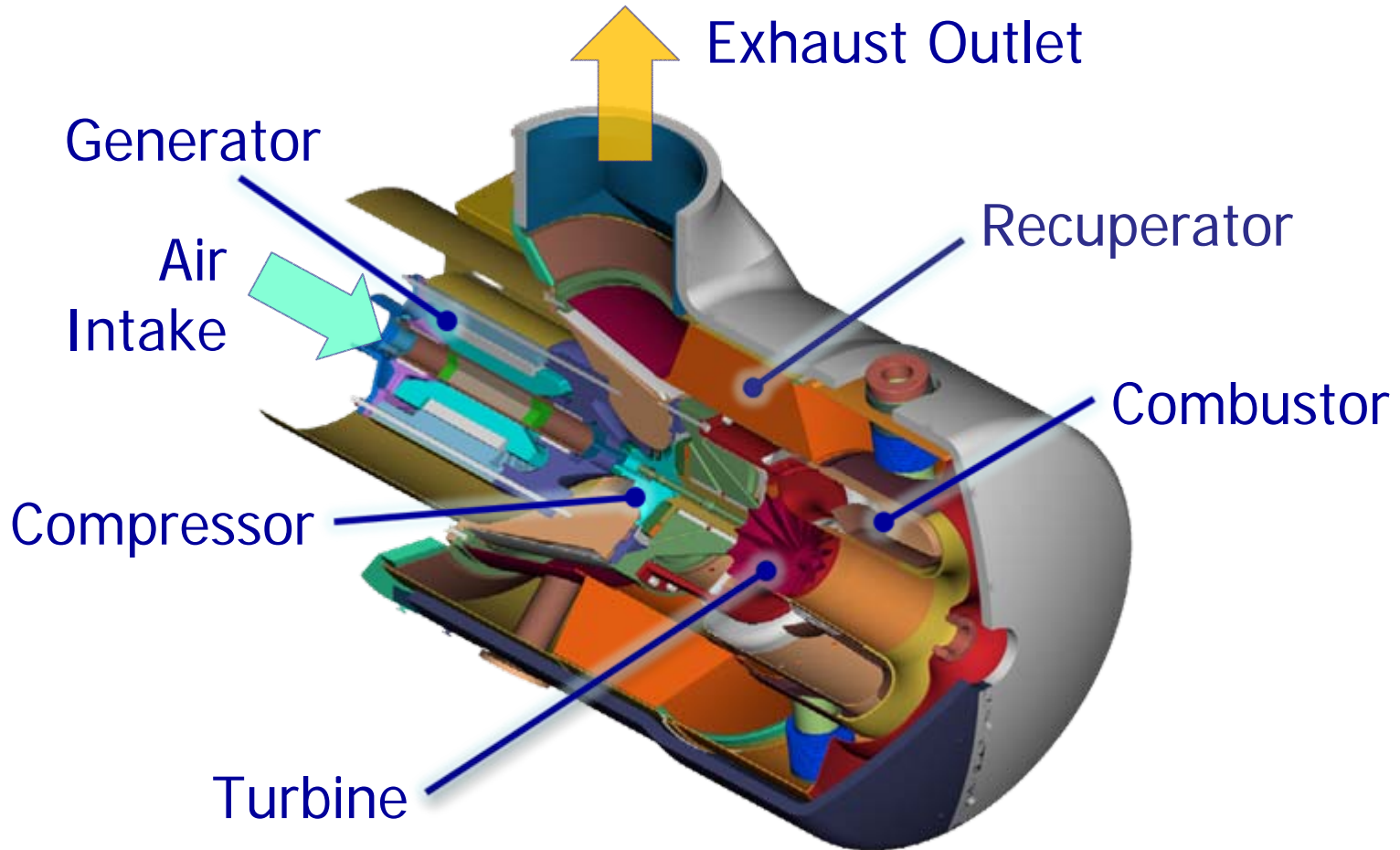
Capstone Turbine Corporation



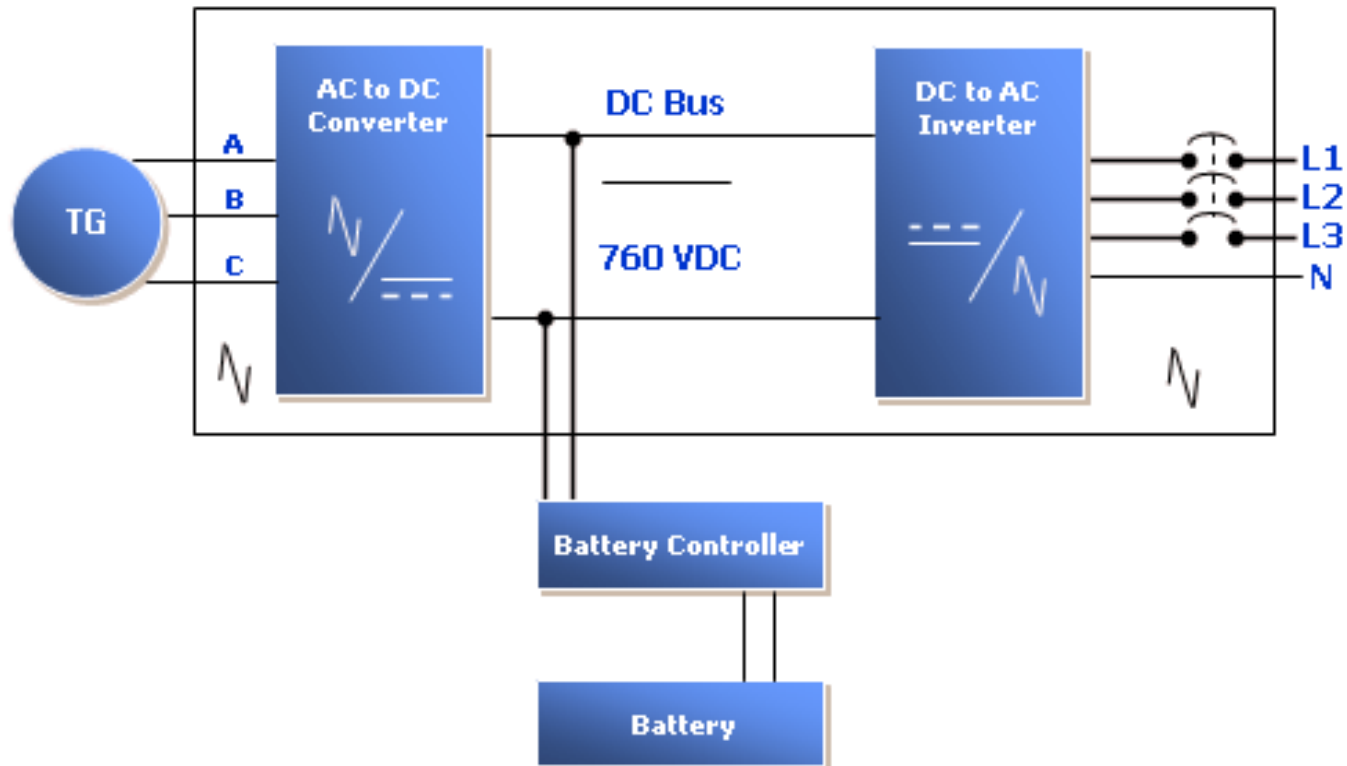
- Founded 1988 - Commercial launch in 1998
- Public Corporation 2000 (NASDAQ "CPST")
- World Leader in Microturbines
- 4 "Frame" Ratings:
 - ❑ C30 (30kW)
 - ❑ C65 (65kW)
 - ❑ C200 (200kW)
 - ❑ C1000 (five C200 Power Modules in a Single Package)
- Nearly 5,000 units shipped
- 20,000,000 cumulative operating hours
 - > 16,000 hour MTBF C65
- 100 Patents Worldwide
 - Air Bearings Eliminate Liquid Lubricants
- ISO 9001 & ISO 14001



Capstone C65 MicroTurbine



Inverter Based Electronics





Data Center Challenges

- **UPS Reliability**
- **High Energy Consumers**
- **Inefficient Energy Solutions**
- **Limited Available Space**
- **Significant Source of Air Emissions**
- **UPS Require Significant Capital Equipment and O&M Expenses.**

Reliability



- Complicated Power Electronics
- No Power Quality Protection During Maintenance
- Single Point of Failure



