WYOMING COUNTY COMMUNITY HOSPITAL
ENERGY PROJECT
COMBINED HEAT AND POWER

Final Report

Prepared for

THE NEW YORK STATE
ENERGY RESEARCH AND DEVELOPMENT AUTHORITY
Albany, NY

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NOTICE

ABSTRACT

The objectives of this project were to improve the annual thermal heat utilization of the existing cogeneration plant, reduce the hospitals dependency on the electric grid for summertime cooling, and to provide a system that allows WCCH to minimize their cooling costs.

Gerster Trane Energy Services programmed the hospital's Tracer Summit building control system to collect all pertinent data to measure the performance of these objectives.

The project increased the heat available by 42%, the heat recovered by 90% and the percent thermal recovery by 16%. The project proved the potential to avoid over 200 kW of demand and nearly 424,000 kWh. WCCH dispatched the cooling plant based on the lowest available fuel during the summer of 2003. This report supports the claim that all objectives were successfully meet.

ACKNOWLEDGEMENTS

We would like to thank Scott Smith and Todd Baldyga from New York State Energy Research and Development Authority (NYSERDA) for all of their assistance during the course of this project.

TABLE OF CONTENTS

FIGURES

TABLES

SUMMARY

WCCH CHP heat recovery project was constructed to improve the utilization of the heat generated by Wyoming County Community Hospital's existing cogeneration plant through the installation of an absorption chiller and additional winter heat recovery. The existing cogeneration system heat recovery system was installed with jacket water heat recovery only and most of the heat was rejected to the atmosphere in the summer. The summer heat sink was limited to domestic hot water. The CHP program enabled the installation of an exhaust heat recovery unit, which raises the heat recovery significantly and enables the absorber to utilize the engines excess heat in the summer for air conditioning and thereby reduces the electrical chilled water peak demand. The secondary benefit of the project reduces the WCCH's dependency on the electric utility for summer cooling.

By more closely matching the electric and thermal profiles, the projects annual thermal utilization was improved by 16%. The existing cogeneration system is electric base loaded with 560 kW capacity to supply the entire facility other than the cooling system. The existing electric cooling system consists of two water-cooled reciprocating chillers rated for nominal 290 tons. In the past WCCH purchased the balance of their electrical requirement in the summer from the utility company. Because the absorber is powered by any combination of cogeneration and boiler heat, WCCH now has the choice of not purchasing utility power for air conditioning. WCCH's long term goal is to eliminate energy price risk by automatically dispatching the cooling plant on the lowest priced commodity.

The energy benefit to WCCH is significant for a facility of this size. In addition to the choice of fuel, the hospital can now produce a significant percentage of its cooling needs from cogeneration heat that was previously going unused. Based on the 2002 cooling season, the project has the potential of displacing 423,939 kWh and over 200 kW from the electric grid.

This project has reduced the hospital dependency on the power grid on a year round basis, and delivered operating flexibility to a facility that is operating in an industry that is continually trying to improve its economic performance

PROJECT OBJECTIVES AND RESULTS

As stated in the abstract an summary, and in the spirit of the original application, the project objectives are as follows:

- Improve the annual thermal heat utilization of the existing cogeneration plant.
- Reduce the hospital's dependency on the electric grid for summertime cooling.
- Provide a system that allows WCCH to minimize their cooling costs.

1. Improve the annual thermal heat utilization of the existing cogeneration plant.

The WCCH cogeneration plant was installed as a base loaded, electric load following system. The heat recovery system was designed to provide base loaded thermal energy to the domestic hot water system. During the heating season, the balance of the thermal energy is used for space heating the building. During the cooling season, the balance of the thermal energy is rejected to the environment through a radiator.

This objective was approached from both the demand side and the supply side. On the supply side, the strategy was to maximize heat available from the cogeneration engine. This was done with the addition of a 1,055,800 Btu/hr exhaust heat recovery device. This device improves both the quality and the amount of heat available to the hospital. With more heat available all year round, both summer and winter demands were added to the heat recovery loop to better match the new thermal profile. A new heat recovery loop was added in the hottest part of the loop for the absorber concentrator loop for heat use in the summer cooling season. A heat loop to the Peet Nursing facility was added to utilize that heat in the heating season. The absorber heat exchanger running during the cooling season is rated for 1,456,000 Btu/hr.

The project included expanding the cogeneration heat recovery loop approximately 300 feet to the Peet nursing home mechanical room. A water to water shell and tube heat exchanger was installed before the primary steam heat exchanger to heat or pre-heat the nursing home space heating hot water perimeter loop with two zones (east and west). The heat exchanger is sized for a maximum of 1,465,000 Btu/hr, similarly sized to the absorber concentrator heat exchanger running in the cooling season.

Through the installation of the absorber, the heat from the engine will be available for cooling with less thermal energy rejected to the environment. The thermal energy from cogenerator is not designed to fully support the absorber in times of peak cooling. This is more fully explained in the next section of this report. The absorber loop is connected to the hospital’s steam boiler for supplemental heat. The absorber thermal system is designed to be base loaded with cogeneration heat through a plate and frame heat exchanger on the absorber’s concentrator loop. The concentrator loop heating can be supplemented with a steam to water shell and tube heat exchanger. The boiler plant has 60-psig steam and 6,500 lbs/hr steam available for the steam side.

The following is a complete description of the project deliverables provided by Gerster Trane Energy Services:

1. Engineering, project management, and documentation
2. Equipment selection, procurement:
   - 385 ton hot water absorber
   - cooling tower
   - cogeneration engine exhaust heat recovery device
   - boiler steam heat exchanger and accessories
   - additional heat rejection fluid cooler
   - additional pumping capacity for cogeneration loop
   - heat recovery heat exchanger and accessories for nursing home heat sink
   - controls
   - outdoor absorber enclosure
3. Absorber mechanical piping modifications and installation, insulation, pumps, controls, auxiliaries.
4. Absorber electrical connections, controls and pumps.
5. Cooling tower removal and installation, piping and electrical connections.
6. Engine exhaust heat recovery device piping and modifications to existing heat recovery installation, modifications to engine enclosure.
7. Controls programming

Figure 1 shows the total heat generated, heat recovered and the balance of the heat rejected for the 12 month period of December 1999 to November 2000. The 12 month period immediately prior to the installation of the project in October 2001 was not used as a base comparison because the cogeneration system was run only during on peak times for the period of August 23, 2000 to July 5, 2001. That decision was made because it was cheaper to buy NYSEG's off peak electricity than produce it with the elevated gas prices of the period. The original system had three heat sink heat exchangers, two for space conditioning, and one for domestic hot water. The top line represents the total heat produced and is the sum of the total heat recovered and the total heat rejected over the course of the year. The gray area is the total heat rejected, and the white area is the total heat recovered. Observe the total heat produced is the highest during the summer cooling months when the generator system is most heavily loaded. That is also the time when the hospital's heat demand was limited to only the domestic hot water. The apparent down turn in heat production and recovery toward the end of 2001 is due to the engine generator top end rebuild spanning the last week in November and the first part of December. The data on Table 1 is plotted on Figure 1.

Figure 2 shows the same in formation for the 12-month period of October 2001 to September 2002. This coincides with the first heating and cooling seasons after the addition of the exhaust heat recovery boiler, Peet nursing home loop, and the absorber heat recovery loop. Observe the total heat recovered profile closely match the total heat produced. Comparing to Figure 1, it should be noted that the total heat produced and the total heat recovered are significantly higher than the base year. Also note compared to the base year the total heat rejected actually decreased. The data on Table 2 is plotted on Figure 2.

Figure 1

Gerster Sales and Service
Wyoming County Community Hospital Energy Project
NYSERDA Job # 6551
Total Heat Generated Before Retrofit
December 1999 - November 2000

