Measured Performance Data from a Supermarket Combined Heat and Power System

EQS Symposium

Session 5: Energy and Efficiency

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Approach & Goals

- Field test to demonstrate CHP technology in a commercially “repeatable” site
  - Show what’s technically possible with current technology
  - Collect detailed data on system and building performance
    - thermal, power, and environmental impacts
- Evaluate economics at this site
  - Extend to other climates and utility rates
- Document installation and operating issues

Project Team

Host Facility:

- Waldbaums/A&P

Project Sponsors:

- NYSERDA
- KeySpan Gas R&D
- Oak Ridge National Laboratory
- National Renewable Energy Laboratory

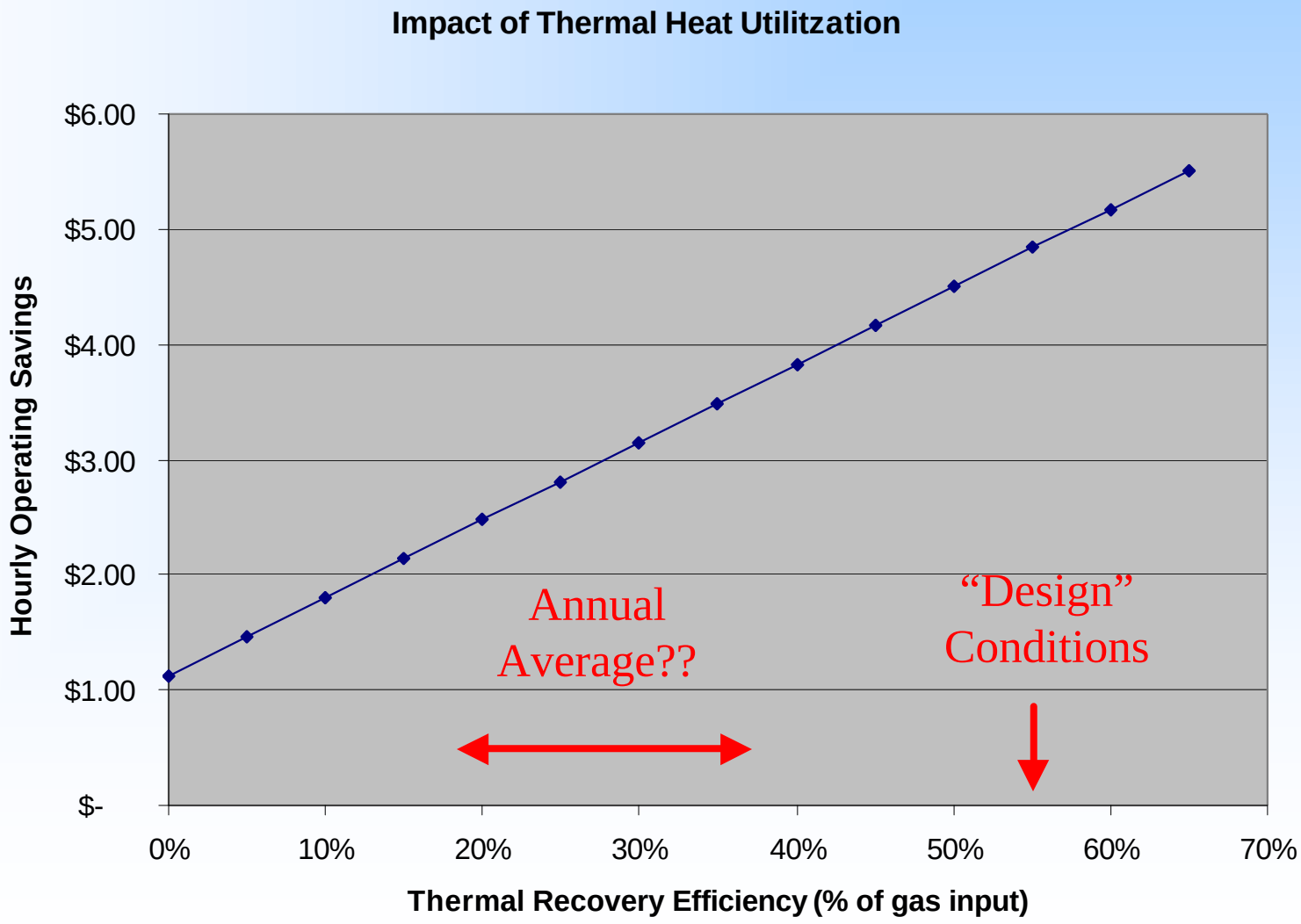
Others:

- AGA, GTI, EPA/ETV

What Makes CHP Cost-Effective?

Heat recovery makes on-site power generation practical

It's the annual average thermal loads that matter!

