Honeywell

Modular Integrated Energy Systems

Task 6 Field Monitoring Interim Report Period Covered: June 2004–December 2004

March 24, 2005

Prepared for:

Oak Ridge National Laboratory
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Section 1. Introduction

This document presents the results of Honeywell's data collection activity for the integrated energy system (or CHP -- Cooling, Heat and Power) system at Ft. Bragg. Much of this work is funded by the U.S. Department of Energy, thru Oak Ridge National Laboratory (ORNL). Honeywell is providing significant cost sharing in this development. A brief description of the overall project is presented in the following paragraphs.

The objective of the ORNL project is to develop packaging technologies for large (2 to 5 MW) integrated energy systems (IES) and field-test a prototype design. The major equipment at the Ft. Bragg site consists of a gas turbine-generator, a heat recovery steam generator, and a waste heat fired absorption chiller. The key goals of the project are:

- Develop a set of "reference" CAD-based IES modular system designs,
- Develop a supervisory control system having on-line optimization,
- Develop a 1000 Ton exhaust-driven absorption chiller,
- Install and monitor the performance of a prototype IES modular system employing the above technologies

The installation site for the packaged IES system is the 82nd Heating Plant at Ft. Bragg, NC. The 82nd plant serves a large number of barracks and other buildings with steam for heating and domestic hot water, and chilled water for cooling. This project is allied with on-going work by the Honeywell's Energy Services Team, serving as a provider of Energy Services Performance Contract (ESPC) services to the U.S. Army at Ft. Bragg. In a related activity, the Honeywell Energy Services Team at Ft. Bragg is also collaborating with the U.S. DOE's Federal Energy Management (FEMP) Program (thru Oak Ridge National Laboratory) to enable the 82nd Central Plant at Ft. Bragg to serve as a showcase IES site for the FEMP program.

1.1 Data Acquisition Overview

This DOE/ORNL funded project includes a period of field performance monitoring for the IES System at the Ft. Bragg 82nd Central Heating Plant. During this period, certain performance data will be collected and analyzed to produce summary reports describing the measured performance of the system. The following sections describe the details of the data collection activity.

1.1.1 Objective

Performance data have been collected by the project team, and made available to a number of interested parties. The data will be used for the following purposes:

- Field monitoring of absorption chiller performance. BroadUSA will monitor the chiller's operation and performance during the field monitoring period of the project.
- Field monitoring of the system control and optimization performance. Honeywell will monitor the performance of the CHP Manager optimization software during the field monitoring period. (Note: Results of this work will be reported separately.)

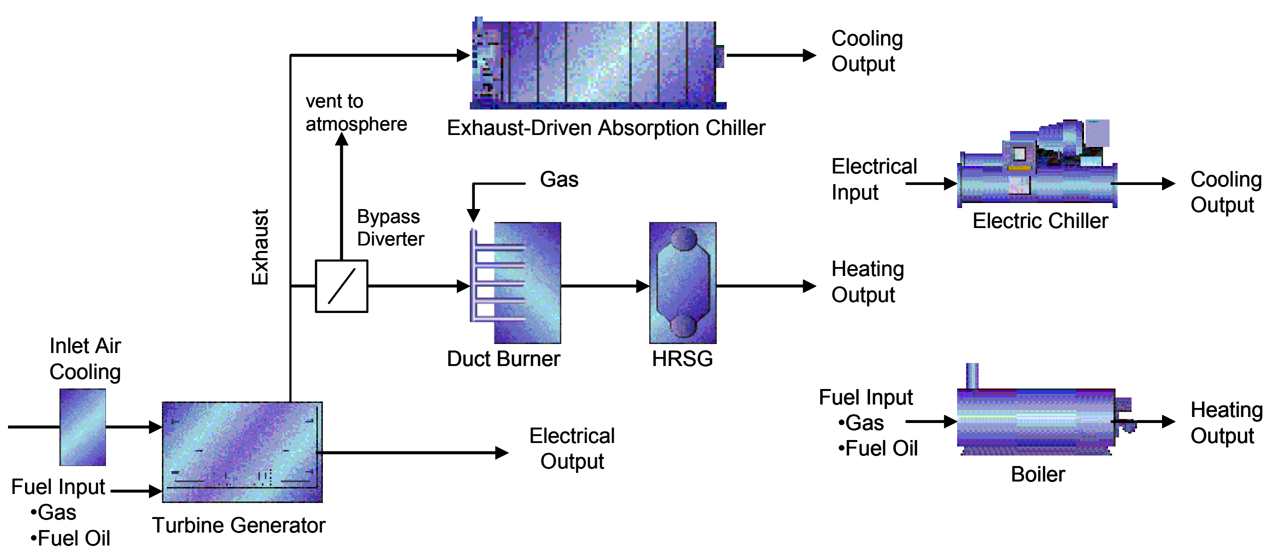
- Sharing of equipment operating data with researchers at Oak Ridge National Lab. These groups are using the data to construct advanced models of IES equipment, as part of other technical work that is not directly associated with this project.
- Sharing of system operational data with researchers at the DOE FEMP Program Office. This activity is in accordance with the memorandum of understanding between DOE, Honeywell, and the U.S. Army, and is related to Honeywell's Energy Services Performance Contract (ESPC) services to the Army at Ft. Bragg.

1.1.2 Other Related Work

As part of the Honeywell's ESPC contract with the Army at Ft. Bragg, there will be a separate activity for Measurement and Verification (M&V) of energy use and cost savings. The M&V activity addresses only the heating portion of the system (installed under the ESPC), and will be accomplished separately (and is not related to this data collection and analysis activity).

1.2 System Overview

A block diagram of the Ft. Bragg 82nd Central Heating Plant IES system is shown in the figure below.



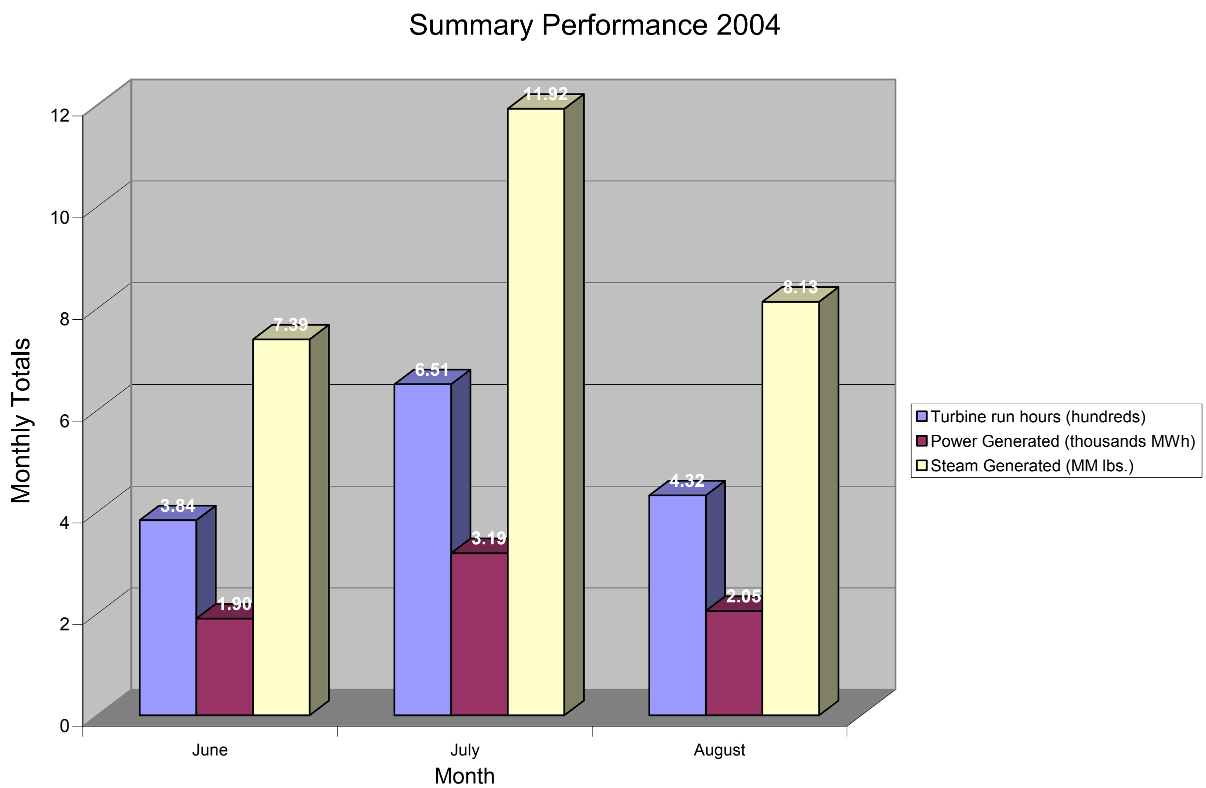
The major equipment in the system consists of a 5MW gas turbine generator, a 1000 ton exhaust-driven absorption chiller, a heat recovery steam generator (HRSG), and a duct burner. Additional technical information is included in a later section of this report.

Section 2. Summary Performance Results

The performance results are arranged by season, with the months of June thru August reported together as the summer months and the months of September thru December reported together as the fall months. Summary performance results are presented in the following sections.

2.1 Summary Performance Results: Summer 2004

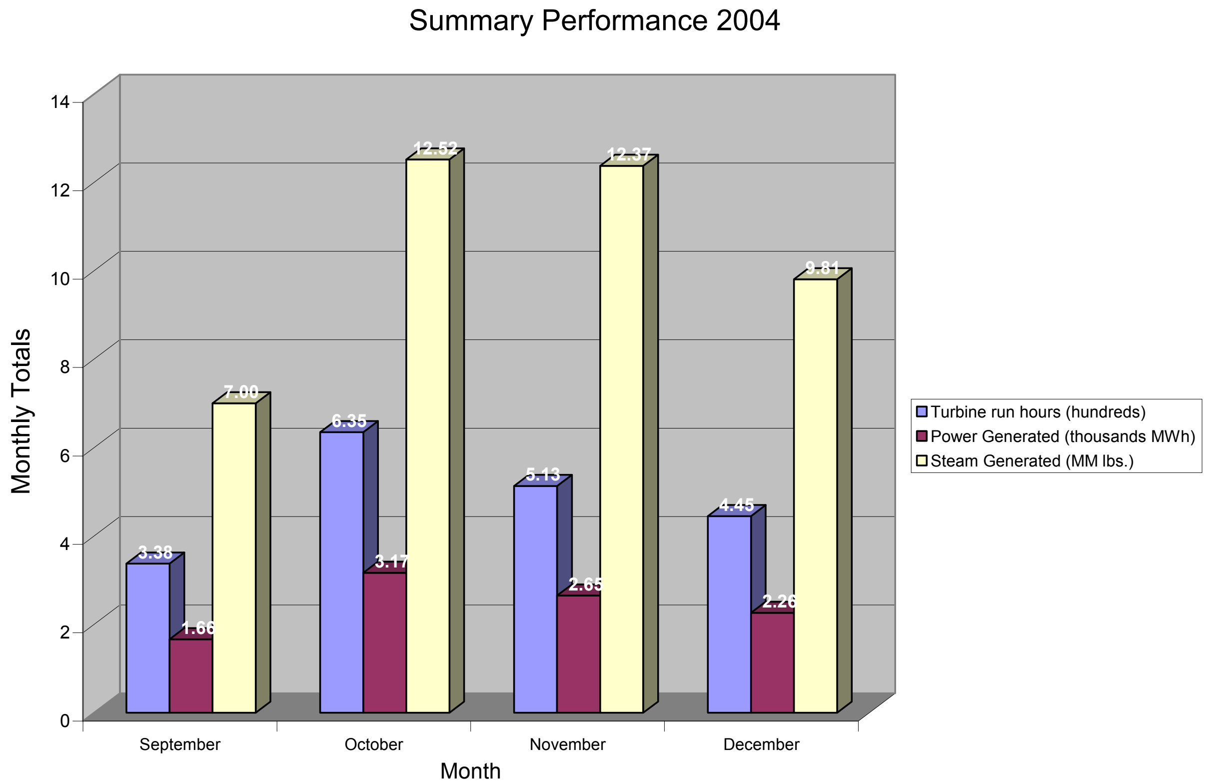
The high level summary results for the summer months of 2004 are shown in the following figure and table.



	Summary Performance Data		
Month	Turbine run hours	Power Generated (MW)	Steam Generated (MM lbs.)
June	384	1,904,408	7,392,141
July	651	3,189,374	11,923,695
August	432	2,053,839	8,130,529

2.2 Summary Performance Results: Fall 2004

The high level summary results for the fall months of 2004 are shown in the following figure and table.



	Summary Performance Data		
Month	Turbine run hours	Power Generated (MW)	Steam Generated (MM lbs.)
September	338	1,664,393	7,001,374
October	635	3,169,605	12,520,358
November	513	2,654,199	12,374,470
December	445	2,262,950	9,808,411

Section 3. Detailed Performance Results: Summer 2004

The detailed performance results are arranged by season, with the months of June thru August reported together as the summer months and the months of September thru December reported together as the fall months. Detailed performance results for the summer period are presented in the following sections.

3.1 Detailed Performance Results: June 2004

The detailed performance results for the month of June 2004 are shown in the table and figure on the following pages.

Field observations noted during the month of June are:

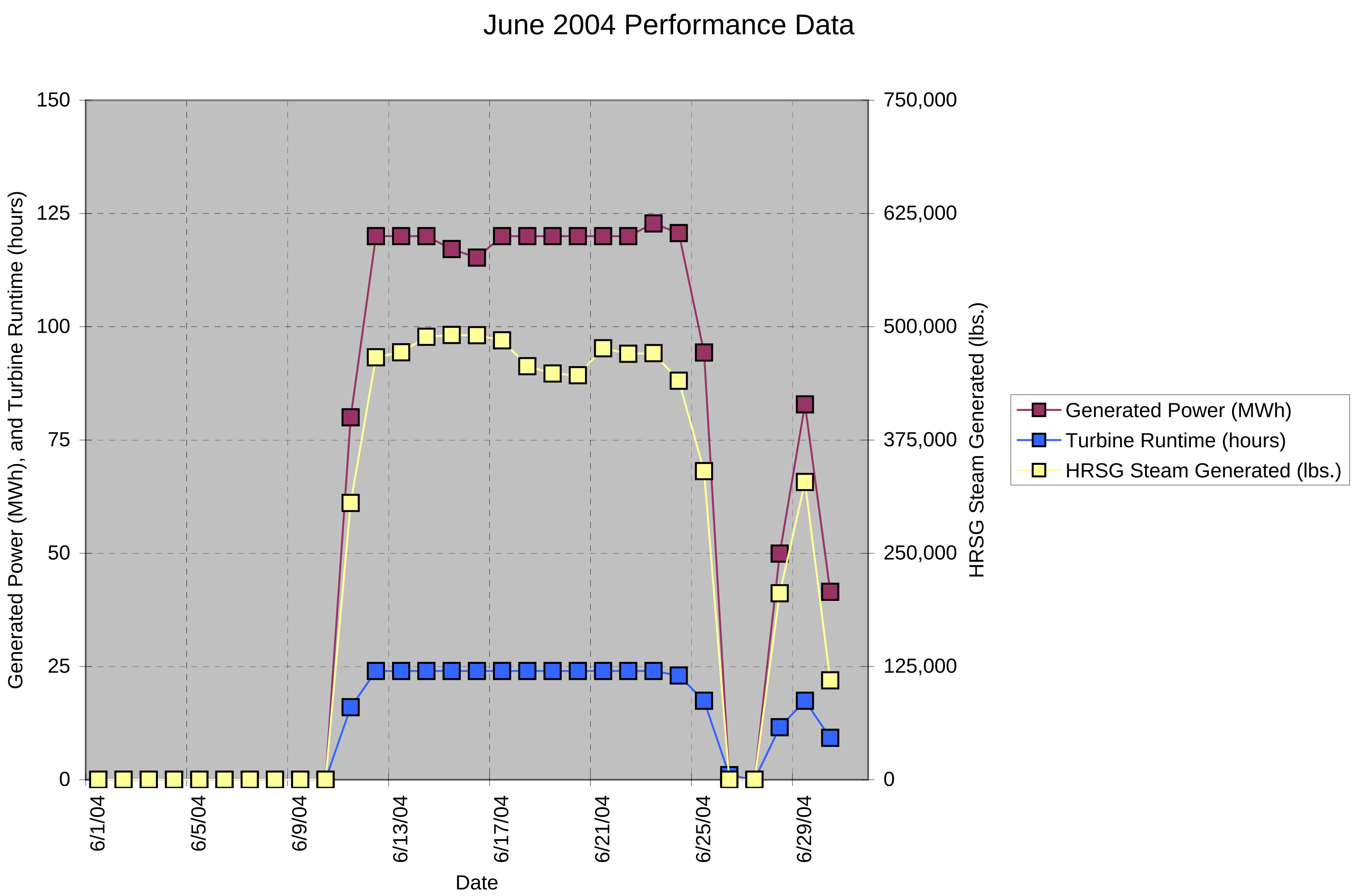
- Although the key IES equipment was operational during the month of May, some of the final commissioning activities continued into June. This resulted in a few short periods of lost operation. However this was not a problem for the buildings on the post, as the auxiliary equipment (conventional steam boiler and electric chiller) were utilized to serve the thermal loads during these periods.
- The collection of performance data began on June 11, with the completion of sensor calibration for the key instrumentation. Data collection then continued for the balance of the month. The monthly totals shown above do not include the period prior to June 11.
- Control interfaces to the absorption chiller were not complete during this period. Some checkout of the chiller did occur during the month, but had a very small impact on the system performance. More effort on chiller startup occurred during the following month.
- Data for natural gas flow to the turbine generator was not available during this month, due to problems with calibration of the flow sensor instrument. (These problems were corrected during the month of August.)

Data analysis comments for the month are:

- Even with the occasional periods of lost operation, the system's performance was very good during the month.

Detailed performance data pertaining to each item of major equipment was not available due to the problems with the natural gas flow instrumentation. This data has been collected and presented for the months of September onward.

Date	Measured Data			
	Generated Power (MWh)	HRSG Steam Generated (lbs.)	Turbine Runtime (hours)	Aux. Boiler#5 Runtime (hours)
1-Jun-04	*N/A*	*N/A*	*N/A*	*N/A*
2-Jun-04	*N/A*	*N/A*	*N/A*	*N/A*
3-Jun-04	*N/A*	*N/A*	*N/A*	*N/A*
4-Jun-04	*N/A*	*N/A*	*N/A*	*N/A*
5-Jun-04	*N/A*	*N/A*	*N/A*	*N/A*
6-Jun-04	*N/A*	*N/A*	*N/A*	*N/A*
7-Jun-04	*N/A*	*N/A*	*N/A*	*N/A*
8-Jun-04	*N/A*	*N/A*	*N/A*	*N/A*
9-Jun-04	*N/A*	*N/A*	*N/A*	*N/A*
10-Jun-04	*N/A*	*N/A*	*N/A*	*N/A*
11-Jun-04	*80*	305,453	*16*	0
12-Jun-04	*120*	466,208	*24*	0
13-Jun-04	*120*	471,801	*24*	0
14-Jun-04	*120*	488,842	*24*	0
15-Jun-04	117	490,926	24	0
16-Jun-04	115	490,554	24	0
17-Jun-04	*120*	485,012	*24*	0
18-Jun-04	*120*	456,440	*24*	0
19-Jun-04	*120*	448,387	*24*	0
20-Jun-04	*120*	446,408	*24*	0
21-Jun-04	*120*	476,198	*24*	0
22-Jun-04	*120*	470,125	*24*	1
23-Jun-04	123	470,837	24	0
24-Jun-04	121	440,421	23	3
25-Jun-04	94	340,562	17	7
26-Jun-04	0	0	1	24
27-Jun-04	0	0	0	24
28-Jun-04	50	205,747	12	14
29-Jun-04	83	328,607	17	8
30-Jun-04	41	109,613	9	24
totals	1,904	7,392,141	384	105
Note: Values in italics are estimates that replace missing data				


June 2004 Performance Data
Generated Power (MWh), and Turbine Runtime (hours)
150
125
100
75
50
25
0
HRSG Steam Generated (lbs.)
750,000
625,000
500,000
375,000
250,000
125,000
0
6/1/04
6/5/04
6/9/04
6/13/04
6/17/04
6/21/04
6/25/04
6/29/04
Date
Generated Power (MWh)
Turbine Runtime (hours)
HRSG Steam Generated (lbs.)

3.2 Detailed Performance Results: July 2004

The detailed performance results for the month of July 2004 are shown in the table and figure on the following pages.

Field observations noted during the month of July are:

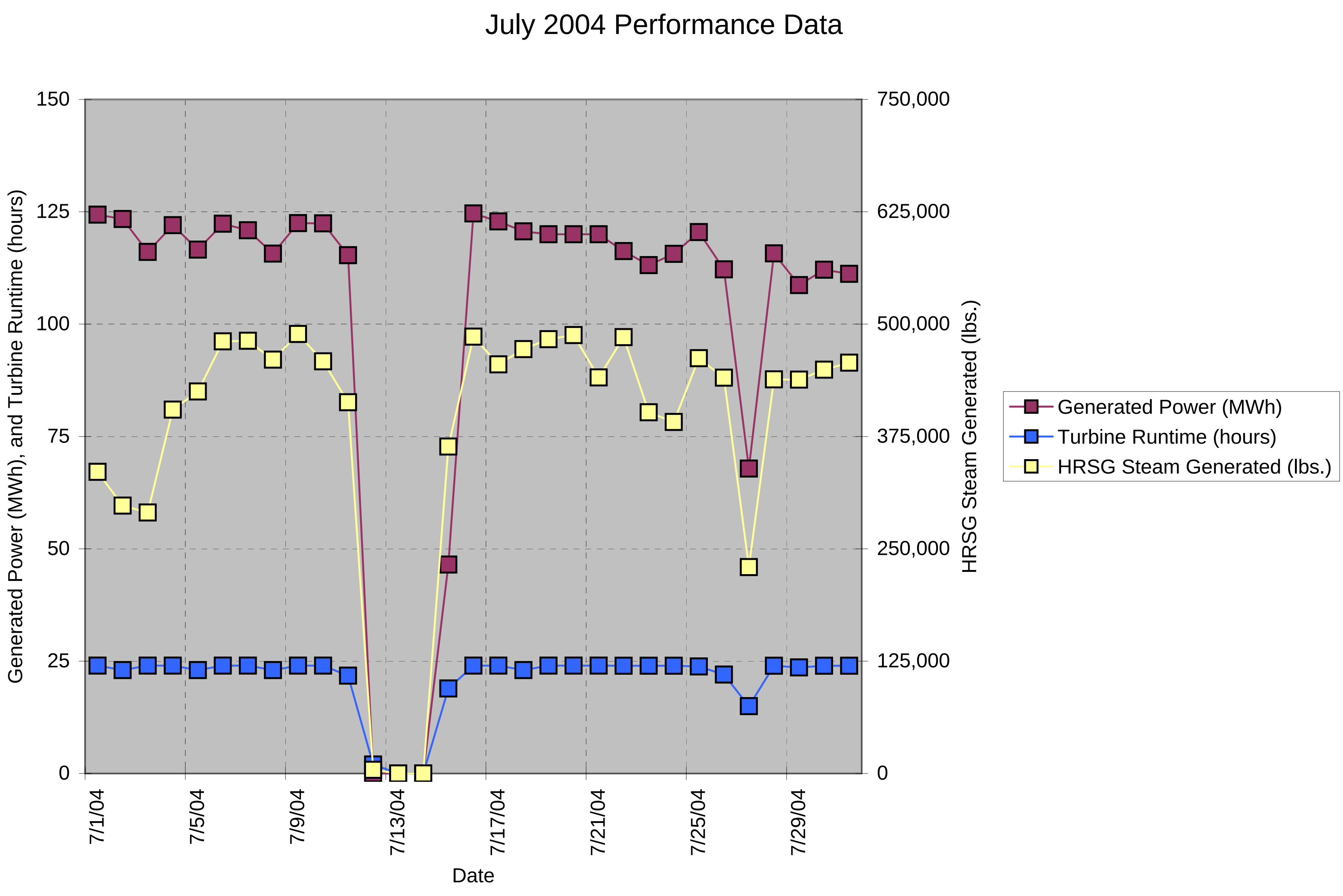
- A few periods of lost operation occurred during the month. The causes were:
  - Problems with various items of the IES hardware (i.e. the chiller guillotine damper, etc.). These were generally corrected fairly quickly.
  - Lightning strikes at the nearby electric substation. These strikes caused a trip of the protective relays on the turbine's main circuit, shutting down the unit. The relays were reset generally within a few hours.
  - A few occasional protective trips internal to the turbine generator's controls. These problems were generally resolved quickly.
- Control interfaces to the absorption chiller were completed during this period. Some checkout of the chiller occurred during the month, but had a small impact on the system performance. More effort on chiller startup occurred during the following month.
- Data for natural gas flow to the turbine generator was not available during this month, due to problems with calibration of the flow sensor instrument. (These problems were corrected during the month of August.)

Data analysis comments for the month are:

- Even with the occasional periods of lost operation, the system's performance was very good during the month.

Detailed performance data pertaining to each item of major equipment was not available due to the problems with the natural gas flow instrumentation. This data has been collected and presented for the months of September onward.

	Measured Data			
Date	Generated Power (MWh)	HRSG Steam Generated (lbs.)	Turbine Runtime (hours)	Aux. Boiler#5 Runtime (hours)
1-Jul-04	124	335,549	24	24
2-Jul-04	123	298,022	23	24
3-Jul-04	116	290,418	24	24
4-Jul-04	122	404,787	24	5
5-Jul-04	117	425,053	23	2
6-Jul-04	122	480,799	24	0
7-Jul-04	121	481,466	24	0
8-Jul-04	116	460,441	23	2
9-Jul-04	122	488,947	24	0
10-Jul-04	122	458,595	24	0
11-Jul-04	115	413,091	22	3
12-Jul-04	0	4,025	2	24
13-Jul-04	0	14	0	24
14-Jul-04	0	24	0	24
15-Jul-04	46	363,729	19	7
16-Jul-04	125	486,067	24	0
17-Jul-04	123	455,172	24	0
18-Jul-04	121	472,106	23	1
19-Jul-04	*120*	483,245	*24*	2
20-Jul-04	*120*	487,807	*24*	1
21-Jul-04	*120*	440,632	*24*	3
22-Jul-04	116	485,567	24	1
23-Jul-04	113	401,907	24	13
24-Jul-04	116	391,072	24	11
25-Jul-04	120	462,102	24	0
26-Jul-04	112	440,325	22	6
27-Jul-04	68	229,669	15	16
28-Jul-04	116	438,470	24	8
29-Jul-04	109	438,286	24	6
30-Jul-04	112	449,215	24	6
31-Jul-04	111	457,097	24	0
totals	3,189	11,923,695	651	237
Note: Values in italics are estimates that replace missing data				



July 2004 Performance Data
Generated Power (MWh), and Turbine Runtime (hours)
HRSG Steam Generated (lbs.)
150
125
100
75
50
25
0
750,000
625,000
500,000
375,000
250,000
125,000
0
7/1/04
7/5/04
7/9/04
7/13/04
7/17/04
7/21/04
7/25/04
7/29/04
Date
Generated Power (MWh)
Turbine Runtime (hours)
HRSG Steam Generated (lbs.)

3.3 Detailed Performance Results: August 2004

The detailed performance results for the month of August 2004 are shown in the table and figure on the following pages.

Field observations noted during the month of August are:

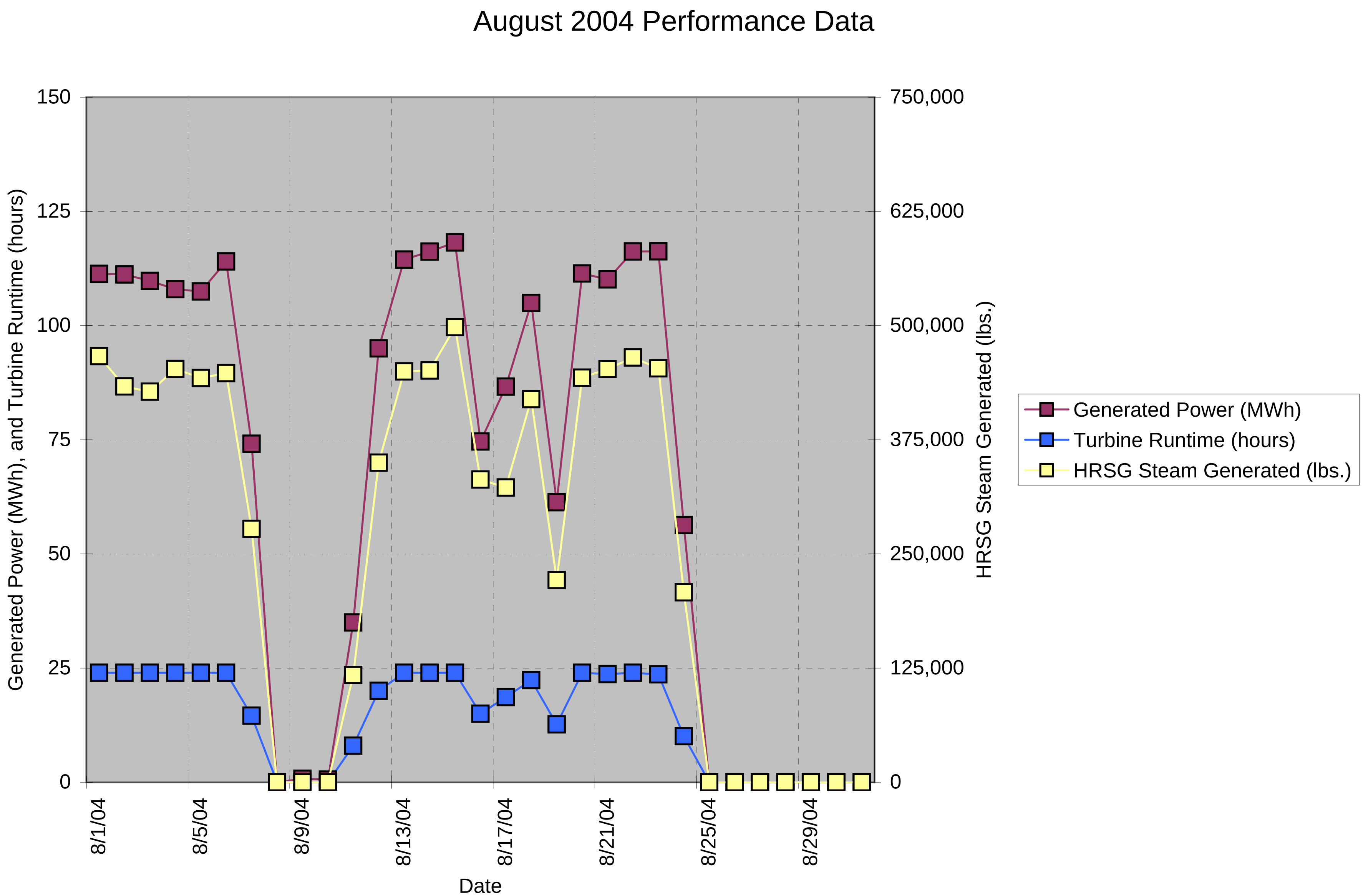
- A few periods of lost operation occurred during the month. The causes were:
  - Problems with various items of the IES hardware (i.e. the chiller guillotine damper, etc.). These were generally corrected fairly quickly.
  - Lightning strikes at the nearby electric substation. These strikes caused a trip of the protective relays on the turbine's main circuit, shutting down the unit. The relays were reset generally within a few hours.
  - A few occasional protective trips internal to the turbine generator's controls. These problems were generally resolved quickly.
- Checkout of the chiller continued during the month, but was not completed due to problems with the chiller guillotine damper. This startup work did have an impact on the system performance. More effort on chiller startup was deferred to the spring of 2005, following repairs to the chiller guillotine damper made in September.
- The IES system was shut down during the last few days of the month, due to the lack of an operating permit from the North Carolina Dept. of Environment and Natural Resources (NCDENR). This permit was received in mid September, and operation was resumed at that time.
- Data for natural gas flow to the turbine generator was not available during this month, due to problems with calibration of the flow sensor instrument. These problems were corrected during the month.

Data analysis comments for the month are:

- Even with the occasional periods of lost operation, the system's performance was very good during the month.

Detailed performance data pertaining to each item of major equipment was not available due to the problems with the natural gas flow instrumentation. This data has been collected and presented for the months of September onward.

	Measured Data			
Date	Generated Power (MWh)	HRSG Steam Generated (lbs.)	Turbine Runtime (hours)	Aux. Boiler#5 Runtime (hours)
1-Aug-04	111	466,522	24	0
2-Aug-04	111	433,330	24	7
3-Aug-04	110	427,628	24	6
4-Aug-04	108	452,474	24	5
5-Aug-04	107	442,536	24	6
6-Aug-04	114	447,956	24	6
7-Aug-04	74	277,396	15	10
8-Aug-04	0	54	0	24
9-Aug-04	1	45	0	24
10-Aug-04	1	62	0	24
11-Aug-04	*35*	117,470	*8*	18
12-Aug-04	*95*	349,901	*20*	6
13-Aug-04	114	449,804	24	0
14-Aug-04	116	450,820	24	0
15-Aug-04	118	498,248	24	0
16-Aug-04	75	331,445	15	9
17-Aug-04	87	322,682	19	14
18-Aug-04	105	419,365	22	8
19-Aug-04	61	221,267	13	16
20-Aug-04	111	442,881	24	8
21-Aug-04	110	452,389	24	1
22-Aug-04	116	465,026	24	5
23-Aug-04	116	453,236	24	7
24-Aug-04	56	207,969	10	17
25-Aug-04	0	24	0	24
26-Aug-04	0	0	0	24
27-Aug-04	0	0	0	24
28-Aug-04	0	0	0	24
29-Aug-04	0	0	*0*	24
30-Aug-04	0	0	*0*	24
31-Aug-04	0	0	0	24
totals	2,054	8,130,529	432	389
Note: Values in italics are estimates that replace missing data				


August 2004 Performance Data
150
125
100
75
50
25
0
750,000
625,000
500,000
375,000
250,000
125,000
0
Generated Power (MWh), and Turbine Runtime (hours)
HRSG Steam Generated (lbs.)
8/1/04
8/5/04
8/9/04
8/13/04
8/17/04
8/21/04
8/25/04
8/29/04
Date
Generated Power (MWh)
Turbine Runtime (hours)
HRSG Steam Generated (lbs.)

Section 4. Detailed Performance Results: Fall 2004

Detailed performance results for the fall period (September thru December) are presented in the following sections. The data for each month is presented in a set of key tables and figures, as follows:

Table or Figure	Data Presented
Summary Data Table	Measured and calculated daily performance indices
Monthly Overview	High level summary of system performance for the month. The parasitic power includes the gas compressor, condensate pump and the boiler/HRSG feedwater pump.
Daily Performance	Daily totals for key performance indices
System Net Energy Efficiency	Hourly data for overall system net energy efficiency (power output plus steam output, divided by fuel energy input) plotted as a function of outdoor ambient temperature. Error bars showing the degree of uncertainty in the data, are shown in the figures. The design data curve includes an estimated 2% in energy losses from the system (for diverter losses, heat loss from ductwork, leaks, etc.). The design data curve also assumes that all exhaust is sent to the HRSG (no diverter losses required to match the thermal load, and no operation of the absorption chiller). As such, this design curve is valid only for the conditions stated above (data analysis for cooling months with operation of the absorption chiller will be handled in a different manner). Note: Some outliers are seen in the plotted data, due to startup periods (or due to bad data and the very limited amount of data cleaning and filling that was done).
Diverter Energy Losses	Selected hourly data for overall net system energy efficiency (power output plus steam output divided by fuel energy input) plotted as a function of diverter damper position. This plot shows the effect of unrecovered energy that is lost thru the diverter in order to maintain the specified steam pressure leaving the heat recovery steam generator (HRSG). This is selected data representing periods of low diverter losses. Error bars showing the degree of uncertainty in the data, are shown in the figures.
Turbine Generator Performance	Hourly data for the turbine generator heat rate and power output, plotted as a function of outdoor ambient temperature. Error bars showing the degree of uncertainty in the data, are shown in the figures. Note: Some outliers are seen in the plotted data, due to startup periods (or due to bad data and the very limited amount of data cleaning and filling that was done).
HRSG Performance	Selected hourly data for the HRSG steam output, plotted as a function of inlet exhaust temperature. This is selected data representing periods of low diverter losses. Error bars showing the degree of uncertainty in the data, are shown in the figures.

4.1 Detailed Performance Results: September 2004

Detailed performance results for the month of September 2004, are shown in the table and figures on the following pages.

Field observations noted during the month are:

- There was no operation of the absorption chiller during the month.
- The IES system was off-line during the first half of the month, due to the lack of an operating permit from the North Carolina Dept. of Environment and Natural Resources (NCDENR). This permit was received in mid September, and operation was resumed at that time.
- Very little simultaneous operation of the auxiliary boiler during the month.
- The duct burner was not operational during this period (waiting for replacement of control components that were damaged by rain water seeping into the motor operators). This was not a problem because the steam load was less than the unfired capacity of the HRSG. The problems with the duct burner controls were corrected in March 2005.

Data analysis comments for the month are:

Table or Figure	Analysis Comments
Summary Data Table	Other than the period of lost operation, the system's performance was very good during the month.
Monthly Overview	The amount of unrecovered energy was greater than desired due to the relatively low steam load in the fall season.
Daily Performance	See comments above.
System Net Energy Efficiency	System net energy efficiency was lower than design, due to extended periods of significant diverter losses required to match the steam load.
Diverter Energy Losses	See comment above.
Turbine Generator Performance	Very good performance, the measured data matches well with the design data (within the expected uncertainty).
HRSG Performance	Good performance, given the diverter losses that were present in some of the data.

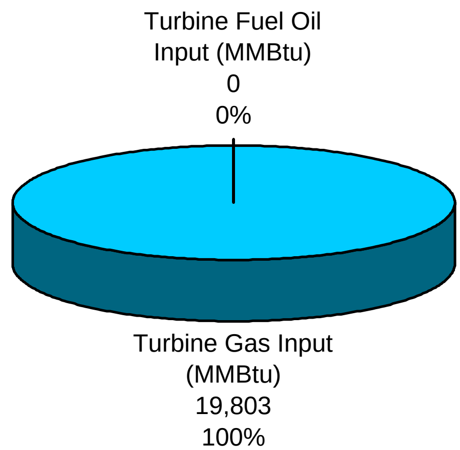
Additional plots of more detailed operating data are presented in Appendix A.

	Measured Data						Calculated Results							
Date	Generated Power (MWh)	HRSG Steam Generated (lbs.)	Turbine Nat. Gas Consumed (MCF)	Turbine Fuel Oil Consumed (gal.)	Turbine Runtime (hours)	Aux. Boiler#5 Runtime (hours)	Turbine Natural Gas Input (MMBtu)	Turbine Fuel Oil Input (MMBtu)	Turbine Total Energy Input (MMBtu)	HRSG Steam Output (MMBtu)	Turbine Power Output (MMBtu)	Total CHP Output (MMBtu)	Net Daily System Efficiency (%)	Parasitic Energy (MWh)
1-Sep-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
2-Sep-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
3-Sep-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
4-Sep-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
5-Sep-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
6-Sep-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
7-Sep-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
8-Sep-04	0	0	2	0	0	23	2	0	2	0	0	0	N/A	0.0
9-Sep-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
10-Sep-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
11-Sep-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
12-Sep-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
13-Sep-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
14-Sep-04	0	0	0	0	0	16	0	0	0	0	0	0	N/A	0.0
15-Sep-04	0	0	0	0	0	0	0	0	0	0	0	0	N/A	0.0
16-Sep-04	55	229,269	648	0	13	1	672	0	672	242	188	430	57.0	1.4
17-Sep-04	115	522,948	1,331	0	24	0	1,380	0	1,380	552	393	945	67.9	2.5
18-Sep-04	120	506,715	1,375	0	24	0	1,426	0	1,426	535	408	943	65.6	2.5
19-Sep-04	123	519,988	1,416	0	24	0	1,469	0	1,469	549	420	969	65.4	2.5
20-Sep-04	125	531,830	1,428	0	24	2	1,481	0	1,481	562	426	988	66.1	2.5
21-Sep-04	124	535,207	1,412	0	24	1	1,464	0	1,464	565	421	987	66.8	2.5
22-Sep-04	71	297,467	809	0	14	11	839	0	839	314	241	555	64.0	1.5
23-Sep-04	118	537,093	1,353	0	24	1	1,404	0	1,404	567	403	971	68.6	2.5
24-Sep-04	118	500,526	1,351	0	24	0	1,401	0	1,401	529	403	932	65.9	2.5
25-Sep-04	119	419,831	1,358	0	24	1	1,408	0	1,408	443	407	850	59.8	2.5
26-Sep-04	119	444,784	1,357	0	24	0	1,407	0	1,407	470	405	875	61.6	2.5
27-Sep-04	116	494,329	1,336	0	24	2	1,386	0	1,386	522	396	918	65.7	2.5
28-Sep-04	115	495,854	1,319	0	24	0	1,368	0	1,368	524	392	916	66.3	2.5
29-Sep-04	117	494,753	1,336	0	24	0	1,386	0	1,386	522	399	922	65.9	2.5
30-Sep-04	110	470,778	1,265	0	23	2	1,311	0	1,311	497	375	872	64.8	2.4
totals	1,664	7,001,374	19,096	0	338	349	19,803	0	19,803	7,393	5,679	13,072	65.4	35.7

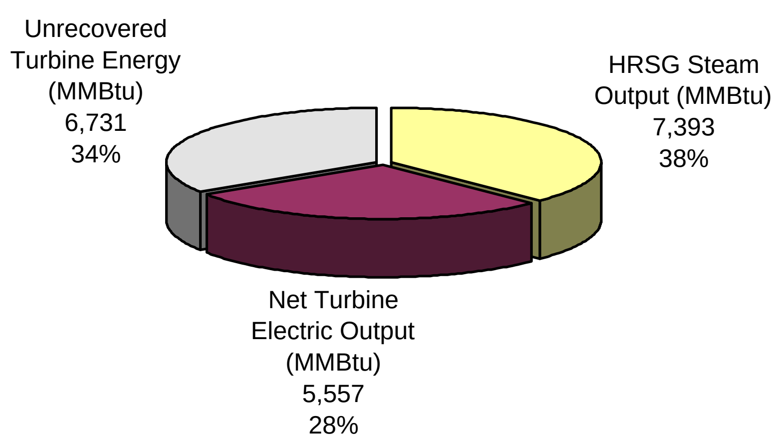
Month

September 2004 Performance Data

Input Energy = 19,803 MMBtu



Output Energy = 19,681 MMBtu

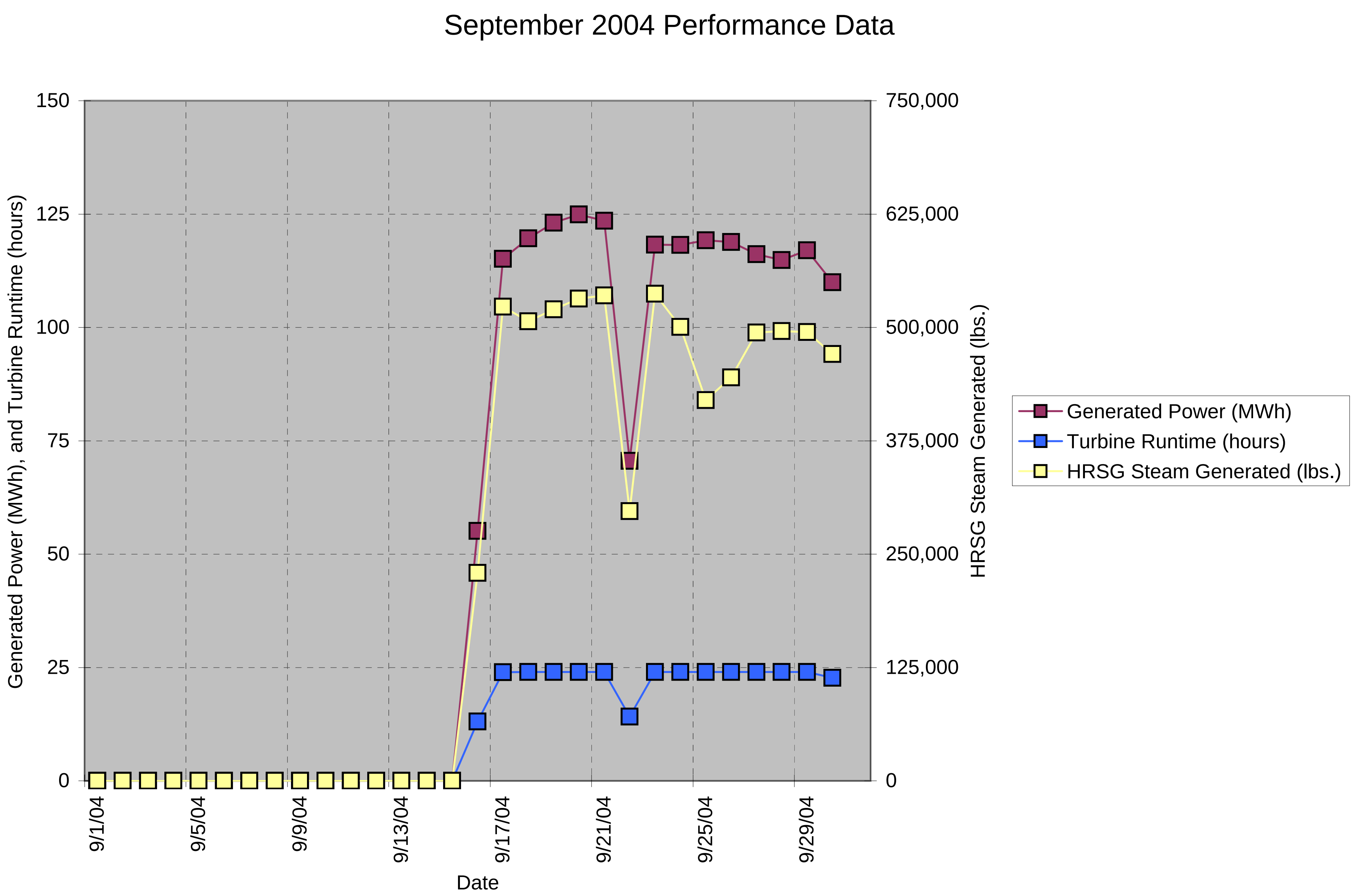


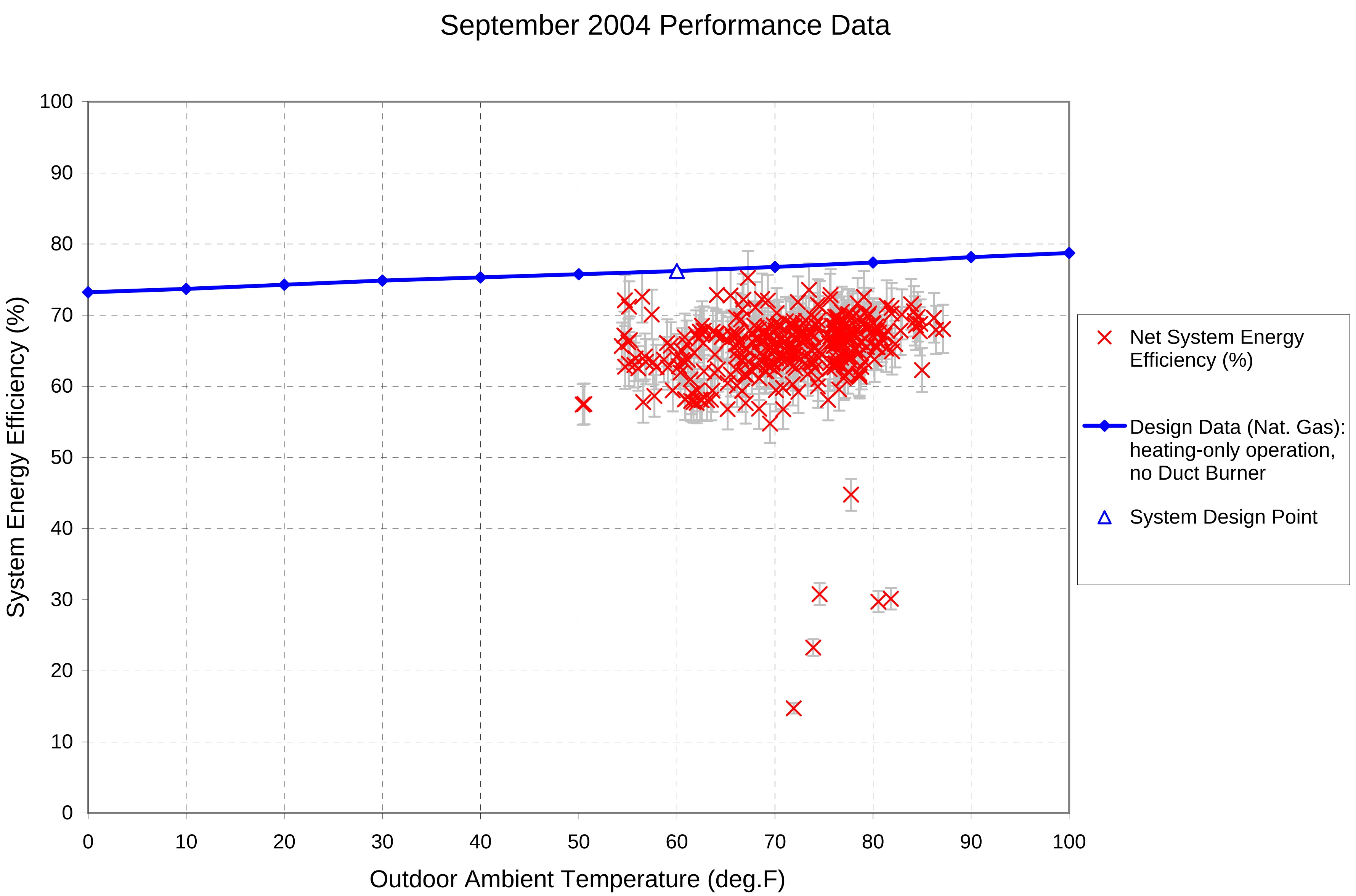
Net CHP Efficiency *

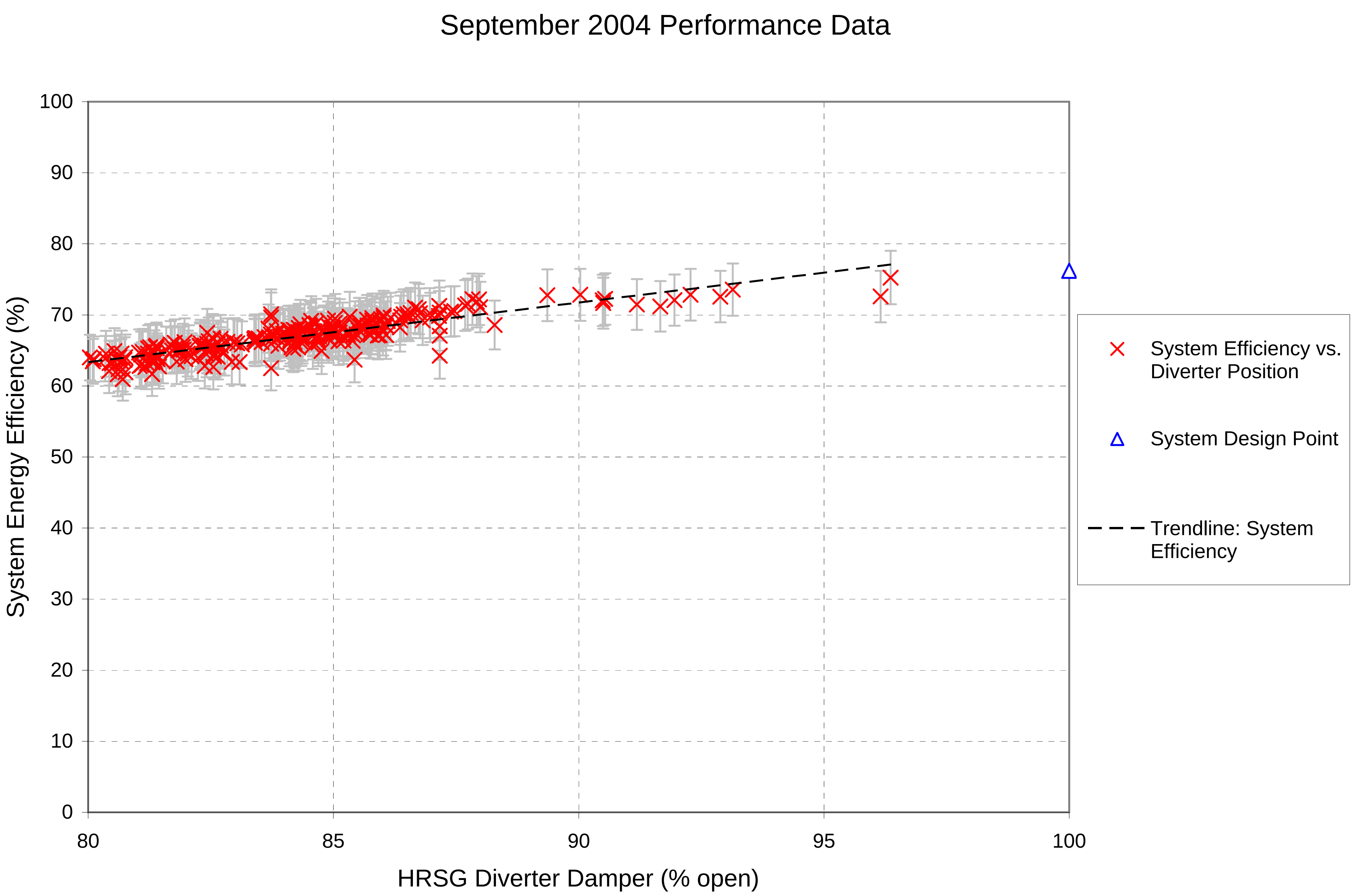
$$n_{CHP \cdot NET} = \frac{NET\ P_{REAL}(kW) + P_{QNET}(kW)}{P_{FUEL \cdot INPUT}(kW)} \times 100$$

