



UTC Power

A United Technologies Company



Onsite Power

New CHP Technologies and Products

UTRC/UTC Power

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DOE/ORNL

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**United
Technologies**

Last Year's Message in Vienna

PureComfort™ 240M launched and PureCycle™ 200 near launch

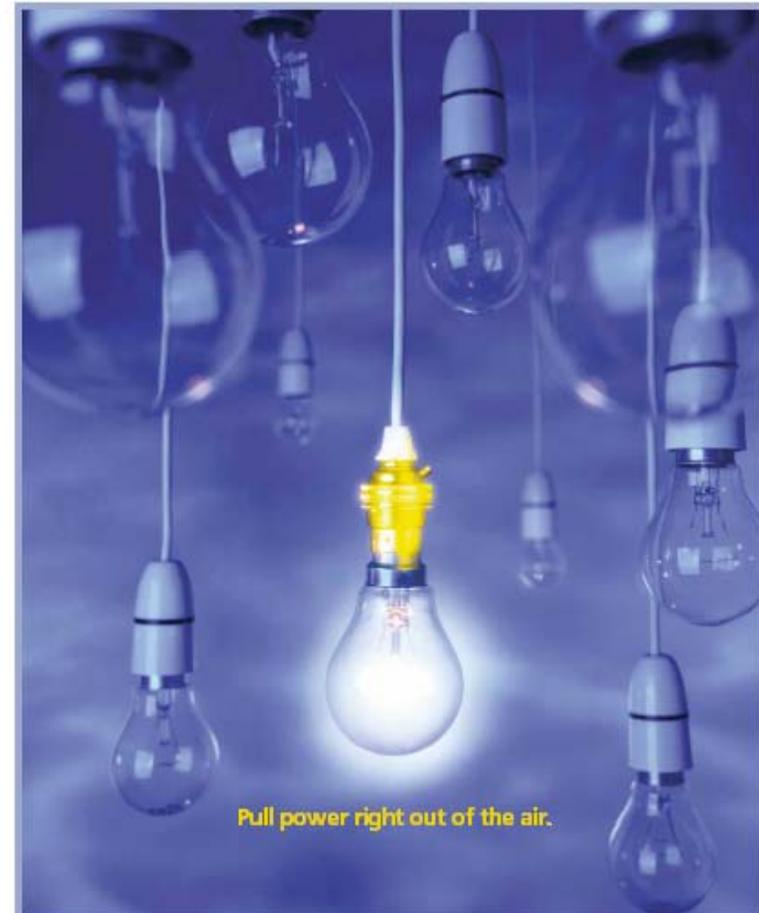
PureComfort™ 240M

**Integrated microturbines
and absorption chiller**



PureCycle™ 200

**ORC system to recycle
waste heat to power**



PureComfort™ System

- What is the system?
- What value does it deliver?
- How has it been improved?
- Where is it operating?

PureCycle™ System

- What is the system?
- How has it been qualified?
- How is it being improved?

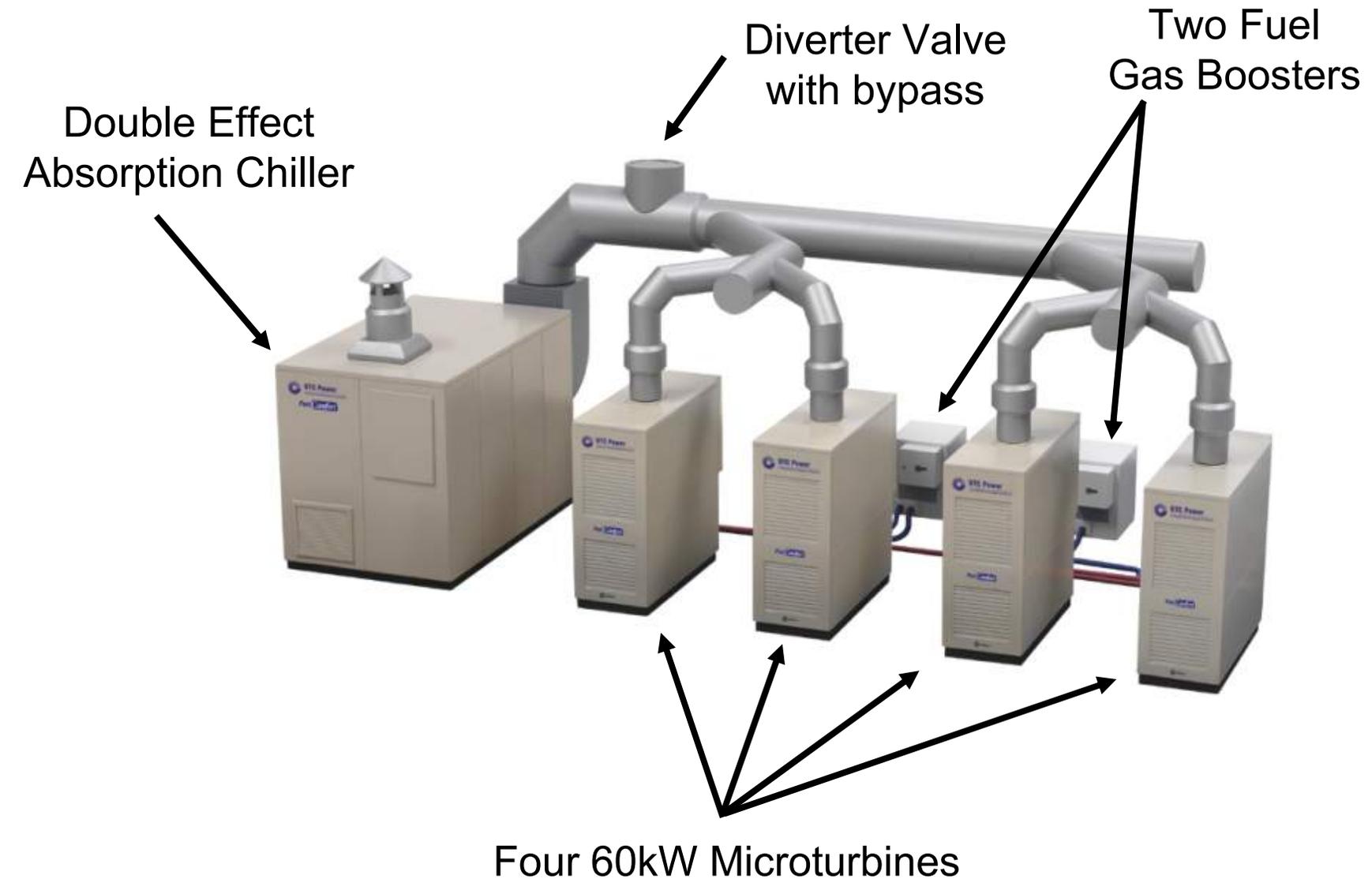
Progress toward 40% electrically efficient microturbine system

