Absorption Cooling and Desiccant Dehumidification Successes in the Southeast

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Oak Ridge National Laboratory (ORNL)

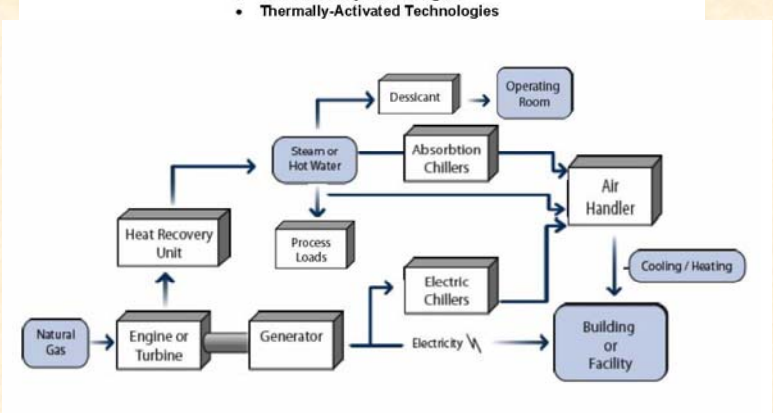
Southeast CHP Roadmap Workshop

September 21, 2005 – Atlanta, Georgia

Why Absorption and Desiccants ?

Major CHP Components

- Prime Mover Technologies
- Heat Recovery Technologies
- Thermally-Activated Technologies



Challenges to Success in the Southeast

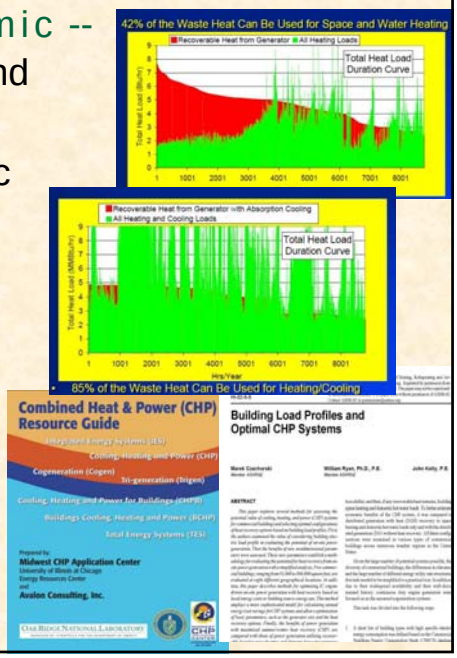
- Saving owner/operator money compared to "conventional system"
- Savings have to come from operating cost differential or incentive programs.
- Government vs. Private concepts of "Success"

Government	**Private**
- efficient fuel use	- return on investment
- disaster relief	- power quality
- grid congestion	- IAQ improvements
- etc.	- back-up power
	- etc.

Key Factors for CHP Success

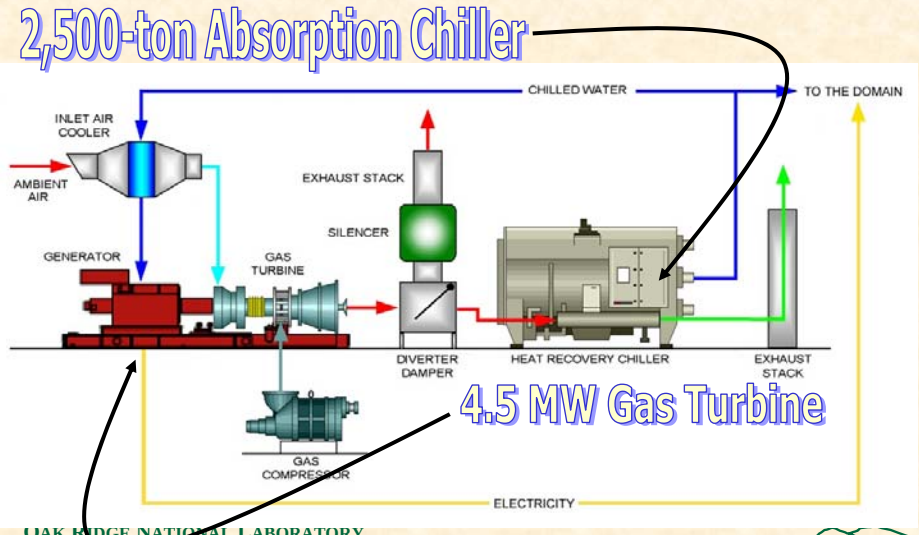
-- Economic --

- Coincidence of electrical and thermal loads
- Differential between electric and gas energy costs
- Installed cost differential
- System capacity and operating hours
- An internal advocate



