Microturbine CHP for Microgrids
Microgrid2017

Why Microturbines for Microgrids?

- ✓Proven: Over 3,000 sites operating in Stand Alone and Dual Mode
- ✓One Moving Part; Air Bearings
- ✓Invertor Based Power Electronics
- ✓Modular and Scalable
- ✓Customizable Controls
- ✓Ultra Low Emissions
- ✓High Efficiency with CHP
- ✓Baseload Power and Heat

A crane lowers the second of two microturbines that play an intricate role in the company's microgrid.

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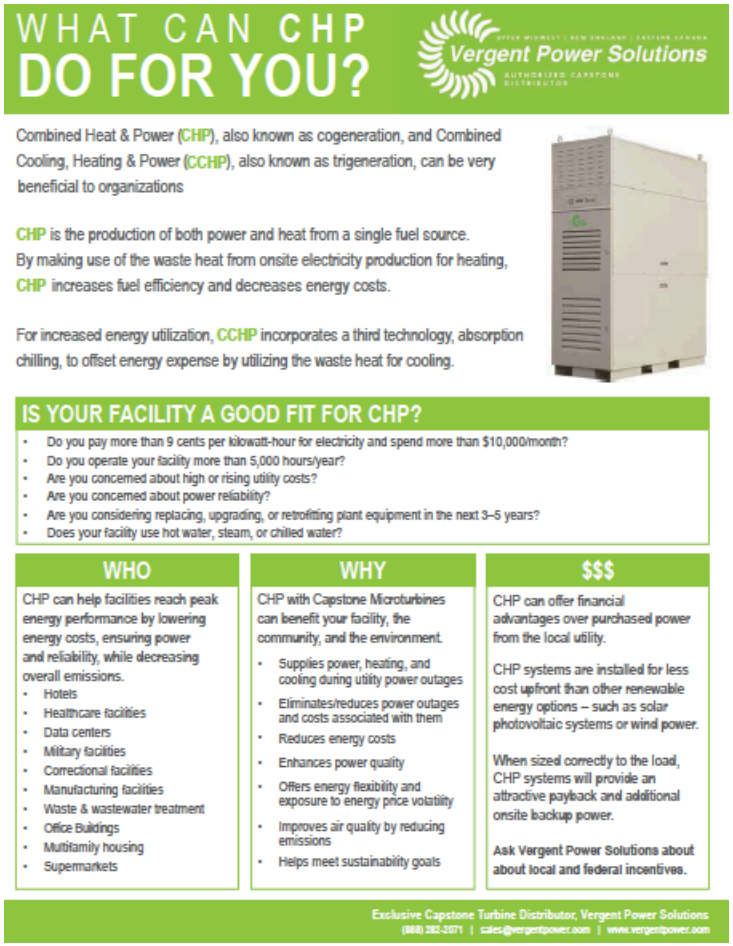
CHP is sold on the basis of…

1. **Cost Savings measure**
   - Essentially a hedge against rising electric rates using stable, low pricing of NG, as well as an efficiency gain
2. **Energy Security measure**
   - Dual Mode CHP can provide valuable backup / critical power
3. **Environmental Positive measure**
   - Leveraging existing sustainability programs or obtain regulatory compliance or favor



WHAT CAN CHP DO FOR YOU?

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Combined Heat & Power (CHP), also known as cogeneration, and Combined Cooling, Heating & Power (CCHP), also known as trigeneration, can be very beneficial to organizations

CHP is the production of both power and heat from a single fuel source. By making use of the waste heat from onsite electricity production for heating, CHP increases fuel efficiency and decreases energy costs.

For increased energy utilization, CCHP incorporates a third technology, absorption chilling, to offset energy expense by utilizing the waste heat for cooling.

IS YOUR FACILITY A GOOD FIT FOR CHP?

- Do you pay more than 9 cents per kilowatt-hour for electricity and spend more than $10,000/month?
- Do you operate your facility more than 5,000 hours/year?
- Are you concerned about high or rising utility costs?
- Are you concerned about power reliability?
- Are you considering replacing, upgrading, or retrofitting plant equipment in the next 3–5 years?
- Does your facility use hot water, steam, or chilled water?