Example of Power Usage Effectiveness



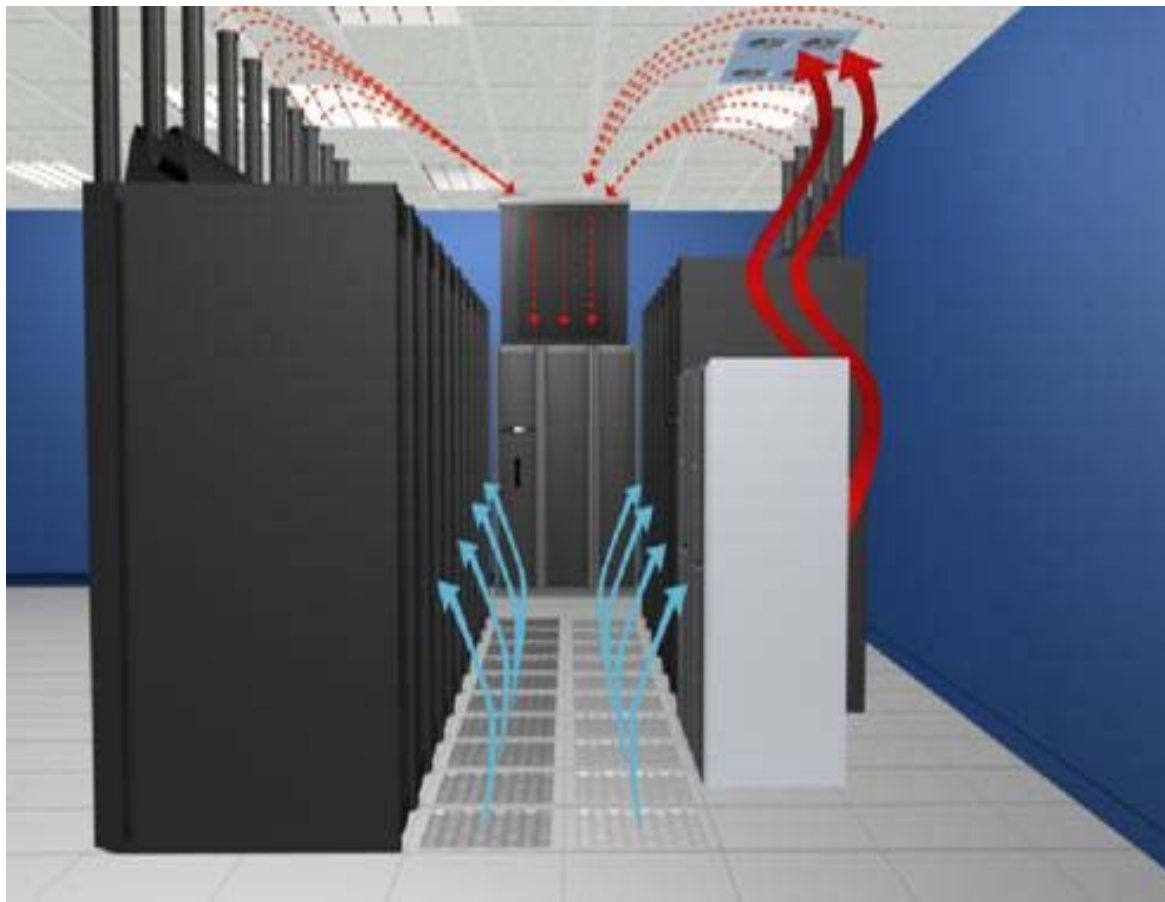
POWER USAGE EFFECTIVENESS



$$\text{PUE} = \text{Total facility power} \div \text{IT equipment power}$$

Limited Floor Space

- UPS Required Indoors
- Significant Heat Source
- Tier IV Installed Cost = \$25K Per KW
- 300 per sq-ft Floor Space



Diesel Generator



- **Large Footprint**
- **Exhaust Emissions**
- **High Noise Levels**
- **Limited Fuel Source**
- **Unreliable**



High Efficiency – CHP/CCHP



| Manufacturer/Type | Efficiency | | Notes |
|--------------------------|------------|-------|------------------|
| | Electric | Total | |
| Capstone C65 ICHP | 29.0% | 80.6% | 60°C Inlet Water |
| UTC PureComfort 240 CCHP | 29.0% | 89.4% | 142RT Cooling |

CCHP Data Center Solution



Data Center/Telecom

- Offset 240KW Electricity
- Provides 42 Tons Cooling
- Offset High Electricity Prices
- UPS Grade Power and Reliability with a Return on Capital Investment

Communication Company Data Center California

One of the United States' largest communication companies was paying steep peak-power costs at a California data-center and switch site. Combine the high peak prices with concern about the site's aging air conditioning and back-up power and company executives knew they needed a change. So they turned to a Capstone microturbine to alleviate both problems. Today, four C65 microturbines that run on low-pressure natural gas serve as the foundation for a combined cooling and power (CCHP) system that has cut the data center's electric bill by two thirds. The CCHP system creates 260 kW of electricity that operates on-site gas compressors, air conditioning pumps and fans, data center computers and the full data center load, which includes the telephone switch and wireless network. Thermal heat from the microturbine exhaust runs a direct-fired 42-ton absorption chiller connected to the air conditioning system. ■



Four C65 Micro Turbines™ running on natural gas provide CCHP at a data center in California.



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Prime Power Data Center Solution



Datacenter/Telecom

- Prime Power for Data Center
- Utility Serves as Back up Source
- Lower Maintenance than Traditional UPS System
- UPS Grade Power

Data Center, Texas

An array of half a dozen Capstone C60 MicroTurbines™ atop a parking structure in downtown Houston assures power security for the data center of one of the world's most renowned engineering and construction companies.

A few miles southeast of the city center, an administration building of the Boeing company uses a Capstone microturbine 24/7 as the prime power source for its data/telecom systems, with the utility grid serving as the back-up source. •



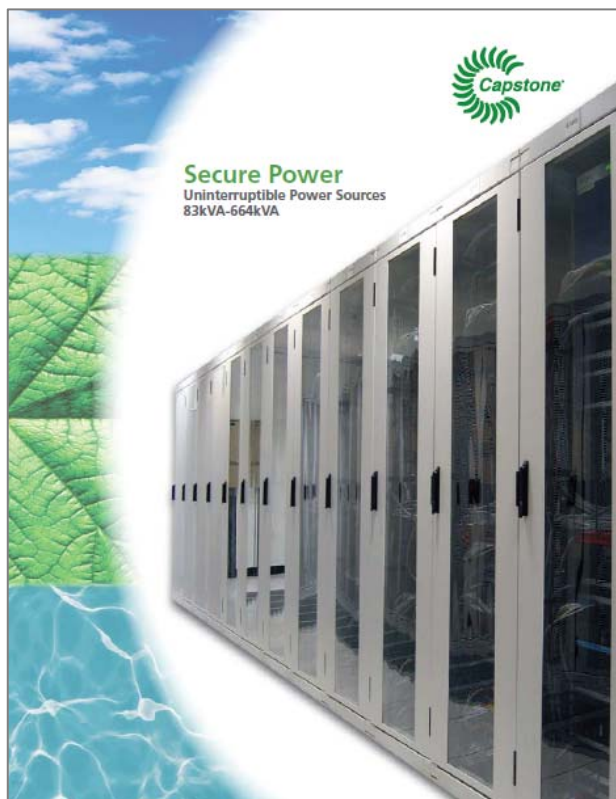
Six Capstone C60 microturbines assure power security at this downtown Houston site.

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Hybrid UPS Solutions

The Most Reliable and Affordable Microturbine-Powered UPS Available



Secure Power's microturbines generate power and heat. Use both and you'll minimize your data center's energy bills, maximize efficiency, and reduce greenhouse gas emissions.

