CHP at a Waldbaums Supermarket

NYSERDA CHP Conference

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Project Team

Host Facility:

- Waldbaums/A&P

Project Sponsors:

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

Others:

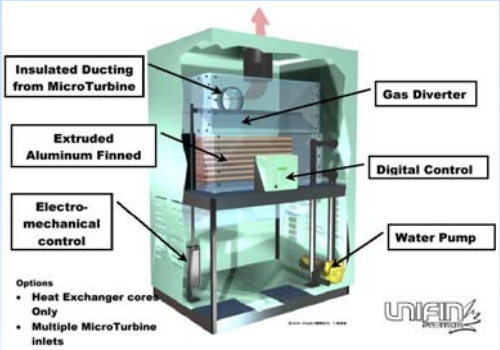
- AGA, Exergy Partners, GTI, EPA/ETV

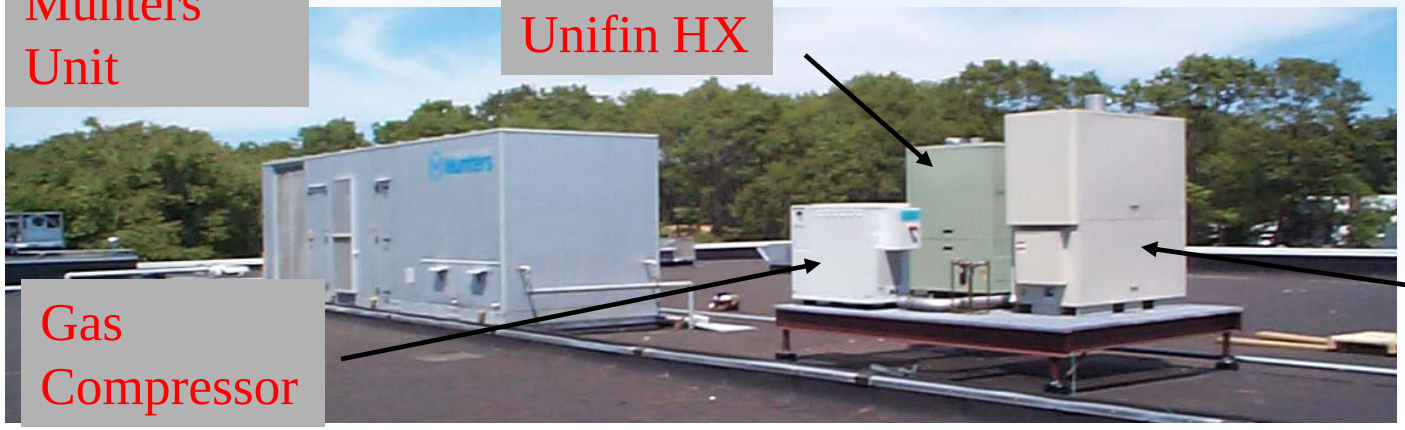
CHP in Supermarkets

- 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

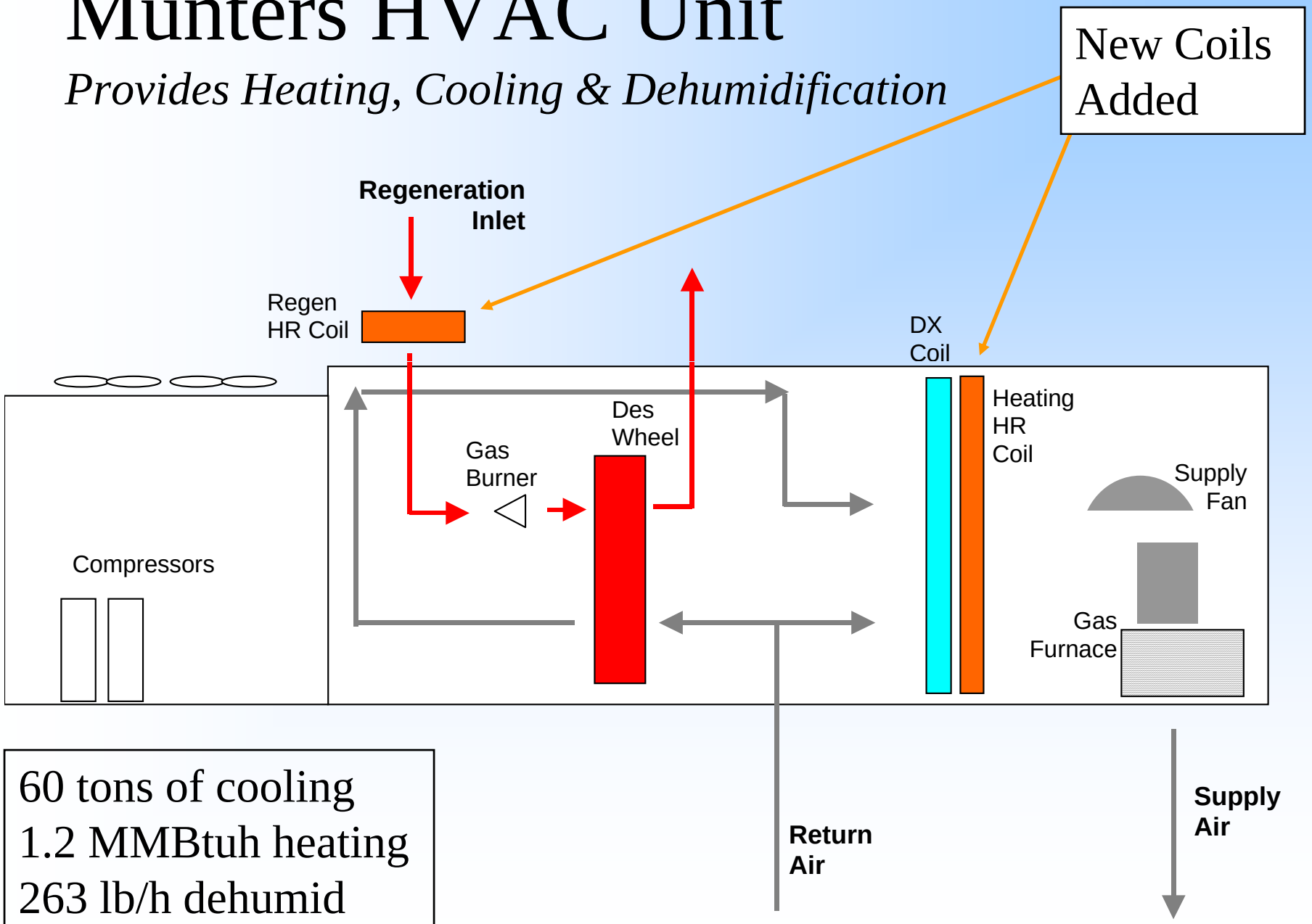
- Capstone 60 kW Microturbine
- Nat. Gas Compressor (scroll)
- Unifin Heat Exchanger
- Hot Water Coils Installed in Munters Unit