GTI article and MAC Resource Guide

Austin Energy System Features Exhaust-Fired Chiller



Modular Components Simplify Construction

- Natural gas compressor
- 4.5-MW combustion turbine with 12.47-kV generator
- Ductwork module directs 950°F exhaust to chiller through diverter valve with bypass stack

Equipment Modules Simplify Construction

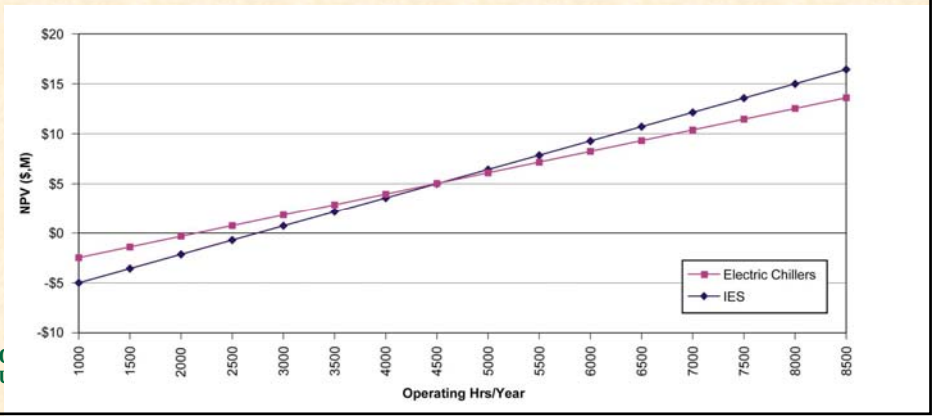
- **2,500-ton exhaust-fired two-stage absorption chiller**
- **Chiller exhaust stack module**
- **200-300-Tons used for turbine inlet air-cooling with inlet air filter**

IES Costs Compared to Using Electricity

Model Input	Integrated Energy System	Electric System
Cost/expected revenue		
Capital cost	**$8M**	**$3M**
Fuel cost, $/MMBtu	**$4M**	**N/A**
Electricity cost/revenue, $/kWh	**$0.06/kWh usage and revenue**	**$0.06/kWh usage**
Cost for system parasitic loads, kW/ton	**0.25**	**0.90**
Loads and equipment capacity		
Prime mover electrical capacity, MW	**4.5-MW Turbine**	**N/A**
Equipment thermal capacity, tons	**2,500-ton Broad absorption chiller**	**2 × 1,200 ton electric centrifugal chiller**

System Recovers Capital Cost When Base-Loaded

- **$8.35M investment**
- **IRR: 19%**
- **Payback: 7 yrs**
- **NPV: $16M**
- **Chilled water revenue: $1.7M/yr**
- **Electricity value: $990K/yr**