- What is the plan?
- What system has been evaluated?
- What efficiency level has been achieved?

Summary

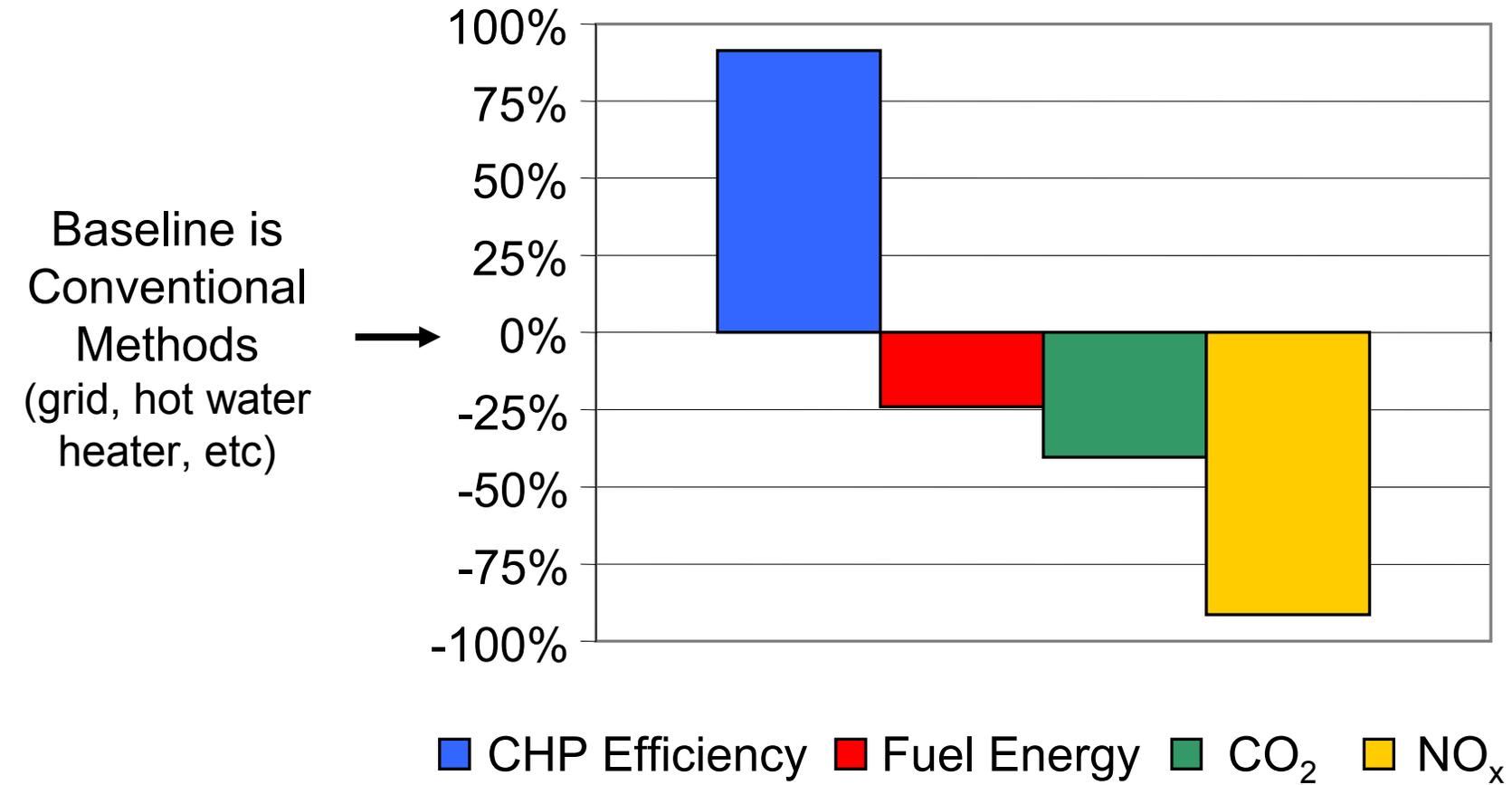
PureComfort™ 240M is a Packaged CHP System