Munters HVAC Unit

Provides Heating, Cooling & Dehumidification



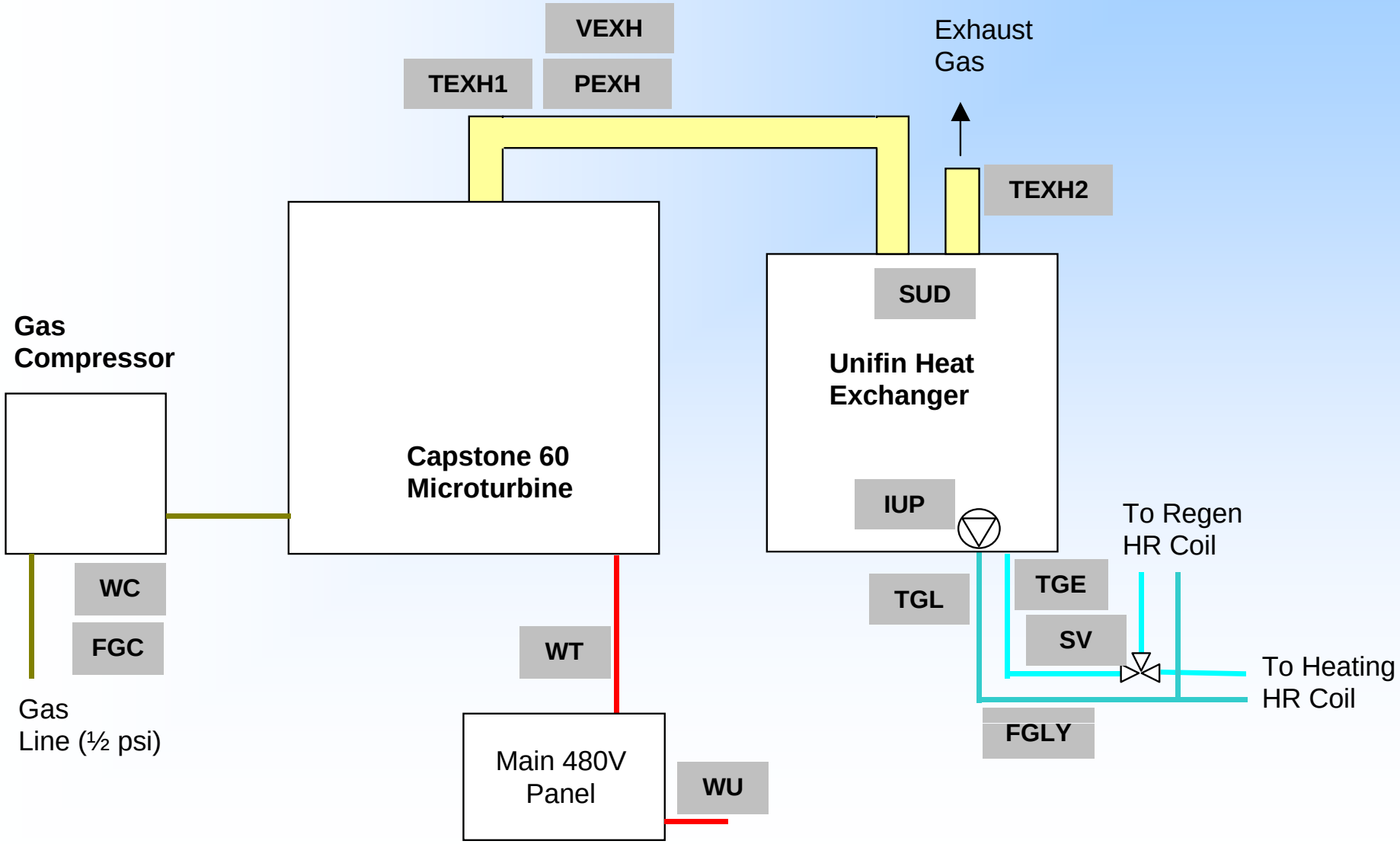
60 tons of cooling
1.2 MMBtuh heating
263 lb/h dehumid