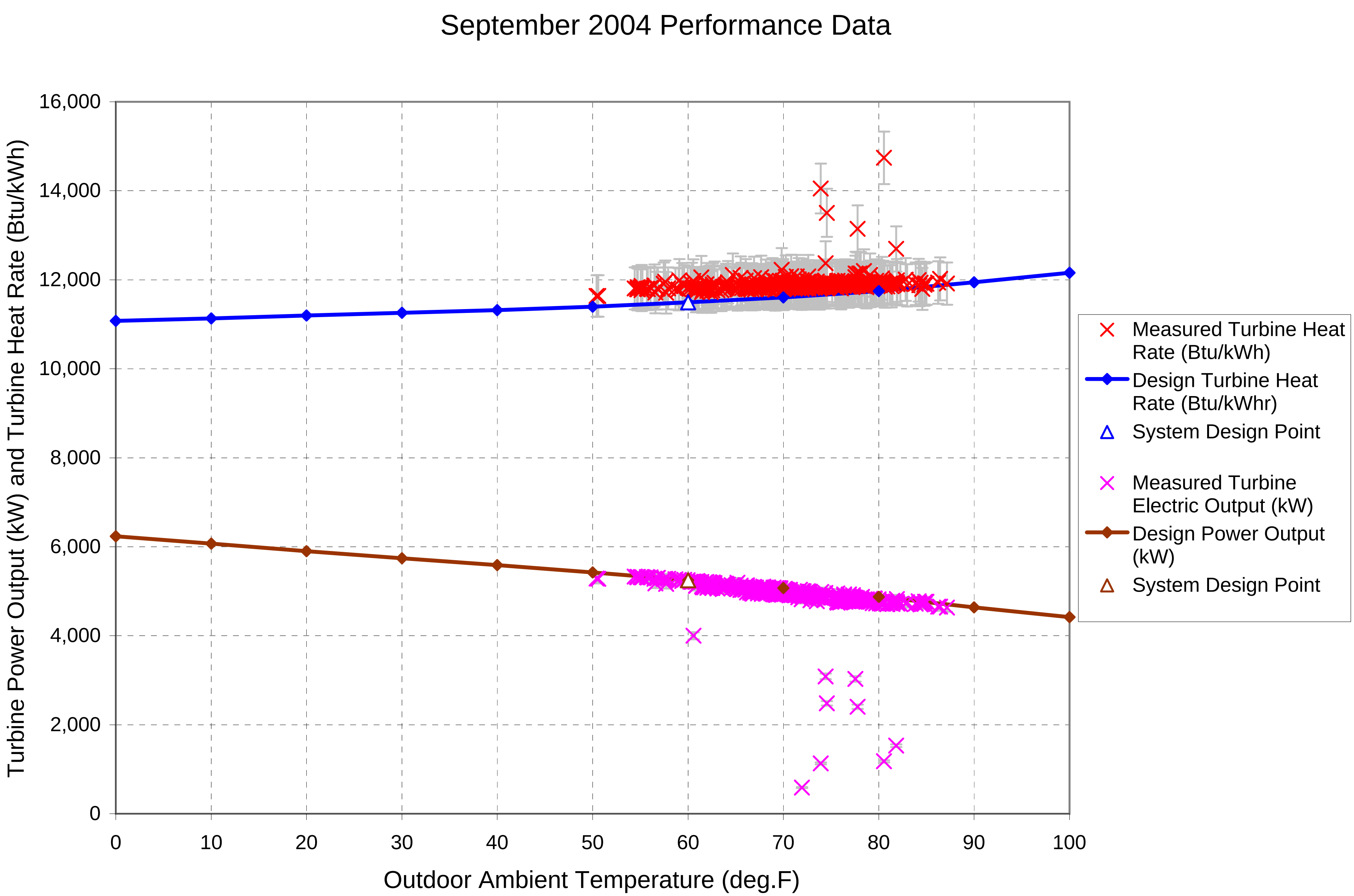
= **65.4%**

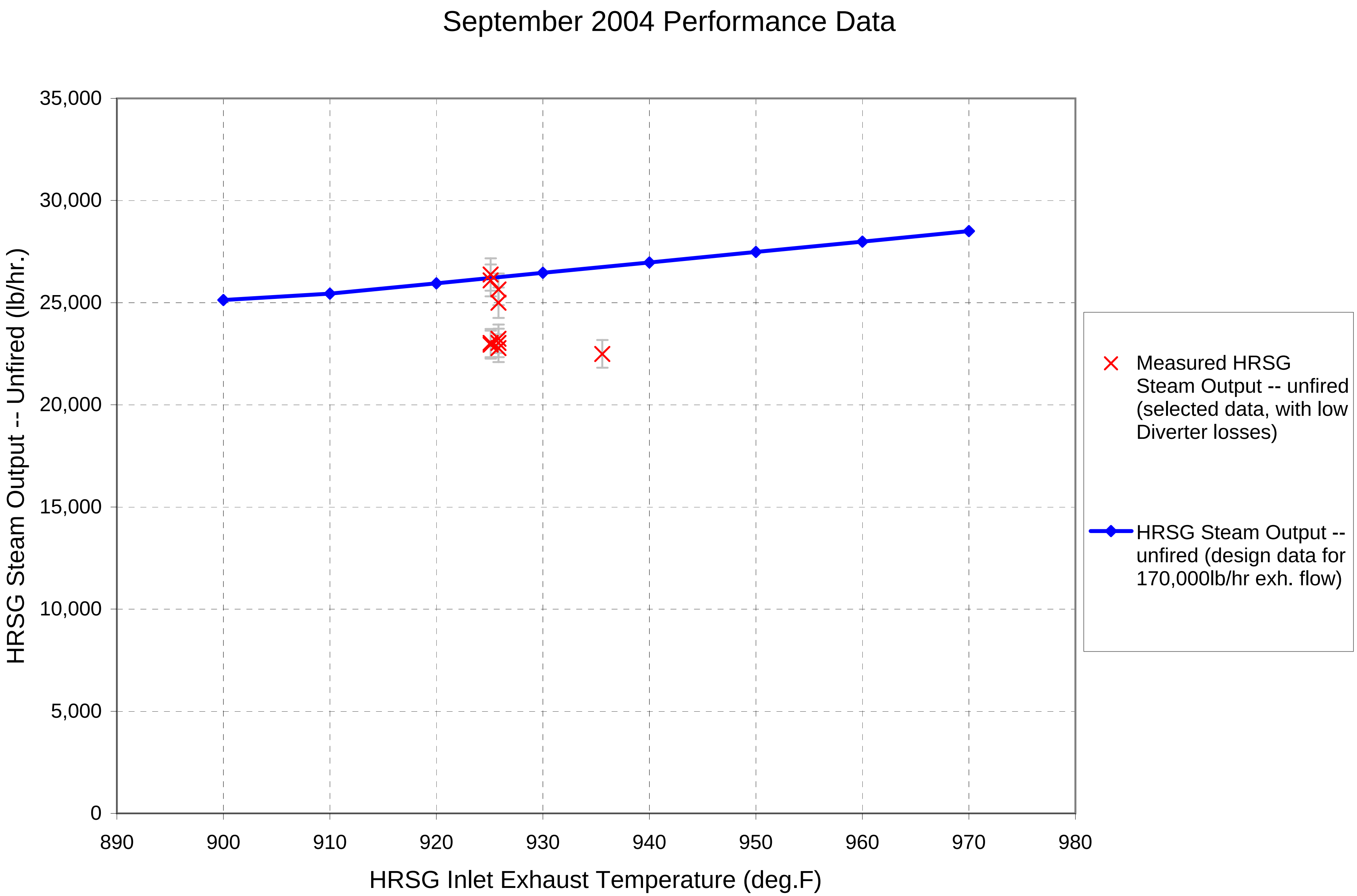
* as defined on page 27 of: “Distributed Generation Combined Heat and Power Long Term Monitoring Protocols” Interim Version, October 29, 2004, prepared by the Association of State Energy Research and Technology Transfer Institutions (ASERTTI) http://www.asertti.org

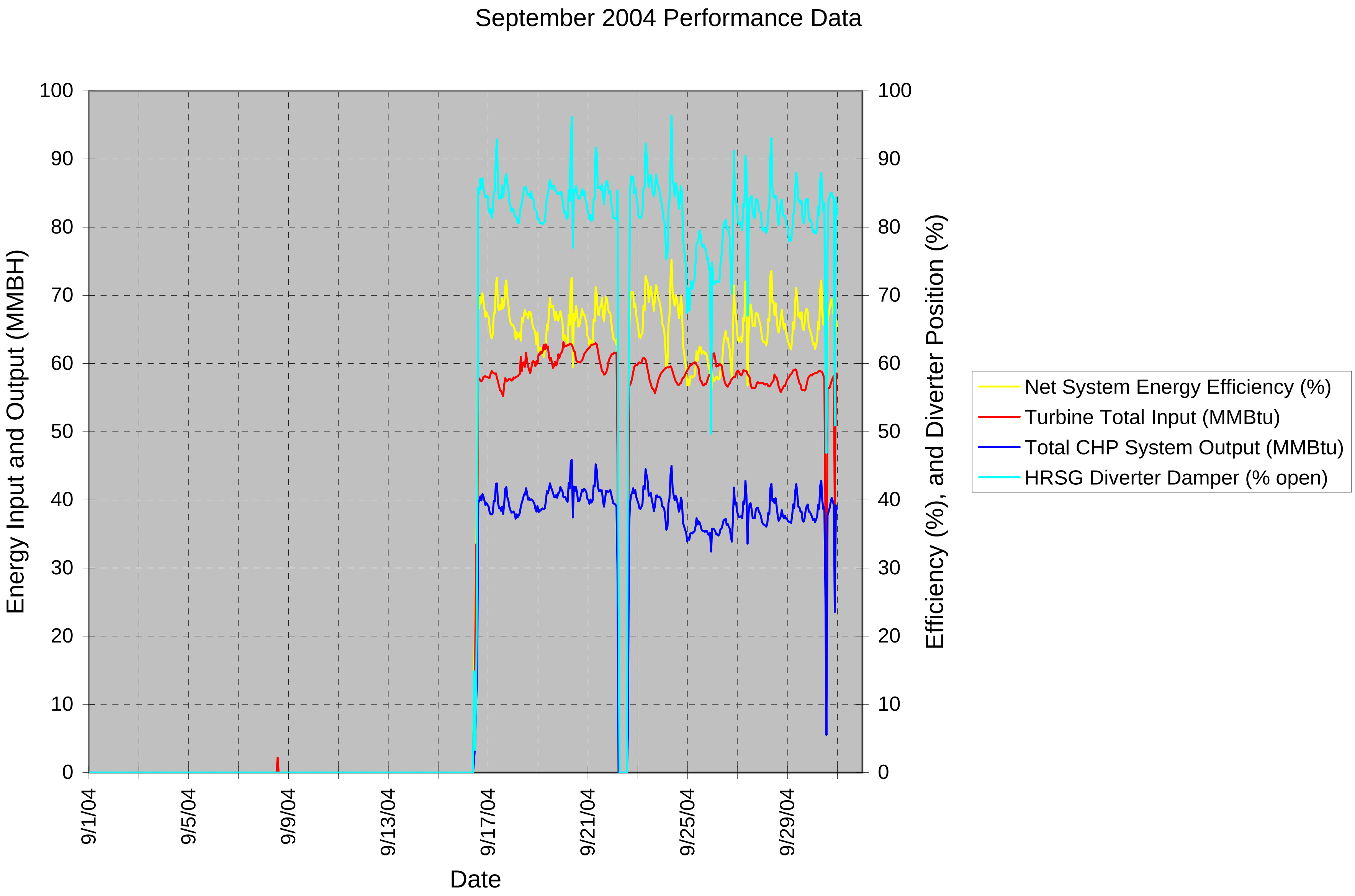

September 2004 Performance Data
Generated Power (MWh), and Turbine Runtime (hours)
HRSG Steam Generated (lbs.)
Date
0
25
50
75
100
125
150
0
125,000
250,000
375,000
500,000
625,000
750,000
9/1/04
9/5/04
9/9/04
9/13/04
9/17/04
9/21/04
9/25/04
9/29/04
Generated Power (MWh)
Turbine Runtime (hours)
HRSG Steam Generated (lbs.)

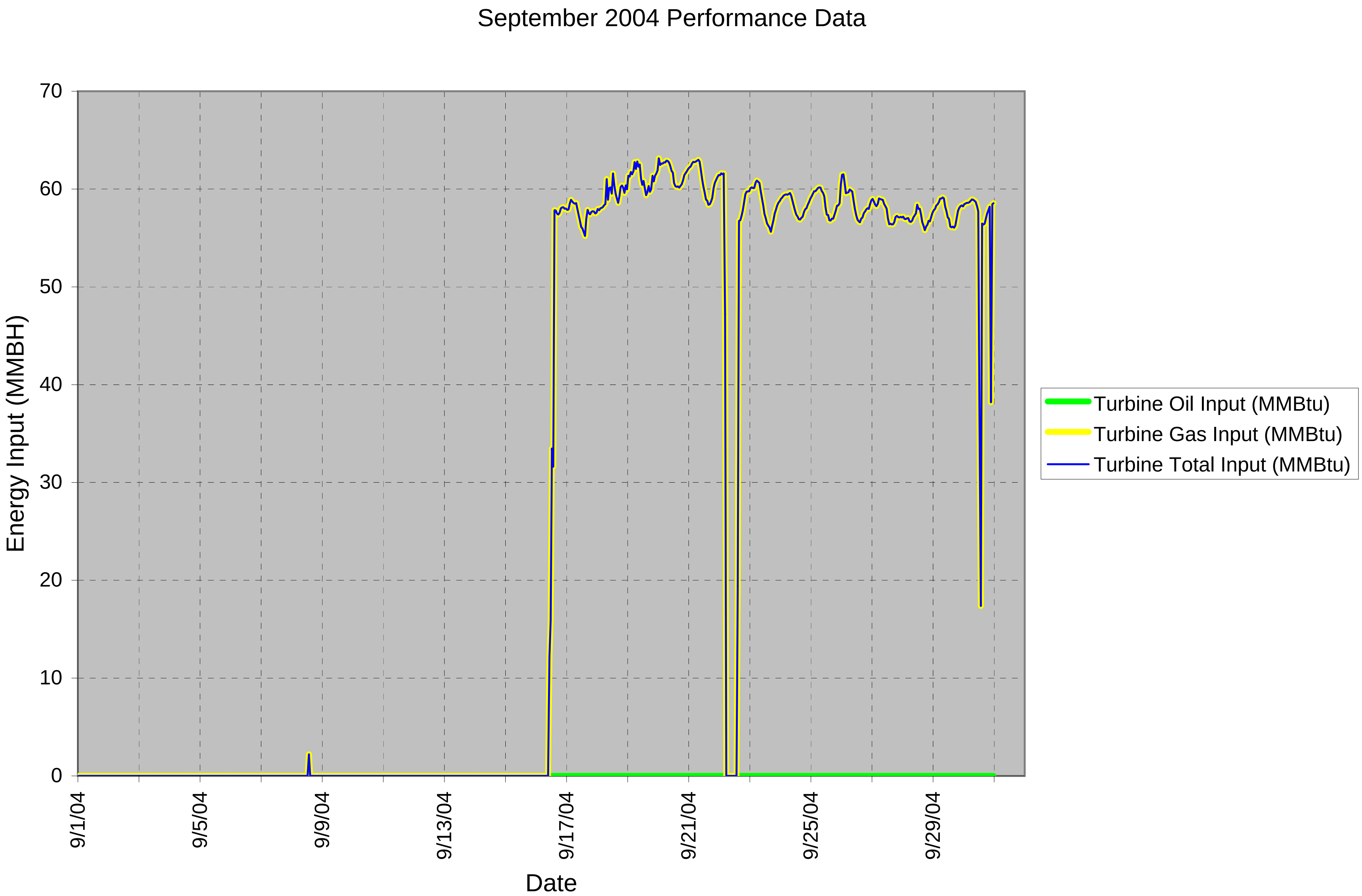

September 2004 Performance Data
System Energy Efficiency (%)
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Outdoor Ambient Temperature (deg.F)
Net System Energy Efficiency (%)
Design Data (Nat. Gas): heating-only operation, no Duct Burner
System Design Point


September 2004 Performance Data
100
90
80
70
60
50
40
30
20
10
0
System Energy Efficiency (%)
80
85
90
95
100
HRSG Diverter Damper (% open)
System Efficiency vs. Diverter Position
System Design Point
Trendline: System Efficiency


September 2004 Performance Data
Turbine Power Output (kW) and Turbine Heat Rate (Btu/kWh)
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
0
10
20
30
40
50
60
70
80
90
100
Outdoor Ambient Temperature (deg.F)
Measured Turbine Heat Rate (Btu/kWh)
Design Turbine Heat Rate (Btu/kWhr)
System Design Point
Measured Turbine Electric Output (kW)
Design Power Output (kW)
System Design Point

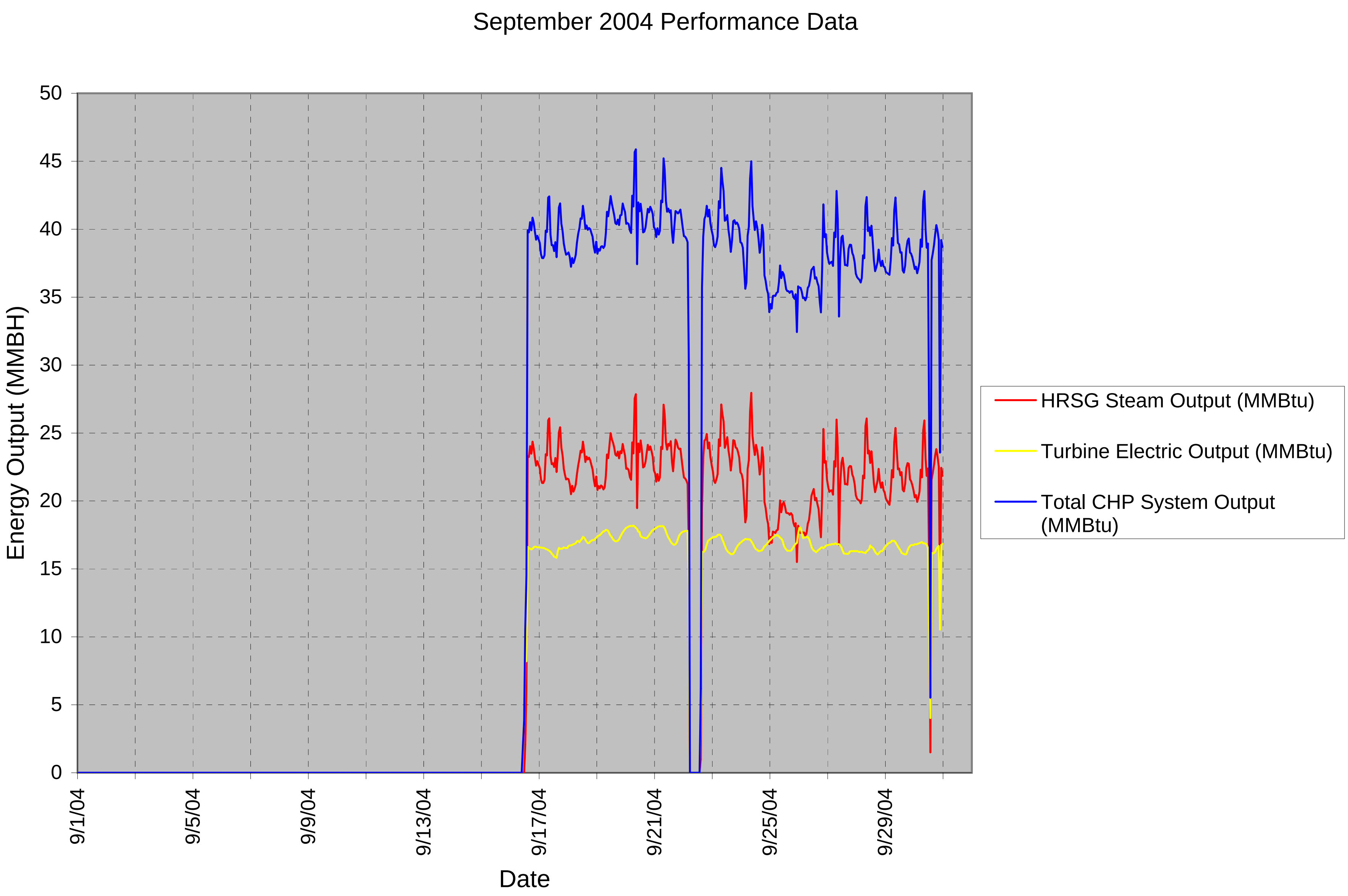

September 2004 Performance Data
HRSG Steam Output -- Unfired (lb/hr.)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
890
900
910
920
930
940
950
960
970
980
HRSG Inlet Exhaust Temperature (deg.F)
Measured HRSG Steam Output -- unfired (selected data, with low Diverter losses)
HRSG Steam Output -- unfired (design data for 170,000lb/hr exh. flow)


September 2004 Performance Data
Energy Input and Output (MMBH)
Efficiency (%), and Diverter Position (%)
Date
0
10
20
30
40
50
60
70
80
90
100
9/1/04
9/5/04
9/9/04
9/13/04
9/17/04
9/21/04
9/25/04
9/29/04
Net System Energy Efficiency (%)
Turbine Total Input (MMBtu)
Total CHP System Output (MMBtu)
HRSG Diverter Damper (% open)



September 2004 Performance Data
Energy Input (MMBH)
70
60
50
40
30
20
10
0
9/1/04
9/5/04
9/9/04
9/13/04
9/17/04
9/21/04
9/25/04
9/29/04
Date
Turbine Oil Input (MMBtu)
Turbine Gas Input (MMBtu)
Turbine Total Input (MMBtu)

Output



September 2004 Performance Data
Energy Output (MMBH)
50
45
40
35
30
25
20
15
10
5
0
9/1/04
9/5/04
9/9/04
9/13/04
9/17/04
9/21/04
9/25/04
9/29/04
Date
HRSG Steam Output (MMBtu)
Turbine Electric Output (MMBtu)
Total CHP System Output (MMBtu)

4.2 Detailed Performance Results: October 2004

Detailed performance results for the month of October 2004, are shown in the table and figures on the following pages.

Field observations noted during the month are:

- There was no operation of the absorption chiller during the month.
- Very little simultaneous operation of the auxiliary boiler during the month.
- The duct burner remained off-line, as described earlier.

Data analysis comments for the month are:

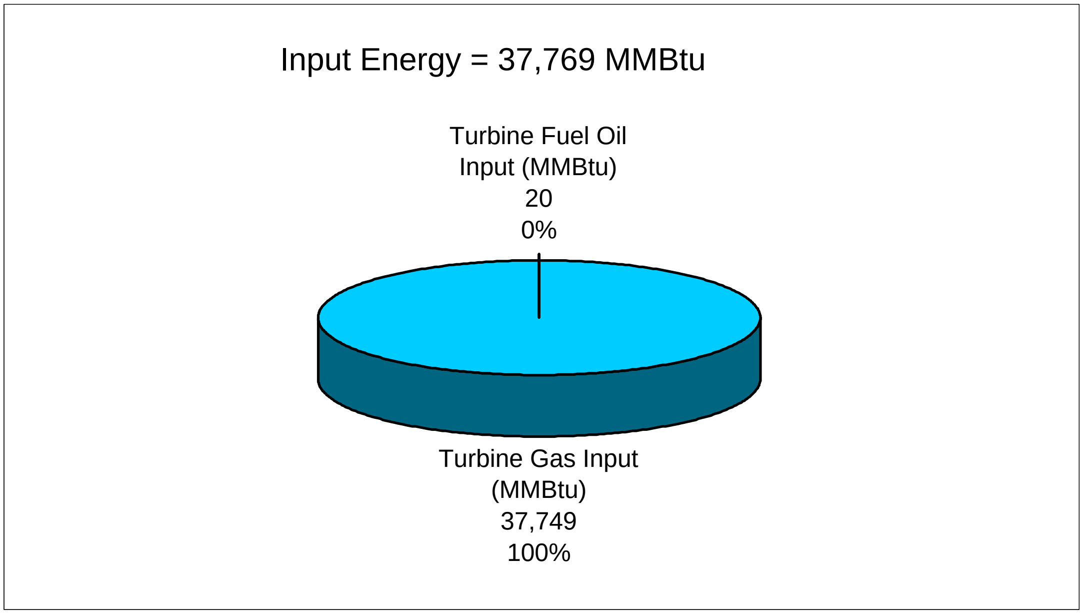
Table or Figure	Analysis Comments
Summary Data Table	Other than a short period of lost operation, the system's performance was very good during the month.
Monthly Overview	The amount of unrecovered energy was greater than desired due to the relatively low steam load in the fall season.
Daily Performance	See comments above.
System Net Energy Efficiency	System net energy efficiency was lower than design, due to extended periods of significant diverter losses required to match the steam load.
Diverter Energy Losses	See comment above.
Turbine Generator Performance	Very good performance, the measured data matches well with the design data (within the expected uncertainty).
HRSG Performance	Good performance, given the diverter losses that were present in some of the data.

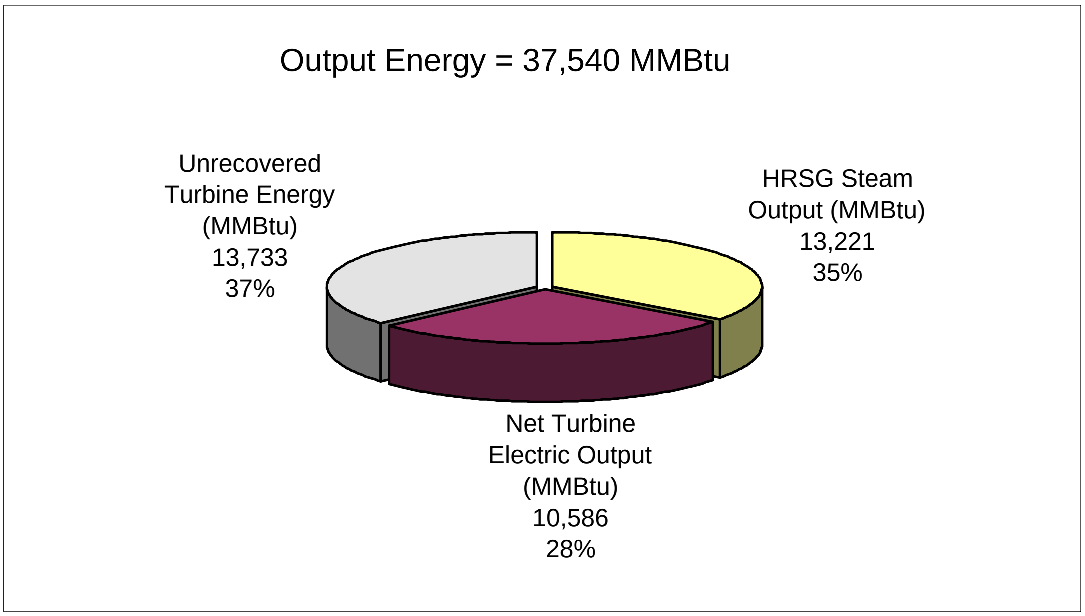
Additional plots of more detailed operating data are presented in Appendix B.

	Measured Data						Calculated Results							
Date	Generated Power (MWh)	HRSG Steam Generated (lbs.)	Turbine Nat. Gas Consumed (MCF)	Turbine Fuel Oil Consumed (gal.)	Turbine Runtime (hours)	Aux. Boiler#5 Runtime (hours)	Turbine Natural Gas Input (MMBtu)	Turbine Fuel Oil Input (MMBtu)	Turbine Total Energy Input (MMBtu)	HRSG Steam Output (MMBtu)	Turbine Power Output (MMBtu)	Total CHP Output (MMBtu)	Net Daily System Efficiency (%)	Parasitic Energy (MWh)
1-Oct-04	118	463,234	1,350	0	24	0	1,400	0	1,400	489	401	890	63.0	2.5
2-Oct-04	117	319,402	1,342	0	24	0	1,392	0	1,392	337	399	737	52.3	2.5
3-Oct-04	115	367,284	1,327	0	24	1	1,376	0	1,376	388	393	781	56.0	2.5
4-Oct-04	118	503,018	1,358	0	24	1	1,409	0	1,409	531	404	935	65.7	2.5
5-Oct-04	120	511,326	1,381	0	24	0	1,432	0	1,432	540	411	951	65.8	2.5
6-Oct-04	123	528,146	1,407	0	24	1	1,460	0	1,460	558	420	978	66.4	2.5
7-Oct-04	103	429,945	1,180	0	20	3	1,223	0	1,223	454	351	805	62.9	2.1
8-Oct-04	3	1,824	54	0	2	22	56	0	56	2	12	14	18.2	0.2
9-Oct-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
10-Oct-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
11-Oct-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
12-Oct-04	66	280,798	778	0	15	10	806	0	806	297	226	522	61.7	1.5
13-Oct-04	116	518,490	1,341	0	24	0	1,390	0	1,390	548	396	944	67.3	2.5
14-Oct-04	117	512,646	1,352	0	24	0	1,402	0	1,402	541	401	942	66.6	2.5
15-Oct-04	119	521,380	1,368	0	24	0	1,418	0	1,418	551	406	957	66.9	2.5
16-Oct-04	121	502,044	1,392	0	24	0	1,444	0	1,444	530	414	945	64.9	2.5
17-Oct-04	121	494,747	1,390	0	24	1	1,442	0	1,442	522	414	936	64.4	2.5
18-Oct-04	118	503,684	1,362	0	24	1	1,413	0	1,413	532	403	935	65.5	2.5
19-Oct-04	116	475,505	1,332	0	24	1	1,382	0	1,382	502	395	897	64.2	2.5
20-Oct-04	120	482,682	1,381	0	24	0	1,432	0	1,432	510	411	921	63.7	2.5
21-Oct-04	122	462,392	1,401	0	24	0	1,453	0	1,453	488	417	906	61.7	2.5
22-Oct-04	121	474,385	1,391	0	24	0	1,443	0	1,443	501	414	915	62.9	2.5
23-Oct-04	124	450,115	1,416	0	24	0	1,469	0	1,469	475	423	899	60.6	2.5
24-Oct-04	124	450,300	1,413	0	24	0	1,465	0	1,465	476	422	897	60.6	2.5
25-Oct-04	117	447,841	1,320	147	23	1	1,369	20	1,389	473	398	871	62.0	2.4
26-Oct-04	123	474,177	1,420	0	24	0	1,472	0	1,472	501	421	922	62.0	2.5
27-Oct-04	123	477,312	1,410	0	24	0	1,462	0	1,462	504	419	923	62.6	2.5
28-Oct-04	122	488,012	1,402	0	24	0	1,454	0	1,454	515	416	931	63.5	2.5
29-Oct-04	121	464,922	1,392	0	24	1	1,443	0	1,443	491	413	904	62.0	2.5
30-Oct-04	118	450,308	1,363	0	24	0	1,413	0	1,413	476	403	879	61.6	2.5
31-Oct-04	121	464,440	1,380	0	25	0	1,431	0	1,431	490	412	903	62.5	2.6
totals	3,170	12,520,358	36,402	147	635	119	37,749	20	37,769	13,221	10,815	24,036	63.0	67.1

Month

October 2004 Performance Data





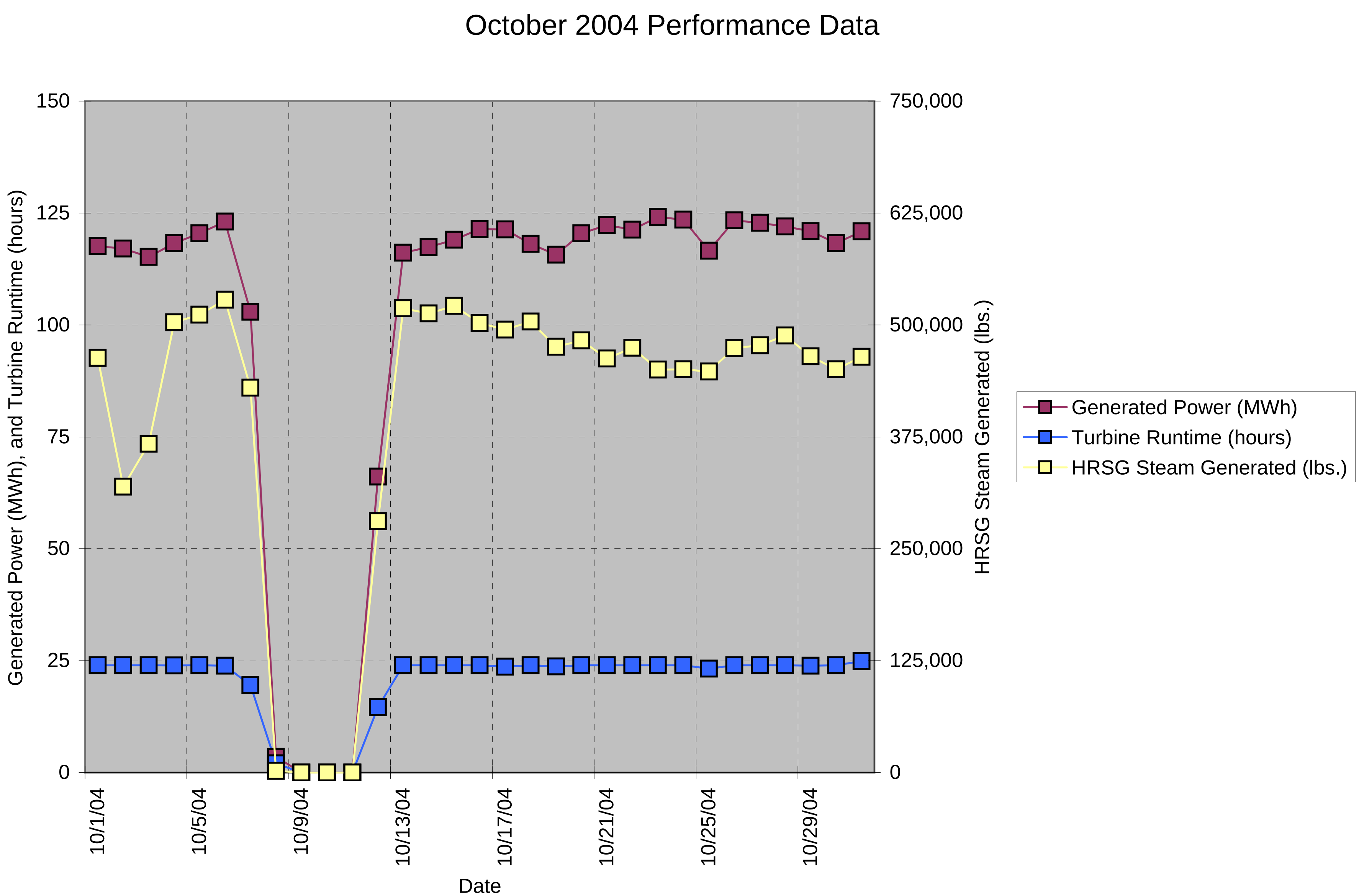
Net CHP Efficiency *

$$n_{CHP \cdot NET} = \frac{NET\ P_{REAL}(kW) + P_{QNET}(kW)}{P_{FUEL \cdot INPUT}(kW)} \times 100$$

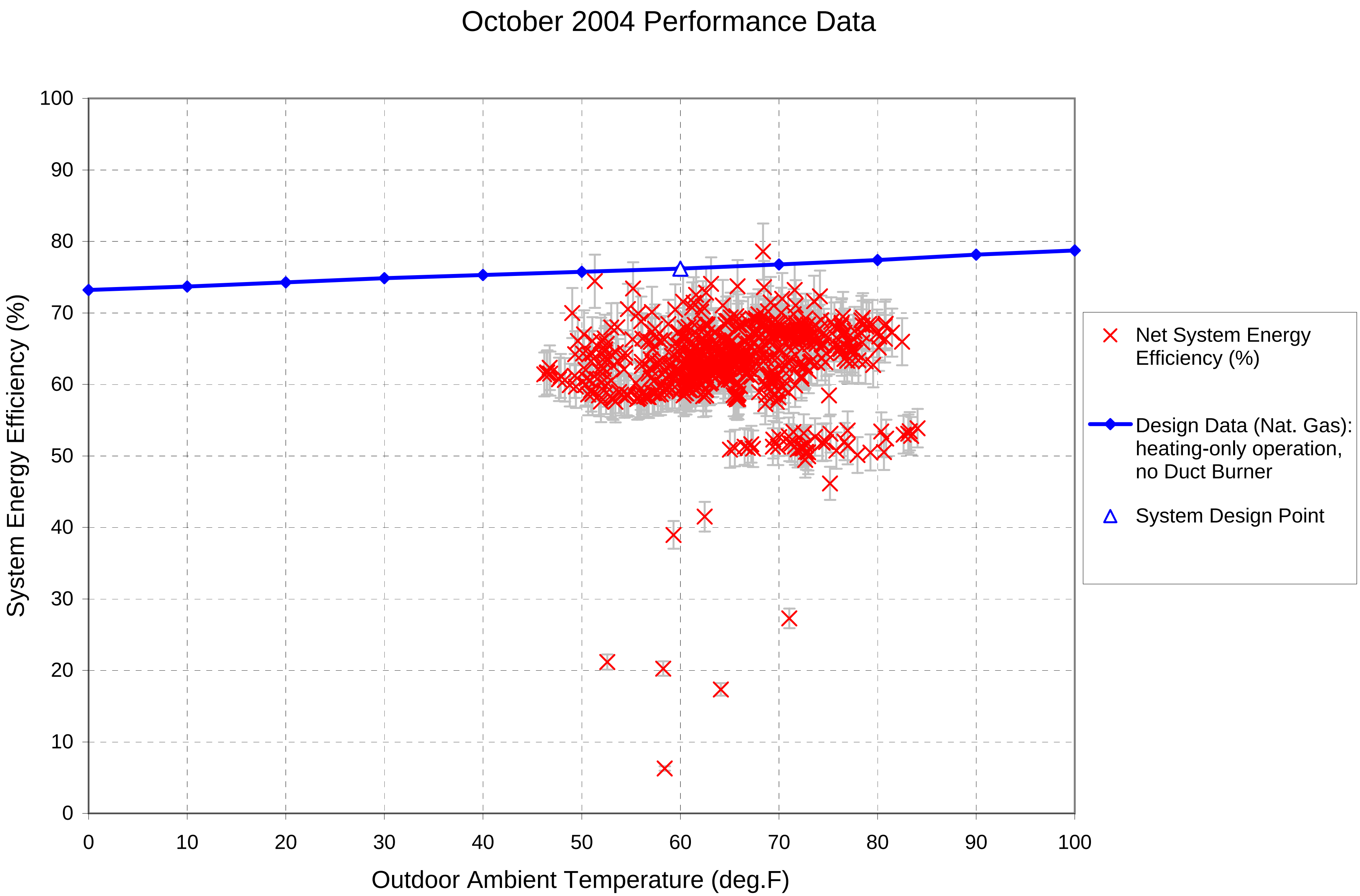
= **63.0%**

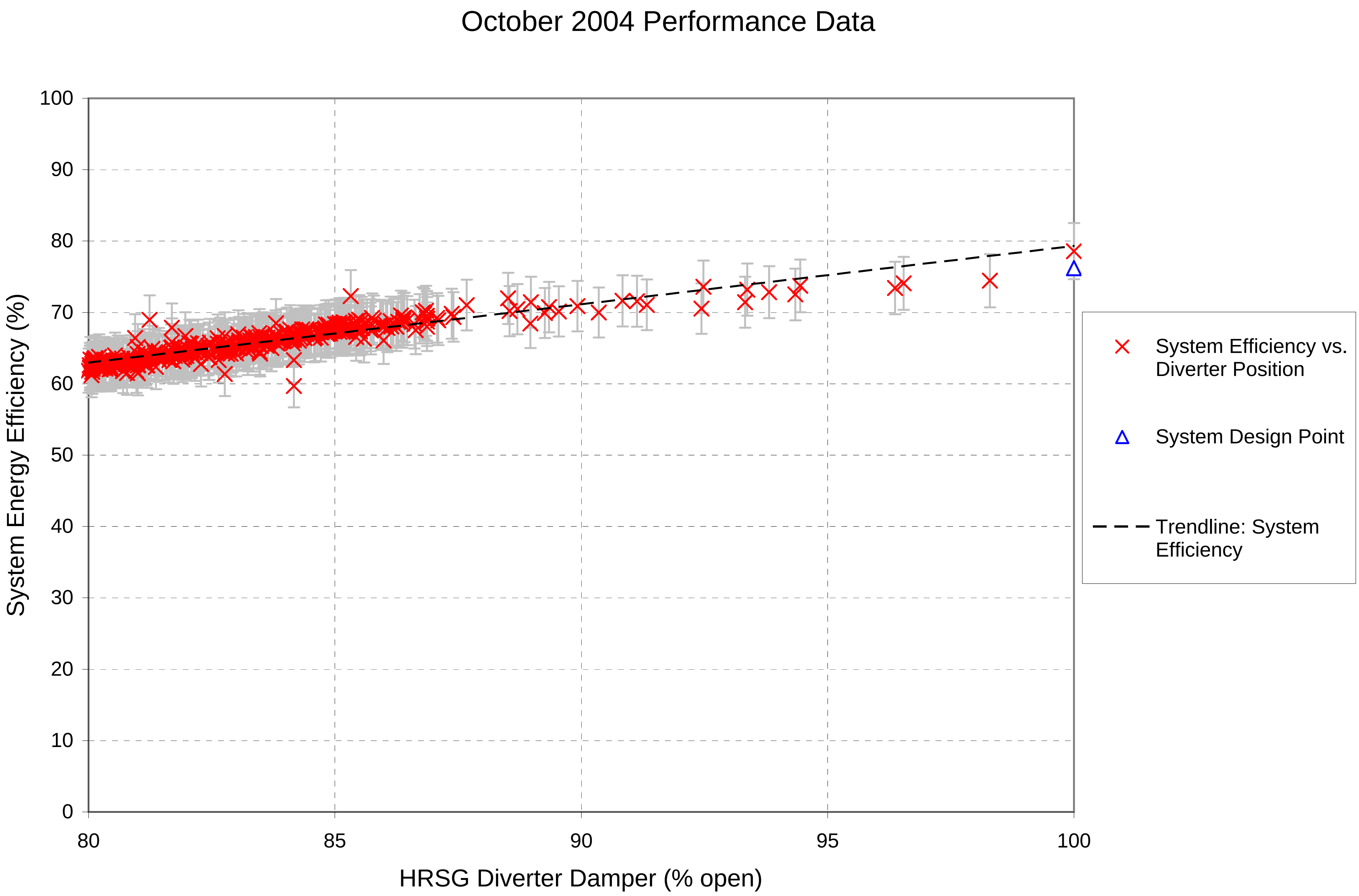
* as defined on page 27 of: "Distributed Generation Combined Heat and Power Long Term Monitoring Protocols" Interim Version, October 29, 2004, prepared by the Association of State Energy Research and Technology Transfer Institutions (ASERTTI) http://www.asertti.org