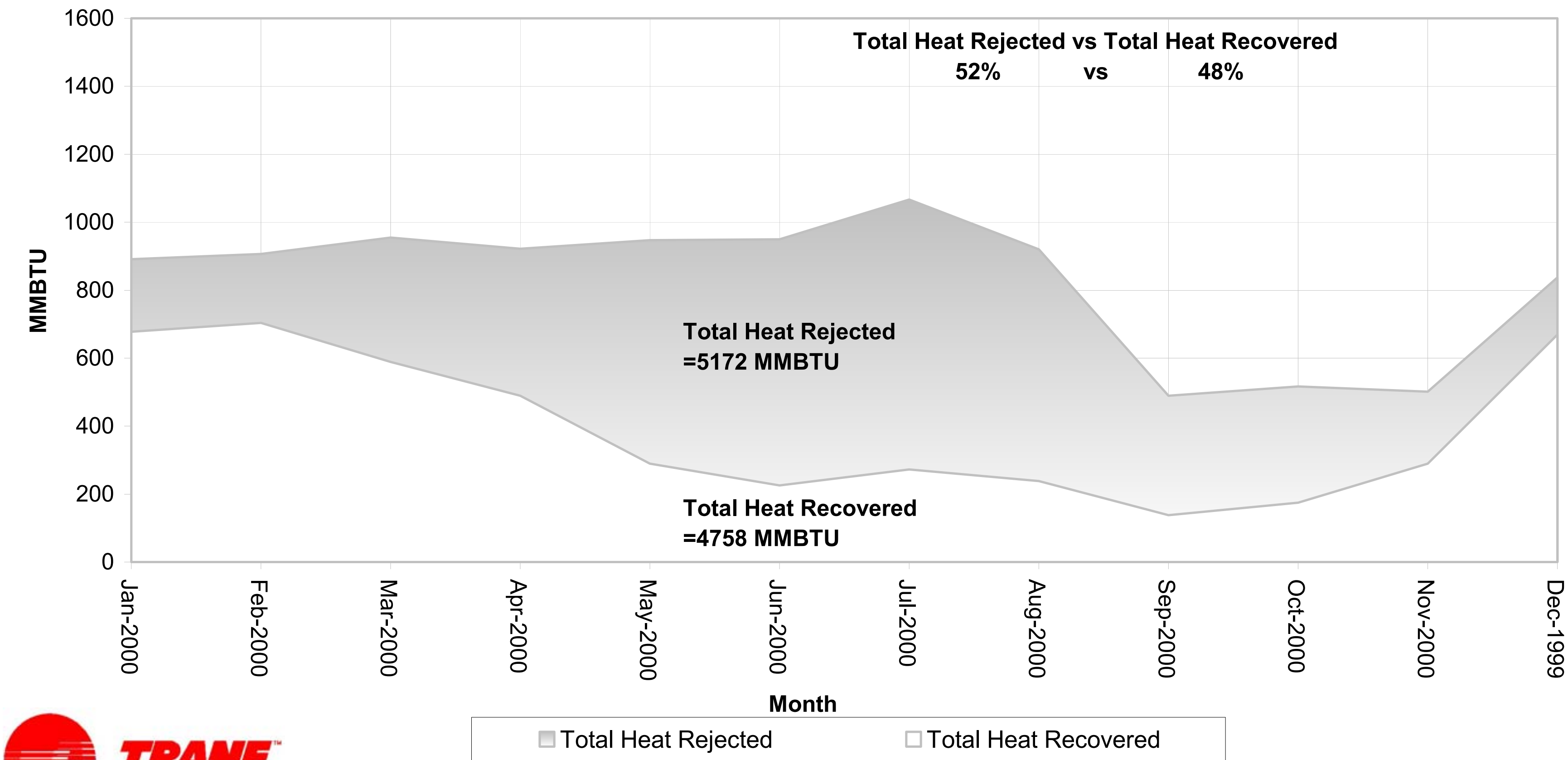


Table 1

Total Heat Generated Before Retrofit

Month	Average Outside Air Temp	Chillers Cooling Calculation	Absorber Cooling Calculation	Percent Thermal Utilization	HR Heat Rejection	HR Peet Loop	HR Absorber Loop	HR Domestic Loop	HR Glycol Loop	HR Hot Water Loop	Total Heat Recovered	HR Exhaust	HR Generator	Percent Electrical Utilization	Generator	NYSEG	Cogen Gas Meter	Cogen Run Time
	Degrees Fahr.			Recovered vs. Produced	MMBtu	MMBtu	MMBtu	MMBtu	MMBtu	MMBtu	MMBtu	MMBtu	MMBtu	Generated vs. Total	Kilowatt hours	Kilowatt hours	Raw MCF	Hours
Jan-2000	23.4	0	0	76%	213.1	0.0	0.0	83.6	108.4	486.1	678.2	0.0	891.2	96%	296,558	12,761	2,706	720
Feb-2000	31.3	0	0	78%	202.8	0.0	0.0	97.1	140.2	466.3	703.6	0.0	907.1	97%	278,958	8,194	2,695	694
Mar-2000	41.2	0	0	62%	366.2	0.0	0.0	81.5	116.9	389.9	588.4	0.0	955.1	96%	288,748	11,260	2,879	737
Apr-2000	45.2	0	0	53%	432.8	0.0	0.0	68.9	84.4	335.8	489.1	0.0	921.8	96%	284,478	11,389	2,826	714
May-2000	59.5	0	0	31%	666.2	0.0	0.0	54.9	24.8	210.3	289.9	0.0	946.7	94%	328,994	20,226	3,337	739
Jun-2000	66.5	0	0	24%	731.5	0.0	0.0	49.1	8.6	167.5	225.2	0.0	949.9	90%	348,937	38,869	3,451	709
Jul-2000	67.6	0	0	26%	796.8	0.0	0.0	77.9	9.7	185.4	272.9	0.0	1067.1	95%	381,386	18,031	3,657	734
Aug-2000	66.9	0	0	26%	683.6	0.0	0.0	77.3	10.7	150.7	238.7	0.0	920.7	77%	326,627	99,109	3,116	722
Sep-2000	60.5	0	0	28%	351.7	0.0	0.0	41.1	13.1	84.1	138.2	0.0	489.5	46%	169,497	196,688	1,606	715
Oct-2000	52.4	0	0	34%	342.5	0.0	0.0	39.4	18.6	117.0	175.0	0.0	517.1	51%	170,443	163,656	1,639	736
Nov-2000	38.7	0	0	58%	217.5	0.0	0.0	21.8	69.4	198.4	289.7	0.0	501.3	54%	160,462	138,234	1,544	712
Dec-1999	32.5	0	0	80%	167.4	0.0	0.0	83.7	125.6	460.4	669.7	0.0	837.0	95%	304,920	17,419	2,727	725
Annual Total	48.8	0	0	48%	5171.9	0.0	0.0	776.2	730.4	3251.9	4758.5	0.0	9904.2	82%	3,340,007	735,834	32,182	8,657

March	Sierra Monitor down during this period. Electric production calculated from average electric / fuel ratio.
July	Missing data for this period. Estimated from remaining days in the month.
Dec & Jan	Data was interpolated from NOAA & electric bills

Figure 2

Gerster Sales and Service
Wyoming County Community Hospital Energy Project
NYSERDA Job # 6551
Total Heat Generated After Retrofit
October 2001-September 2002

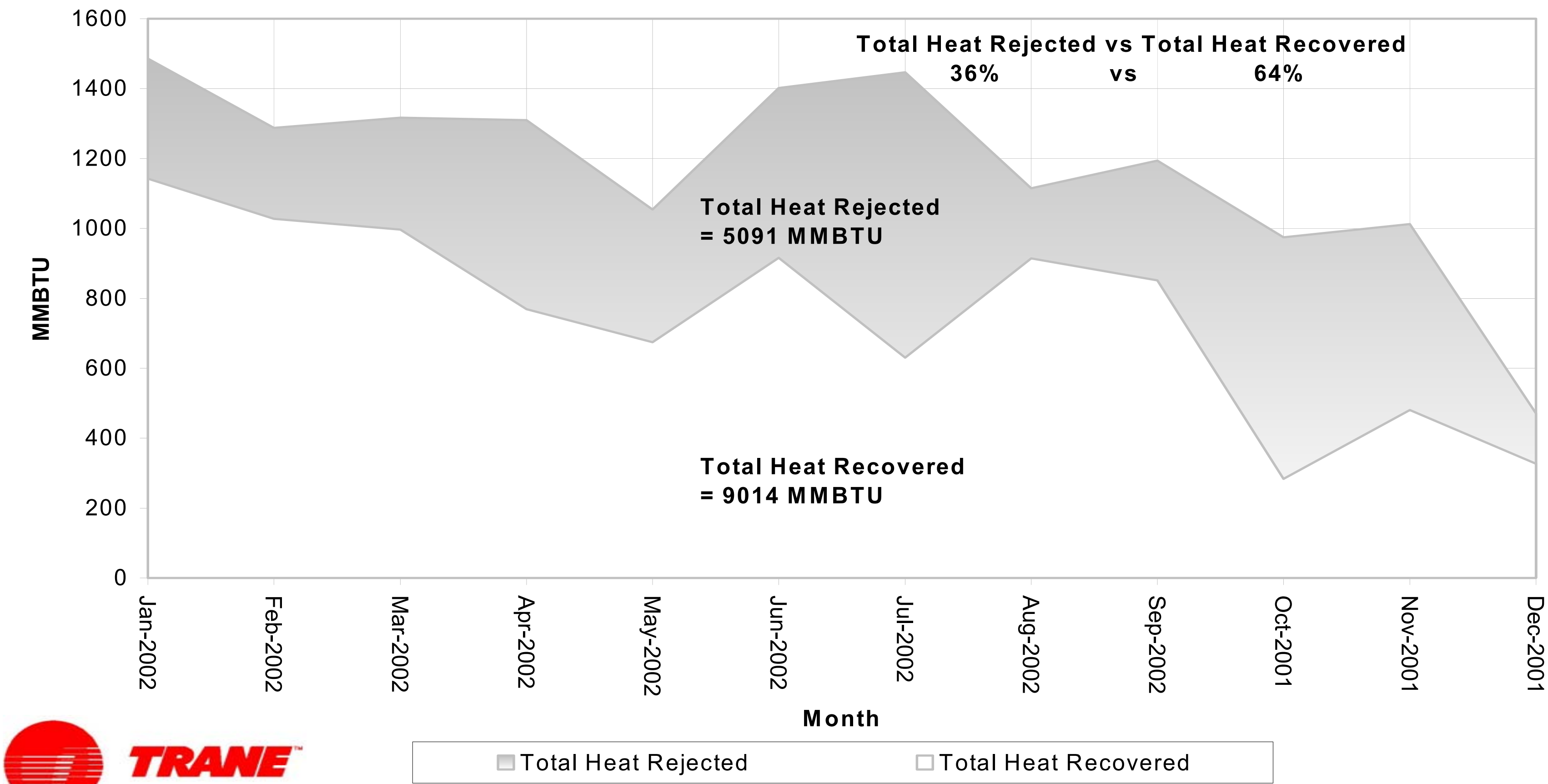


Table 2

Total Heat Generated After Retrofit

Month	Average Outside Air Temp	Chillers Cooling Calculation	Absorber Cooling Calculation	Percent Thermal Utilization	HR Heat Rejection	HR Peet Loop	HR Absorber Loop	HR Domestic Loop	HR Glycol Loop	HR Hot Water Loop	Total Heat Recovered	HR Exhaust	HR Generator	Percent Electrical Utilization	Generator	NYSEG	Cogen Gas Meter	Cogen Run Time
	Degrees Fahr.	ton-hours	ton-hours	Recovered vs. Produced	MMBtu	MMBtu	MMBtu	MMBtu	MMBtu	MMBtu	MMBtu	MMBtu	MMBtu	Generated vs. Total	Kilowatt hours	Kilowatt hours	Raw MCF	Hours
Jan-2002	33	0	0	77%	344	204	19	55	305	558	1,142	574	911	94%	284,120	16,699	2,723	724
Feb-2002	33	0	0	80%	261	144	17	67	320	480	1,028	498	790	93%	246,489	19,847	2,389	648
Mar-2002	36	0	0	76%	325	151	3	86	308	449	997	510	807	94%	280,824	16,524	2,749	729
Apr-2002	48	11,307	7,494	59%	545	76	133	101	130	328	769	512	798	94%	297,978	20,084	2,851	708
May-2002	53	753	35,436	64%	383	5	350	73	25	222	675	414	640	74%	238,746	84,849	2,306	565
Jun-2002	68	0	107,376	65%	491	16	618	97	9	176	916	558	844	95%	329,414	18,466	3,147	716
Jul-2002	73	66,096	54,659	44%	825	5	422	115	6	82	630	575	873	89%	364,447	46,212	3,403	720
Aug-2002	70	57,404	31,603	82%	202	4	769	57	7	78	914	439	675	66%	270,306	137,808	2,547	560
Sep-2002	66	23,872	69,867	71%	349	9	650	81	12	99	852	465	729	81%	280,070	67,140	2,709	634
Oct-2001	52	0	0	29%	691	198	13	24	36	13	284	377	598	67%	242,323	118,749	2,245	479
Nov-2001	48	0	0	47%	532	125	13	50	67	225	480	391	621	74%	229,489	80,420	2,300	527
Dec-2001	36	0	0	69%	144	55	6	10	96	161	327	182	289	29%	84,547	210,625	836	245
Annual Total	51	159,433	306,435	64%	5,091	992	3,013	816	1,320	2,872	9,014	5,495	8,576	79%	3,148,753	837,423	30,205	7,256

Table 3 below summarizes the comparison of Figures 1 and 2 .

Table 3

Thermal Recovery Performance Before and After CHP Project (Figures 1,2)

	Total MMBtu Available	Total MMBtu Recovered	Thermal Utilization
Before (Figure 1)	9,930	4,758	48%
After (Figure 2)	14,105	9,014	64%
Percent improvement	42%	90%	16%

The CHP heat recovery project increased the total heat recovery available by 4,175 MMBtu and increased the recovered heat by 4,256 MMBtu. Of the 9,014 MMbtu recovered 5,989 MMbtu was used for heating. The new Peet loop makes up 17% of the total energy recovered for heating.