Installed CHP System

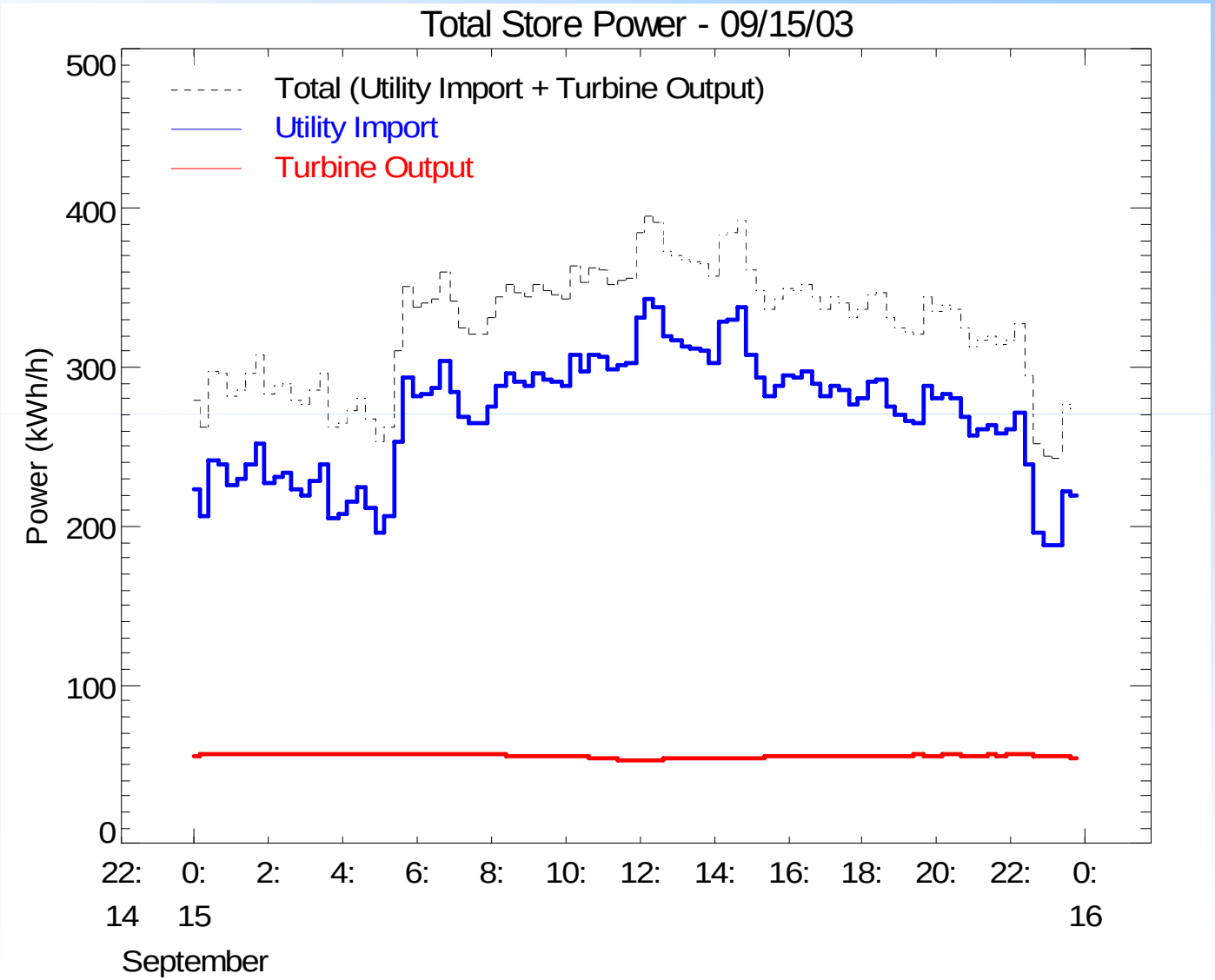
Field Monitoring

- Installed 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



Turbine Impact on Store



Peak Total Demand: 395.5 kW @ 12:15 PM

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

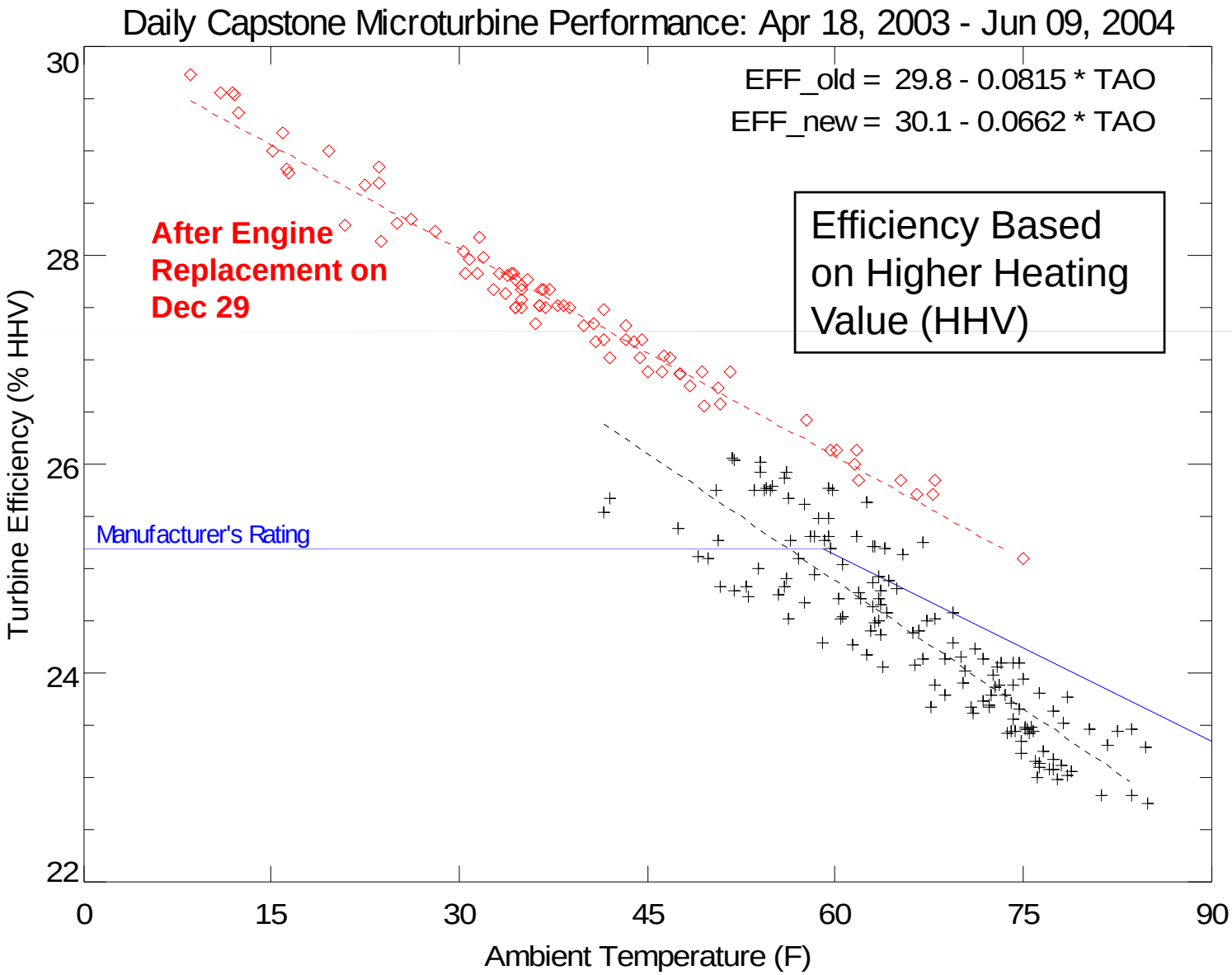
Overall CHP Performance

	[1] Turbine	[2]	[3] Parasitic Loads	[4]	[5] Heat Recovered	[6]	[7] = [1-3] / [2]	[8] = [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 (%)**	**% of Month in Operation**
April-03	15,356	209,649	1,097.3	250.0	16,162	0	23.2%	30.5%	39%
May-03	30,414	411,031	2,113.0	474.6	29,084	2,045	23.5%	30.7%	73%
June-03	39,087	549,741	2,767.1	530.1	18	17,223	22.5%	25.4%	99%
July-03	39,185	568,723	2,878.3	635.8	103	72,102	21.8%	34.1%	100%
August-03	10,864	161,883	838.9	185.7	0	46,035	21.1%	49.2%	29%