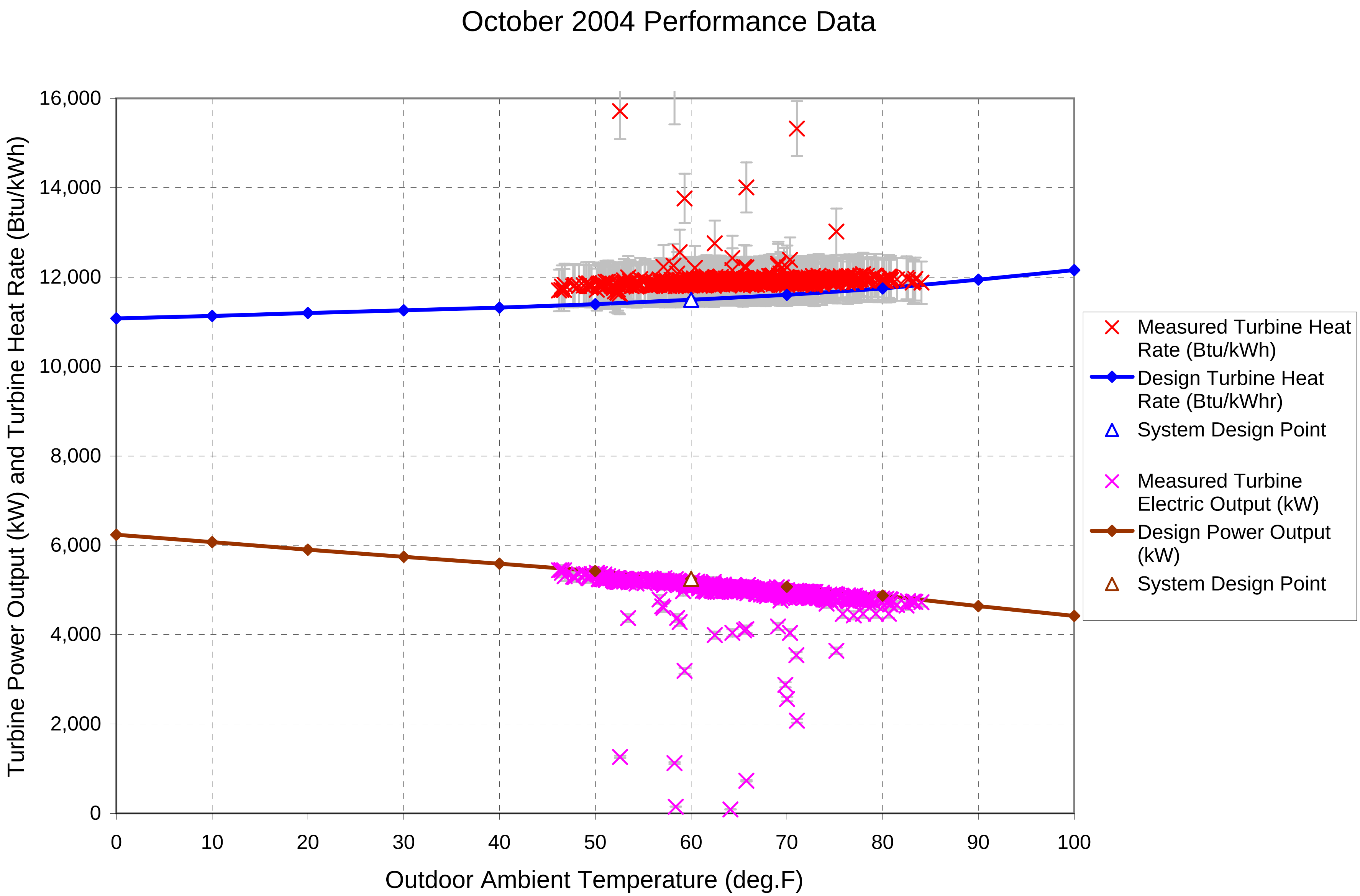
Daily

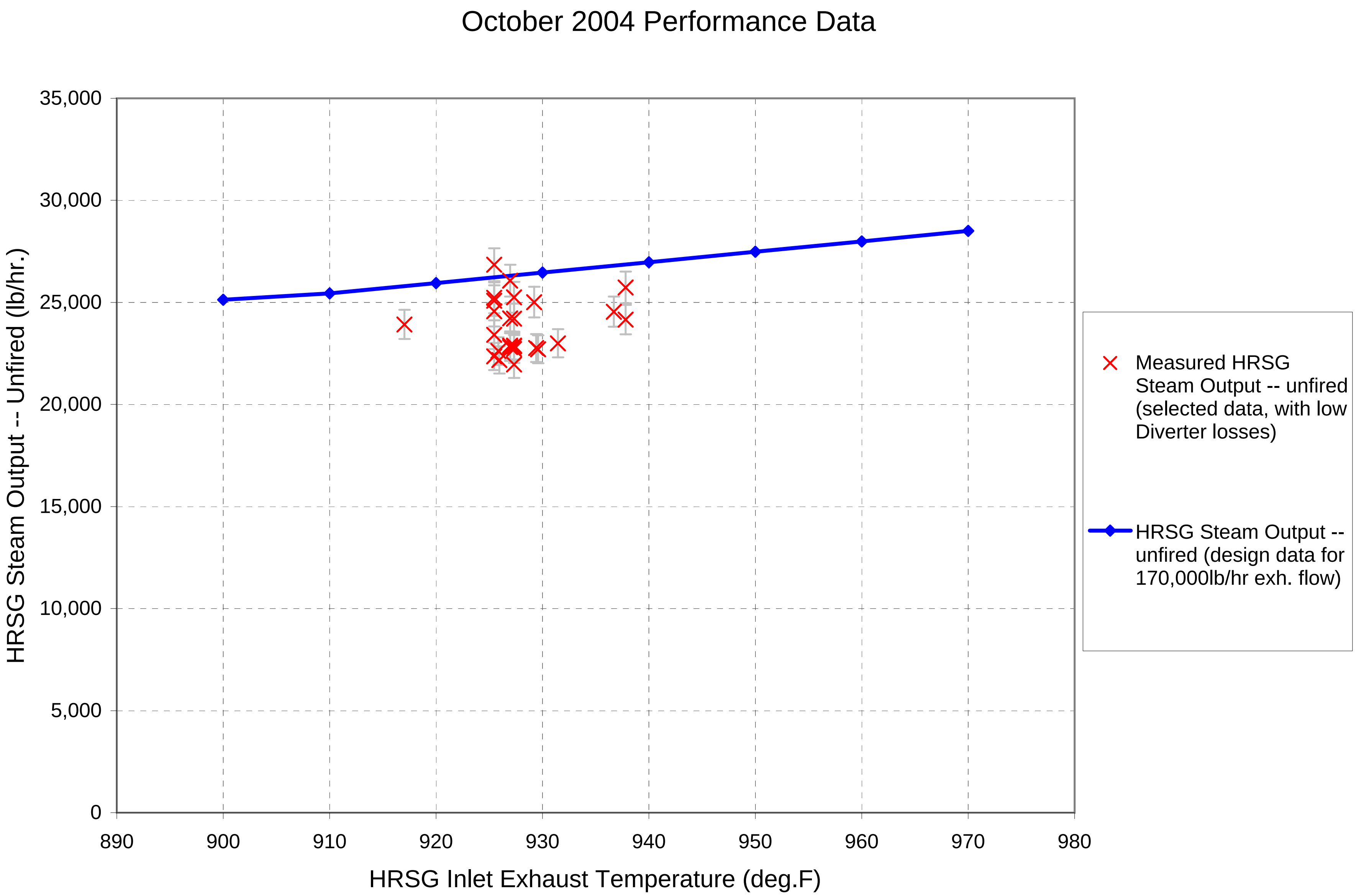


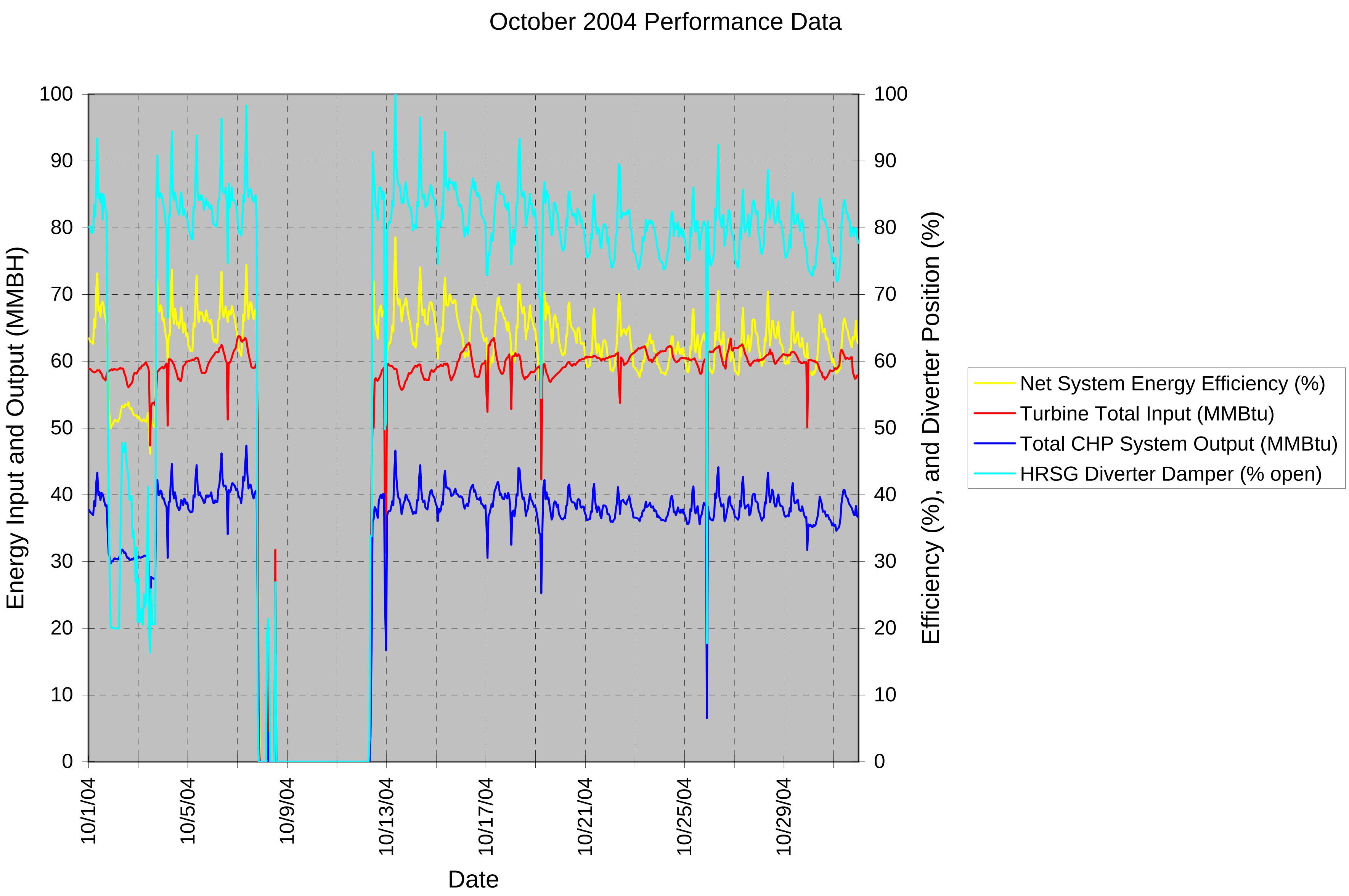
October 2004 Performance Data
150
125
100
75
50
25
0
750,000
625,000
500,000
375,000
250,000
125,000
0
Generated Power (MWh), and Turbine Runtime (hours)
HRSG Steam Generated (lbs.)
10/1/04
10/5/04
10/9/04
10/13/04
10/17/04
10/21/04
10/25/04
10/29/04
Date
Generated Power (MWh)
Turbine Runtime (hours)
HRSG Steam Generated (lbs.)


October 2004 Performance Data
System Energy Efficiency (%)
0
10
20
30
40
50
60
70
80
90
100
Outdoor Ambient Temperature (deg.F)
Net System Energy Efficiency (%)
Design Data (Nat. Gas): heating-only operation, no Duct Burner
System Design Point

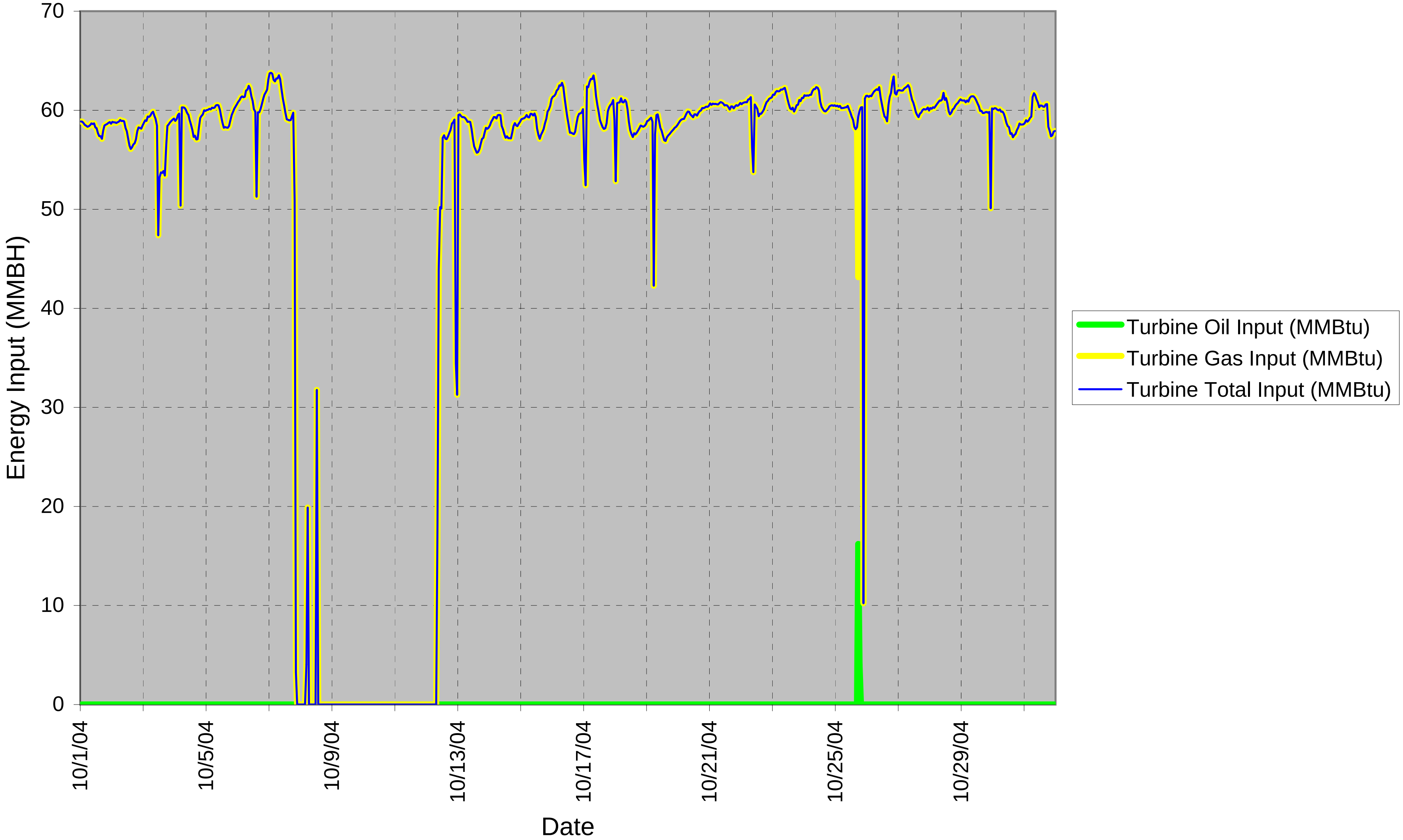

October 2004 Performance Data
System Energy Efficiency (%)
100
90
80
70
60
50
40
30
20
10
0
80
85
90
95
100
HRSG Diverter Damper (% open)
System Efficiency vs. Diverter Position
System Design Point
Trendline: System Efficiency


October 2004 Performance Data
Turbine Power Output (kW) and Turbine Heat Rate (Btu/kWh)
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
0
10
20
30
40
50
60
70
80
90
100
Outdoor Ambient Temperature (deg.F)
Measured Turbine Heat Rate (Btu/kWh)
Design Turbine Heat Rate (Btu/kWhr)
System Design Point
Measured Turbine Electric Output (kW)
Design Power Output (kW)
System Design Point

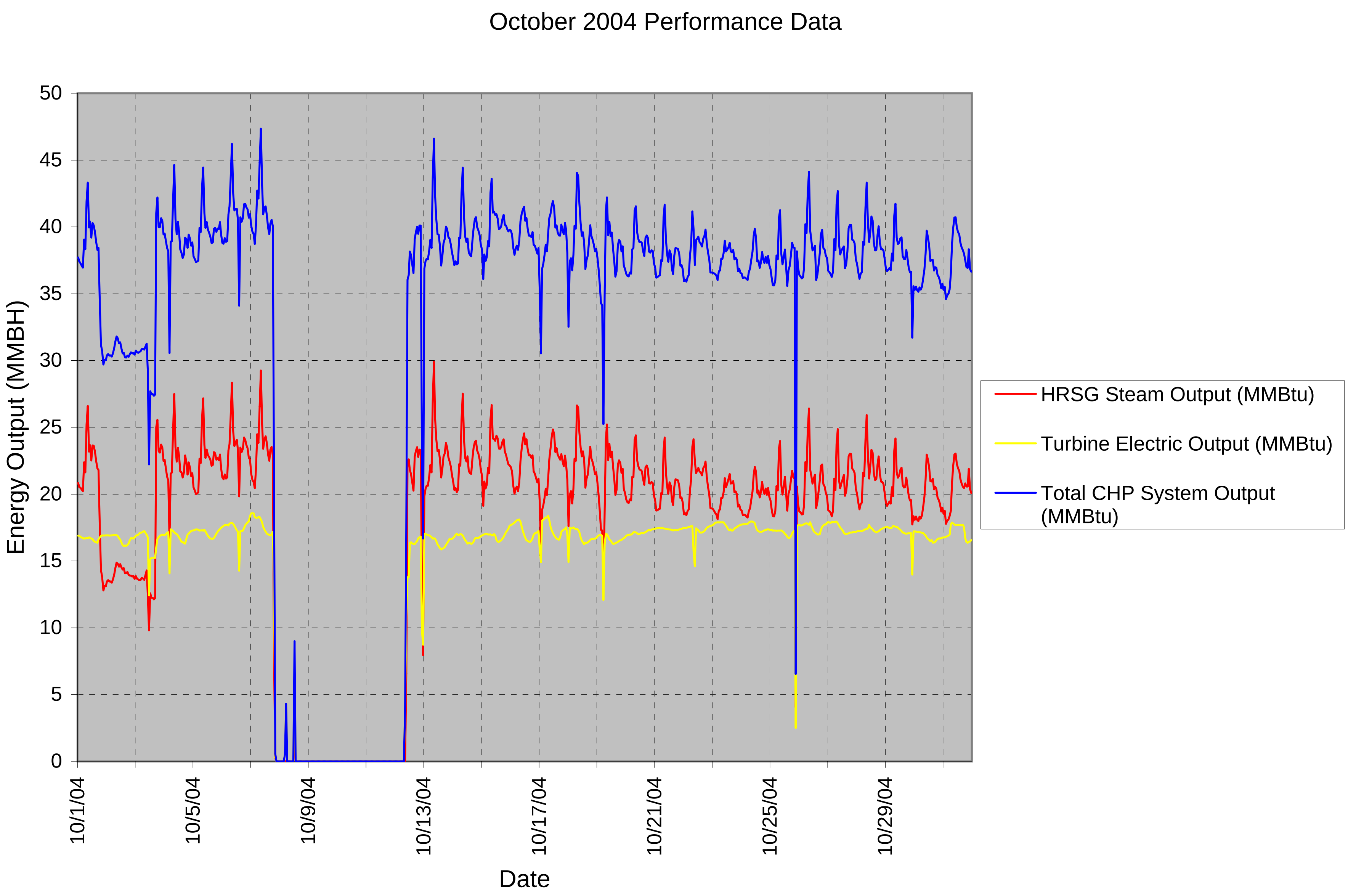

October 2004 Performance Data
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
HRSG Steam Output -- Unfired (lb/hr.)
890
900
910
920
930
940
950
960
970
980
HRSG Inlet Exhaust Temperature (deg.F)
Measured HRSG Steam Output -- unfired (selected data, with low Diverter losses)
HRSG Steam Output -- unfired (design data for 170,000lb/hr exh. flow)


October 2004 Performance Data
Energy Input and Output (MMBH)
Efficiency (%), and Diverter Position (%)
0
10
20
30
40
50
60
70
80
90
100
10/1/04
10/5/04
10/9/04
10/13/04
10/17/04
10/21/04
10/25/04
10/29/04
Date
Net System Energy Efficiency (%)
Turbine Total Input (MMBtu)
Total CHP System Output (MMBtu)
HRSG Diverter Damper (% open)

October 2004 Performance Data



Output


October 2004 Performance Data
Energy Output (MMBH)
50
45
40
35
30
25
20
15
10
5
0
10/1/04
10/5/04
10/9/04
10/13/04
10/17/04
10/21/04
10/25/04
10/29/04
Date
HRSG Steam Output (MMBtu)
Turbine Electric Output (MMBtu)
Total CHP System Output (MMBtu)

4.3 Detailed Performance Results: November 2004

Detailed performance results for the month of November 2004, are shown in the table and figures on the following pages.

Field observations noted during the month are:

- The IES system was off-line during the last few days of the month, due to high fuel prices.
- Some periods of simultaneous operation of the auxiliary boiler during the month.
- The duct burner remained off-line, as described earlier. At times, this required that the auxiliary boiler be brought on line to provide supplemental steam to meet the thermal load. Note that due to the nature of the control interfaces to the existing auxiliary boiler controls at this site, it is necessary to divert (waste) some exhaust energy in order to maintain the desired steam pressure (during periods when operating both the auxiliary boiler and the turbine).

Data analysis comments for the month are:

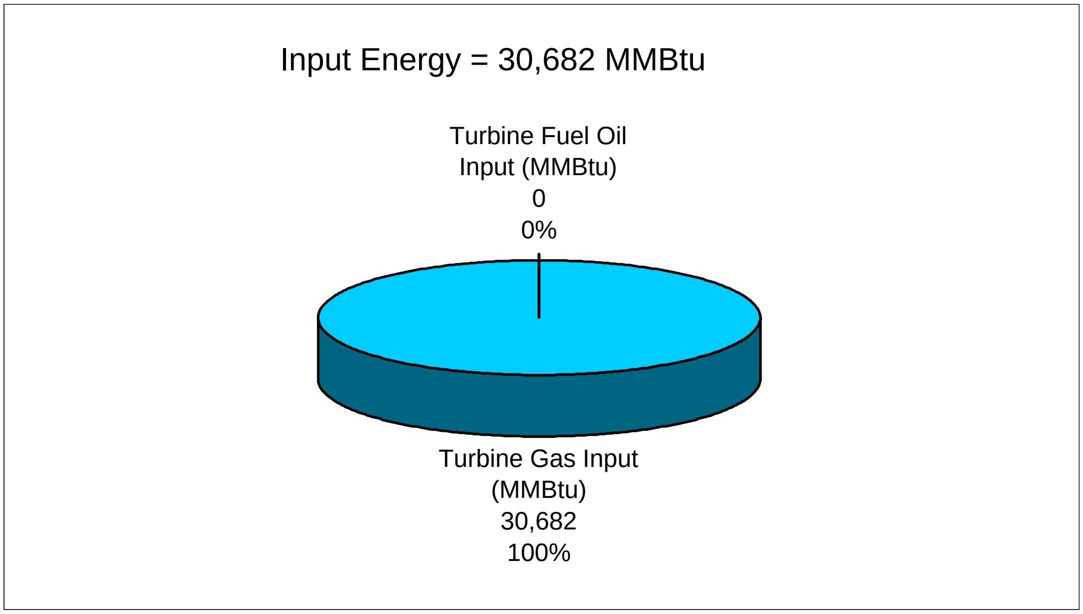
Table or Figure	Analysis Comments
Summary Data Table	Other than the period of lost operation, the system's performance was very good during the month.
Monthly Overview	Improved performance this month (less unrecovered energy), due to the increased steam load entering the winter season (less diverter loss than seen in previous months).
Daily Performance	See comments above.
System Net Energy Efficiency	System net energy efficiency was within the expected range, although there were some periods of significant diverter losses required to match the steam load. Overall, the measured data matches well with the design data (within the expected uncertainty).
Diverter Energy Losses	See comment above.
Turbine Generator Performance	Very good performance, the measured data matches well with the design data (within the expected uncertainty).
HRSG Performance	Good performance, given the diverter losses that were present in some of the data.

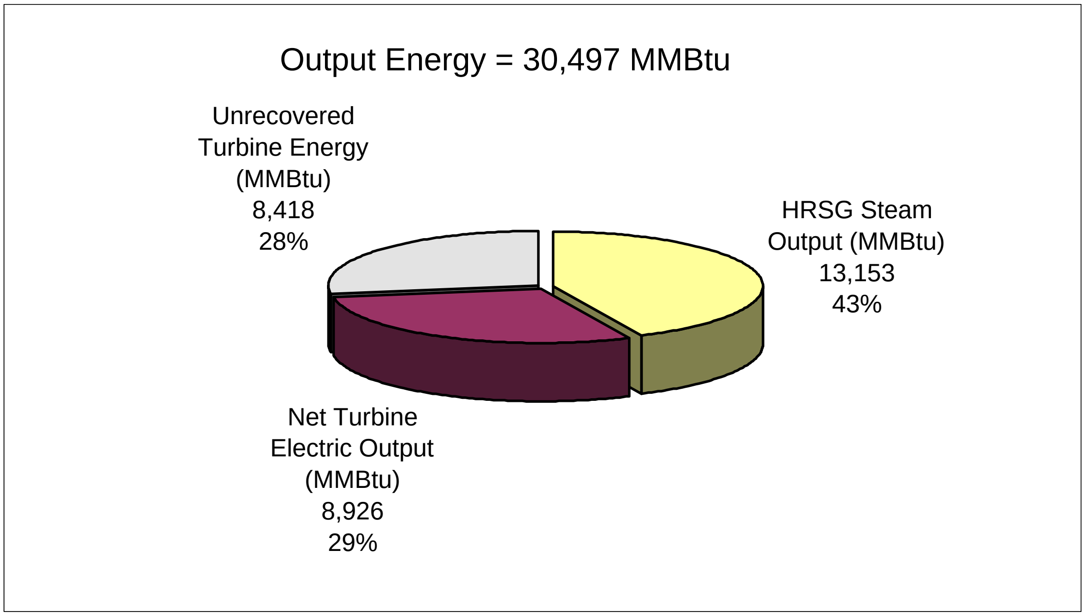
Additional plots of more detailed operating data are presented in Appendix C.

	Measured Data						Calculated Results							
Date	Generated Power (MWh)	HRSG Steam Generated (lbs.)	Turbine Nat. Gas Consumed (MCF)	Turbine Fuel Oil Consumed (gal.)	Turbine Runtime (hours)	Aux. Boiler#5 Runtime (hours)	Turbine Natural Gas Input (MMBtu)	Turbine Fuel Oil Input (MMBtu)	Turbine Total Energy Input (MMBtu)	HRSG Steam Output (MMBtu)	Turbine Power Output (MMBtu)	Total CHP Output (MMBtu)	Net Daily System Efficiency (%)	Parasitic Energy (MWh)
1-Nov-04	115	478,455	1,292	0	24	0	1,339	0	1,339	505	393	898	66.4	2.5
2-Nov-04	91	353,975	1,022	0	19	7	1,060	0	1,060	374	311	685	64.0	2.0
3-Nov-04	120	446,584	1,327	0	24	0	1,376	0	1,376	472	409	881	63.4	2.5
4-Nov-04	122	492,685	1,346	0	24	0	1,396	0	1,396	520	416	936	66.5	2.5
5-Nov-04	125	546,721	1,376	0	24	1	1,427	0	1,427	577	427	1,004	69.8	2.5
6-Nov-04	126	568,644	1,393	0	24	0	1,445	0	1,445	600	431	1,032	70.8	2.5
7-Nov-04	124	557,653	1,369	0	24	2	1,420	0	1,420	589	423	1,012	70.7	2.5
8-Nov-04	124	567,770	1,368	0	24	0	1,418	0	1,418	600	423	1,022	71.5	2.5
9-Nov-04	130	600,621	1,432	0	24	1	1,485	0	1,485	634	444	1,078	72.0	2.5
10-Nov-04	132	642,756	1,448	0	24	6	1,501	0	1,501	679	449	1,128	74.6	2.5
11-Nov-04	128	676,144	1,414	0	24	1	1,466	0	1,466	714	436	1,150	77.9	2.5
12-Nov-04	122	597,739	1,368	0	24	0	1,419	0	1,419	631	418	1,049	73.4	2.5
13-Nov-04	129	648,413	1,419	0	24	7	1,472	0	1,472	685	439	1,124	75.8	2.5
14-Nov-04	133	636,779	1,459	0	24	19	1,513	0	1,513	672	455	1,127	73.9	2.5
15-Nov-04	132	636,563	1,450	0	24	19	1,504	0	1,504	672	450	1,123	74.1	2.5
16-Nov-04	130	644,710	1,438	0	24	17	1,491	0	1,491	681	445	1,126	74.9	2.5
17-Nov-04	127	580,249	1,407	0	24	20	1,459	0	1,459	613	432	1,045	71.1	2.5
18-Nov-04	116	565,060	1,317	0	24	16	1,366	0	1,366	597	395	991	69.2	2.5
19-Nov-04	122	567,801	1,354	0	24	19	1,404	0	1,404	600	416	1,015	71.7	2.5
20-Nov-04	121	633,901	1,349	0	24	0	1,399	0	1,399	669	413	1,082	76.8	2.5
21-Nov-04	122	643,983	1,359	0	24	0	1,409	0	1,409	680	416	1,096	77.2	2.5
22-Nov-04	79	368,526	880	0	15	14	913	0	913	389	270	659	71.2	1.6
23-Nov-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
24-Nov-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
25-Nov-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
26-Nov-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
27-Nov-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
28-Nov-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
29-Nov-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
30-Nov-04	0	0	0	0	0	24	0	0	0	0	0	0	N/A	0.0
totals	2,670	12,455,733	29,587	0	513	341	30,682	0	30,682	13,153	9,111	22,264	72.0	54.3

Month

November 2004 Performance Data





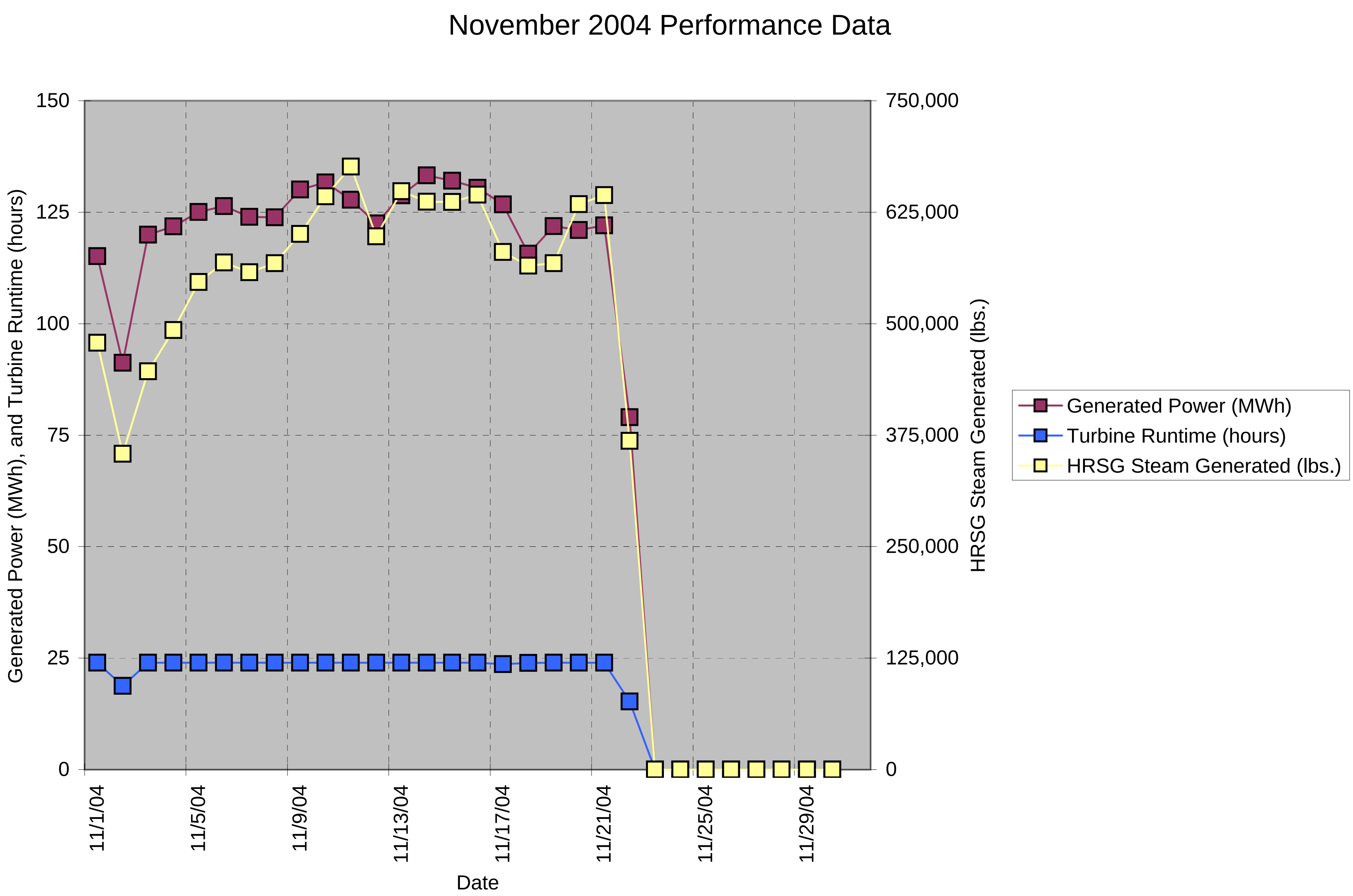
Net CHP Efficiency *

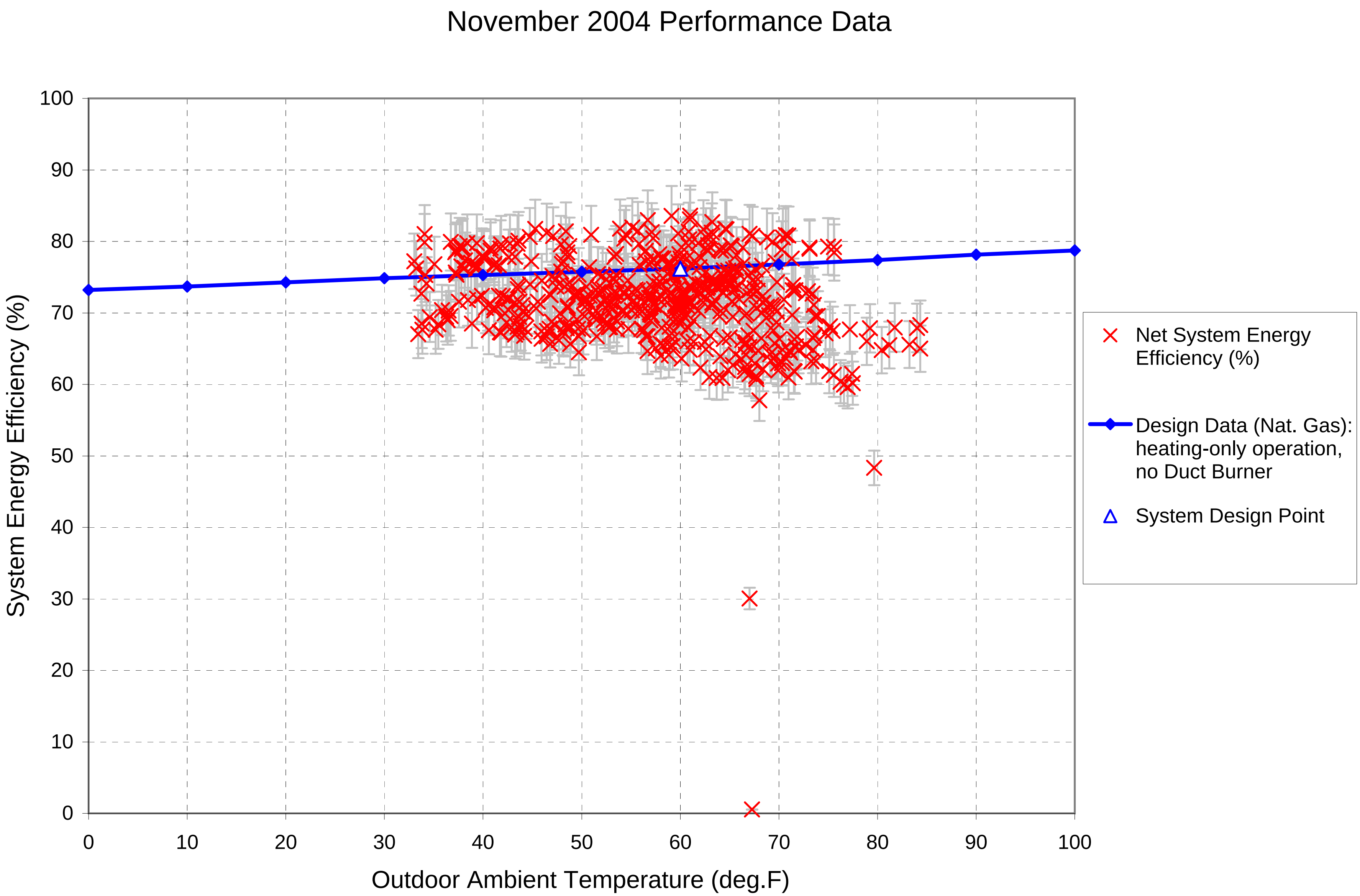
$$n_{CHP \cdot NET} = \frac{NET\ P_{REAL}(kW) + P_{QNET}(kW)}{P_{FUEL \cdot INPUT}(kW)} \times 100$$

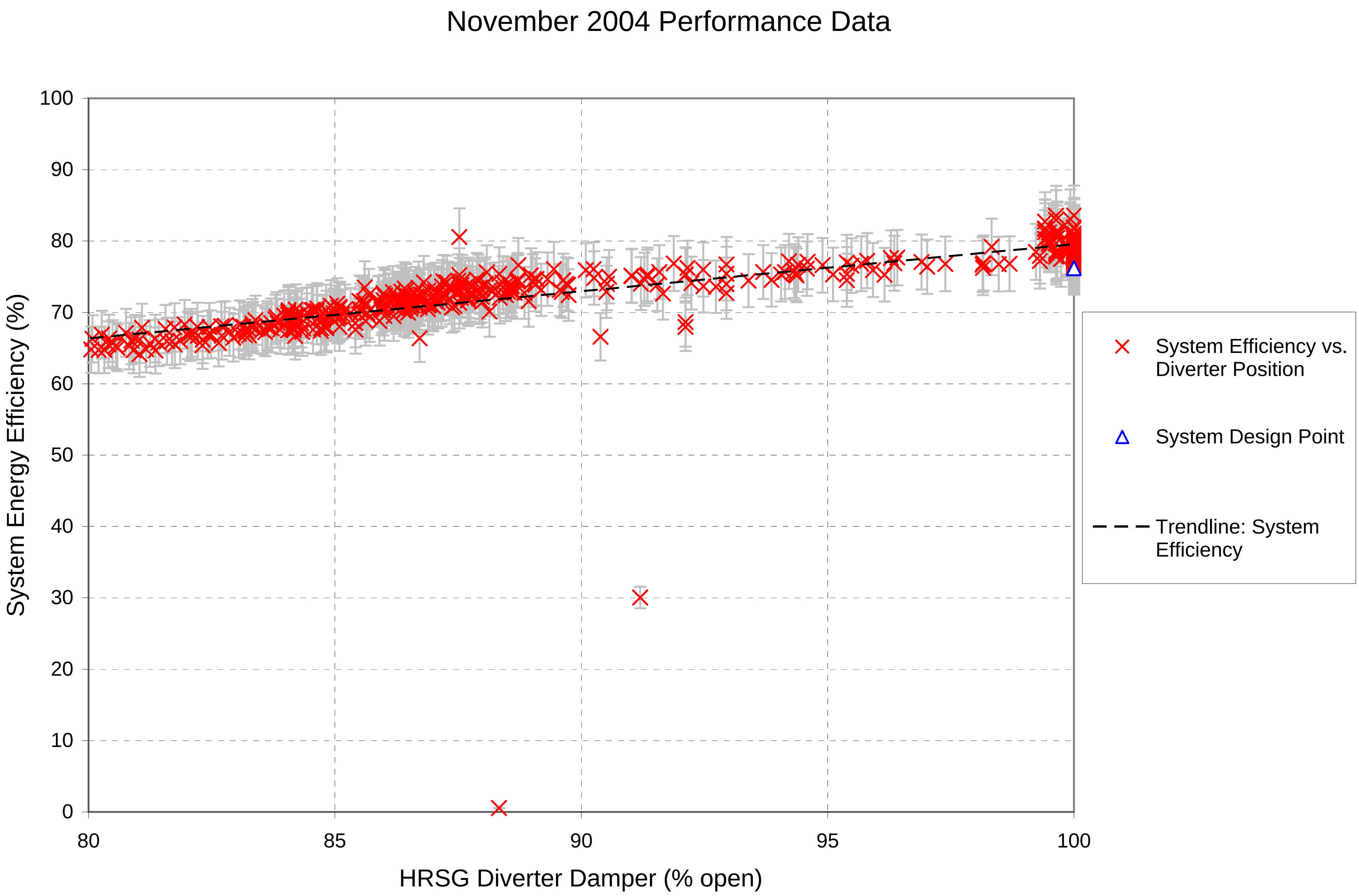
= **72.0%**

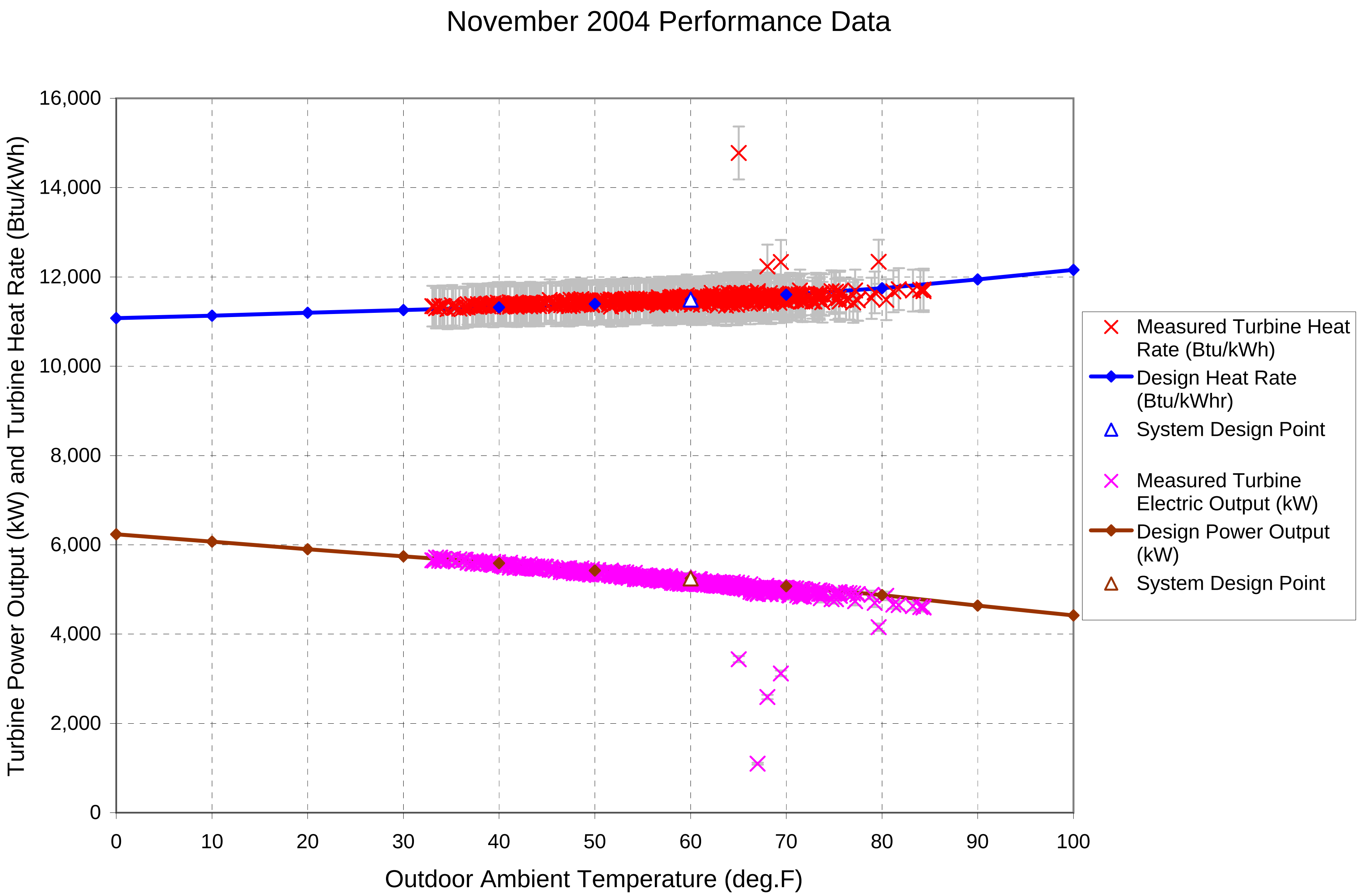
* as defined on page 27 of: “Distributed Generation Combined Heat and Power Long Term Monitoring Protocols” Interim Version, October 29, 2004, prepared by the Association of State Energy Research and Technology Transfer Institutions (ASERTTI) http://www.asertti.org

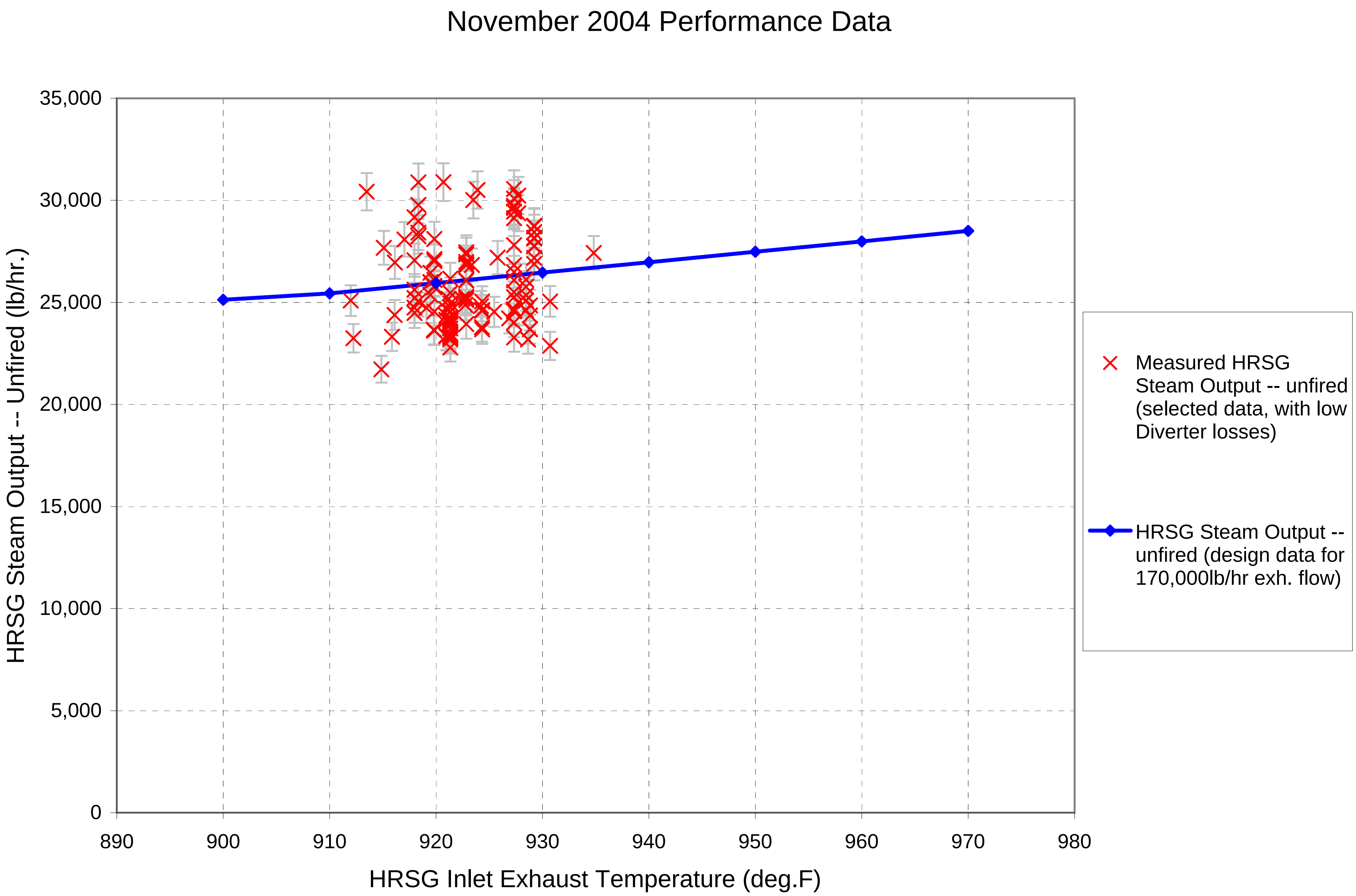
Daily

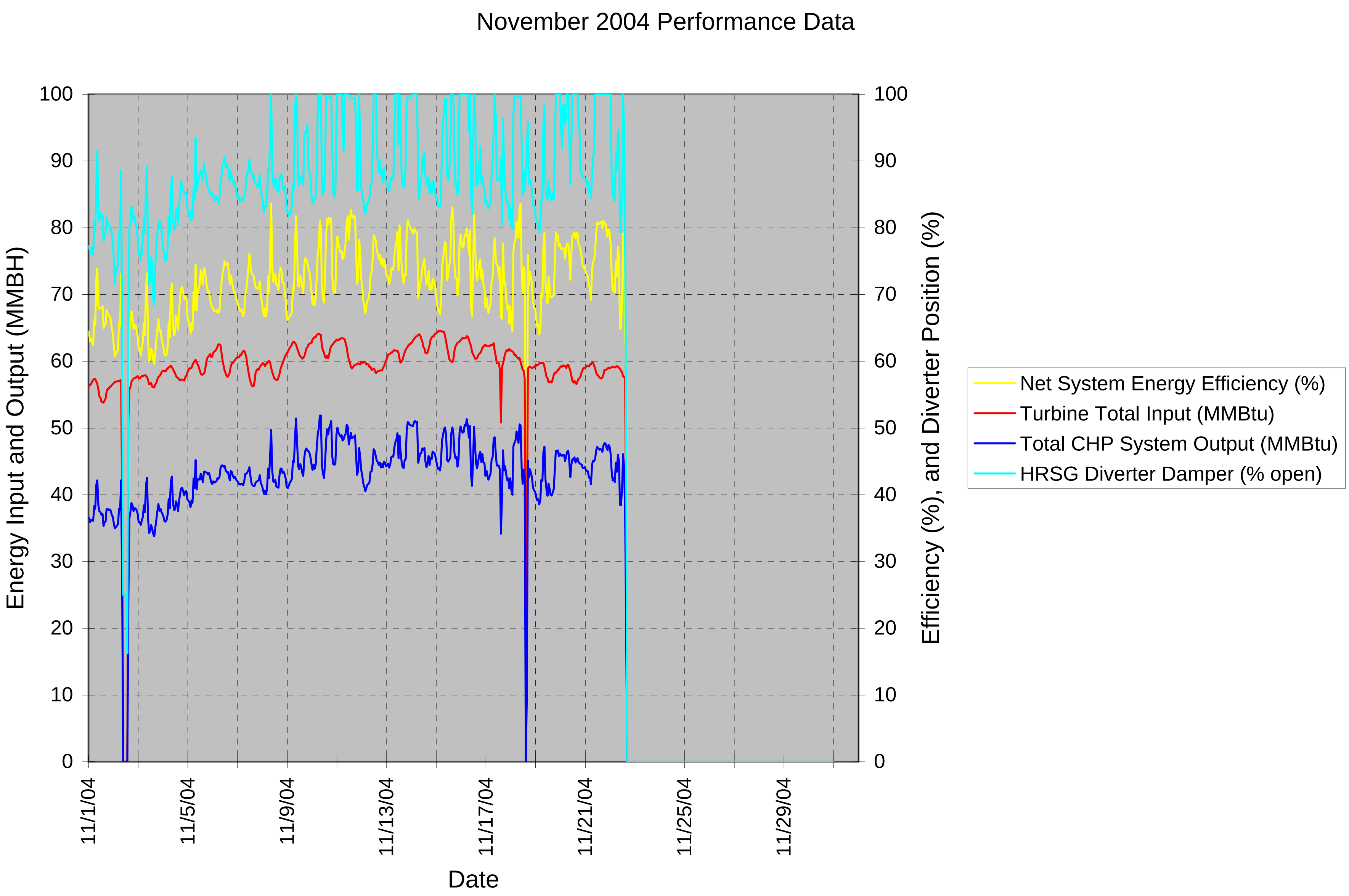

November 2004 Performance Data
150
125
100
75
50
25
0
750,000
625,000
500,000
375,000
250,000
125,000
0
Generated Power (MWh), and Turbine Runtime (hours)
HRSG Steam Generated (lbs.)
11/1/04
11/5/04
11/9/04
11/13/04
11/17/04
11/21/04
11/25/04
11/29/04
Date
Generated Power (MWh)
Turbine Runtime (hours)
HRSG Steam Generated (lbs.)