229 kW net power and 161 RT on ISO day → 91% CHP



Recycling Microturbine Exhaust Reduces Energy and Emissions

Lower fuel use, NO_x, and greenhouse gas emissions



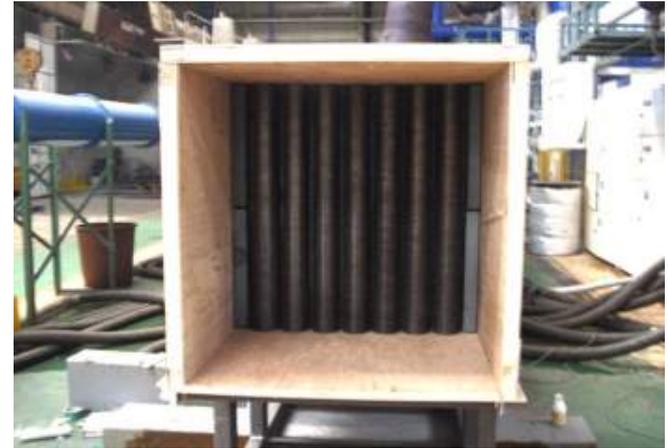
New Technology Inserted Into Chiller

Lower pressure drop reduces microturbine backpressure

Smoke Tubes (Old)



Liquid Tubes (New)



Cooling capacity	Smoke Tube HX	Liquid Tube HX
Backpressure (8" H2O limit)		
PureComfort 240M	110 tons 7" H2O	120 tons 5" H2O
PureComfort 300M	125 tons 9" H2O	140 tons 6" H2O
PureComfort 360M	140 tons 12" H2O	155 tons 7.5" H2O

Expanded PureComfort™ System Offerings

All use same double-effect absorption chiller/heater

PureComfort™ 240M



Released Dec 03

- **Four microturbines**
- **Two fuel gas boosters**
- **Ducting, RMS gateway**
- **229 kWe/161 RT @ ISO**

PureComfort™ 300M



Released Jul 04

- **Five microturbines**
- **Three fuel gas boosters**
- **Ducting, RMS Gateway**
- **287 kWe/188 RT @ ISO**

PureComfort™ 360M

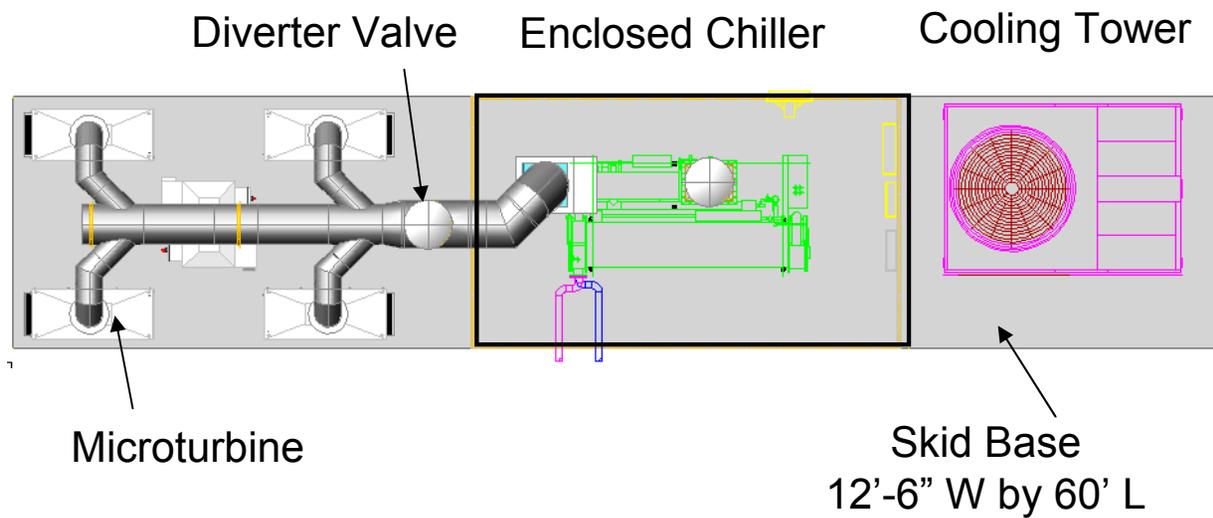


Released Jul 04

- **Six microturbines**
- **Three fuel gas boosters**
- **Ducting, RMS Gateway**
- **344 kWe/210 RT @ ISO**

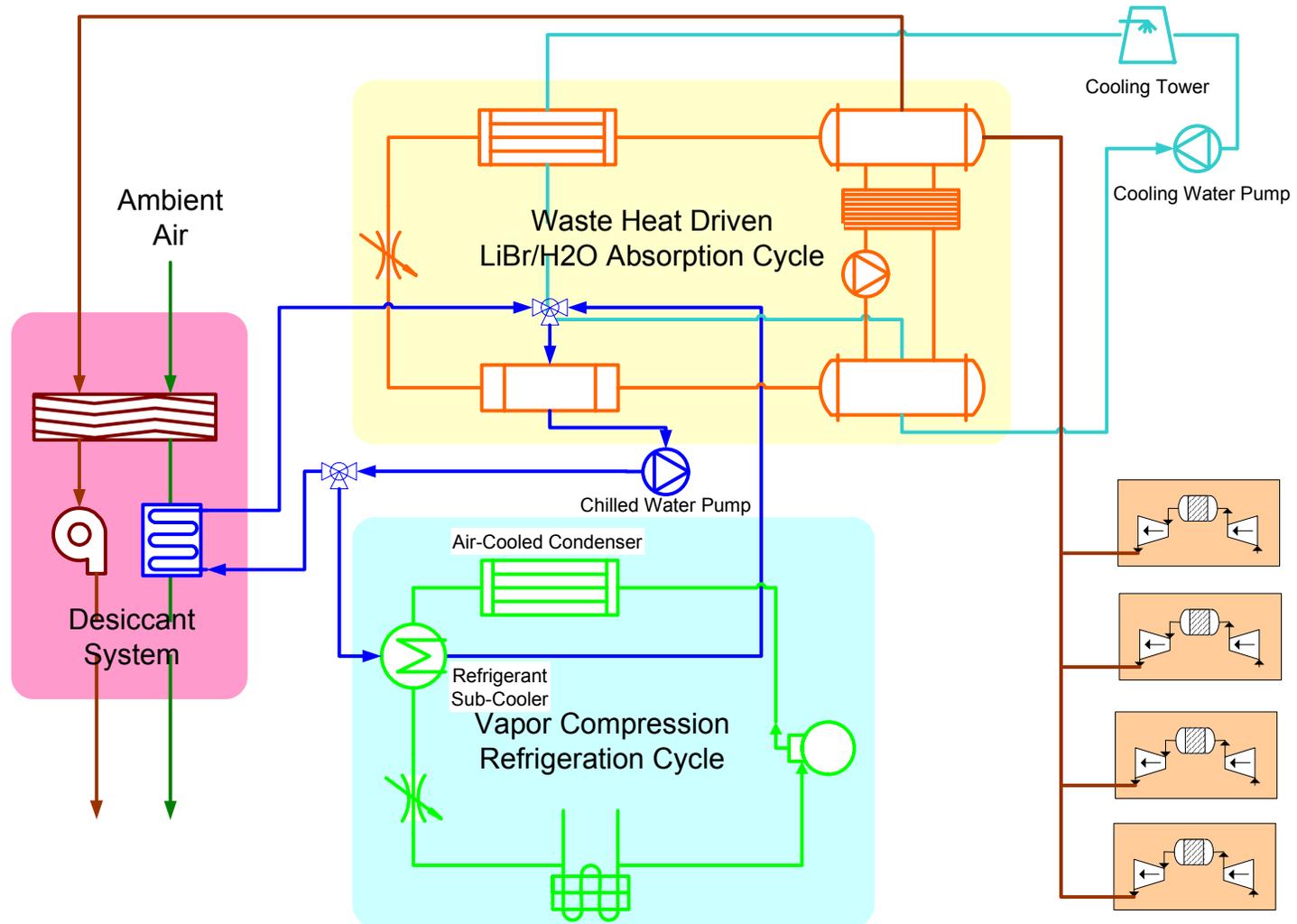
Skidded PureComfort™ 240M Installed at A&P