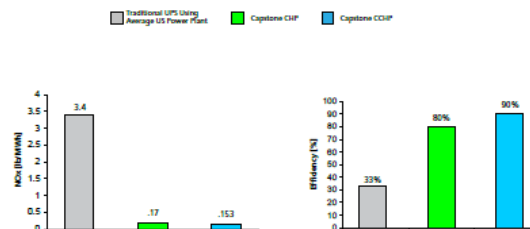
CCHP and CHP
 With Secure Power in a CCHP application, the microturbines' clean exhaust is used to drive an absorption chiller to meet your data center's air-conditioning needs. Or use Secure Power as a CHP application and the waste heat energy will support your building's heating needs.

Secure Power provides air conditioning that's virtually electricity-free and cuts operating costs. You can automatically switch between cooling and heating as needed with the advanced functionality of the Secure Power Capstone microturbines.

Secure Power CCHP and CHP solutions: Cooling when it's hot, heating when it's not and reliable, affordable power every day.



Secure Power: Cleaner and More Efficient





Hybrid UPS Overview

- Clean-and-Green (ultra-low exhaust emissions)
- 99.999999% Availability
- IT-grade Power
- Up to 90% Fuel Efficient
- Multi-fuel Capable
- Multiple Power Modules – no single point of failure
- Low Maintenance – only 1 moving part, no liquid lubricants
- No Indoor Space Required (and associated costs)
- Expands to Match Load Growth
- Reduces Energy Cost
 - ✓ CHP – use waste heat for building heating
 - ✓ CCHP – use absorption chiller for air conditioning



Hybrid UPS Solution

Hybrid UPS

- Microturbines are Dispatched
 - Run when Economical
- Three Power Connections
 - Stand Alone AC Output
 - Grid Connect AC Input
 - DC Battery Input
- Three Operating Modes
 - High Efficiency Mode
 - Standard UPS Mode
 - Emergency Mode
- Low Life Cycle Cost



Hybrid UPS Components

| Component | Function |
|--|--|
| <ul style="list-style-type: none">• Load Control Module 1 | <ul style="list-style-type: none">• Grid Connected to Utility Source• Import or Export Power• IEEE 1547 Protective Functions |
| <ul style="list-style-type: none">• Load Control Module 2 | <ul style="list-style-type: none">• Stand Alone Power Output• Maintains Synch with Utility Bus |
| <ul style="list-style-type: none">• Generator Control Module | <ul style="list-style-type: none">• Converts High Frequency Turbine Generator Output to 760V DC Bus• Use 760 DC to Start Microturbine |
| <ul style="list-style-type: none">• Battery Control Module | <ul style="list-style-type: none">• Connects Internal 760V DC to Customer DC Bus Voltage (eg 400V)• Imports Power from External Battery in Emergency Mode |

SU Green Data Center Project



Partners

- IBM
- NYSERDA
- Syracuse Univ.



Major Goal is High Efficiency
“50% Less Energy than Typical Facility”