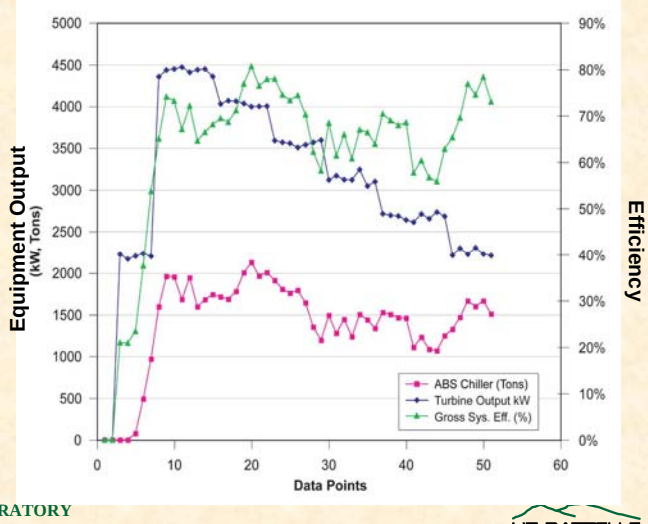


IES Efficiency Depends on Using Turbine Exhaust for Cooling

85% Measured IES Efficiency

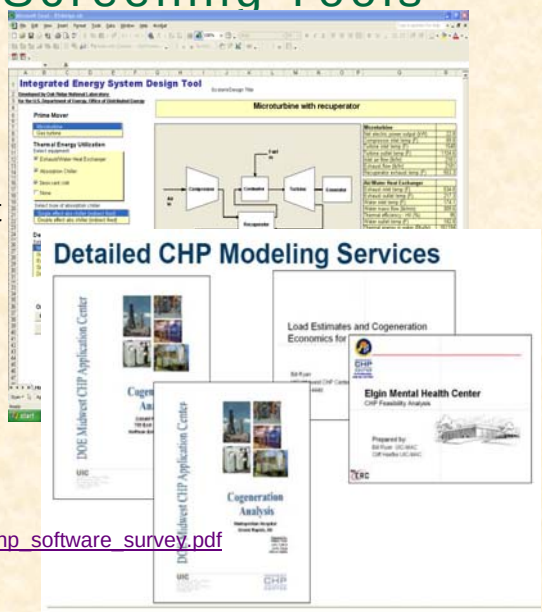
Efficiency correlation:

- **turbine output R^2 =0.49**
- **Chiller output R^2 =0.91**



Application Screening Tools

- ORNL BCHP Screening Tool
- Many computer/check-list survey tools to aid prospective customers
- Hudson: “Survey of DER/CHP Software”



www.ornl.gov/sci/femp/pdfs/0302_chp_software_survey.pdf

Successful Absorption Cooling Installation

-- IC Thomasson’s Opryland Hotel, Nashville --

- **5 MW gas turbine system with heat recovery, chiller**
- **1,000 RT double-effect absorption chiller**
- **Inlet air cooler uses 300 RT of CW output**
- **Operating since 1996**
- **O&M costs reduced from $3 million /yr “pre-BCHP” to $2 million/yr**

OPRYLAND Hotel and Convention Center

Case Study provided by:
IC Thomasson Associates, Inc.
Consulting Engineers
Nashville, Tn

Factors in Opryland Success

- Big – 5 MW Turbine and 1,000 RTons Abs. chiller
- Hotel – Long operating hours + laundry and heating
  - 3000 rooms
  - 600,000 sq. ft. convention ctr.
  - 7+ acres under roof
- Experience – IC Thomasson prior engineering designs

Opryland Success Indicators

Operating and Maintenance Costs

Mountain Home VA Hospital

– Johnson City, TN –

- One, 3.4MWe engine-generator w/ heat recovery steam generators
- Two, 1.8MWe, back-up, engine generators w/ heat recovery
- One, 1000-Rton absorption chiller
- Sells steam and chilled water to East Tennessee State Univ.

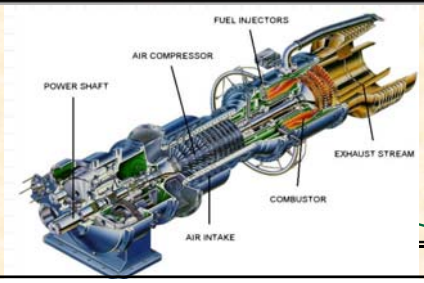
Factors in Mountain Home VA Hospital Success

- Big installation, large capacity
- Hospital and University – many occupied/operating hours
- Enhanced-Use Leasing/ ESPCs made capital-use cost avoidance possible
- $5 M in energy upgrades
  $35 M capital cost avoidance
  $5 - $10 M in savings
  20 -25% reduced energy use

ESG ENERGY SYSTEMS GROUP
CITIZENS GAS
INDIANA GAS
SIGECO

CHP Installation at Middle Tennessee University -- Murfeesboro

- 53 Buildings
- 2,813,000 sq. ft. of academic and residence space
- 18,000 Students
- CHP replaced 30-year old system
- 5 MW Solar gas turbine HRSG with duct burners (in lieu of 100,000 lb/h coal boiler)
- Overall Plant emissions reduced by 20%



Waldbaum's IGA Supermarket – Hauppauge, NY – Desiccant CHP System

- 60 kW Capstone microturbine
- Unifin heat recovery heat exchanger
- Heating or desiccant regeneration
- Roof mounted next to store's air handling unit to provide heating, cooling, ventilation and dehumidification