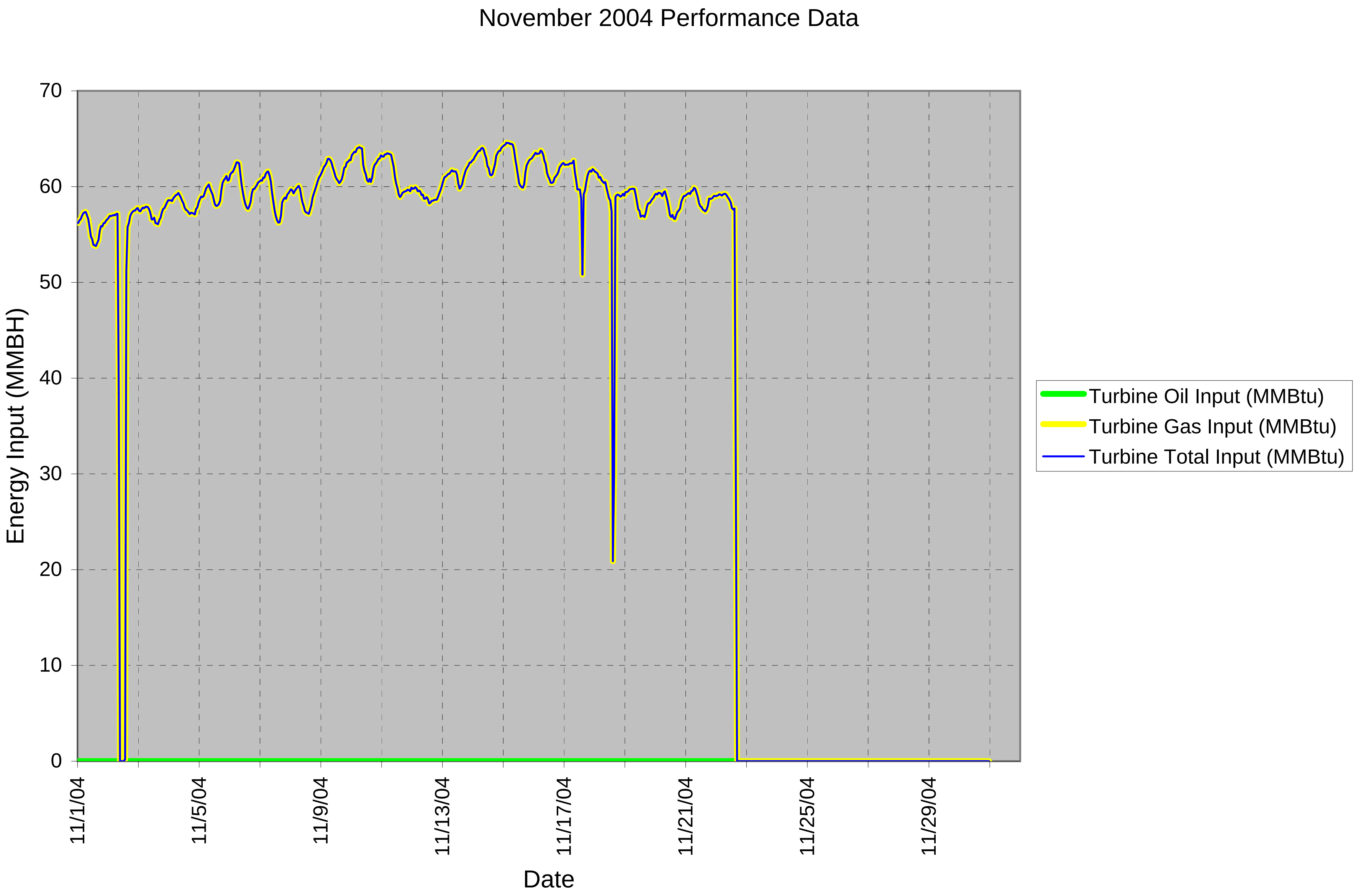

November 2004 Performance Data
System Energy Efficiency (%)
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Outdoor Ambient Temperature (deg.F)
Net System Energy Efficiency (%)
Design Data (Nat. Gas): heating-only operation, no Duct Burner
System Design Point


November 2004 Performance Data
System Energy Efficiency (%)
100
90
80
70
60
50
40
30
20
10
0
80
85
90
95
100
HRSG Diverter Damper (% open)
System Efficiency vs. Diverter Position
System Design Point
Trendline: System Efficiency


November 2004 Performance Data
Turbine Power Output (kW) and Turbine Heat Rate (Btu/kWh)
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
0
10
20
30
40
50
60
70
80
90
100
Outdoor Ambient Temperature (deg.F)
Measured Turbine Heat Rate (Btu/kWh)
Design Heat Rate (Btu/kWhr)
System Design Point
Measured Turbine Electric Output (kW)
Design Power Output (kW)
System Design Point

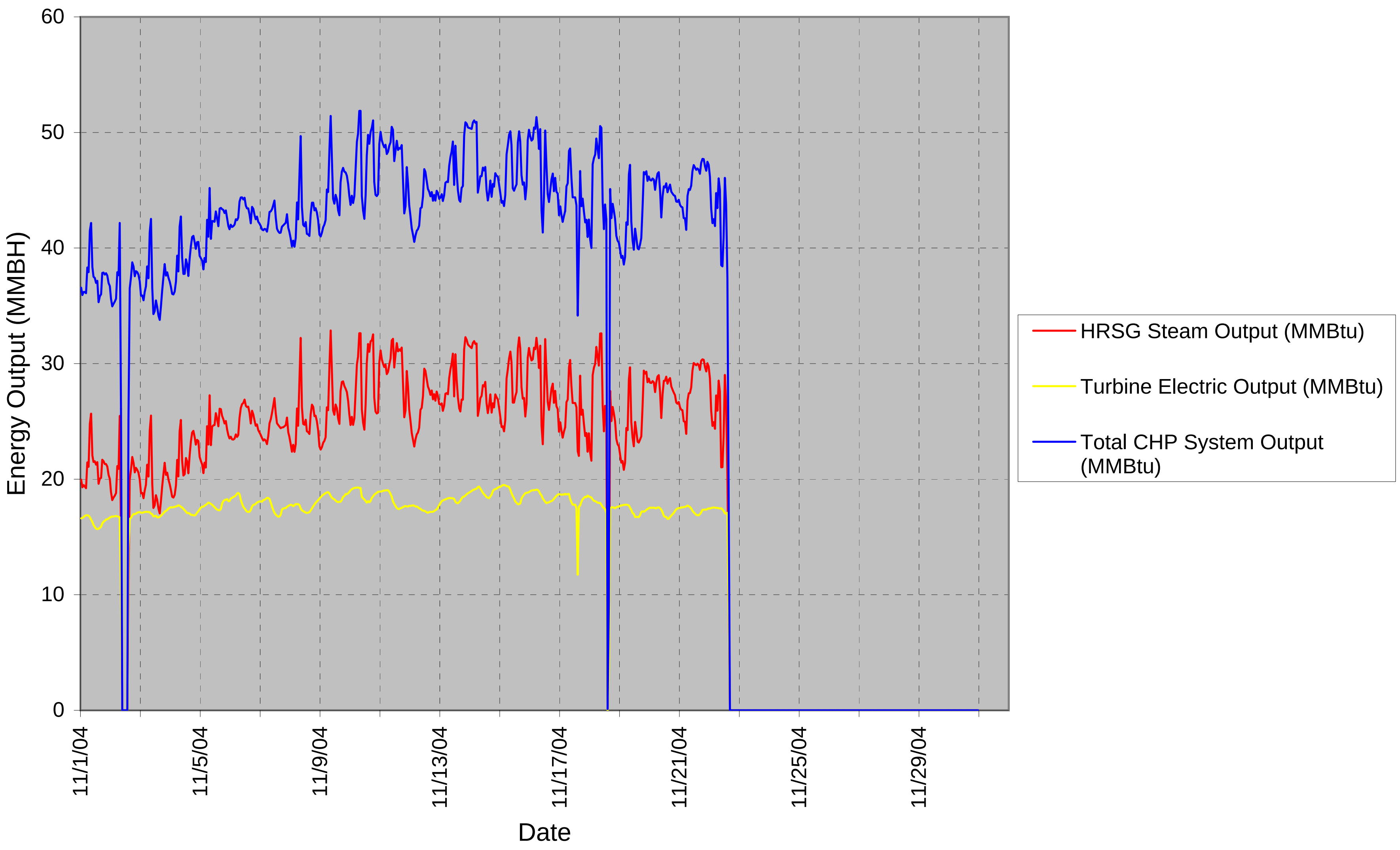

November 2004 Performance Data
HRSG Steam Output -- Unfired (lb/hr.)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
890
900
910
920
930
940
950
960
970
980
HRSG Inlet Exhaust Temperature (deg.F)
Measured HRSG Steam Output -- unfired (selected data, with low Diverter losses)
HRSG Steam Output -- unfired (design data for 170,000lb/hr exh. flow)


November 2004 Performance Data
Energy Input and Output (MMBH)
Efficiency (%), and Diverter Position (%)
Date
0
10
20
30
40
50
60
70
80
90
100
11/1/04
11/5/04
11/9/04
11/13/04
11/17/04
11/21/04
11/25/04
11/29/04
Net System Energy Efficiency (%)
Turbine Total Input (MMBtu)
Total CHP System Output (MMBtu)
HRSG Diverter Damper (% open)


November 2004 Performance Data
Energy Input (MMBH)
70
60
50
40
30
20
10
0
11/1/04
11/5/04
11/9/04
11/13/04
11/17/04
11/21/04
11/25/04
11/29/04
Date
Turbine Oil Input (MMBtu)
Turbine Gas Input (MMBtu)
Turbine Total Input (MMBtu)

Output

November 2004 Performance Data



4.4 Detailed Performance Results: December 2004

Detailed performance results for the month of December 2004, are shown in the table and figures on the following pages.

Field observations noted during the month are:

- The IES system was off-line during the first few days of the month, due to high fuel prices.
- Some periods of operation with fuel oil firing the turbine.
- Significant periods of simultaneous operation of the auxiliary boiler during the month.
- The duct burner remained off-line, as described earlier. During most of the month, the auxiliary boiler was operated to provide supplemental steam to meet the thermal load. As described earlier, this resulted in diverting some exhaust energy in order to maintain the desired steam pressure.

Data analysis comments for the month are:

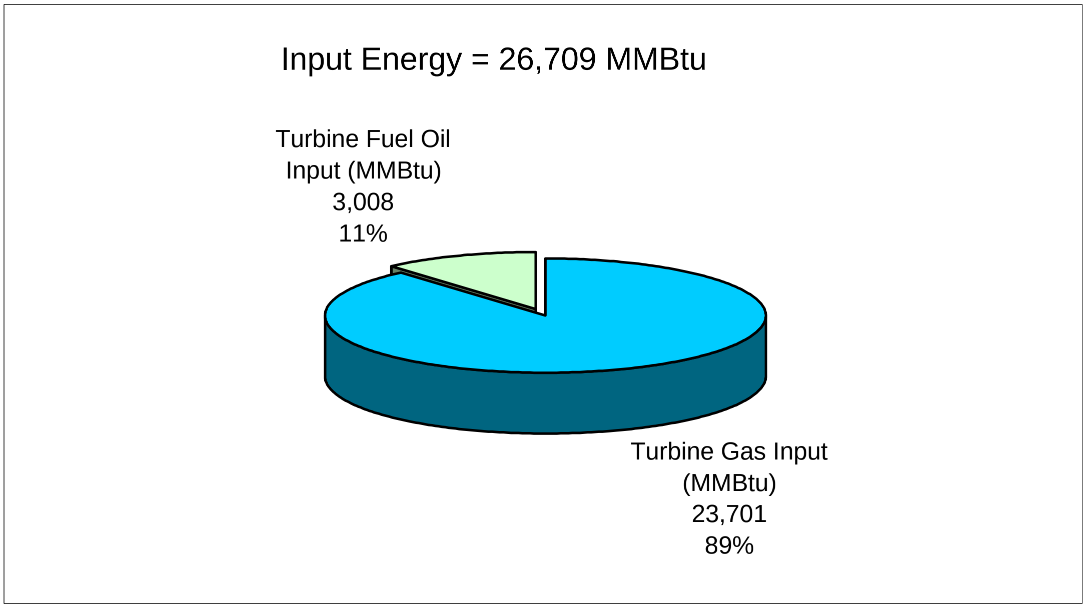
Table or Figure	Analysis Comments
Summary Data Table	Other than the period of lost operation, the system's performance was very good during the month.
Monthly Overview	The amount of unrecovered energy was greater than desired due to significant simultaneous operation of the auxiliary boiler (see notes above).
Daily Performance	See comments above.
System Net Energy Efficiency	System net energy efficiency was within the expected range, although there were some periods of significant diverter losses required to match the steam load. Overall, the measured data matches well with the design data (within the expected uncertainty).
Diverter Energy Losses	See comment above.
Turbine Generator Performance	Very good performance, the measured data matches well with the design data (within the expected uncertainty).
HRSG Performance	Good performance, given the diverter losses that were present in some of the data.

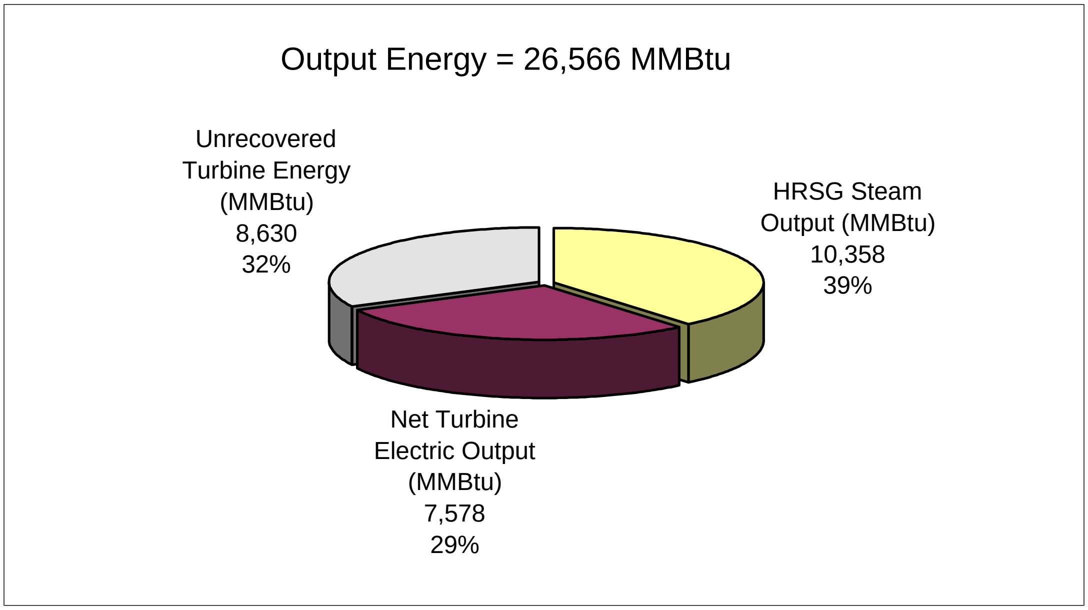
Additional plots of more detailed operating data are presented in Appendix D.

Date		Measured Data							Calculated Results							
Date		Generated Power (MWh)	HRSG Steam Generated (lbs.)	Turbine Nat. Gas Consumed (MCF)	Turbine Fuel Oil Consumed (gal.)	Turbine Runtime (hours)	Aux. Boiler#5 Runtime (hours)		Turbine Natural Gas Input (MMBtu)	Turbine Fuel Oil Input (MMBtu)	Turbine Total Energy Input (MMBtu)	HRSG Steam Output (MMBtu)	Turbine Power Output (MMBtu)	Total CHP Output (MMBtu)	Net Daily System Efficiency (%)	Parasitic Energy (MWh)
1-Dec-04		0	0	0	0	0	23		0	0	0	0	0	0	N/A	0.0
2-Dec-04		0	0	0	0	0	24		0	0	0	0	0	0	N/A	0.0
3-Dec-04		0	0	0	0	0	24		0	0	0	0	0	0	N/A	0.0
4-Dec-04		0	0	0	0	0	24		0	0	0	0	0	0	N/A	0.0
5-Dec-04		0	0	0	0	0	24		0	0	0	0	0	0	N/A	0.0
6-Dec-04		0	0	0	0	0	24		0	0	0	0	0	0	N/A	0.0
7-Dec-04		0	0	0	0	0	24		0	0	0	0	0	0	N/A	0.0
8-Dec-04		2	2,226	195	0	9	24		203	0	203	2	5	8	16.2	0.9
9-Dec-04		121	652,124	1,369	0	23	3		1,420	0	1,420	689	412	1,101	76.6	2.5
10-Dec-04		116	628,779	1,324	0	24	11		1,373	0	1,373	664	396	1,060	76.6	2.5
11-Dec-04		126	644,843	1,412	0	24	14		1,464	0	1,464	681	429	1,110	75.3	2.5
12-Dec-04		128	570,299	1,435	0	24	24		1,488	0	1,488	602	438	1,040	69.4	2.5
13-Dec-04		127	599,356	1,420	0	24	24		1,472	0	1,472	633	433	1,066	71.8	2.5
14-Dec-04		69	297,058	770	0	12	24		798	0	798	314	234	548	66.1	1.3
15-Dec-04		42	170,288	124	2,945	11	23		128	406	535	180	145	324	59.8	0.6
16-Dec-04		110	511,093	0	9,662	24	24		0	1,333	1,333	540	374	914	67.9	0.9
17-Dec-04		70	305,560	13	6,061	14	24		14	836	850	323	240	563	62.5	0.5
18-Dec-04		2	0	61	0	2	24		63	0	63	0	8	8	20.3	0.2
19-Dec-04		1	0	54	0	3	24		57	0	57	0	4	4	17.9	0.3
20-Dec-04		32	33	18	2,698	6	24		19	372	391	0	108	108	27.0	0.3
21-Dec-04		66	237,043	686	433	14	24		712	60	771	250	225	475	56.9	1.4
22-Dec-04		122	479,027	1,361	0	24	24		1,411	0	1,411	506	417	923	64.8	2.5
23-Dec-04		121	413,087	1,366	0	24	19		1,416	0	1,416	436	414	850	59.5	2.5
24-Dec-04		130	475,092	1,440	0	24	24		1,493	0	1,493	502	443	944	62.6	2.5
25-Dec-04		134	541,876	1,490	0	24	24		1,546	0	1,546	572	459	1,031	66.2	2.5
26-Dec-04		135	566,174	1,500	0	24	24		1,556	0	1,556	598	459	1,057	67.4	2.5
27-Dec-04		136	587,223	1,513	0	24	24		1,569	0	1,569	620	464	1,085	68.6	2.5
28-Dec-04		114	524,553	1,267	0	20	20		1,314	0	1,314	554	389	943	72.2	2.1
29-Dec-04		130	555,277	1,455	0	24	24		1,509	0	1,509	586	443	1,029	67.6	2.5
30-Dec-04		127	504,489	1,428	0	24	24		1,480	0	1,480	533	433	966	64.6	2.5
31-Dec-04		102	542,912	1,154	0	19	19		1,197	0	1,197	573	348	922	76.5	2.0
totals		2,263	9,808,411	22,855	21,799	445	684		23,701	3,008	26,709	10,358	7,721	18,079	67.2	43.4

Month

December 2004 Performance Data





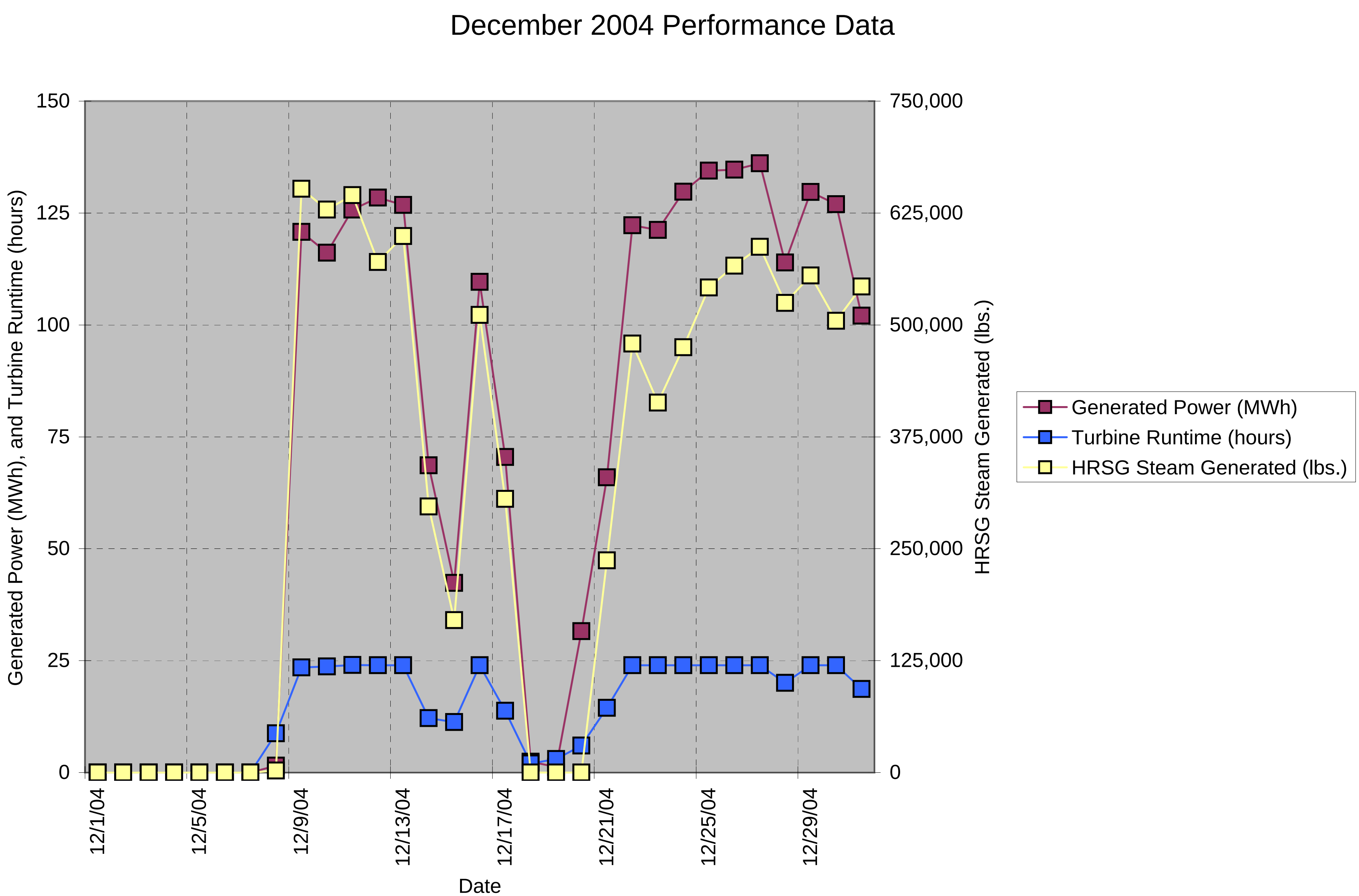
Net CHP Efficiency *

$$n_{CHP \cdot NET} = \frac{NET\ P_{REAL}(kW) + P_{QNET}(kW)}{P_{FUEL \cdot INPUT}(kW)} \times 100$$

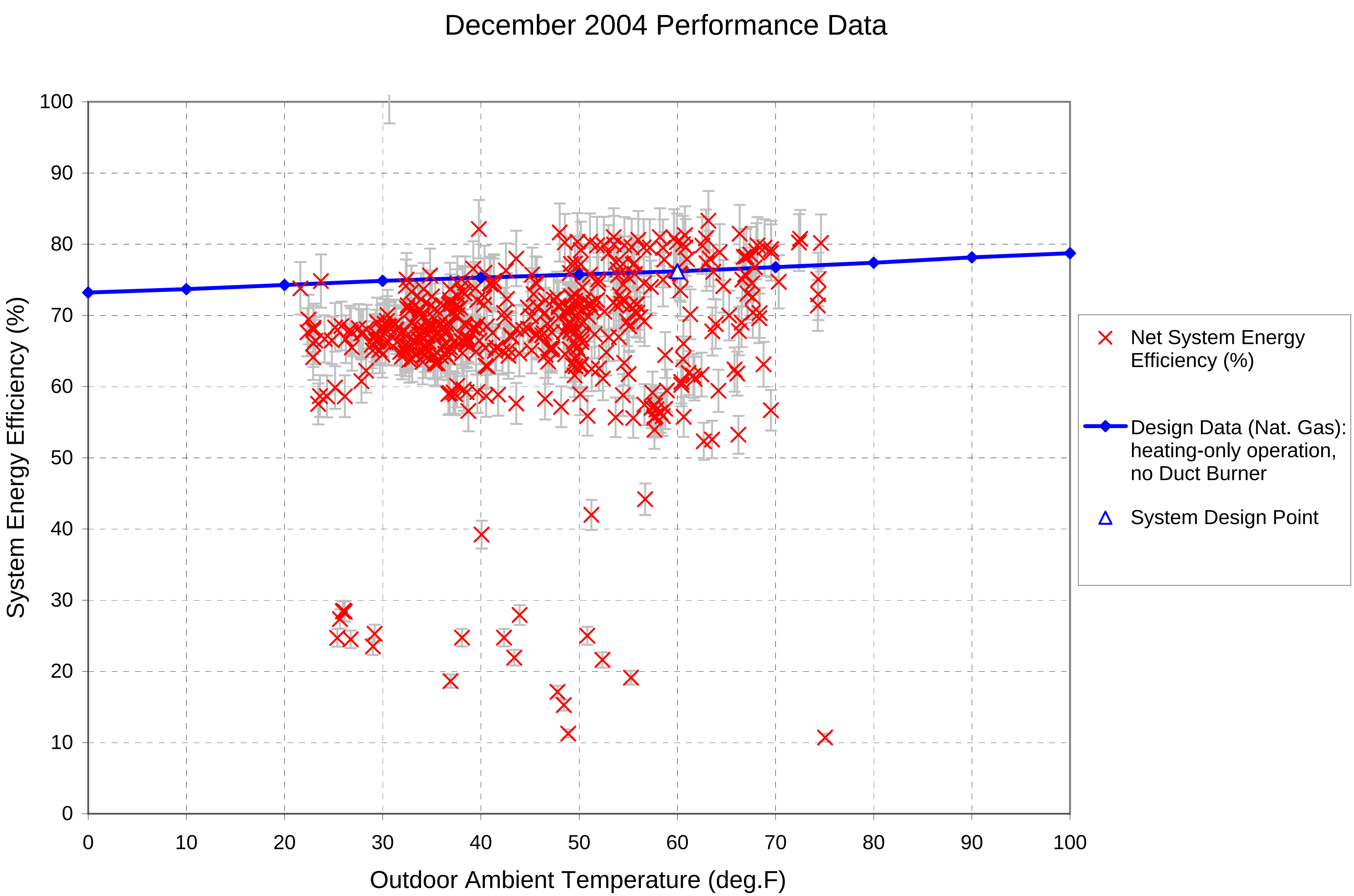
= **67.2%**

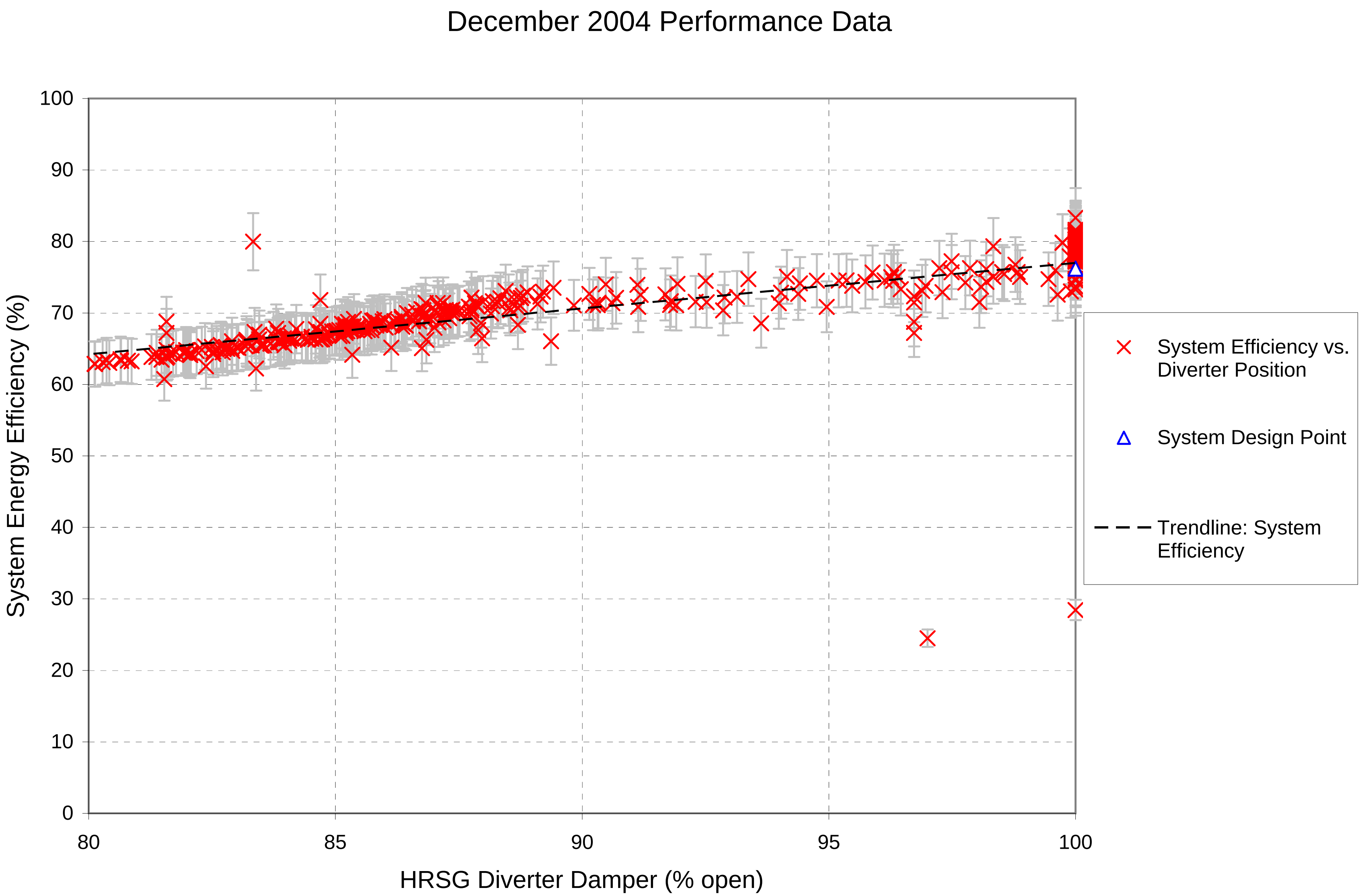
* as defined on page 27 of: “Distributed Generation Combined Heat and Power Long Term Monitoring Protocols” Interim Version, October 29, 2004, prepared by the Association of State Energy Research and Technology Transfer Institutions (ASERTTI) http://www.asertti.org

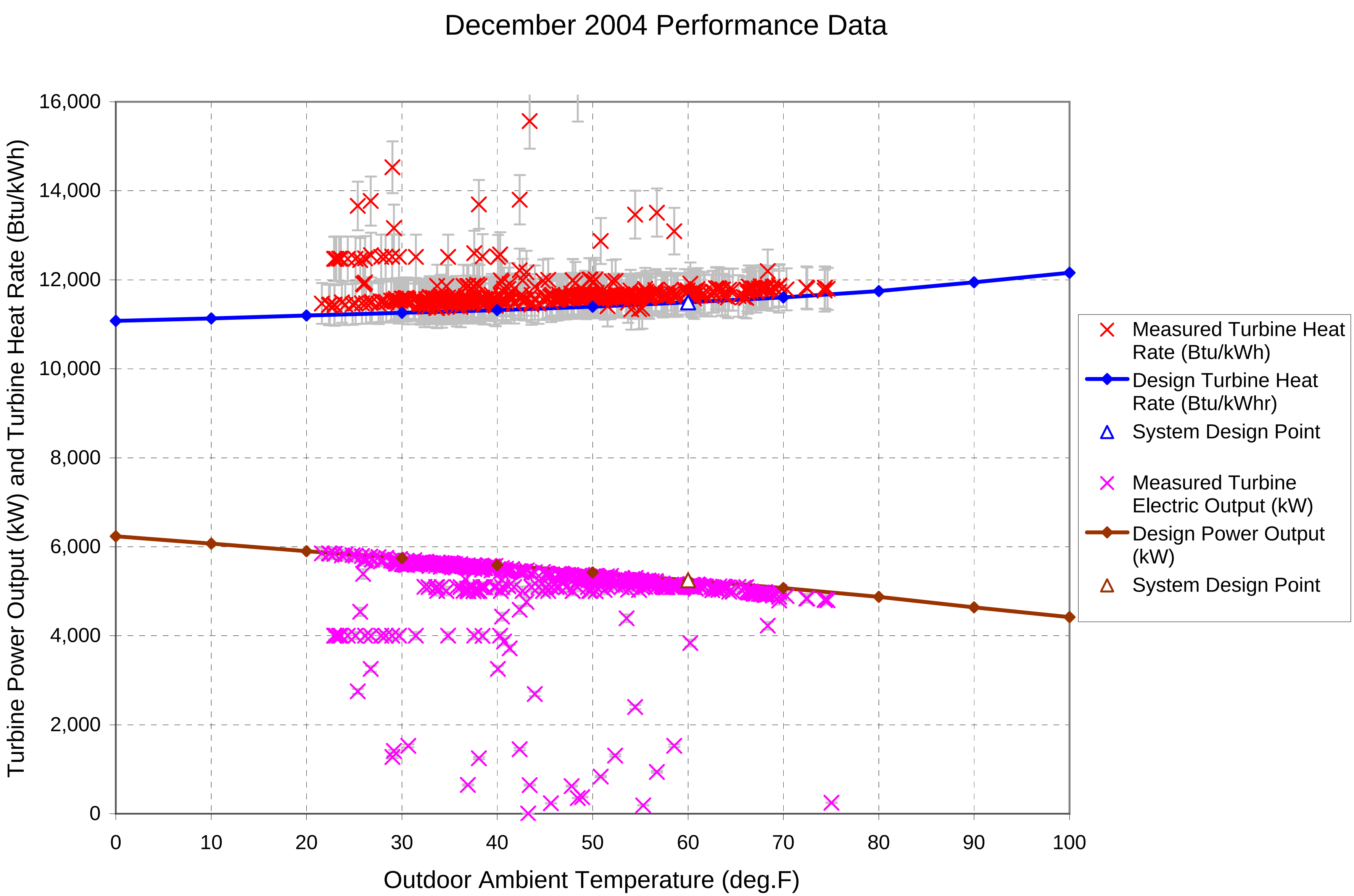
Daily

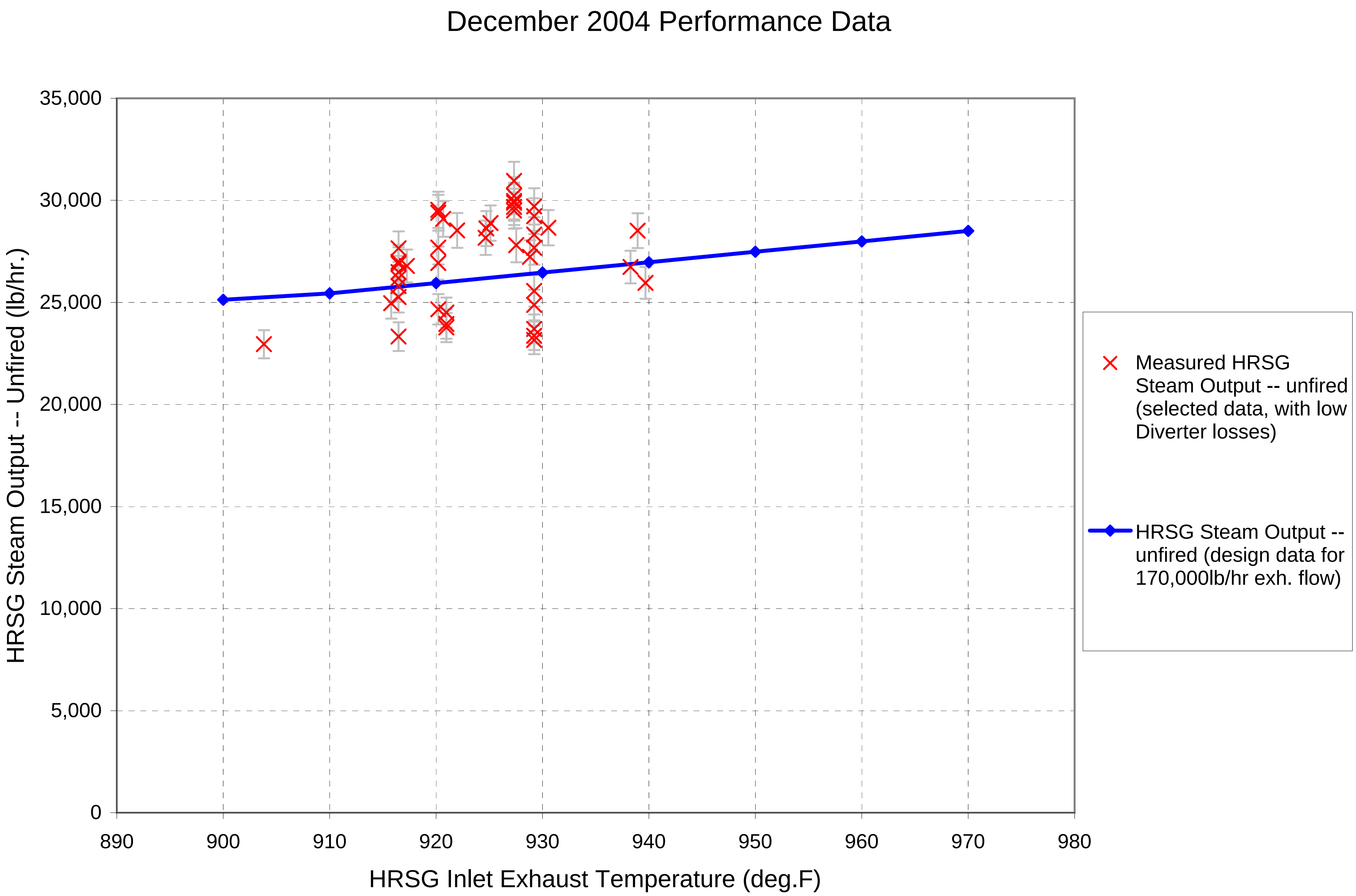


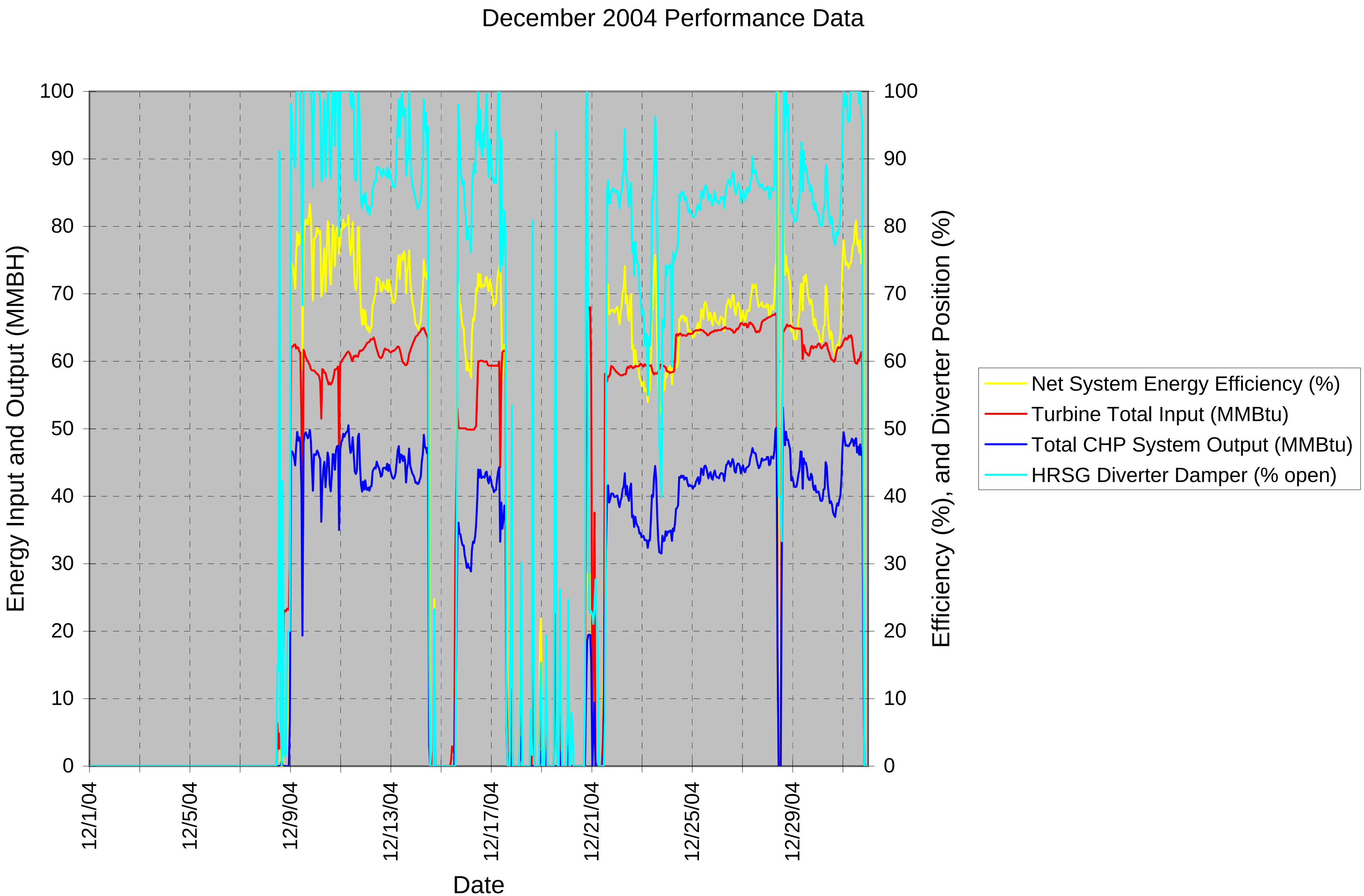
December 2004 Performance Data
Generated Power (MWh), and Turbine Runtime (hours)
HRSG Steam Generated (lbs.)
150
125
100
75
50
25
0
750,000
625,000
500,000
375,000
250,000
125,000
0
12/1/04
12/5/04
12/9/04
12/13/04
12/17/04
12/21/04
12/25/04
12/29/04
Date
Generated Power (MWh)
Turbine Runtime (hours)
HRSG Steam Generated (lbs.)