WHO

CHP can help facilities reach peak energy performance by lowering energy costs, ensuring power and reliability, while decreasing overall emissions.

- Hotels
- Healthcare facilities
- Data centers
- Military facilities
- Correctional facilities
- Manufacturing facilities
- Waste & wastewater treatment
- Office Buildings
- Multifamily housing
- Supermarkets

WHY

CHP with Capstone Microturbines can benefit your facility, the community, and the environment.

- Supplies power, heating, and cooling during utility power outages
- Eliminates/reduces power outages and costs associated with them
- Reduces energy costs
- Enhances power quality
- Offers energy flexibility and exposure to energy price volatility
- Improves air quality by reducing emissions
- Helps meet sustainability goals

$$$

CHP can offer financial advantages over purchased power from the local utility.

CHP systems are installed for less cost upfront than other renewable energy options – such as solar photovoltaic systems or wind power.

When sized correctly to the load, CHP systems will provide an attractive payback and additional onsite backup power.

Ask Vergent Power Solutions about about local and federal incentives.

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CHP: A Better Backup than Gensets

Table 2: Comparison between CHP and Backup Generators

	CHP	Backup Generators
System Performance	• Designed and maintained to run continuously • High performance reliability	• Only used during emergencies
Fuel Supply	• Natural gas infrastructure typically not impacted by severe weather	• Limited by on-site storage
Transition from Grid Power	• May be configured for "flicker-free" transfer from grid connection to "island mode"	• Lag time may impact critical system performance
Energy Outputs	• Electricity • Thermal (heating, cooling, hot/chilled water)	• Electricity
Emissions	• Typically natural gas fueled • Achieve greater system efficiencies (80%) • Lower emissions	• Commonly burn diesel fuel

www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_for_reliability_guidance.pdf

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MicroTurbine Technology Fundamentals

Turbine Engine + Generator + Power Electronics + Controls

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Microturbine Technology

- Simple Design and Architecture
- Reliability and Availability
- Fuel Flexibility
- Environmental Sustainability
- Ease of Interconnection/Installation/Operation
- Upward market momentum
- Scalable and Modular
- Invertor Based Electronics
- Patented Air Bearings

ONLY ONE MOVING PART

NO OIL – NO COOLANTS – NO FRICTION

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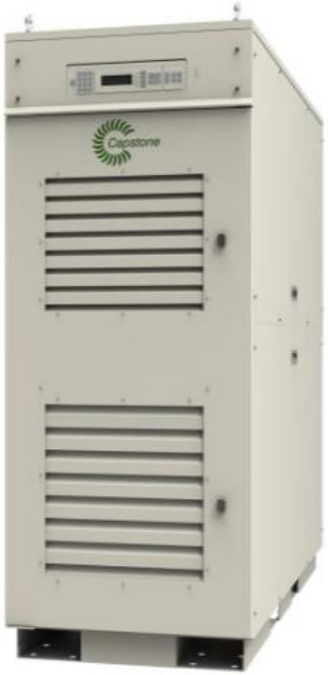
Modular + Scalable CHP