Waldbaum's Successful Results
- Combined IC generator and desiccant -

- Electricity savings at New York Rates

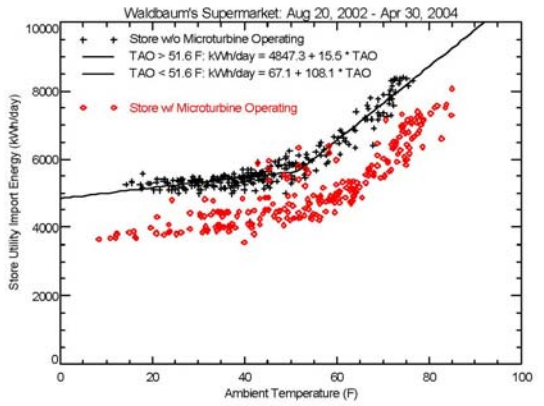


Figure 10. Daily Store Electricity Use Variation with Ambient Temperature

Waldbaum's Successful Results
- Combined IC generator and desiccant -

- Waste heat used for space heating and desiccant regeneration

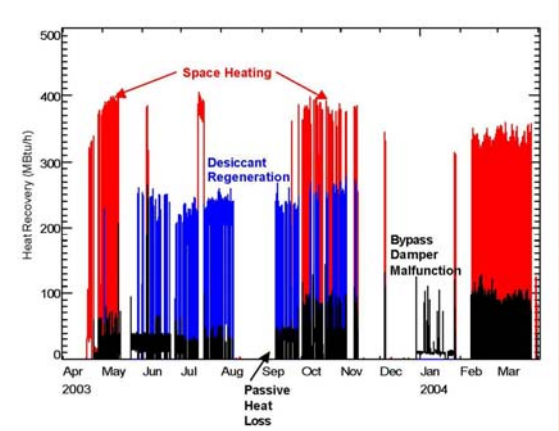
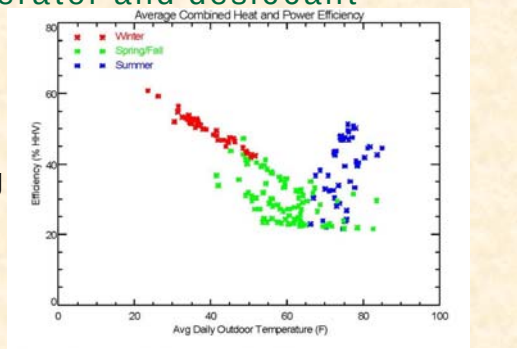


Figure 19. Useful Heat Recovery for Space Heating and Desiccant Dehumidification

Waldbaum's Successful Results
- Combined IC generator and desiccant -

- Combined efficiencies of 40 – 60 %, high heating values



- Modeling allows estimated savings in different climates and rate structures

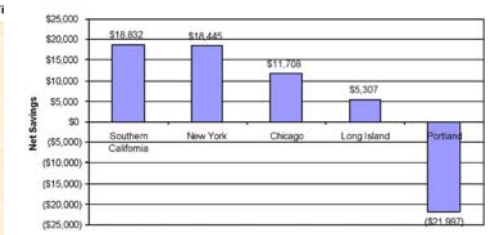


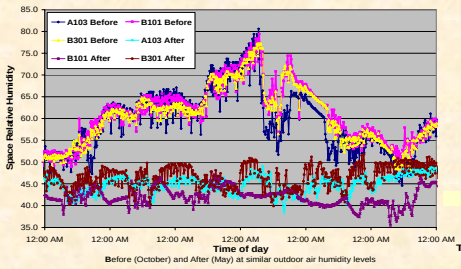
Figure 40. Net Savings for Supermarket CHP System By Location

Timber Ridge Elementary School –
Mairetta, Georgia – non-CHP Desiccant

- **15-years old school**
- **High Capacity rooftop system with VAV boxes serving 19 zones**
  Classrooms–Hallways- Storage rooms
- **No zone reheat (economy)**
- **IAQ complaints Outside air cutoff (periodic discomfort)**
- **Room dehumidifiers installed**

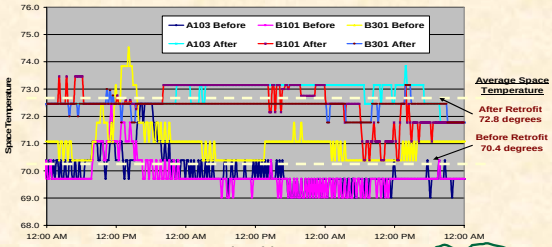
Timber Ridge Elementary School –
Mairetta, Georgia – non-CHP Desiccant

Typical Space Relative Humidity Before and After Hybrid Rooftop Installation Retrofit