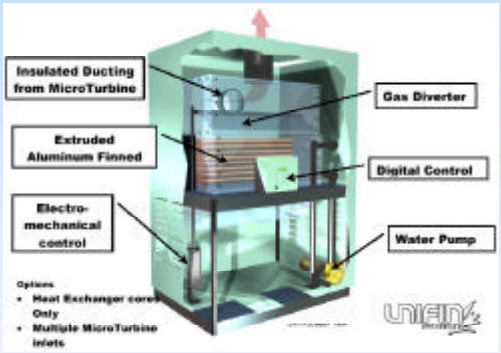


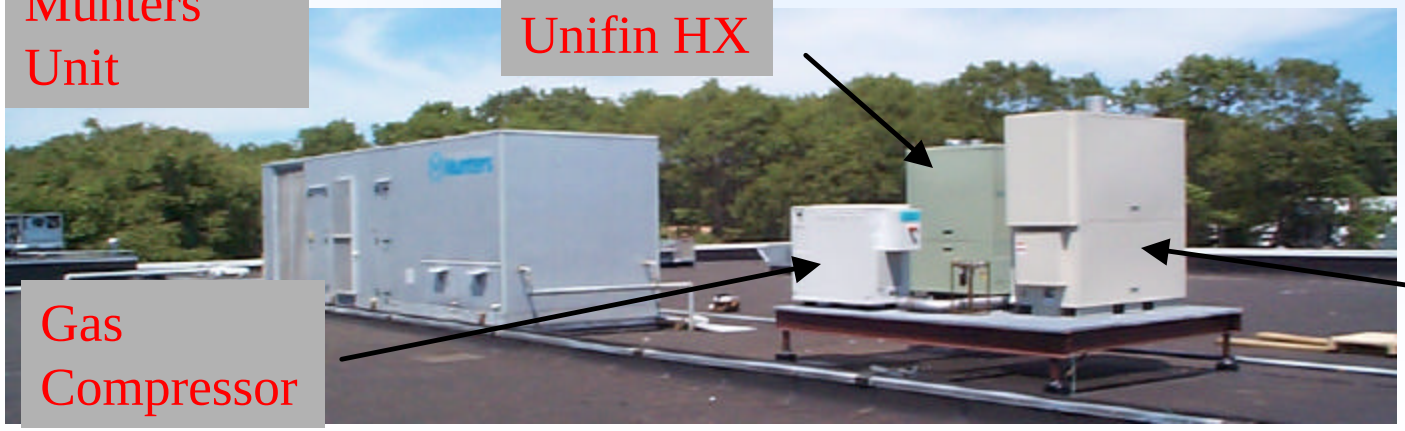
CHP in Supermarkets

- Peak is 400-600 kW for typical store
- Significant space heating loads due to refrigerated display cases
- Desiccant dehumidification is widely used in supermarkets
  - more than 1,000 desiccant units in US stores
- Good balance between thermal and electrical loads

The CHP System

- Capstone 60 kW Microturbine
- Nat. Gas Compressor (scroll)
- Unifin Heat Exchanger
- Hot Water Coils Installed in Munters Unit