Green Data Center Overview



- SU South Campus Location

- 12,000 ft² facility
- 6,000 ft² data floor

- \$12.4 Million Project

- \$5 million IBM
- \$2 million NYSERDA

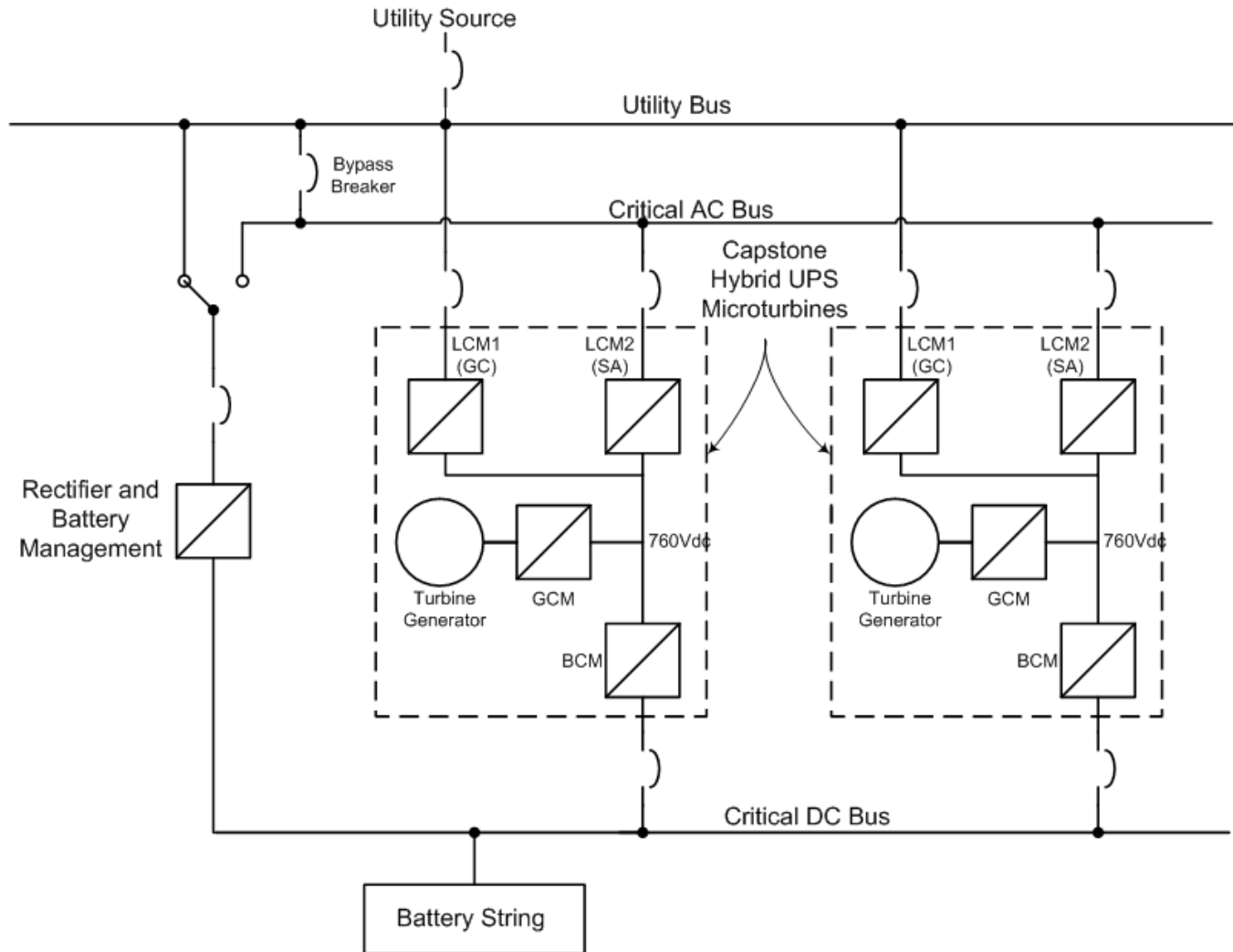
- Efficiency Improvements

- 12 Patented Capstone 65kW Hybrid UPS Microturbines
- Advanced CCHP System Integration by BHP Energy, LLC
- IBM Rear Door Chilled Water HX
- DC Power Distribution

- Performance Monitoring by Syracuse University



Example System One-Line



Project Status

- Ground Breaking – May 29, 2009
- Start Equipment Install – September 2009
- Initial Operation/Ribbon Cutting – November 2009
- More Info at:

<http://cpdc.syr.edu/>





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Power When and Where You Need It.
Clean and Simple.

Capstone Turbine Corporation
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Reliability
21,271,473.35
Total fuel operating hours
MTR: 14,000 (C60) and 15,300 (C30)

Solutions
Choose a Solution:
DOCUMENT LIBRARY
SUSTAINABILITY CALCULATOR
ECONOMIC CALCULATOR
FEDERAL (GSA) SALES
FIND A DISTRIBUTOR

Recent News
Capstone Turbine Names EXI - Electromeo Costa Rican Distributor
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Capstone Turbine Corporation Announces First Quarter Fiscal 2010 Operating Results
Capstone Turbine Corporation Announces First Quarter Fiscal 2010 Operating Results First Quarter Revenue \$13.7 Million Up 83% From ... 8/10/2009
Capstone Turbine Adds Distributor for Arkansas, Kansas and Missouri
Capstone Turbine Adds Distributor For Arkansas, Kansas And Missouri CHATSWORTH, Calif., July 27, 2009 (GLOBE NEWSWIRE) -- Capstone Turbine ... 7/27/2009

To get the benefits of a Capstone Energy Solution at your facility, Call toll-free in US: 866-4-CAPSTONE (866-422-7786)

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Addendum

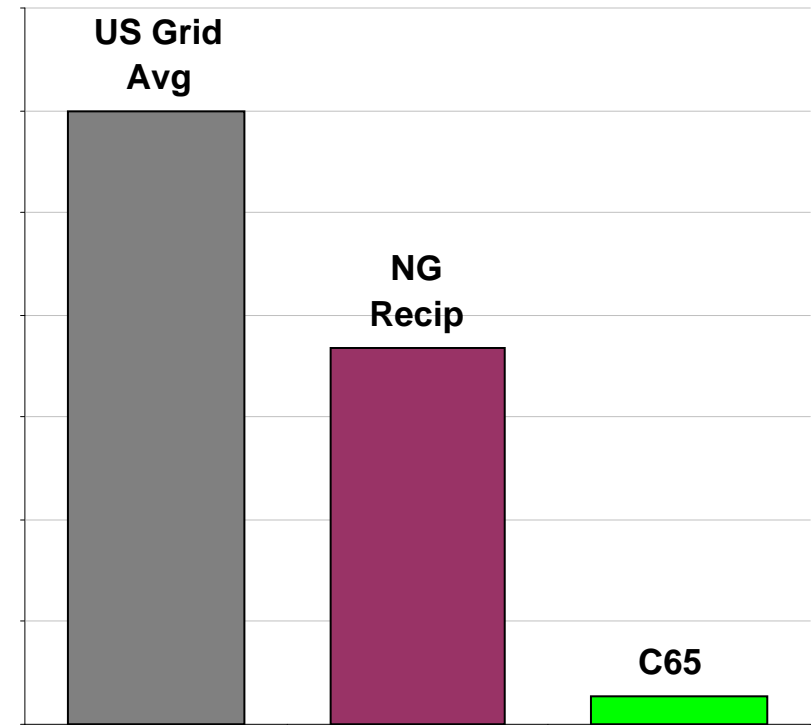
Emissions Comparison



| CARB Natural Gas Emission Standard | | | | |
|------------------------------------|--------|------|------|-----------|
| | Units | 2003 | 2007 | Reduction |
| NOx | lb/MWh | 0.5 | 0.07 | 86% |
| CO | lb/MWh | 6.0 | 0.10 | 98% |
| VOC | lb/MWh | 1.0 | 0.02 | 98% |

- CARB 2007 is an extremely stringent emissions standard that exceeds the requirements of federal standards
- Only Microturbines, Fuel Cells, Solar and Wind meet standard