This project also increased the overall fuel conversion efficiency of the cogeneration plant. Fuel conversion efficiency is the ratio of energy used to energy consumed. In this case the sum in Btu's of the power produced and the energy recovered is compared to the energy in fuel input to the engine generator. Adding the exhaust heat recovery boiler increased the energy recovered from the gas burned in the engine. As explained above and in Figures 1 and 2, the amount of heat recovered was increased by the addition of the new heat recovery devices. Figure 3 shows the fuel conversion efficiency on a monthly basis over the 12 month period of December 1999 to November 2000. Note the overall efficiency is higher during the heating seasons. The periods of low efficiency correlate with times the cogeneration unit was off line for planned or unplanned maintenance. The average fuel efficiency was 44%. Compared to the average fuel conversion efficiency for a coal fired power plant of 30%, this was operating 14% better.

Figure 3 also shows the fuel conversion efficiency on a daily basis over initial 12 month period of operation from October 2001 to September 2002. Again the periods of low efficiency correlate with times the cogeneration unit was off line for planned or unplanned maintenance. Thermal efficiency was highest in the cooling and heating seasons. The average fuel efficiency was 63%. Compared to the average fuel conversion efficiency for the base period, this was operating 19% better due to both active supply and demand side management.

Figure 4 shows the daily fuel conversion efficiency plotted versus daily average outside air temperature for the over initial 12 month period of operation from October 2001 to September 2002. Similar to the results observed in Figure 3, thermal efficiency was highest at the coldest (heating season) and warmest (cooling season) times of the year. This graph is shown as a scatter plot and as before low efficiencies correlate with engine down times.

Figure 3

Gerster Sales and Service
Wyoming County Community Hospital Energy Project
NYSERDA Job # 6551
Fuel Conversion Efficiency
Before (December 1999 - November 2000)
and
After (October 2001-September 2002)
Retrofit

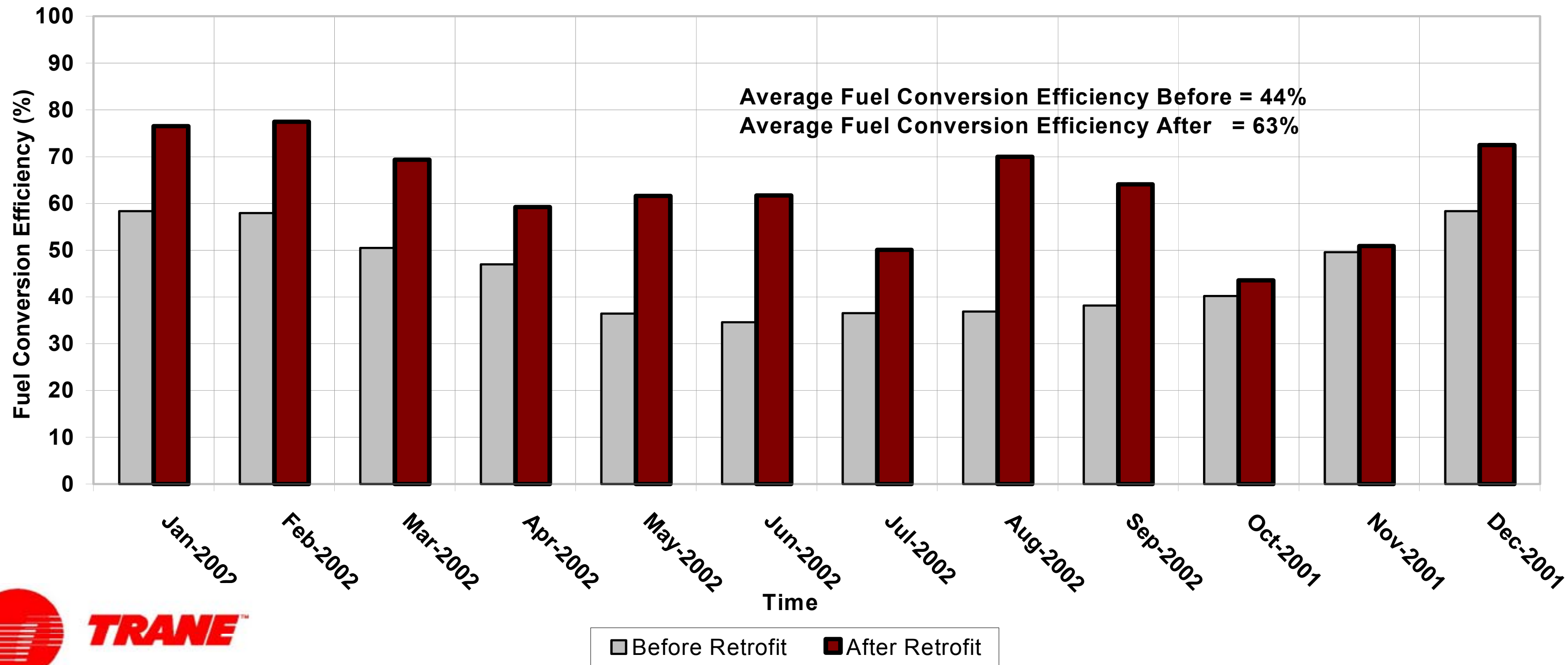
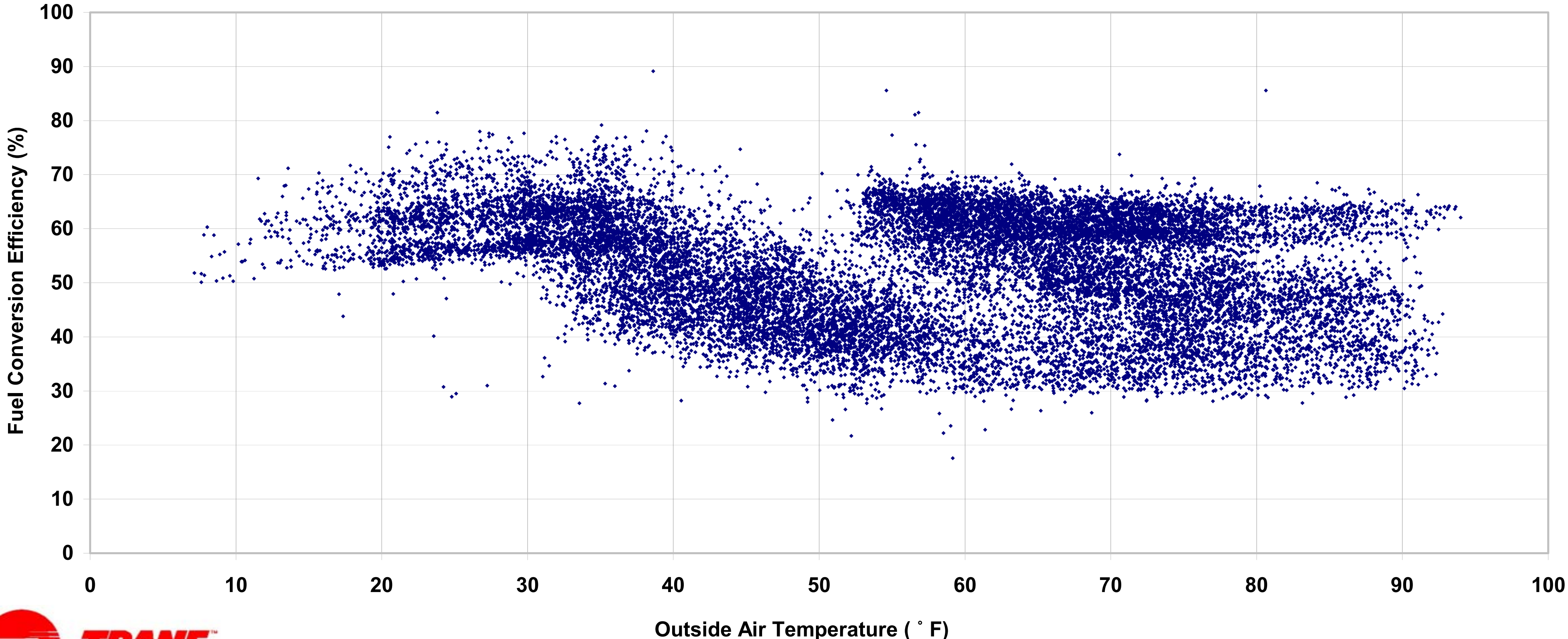


Figure 4

Gerster Sales and Service
Wyoming County Community Hospital Energy Project
NYSERDA Job # 6551
Fuel Conversion Efficiency After Retrofit vs Outside Air Temperature
October 2001 - September 2002



2. Reduce the hospital's dependency on the electric grid for summertime cooling.

To understand how this objective is met, it is essential that the plants operating characteristics be properly conveyed. The project plan is to utilize the absorber instead of the two electric chillers. The two chillers are rated for 150 tons and 168 tons with a total peak electrical capacity of 290 kW. Based on past operating practice and conditions as conveyed by the hospital operating staff, the electric chillers are estimated to have consumed 558,431 kWh per year at a cost of $49,812. The electrical cost of $49,812 includes on peak, off-peak, and demands charges. This calculation is detailed in the following Table 4.

Table 4
Wyoming County Community Hospital
Absorber Project
Bin Temperature and Electric Chiller Consumption Analysis

Electric Chiller

Bin Temp Outdoor °F	Bin Hours	Compressors Operating	Chiller kW 72.5/Comp.	kWh
82	409	4	290	118,610
77	419	3.5	254	106,321
72	570	2.5	181	103,313
67	620	2	145	89,900
62	510	2	145	73,950
57	406	1.5	109	44,153
52	306	1	73	22,185
				558,431

The chilled water return line from the hospital flows through the absorber and then through both electric machines. There are two heat exchangers that put energy in the concentrator loop. The cogeneration heat recovery loop heat exchanger adds free heat (and therefore free cooling), and the steam heat exchanger adds boiler heat. The absorber system was commissioned from early spring and through the summer of 2002. The absorber was successfully operated using the following combinations of thermal and electric energy:

Scenario 1: Absorber powered with steam only from the boiler

Scenario 2: all cooling from electric chillers

Scenario 3: Absorber powered by heat recovery loop base loaded followed by electric chillers