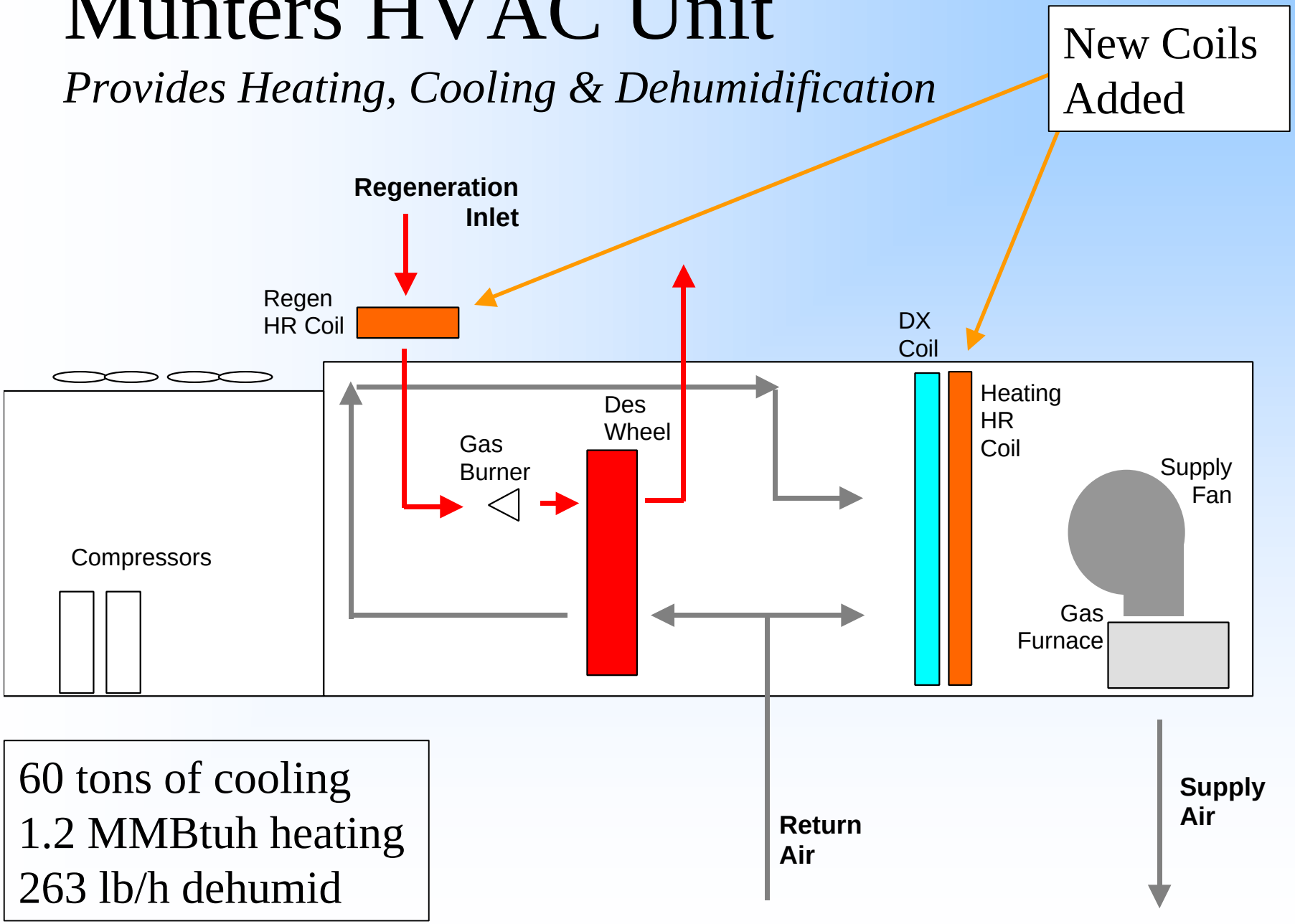




Installed CHP System

Munters HVAC Unit

Provides Heating, Cooling & Dehumidification



60 tons of cooling
1.2 MMBtuh heating
263 lb/h dehumid

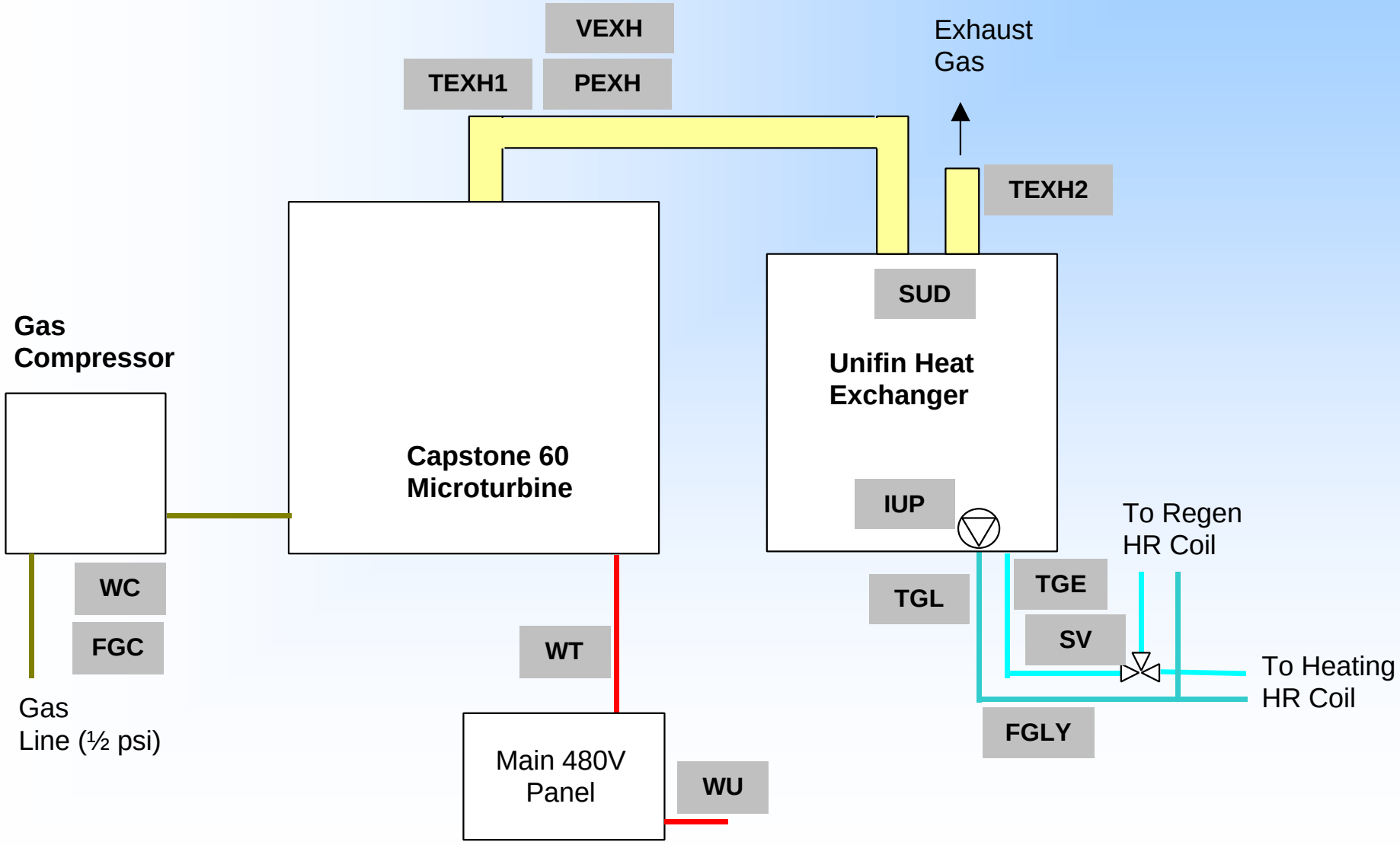
CHP System Summary

- CHP System sized for thermal loads
  - provide 60 kW of baseload power
  - grid-parallel operation only
  - may consider scheduling turbine operation for periods when heat recovery loads are low
- System can use heat recovery when available *or* Munters systems: fully redundant

Field Monitoring

- Intalled data logging equipment to quantify thermal and electric performance
  - electrical turbine output (kW, amps, volts)
  - thermal output of Unifin HX (flow, ΔT)
  - turbine exhaust (T, static P, flow)
  - desiccant/HVAC unit performance (T, RH, kW)