Ribbon-Cutting held May 17, 2005



PureComfort™ 240M Thermal Integration at A&P

Provides space heating/cooling, sub-cooling, and desiccant regeneration



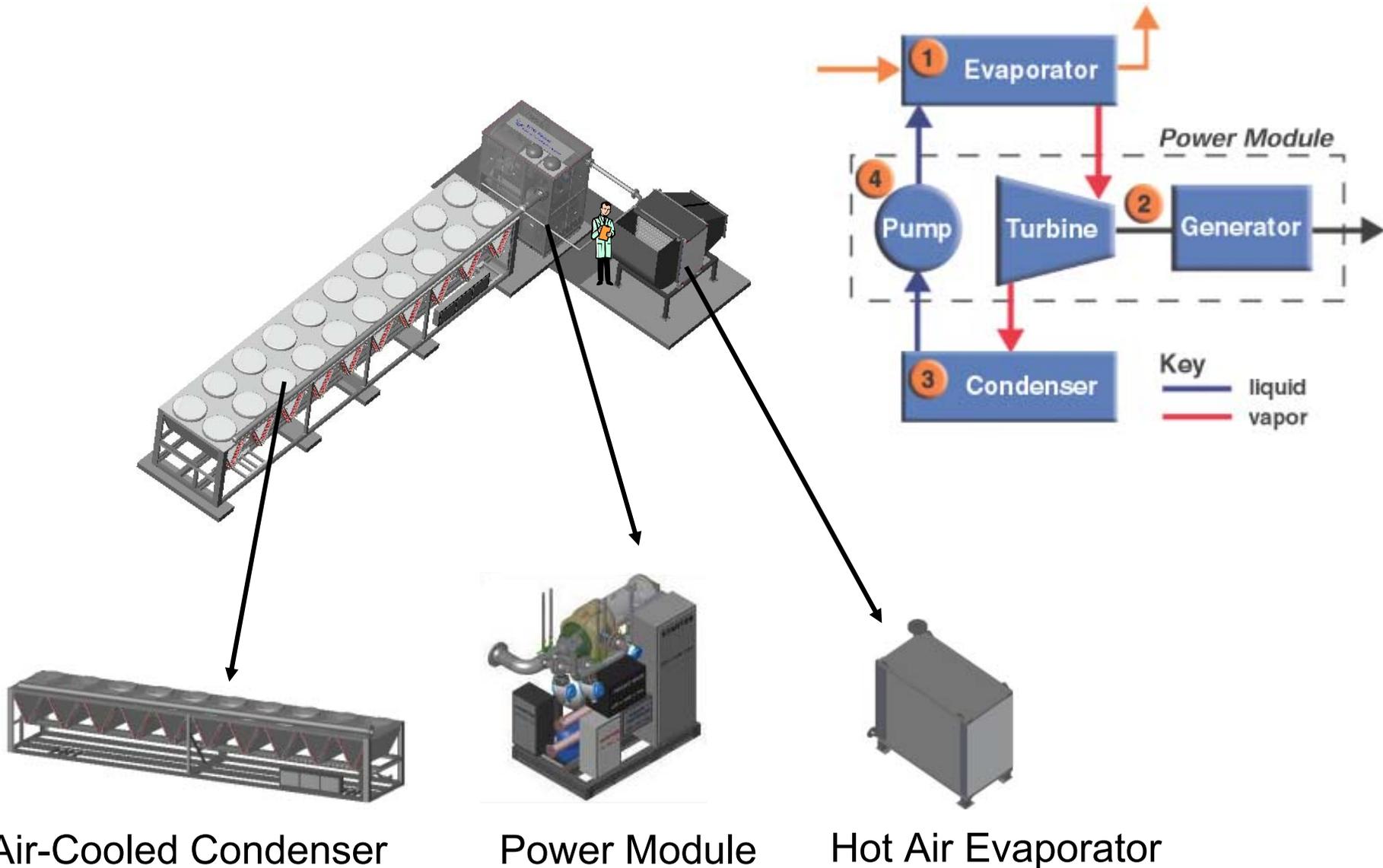
Projected Energy Cost Savings With PureComfort™ 240M