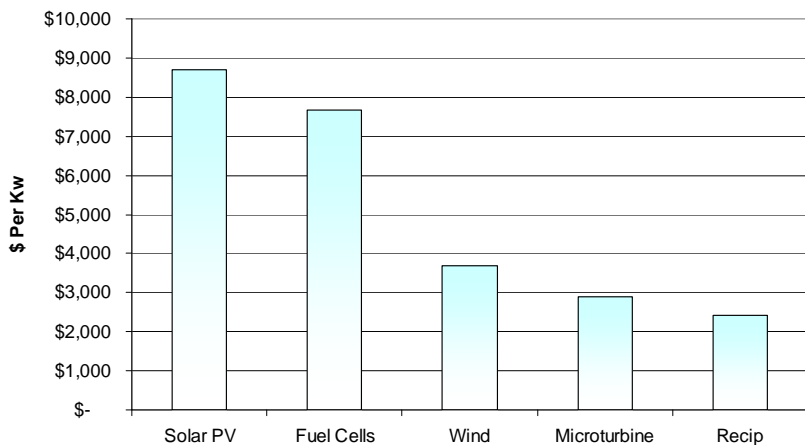
Relative NOx Emissions



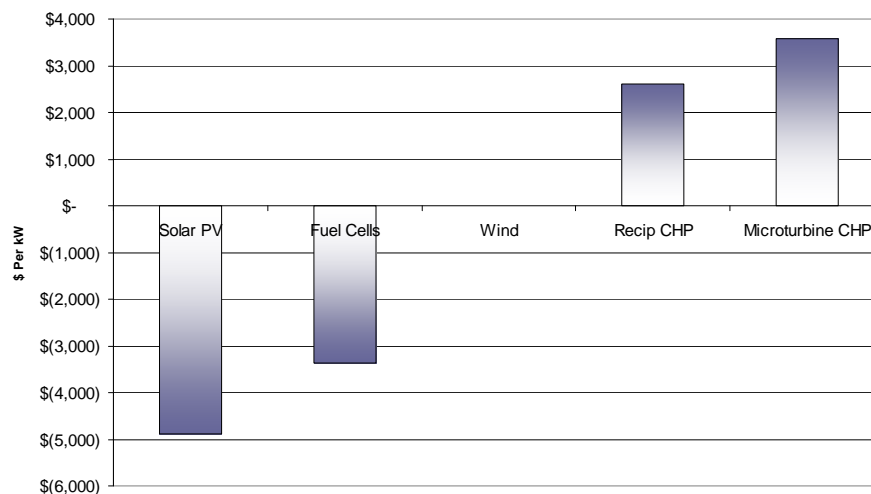
Source: EPA and ASME

Technology Comparison

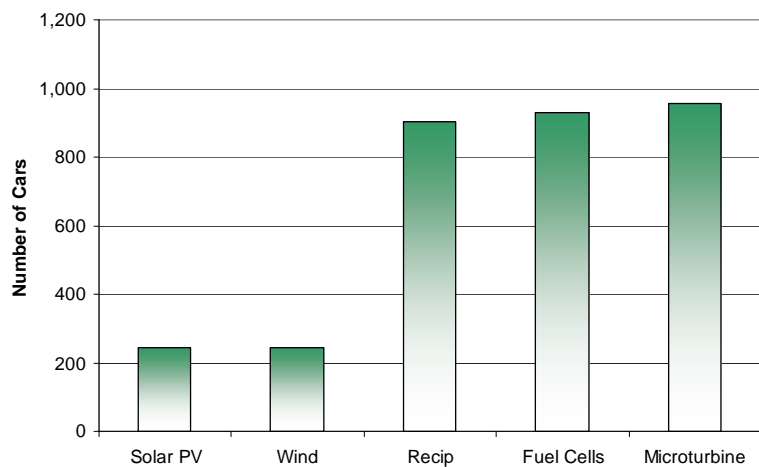
Sample Installed Cost



Sample Net Benefit of Ownership Over 10 Years



Equivalent Cars Removed (CO2) for 1 MW Project



Assumptions

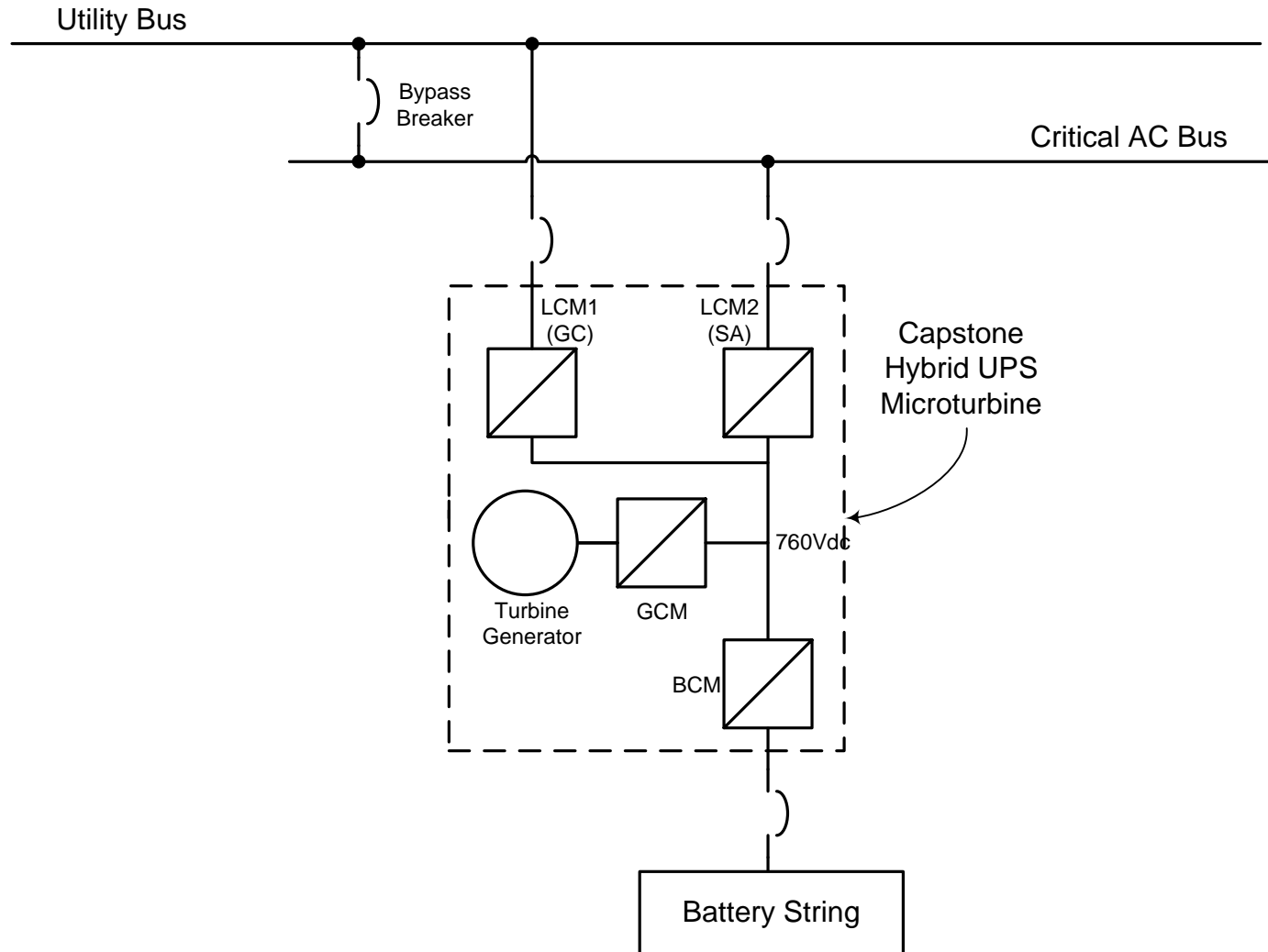
- Capstone C200 System
- Combined Heat and Power Systems
- Natural Gas Fueled
- California Emission Standards
- Initial Investment Data: CA Statewide SGIP Program Statistics through Q4 2007
- Analysis assumes no incentives