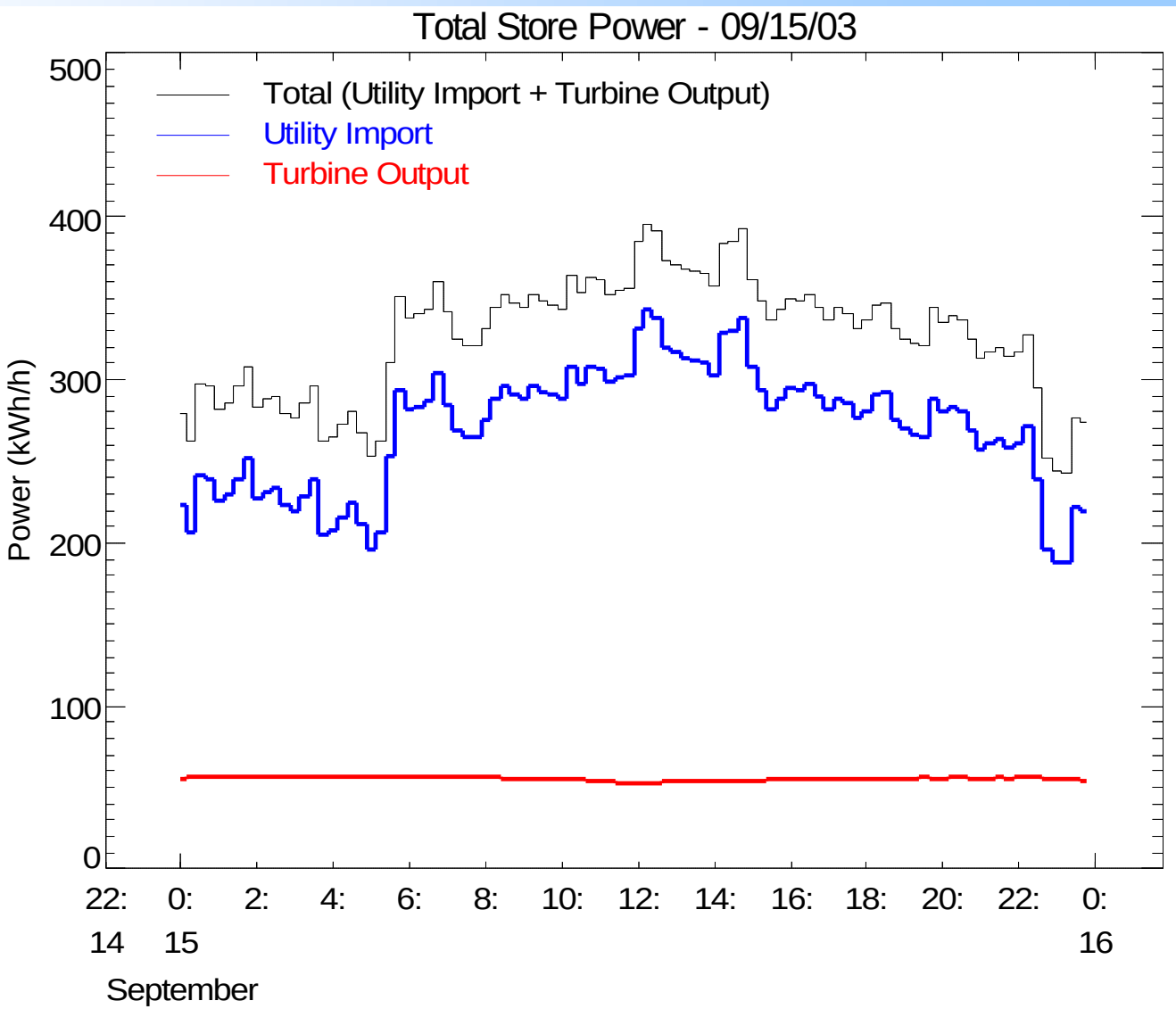
CHP Monitoring Points



Project History

- Equipment commissioned and instrumentation installed in August 2002
- Interconnection issue with local electric utility delayed startup until April 2003
  - non-radial electrical feed at the site required property owner to be involved
  - problem highlighted issues about interconnection in commercial tenant/owner properties