Minimal natural gas for winter heating since January 2005 commissioning

Quantity	% of Annual Baseline – Energy	Annual Cost Savings [\$]*
Grid Electricity	54%	\$44,000
Refrigeration Compression	10%	\$10,000
Space Cooling Compression	70%	\$45,000
Desiccant Regeneration	50%	\$9,000
Space Heating	75%	\$21,000
Total		\$129,000

PureCycle™ 200 Creates Power From Wasted Thermal Energy

Organic Rankine Cycle based on HVAC components from Carrier



Completed PureCycle™ 200 Field Tests

Over 1000 hrs each

Austin Energy (Austin, TX)
Landfill flare exhaust



US Energy (Danville, IL)
Landfill recip exhaust

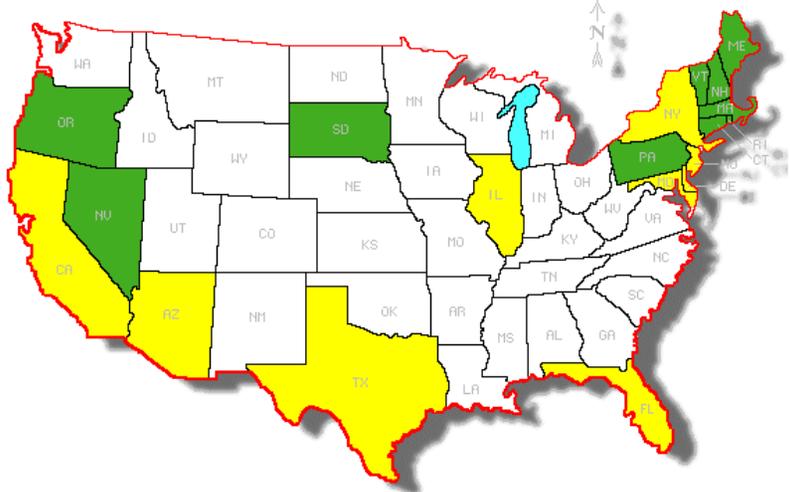


PureCycle™ 200 Launched in July 2004

Recycles wasted thermal energy from many sources



The image features the **PureCycle™ 200** logo in blue and black text. Below the logo is a detailed 3D rendering of the PureCycle 200 engine, a large industrial unit with a complex piping system and a large cooling fan on the side. To the left of the engine are three small square images: a stack of papers, a dark industrial interior, and a white lotus flower on a pond. At the bottom left is the **UTC Power** logo, which includes a stylized sunburst icon and the text "UTC Power A United Technologies Company". At the bottom right are two red circles with diagonal slashes, each containing the text "Fuel" and "NO_x" respectively, indicating that the engine does not require fuel and produces no NO_x emissions.