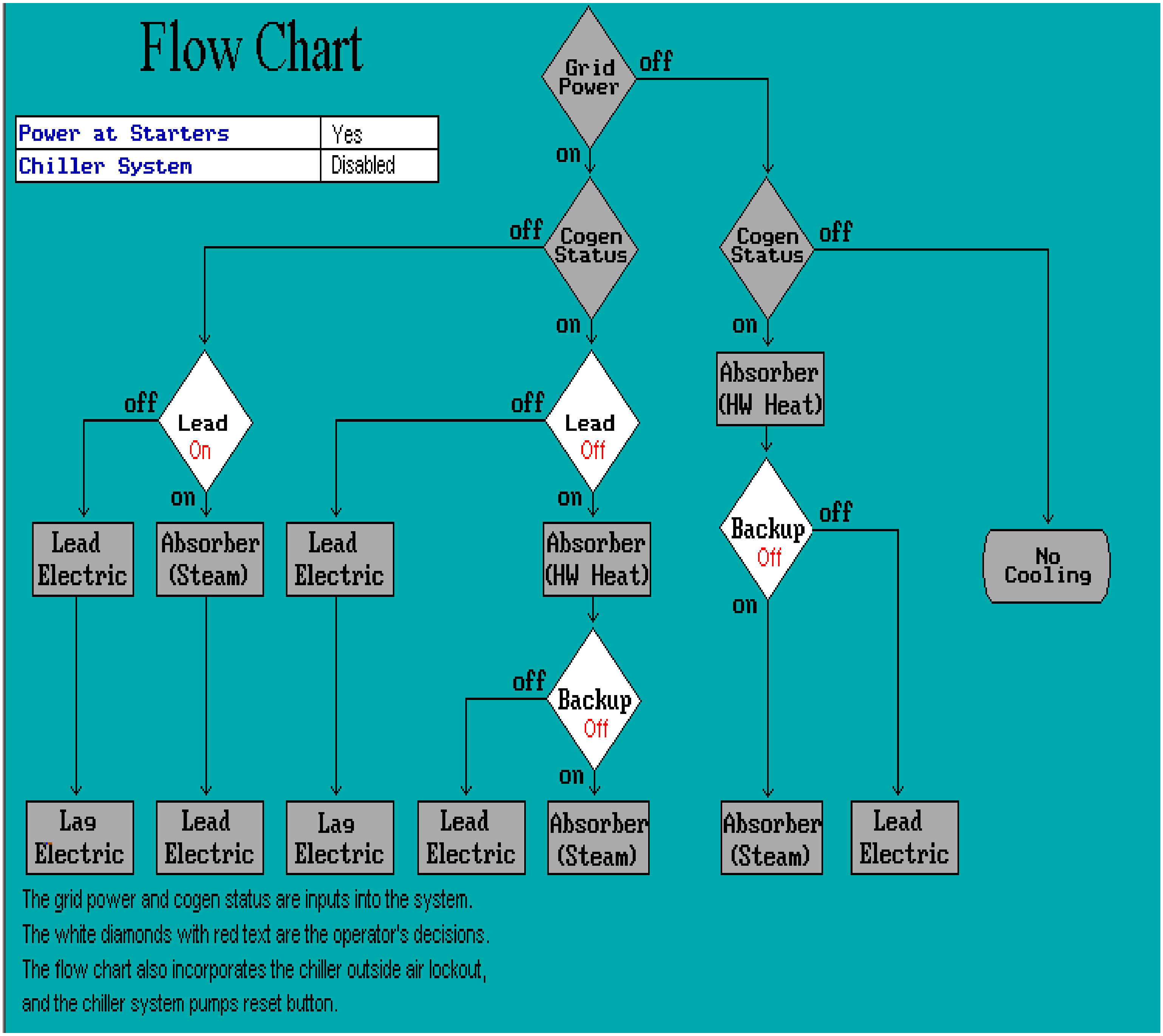
Scenario 4: Absorber powered with heat recovery loop base loaded followed by steam

Figure 5 is a screen print of the Trane Tracer Summit control system graphic flow chart developed to aid the on-site system operator’s decision making. The control system is designed to allow the operator to make automated system mode changes. The primary system mode selection is based on energy prices.

During the summer of 2002, WCCH decided to operate the cooling system in the mode that allowed the most favorable economics. The mode with favorable economics was the cogeneration thermal recovery base loaded absorber followed by electric chillers for peak cooling (scenario 3). Energy economic calculations proved steam was not economic for peak cooling (scenario 4) due to higher than anticipated natural gas prices. The plant operated in scenario 4 for May and June, and scenario 3 for the remainder of the cooling season starting in July 2002.

In addition to thermal performance, Table 2 also shows the cooling production from the electric and absorption chillers. During May and June the absorber produced 35,436 and 107,376 ton hours of cooling respectively. A total of 69,872 ton hours came from steam. Since the plant ran according to scenario 3 from July to the end of the cooling season, the total ton hours from free cooling are 236,563, or the difference between the total cooling put out by the absorber (306,435 ton hours) and the amount attributed to steam (69,872 ton hours).

Figure 5


Flow Chart
Power at Starters
Yes
Chiller System
Disabled
Grid Power
off
on
Cogen Status
off
on
Cogen Status
off
on
Absorber (HW Heat)
Lead On
off
on
Lead Off
off
on
Backup Off
off
on
No Cooling
Lead Electric
Absorber (Steam)
Lead Electric
Absorber (HW Heat)
Backup Off
off
on
Lag Electric
Lead Electric
Lag Electric
Lead Electric
Absorber (Steam)
Absorber (Steam)
Lead Electric
The grid power and cogen status are inputs into the system.
The white diamonds with red text are the operator's decisions.
The flow chart also incorporates the chiller outside air lockout,
and the chiller system pumps reset button.

Figures 6 and 7 show the tons produced by the absorber using the heat recovery loop as the only source of thermal energy (scenario 3 from above) on peak and average cooling days respectively. The absorber produced an average 100 tons on fully loaded peak cooling days and 88 tons of cooling on partly loaded average cooling days. On both figures the area in white represents the amount of electric cooling displaced.

Figure 8 shows the operation of the absorber on a average cooling day when all of the cooling is provided by the absorber and the cogeneration heat is used first (scenario 2). Note that all of the cooling shown displaces electric cooling. The hospital made a decision to discontinue this operating mode after June because of rising gas prices. It is interesting to note the interaction between the changing proportions of cooling coming from the heat recovery and steam. The amount of steam introduced in to the concentrator loop is continually set back in an effort to improve the temperature approach of the heat recovery heat exchanger and take more heat from the cogeneration system. During this cycle if the temperatures to the building start to drop the setback scheme is stopped. You will notice that on a similar average cooling day in August (figure 7) with the electric following (scenario 3 from above) the heat recovery appears to do more cooling. This did not go unnoticed, and the set back scheme above was later modified as part of the commissioning process. The revised setback scheme allows the absorber to produce between 80 and 100 tons on heat recovery alone similar to the results observed in Figures 6 and 7. Unfortunately the absorber was not operated in scenario 2 for any appreciable length of time for the remainder of the cooling season.

System performance is calculated using interval data collected from Trane's DDC system. The heat exchanger temperature differences are measured and stored in the database on the enclosed CD in Appendix B. Most anomalies in the data are explained by generator outages. Appendix C is a report that summarizes the outages for the time period included on the CD. The absorber experienced one significant period of down time during the first 2 weeks of July 2002. The root cause of which was a brine solution pump blocked with residual weld slag. The pump was repair was made under warranty.

The cogeneration system was installed with the capability to operate primarily parallel to utility, with the option of operating grid-isolated in the event of problems on the utility system. The primary reason WCCH operates in the grid-isolated mode is to avoid paralleling with the utility when the utility has power quality or outage problems. The utility is susceptible to severe power quality problems, including disruption of certain services for up to three hours after an outage. The utility's power quality problems are usually weather related and occur in the summer resulting in frequent electrical outages and disturbances. The utility problems adversely effect the equipment and operation of the hospital. In the original project the generator was sized to optimize the hospital economic return on assets. This translated to a design were the generator was base loaded to handle a large portion of the hospital's thermal load, and all of electrical load less the electric chillers. A larger generator would be oversized for both thermal all year and electric loads for a large portion of the year. With an absorber, WCCH is able to operate grid-isolated in the summer should the need arise.

Figure 6

Gerster Trane
Wyoming County Community Hospital Energy Project
Absorber and Electric Providing Cooling
Peak Cooling Day (High ?88°F, Low ?69°F)
Friday, August 16, 2002 (?79°F Average Outside Air Temperature)

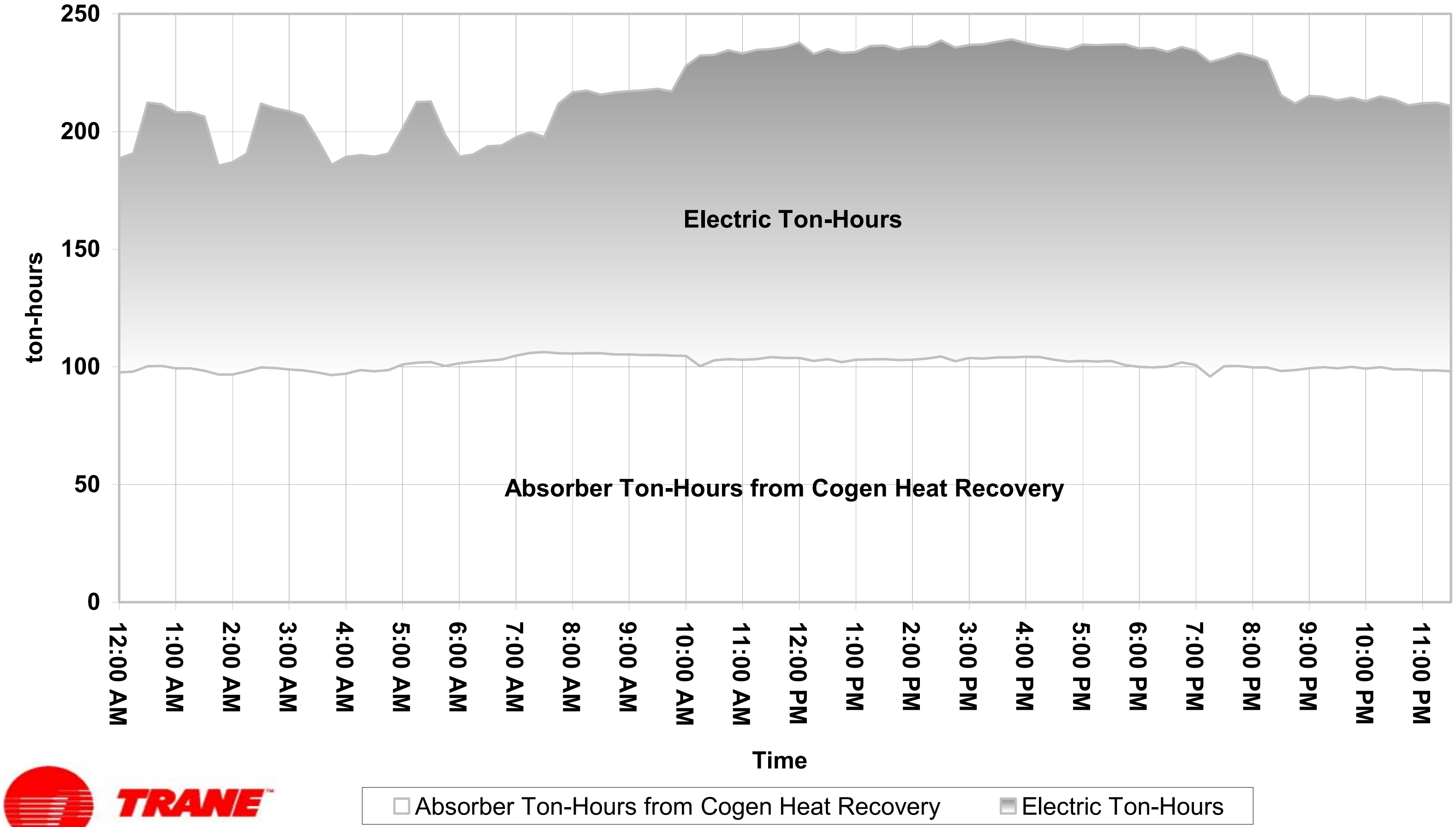


Figure 7

Gerster Trane
Wyoming County Community Hospital Energy Project
Absorber and Electric Providing Cooling
Average Cooling Day (High ?74°F, Low ?54°F)
Wednesday, August 7, 2002 (?64°F Average Outside Air Temperature)