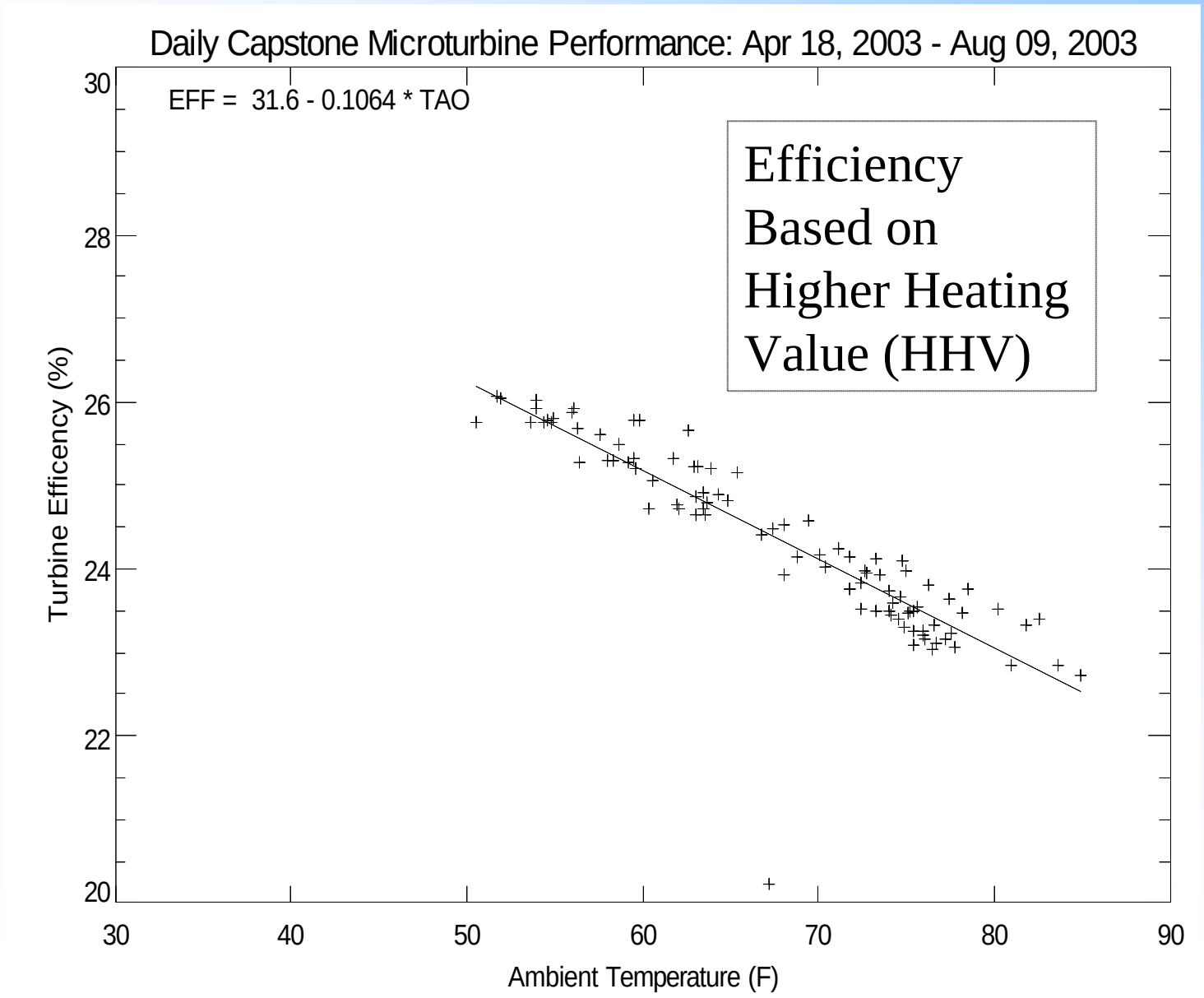
Turbine Impact on Store Demand



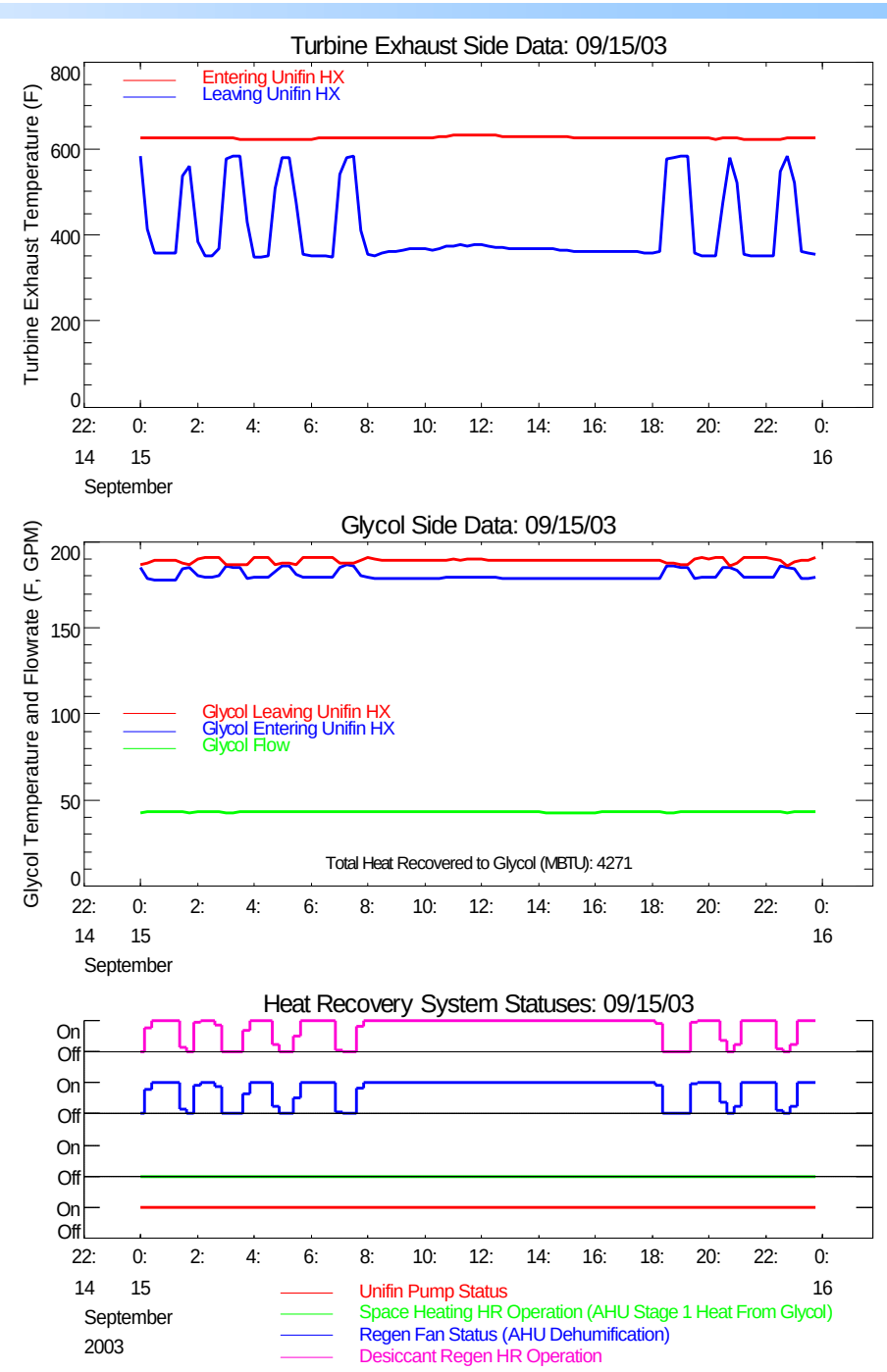
Peak Total Demand: 395.5 kW @ 12:15 PM

Peak Utility Import Demand: 342.5 kW @ 12:15 PM

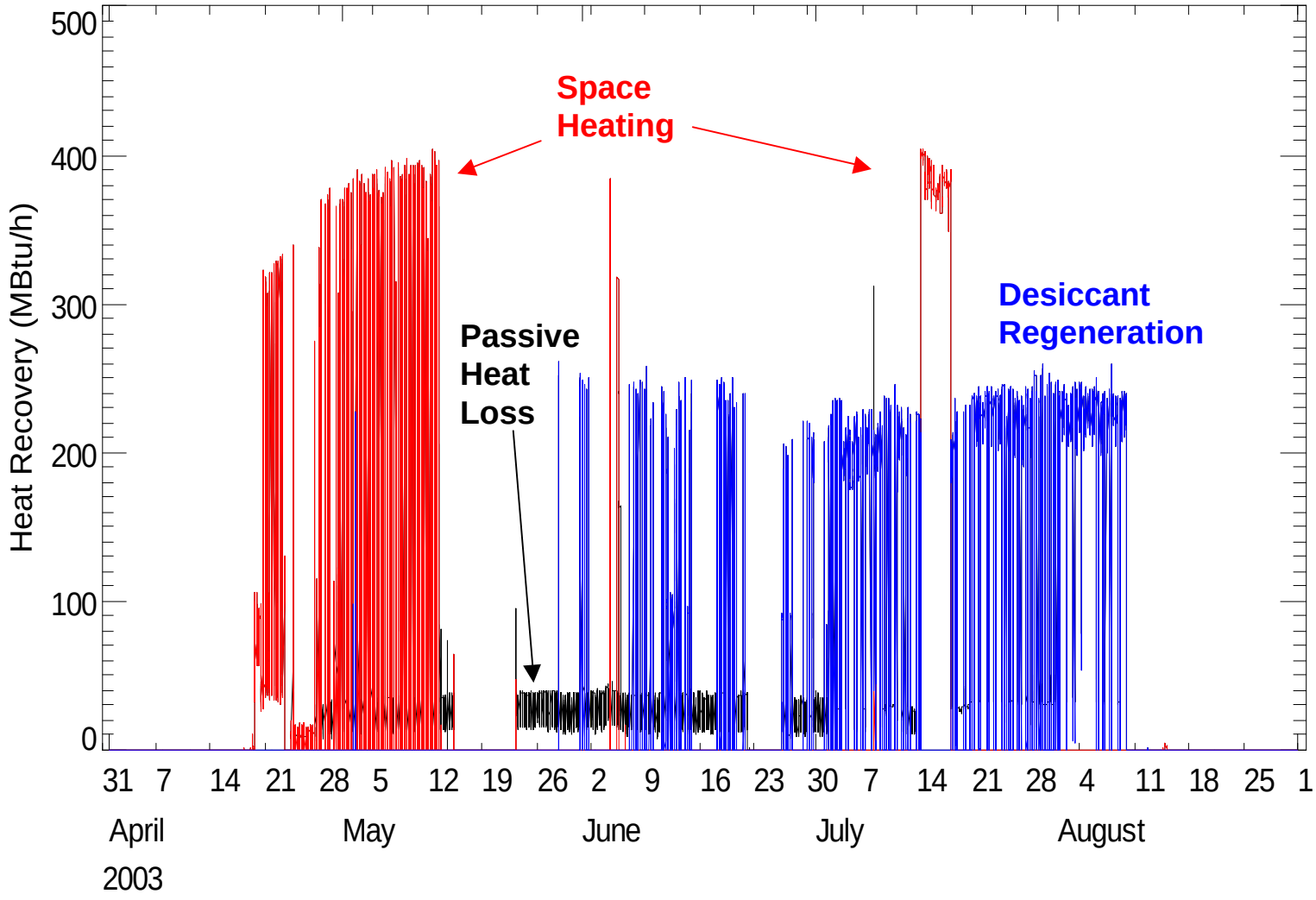
Turbine Efficiency Trend



Typical Performance of Heat Recovery System



HR Rate in Different Modes



Overall CHP Performance

	Turbine		Parasitic Loads		Heat Recovered			[1-3-4+5+6] / [2]
Date	Power Output (kWh)	Gas Input (MBTU)	Gas Compressor (kWh)	Heat Recovery Glycol Pump (kWh)	Space Heating (MBTU)	Desiccant Regen (MBTU)	"Net" Turbine Generation Efficiency (%)	"Net" CHP Efficiency (%)
April-03	15,356	209,649	1,097.3	250.0	16,162	0	23.2%	30.5%
May-03	30,414	411,031	2,113.0	474.6	29,084	2,045	23.5%	30.7%
June-03	39,087	549,741	2,767.1	530.1	18	17,223	22.5%	25.4%
July-03	39,185	568,723	2,878.3	635.8	103	72,102	21.8%	34.1%
August-03	10,864	161,883	838.9	185.7	0	46,035	21.1%	49.2%
Totals	***124,042***	***1,739,144***	***8,856***	***1,890***	***45,367***	***91,371***	***22.6%***	***30.1%***