December 2004 Performance Data
System Energy Efficiency (%)
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Outdoor Ambient Temperature (deg.F)
Net System Energy Efficiency (%)
Design Data (Nat. Gas): heating-only operation, no Duct Burner
System Design Point

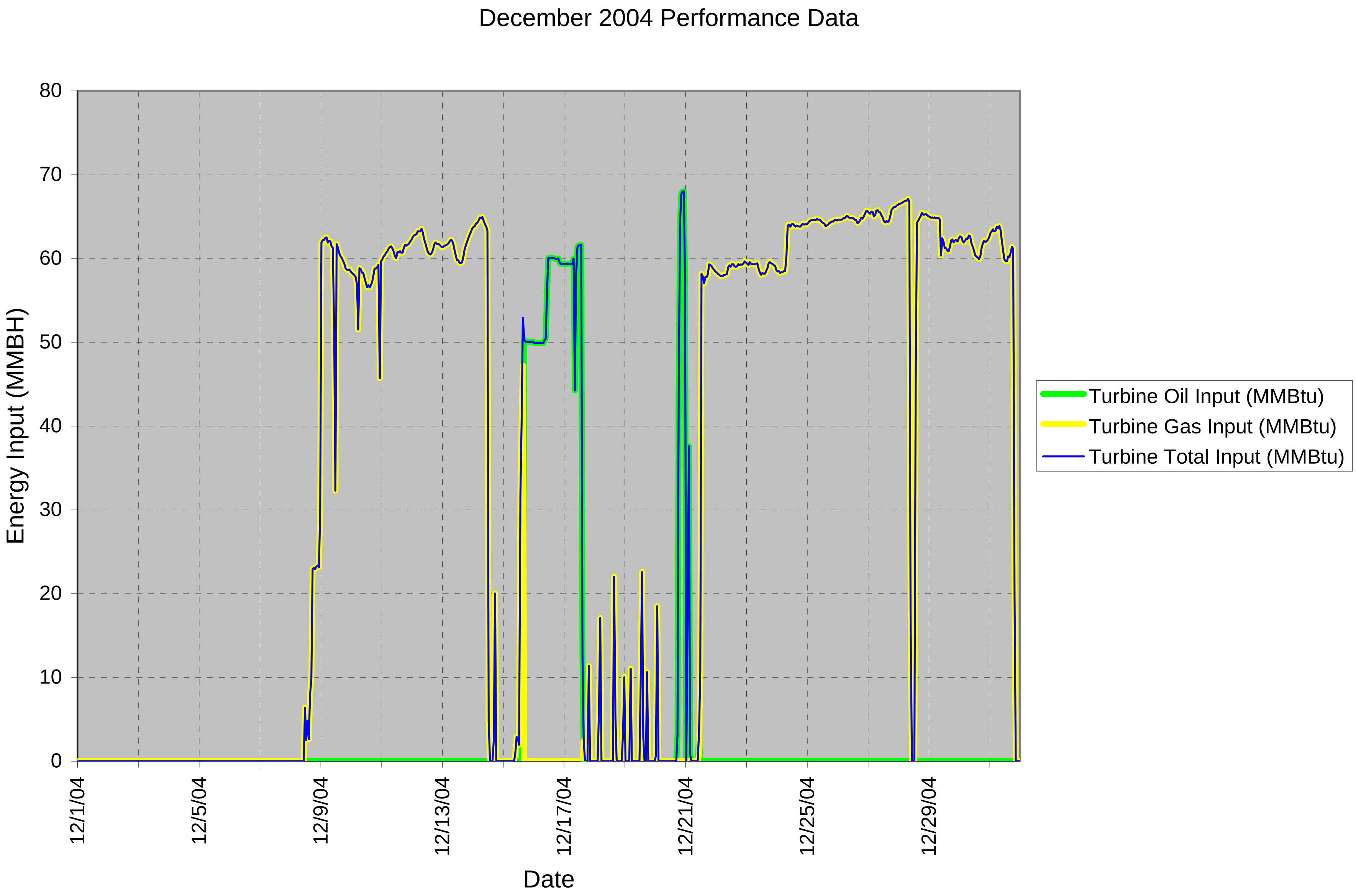

December 2004 Performance Data
System Energy Efficiency (%)
100
90
80
70
60
50
40
30
20
10
0
80
85
90
95
100
HRSG Diverter Damper (% open)
System Efficiency vs. Diverter Position
System Design Point
Trendline: System Efficiency


December 2004 Performance Data
Turbine Power Output (kW) and Turbine Heat Rate (Btu/kWh)
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
0
10
20
30
40
50
60
70
80
90
100
Outdoor Ambient Temperature (deg.F)
Measured Turbine Heat Rate (Btu/kWh)
Design Turbine Heat Rate (Btu/kWhr)
System Design Point
Measured Turbine Electric Output (kW)
Design Power Output (kW)
System Design Point

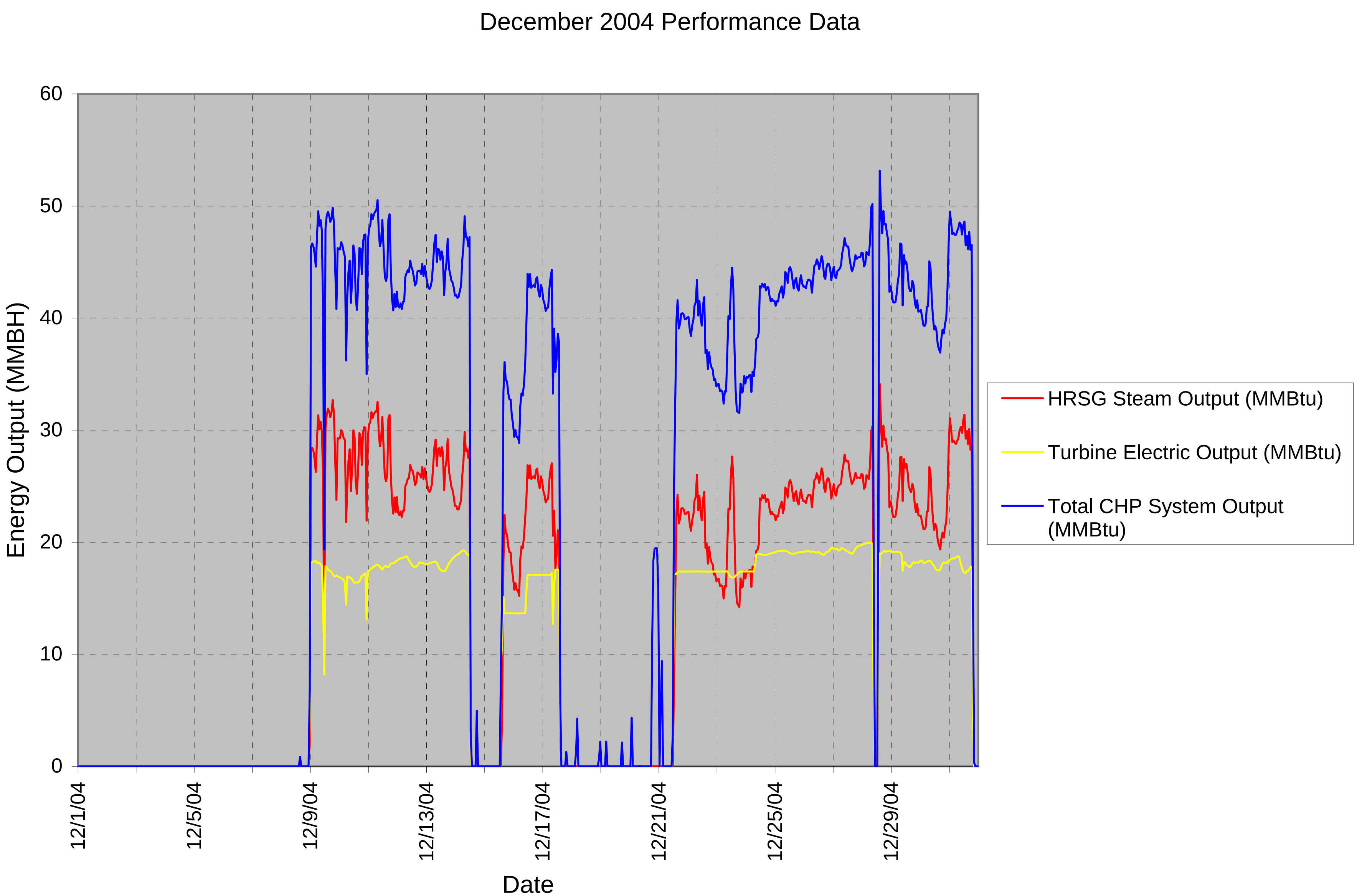

December 2004 Performance Data
HRSG Steam Output -- Unfired (lb/hr.)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
890
900
910
920
930
940
950
960
970
980
HRSG Inlet Exhaust Temperature (deg.F)
Measured HRSG Steam Output -- unfired (selected data, with low Diverter losses)
HRSG Steam Output -- unfired (design data for 170,000lb/hr exh. flow)


December 2004 Performance Data
Energy Input and Output (MMBH)
Efficiency (%), and Diverter Position (%)
0
10
20
30
40
50
60
70
80
90
100
12/1/04
12/5/04
12/9/04
12/13/04
12/17/04
12/21/04
12/25/04
12/29/04
Date
Net System Energy Efficiency (%)
Turbine Total Input (MMBtu)
Total CHP System Output (MMBtu)
HRSG Diverter Damper (% open)

Input


December 2004 Performance Data
80
70
60
50
40
30
20
10
0
Energy Input (MMBH)
12/1/04
12/5/04
12/9/04
12/13/04
12/17/04
12/21/04
12/25/04
12/29/04
Date
Turbine Oil Input (MMBtu)
Turbine Gas Input (MMBtu)
Turbine Total Input (MMBtu)

Output


December 2004 Performance Data
Energy Output (MMBH)
60
50
40
30
20
10
0
12/1/04
12/5/04
12/9/04
12/13/04
12/17/04
12/21/04
12/25/04
12/29/04
Date
HRSG Steam Output (MMBtu)
Turbine Electric Output (MMBtu)
Total CHP System Output (MMBtu)

Section 5. Background Data

The following sections present background information describing the IES system and the data collection and data analysis activity.

5.1 Data Collection and Analysis Approach

Operation of the IES system at the 82nd Central Heating Plant is governed by a conventional SCADA control system implemented using the Honeywell Enterprise Building Integrator (EBI) product. This plant control system is used by operators on a daily basis to control the operation of all plant equipment.

5.1.1 Approach

The technical approach for this the data collection and data analysis activity is guided by the process described in the "Distributed Generation Combined Heat and Power Long Term Monitoring Protocols" Interim Version, October 29, 2004, prepared by the Association of State Energy Research and Technology Transfer Institutions (ASERTTI) http://www.asertti.org. Our work utilizes this protocol and the field instrumentation that was available at the site when system operations began in mid-2004.

5.1.2 Data Collection

Collection of performance data for this project is accomplished by the Honeywell EBI system, using the same instrumentation that is used to control the plant's operation. This project data is stored in EBI, along with all other plant information (i.e. that is used by the plant operators, and facility managers).

The project team has archived the raw data for use on this project. This archive will be made available to all parties working with, or for, Oak Ridge National Lab and DOE.

5.1.3 Data Format

The performance data is collected and presented as follows:

- This activity addresses hourly data only. The raw field data is in the form of hourly averaged values.
- Use the EBI data in raw form only -- with minimal manual cleaning and filling of the data. This is most representative of how plant operators will use the ASERTTI protocol.
- Hourly data for natural gas consumption is adjusted by applying a correction factor. This adjustment is based on daily logs of manual readings taken from a utility grade gas meter by the plant operators. The correction factor is calculated for the entire month and is then applied to all of the gas consumption data for the month. A new correction factor is computed for the next month.
- The plots generally include all of the measured and calculated data. However, zero values in the calculated data are excluded in most cases (for clarity). The HRSG performance

data is selected for periods when the diverter damper is nearly full open (nearly all exhaust flow thru the HRSG).

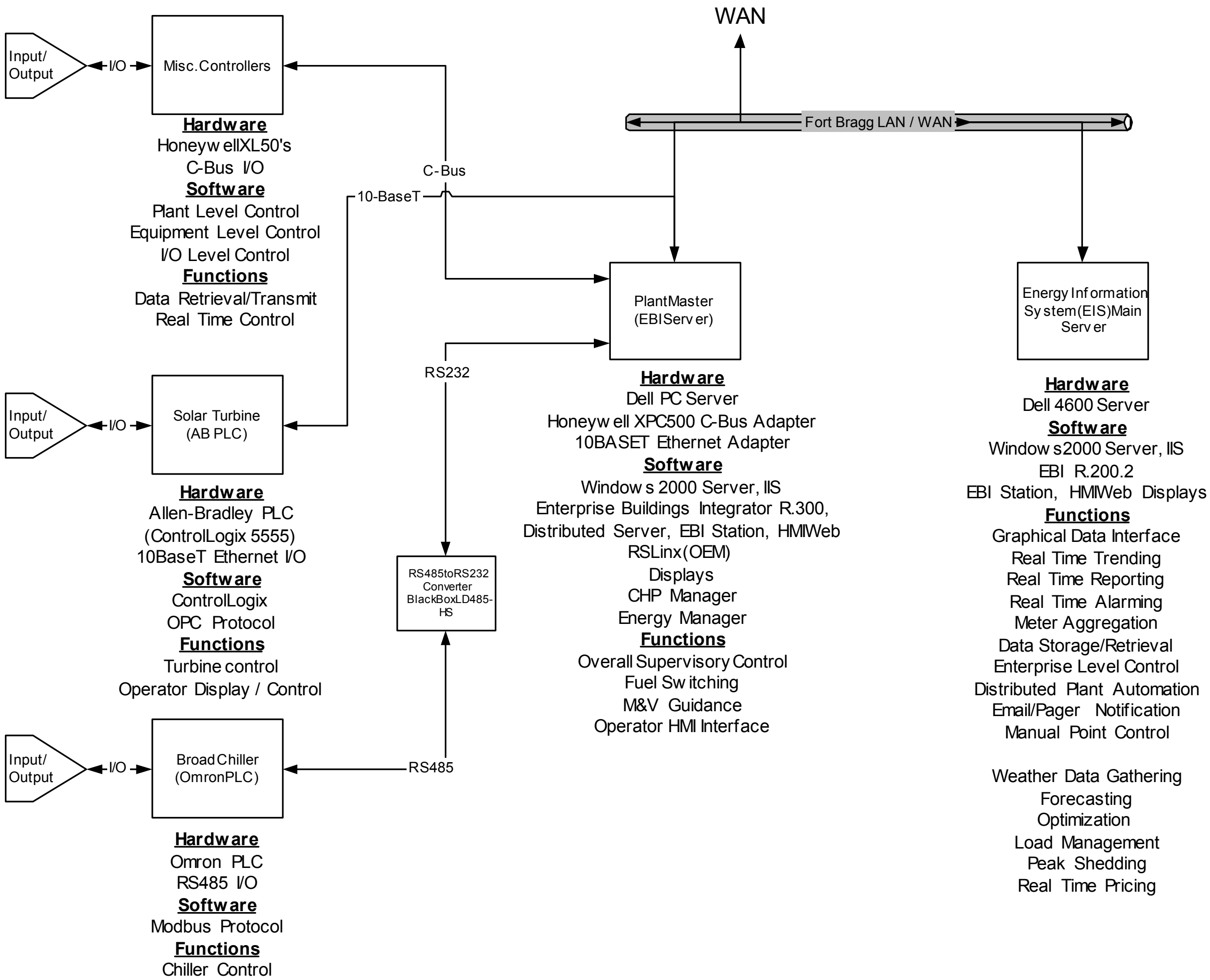
- The system net energy efficiency calculations were computed as defined on page 27 of the ASERTTI "Distributed Generation Combined Heat and Power Long Term Monitoring Protocols".

5.2 Instrumentation

A set of instrument points in the EBI system was selected for use in data collection. The list of instrumentation is shown in the following table.

Point Name	Description	Units	Typical Value	Honeywell Sensor	Solar Sensor
AN_Engine_Fired_Hours	Cumulative Operating Hours for Turbine	hours	- - -		x
AN_Total_Kw	Turbine Generator kW Output	kW	up to 5000		x
Boiler_5_Status	Aux. Boiler#5 On/Off Status	binary	- - -	x	
HPNG_Flow_A	Natural Gas Flowrate to Turbine	lb per hr.	up to 3000	x	
HRSG_Div_Dmpr	HRSG Diverter Damper Position	% open	- - -	x	
HRSG_Steam_Flow_A	Steam Flowrate from HRSG	lb per hr.	up to 28,000 (unfired) up to 80,000 (fired)	x	
AN_T1_Temperature	Outdoor Ambient Temperature	deg. F	- - -		x
TurbFOflow_A	Turbine Fuel Oil Consumption Rate	lb per min.	up to 50	x	
AN_Exhaust_Gas_Flow	Turbine Exhaust Flow Rate	lb per hr.	up to 190,000		x
HRSG_InltDct_Tmp_A	HRSG Exhaust Inlet Temperature	deg. F	up to 990F	x	
Deaerator_Temp	Deaerator Temperature	deg. F	up to 190F	x	
Boiler_Outlet_PSI	Steam Header Pressure	psig	120 to 130	x	

A top level overview of the plant control system is shown in the following figure.



5.3 Measurement Uncertainty

The measured data and calculated data have been evaluated for measurement uncertainty according to the guidelines offered in the ASERTTI protocols. The approach taken is as follows:

- Measured data is taken from the Plant Control System as hourly average readings (computed from sensor data sampled at six minute intervals).
- Measured data errors are estimated as a composite of error sources (sensor, transmitter, analog input electronics, sensor calibration, etc.).
- All errors are defined as relative error, in % of reading.

Estimates of the measured and calculated data uncertainties are presented in the following tables.

Given Data	Estimated Error	Source
HPNG_Correction	0.5%	comparison with manual readings of utility-grade gas meter
Gas_Density	1.0%	data from gas supplier
Gas_LHV	2.0%	data from gas supplier
Oil_LHV	1.5%	data from fuel oil supplier
Oil_Density	1.0%	data from fuel oil supplier
Thermal_Content	2.0%	manual off-line calculation based on monthly averages of measured steam pressure and temperature of feedwater

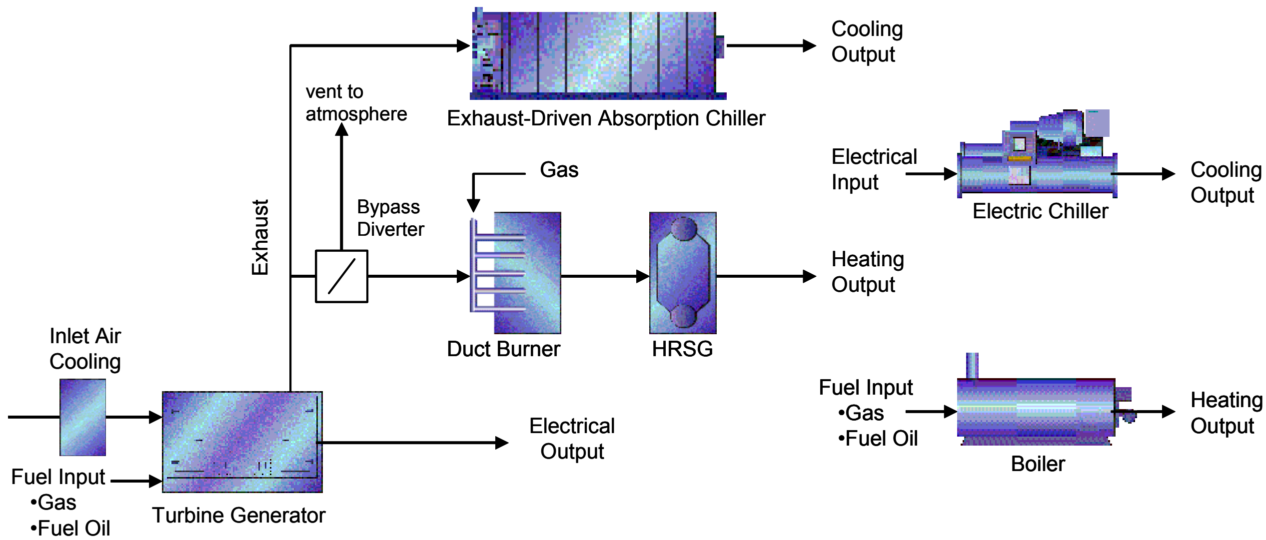
Measured Data	Estimated Error	Source
HPNG_Flow	3.0%	field instrumentation
TurbFO_Flow	3.0%	field instrumentation
HRSGSteam_Flow	3.0%	field instrumentation
TurbineGenerator_kW	2.0%	internal turbine generator instrumentation, (uncertainty also accounts for outdoor ambient temperature effects, as applied to turbine output plots)

Calculated Data	Estimated Error	Source
GasFuel_Input	3.77%	(HPNG_Flow)*(HPNG_Correction)*(Gas_Density)*(Gas_LHV)
OilFuel_Input	3.50%	(TurbFO_Flow)*(Oil_LHV)/(Oil_Density)
HRSGSteam_Output	3.61%	(HRSGSteam_Flow)*(Thermal_Content)

Calculated Results	Estimated Error	Source
MeasuredSystem_EnergyEfficiency	5.22%	(Energy_Output)/(GasFuel_Input), or (Energy_Output)/(OilFuel_Input)
Heat_Rate	4.27%	(GasFuel_Input)/(TurbineGenerator_kW), or (OilFuel_Input)/(TurbineGenerator_kW)

5.4 System Description

A block diagram of the Ft. Bragg 82nd Central Heating Plant IES system is shown in the figure below.



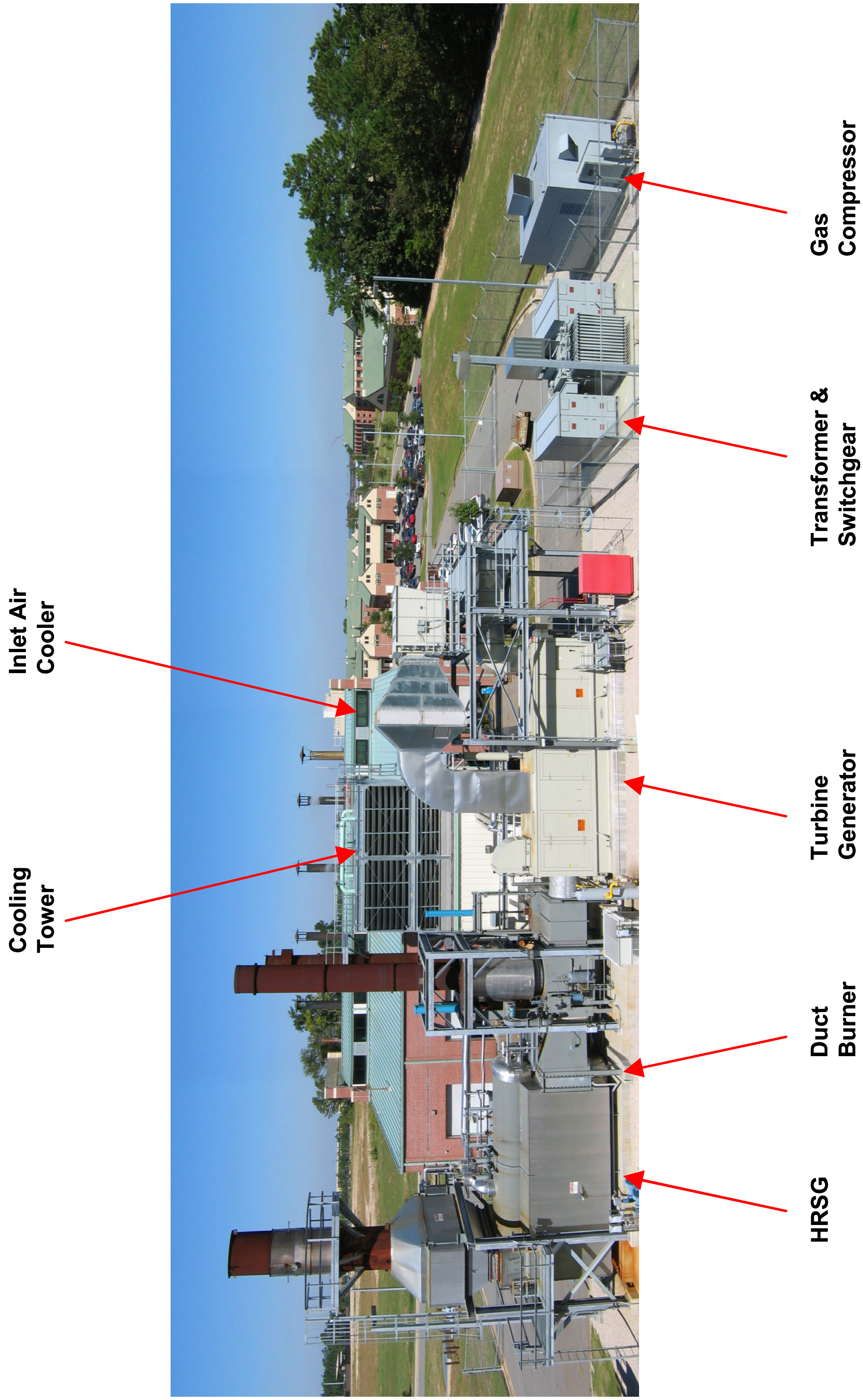
The major IES equipment in the system is described in the following table.

Equipment	Description
Gas Turbine	one Solar Turbines, Taurus 60 dual-fuel gas turbine (4160 volt, 3 phase, nominal 5MW electrical output), with SoLoNox burner technology www.solarturbines.com
Absorption Chiller	one Broad Air Conditioning, 1000 tons capacity, exhaust-driven, 44F/54F CHW design, 85F/95.2F CDW design www.broadusa.com
Heat Recovery Steam Generator (HRSG)	one Rentech Boiler Systems, type "O" shop-assembled, 28,700 pph at 125psig (unfired), 81,200 pph (fired) www.rentechboilers.com
Duct Burner	Coen, rated at 55.2 MMBH on natural gas www.coen.com

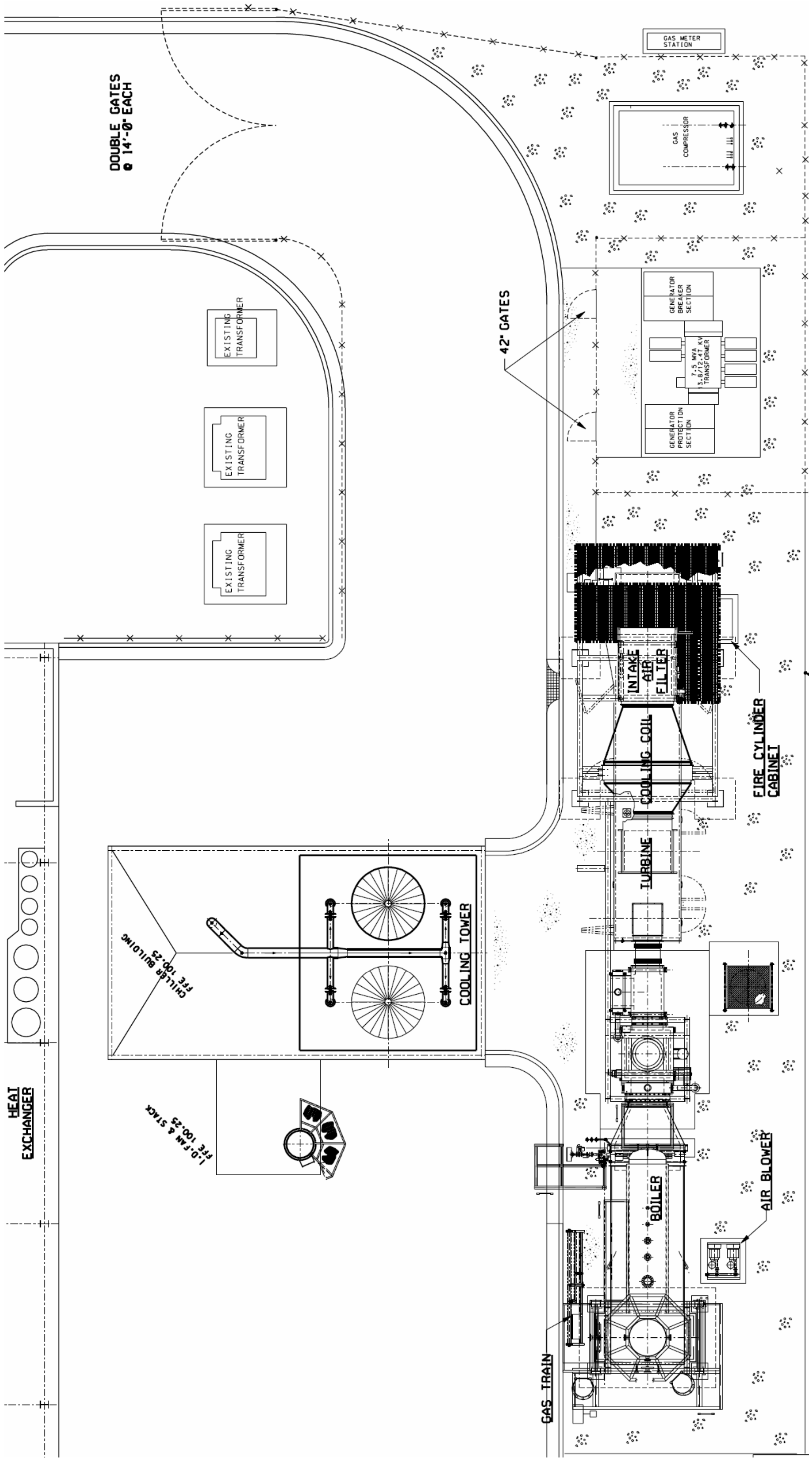
The major auxiliary equipment in the system is described in the following table.

Equipment	Description
Boiler	English, rated at 60,000 pounds of steam per hour, 125 psig
Electric Chiller	Trane, 800 tons nominal capacity

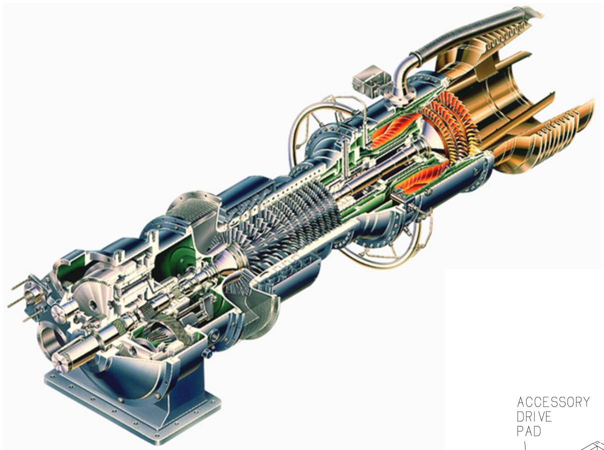
The equipment installation is shown in the photo below.

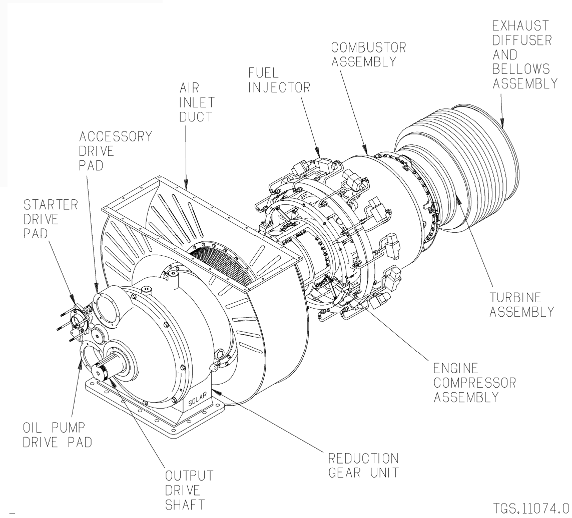


The physical arrangement of the equipment is shown in the figure below.

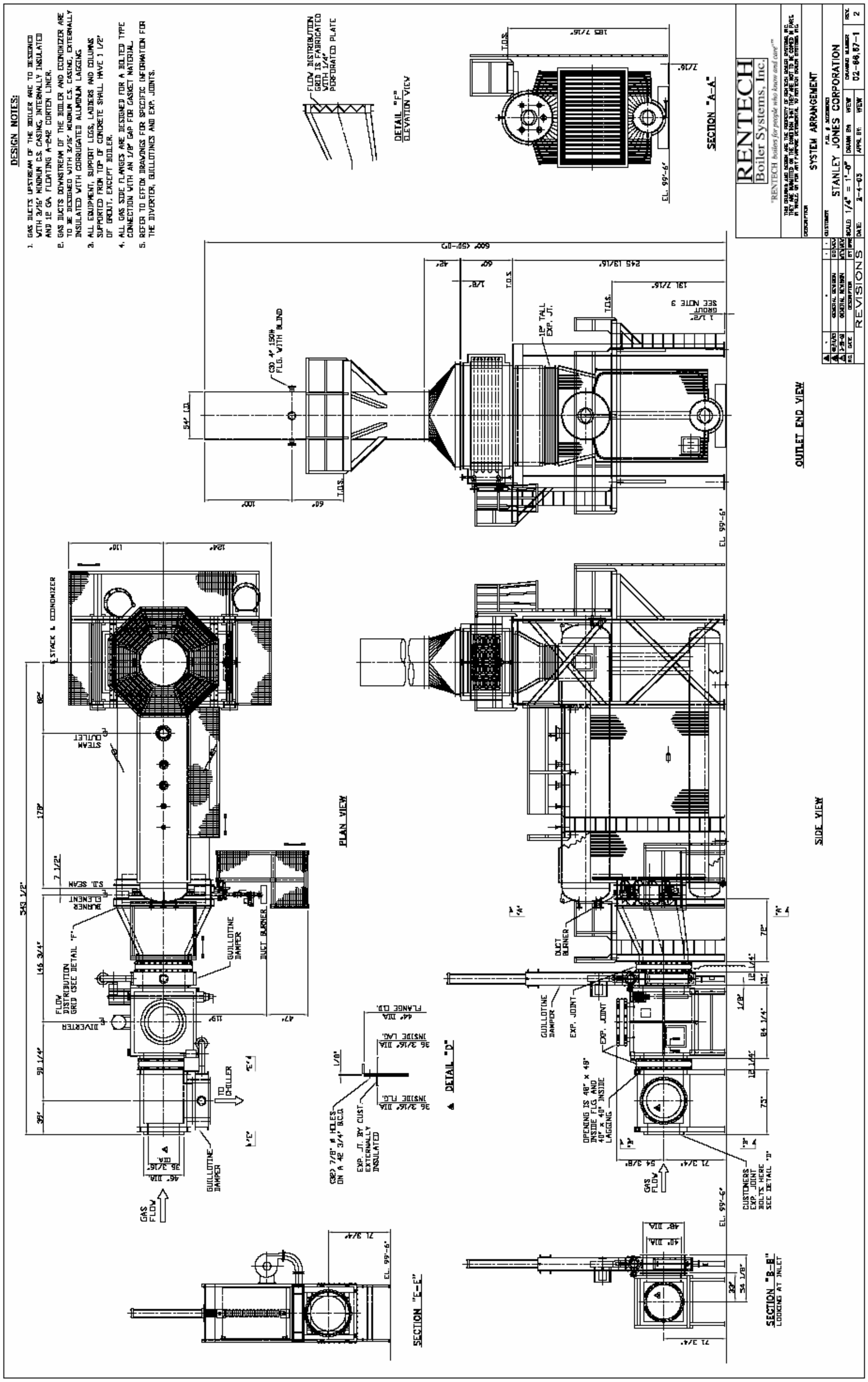


The details of the turbine generator are shown in the figures below.





The details of the heat recovery generator are shown in the figure below.



The absorption chiller is shown in the figure below.

The EBI plant control system is tied into the Honeywell Energy Information Center at Ft. Bragg. A photo of this operations center is shown below.

5.5 Site Description

The following sections present a background description of the IES project at Ft. Bragg.

5.5.1 Technical Description

The site for this system is the 82nd Central Heating Plant at Ft. Bragg, NC, which is the largest of 14 central plants on the post. This IES system is an important element of the Army's strategy to improve energy efficiency and reduce operating cost at Ft. Bragg. The project was a combination of an Energy Services Performance Contract (ESPC) between the Army and Honeywell (providing the turbine generator, HRSG, and other components), and the IES R&D project funded by the DOE's Office of Distributed Energy Resources and administered by Oak Ridge National Laboratory (providing the absorption chiller and advanced controls). Data gathering and technical support was provided by Federal Energy Management Program (FEMP).

The 82nd plant provides district heating and cooling to serve a large number of barracks and other buildings with 125psig steam for heating, 170 deg. F. hot water (converted from steam), and 44 deg. F. chilled water for cooling. The plant originally contained five large water tube steam boilers. Four of these boilers were poorly performing, unreliable and in need of replacement. This condition provided an excellent application for installing an integrated energy system (or cooling, heating, and power system).

The IES system's major equipment consists of a 5MW gas turbine generator, a heat recovery steam generator (HRSG), and a 1000 ton exhaust-driven absorption chiller. The IES equipment is fired with natural gas, and can also be fired with fuel oil as a backup fuel source. The plant also includes an auxiliary steam boiler and an auxiliary electric centrifugal chiller, for backup or to provide additional capacity when required. The IES system has an electrical generating capacity of 5250 kW, and a heating capacity of 28,700 lbs. per hour of steam at nominal ambient conditions (60 deg. F.). The plant serves a year-around heating load for domestic hot water and food service needs. Space heating loads are served during the fall and winter months. Cooling is provided during the spring, summer, and early fall.

The IES system operates in a base load condition, essentially offsetting some of the electric demand on the post. The balance of the electric load is purchased from the local electric utility. During periods of low heating load, the heating demand is less than the maximum thermal output of the IES system. During periods of high heating load, the auxiliary duct burner is employed to increase the output of the HRSG. At present, all of the cooling load for the building served can be satisfied by the 1000 ton absorption chiller.

The IES system is operated in a number of different load-following strategies, based on achieving the best economic performance. The appropriate operating strategy is determined by an on-line optimization function that is resident in the plant's supervisory control system. The optimizer guides the plant operator by recommending the optimal setpoints for electric power generation, heating, and cooling equipment.

This project is a key contributor to the post's Force Protection and energy security initiative. The on-site generation capacity of this IES system is a valuable asset that can be used to mitigate the effects of utility plant outages and other disruptions on the electrical grid.

5.5.2 Relevance to Federal Energy Policy

This project adheres to the requirements Executive Order 13123 “Greening the Government Through Efficient Energy Management”, dated June 1999. The project satisfies the objectives of the following sections of the Executive Order:

Section	Order Instructions	Project Relevance
Sec. 206 Source Energy	“The Federal Government shall strive to reduce total energy use and associated greenhouse gas and other air emissions, as measured at the source. To that end, agencies shall undertake life-cycle cost-effective projects in which source energy decreases, even if site energy use increases. In such cases, agencies will receive credit toward energy reduction goals through guidelines developed by DOE..”	The project’s advanced natural gas fired gas turbine produces electric power with lower emissions than many existing coal-fired central power plants.
Sec. 403 (a) Financing Mechanisms	“Agencies shall maximize their use of available alternative financing contracting mechanisms, including Energy-Savings Performance Contracts and utility energy-efficiency service contracts, when life-cycle cost-effective, to reduce energy use and cost in their facilities and operations.”	The project was financed thru an Energy Services Performance Contract (ESPC).
Sec. 403 (g) Highly Efficient Systems	“Agencies shall implement district energy systems, and other highly efficient systems, in new construction or retrofit projects when life-cycle cost-effective. Agencies shall consider combined cooling, heat, and power when upgrading and assessing facility power needs and shall use combined cooling, heat, and power systems when life-cycle cost-effective.”	The project employs a combined cooling, heat, and power design to provide highly efficient operation.

5.5.3 Environmental and/or Non-Energy Benefits

By converting fuel into both electrical and thermal energy, this system improves the overall energy efficiency of the 82nd plant. The electricity produced displaces some of the power that was previously purchased from the local electric utility, generated in part at coal-fired power plants. The related transmission and distribution losses are avoided thru the use of on-site generation. Emissions are effectively decreased by reducing the need for utility-provided power from coal-fired central plants. In addition, this IES system reduces emissions by replacing the poorly performing steam boilers at the 82nd Plant. The turbine generator employs state-of-the-art low NOx burners that offer excellent emissions performance, with NOx emissions measured at less than 25ppmv under steady-state operating conditions. This emissions performance provides a significant reduction over the approximate 290 ppm NOx emissions produced by the existing steam boilers.

The poor condition of the existing steam boilers had resulted in significant water make-up and chemical treatment costs. Frequent cycling of these boilers also resulted in significant blowdown effluent, contributing to water treatment loads on the post. The IES system eliminates these problems and associated impacts on the post’s sanitary sewer and wastewater treatment systems. These changes will benefit the post’s efforts to improve the performance of its wastewater treatment plant and its effluent water quality.

5.5.4 Project History

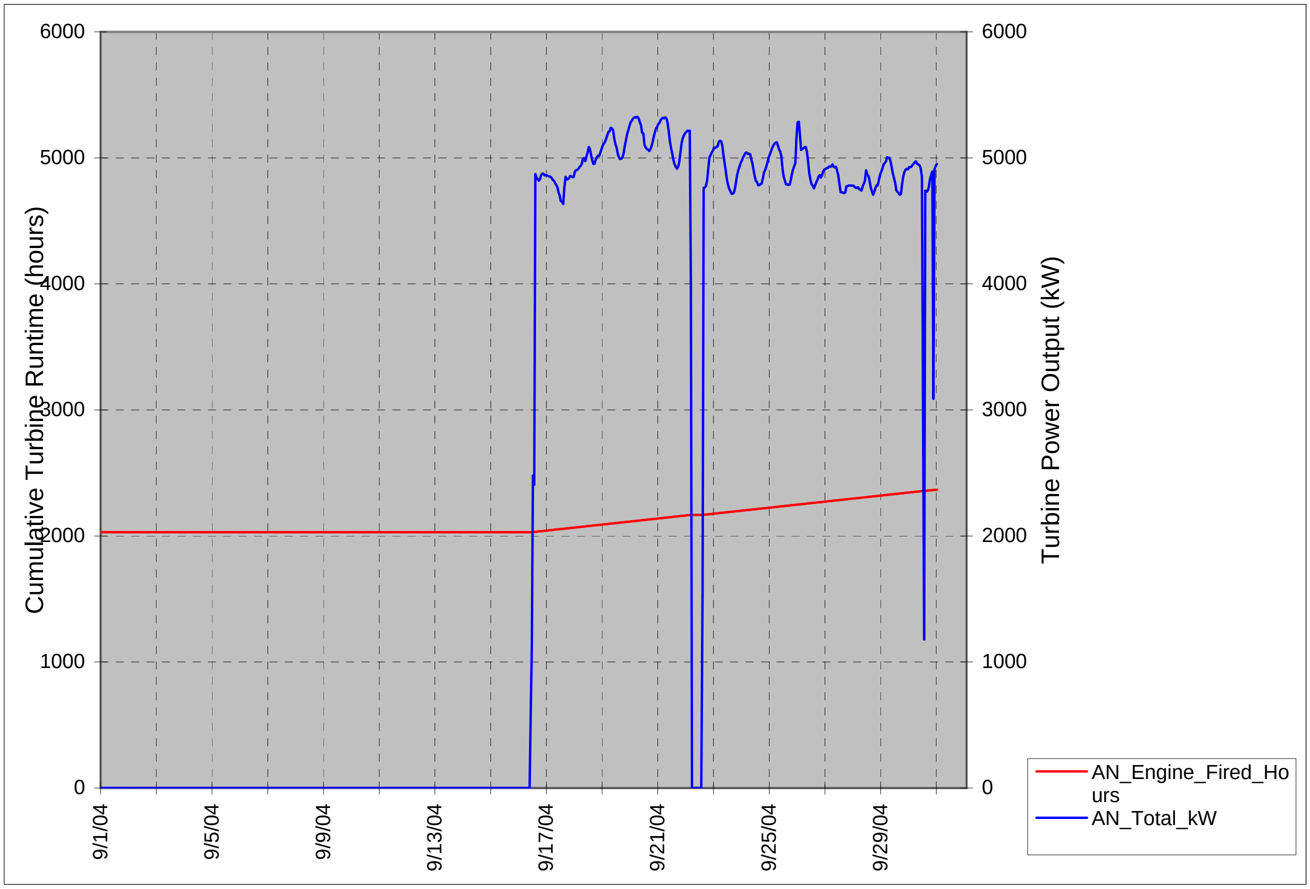
The key dates in the history of the project are:

- Design Phase & Approvals: 2002 and early 2003
- Construction: 3Q2003 and 1Q2004
- Startup and Commissioning: 2Q2004
- Commercial Operation: June 1, 2004

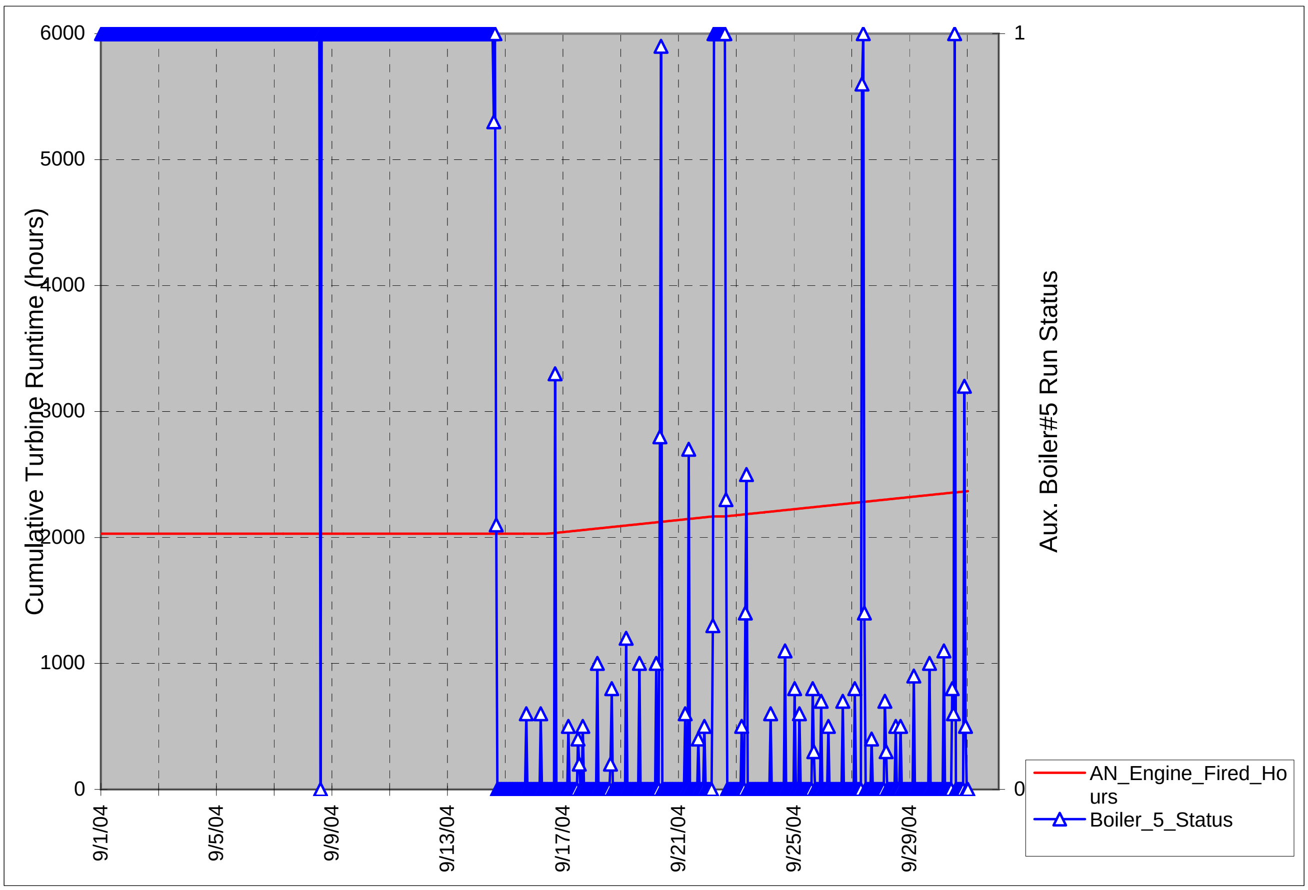
Appendix A

Detailed Operational Data: September 2004

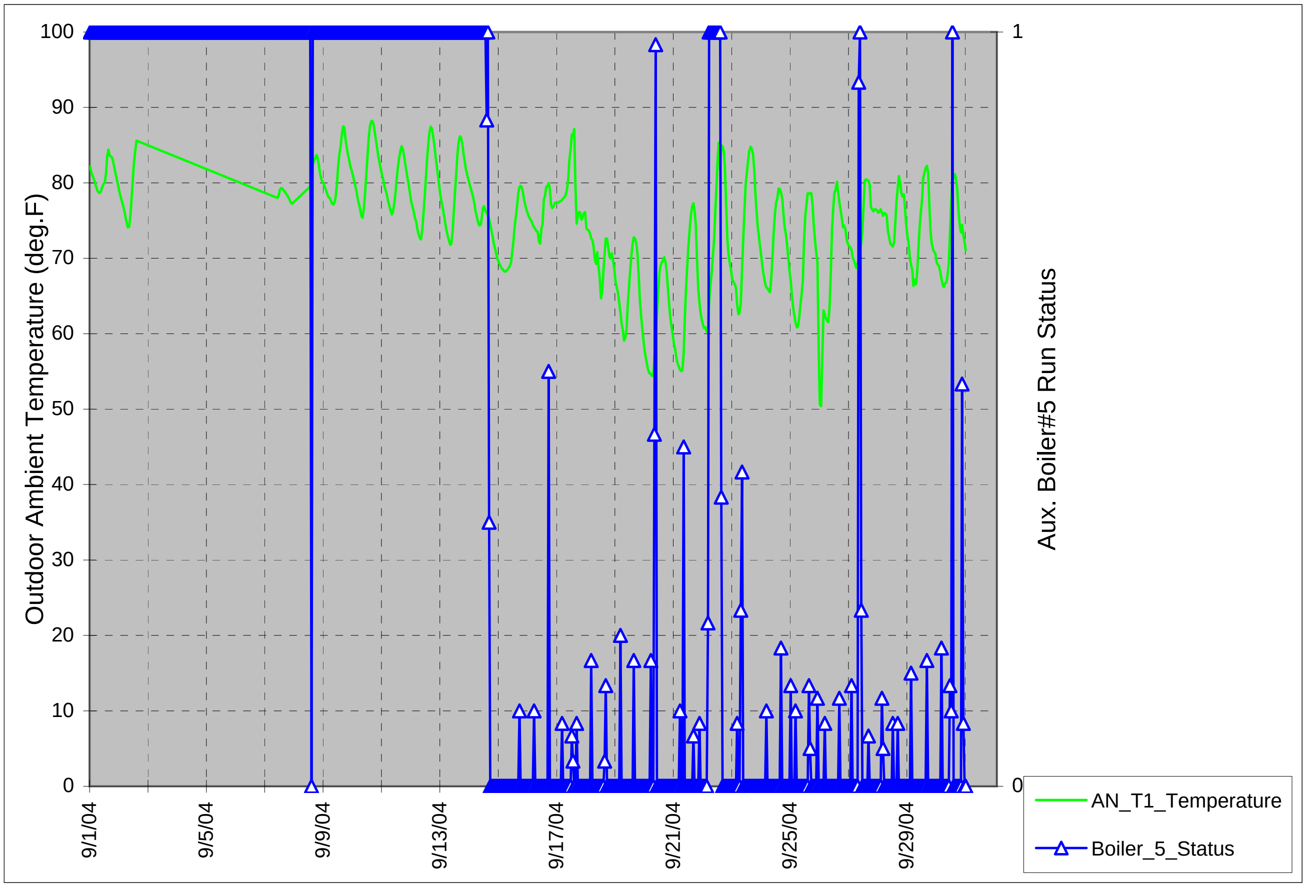
Misc. Plots

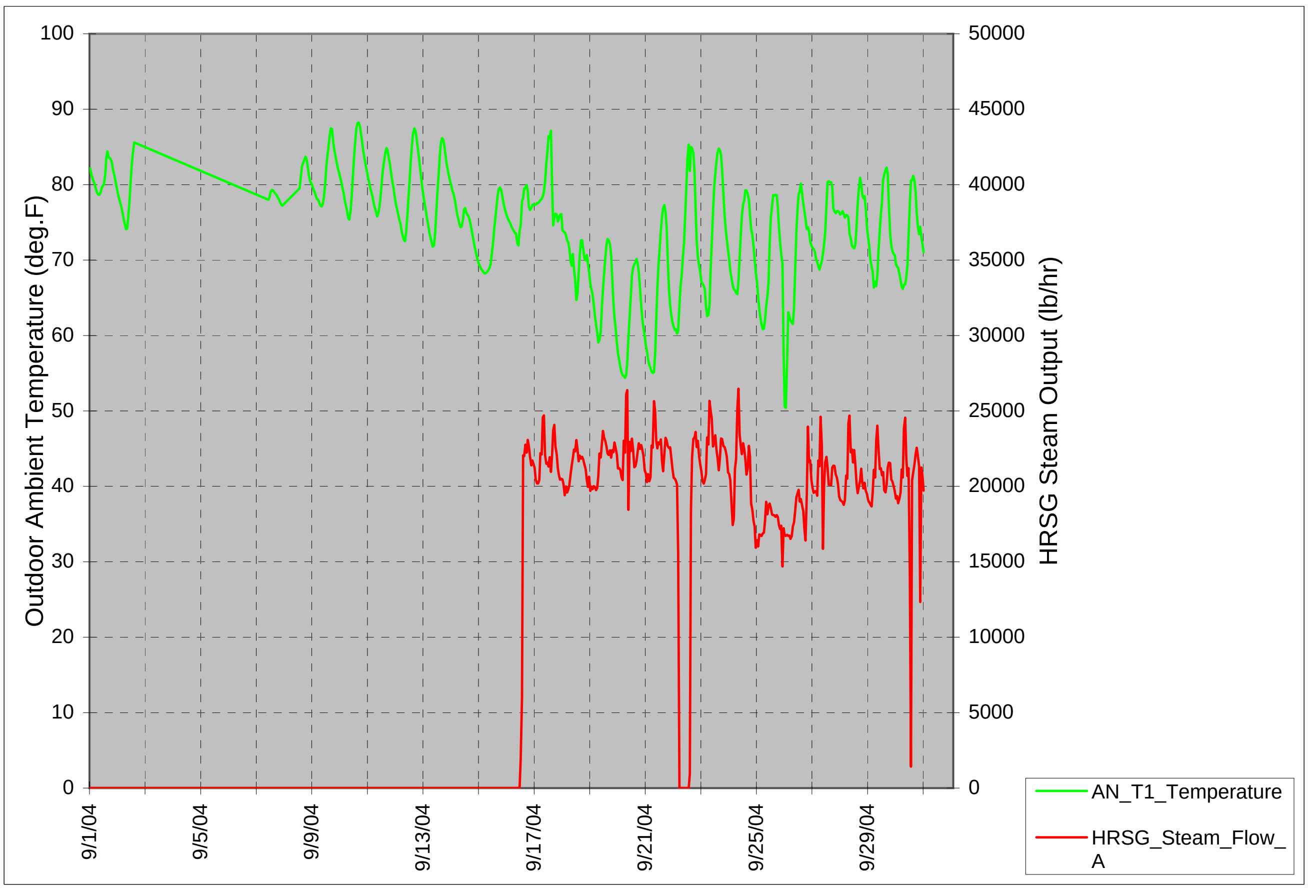


6000
5000
4000
3000
2000
1000
0
Cumulative Turbine Runtime (hours)
Turbine Power Output (kW)
9/1/04
9/5/04
9/9/04
9/13/04
9/17/04
9/21/04
9/25/04
9/29/04
AN_Engine_Fired_Hours
AN_Total_kW