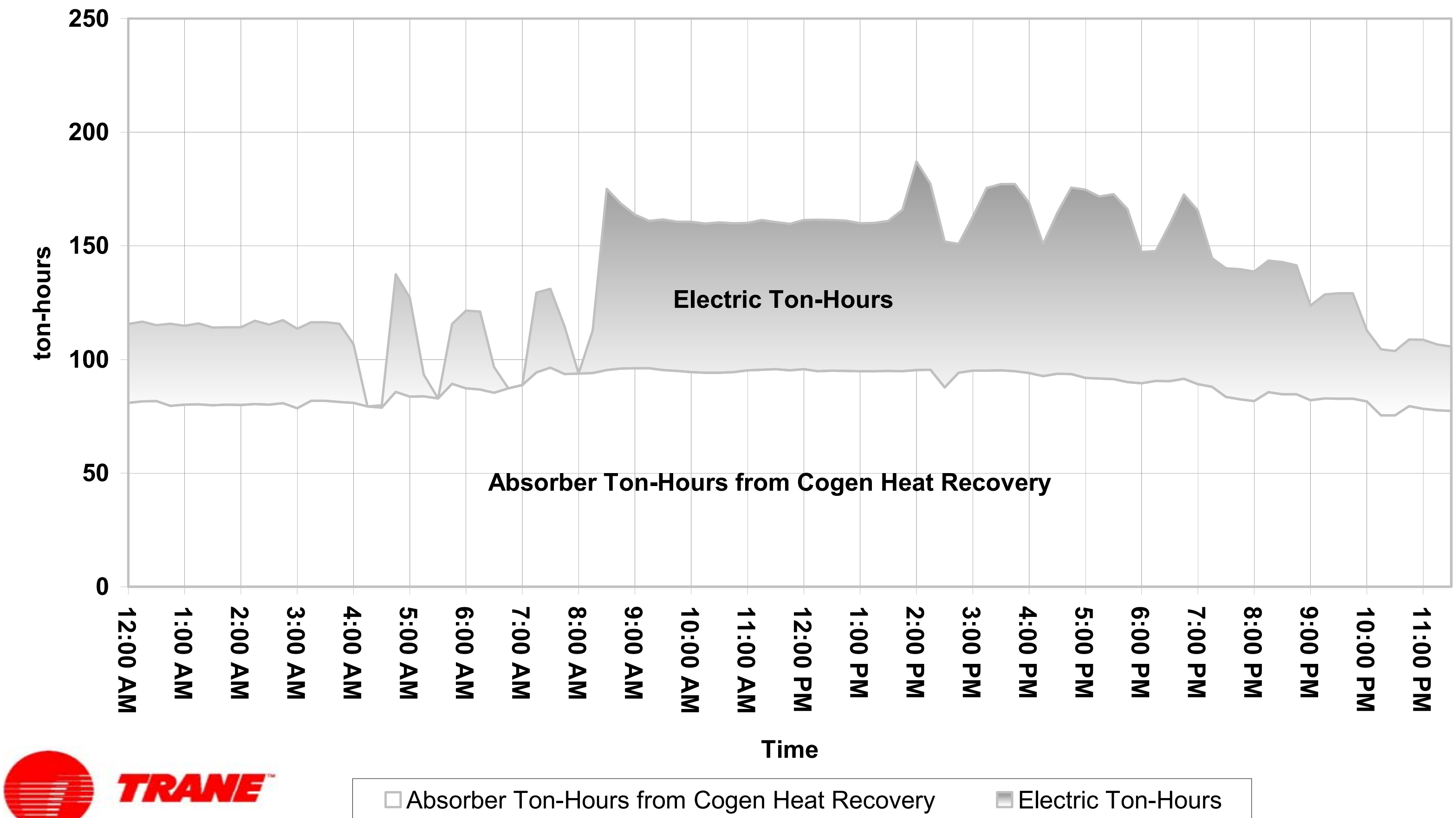
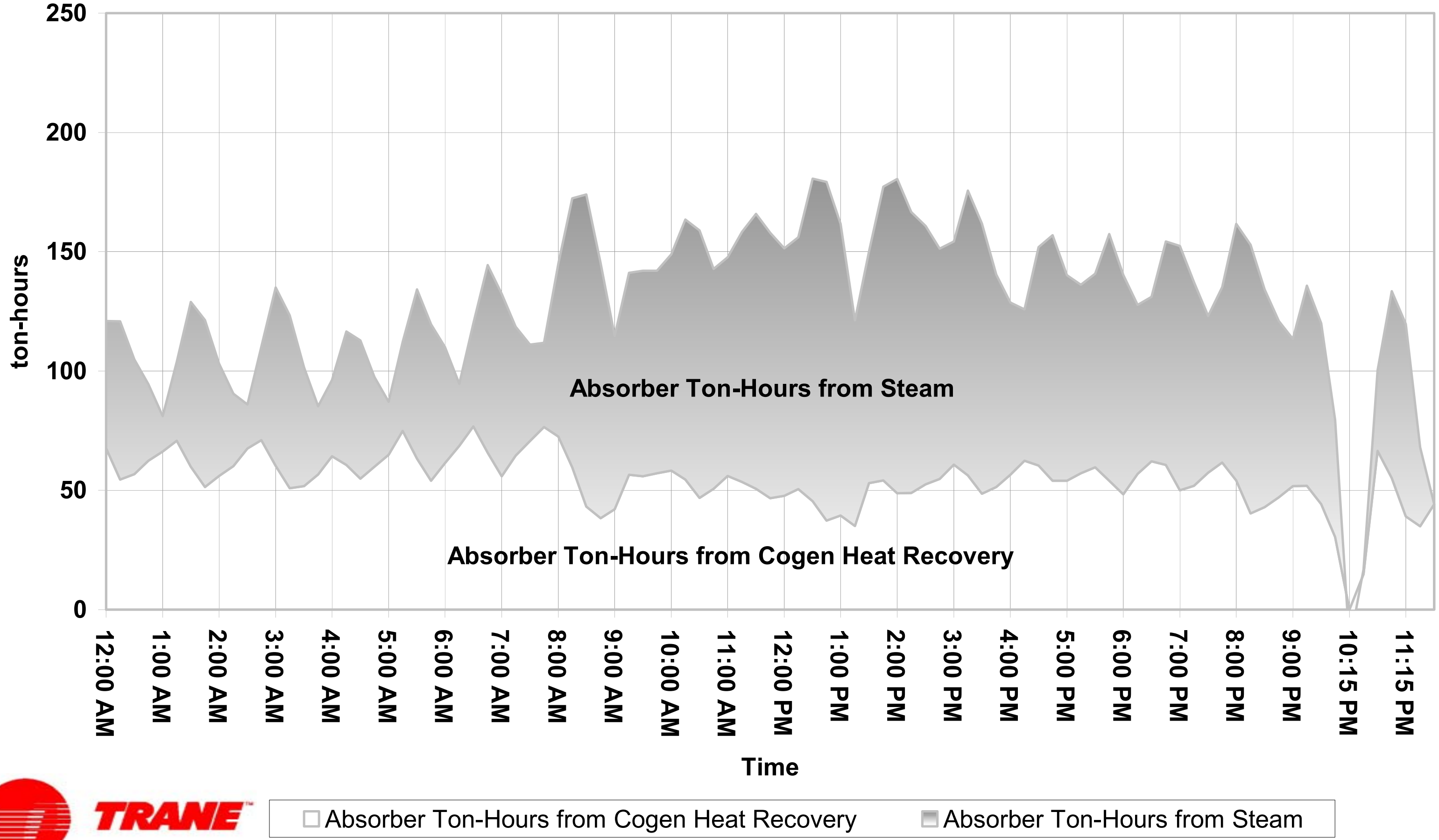


Figure 8

Gerster Trane
Wyoming County Community Hospital Energy Project
Absorber Providing All Cooling
Average Cooling Day (High ?73°F, Low ?57°F)
Friday, June 14, 2002 (?65°F Average Outside Air Temperature)

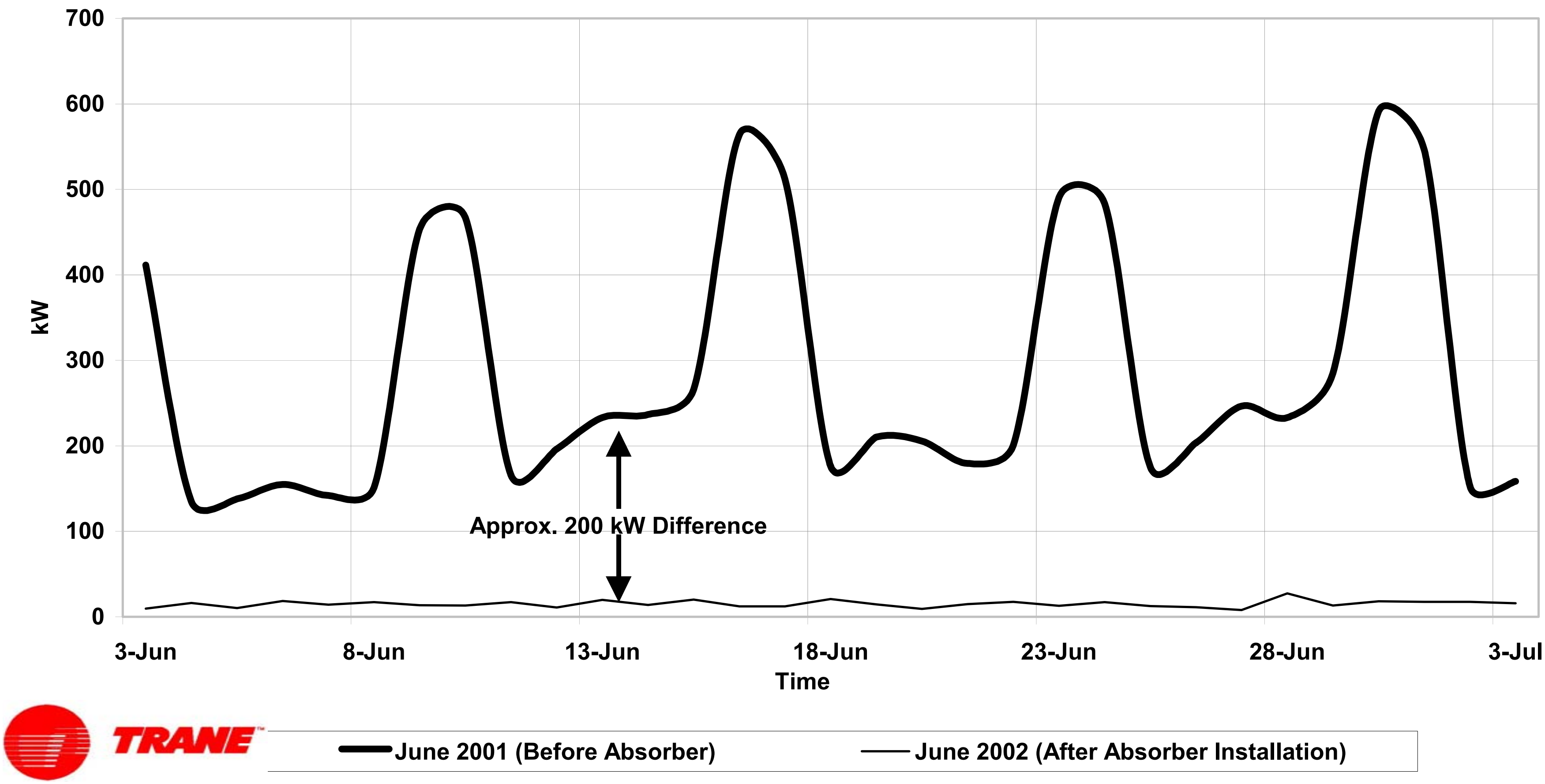


TRANE

Figure 9 shows the purchased power from NYSEG in June 2001 before the project and June 2002 after the project. For all of June 2002 the absorber was run with the cogeneration heat to preheating the concentrator loop and steam from the boiler to do the remainder of the cooling (scenario 4 from above), the electric chillers where not run. Note the highest demands on the utility system during 2001 came during off peak hours while the cogeneration plant was turned off for economic considerations. The power from NYSEG in 2002 was only what was required to synchronize the generator to utility frequency. Comparing the on peak hours of June 2001 to those of 2002, it is apparent that by displacing electricity that was consumed by the electric chillers in 2001 the hospital has reduced its dependency NYSEG's system.