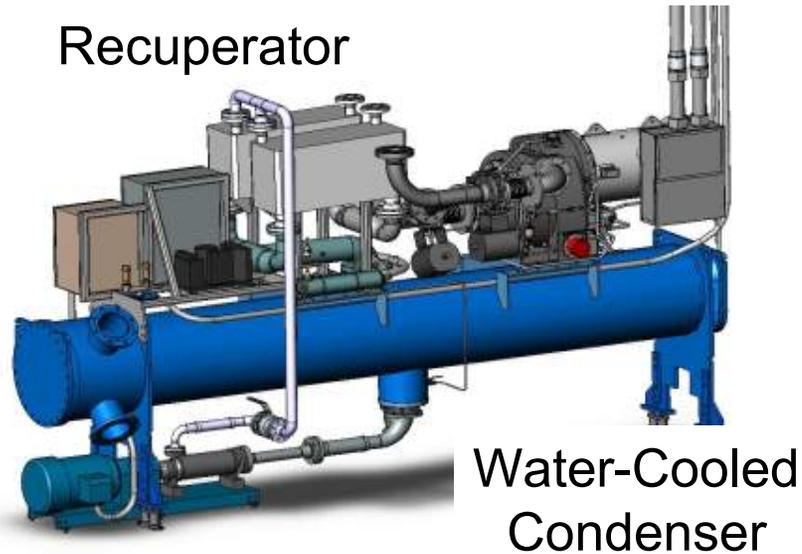


Green: Waste Heat is Renewable
Yellow: Under consideration

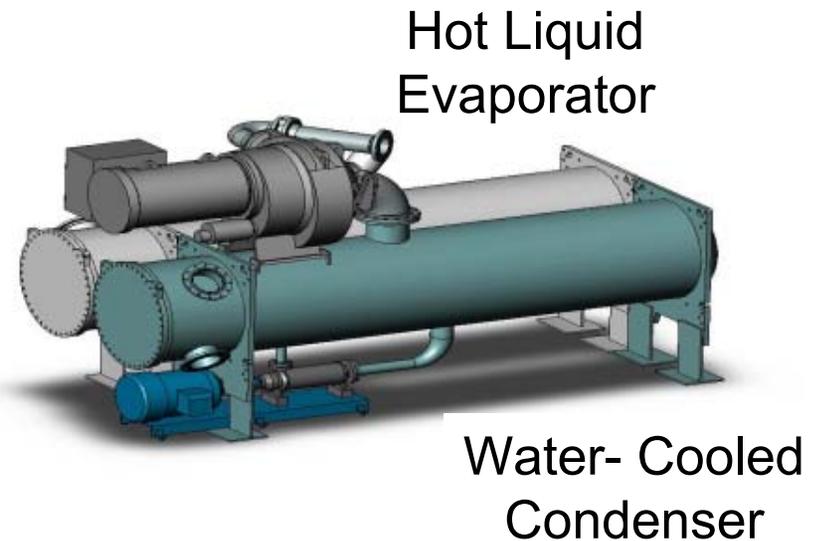
PureCycle™ 200 Technology Enhancements

Diversify waste heat source and increase system efficiency

Water-cooled condenser + recuperator
increase system efficiency ~50%



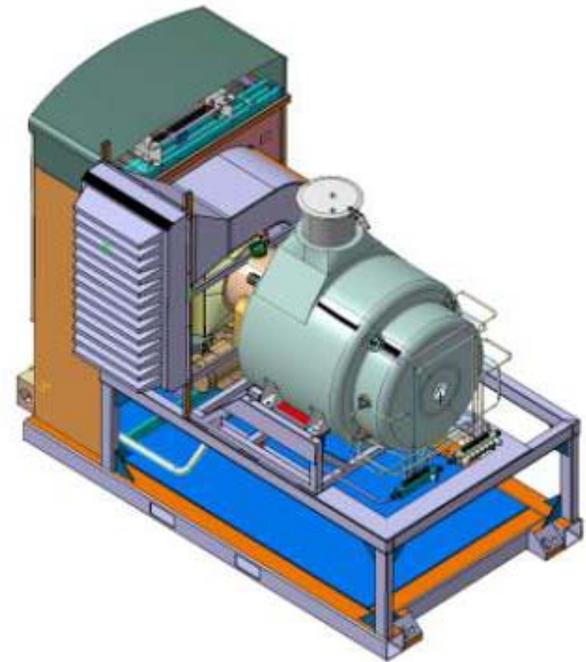
Evaporator design to accept
hot liquids/steam



Progress Toward DOE 40% Goal

UTRC and Capstone “Going forward together”

- DOE Advanced Microturbine System Goals
 - Electrical efficiency = 40%
 - $\text{NO}_x = 7$ PPM on natural gas fuel
 - Multi-fuel capability
 - 11,000 hour between major overhaul
 - System cost = \$500US/kW
- UTRC/Capstone Goal and Approach
 - Affordably increase 33% Capstone C200 microturbine to 40% microturbine/ORC system with $\text{NO}_x < 7$ ppm

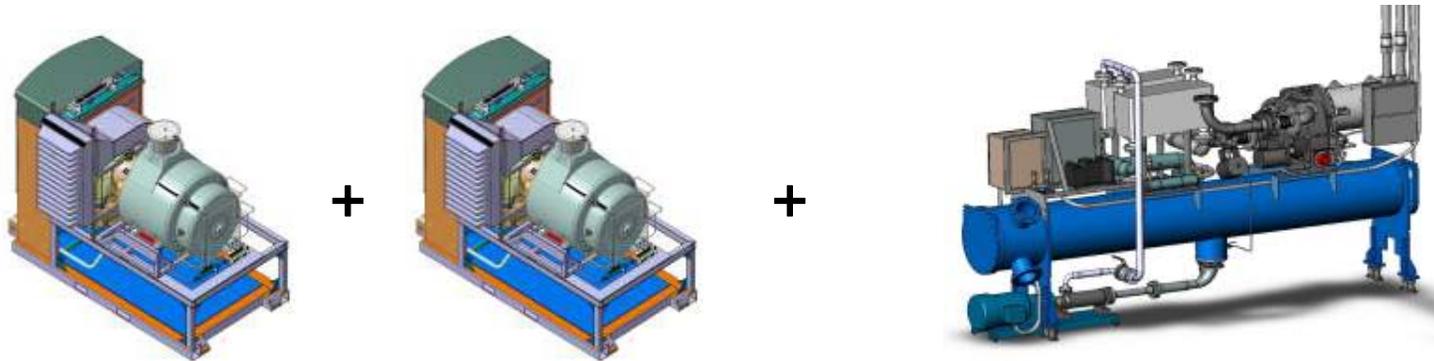


Integrated System Approach to 40%

Two Capstone C200 + ORC

Integrate C200/ORC system

- Substitute water-cooled condenser
- Mechanical and control integration with C200
- Test integrated system



$$\begin{aligned}\text{System Efficiency} &= (P_{C200} + P_{ORC})/E_{\text{fuel}} \\ &= \text{Eff}_{C200} \times (P_{C200} + P_{ORC})/P_{C200} \\ &= 33\% \times (400 + 85)/400 \\ &= 40\%\end{aligned}$$