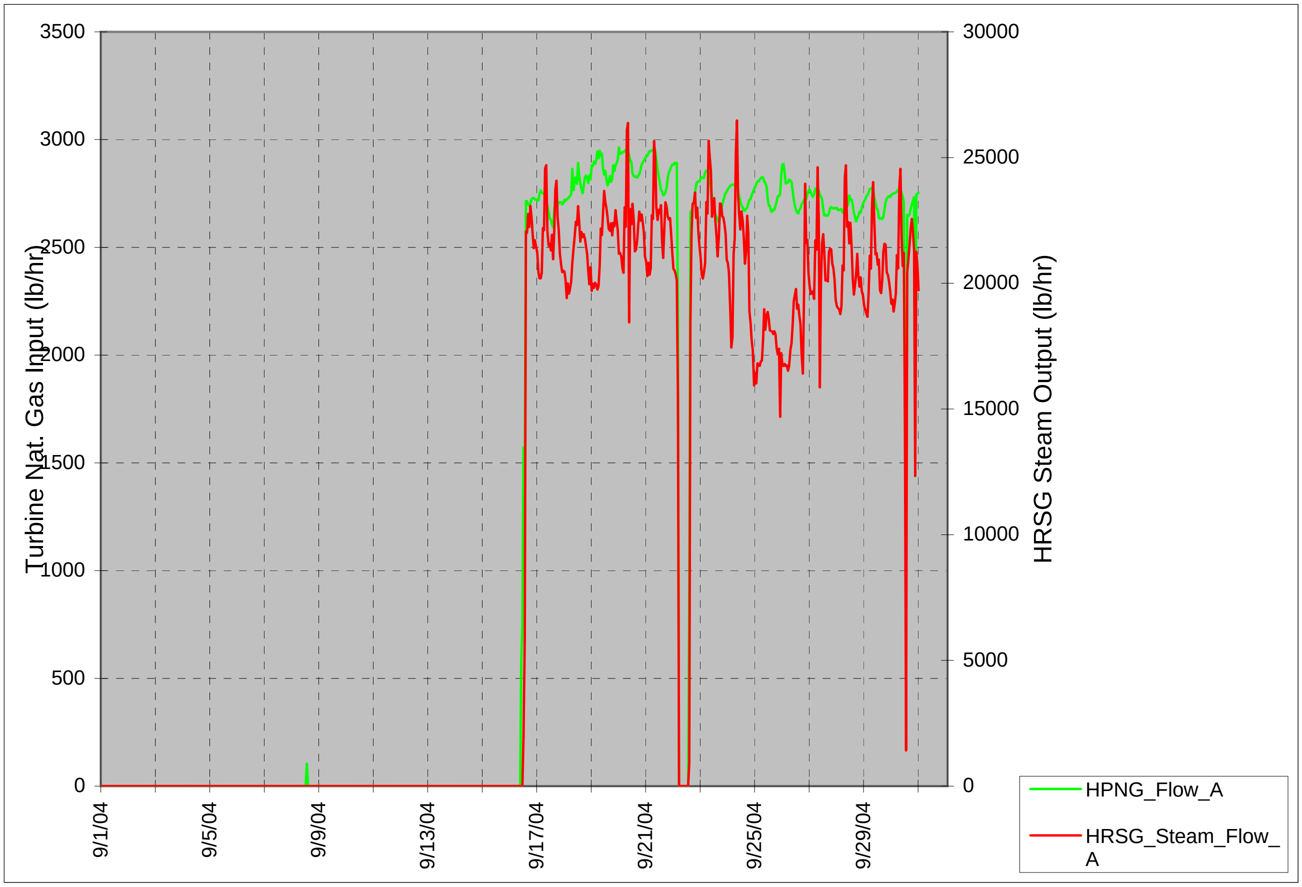


6000
5000
4000
3000
2000
1000
0
1
0
Cumulative Turbine Runtime (hours)
Aux. Boiler#5 Run Status
9/1/04
9/5/04
9/9/04
9/13/04
9/17/04
9/21/04
9/25/04
9/29/04
AN_Engine_Fired_Hours
Boiler_5_Status

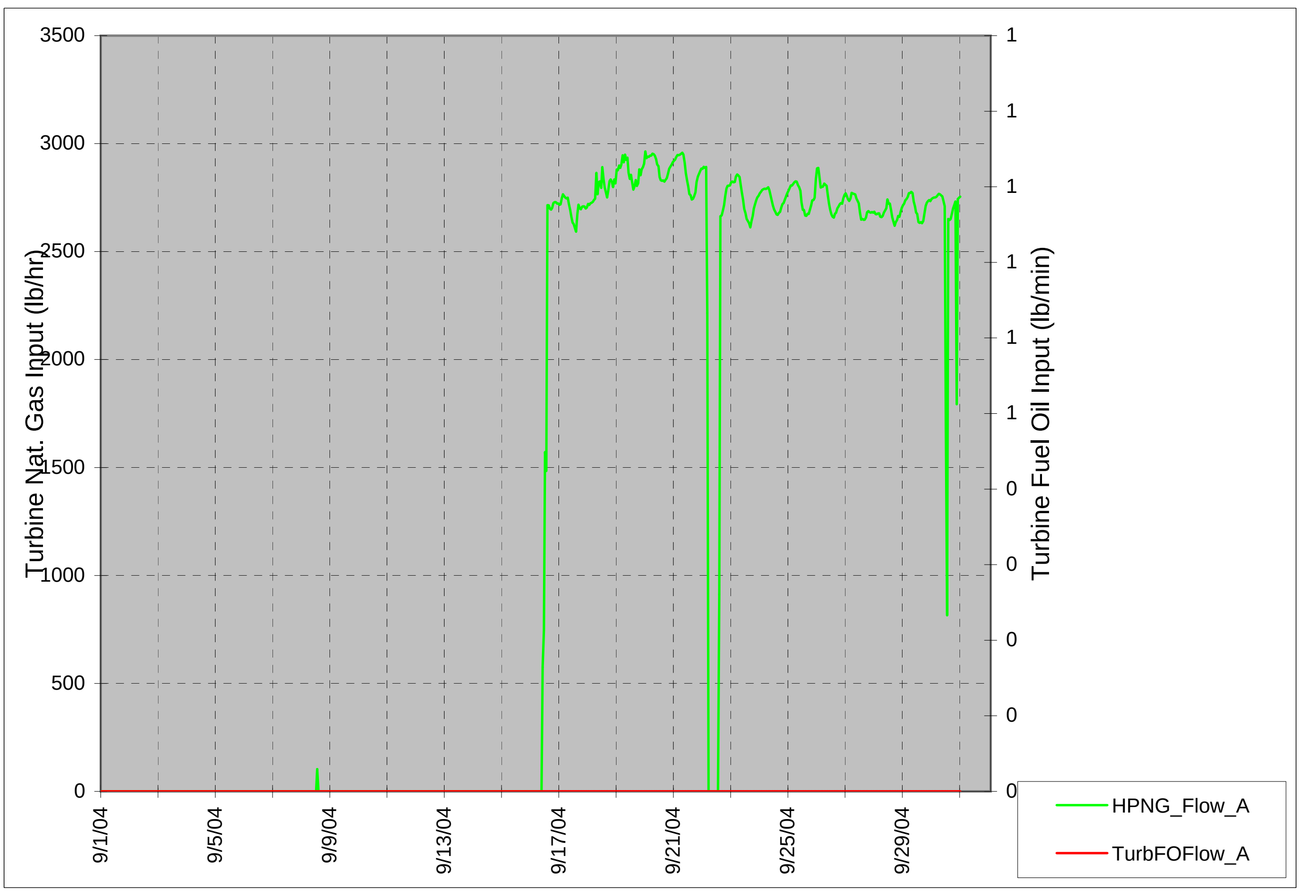

Outdoor Ambient Temperature (deg.F)
Aux. Boiler#5 Run Status
AN_T1_Temperature
Boiler_5_Status


Outdoor Ambient Temperature (deg.F)
HRSG Steam Output (lb/hr)
AN_T1_Temperature
HRSG_Steam_Flow_A

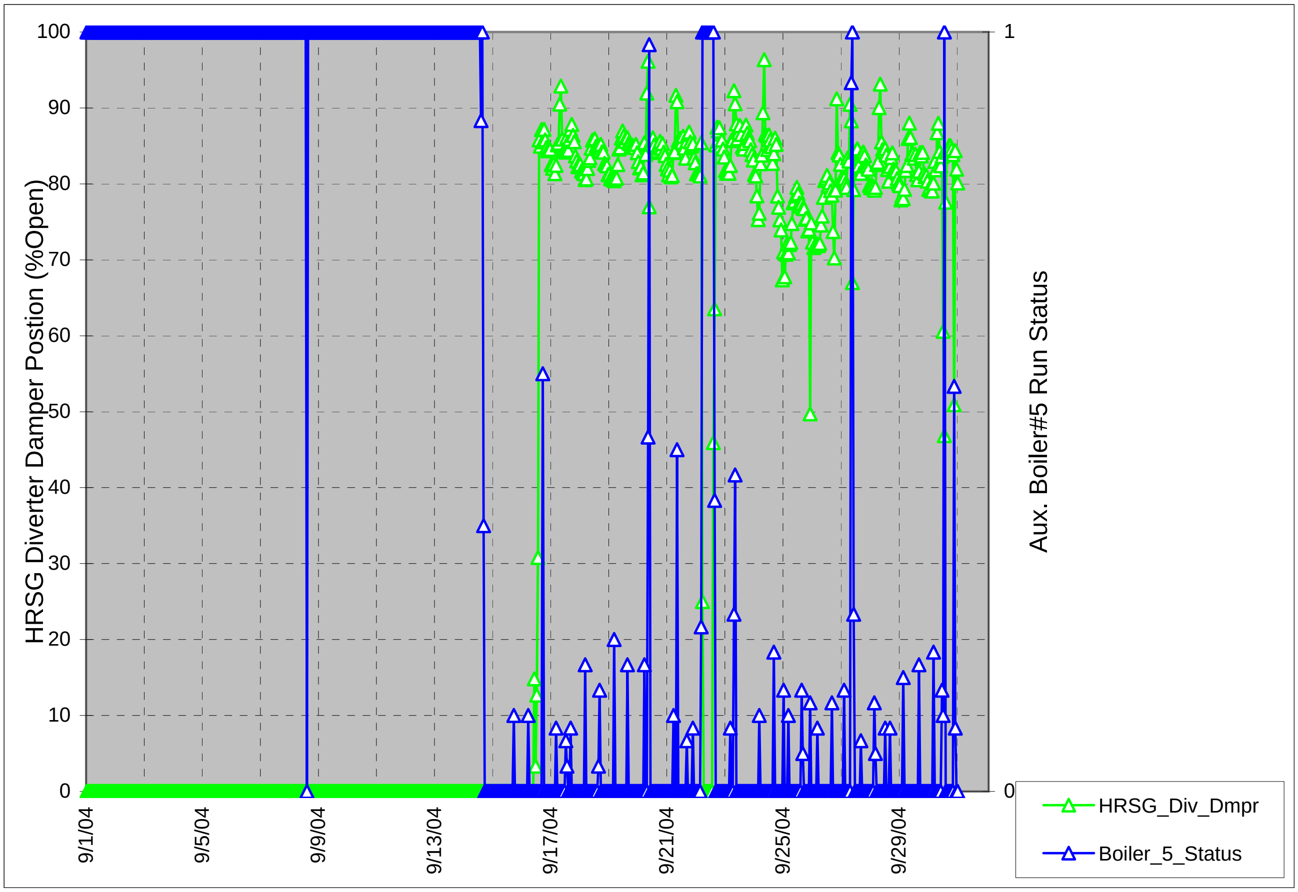
Misc. Plots

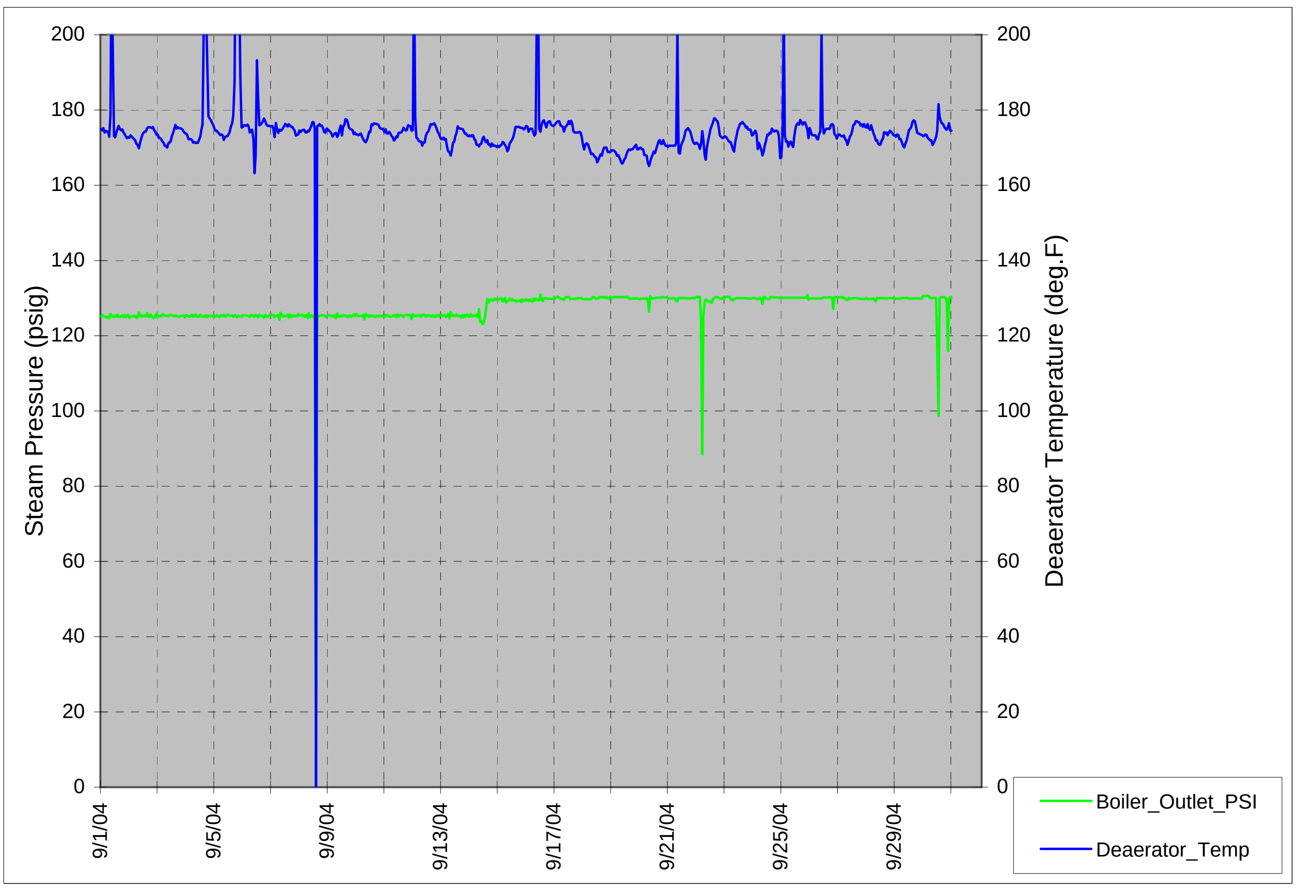


Turbine Nat. Gas Input (lb/hr)
HRSG Steam Output (lb/hr)
3500
3000
2500
2000
1500
1000
500
0
30000
25000
20000
15000
10000
5000
0
9/1/04
9/5/04
9/9/04
9/13/04
9/17/04
9/21/04
9/25/04
9/29/04
HPNG_Flow_A
HRSG_Steam_Flow_A

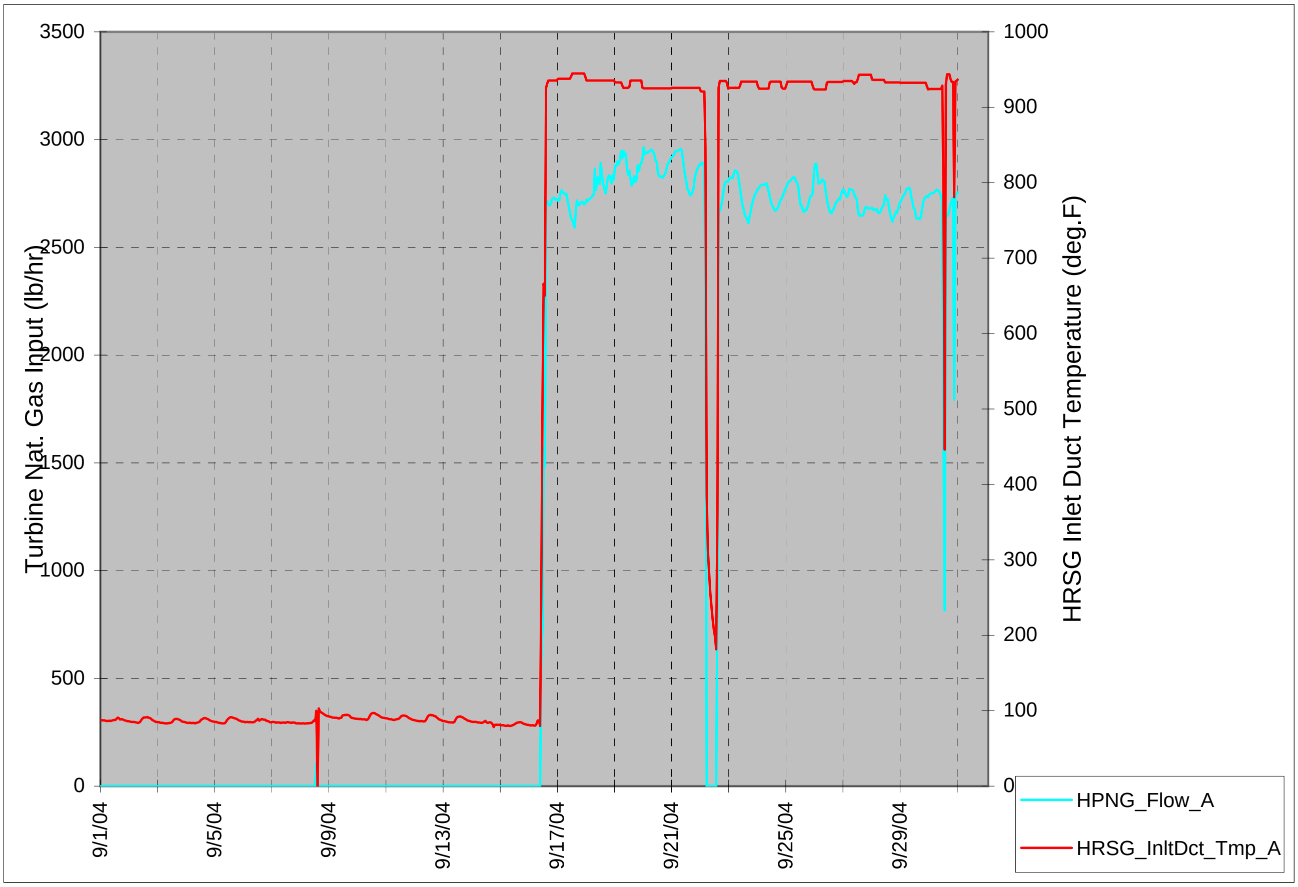


Turbine Nat. Gas Input (lb/hr)
Turbine Fuel Oil Input (lb/min)
3500
3000
2500
2000
1500
1000
500
0
1
1
1
1
1
1
0
0
0
0
0
9/1/04
9/5/04
9/9/04
9/13/04
9/17/04
9/21/04
9/25/04
9/29/04
HPNG_Flow_A
TurbFOFlow_A

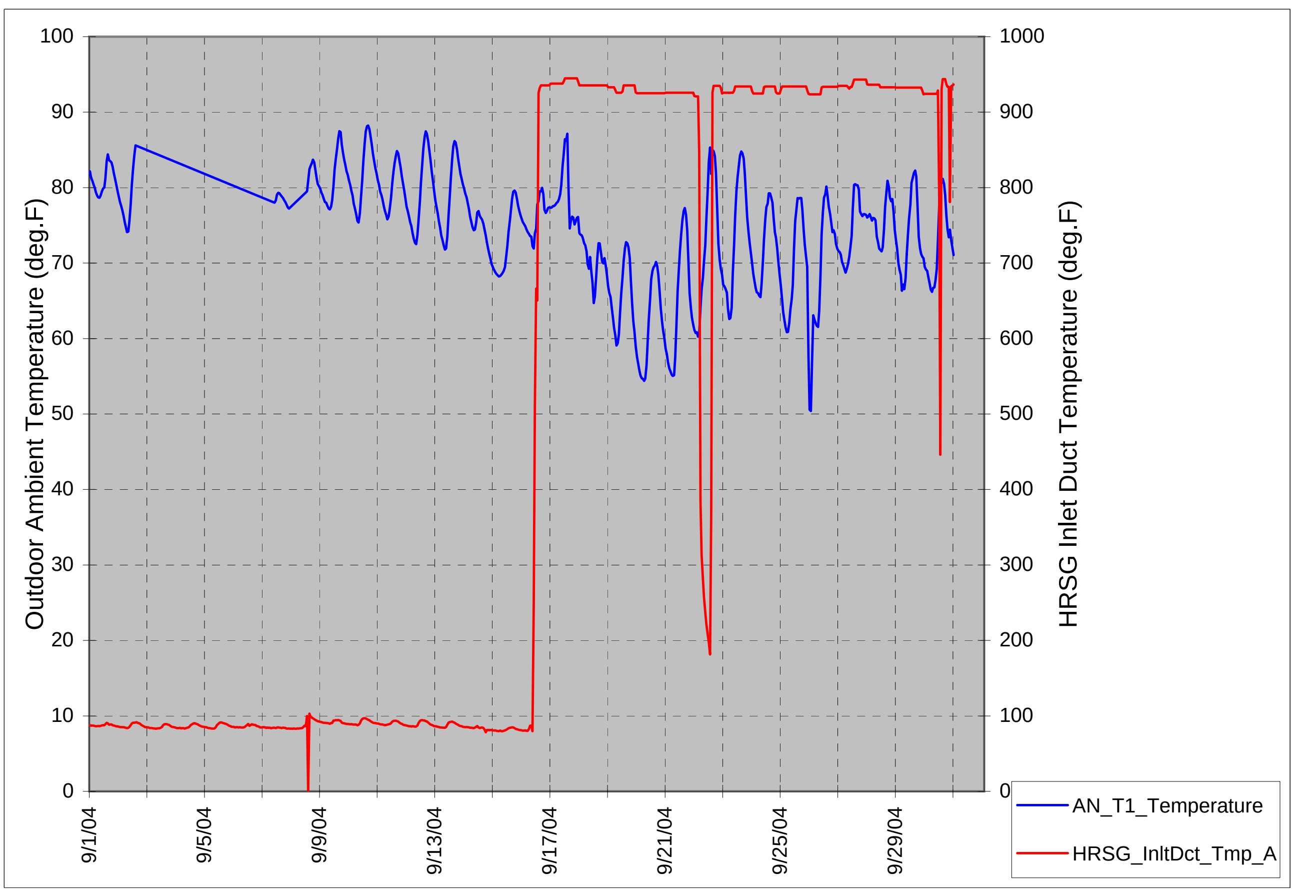

HRSG Diverter Damper Postion (%Open)
Aux. Boiler#5 Run Status
HRSG_Div_Dmpr
Boiler_5_Status
100
90
80
70
60
50
40
30
20
10
0
1
0
9/1/04
9/5/04
9/9/04
9/13/04
9/17/04
9/21/04
9/25/04
9/29/04


Steam Pressure (psig)
Deaerator Temperature (deg.F)
Boiler_Outlet_PSI
Deaerator_Temp
200
180
160
140
120
100
80
60
40
20
0
9/1/04
9/5/04
9/9/04
9/13/04
9/17/04
9/21/04
9/25/04
9/29/04

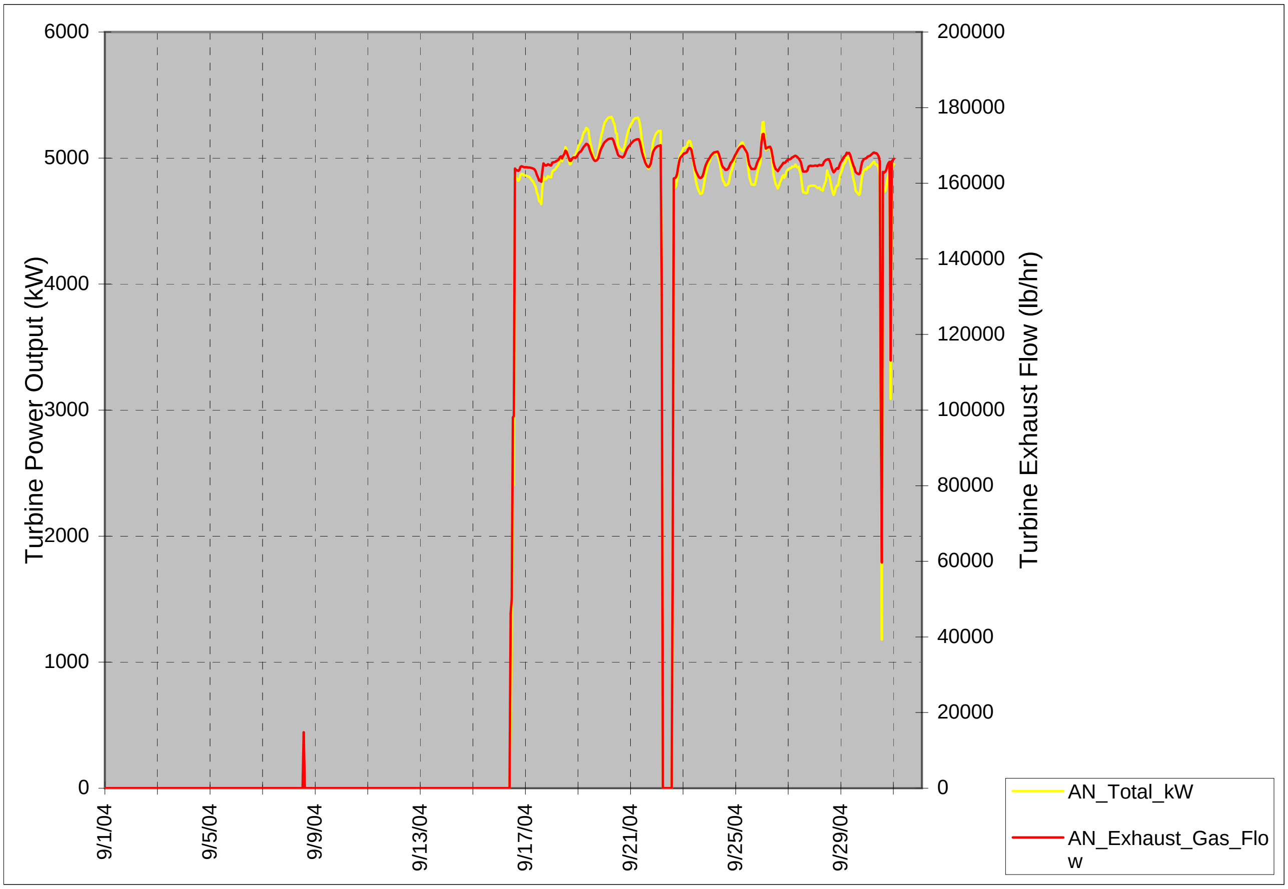
Misc. Plots

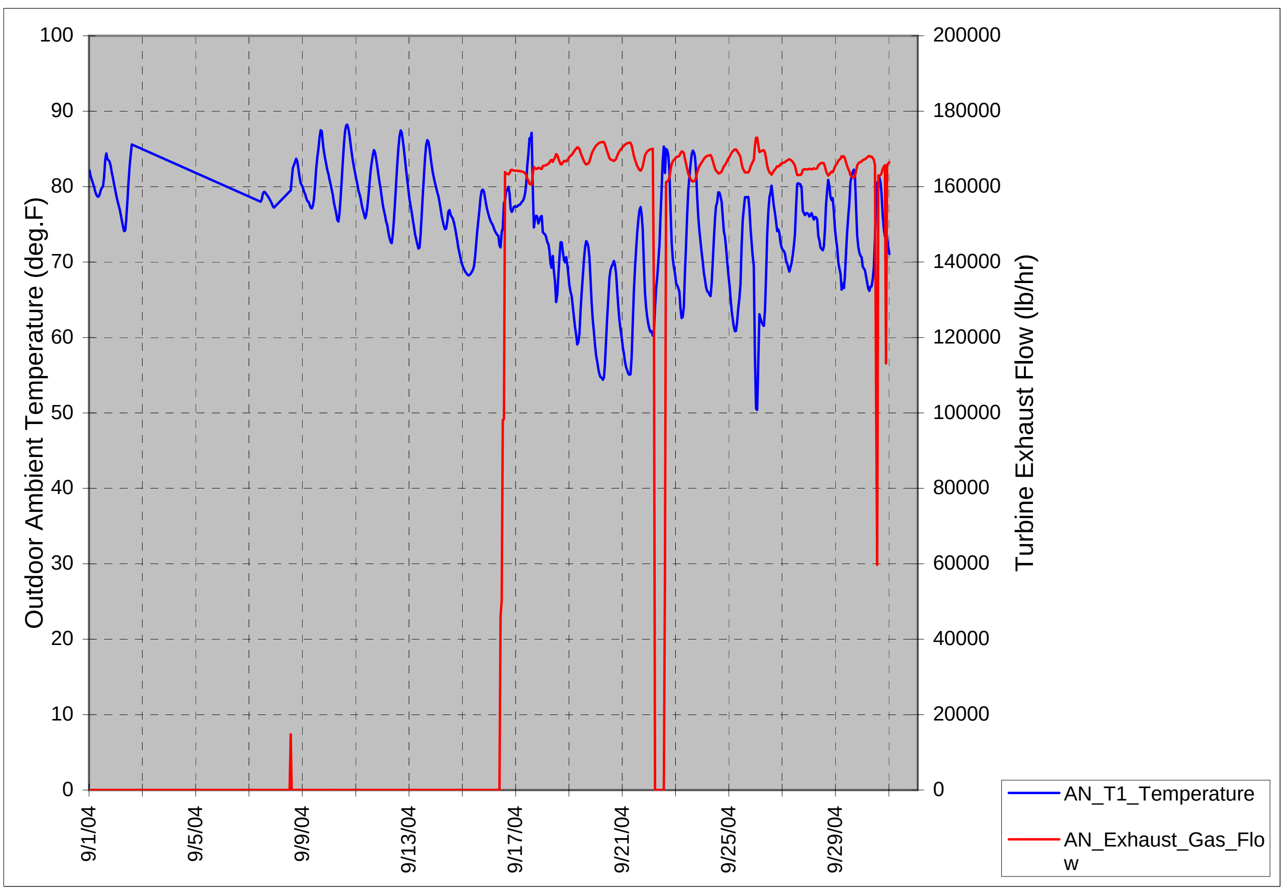


Turbine Nat. Gas Input (lb/hr)
HRSG Inlet Duct Temperature (deg.F)
3500
3000
2500
2000
1500
1000
500
0
1000
900
800
700
600
500
400
300
200
100
0
9/1/04
9/5/04
9/9/04
9/13/04
9/17/04
9/21/04
9/25/04
9/29/04
HPNG_Flow_A
HRSG_InltDct_Tmp_A



Outdoor Ambient Temperature (deg.F)
HRSG Inlet Duct Temperature (deg.F)
100
90
80
70
60
50
40
30
20
10
0
1000
900
800
700
600
500
400
300
200
100
0
9/1/04
9/5/04
9/9/04
9/13/04
9/17/04
9/21/04
9/25/04
9/29/04
AN_T1_Temperature
HRSG_InltDct_Tmp_A

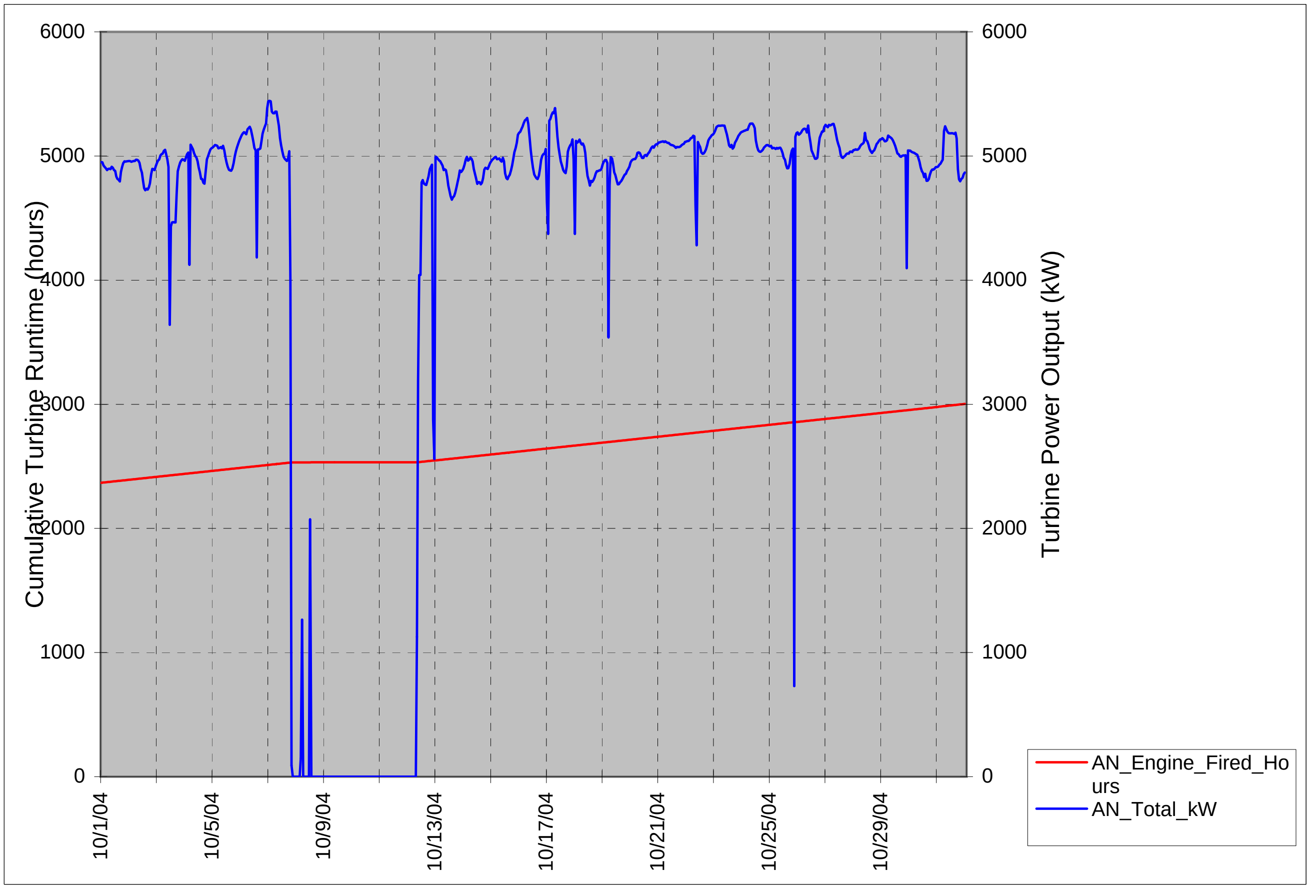

6000
5000
4000
3000
2000
1000
0
Turbine Power Output (kW)
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Turbine Exhaust Flow (lb/hr)
9/1/04
9/5/04
9/9/04
9/13/04
9/17/04
9/21/04
9/25/04
9/29/04
AN_Total_kW
AN_Exhaust_Gas_Flow


100
90
80
70
60
50
40
30
20
10
0
Outdoor Ambient Temperature (deg.F)
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Turbine Exhaust Flow (lb/hr)
9/1/04
9/5/04
9/9/04
9/13/04
9/17/04
9/21/04
9/25/04
9/29/04
AN_T1_Temperature
AN_Exhaust_Gas_Flow

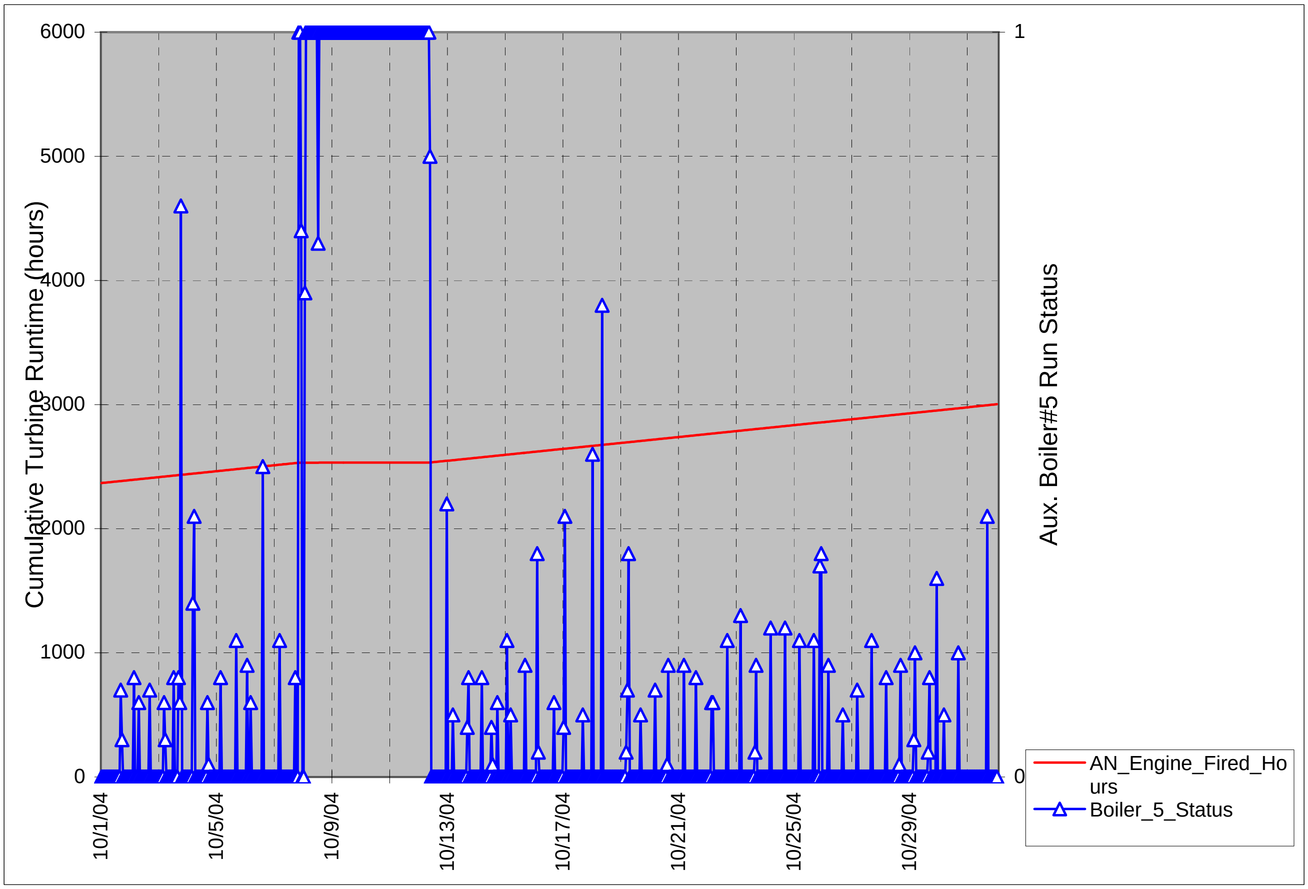
Appendix B

Detailed Operational Data: October 2004

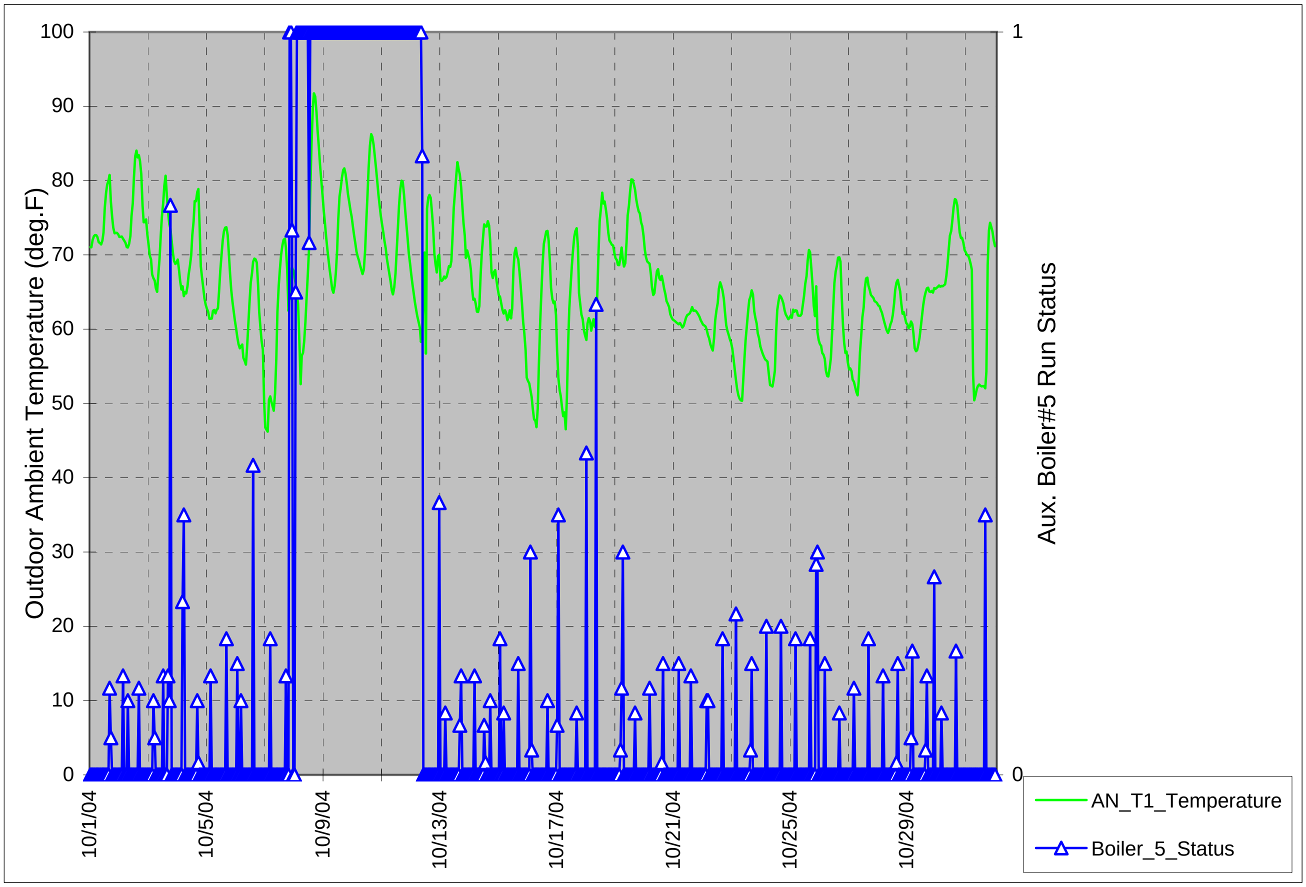
Misc. Plots



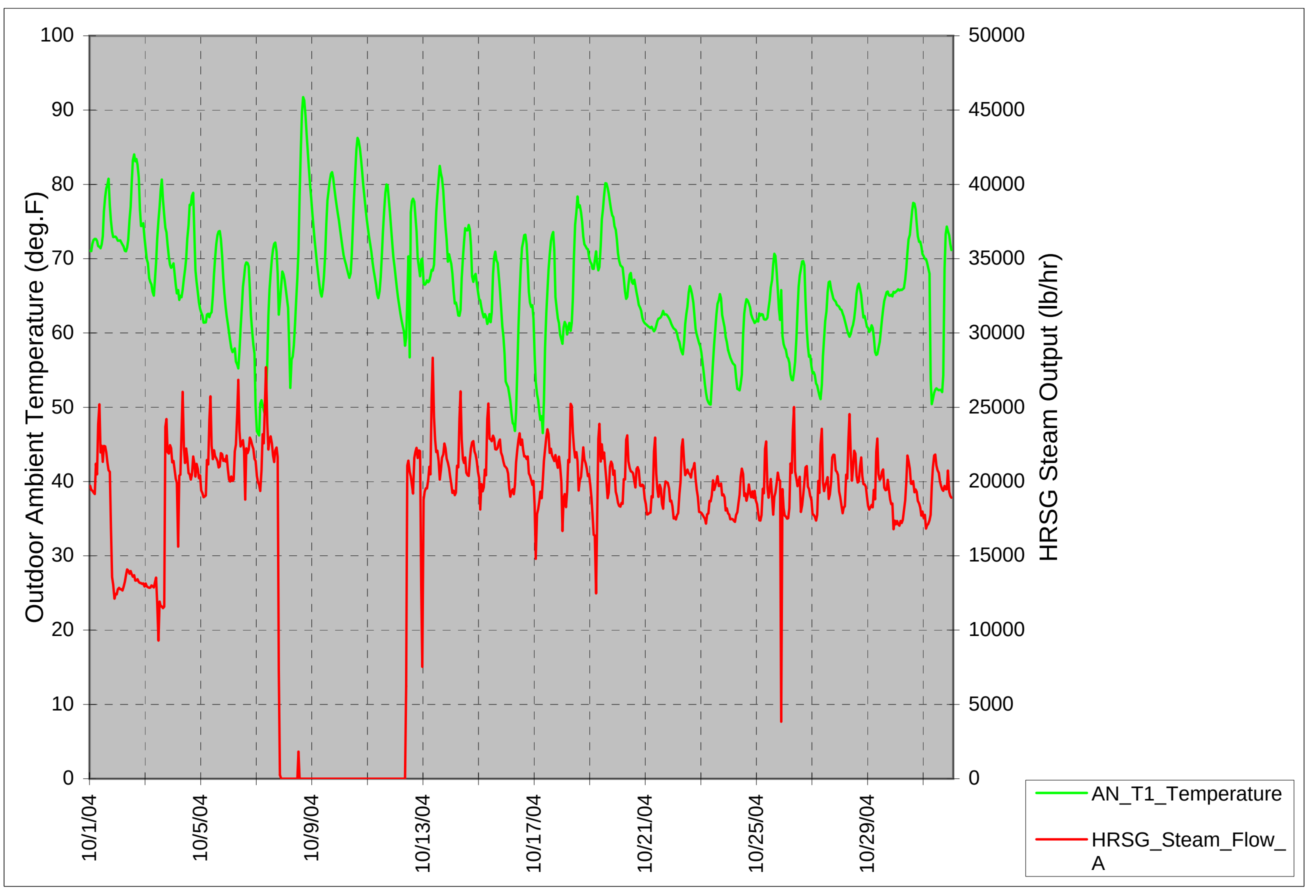
6000
5000
4000
3000
2000
1000
0
Cumulative Turbine Runtime (hours)
Turbine Power Output (kW)
10/1/04
10/5/04
10/9/04
10/13/04
10/17/04
10/21/04
10/25/04
10/29/04
AN_Engine_Fired_Hours
AN_Total_kW



6000
5000
4000
3000
2000
1000
0
1
0
Cumulative Turbine Runtime (hours)
Aux. Boiler#5 Run Status
10/1/04
10/5/04
10/9/04
10/13/04
10/17/04
10/21/04
10/25/04
10/29/04
AN_Engine_Fired_Hours
Boiler_5_Status