September-03	22,210	328,755	1,627.2	359.1	457	40,837	21.4%	33.6%	58%
October-03	33,777	465,929	2,312.4	512.2	21,063	12,828	23.0%	29.9%	80%
November-03	10,005	138,575	693.8	153.3	5,939	6,192	22.9%	31.3%	25%
December-03	5,290	66,833	370.7	81.7	4,688	0	25.1%	31.7%	13%
January-04	34,702	417,133	2,394.5	535.4	2,769	0	26.4%	26.7%	83%
February-04	27,701	341,383	1,904.6	426.4	92,226	0	25.8%	52.4%	73%
March-04	35,160	440,680	2,425.9	544.4	102,987	0	25.4%	48.3%	84%
Year	***303,749***	***4,100,315***	***21,424***	***4,689***	***275,496***	***197,263***	***23.5%***	***34.6%***	**63%**

Note: Actual natural gas HHV is used.

$$EFF = \frac{W_{output} - W_{parasitic} + Q_{hr}}{G_{input}}$$

Turbine Efficiency Trend



Summer Days Desiccant Drying

	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%***

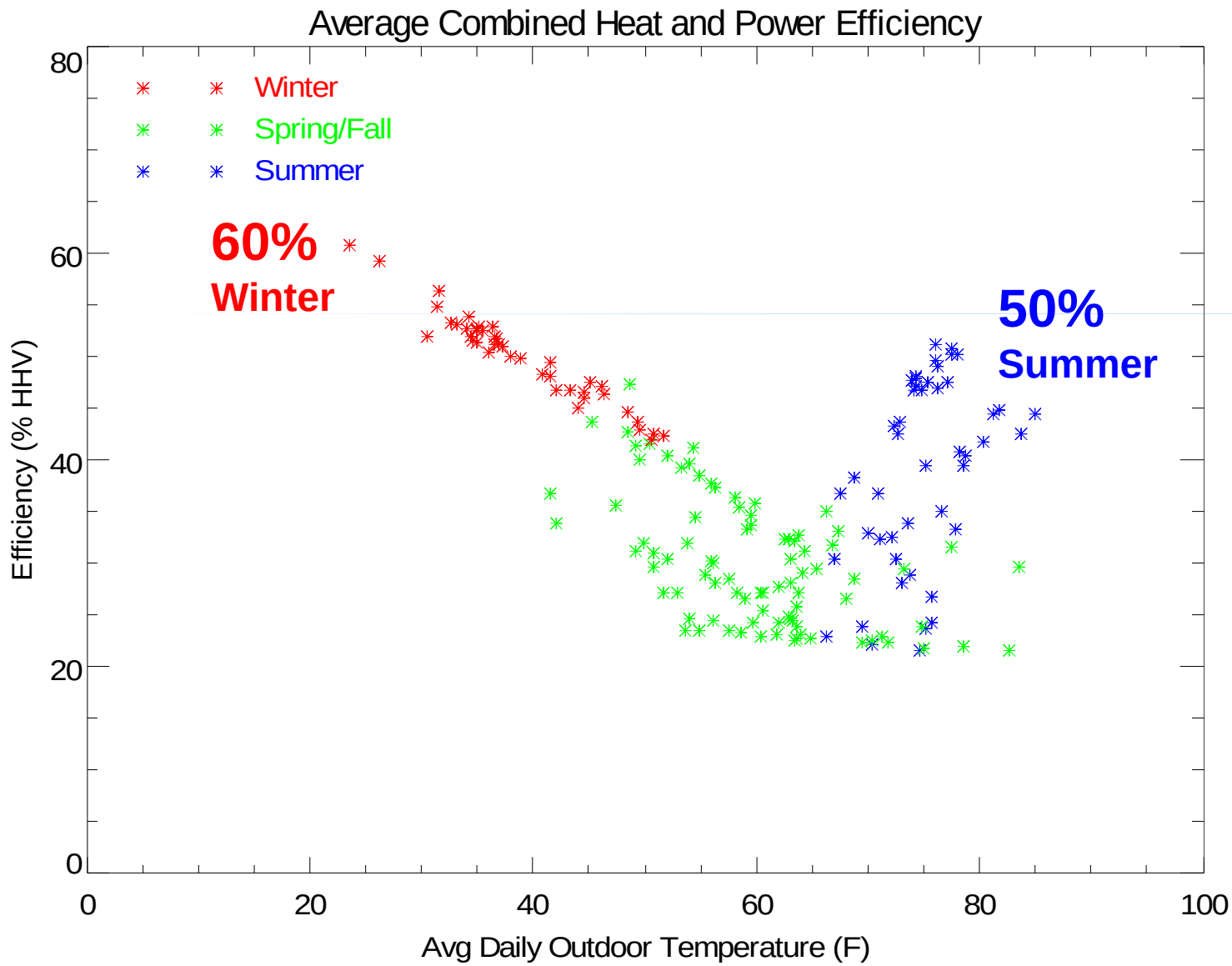
Note: Actual natural gas HHV is used.