30kW or 65kW

65kW with CHP

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Larger Packaged Solutions

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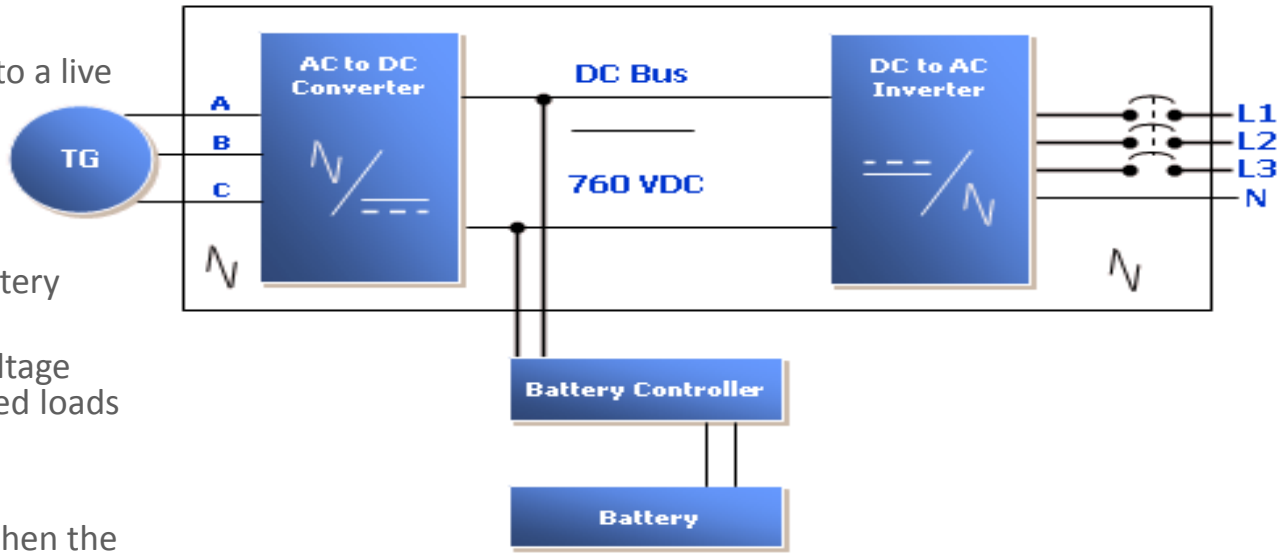
Invertor-Based // 3 Operating Modes:

- Grid Connect
  - Automatically synchronizes to a live utility grid
    - 400-480 VAC – 50/60 Hz
- Stand Alone
  - Equipped with on-board battery system
  - Provides user-configured voltage and frequency to grid-isolated loads
- Dual Mode
  - Functions in Grid Connect when the grid is available, switches to Stand Alone when the grid goes offline



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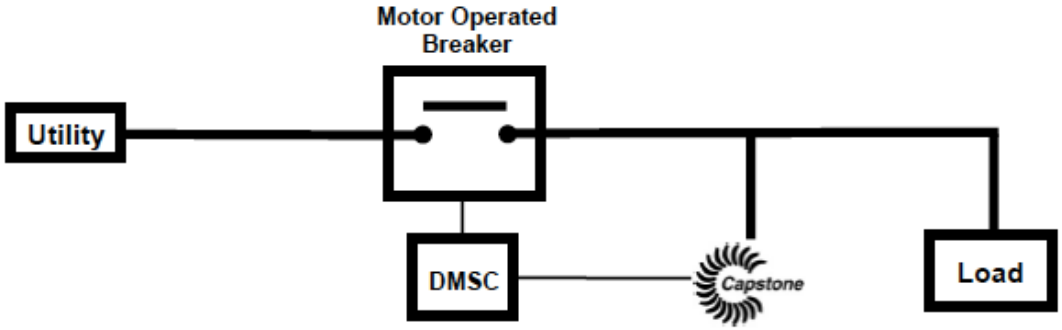
Grid Connect to Stand Alone Transition



- In Dual Mode, the CHP has the ability to operate both in parallel with and independent of the utility grid
- Dual Mode System Controller interfaces with an external motorized breaker that connects or isolates the CHP and protected loads from the utility grid
- If the grid power is interrupted the MOB will open, the DMSC will restore power in 10 seconds
- When the grid returns loads will reconnect to the grid in < 5 seconds.