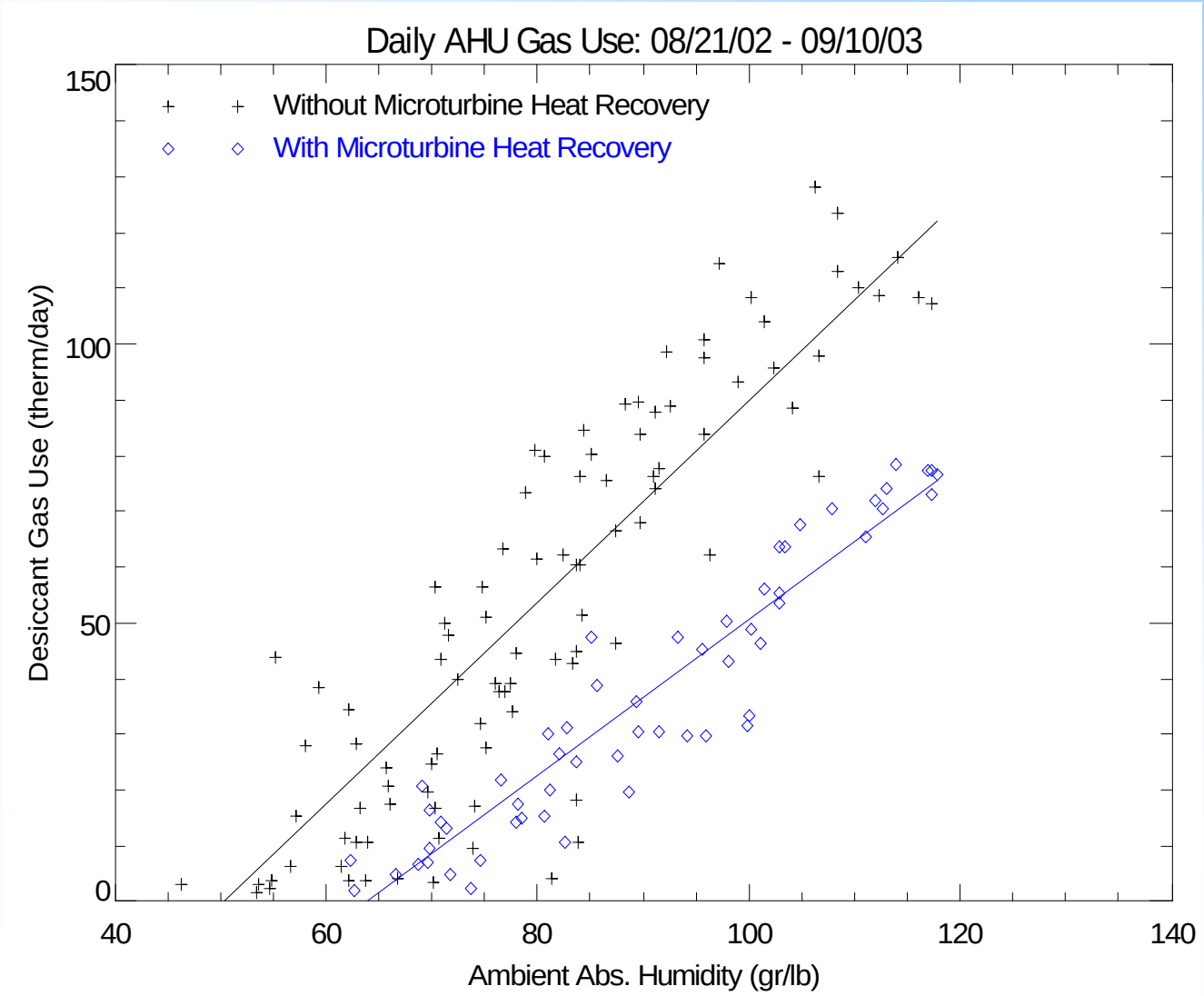
Note: Actual natural gas HHV is used.