Hybrid UPS – Capstone Scope

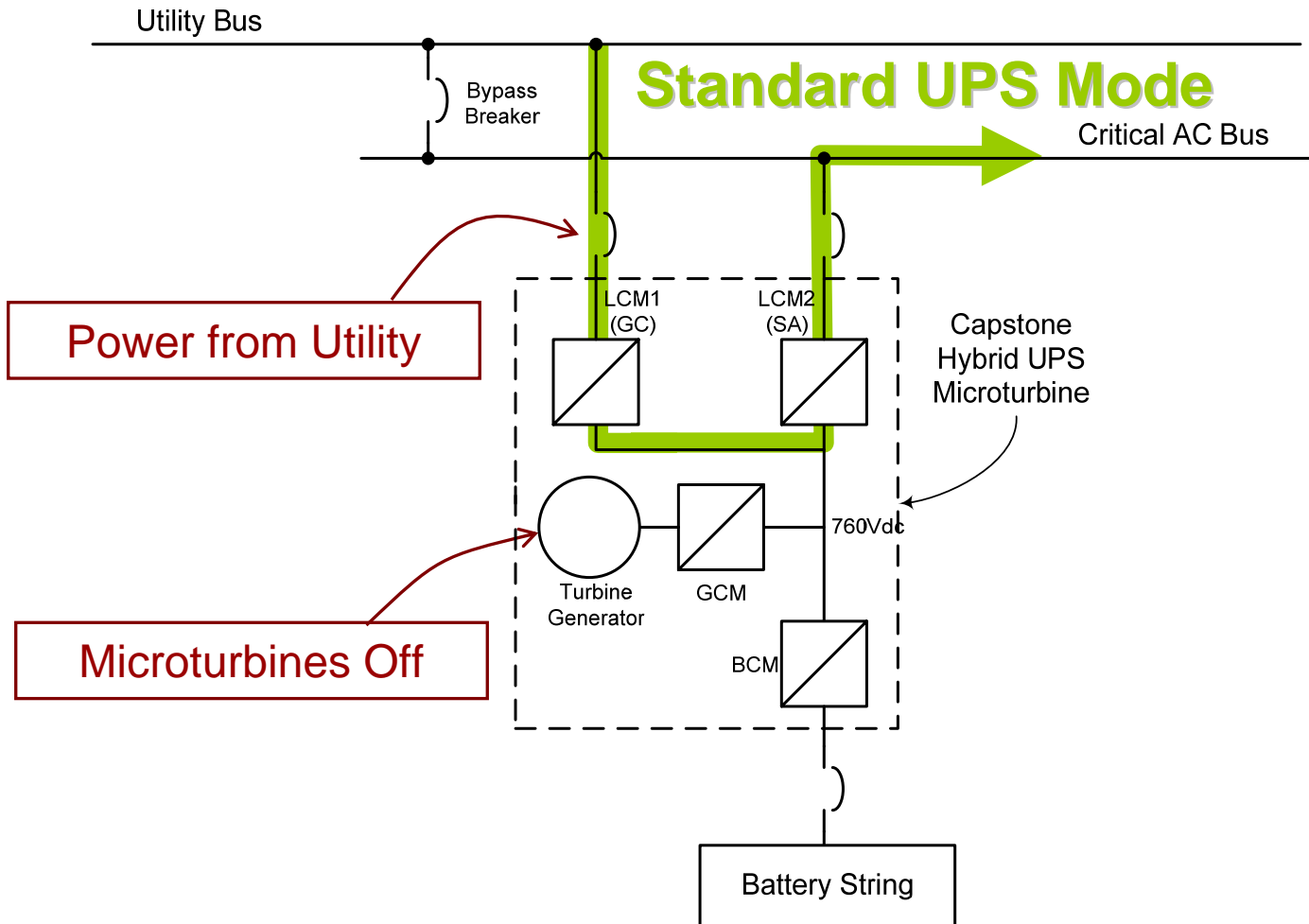


- Hybrid UPS Microturbines
 - CHP, CCHP, or Electric Only Application
 - Natural Gas Fuels
- Accessories
 - 15 Minute External Battery Packs