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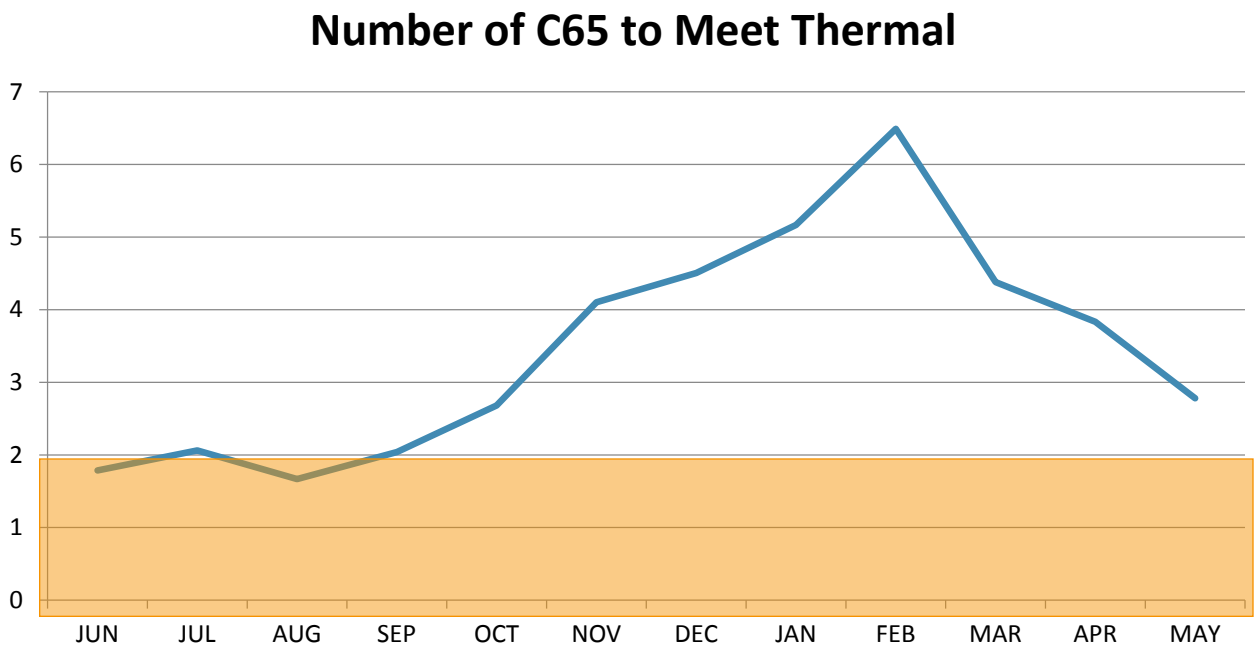
Typical CHP Sizing for Thermal Baseload

- 130kW CHP System is recommended for this site to minimize CAPEX and optimize payback
- CHP will operate at max efficiency

Shaded area represents the thermal output of 130kW system



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System Design Philosophy for Resiliency

- Different approach from typical CHP sizing
- Minimum N+1
- Primary parameter for system sizing is maximum steady state power output available during Emergency Mode Operation
- Assume worst case assumptions for power output including maximum ambient temp, altitude, back pressure and parasitic loads
- Example:
  - Ambient: a 65kW Microturbine at 100 deg F; elevation 380 ft; 8” backpressure including 4kW gas compression parasitic load
  - Multiply by 0.80 to get adjusted real power of 37.6 kW

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Other Design Considerations

- Fuel supply chain, backup fuels
- Other generation sources, synchronization
- Transformer Sizing for Stand Alone operation
- Controls – Controls – Controls
- Serviceability
- Remote Monitoring
- Onsite parts storage
- Local personnel training