Winter Days – Space Heating

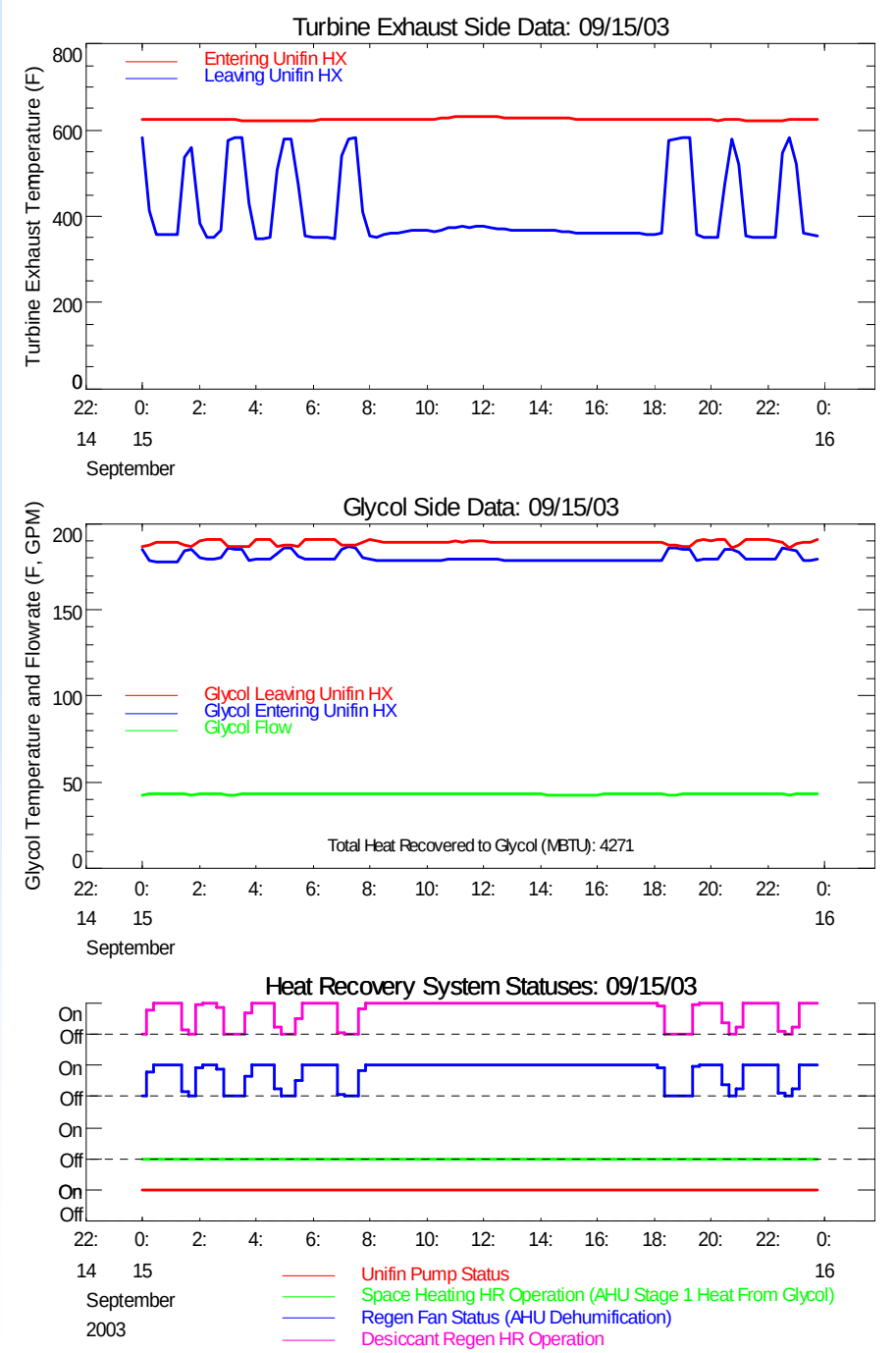
	[1]	[2]	[3]	[4]	[5]	[6]	[7] = [1-3] / [2]	[8] – [1-3-4+5+6] / [2]
	Turbine		Parasitic Loads		Heat Recovered			
Date	Power Output (kWh)	Gas Input (MBTU)	Gas Compressor (kWh)	Heat Recovery Glycol Pump (kWh)	Space Heating (MBTU)	Desiccant Regen (MBTU)	"Net" Turbine Generation Efficiency (%)	"Net" CHP Efficiency (%)
Feb 9, 2004	503.6	6,313	35.7	7.9	1,496	0	25.3%	48.6%
Feb 10, 2004	1,366.0	16,959	93.5	20.8	3,881	0	25.6%	48.1%
Feb 11, 2004	1,365.4	16,809	93.8	20.9	4,573	0	25.8%	52.6%
Feb 12, 2004	1,365.6	16,533	94.5	21.0	5,067	0	26.2%	56.5%
Feb 13, 2004	1,365.6	16,834	93.7	20.9	4,462	0	25.8%	51.9%
Feb 14, 2004	1,365.5	16,934	93.5	21.1	4,416	0	25.6%	51.3%
Feb 15, 2004	1,365.3	16,433	94.5	21.2	5,474	0	26.4%	59.3%
Feb 16, 2004	1,364.9	16,232	95.4	21.2	5,607	0	26.7%	60.8%
Feb 17, 2004	1,326.5	16,032	92.6	20.5	5,198	0	26.3%	58.3%
Feb 18, 2004	1,296.7	15,932	89.4	20.0	4,420	0	25.9%	53.2%
Feb 19, 2004	1,361.7	16,733	93.2	21.0	4,536	0	25.9%	52.6%
Feb 20, 2004	1,365.2	16,934	93.5	21.0	4,466	0	25.6%	51.6%
Feb 21, 2004	1,365.7	17,134	92.6	21.0	4,227	0	25.4%	49.6%
Feb 22, 2004	1,365.3	16,934	93.2	21.0	4,198	0	25.6%	50.0%
Totals	***27,701***	***341,383***	***1,905***	***426***	***92,226***	***0***	***25.8%***	***52.4%***