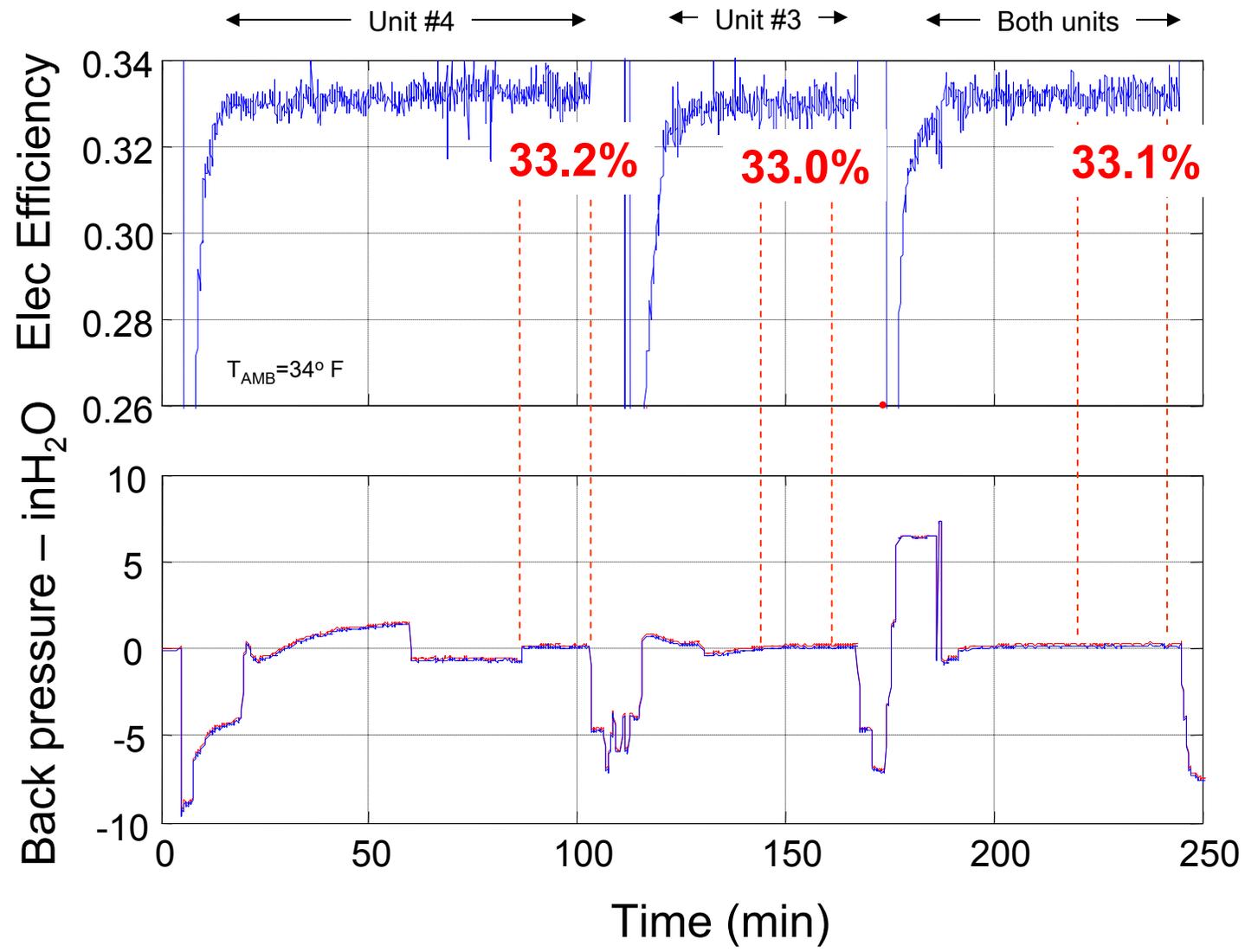
Major Components Integrated AT UTRC

C200 Beta Systems + Water-Cooled Condenser ORC



Capstone C200 Systems Achieved High Electrical Efficiency

Both units over 33% without backpressure

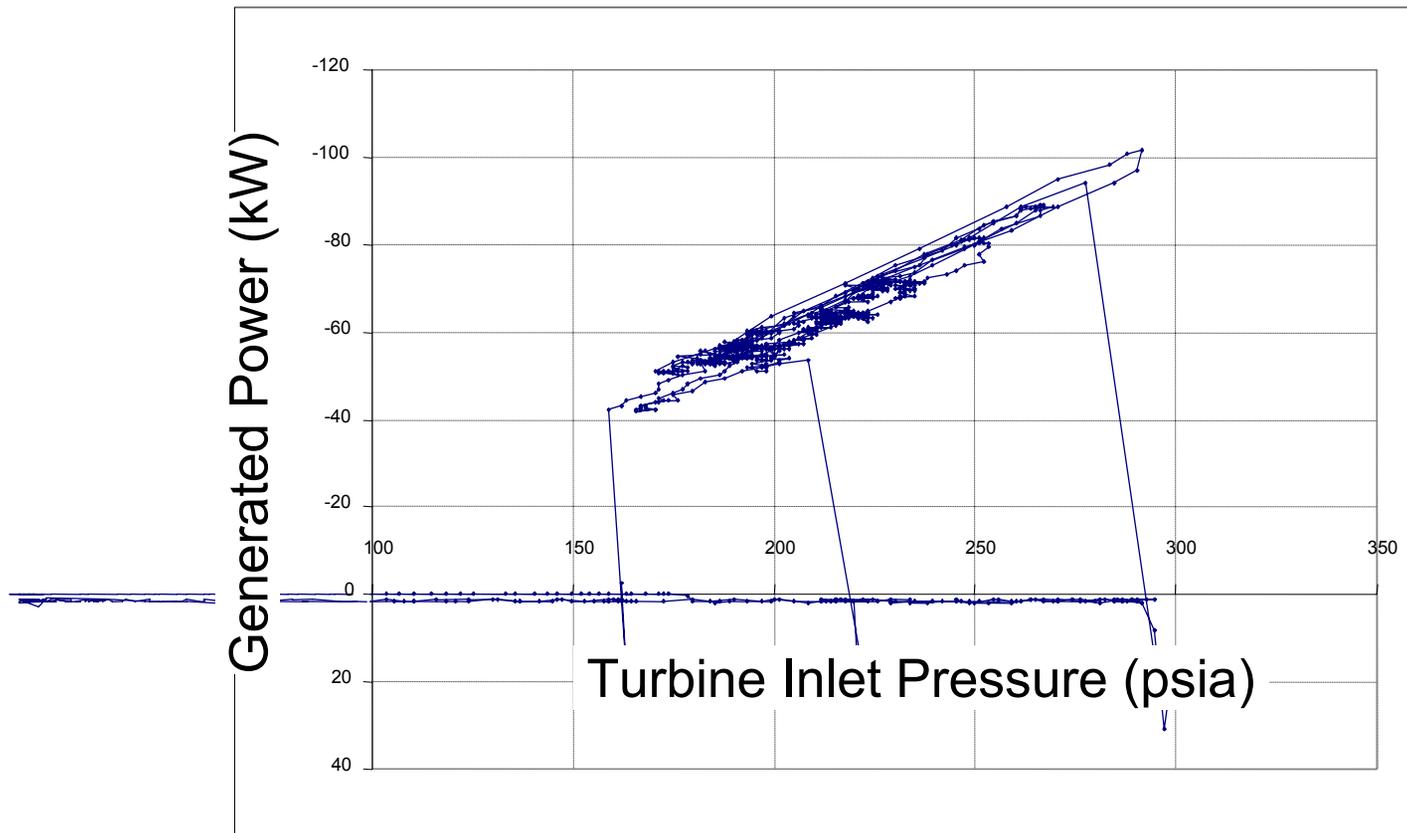


ORC System Electrical Efficiency ~13%

System and components operated as predicted

Exhaust energy drives PureCycle™ turbine inlet pressure

- With 300 psia turbine inlet pressure, produced 100 kW gross (85 kW net) during quasi-steady transient tests
- C200 Beta exhaust energy was low at steady state



Integrated System Achieved 38% Electrical Efficiency

ORC power was low because of high cabinet cooling of C200 Beta design

Parameter		Integrated System			
		Spec	Meas	Spec	Meas
Ambient Temperature	F	34	34	34	34
C200 Beta Backpressure	in H ₂ O	0	0	4	4
C200 Beta Power	kW	400	400	400	400