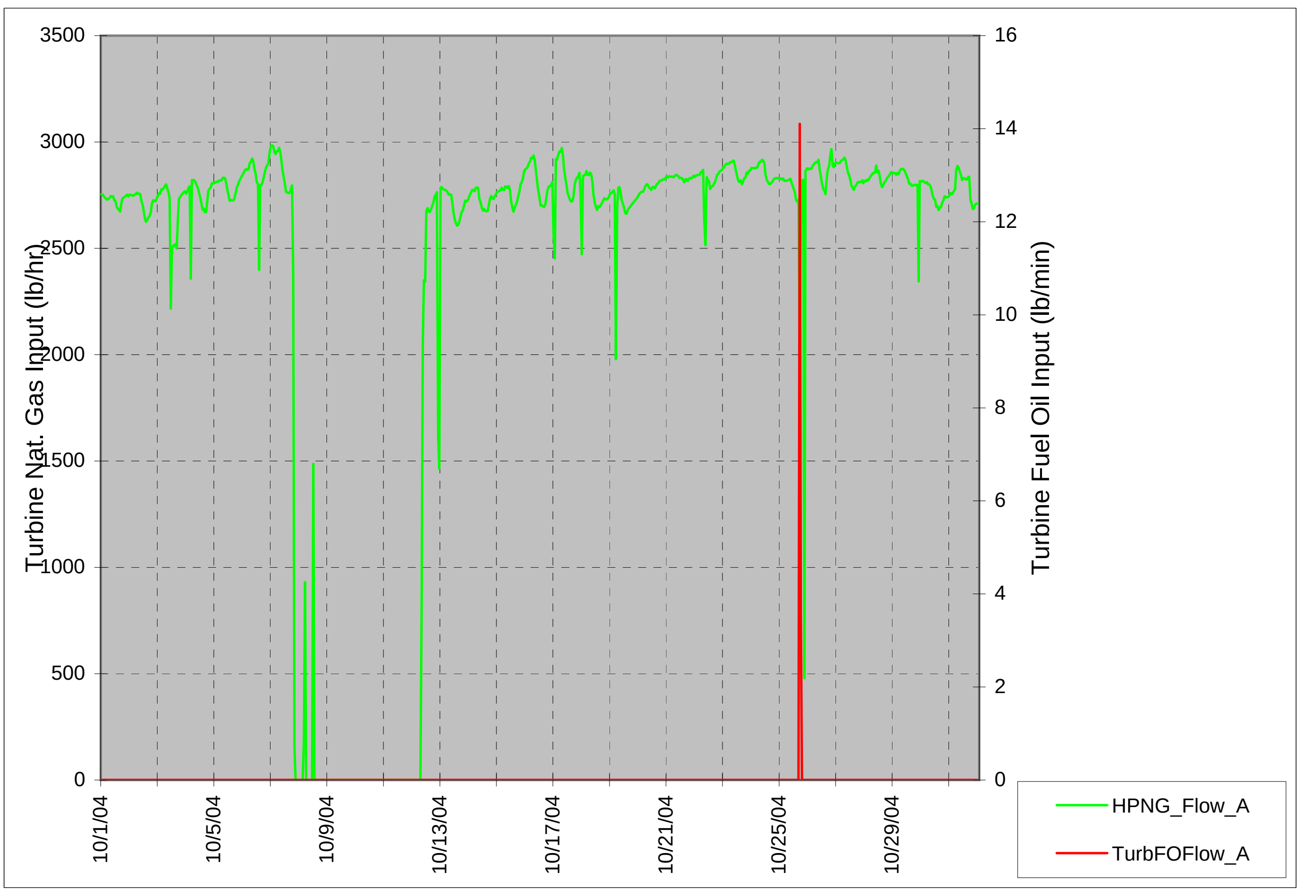
100
90
80
70
60
50
40
30
20
10
0
1
0
Outdoor Ambient Temperature (deg.F)
Aux. Boiler#5 Run Status
10/1/04
10/5/04
10/9/04
10/13/04
10/17/04
10/21/04
10/25/04
10/29/04
AN_T1_Temperature
Boiler_5_Status



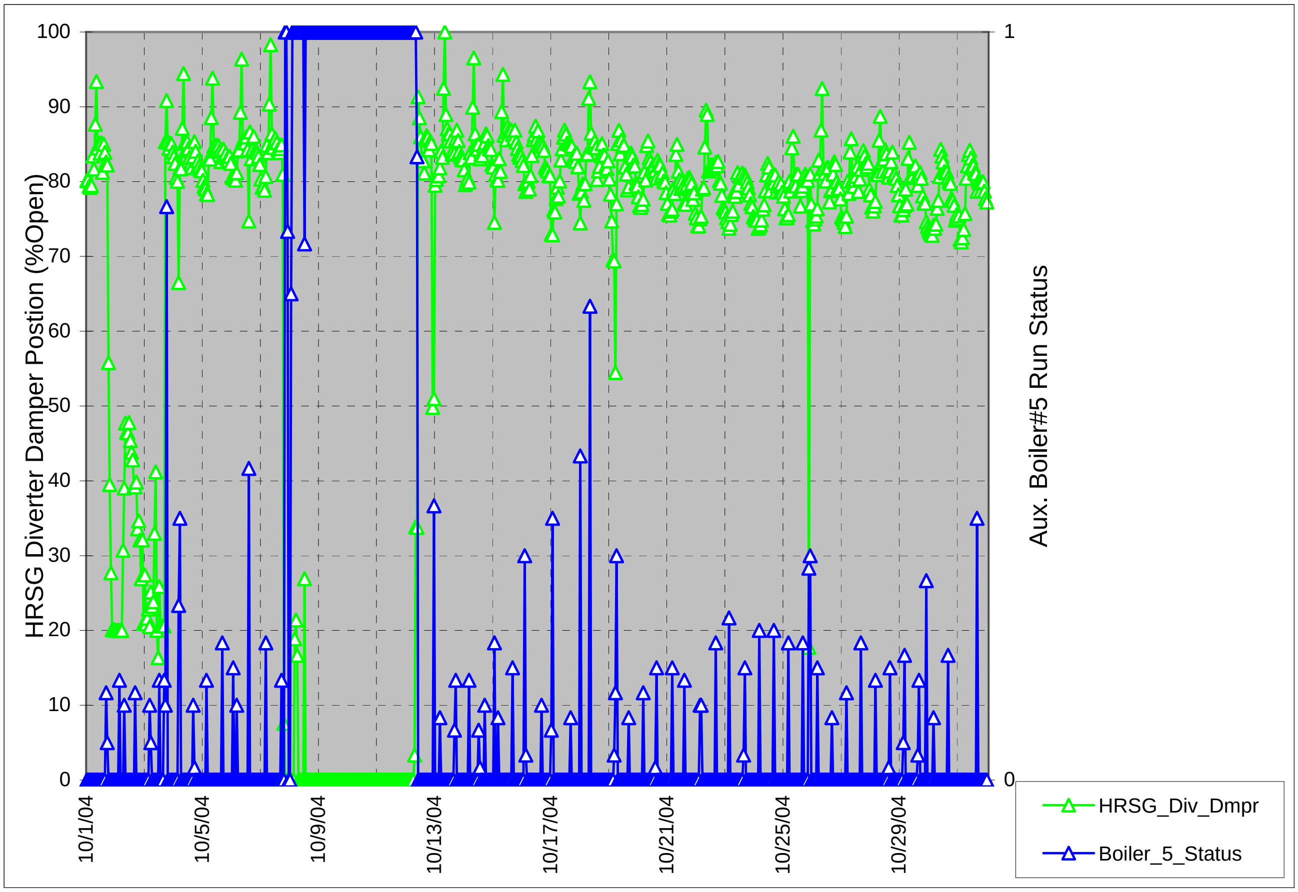
100
90
80
70
60
50
40
30
20
10
0
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
Outdoor Ambient Temperature (deg.F)
HRSG Steam Output (lb/hr)
10/1/04
10/5/04
10/9/04
10/13/04
10/17/04
10/21/04
10/25/04
10/29/04
AN_T1_Temperature
HRSG_Steam_Flow_A

Misc. Plots

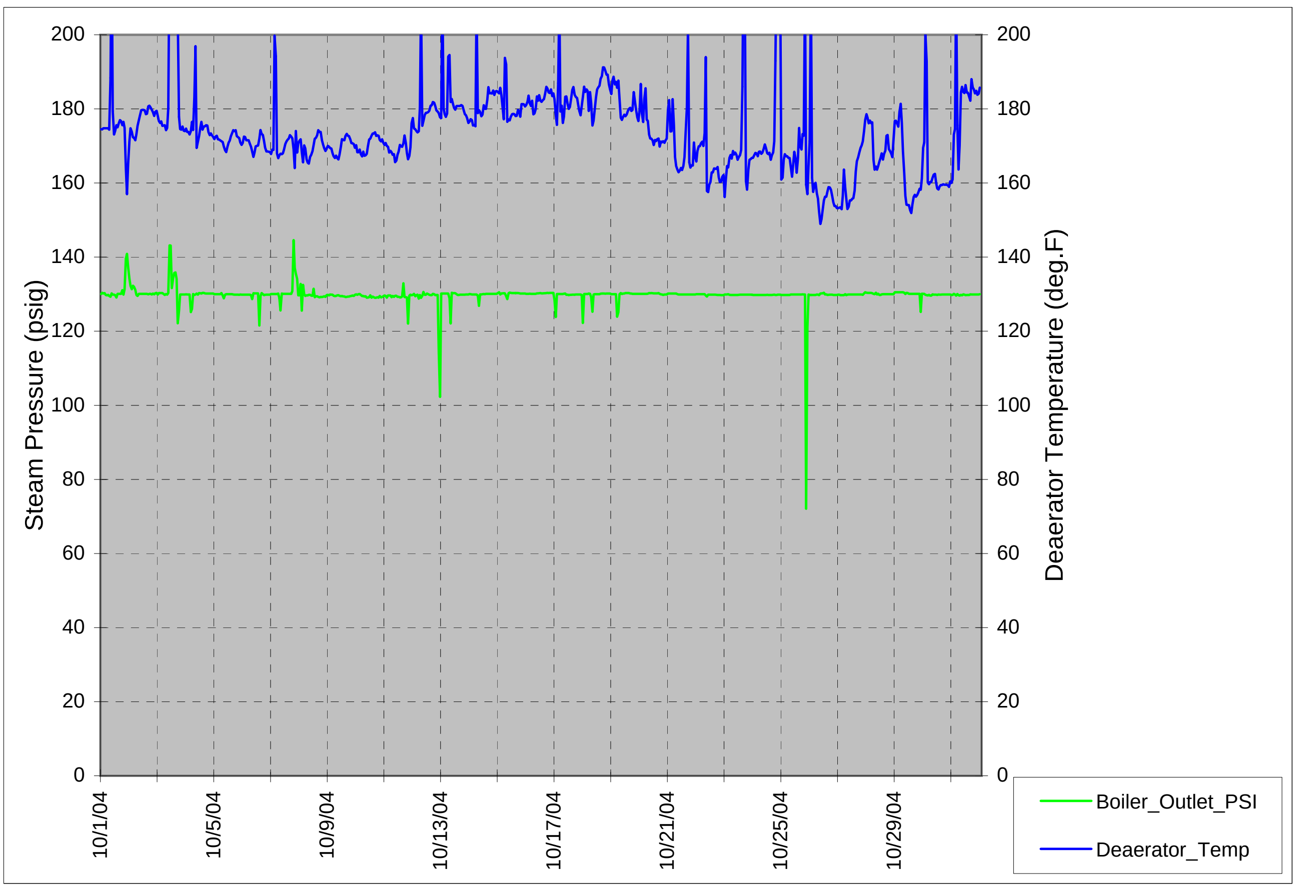
3500
3000
2500
2000
1500
1000
500
0
Turbine Nat. Gas Input (lb/hr)
30000
25000
20000
15000
10000
5000
0
HRSG Steam Output (lb/hr)
10/1/04
10/5/04
10/9/04
10/13/04
10/17/04
10/21/04
10/25/04
10/29/04
HPNG_Flow_A
HRSG_Steam_Flow_A



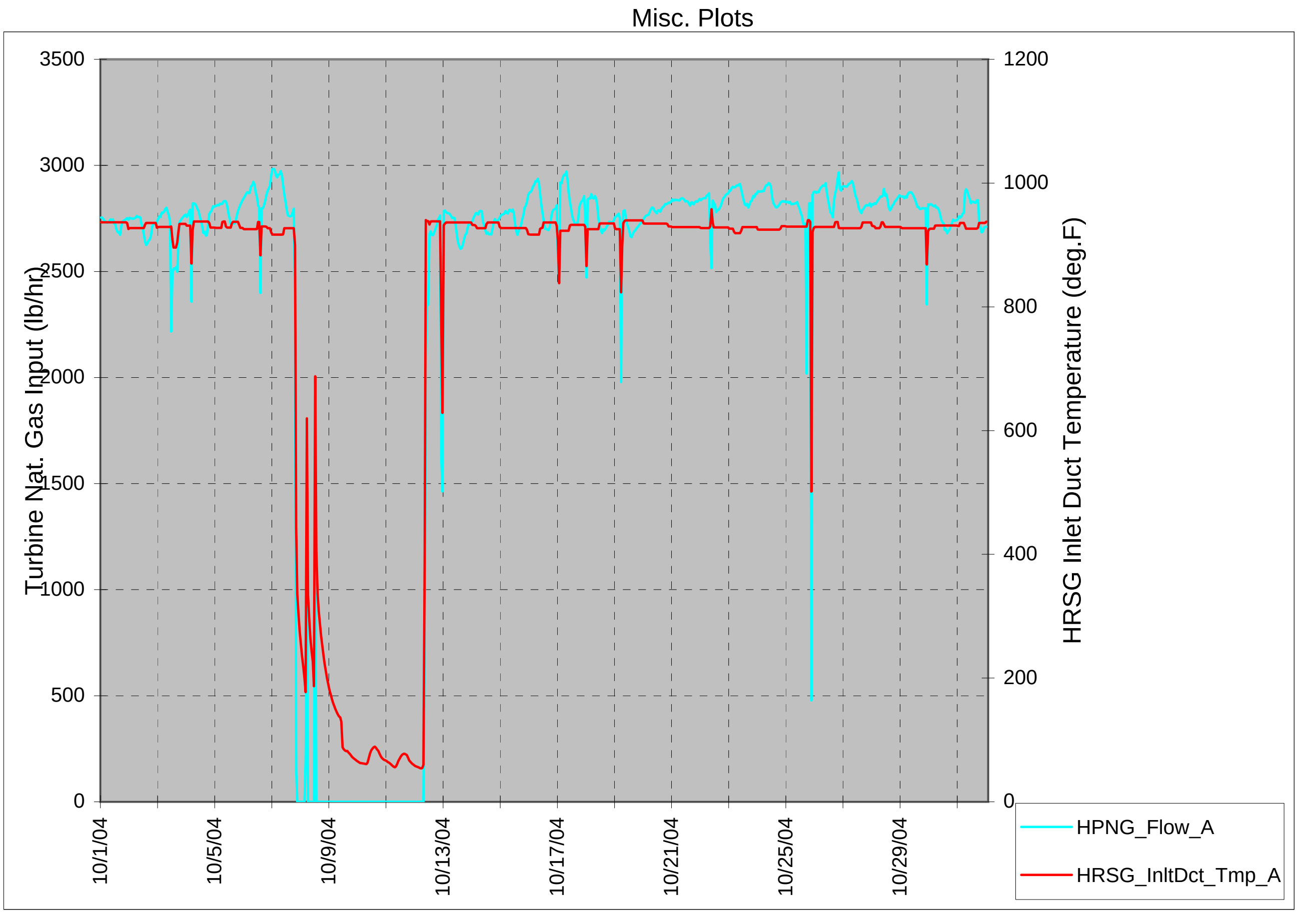
3500
3000
2500
2000
1500
1000
500
0
Turbine Nat. Gas Input (lb/hr)
16
14
12
10
8
6
4
2
0
Turbine Fuel Oil Input (lb/min)
10/1/04
10/5/04
10/9/04
10/13/04
10/17/04
10/21/04
10/25/04
10/29/04
HPNG_Flow_A
TurbFOFlow_A

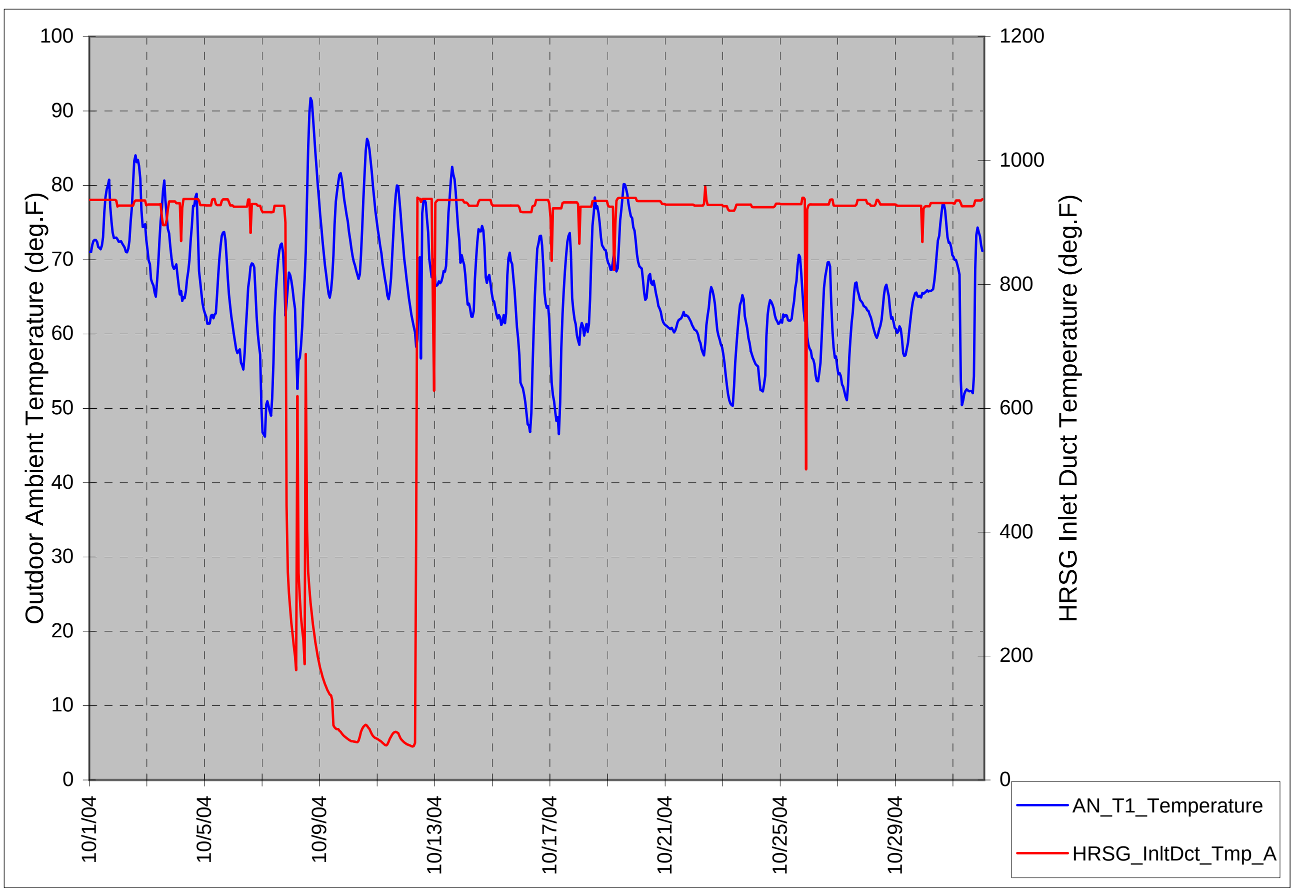


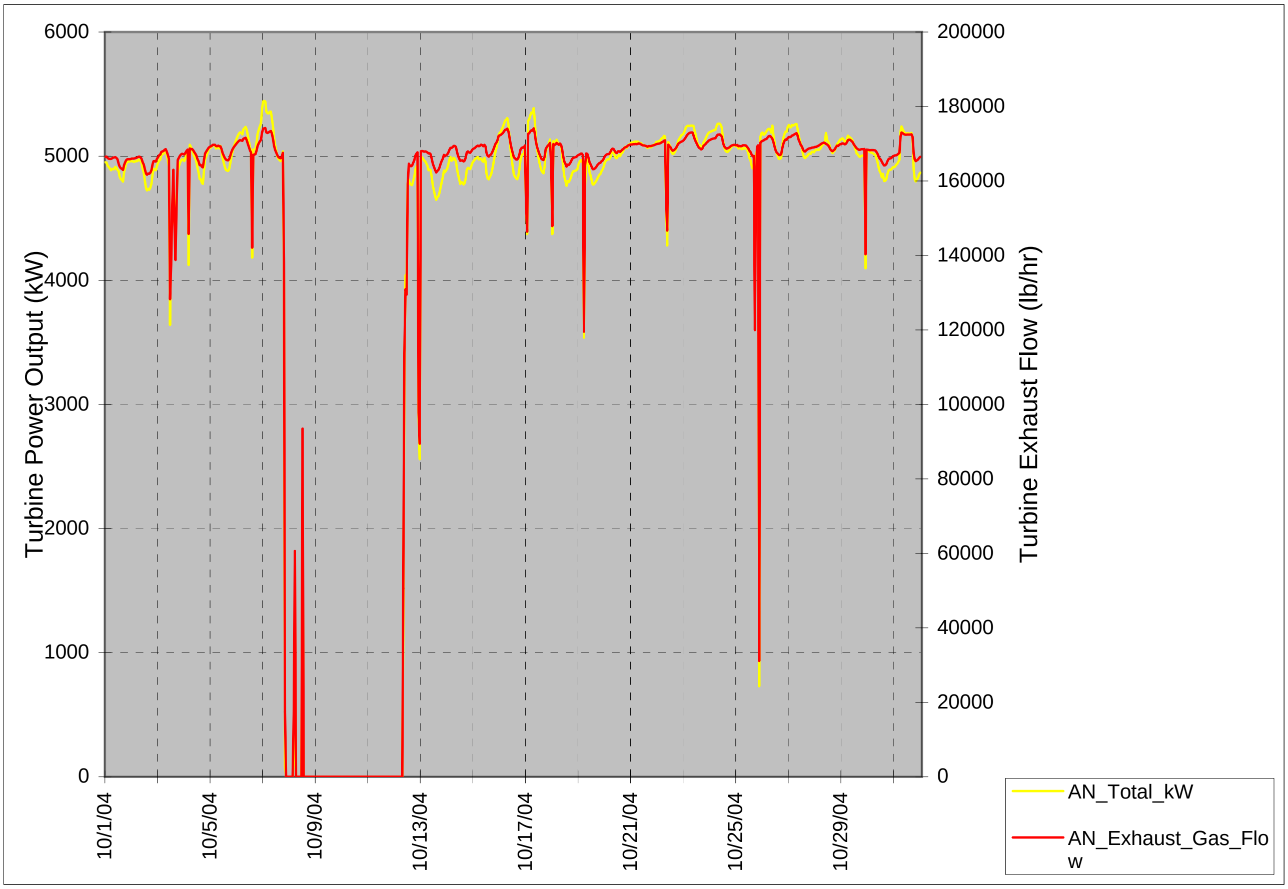
100
90
80
70
60
50
40
30
20
10
0
1
0
HRSG Diverter Damper Postion (%Open)
Aux. Boiler#5 Run Status
10/1/04
10/5/04
10/9/04
10/13/04
10/17/04
10/21/04
10/25/04
10/29/04
HRSG_Div_Dmpr
Boiler_5_Status

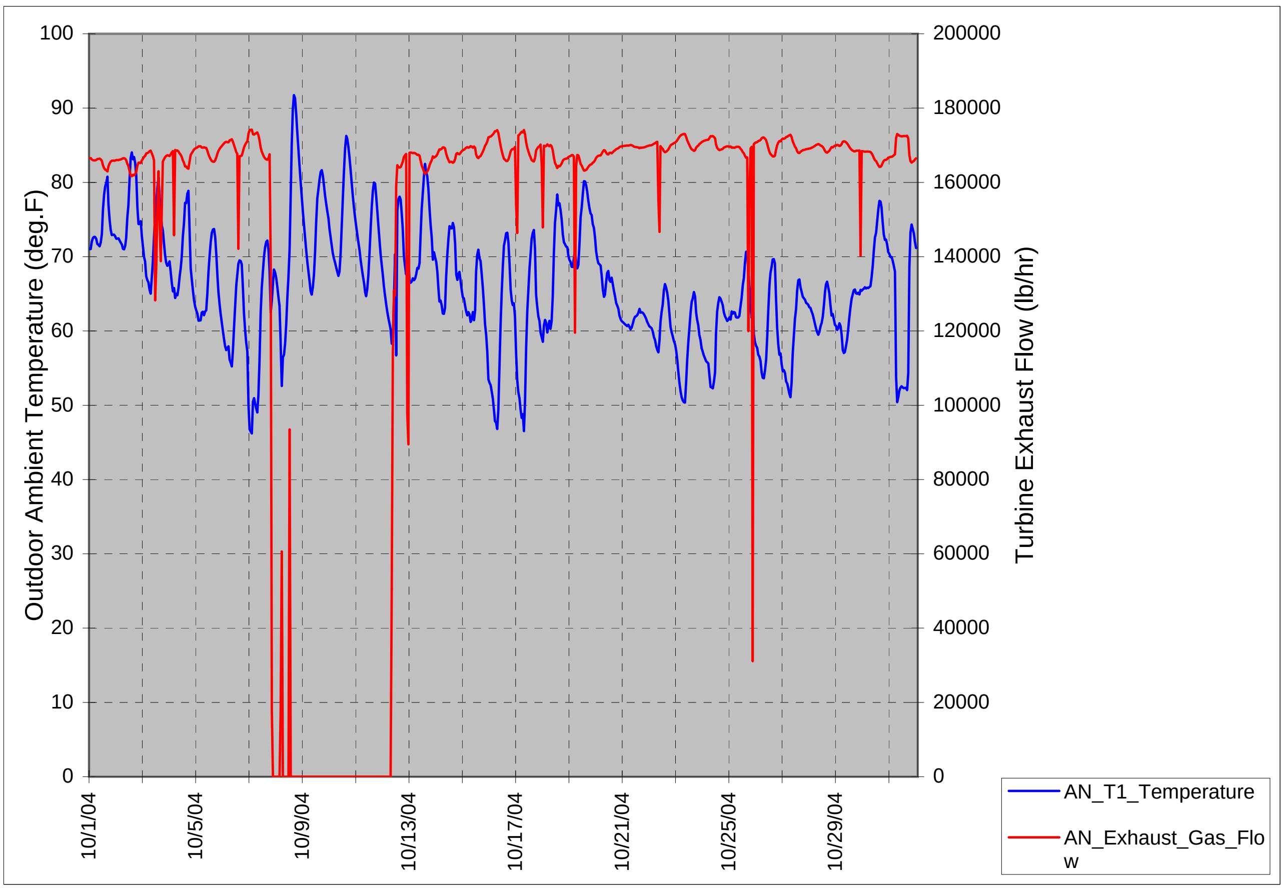


200
180
160
140
120
100
80
60
40
20
0
Steam Pressure (psig)
Deaerator Temperature (deg.F)
10/1/04
10/5/04
10/9/04
10/13/04
10/17/04
10/21/04
10/25/04
10/29/04
Boiler_Outlet_PSI
Deaerator_Temp


Misc. Plots
3500
3000
2500
2000
1500
1000
500
0
1200
1000
800
600
400
200
0
Turbine Nat. Gas Input (lb/hr)
HRSG Inlet Duct Temperature (deg.F)
10/1/04
10/5/04
10/9/04
10/13/04
10/17/04
10/21/04
10/25/04
10/29/04
HPNG_Flow_A
HRSG_InltDct_Tmp_A


100
90
80
70
60
50
40
30
20
10
0
1200
1000
800
600
400
200
0
Outdoor Ambient Temperature (deg.F)
HRSG Inlet Duct Temperature (deg.F)
10/1/04
10/5/04
10/9/04
10/13/04
10/17/04
10/21/04
10/25/04
10/29/04
AN_T1_Temperature
HRSG_InltDct_Tmp_A

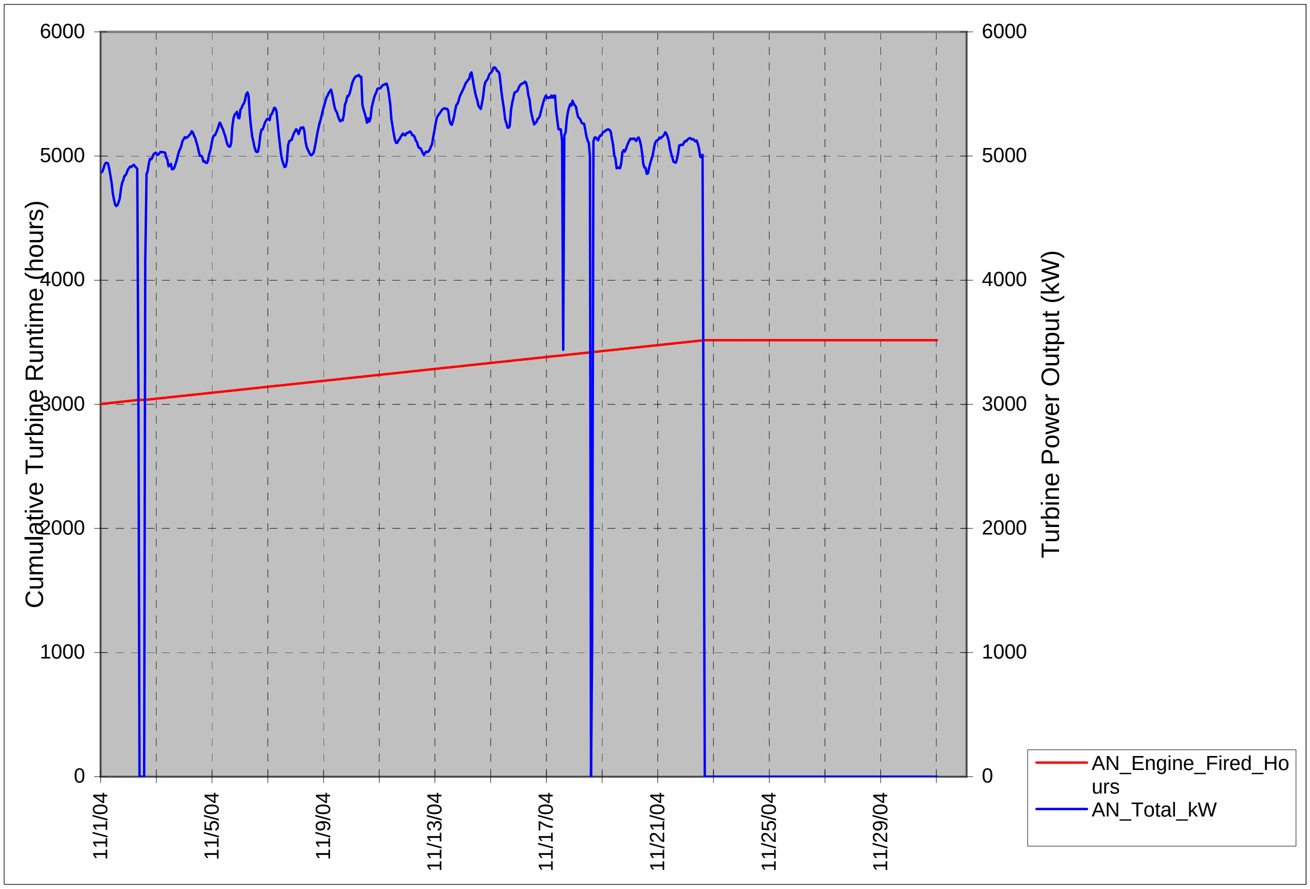

6000
5000
4000
3000
2000
1000
0
Turbine Power Output (kW)
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Turbine Exhaust Flow (lb/hr)
10/1/04
10/5/04
10/9/04
10/13/04
10/17/04
10/21/04
10/25/04
10/29/04
AN_Total_kW
AN_Exhaust_Gas_Flow

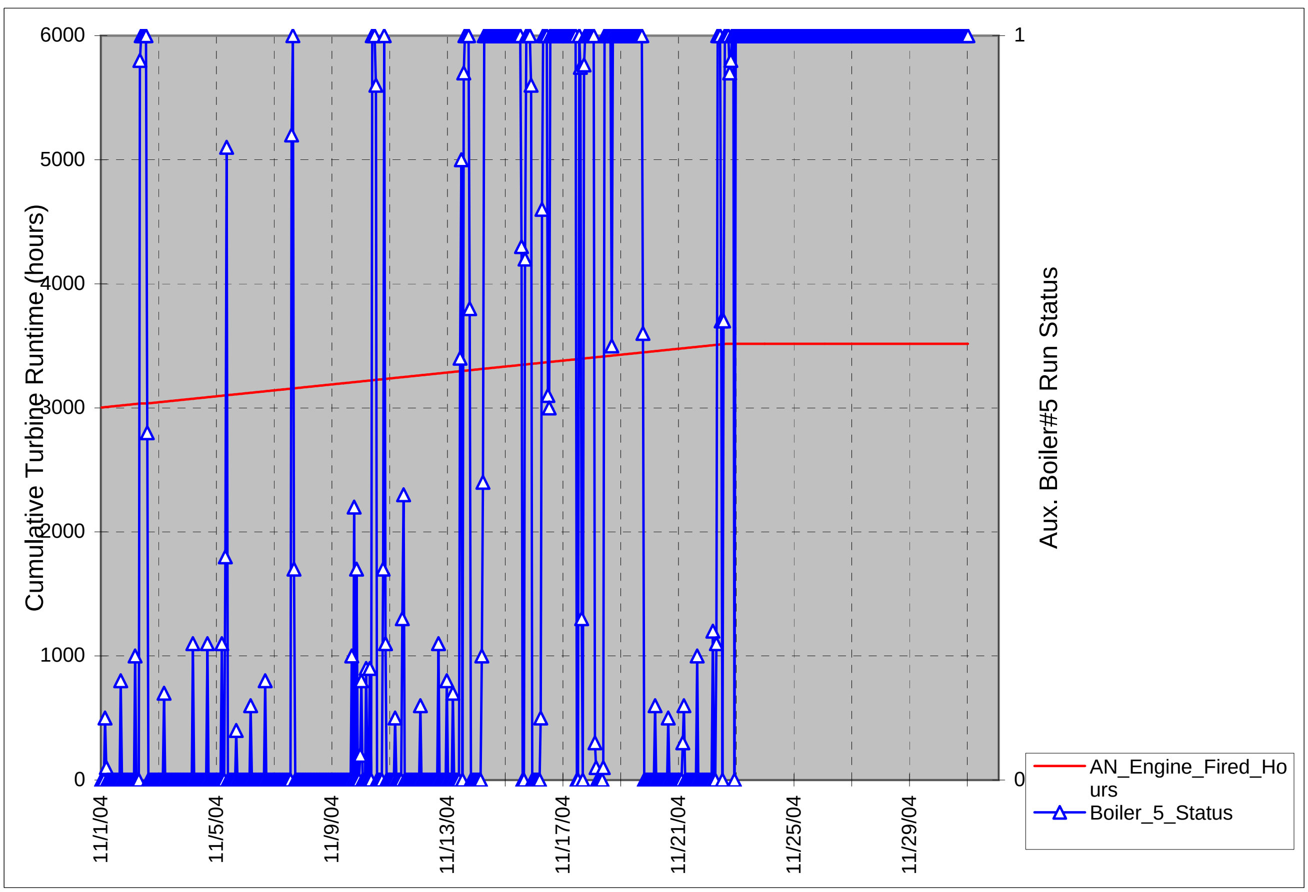

100
90
80
70
60
50
40
30
20
10
0
Outdoor Ambient Temperature (deg.F)
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Turbine Exhaust Flow (lb/hr)
10/1/04
10/5/04
10/9/04
10/13/04
10/17/04
10/21/04
10/25/04
10/29/04
AN_T1_Temperature
AN_Exhaust_Gas_Flow

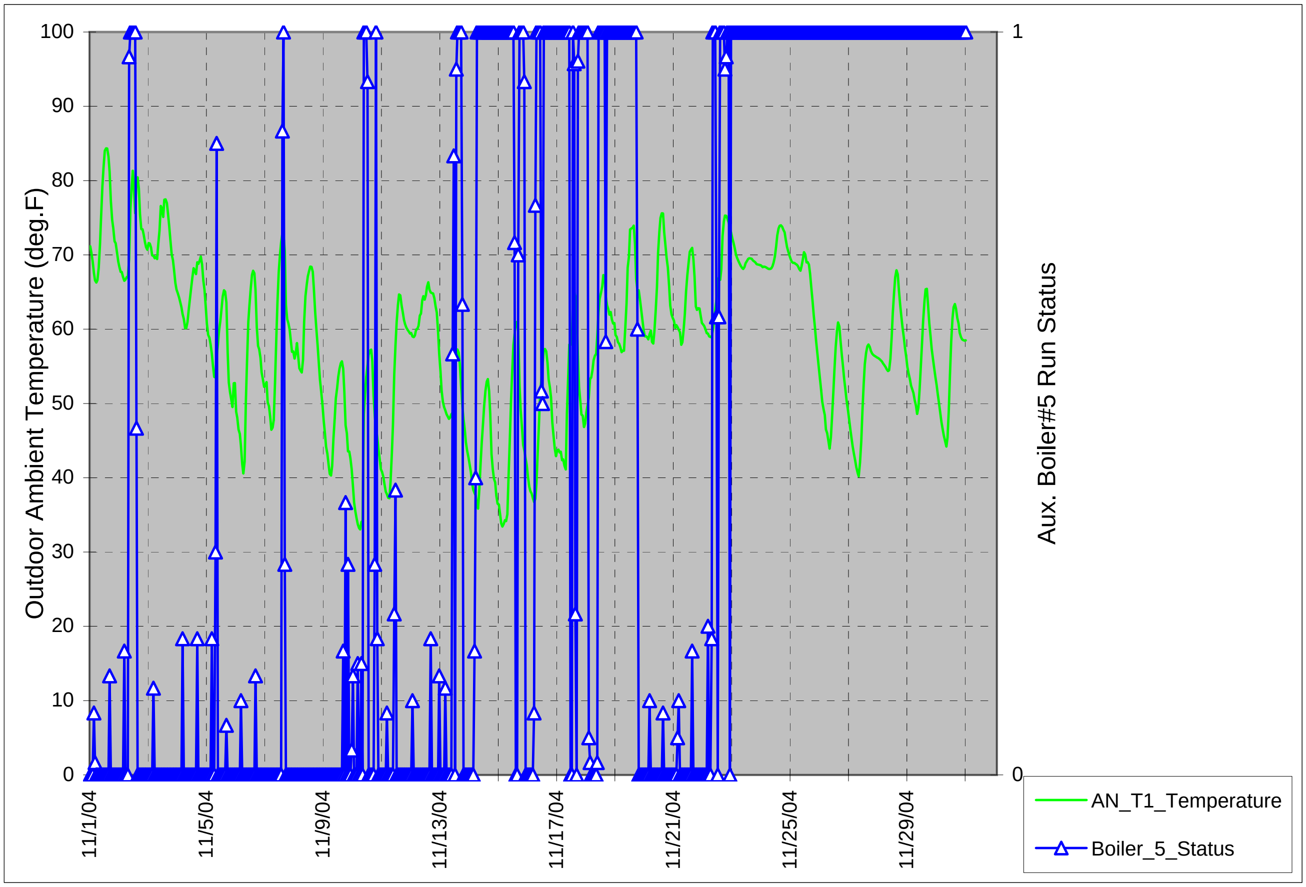
Appendix C

Detailed Operational Data: November 2004

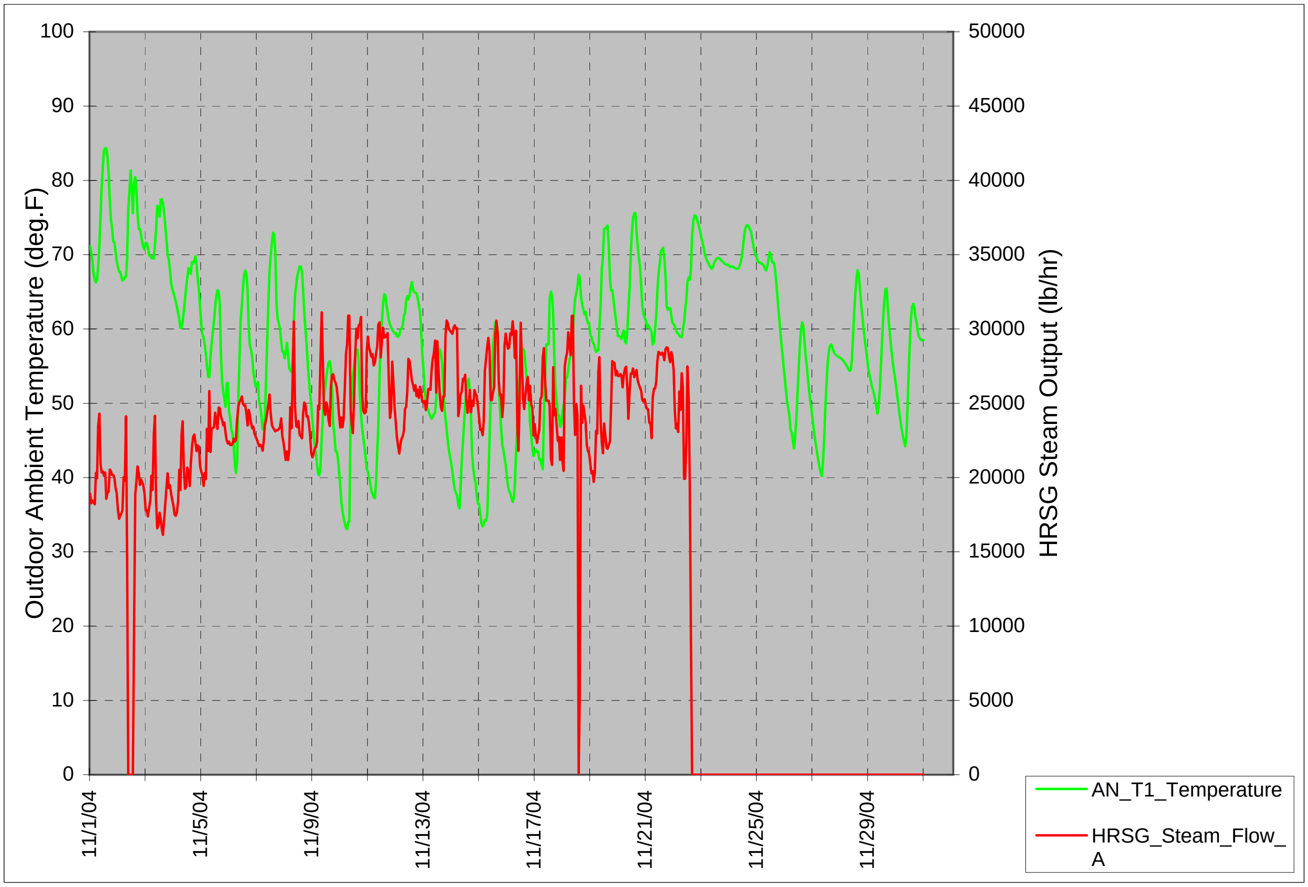
Misc. Plots


Cumulative Turbine Runtime (hours)
Turbine Power Output (kW)
6000
5000
4000
3000
2000
1000
0
11/1/04
11/5/04
11/9/04
11/13/04
11/17/04
11/21/04
11/25/04
11/29/04
AN_Engine_Fired_Hours
AN_Total_kW


Cumulative Turbine Runtime (hours)
Aux. Boiler#5 Run Status
6000
5000
4000
3000
2000
1000
0
1
0
11/1/04
11/5/04
11/9/04
11/13/04
11/17/04
11/21/04
11/25/04
11/29/04
AN_Engine_Fired_Hours
Boiler_5_Status

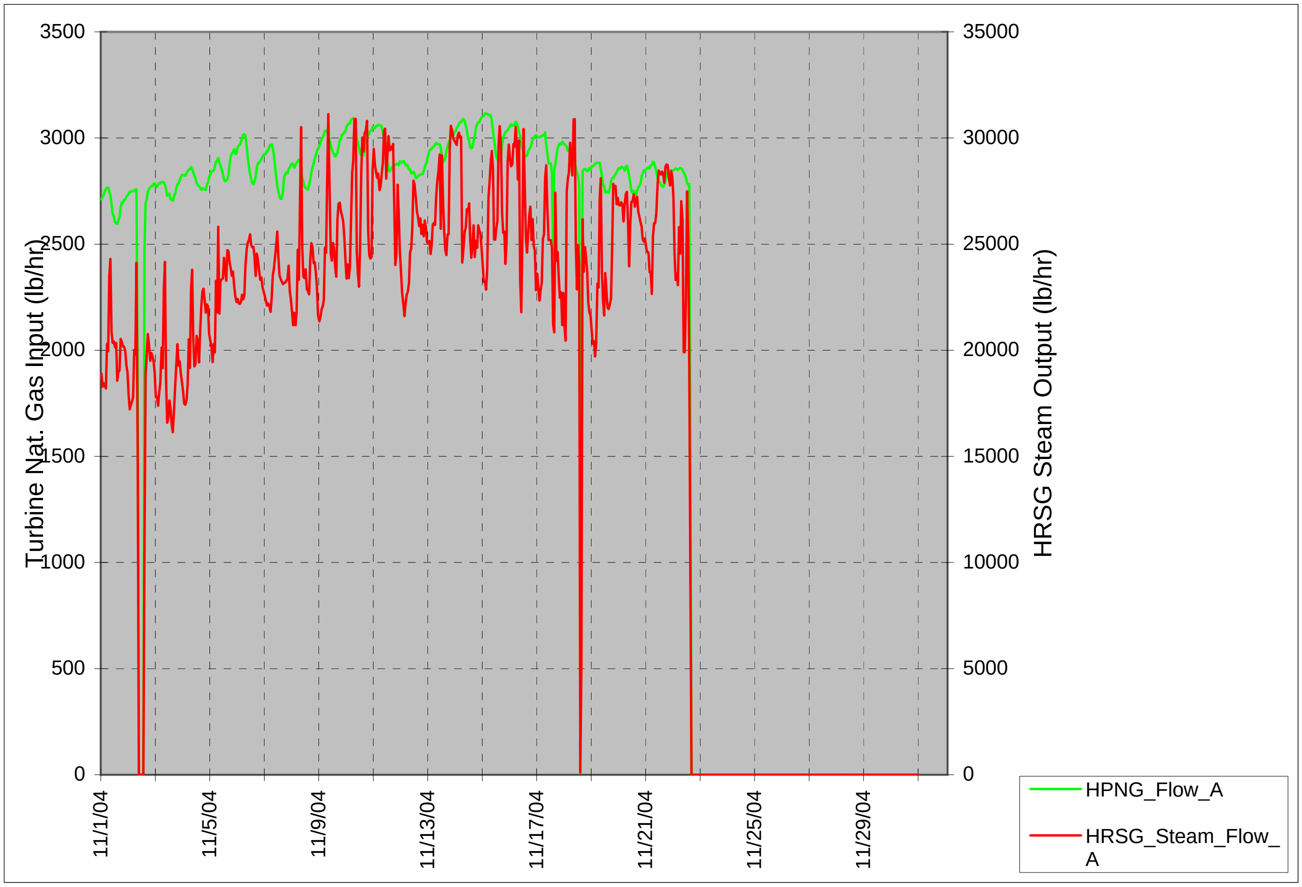


Outdoor Ambient Temperature (deg.F)
Aux. Boiler#5 Run Status
100
90
80
70
60
50
40
30
20
10
0
1
0
11/1/04
11/5/04
11/9/04
11/13/04
11/17/04
11/21/04
11/25/04
11/29/04
AN_T1_Temperature
Boiler_5_Status

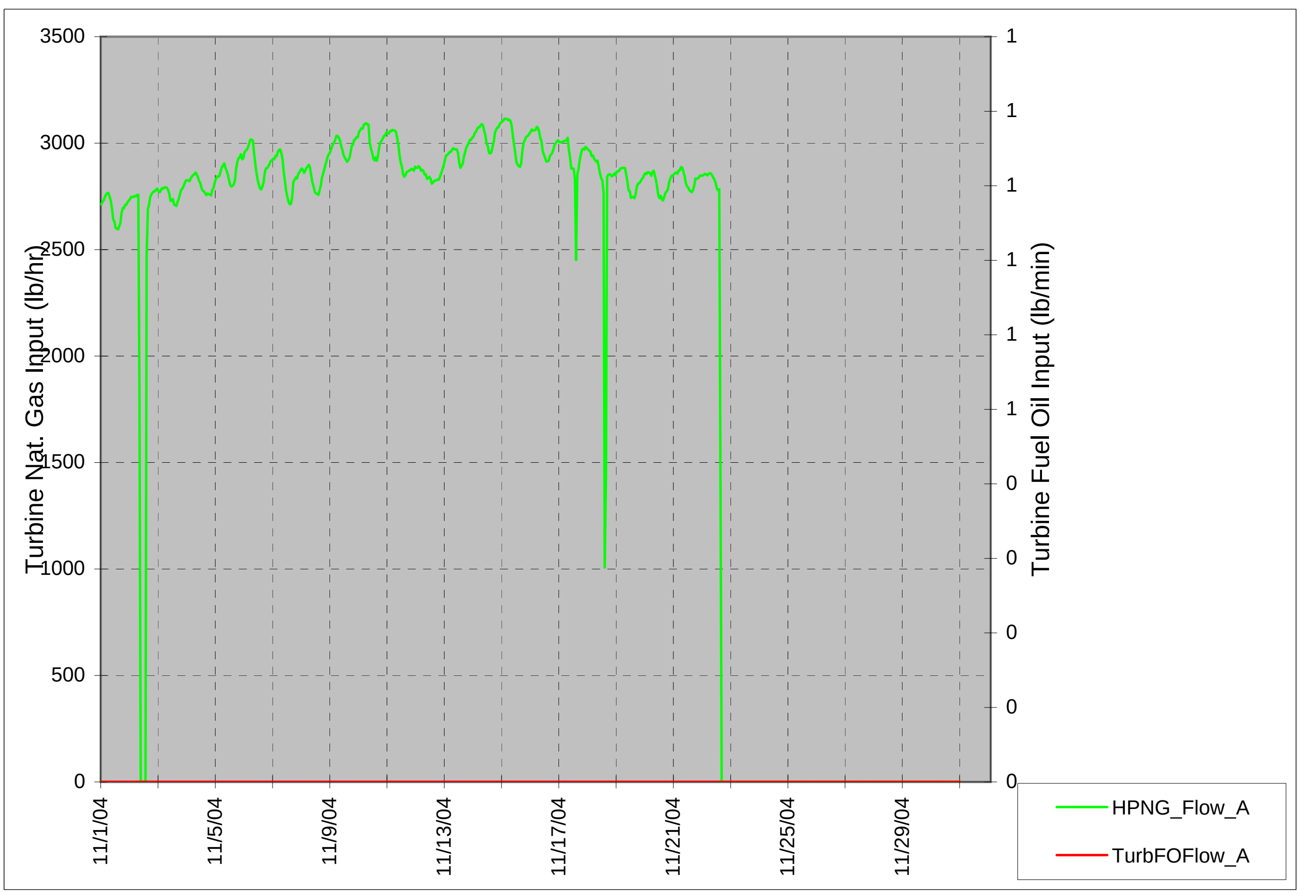


Outdoor Ambient Temperature (deg.F)
HRSG Steam Output (lb/hr)
100
90
80
70
60
50
40
30
20
10
0
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
11/1/04
11/5/04
11/9/04
11/13/04
11/17/04
11/21/04
11/25/04
11/29/04
AN_T1_Temperature
HRSG_Steam_Flow_A