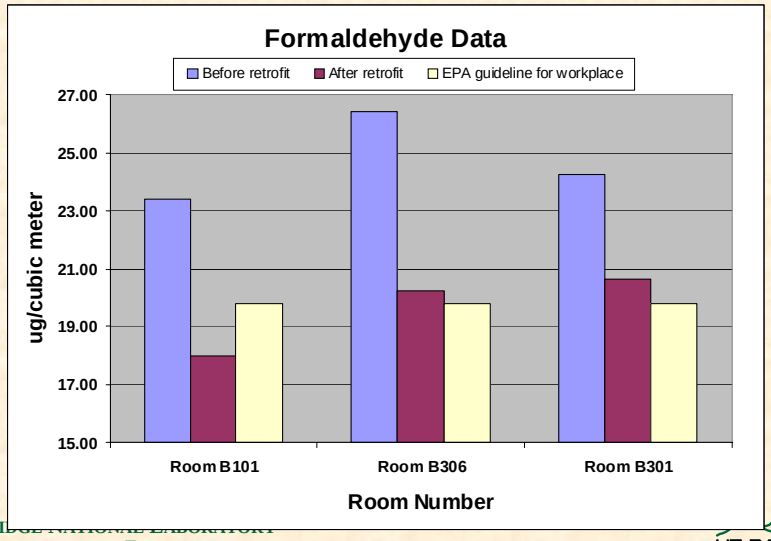
Before (October) and After (May) at similar outdoor air humidity levels

Typical Space Temperatures Before and Afer Revolution System Retrofit
(controlled by teachers vis thermostat in each room)



Before (October) and After (May) with similar outdoor air temperature levels

School IAQ Data

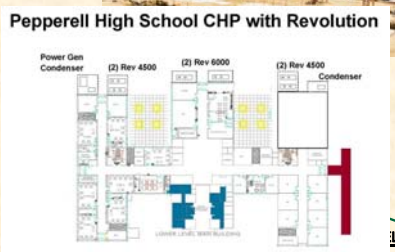


Testimonial "Thank You" Letter -- October 15, 2004

- **From school's HVAC maintenance supervisor**
  - **"…. Installed over one weekend……."**
  - **"… delivers required amount of outdoor air…."**
  - **"… excellent temperature and humidity control…"**
  - **"… energy consumption far less than that used by conventional packaged system replaced…"**
  - **"… IAQ improved significantly and now very acceptable…"**
  - **"… the teachers are very happy with the new system…"**
  - **"… pressured to address remainder of school…"**

Pepperell High School Integrated CHP/Desiccant – Lindale , Georgia –

- 200 kW, Deutz IC Engine prime mover
- Six (6) Semco, Revolution units as dedicated outdoor air systems (DOAS)
- Grid Independent approach avoids inter-connect permitting
- IC Engine – DOAS match



Pepperell High School Integrated CHP/Desiccant – Lindale , Georgia – Design Advantages

- Simple switching allows 200 kW for emergency back-up req.
- Unoccupied advantages – minimal outdoor air – desiccant-only operation
- DOAS Heating in the winter
- Uncoupled latent loads
  - More efficient sensible cooling
  - Higher cooling thermostat set-points

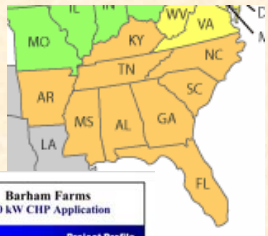
Pepperell High School Integrated CHP/Desiccant – Lindale , Georgia – Preliminary Performance Analysis

Combined system efficiency	
Deutz Gen-Set	Deutz 200 alone
KW produced	200 KW
Energy input (gas)	19,600,000 btu/hr.
Thermal energy produced	978,000 btu/hr
Electrical efficiency	35%
Thermal efficiency	50%
Combined efficiency	**85%**
Deutz - IADR Combined System Efficiency	Combined System Efficiency
Cooling season system efficiency (at design)	**84%**
Heating season system efficiency (at design)	**82%**

Operating cost analysis (at design)	Per System	Total
IADR off the grid		6 required
Electrical cost at $.05/KWH (2003 actual cost)	$2.25/hr.	
Gas regeneration cost $.55/therm (2003 cost)	$1.32.hr.	
Operating cost at design (non CHP)	$3.57/hr.	$14.28/hr.
IADR with Deutz 200 (CHP)		
Electrical cost at $.054/KWH (based on $.55/therm)	$2.48/hr.	
Hot water regeneration from Deutz 200	$0/hr.	
Operating cost at design (CHP)	$2.48/hr.	$9.92/hr.
Energy cost reduction based on simple analysis	**31%**	

Find Unique Southeast Region Opportunities

- Basic idea for Regional CHP application centers
- Desiccant dehumidification could be more valuable in the southeast
- Opportunities for DE that uniquely fit this region
- Emissions and citing requirements different



Barriers to CHP

- Ownership concerns
- Project specific details
- Utility inter-connection problems
- Environmental concerns
- No, industry-wide, acceptance of CHP
- Uncertainty about utility rate projections
- Long (> 3-4 year) paybacks
- Complex systems requiring technically astute operators
- CHP “Hype” from certain sources