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Payback Analysis

	Initial	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Total Installed Cost	$678,100										
Fuel, O&M, and Other Costs		$150,740	$157,262	$164,110	$171,300	$178,850	$186,777	$195,100	$203,840	$213,017	$222,652
Savings/Avoided Costs	Include in Analysis?										
Electricity Productio		$150,262	$162,283	$175,266	$189,287	$204,430	$220,784	$238,447	$257,523	$278,125	$300,374
Heat Cogeneratio	$0	$97,090	$101,945	$107,042	$112,394	$118,014	$123,915	$130,110	$136,616	$143,447	$150,619
Coolin	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Power Quality/ Reliabili	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Financing/ Inv. Tax Credi	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Incentiv	$200,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Depreciation Tax Bene		~~$55,604~~	~~$88,967~~	~~$53,380~~	~~$32,028~~	~~$32,028~~	~~$16,014~~	~~$0~~	~~$0~~	~~$0~~	~~$0~~
Total	$200,000	$247,352	$264,228	$282,308	$301,681	$322,444	$344,699	$368,557	$394,138	$421,571	$450,993
Net Cash Flow	($478,100)	$96,612	$106,966	$118,198	$130,381	$143,594	$157,922	$173,457	$190,298	$208,554	$228,341
Cumulative Cash Flow	($478,100)	($381,488)	($274,522)	($156,324)	($25,943)	$117,651	$275,573	$449,030	$639,328	$847,882	$1,076,223

Depreciation Method	MACRS 5 YR (half-yr convetion		Annual Savings (Year 1)	$96,612	
			10 yr IRR	24.5%	
Depreciation Timeline	5 years	Discount Rate	5.0%	10 yr NPV	$677,346
Tax Rate	41%			Payback Period [Years]	4.18

Operating Hours/year	
Microturbine	8,322
Heat	8,322
Cooling	0

Integrating CHP into Microgrids provides valuable payback incentive

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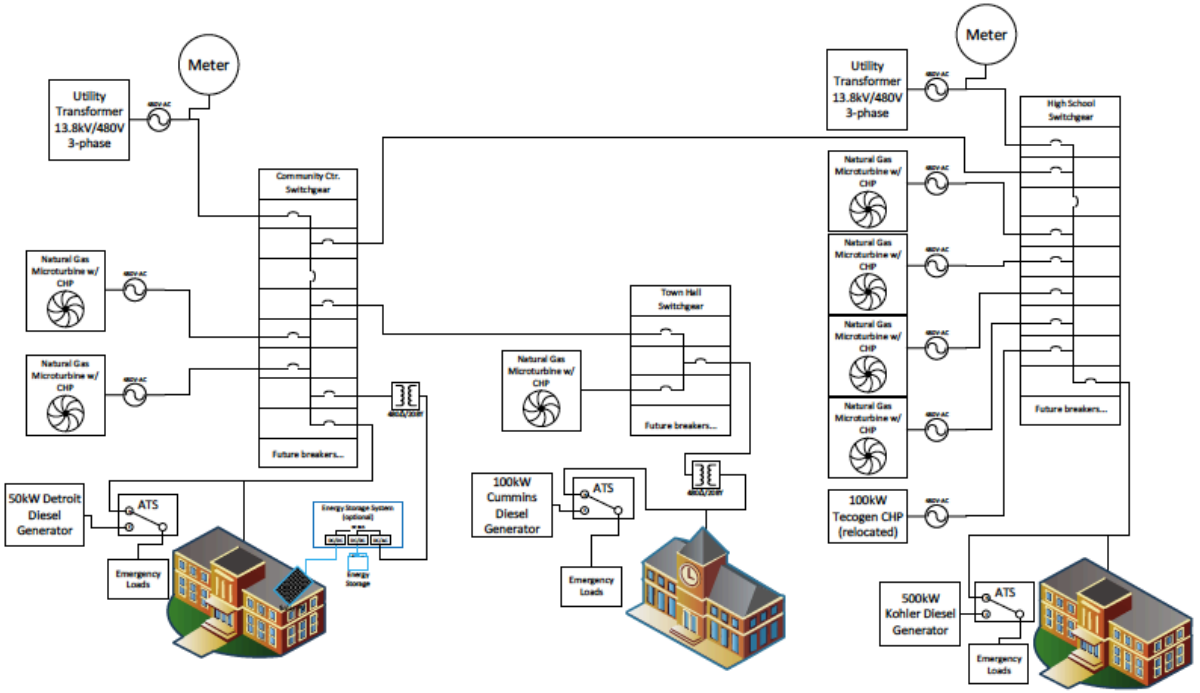
Modular Microturbine CHP Approach