C200 Beta Electrical Efficiency	%	32.6	33.1	32.3	32.8
PureCycle™ Power	kW	80.8	63.5	82.0	64.6
System Efficiency	%	39.2	38.4	38.9	38.0

UTC Continues on Pathway to Impact CHP Marketplace

Efficient, clean, reliable CHP products expand customer choice

Family of PureComfort™ systems expanded

- Integrated microturbine-chiller/heater systems are 4 season products
- Reduced fuel, reduced NO_x, and reduced CO₂
- Gaining market acceptance

PureCycle™ 200 launched

- Recycles waste heat into “free” electrical power – without fuel or emissions
- Technology improvements broaden opportunities and value

Integrated C200/ PureCycle™ system achieved 38% electrical efficiency

- Successful integration of UTC and Capstone technologies – best in class!

UTC Power Sales Staff – Call Us!

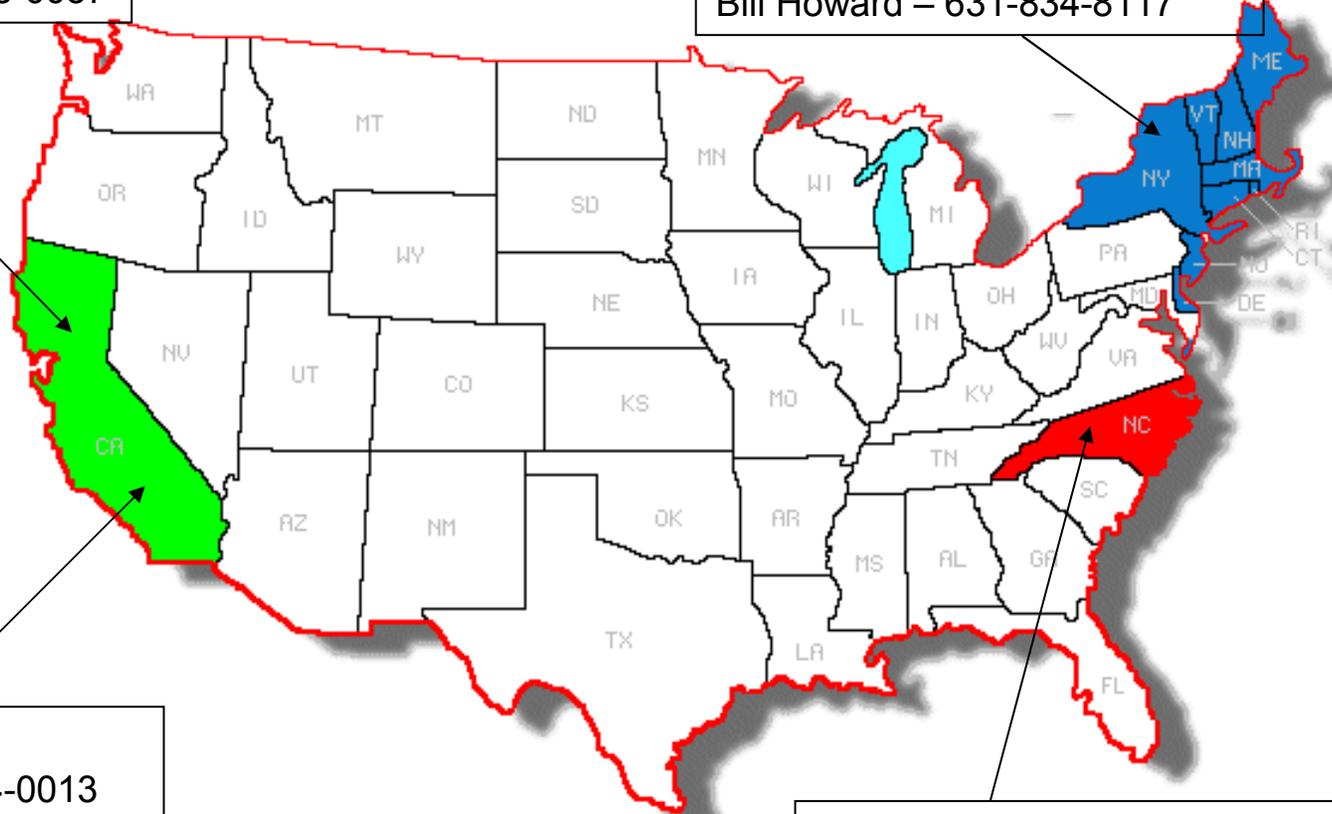
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