 - Fuel Gas Boosters
 - Capstone UPS Controller
 - Communications Accessories
- Factory Protection Plans

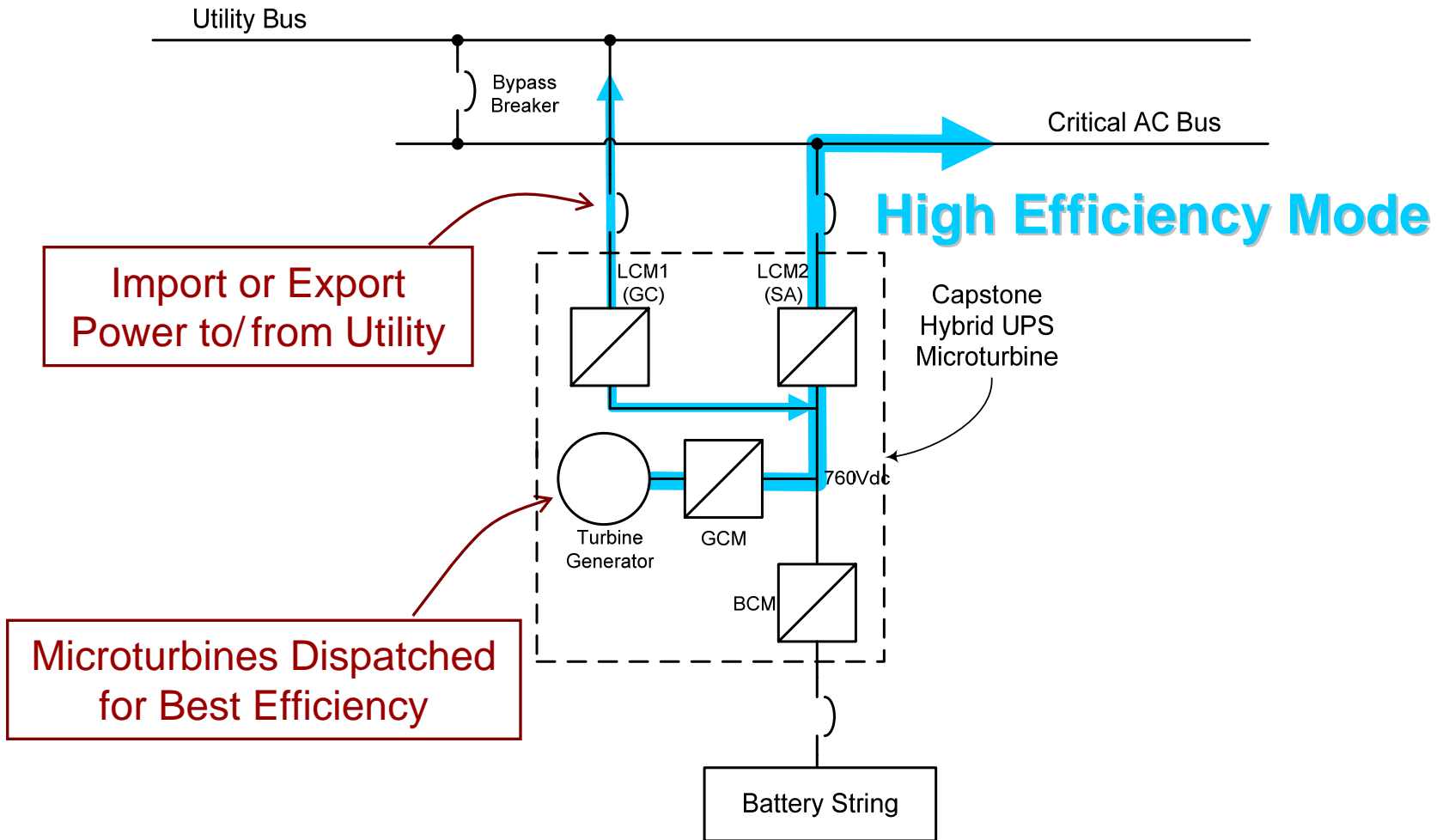
Hybrid UPS



Hybrid UPS



Hybrid UPS



Hybrid UPS