Figure 9

Gerster Sales and Service
Wyoming County Community Hospital Energy Project
NYSERDA Job # 6551
Facilities Demand on NYSEG System
Before (June 2001) & After (June 2002)
Retrofit



3. Provide a system that allows WCCH to minimize their cooling costs.

As seen in Figure 9 the functionality of a flexible system has been provided. The hospital has been actively managing their energy decisions long before the absorber project. As mentioned else where in this report the hospital ran the cogeneration system on peak only because the high gas prices for a period of nearly a year ending in July 2001. Gerster Trane Energy Services developed the spread sheet tool shown in figure 10 below with the July prices.

Figure 10

Cooling Decision Matrix

Cooling Driver	Equipment Running	Fuel	Price	$ / ton hr	Priority with 7/2002 prices
Cogen Heat	Absorber on cogen heat only	waste heat	free	free	1
Boiler Heat	Absorber on gas fired steam heat	gas	$ 3.000	$ 0.072	
		gas	$ 3.500	$ 0.084	
		gas	$ 4.000	$ 0.096	
		gas	$ 4.350	$ 0.104	3
		gas	$ 5.000	$ 0.120	
		gas	$ 5.500	$ 0.132	
Cogen Electric	Electric chillers on generator power	gas	$ 3.000	$ 0.027	
		gas	$ 3.500	$ 0.031	
		gas	$ 4.000	$ 0.036	
		gas	$ 4.350	$ 0.039	2
		gas	$ 5.000	$ 0.045	
		gas	$ 5.500	$ 0.049	
NYSEG on peak	Electrics on NYSEG power on peak	electric	$ 0.073	$ 0.062	2
NYSEG off peak	Electrics on NYSEG power off peak	electric	$ 0.044	$ 0.037	2
Boiler Heat	Absorber on oil fired steam	oil	$ 0.500	$ 0.086	
		oil	$ 0.600	$ 0.103	
		oil	$ 0.700	$ 0.120	
		oil	$ 0.800	$ 0.137	4
		oil	$ 0.900	$ 0.154	
		oil	$ 1.000	$ 0.171	
		oil	$ 1.100	$ 0.189	

Notes:
1. Current prices (7/2002) are highlighted
2. The electric chillers cannot deferentiate electric sources (cogen or NYSEG) therefore they all have the same priority

The tool is used by looking up the current fuel price for gas, electric and fuel oil. The operating priority is then changed by sorting by the lowest cost per ton hour. NYSEG's average electricity cost was $0.089 per kWh. Because this matrix is looking at marginal production costs, only the variable components of the NYSEG rates are used. Whenever the cogeneration unit is operating the first priority is to base load the absorber with cogeneration heat.

The cost per ton hour for the gas boiler driven absorber is calculated as with the following formula:

$/ton hour = $/mcf*12,000BTUHper ton / (1,000,000 Btu/MCF x.75 boiler efficiency x .66 cop)

The cost per ton hour for the oil boiler driven absorber is calculated as with the following formula:

$/ton hour = $/gallon*12,000BTUHper ton / (140,000 Btu/gallon x.75 boiler efficiency x .66 cop)

The cost per ton hour for the electric chillers is calculated as with the following formula:

$/ton hour = $/kWh* .91 kW per ton.

The marginal electricity components went up to $.067 off peak and $.086 on peak on January 1, 2003. Using the above formulas, it has been determined that when the gas is purchased for less than $3.00 per MCF, it is more economical to run the absorber on gas fired steam.

ECONOMICS

It was shown earlier that the project improves the cogeneration plant fuel conversion efficiency. The added heat recovery improves the economics of the generation plant. Based on the project years gas price the average cost to produce electricity went down by 24%. The project year and the base year have similar power produced, but the project year has significantly more heat recovery credited to the generation costs. The following analysis in tables 5 and 6 compare the marginal production costs before and after the project.

Table 5
Marginal Generation Cost After Retrofit

After Absorber Was Installed (10/01 - 9/02)

Facility Gas Cost		$261,598			
Facility Gas Use		53,534	MCF	=	$4.89 $/MCF
Cogen Fuel Used		37,455	MCF		
	*	$4.89	$/MCF		
		$183,157			
Gas Avoided from Heat Recovery		8,630	MCF		
(heating only heat exchangers)	*	$4.89	$/MCF		
		$42,203			
Gas avoided from Heat Recovery		4,231	MCF		
(absorber heat exchanger)	*	$4.89	$/MCF		
		$20,690			
Cogenerated Electricity		3,148,753	kWh		

Marginal Cost of Cogenerated Electricity

$$\frac{\$183{,}157 - \$62{,}892}{3{,}148{,}753} = \$0.0382 \ \$/kWh$$

Table 6
Marginal Generation Cost Before Retrofit

Before Absorber Was Installed (12/99 - 11/00)
* Summer of 2001, Cogen was not run on off peak time

Cogen Fuel Used		40,990	MCF
	*	$4.89	$/MCF
		$200,443	
Gas Avoided from Heat Recovery		6,845	MCF
(heating only heat exchangers)	*	$4.89	$/MCF
		$33,470	
Cogenerated Electricity		3,340,007	kWh

Marginal Cost of Cogenerated Electricity

$$\frac{\$200{,}443 - \$33{,}470}{3{,}340{,}007} = \$0.0500 \ \$/kWh$$

(Based on 10/01-9/02 Average Gas Price)

Table 7 depicts the ton hours actually produced from the absorber as it was operated in the 2002 cooling season. The tons produced by the absorber come from the trends provided on the enclosed CD in Appendix B. More specifically, the ton hour trend is calculated from the temperature rise across the absorber. To be conservative, credit in kWh is taken at the full load nameplate efficiency.

Table 7

Wyoming County Community Hospital

Actual Absorber Heat Recovery and Steam Ton Hrs

2002 Absorber Ton Hours	kWh Avoided (.91kW/ton)
306,435	278,856

Table 8 shows the total ton hours produced by the entire cooling plant. This trend was derived from the temperature rise across both the absorber and the electric chillers. This table converts total ton hours produced to potential energy savings if all of the cooling had been provided by the absorber. This estimate is again conservative because it is based on the way the system is operating now.

Table 8

Wyoming County Community Hospital

Potential Absorber Ton Hrs with no Electric Cooling

2002 Absorber and Electric Chiller Ton Hours	kWh Avoided (.91kW/ton)
465,868	423,939

Several changes were made to improve the cooling plant between the time this project was conceived and last cooling season. The improvements include an aggressive coil-cleaning project completed by the hospital, more controlled chemical treatment of the cooling tower water, and a new chilled water reset program. The new cooling tower is sized for the absorber, however is oversized for the electric chillers. This improves the overall performance of the electric chillers. The plant improvements are the reason that potential performance shown on Table 8 is different from the original estimate shown in Table 4. While difficult to quantify the actual energy savings from the combined effect of the chilled water plant improvements, it is safe to say that the reported potential savings if compared to the plant before the improvements would be at least 15% greater.

There were exactly twice as many cooling degree-days in the cooling season of 2002 than the 30-year average. Potential savings could be adjusted downward to reflect the average cooling year.

The net heating savings is taken from the difference in heating savings before and after the project at the average gas cost. From Table 6 the heating savings is the $33,470. There were 6342 heating degree days in that period. Table 5 shows a heating savings of $42,203. Knowing that there was 5965 heating degree days in the project year, the savings are adjusted to $44,870. The additional heating derived from the project is has a value of $11,400. The cooling savings are derived from the cogeneration heat put into the absorber. That credit is $20,690 from table 5. The total incremental savings were $32,090. Heating credit savings are maximized when gas prices are high. Cooling savings are maximized when price difference between gas and electric are high. This was not the case for the project year. While the savings would be better with a lower gas price during the cooling season, it is important to remember the hospital was able to minimize its energy costs for cooling by dispatching the plant in a judicious manor. This is not a choice the hospital had in the past.

The total project cost was $706,000 broken down as follows:

Description	Cost
Chiller	$ 168,482
Building and relocation costs	$ 151,117
Cooling Tower	$ 31,852
Exhaust Heat Recovery Unit	$ 33,069
Loop Mechanical equipment	$ 34,514
Loop Electrical equipment	$ 26,944
Mechanical installation	$ 175,280
Electrical installation	$ 23,062
Controls installation	$ 61,681
Total	$ 706,000

The maximum NYSERDA incentive is $353,000, of which $128,000 is performance based. The simple payback to the hospital after all potential NYSERDA incentives is 11 years based on year one savings.

ENVIRONMENTAL BENEFITS

The cogeneration system was installed in 1999, predating the heat recovery improvements. The environmental benefits are related to the reduced electric consumption, and are based on NYSERDA's Technical Assistance Evaluation released in the spring of 2002:

- The maximum reduction potential of 423,939 kWh equates to a N0x reduction of 551 pounds. Actual NOx reduction from the report year of October 2001 to September 2002 was 363 pounds based on 278,856 kWh avoided. An additional 166 pounds of NOx reduction is attributed to the added heat recovery.
- The maximum reduction potential of 423,939 kWh equates to a SO2 reduction of 1,272. Actual SO2 reduction from the report year of October 2001 to September 2002 was 837 pounds based on 278,856 kWh avoided.
- The maximum reduction potential of 423,939 kWh equates to a CO2 reduction of 373,914 pounds. Actual CO2 reduction from the report year of October 2001 to September 2002 was 245,951 pounds based on 278,856 kWh avoided. An additional 194,220 pounds of CO2 reduction is attributed to the added heat recovery.