Daily Summertime CHP Performance

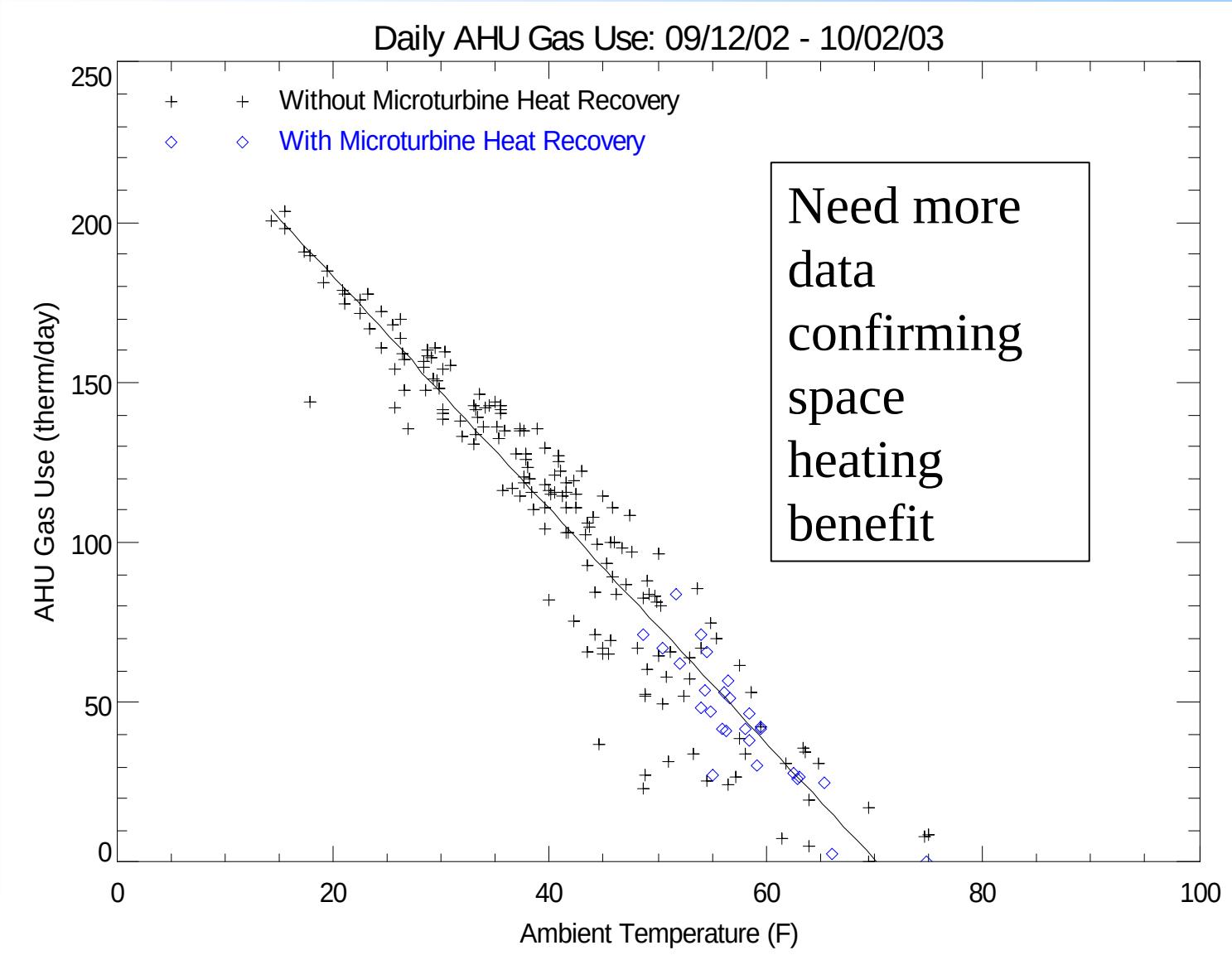
	Turbine		Parasitic Loads		Heat Recovered			[1-3-4+5+6] / [2]
Date	Power Output (kWh)	Gas Input (MBTU)	Gas Compressor (kWh)	Heat Recovery Glycol Pump (kWh)	Space Heating (MBTU)	Desiccant Regen (MBTU)	"Net" Turbine Generation Efficiency (%)	"Net" CHP Efficiency (%)
Aug 1, 2003	1,265.9	18,428	92.9	20.6	0	4,868	21.7%	47.8%
Aug 2, 2003	1,221.1	18,025	93.1	20.6	0	5,310	21.4%	50.4%
Aug 3, 2003	1,223.8	18,025	93.2	20.6	0	5,308	21.4%	50.5%
Aug 4, 2003	1,220.1	17,925	93.0	20.5	0	5,358	21.5%	51.0%
Aug 5, 2003	1,222.1	17,937	92.7	20.6	0	5,434	21.5%	51.4%
Aug 6, 2003	1,210.8	17,836	92.8	20.6	0	4,791	21.4%	47.9%
Aug 7, 2003	1,205.5	17,735	92.8	20.6	0	4,649	21.4%	47.2%
Aug 8, 2003	1,213.4	17,936	92.8	20.6	0	5,193	21.3%	49.9%
Aug 9, 2003	1,222.1	17,936	93.0	20.5	0	5,083	21.5%	49.4%
Aug 10, 2003	22.5	100	1.8	0.4	0	39		
Totals	***10,864***	***161,883***	***839***	***186***	***0***	***46,035***	***21.1%***	***49.2%***

Note: Actual natural gas HHV is used.

Impact of Heat Recovery on Desiccant Gas Use



HR Impact on Space Heating



ETV Emissions Testing

- NYSERDA funded Environmental Technology Verification (ETV) testing at this site
- High-precision testing in June 03 confirmed our thermal and power measurements
- Also collected emissions data:

	Capstone Rated Performance	Measured Performance
Nitrogen Oxides - NO_x (ppmv @ 15% O_2)	< 9	3.1
Carbon Monoxide - CO (ppmv @ 15% O_2)	< 40	3.7
Total Hydrocarbons - THC (ppmv @ 15% O_2)	< 9	0.9

Next Steps

- Continue system monitoring through heating season
- Evaluate system economics based on measured data
  - Extend to other climates & utility rates
- Quantify environmental benefits of system compared to base building

More Information

- CDH Monitoring & Monthly Reports:

  www.cdhenergy.com

  (Online data access – Waldbaums)

  (user/pass: waldbaums/microturbine)

- ETV Report

  www.epa.gov/etv/verifications/vcenter3-3.html

  (sep 03 report)