Note: Actual natural gas HHV is used.

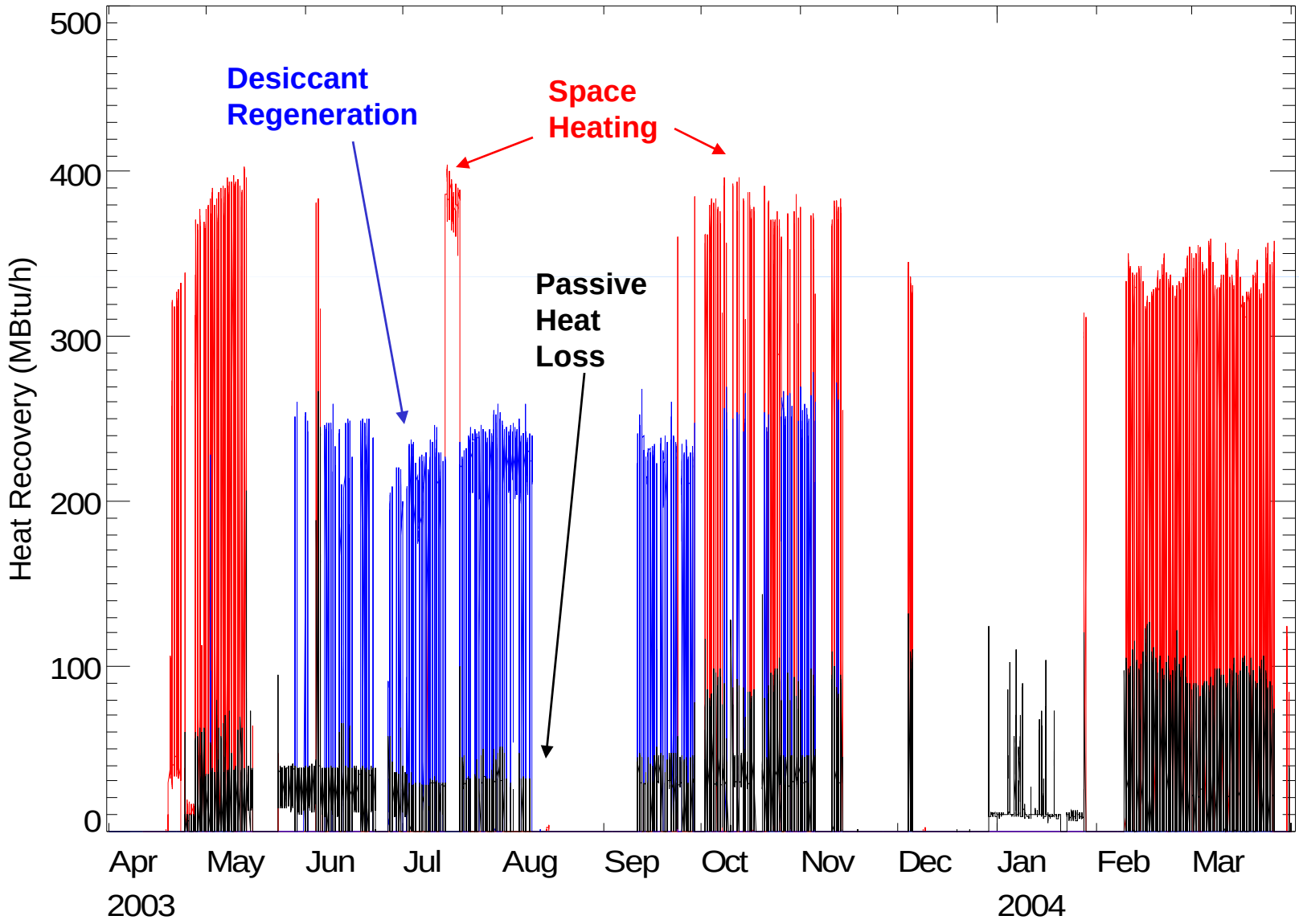
CHP Efficiency Trends



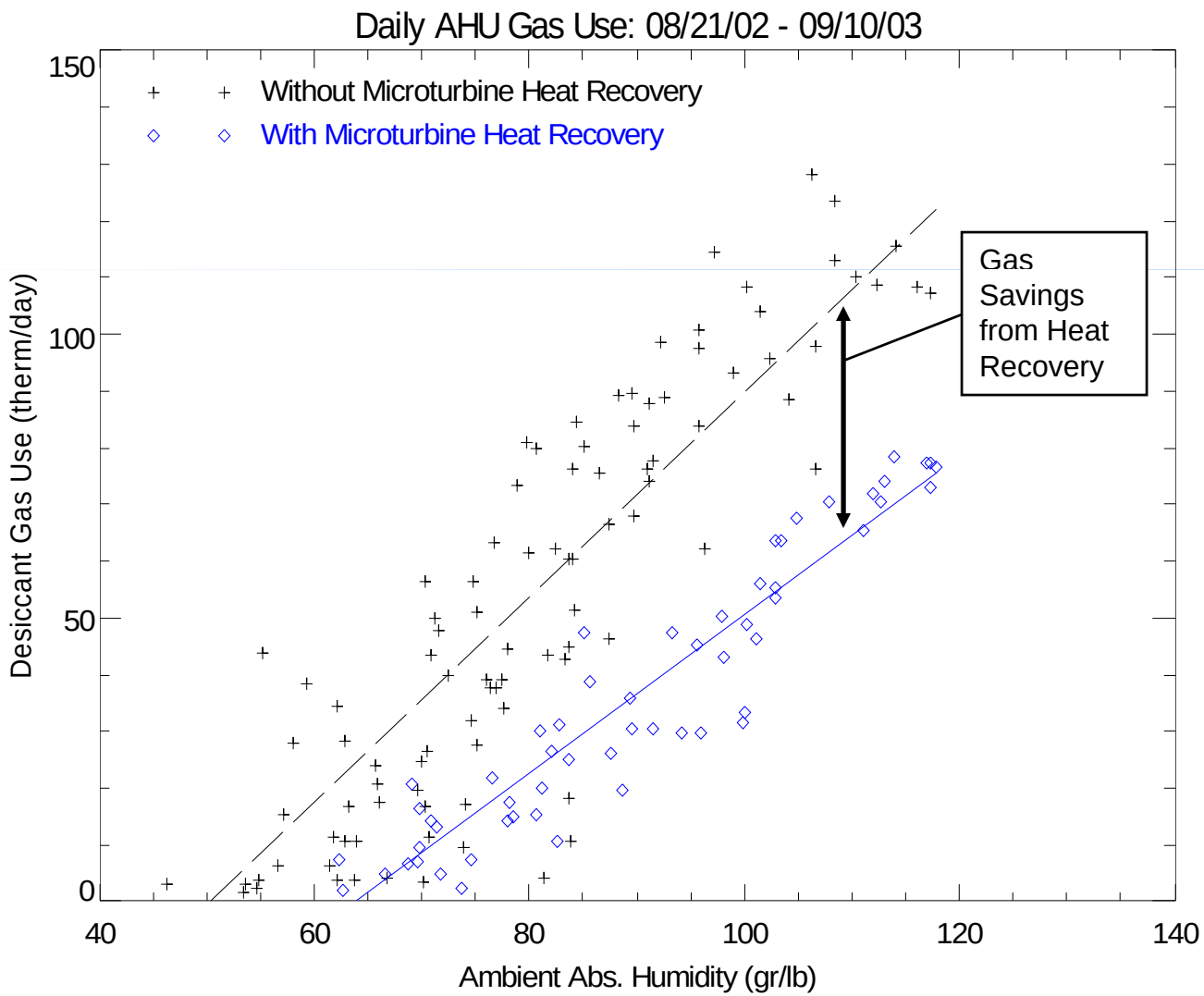
Typical Performance of Heat Recovery System