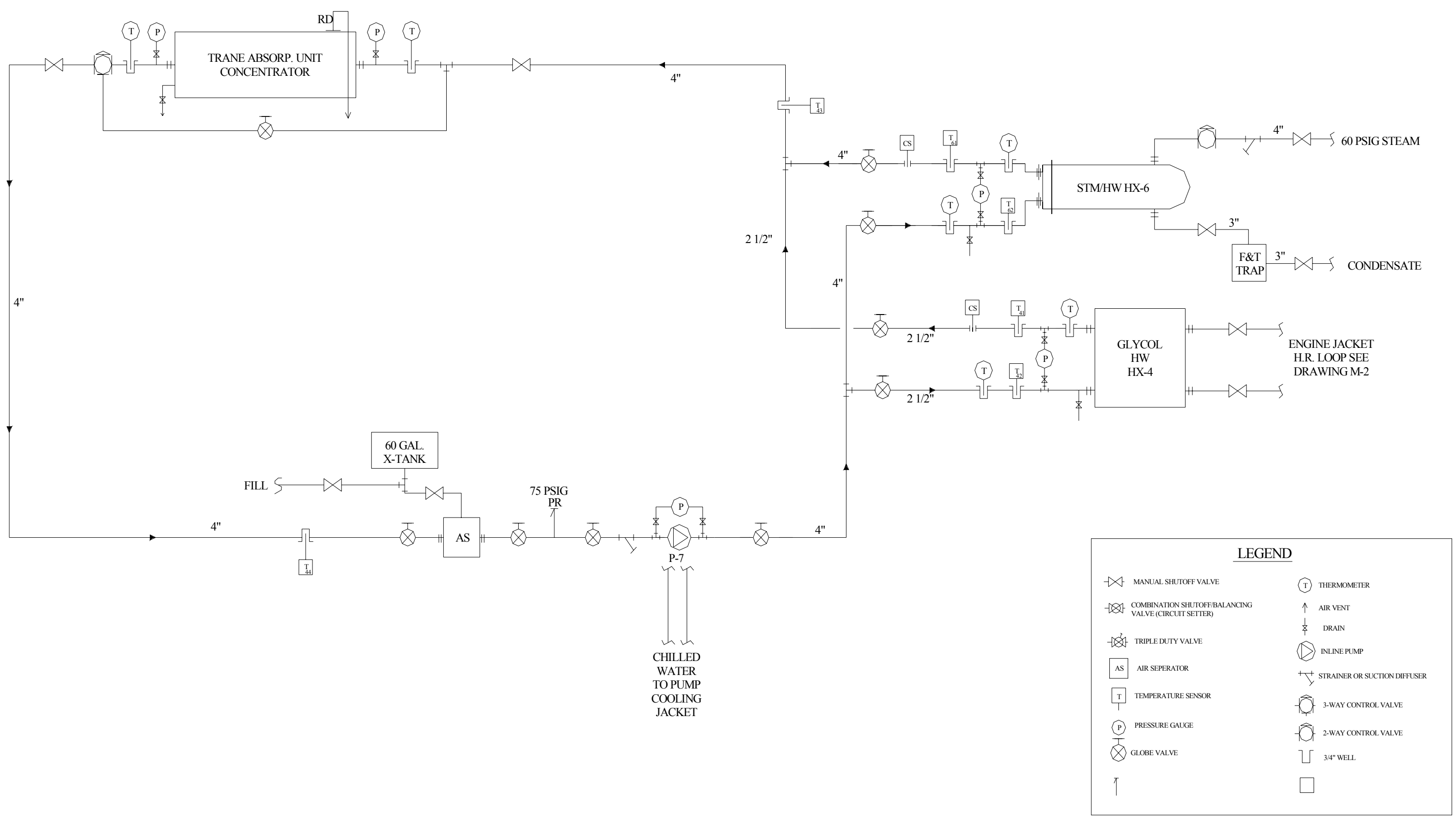
LESSONS LEARNED

From a design and construction standpoint, it proved to be imperative to have the absorber loop heat exchanger inserted into the cogeneration heat recovery loop at a point were the highest quality heat was available. Hospital operation considerations dictated the new chiller was relocated to remote building. This change in location was not originally anticipated. Project commissioning should not be underestimated on a project of this complexity. Significant man hours were spent optimizing flows, approach temperatures, set points and reset schedules to optimize all combinations of absorber (base and fully loaded) and electric chillers (leading and following) on both design cooling days and low need days.

The overall operating savings are greatly affected by two variables that are interrelated and difficult to control, fuel prices and engine down time. The decisions to operate the cooling plant are multi tiered. Cooling can be accomplished with the electric chillers by themselves, or with a combination of electric and absorber. The absorber can be run base loaded only with its only heat input being cogeneration heat, or supplemented with steam from the boiler. The boiler can be fired with either natural gas or fuel oil. The combinations and permutations lead to a priority scheme that can be optimized based on energy prices. The decision is not easy or intuitive, as the effects on the project economics are interactive. To complicate matters further not only are the economics of the hospital affected, but also $128,000 of NYSERDA's incentives is performance based and, therefore, tied to electrical energy savings, which in turn are related to fuel prices.

That being said, the flexibility of the cooling system requires that on a ongoing basis natural gas and electric energy prices are evaluated and certain "break even" energy price points are established so to maximize the lowest cost ton/hour. It is equally important to evaluate gas and electric rate options to maximize future rate structures such as; exposure to hourly electric prices, on-peak and off-peak kW charges, time of use, declining block rates. These analyses are complicated and time consuming, and are bound to become increasingly more so as electric rates change and the hospital becomes more exposed to real time price volatility. An automated dispatch tool is the next logical step of progression for this project. Inputs to the tool would include day-ahead gas fuel and electric prices. A Monte Carlo simulation would be run against parameters including projected cooling need, energy delivery price schedules for both electric and gas, and planned maintenance shutdowns.

The flexibility designed into the system is a great asset for the hospital, as they are poised to optimize their energy decisions for years to come.



WYOMING COUNTY COMMUNITY HOSPITAL

ABSORPTION COOLING PROJECT

400 N. MAIN STREET WARSAW, NY

GERSTER TRANE
45 EARHART DR.
SUITE 103
WILLIAMSVILLE, NY
PHONE: 716-626-1260
FAX: 716-626-9412

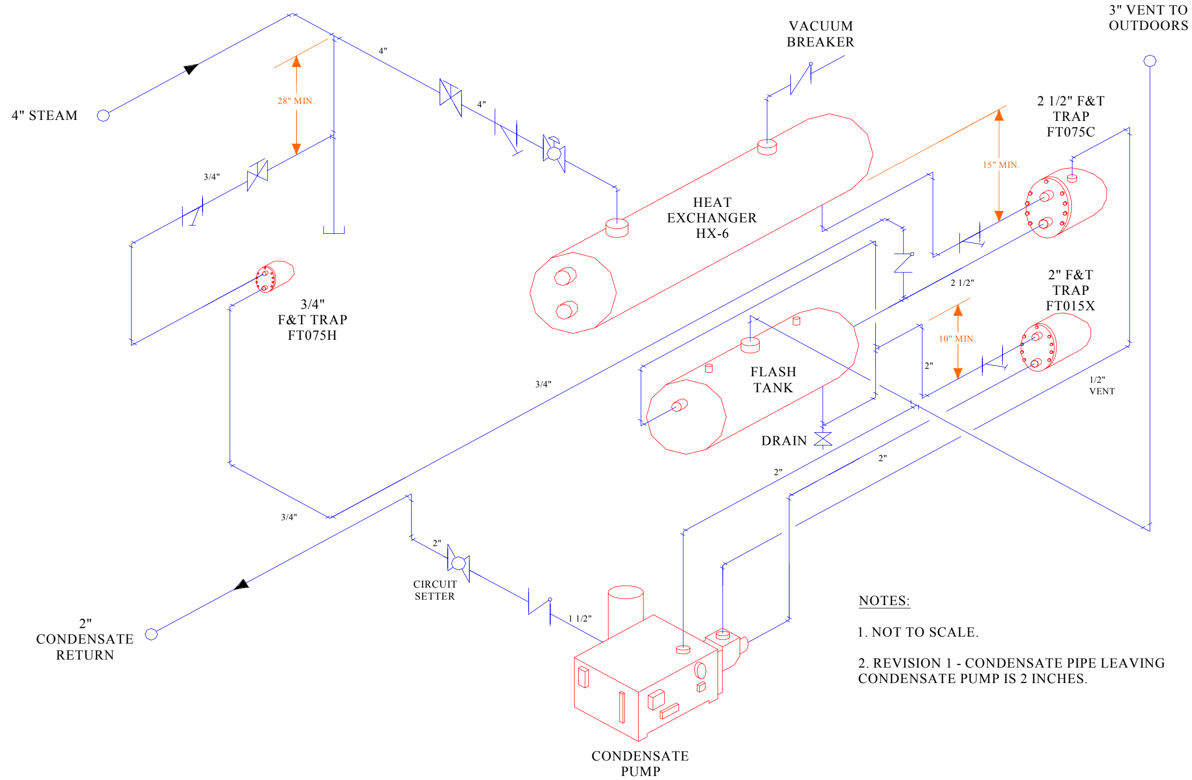
JOB NO.	427309
DATE:	7-03-01
DRAWN BY:	WFL
CHK BY:	TAL
SCALE:	NONE

REVISION

NUM	DATE	BY
1	7-17-01	WFL
2	7-26-01	WFL
3	8-09-01	WFL
4	10-3-01	WFL
5	5-17-02	WFL

DRAWING TITLE:

HOT WATER CONCENTRATOR



NOTES:

1. NOT TO SCALE.

2. REVISION 1 - CONDENSATE PIPE LEAVING CONDENSATE PUMP IS 2 INCHES.

WYOMING COUNTY
COMMUNITY HOSPITAL
ABSORPTION COOLING PROJECT
400 N. MAIN STREET WARSAW, NY

GERSTER
TRANE
45 EARHART DR.
SUITE 103
WILLIAMSVILLE, NY
PHONE: 716-626-1260
FAX: 716-626-9412

JOB NO.	427309
DATE:	9-24-01
DRAWN BY:	WFL
CHK BY:	TAL
SCALE:	NONE

REVISION

NUM	DATE	BY
1	9-28-01	WFL
2	4-5-02	WFL
3	4-12-02	WFL
4	4-22-02	WFL
5	4-26-02	WFL

DRAWING TITLE:

STEAM & CONDENSATE PIPING FOR HX-6

DRAWING NUMBER:

M-7

Appendix

Wyoming County Community Hospital
Outages
CHP Report Year
October 2001 - September 2002