- Small building blocks with integrated heat recovery
- Installed modular systems near to heating load
- Common electrical bus
- Easier to transport electrons than btus



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Case Studies

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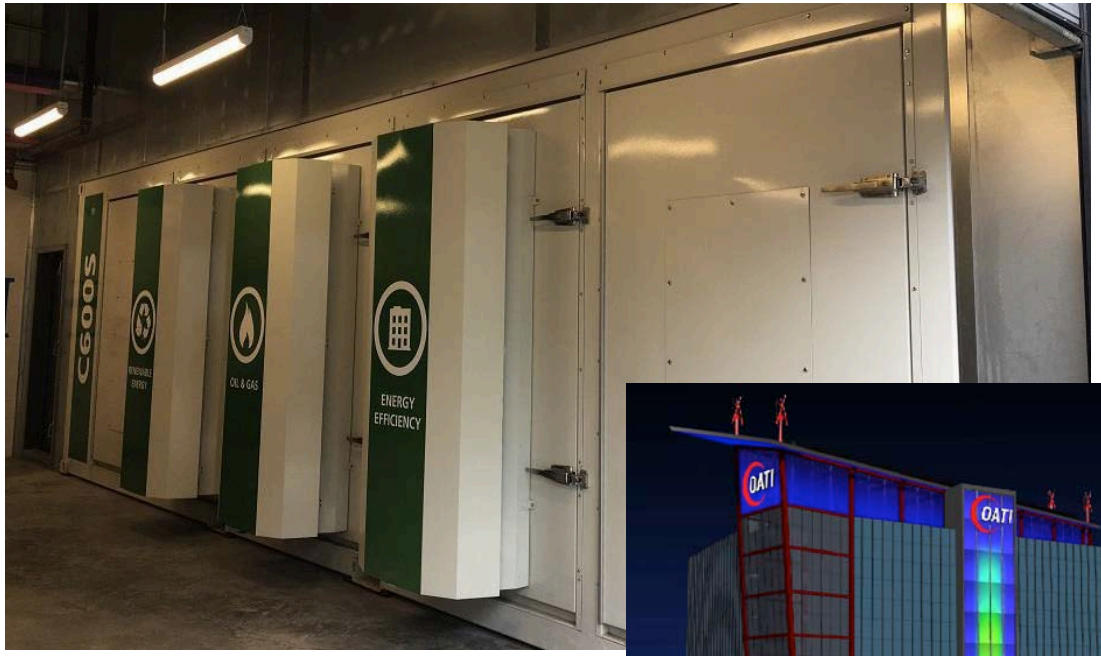
Case Study – Microgrid Data Center

- 600kW Microturbine CCHP
- PV array, wind turbines, energy storage, backup generator
- 200 tons of cooling, 3MMBTU hot water from turbine
- Can run in “Normal” and “Emergency” modes for both GRID CONNECT and ISLAND
- GridMind performs resource optimization



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Island Diesel Microgrid

- Monhegan Island is 12 nautical miles off mainland with no subsea power cable
- Entire island is powered by 260kW diesel-fueled microturbines that meet EPA Tier IV final
- Phase 2 will include CHP for certain public buildings
- Complemented by 20kW solar array
- Utility runs 2-4 units during busy season, 1-2 microturbines during winter

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Utility Owned Island Propane Microgrid

- SoCalEdison
- Catalina Island, CA
- 1.5MW plant comprised of twenty-three 65kW microturbines
- Propane fuel
- 25,000 metered customers
- Significant emission reductions and enhanced load flexibility
- Reduces diesel consumption by 200,000 gallons per year

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Sierra Nevada Brewery Microgrid

- Two 1MW Microturbine packages
- Recovering exhaust for steam
- Synchronized with onsite solar (2MW capacity) and other generation

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Upcoming Microturbine Microgrids in 2017-2018…

- Philadelphia Navy Yard
- Gordon Bubolz Environmental Center

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Thank You!

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Superior energy technology made simple, for our customers and the world