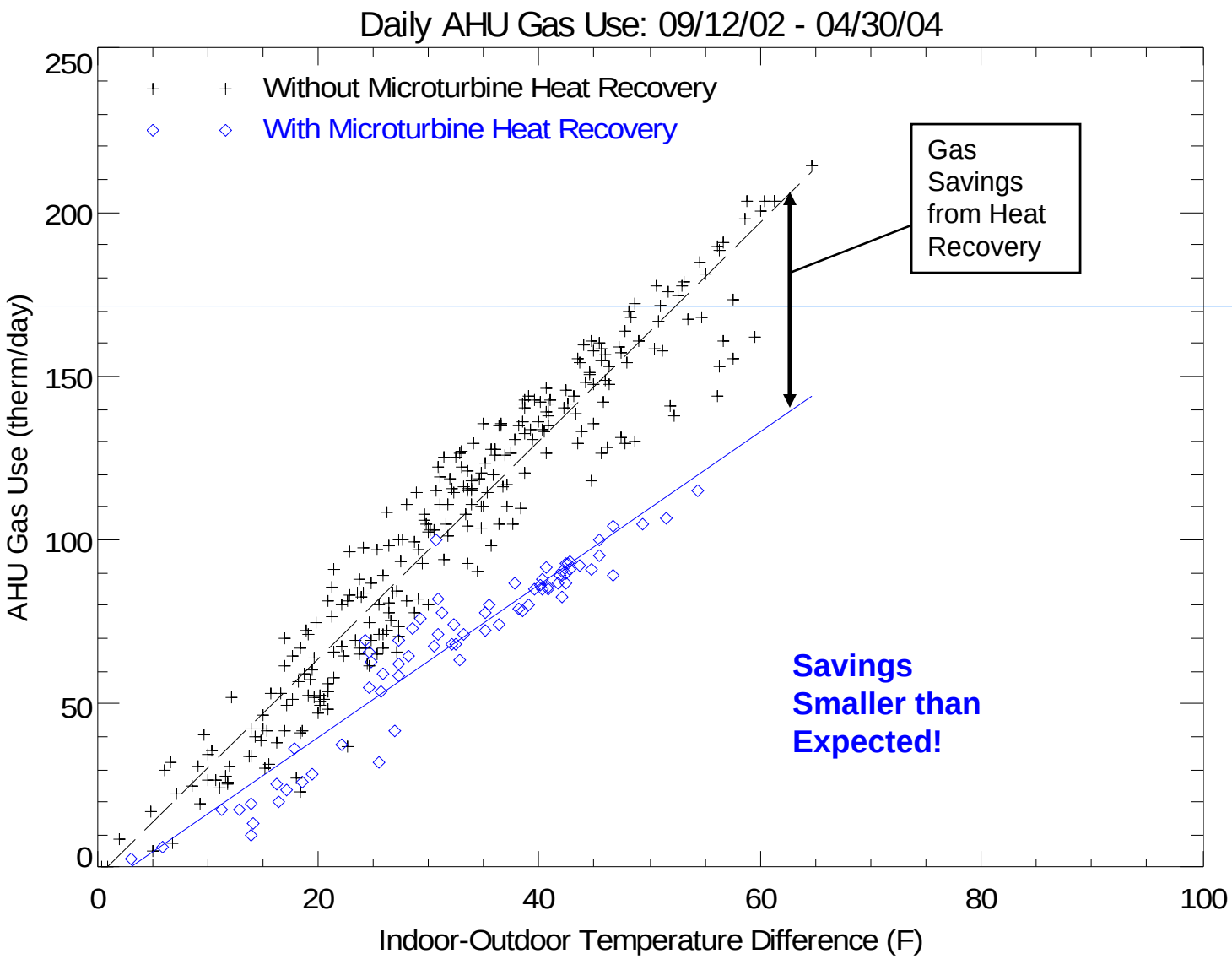
HR Rate in Different Modes



Impact of Heat Recovery on Desiccant Gas Use



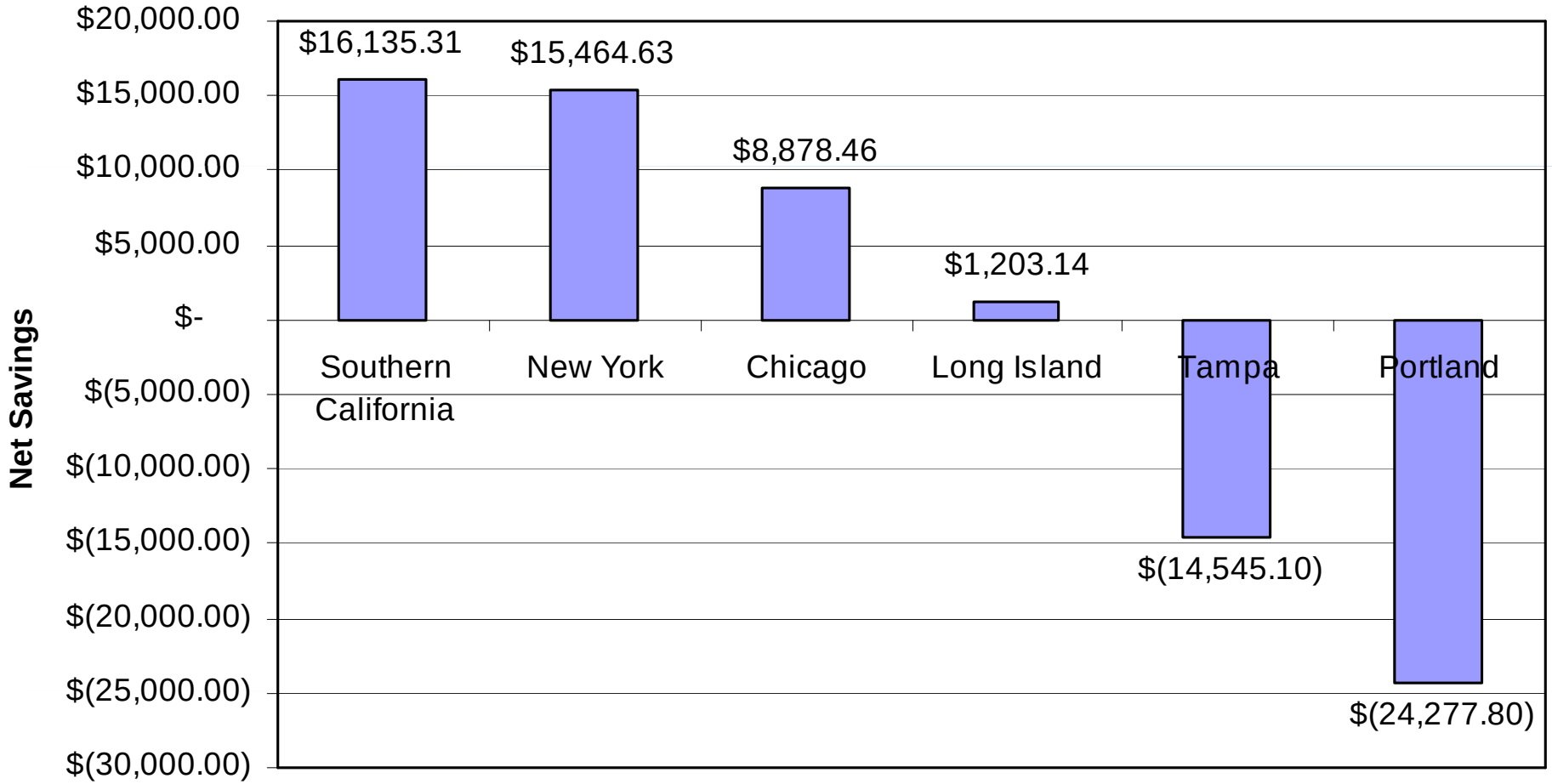
HR Impact on Space Heating



“What If” Annual Analysis

- Used measured trends with TMY weather data
- Assume more optimum Heat Recovery
  - Address minor set point/control issues
- What if: turbine ran for entire year
  - Annual CHP efficiency increases to 48-50%
  - Heat recovery saves more than 20,000 therms (mostly space heating)

Economics in Other Locations



ETV Emissions Testing

- NYSERDA funded Environmental Technology Verification (ETV) testing at this site
- High-precision testing in June 03 confirmed CDH's 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

More Information

- CDH Online Monitoring & Project Reports:

  www.cdhenergy.com

  click on: Online data access – Waldbaums

  (user/pass: waldbaums/microturbine)

- ETV Report

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

  (sep 03 report)