Off Line	On Line	Total Hours Off Line	Reason
10/10/01 3:15 PM	10/10/01 3:30 PM	0:15:00	Engine Related
10/11/01 11:50 AM	10/11/01 2:05 PM	2:15:00	Engine Related
10/15/01 10:55 AM	10/15/01 12:25 PM	1:30:00	Engine Related
10/15/01 1:00 PM	10/15/01 1:45 PM	0:45:00	Engine Related
10/17/01 11:45 PM	10/18/01 12:00 AM	0:15:00	Engine Related
10/21/01 12:45 PM	10/21/01 1:30 PM	0:45:00	Engine Related
10/21/01 2:30 PM	10/21/01 3:00 PM	0:30:00	Engine Related
10/22/01 4:00 PM	10/22/01 4:45 PM	0:45:00	Engine Related
10/27/01 11:00 AM	10/27/01 1:00 PM	2:00:00	Engine Related
10/28/01 8:00 AM	10/29/01 2:15 PM	30:15:00	Construction Related
11/5/01 4:00 PM	11/5/01 4:30 PM	0:30:00	Engine Related
11/10/01 8:00 AM	11/10/01 3:30 PM	7:30:00	Planned Maintenance
11/16/01 10:40 AM	11/16/01 11:25 AM	0:45:00	NYSEG Related
11/22/01 4:00 PM	11/22/01 4:45 PM	0:45:00	NYSEG Related
11/23/01 8:35 AM	11/30/01 11:59 PM	183:24:00	Engine Related
12/1/01 12:00 AM	12/11/01 1:45 PM	253:45:00	Engine Related
12/8/01 8:00 AM	12/8/01 4:00 PM	8:00:00	Planned Maintenance
12/13/01 4:00 PM	12/22/01 5:00 PM	217:00:00	Engine Related
12/26/01 8:45 AM	12/27/01 11:15 AM	26:30:00	Engine Related
12/31/01 4:45 AM	12/31/01 6:15 AM	1:30:00	Engine Related
1/7/02 6:00 AM	1/7/02 6:45 AM	0:45:00	Engine Related
1/7/02 7:15 AM	1/7/02 6:00 PM	10:45:00	Construction Related
1/8/02 8:30 PM	1/8/02 9:00 PM	0:30:00	Engine Related
1/9/02 12:30 PM	1/9/02 1:30 PM	1:00:00	Construction Related
1/12/02 8:15 AM	1/12/02 1:00 PM	4:45:00	Planned Maintenance
1/29/02 3:35 PM	1/29/02 3:50 PM	0:15:00	Engine Related
1/31/02 6:10 PM	1/31/02 6:25 PM	0:15:00	NYSEG Related
1/31/02 6:30 PM	1/31/02 7:30 PM	1:00:00	NYSEG Related
1/31/02 7:30 PM	1/31/02 8:00 PM	0:30:00	NYSEG Related
2/1/02 12:35 PM	2/1/02 1:05 PM	0:30:00	NYSEG Related
2/1/02 1:20 PM	2/1/02 1:50 PM	0:30:00	NYSEG Related
2/5/02 2:05 PM	2/5/02 3:50 PM	1:45:00	NYSEG Related
2/8/02 5:05 AM	2/8/02 5:20 AM	0:15:00	Engine Related
2/8/02 9:20 AM	2/8/02 9:50 AM	0:30:00	Engine Related
2/9/02 8:15 AM	2/9/02 12:00 PM	3:45:00	Planned Maintenance
2/12/02 8:15 AM	2/12/02 8:30 AM	0:15:00	Engine Related
2/14/02 6:40 AM	2/14/02 7:10 AM	0:30:00	Engine Related
2/19/02 10:15 AM	2/19/02 3:00 PM	4:45:00	Engine Related
2/21/02 2:50 PM	2/21/02 6:05 PM	3:15:00	Engine Related
2/22/02 8:15 AM	2/22/02 8:30 AM	0:15:00	Engine Related
2/23/02 8:00 AM	2/23/02 12:45 PM	4:45:00	Engine Related
2/26/02 8:45 PM	2/26/02 11:30 PM	2:45:00	Engine Related

2/28/02 6:00 AM	2/28/02 6:45 AM	0:45:00	Engine Related
3/9/02 8:20 PM	3/9/02 8:25 PM	0:05:00	NYSEG Related
3/9/02 8:10 AM	3/9/02 1:25 PM	5:15:00	Planned Maintenance
3/25/02 2:50 PM	3/25/02 3:35 PM	0:45:00	Engine Related
3/27/02 6:45 AM	3/27/02 8:15 AM	1:30:00	Owner Initiated
4/13/02 12:00 AM	4/13/02 4:45 PM	16:45:00	Planned Maintenance
5/8/02 6:15 PM	5/8/02 6:30 PM	0:15:00	NYSEG Related
5/11/02 8:15 AM	5/18/02 1:15 PM	173:00:00	Planned Maintenance
5/23/02 1:20 PM	5/23/02 1:35 PM	0:15:00	NYSEG Related
5/25/02 11:40 AM	5/25/02 5:25 PM	5:45:00	Construction Related
6/13/02 11:55 AM	6/13/02 12:25 PM	0:30:00	NYSEG Related
6/14/02 9:55 PM	6/14/02 10:10 PM	0:15:00	NYSEG Related
6/19/02 9:45 AM	6/19/02 12:30 PM	2:45:00	NYSEG Related
7/12/02 11:40 PM	7/13/02 9:40 PM	22:00:00	Planned Maintenance
7/17/02 1:10 PM	7/17/02 1:40 PM	0:30:00	Engine Related
7/17/02 1:50 PM	7/17/02 2:05 PM	0:15:00	Engine Related
7/17/02 2:30 PM	7/17/02 3:30 PM	1:00:00	Engine Related
7/17/02 3:50 PM	7/17/02 4:50 PM	1:00:00	Engine Related
8/17/02 8:25 AM	8/23/02 4:00 PM	151:35:00	Engine Related
8/30/02 6:30 PM	9/3/02 7:00 PM	96:30:00	Engine Related
9/9/02 5:15 AM	9/9/02 8:05 AM	2:50:00	NYSEG Related
9/9/02 8:25 AM	9/9/02 8:40 AM	0:15:00	NYSEG Related
9/9/02 12:05 PM	9/9/02 12:45 PM	0:40:00	NYSEG Related
9/9/02 2:45 PM	9/9/02 6:15 PM	3:30:00	NYSEG Related
9/9/02 8:10 PM	9/9/02 8:15 PM	0:05:00	NYSEG Related
9/9/02 8:25 PM	9/9/02 9:20 PM	0:55:00	NYSEG Related
9/12/02 8:20 AM	9/12/02 10:20 AM	2:00:00	Engine Related
9/26/02 10:15 PM	9/26/02 10:45 PM	0:30:00	Engine Related
9/27/02 11:20 PM	9/28/02 12:05 AM	0:45:00	Engine Related
9/28/02 8:10 AM	9/28/02 3:25 PM	7:15:00	Planned Maintenance

NYSERDA Absorption Cooling Project
Agreement No. 6551
Wyoming County Community Hospital
400 North Main Street Warsaw, NY
Gerster Trane Energy Services
45 Earhart Drive
Suites 103 - 108
Buffalo, NY 14221

NG Cost	Oil Used (gal)	Oil Cost	Other Fuel Type	Other Fuel Type Units	Other Fuel Used	Other Fuel Cost	Maintenance Cost	Grid Peak Electricity Consumption	Grid Total Electricity Consumption	Electricity Dollars	Technical Difficulties
$18,974	n/a	n/a	n/a	n/a	n/a	n/a	$3,600	193	118,749	$17,565	
$19,138	n/a	n/a	n/a	n/a	n/a	n/a	$3,600	114.5	80,420	$7,984	
$16,856	n/a	n/a	n/a	n/a	n/a	n/a	$3,600	109.1	210,625	$19,668	MCF calculated from utility bill therms
$21,964	n/a	n/a	n/a	n/a	n/a	n/a	$3,600	106.7	16,699	$14,581	
$20,842	n/a	n/a	n/a	n/a	n/a	n/a	$3,600	25	19,647	$3,628	MCF calculated from utility bill therms
$22,101	n/a	n/a	n/a	n/a	n/a	n/a	$3,600	18.4	16,523	$7,346	
$20,920	n/a	n/a	n/a	n/a	n/a	n/a	$3,600	187.2	20,084	$7,131	
$20,016	n/a	n/a	n/a	n/a	n/a	n/a	$3,600	166.3	84,849	$10,978	
$30,180	n/a	n/a	n/a	n/a	n/a	n/a	$3,600	84.6	18,465	$8,241	
$28,957	n/a	n/a	n/a	n/a	n/a	n/a	$3,600	310.3	46,212	$9,868	
$19,703	n/a	n/a	n/a	n/a	n/a	n/a	$3,600	195.8	137,809	$4,687	
$21,947	n/a	n/a	n/a	n/a	n/a	n/a	$3,600	371.2	67,142	$16,402	
$261,598							$43,200	n/a	837,225	$128,080	

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Prime Mover #	Start Date	End Date	Hours Run	kWh Output	Heat Recovered MMBtu	Heat Recovery Medium	Fuel Type	Fuel Units	Fuel Used	Technical Difficulties
Engine #1	10/01/01	10/31/01	479	242,323	284.0	Glycol	Nat Gas	MCF	2,245	
Engine #1	11/01/01	11/30/01	527	229,489	480.2	Glycol	Nat Gas	MCF	2,300	
Engine #1	12/01/01	12/31/01	245	84,547	327.1	Glycol	Nat Gas	MCF	836	
Engine #1	01/01/02	01/31/02	724	284,120	1142.1	Glycol	Nat Gas	MCF	2,723	
Engine #1	02/01/02	02/28/02	648	246,489	1027.8	Glycol	Nat Gas	MCF	2,389	
Engine #1	03/01/02	03/31/02	729	280,184	996.73	Glycol	Nat Gas	MCF	2,749	
Engine #1	04/01/02	04/30/02	708	297,977	769	Glycol	Nat Gas	MCF	2,851	
Engine #1	05/01/02	05/31/02	565	238,746	674.6	Glycol	Nat Gas	MCF	2,306	
Engine #1	06/01/02	06/30/02	716	329,414	915.7	Glycol	Nat Gas	MCF	3,147	
Engine #1	07/01/02	07/31/02	716	364,445	630.2	Glycol	Nat Gas	MCF	3,403	
Engine #1	08/01/02	08/31/02	559	270,306	914.3	Glycol	Nat Gas	MCF	2,547	
Engine #1	09/01/02	09/30/02	634	280,071	851.6	Glycol	Nat Gas	MCF	2,709	
Total			7,251	3,148,112	9,013				30,206	

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Wyoming County Community Hospital
400 North Main Street Warsaw, NY
Gerster Trane Energy Services
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Buffalo, NY 14221

Prime Mover #	Date	Downtime Due to Repair in hours	Planned?	Maintenance Activity	Cost of Maintenance
Engine #1	Oct-01	n/a	yes	planned maintenance	**$3,600**
Engine #1	Nov-01	n/a	yes	planned maintenance	**$3,600**
Engine #1	Dec-01	n/a	yes	planned maintenance	**$3,600**
Engine #1	Jan-02	n/a	yes	planned maintenance	**$3,600**
Engine #1	Feb-02	n/a	yes	planned maintenance	**$3,600**
Engine #1	Mar-02	n/a	yes	planned maintenance	**$3,600**
Engine #1	Apr-02	n/a	yes	planned maintenance	**$3,600**
Engine #1	May-02	n/a	yes	planned maintenance	**$3,600**
Engine #1	Jun-02	n/a	yes	planned maintenance	**$3,600**
Engine #1	Jul-02	n/a	yes	planned maintenance	**$3,600**
Engine #1	Aug-02	n/a	yes	planned maintenance	**$3,600**
Engine #1	Sep-02	n/a	yes	planned maintenance	**$3,600**
Total					**$43,200**