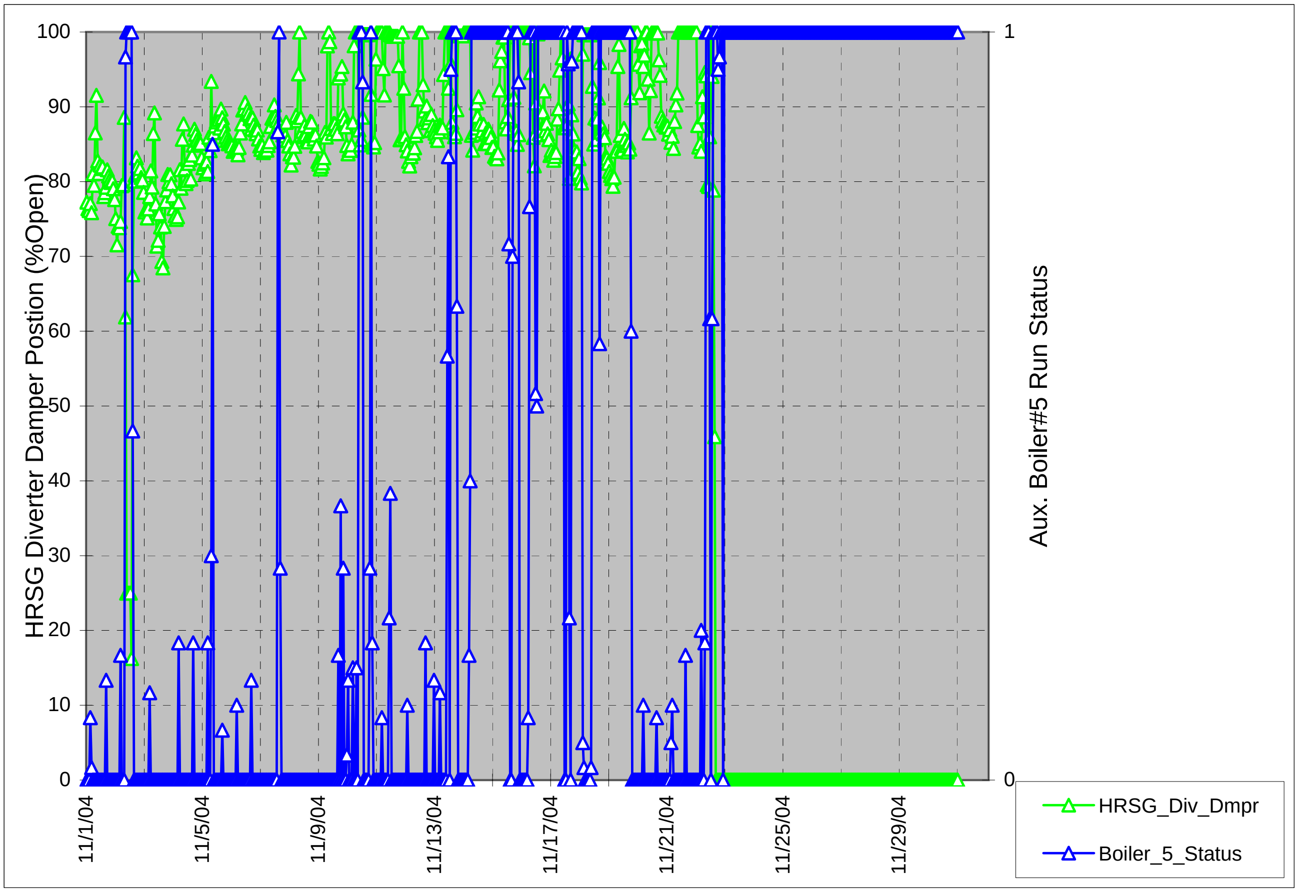
Misc. Plots



3500
3000
2500
2000
1500
1000
500
0
35000
30000
25000
20000
15000
10000
5000
0
Turbine Nat. Gas Input (lb/hr)
HRSG Steam Output (lb/hr)
11/1/04
11/5/04
11/9/04
11/13/04
11/17/04
11/21/04
11/25/04
11/29/04
HPNG_Flow_A
HRSG_Steam_Flow_A

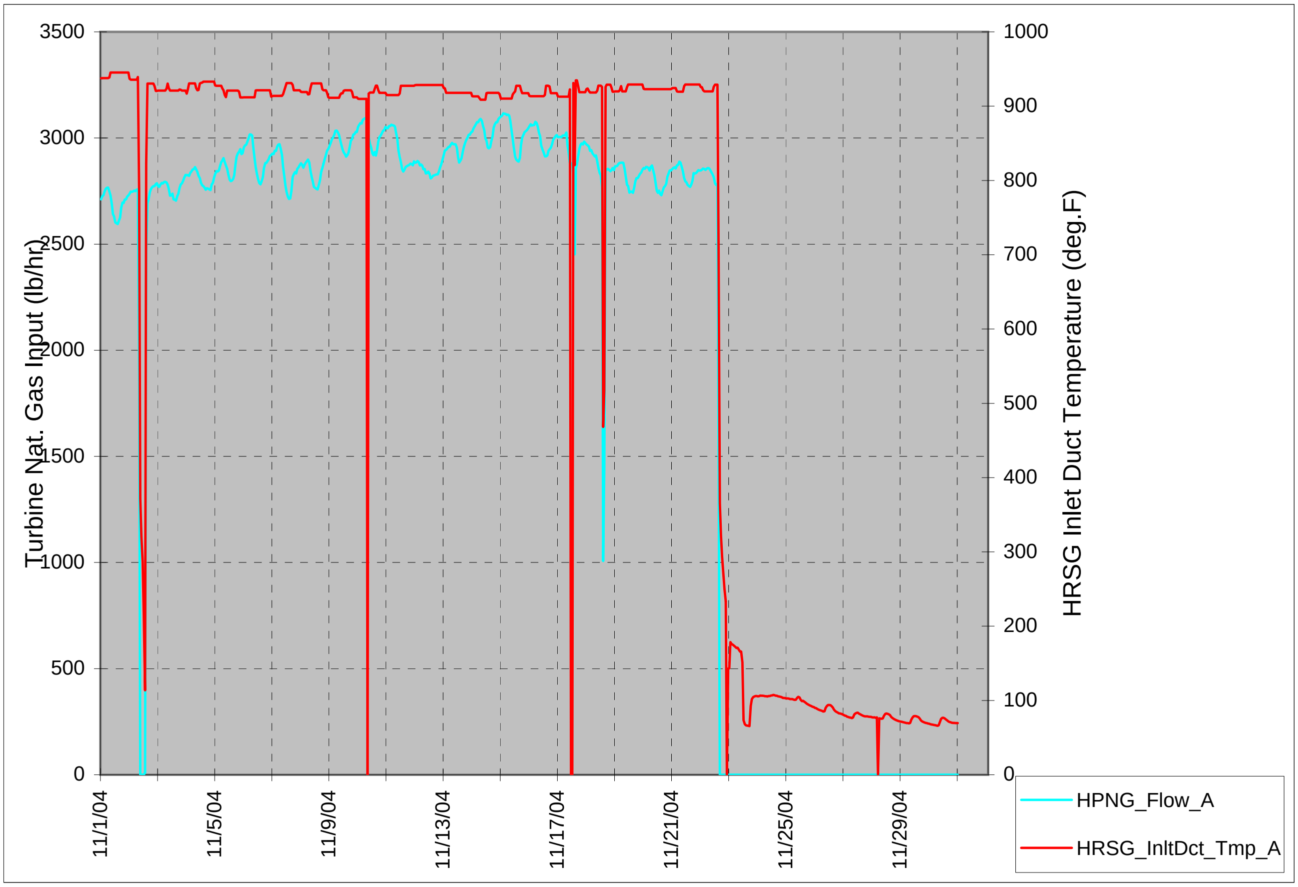


3500
3000
2500
2000
1500
1000
500
0
1
1
1
1
1
1
0
0
0
0
0
Turbine Nat. Gas Input (lb/hr)
Turbine Fuel Oil Input (lb/min)
11/1/04
11/5/04
11/9/04
11/13/04
11/17/04
11/21/04
11/25/04
11/29/04
HPNG_Flow_A
TurbFOFlow_A

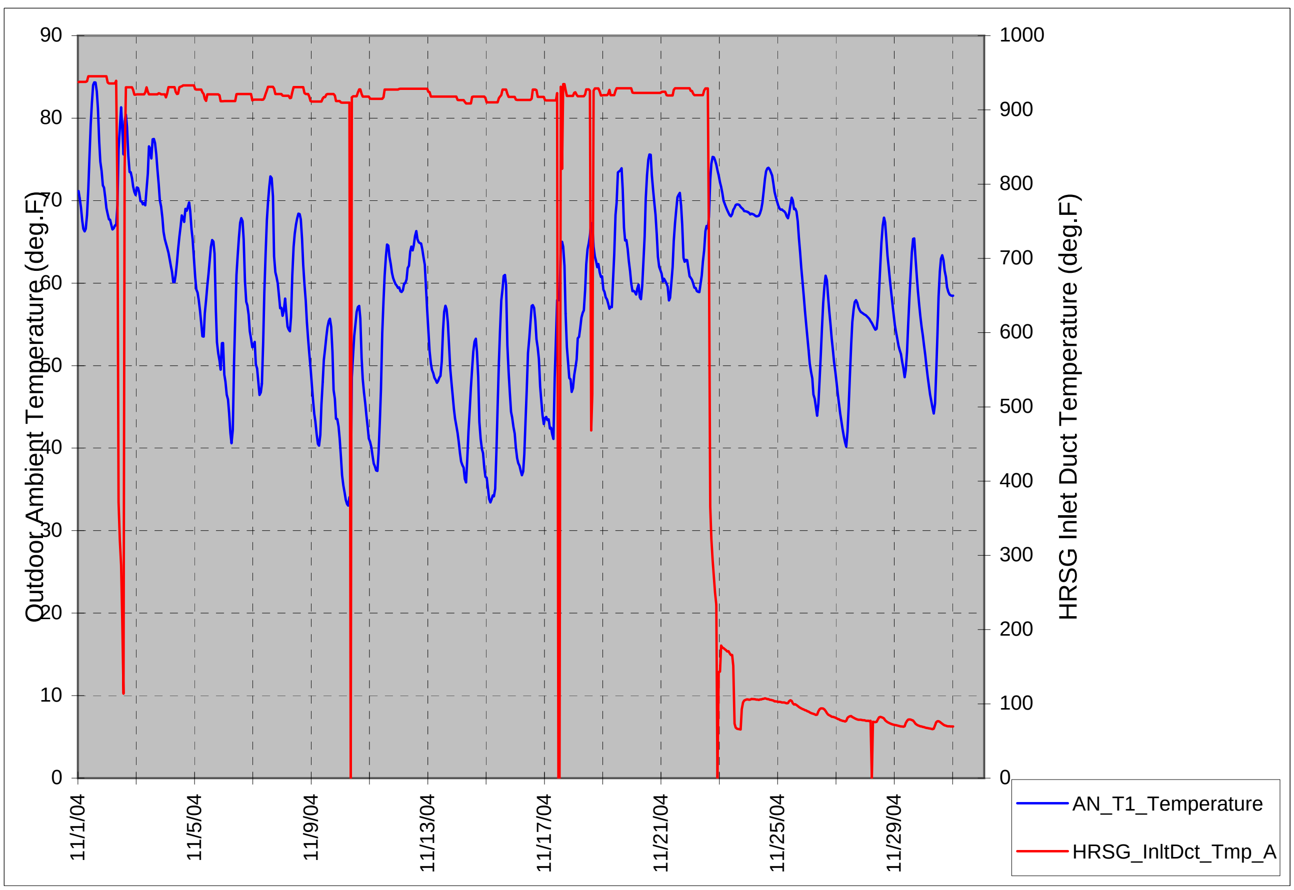

HRSG Diverter Damper Postion (%Open)
Aux. Boiler#5 Run Status
100
90
80
70
60
50
40
30
20
10
0
1
0
11/1/04
11/5/04
11/9/04
11/13/04
11/17/04
11/21/04
11/25/04
11/29/04
HRSG_Div_Dmpr
Boiler_5_Status


Steam Pressure (psig)
Deaerator Temperature (deg.F)
200
180
160
140
120
100
80
60
40
20
0
11/1/04
11/5/04
11/9/04
11/13/04
11/17/04
11/21/04
11/25/04
11/29/04
Boiler_Outlet_PSI
Deaerator_Temp

Misc. Plots

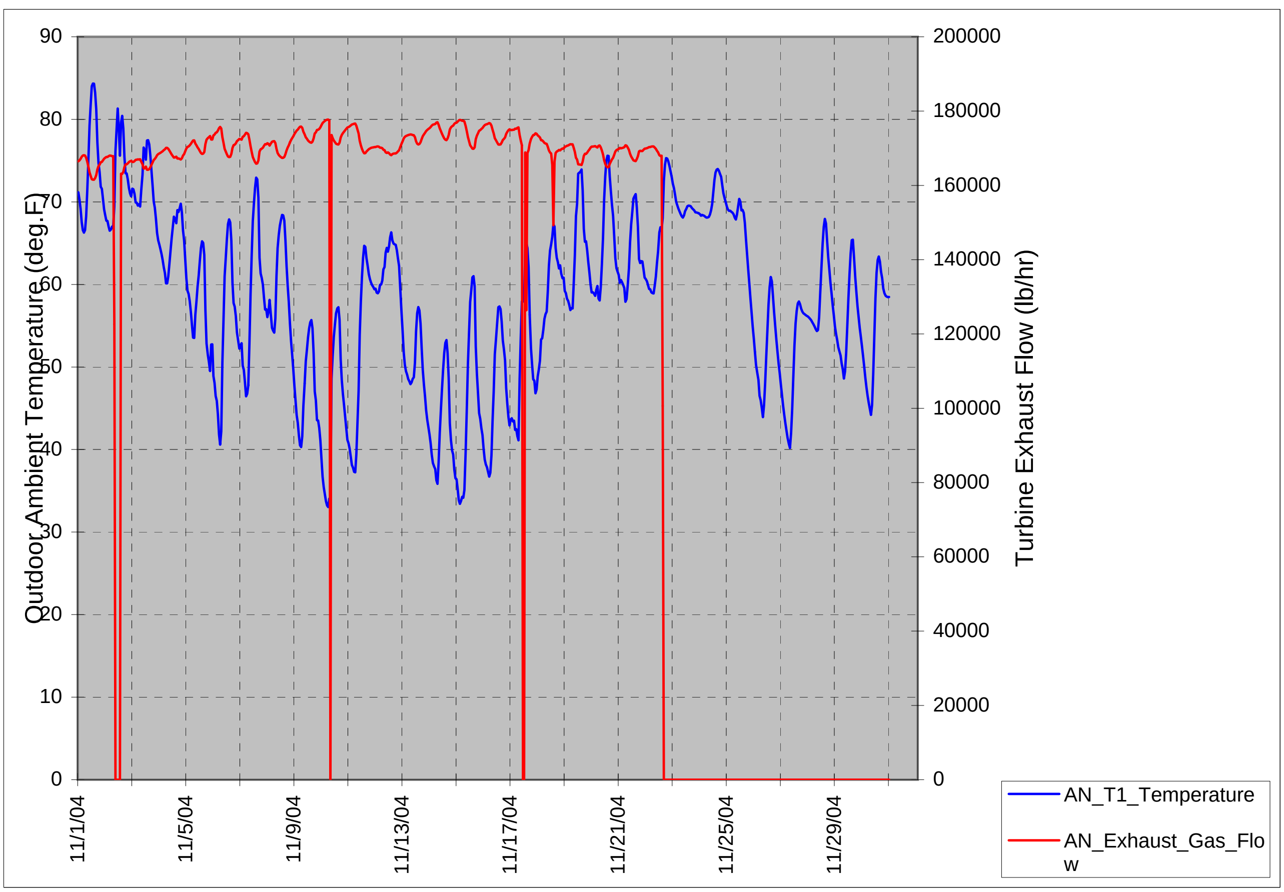


Turbine Nat. Gas Input (lb/hr)
HRSG Inlet Duct Temperature (deg.F)
3500
3000
2500
2000
1500
1000
500
0
1000
900
800
700
600
500
400
300
200
100
0
11/1/04
11/5/04
11/9/04
11/13/04
11/17/04
11/21/04
11/25/04
11/29/04
HPNG_Flow_A
HRSG_InltDct_Tmp_A



Outdoor Ambient Temperature (deg.F)
HRSG Inlet Duct Temperature (deg.F)
90
80
70
60
50
40
30
20
10
0
1000
900
800
700
600
500
400
300
200
100
0
11/1/04
11/5/04
11/9/04
11/13/04
11/17/04
11/21/04
11/25/04
11/29/04
AN_T1_Temperature
HRSG_InltDct_Tmp_A

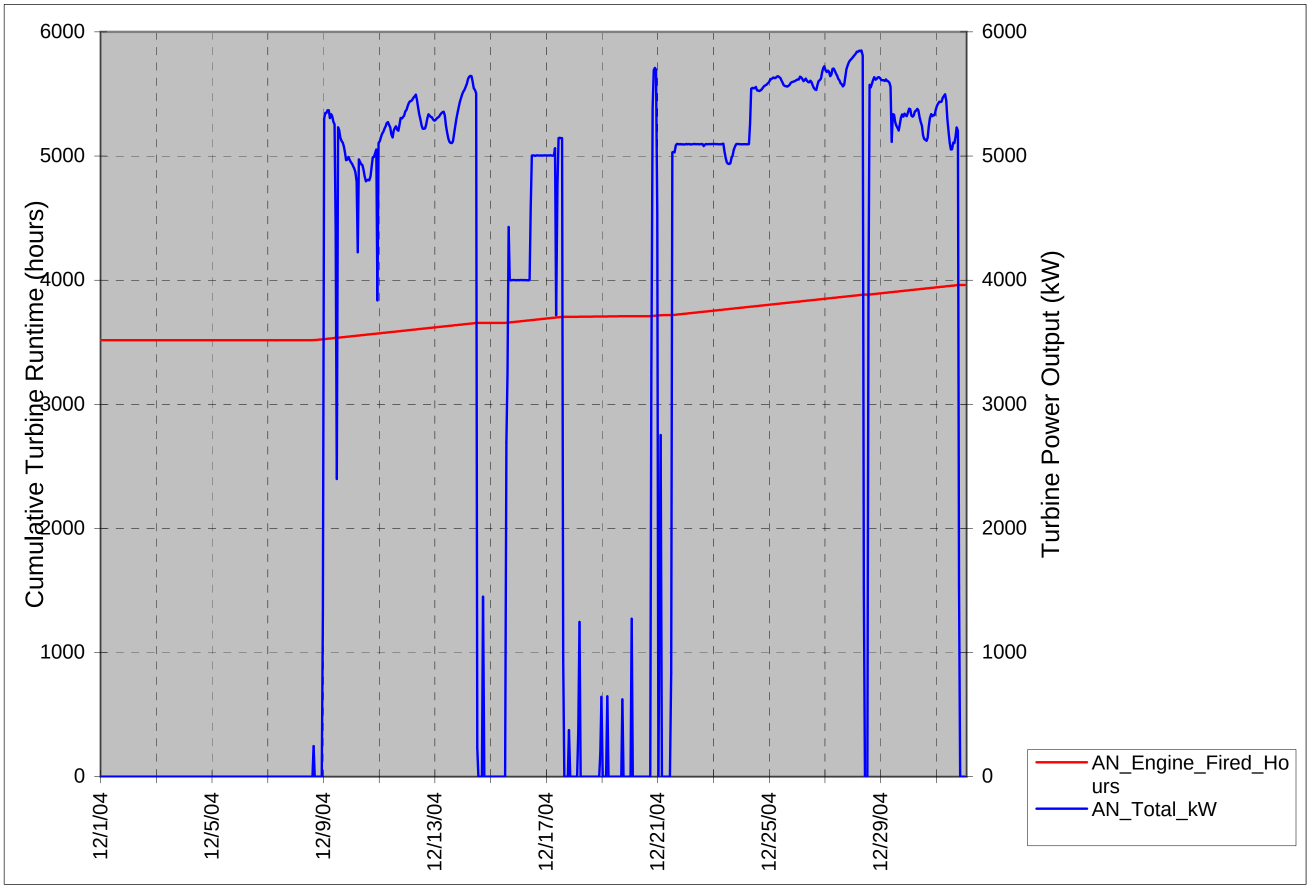

6000
5000
4000
3000
2000
1000
0
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Turbine Power Output (kW)
Turbine Exhaust Flow (lb/hr)
11/1/04
11/5/04
11/9/04
11/13/04
11/17/04
11/21/04
11/25/04
11/29/04
AN_Total_kW
AN_Exhaust_Gas_Flow


90
80
70
60
50
40
30
20
10
0
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Outdoor Ambient Temperature (deg.F)
Turbine Exhaust Flow (lb/hr)
11/1/04
11/5/04
11/9/04
11/13/04
11/17/04
11/21/04
11/25/04
11/29/04
AN_T1_Temperature
AN_Exhaust_Gas_Flow

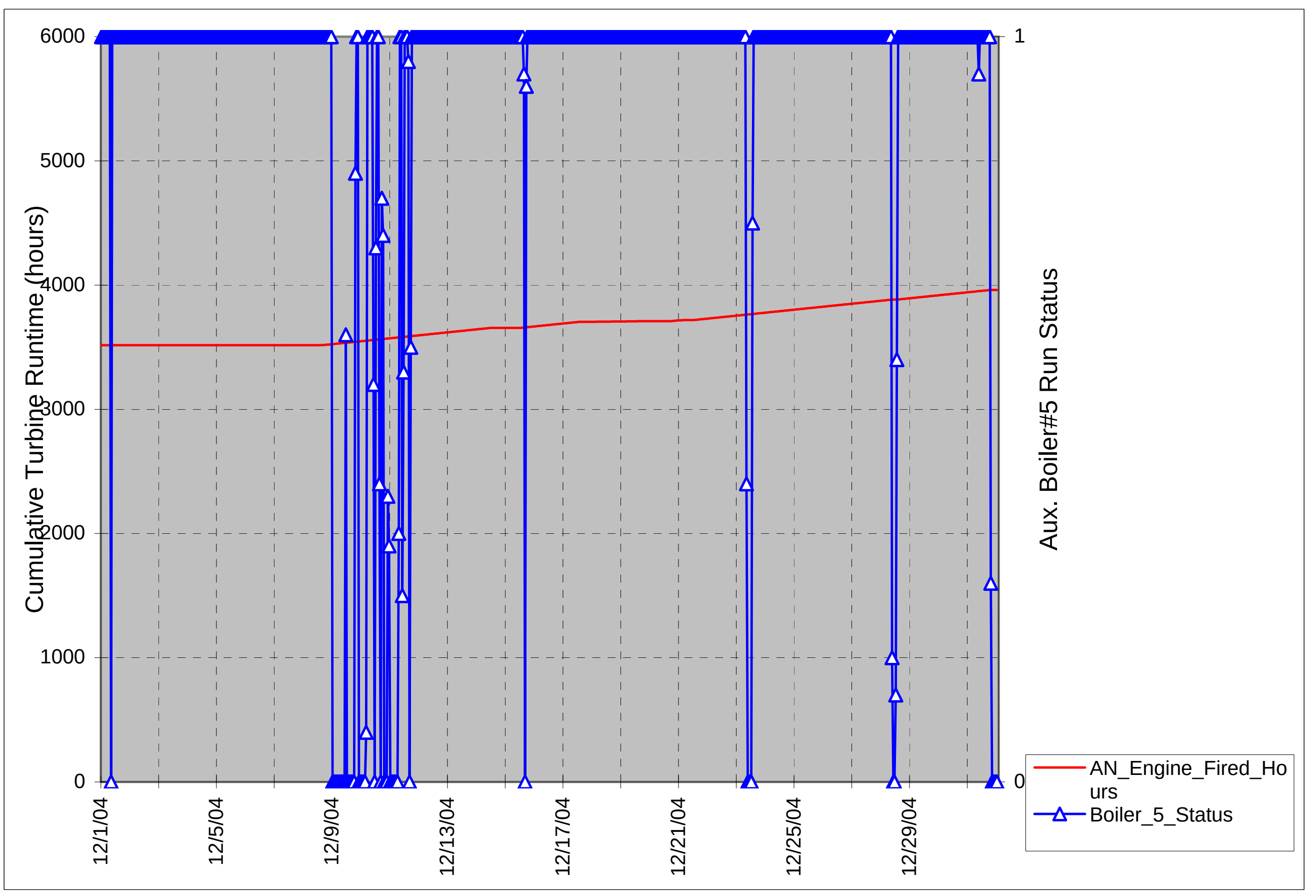
Appendix D

Detailed Operational Data: December 2004

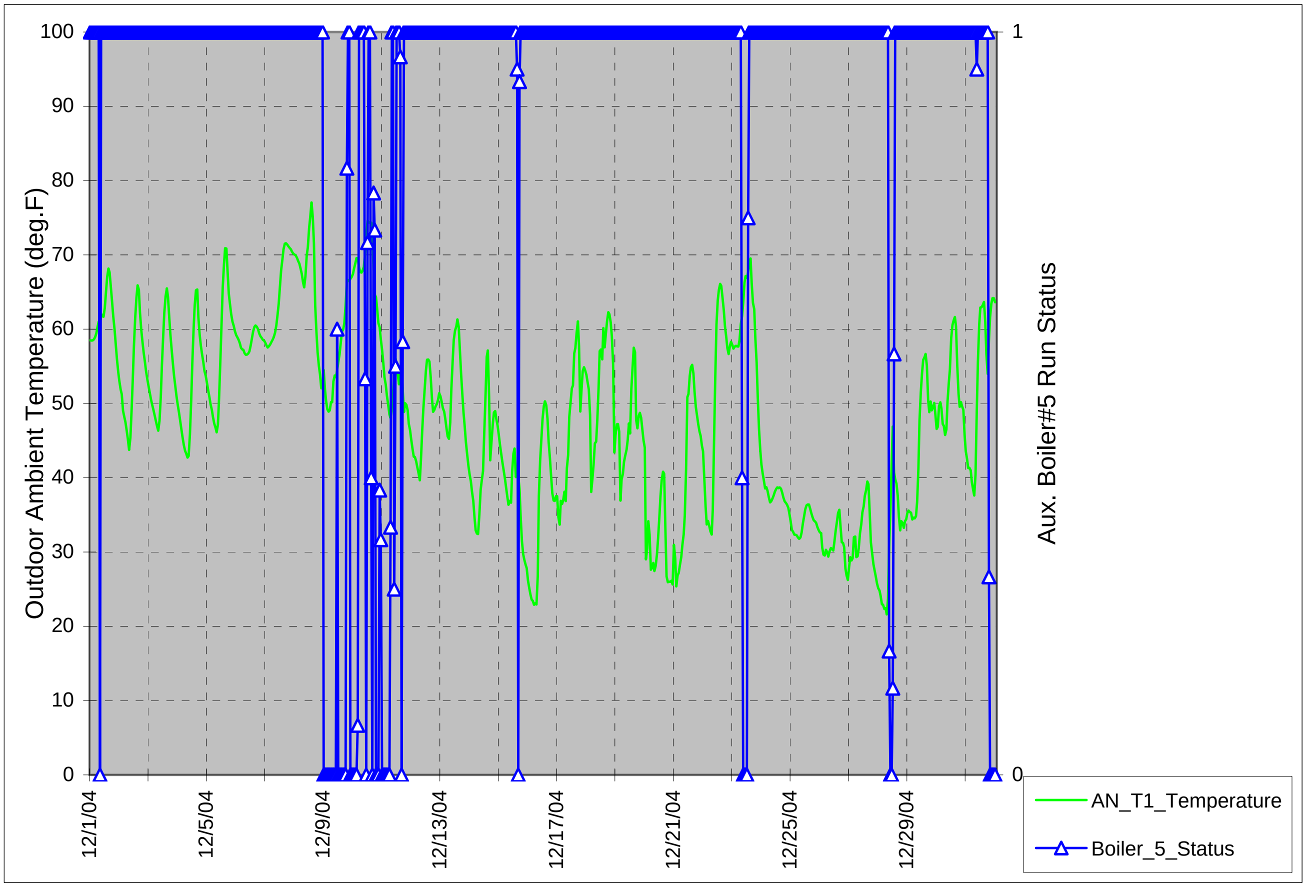
Misc. Plots

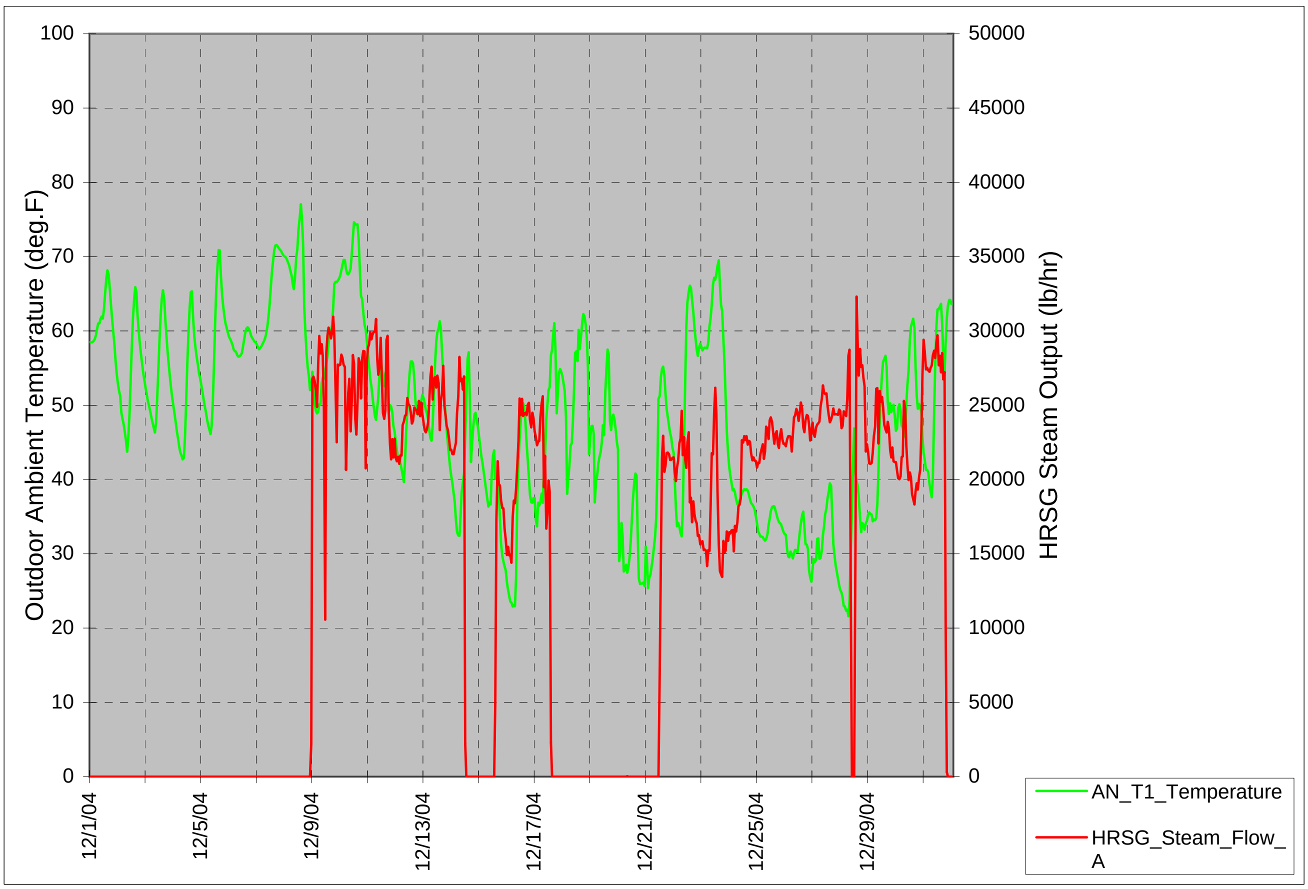


Cumulative Turbine Runtime (hours)
Turbine Power Output (kW)
0
1000
2000
3000
4000
5000
6000
12/1/04
12/5/04
12/9/04
12/13/04
12/17/04
12/21/04
12/25/04
12/29/04
AN_Engine_Fired_Hours
AN_Total_kW

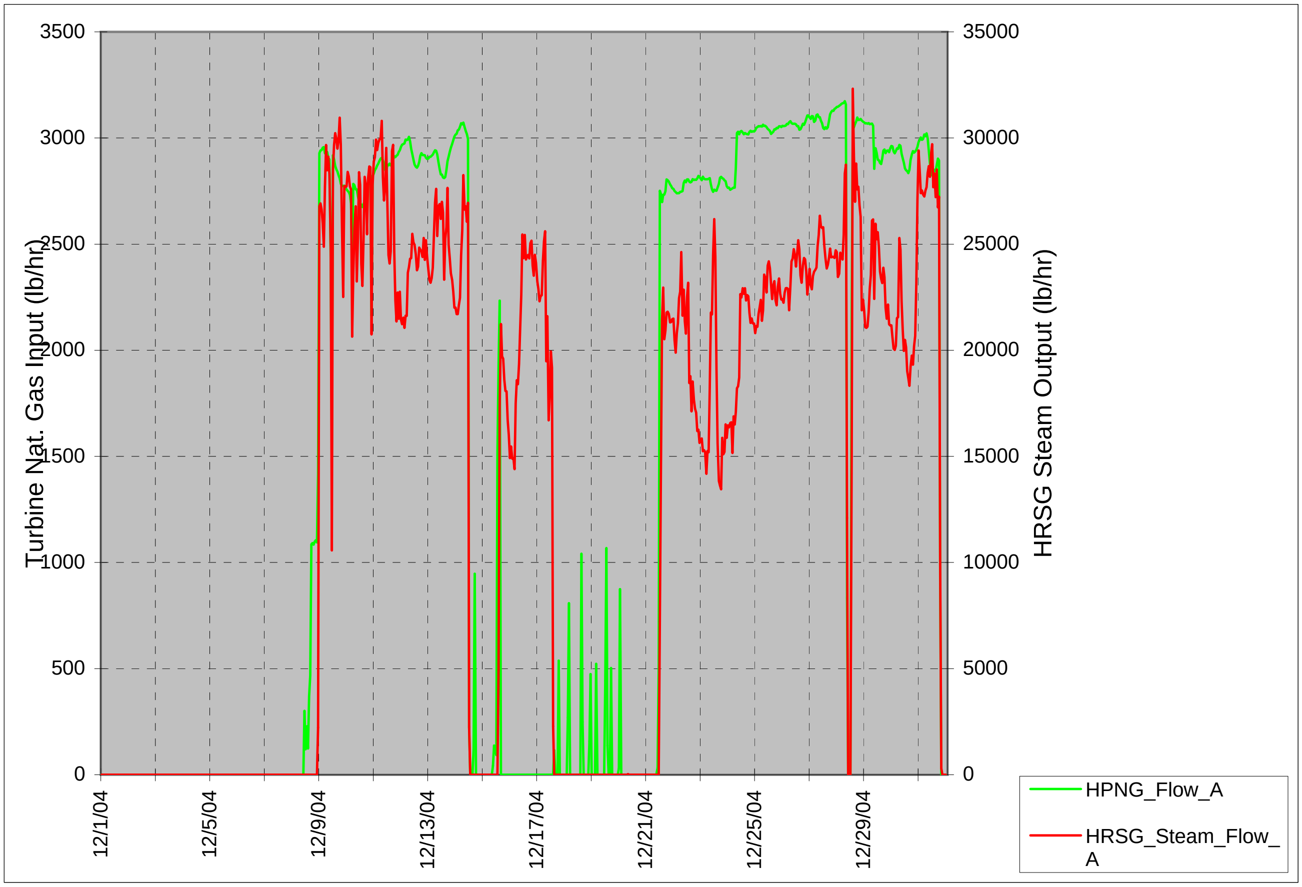


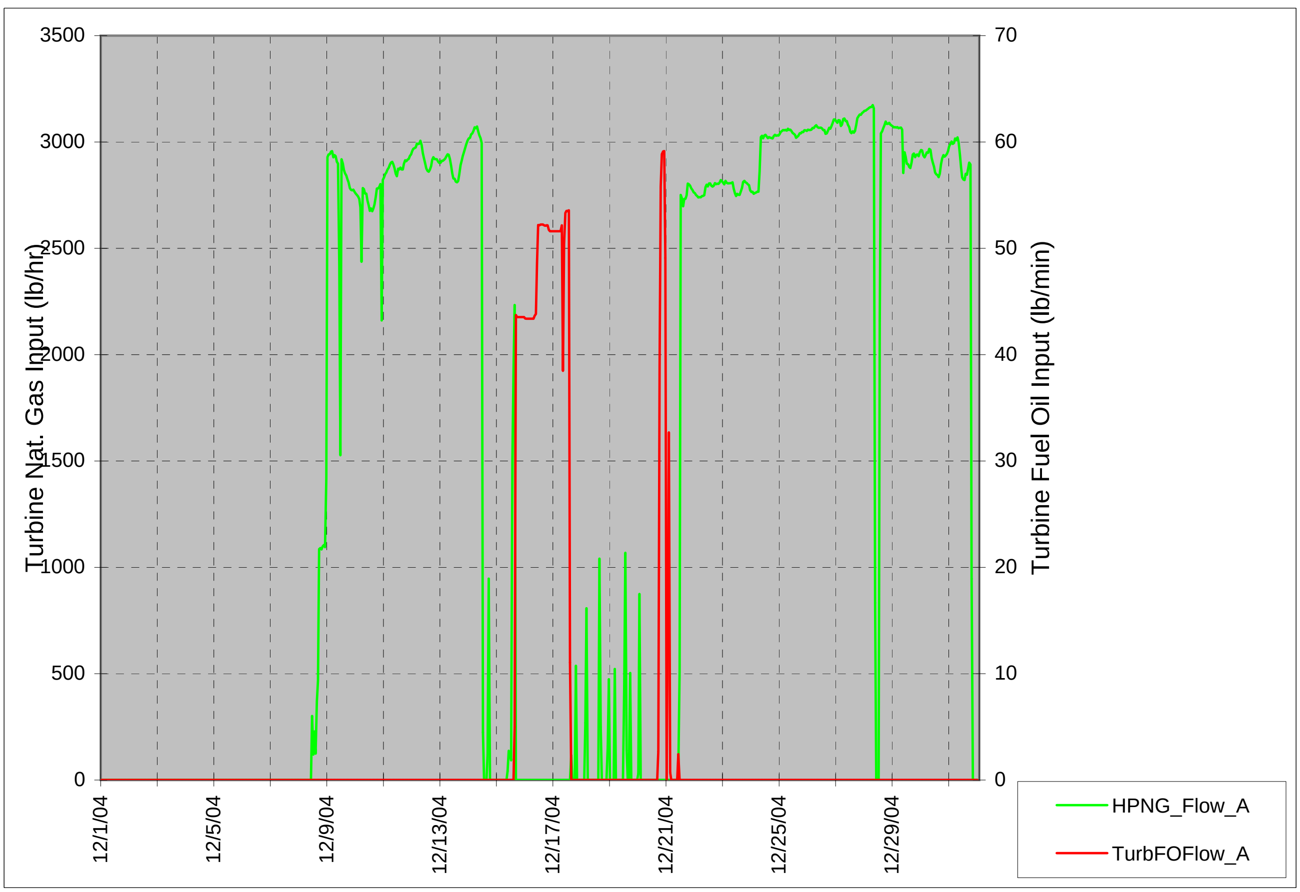
Cumulative Turbine Runtime (hours)
Aux. Boiler#5 Run Status
0
1000
2000
3000
4000
5000
6000
1
0
12/1/04
12/5/04
12/9/04
12/13/04
12/17/04
12/21/04
12/25/04
12/29/04
AN_Engine_Fired_Hours
Boiler_5_Status

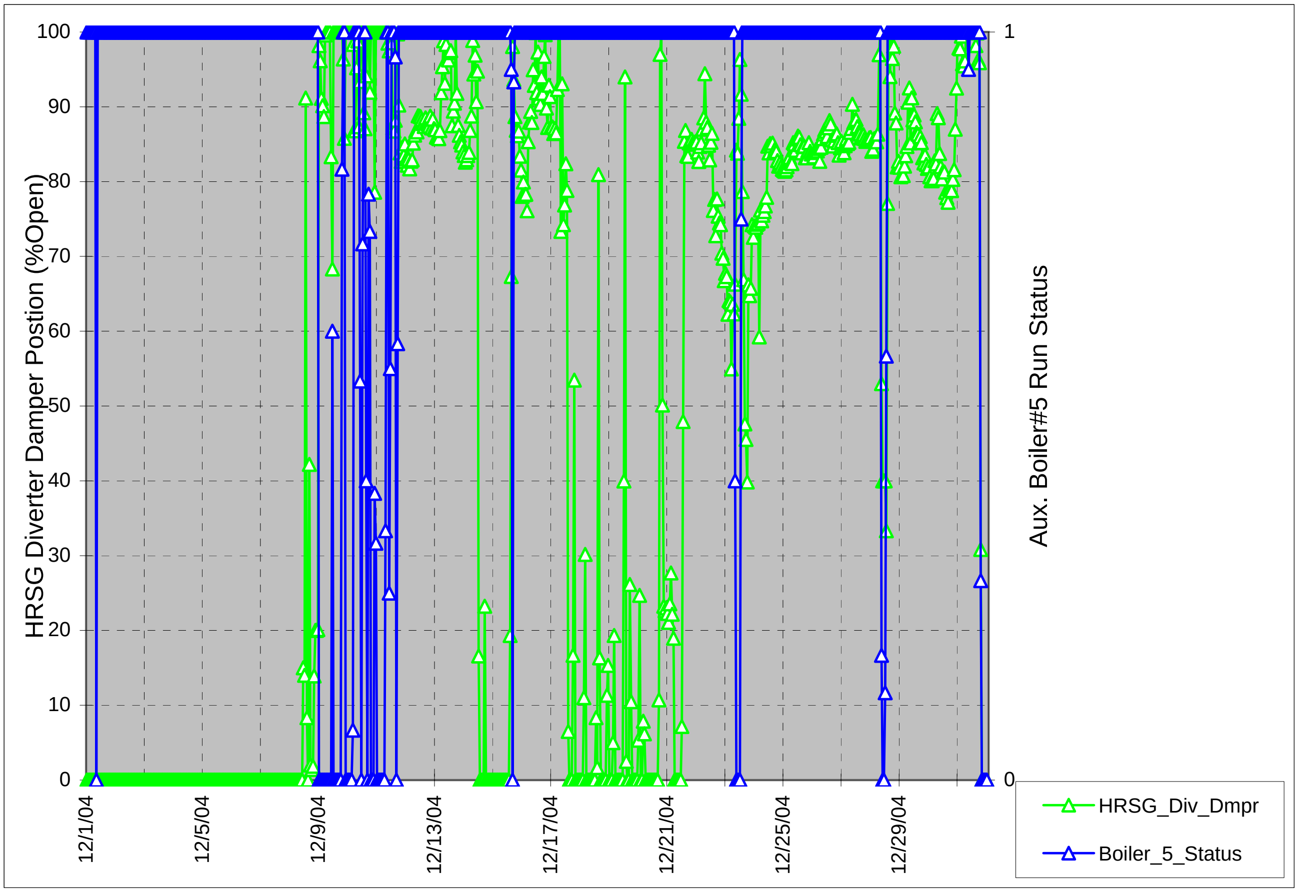

Outdoor Ambient Temperature (deg.F)
Aux. Boiler#5 Run Status
100
90
80
70
60
50
40
30
20
10
0
1
0
12/1/04
12/5/04
12/9/04
12/13/04
12/17/04
12/21/04
12/25/04
12/29/04
AN_T1_Temperature
Boiler_5_Status


Outdoor Ambient Temperature (deg.F)
HRSG Steam Output (lb/hr)
100
90
80
70
60
50
40
30
20
10
0
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
12/1/04
12/5/04
12/9/04
12/13/04
12/17/04
12/21/04
12/25/04
12/29/04
AN_T1_Temperature
HRSG_Steam_Flow_A

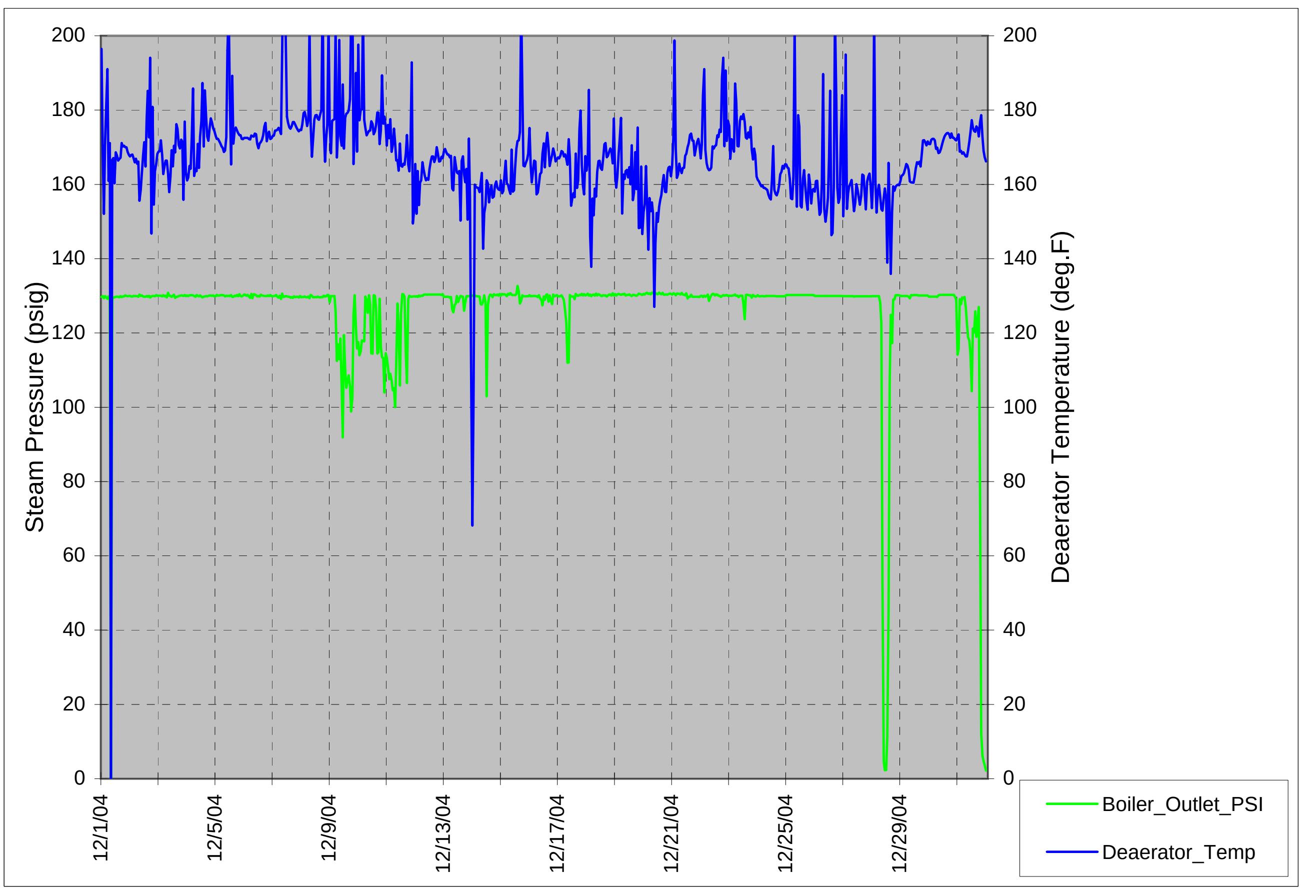
Misc. Plots


3500
3000
2500
2000
1500
1000
500
0
Turbine Nat. Gas Input (lb/hr)
35000
30000
25000
20000
15000
10000
5000
0
HRSG Steam Output (lb/hr)
12/1/04
12/5/04
12/9/04
12/13/04
12/17/04
12/21/04
12/25/04
12/29/04
HPNG_Flow_A
HRSG_Steam_Flow_A


3500
3000
2500
2000
1500
1000
500
0
Turbine Nat. Gas Input (lb/hr)
70
60
50
40
30
20
10
0
Turbine Fuel Oil Input (lb/min)
12/1/04
12/5/04
12/9/04
12/13/04
12/17/04
12/21/04
12/25/04
12/29/04
HPNG_Flow_A
TurbFOFlow_A

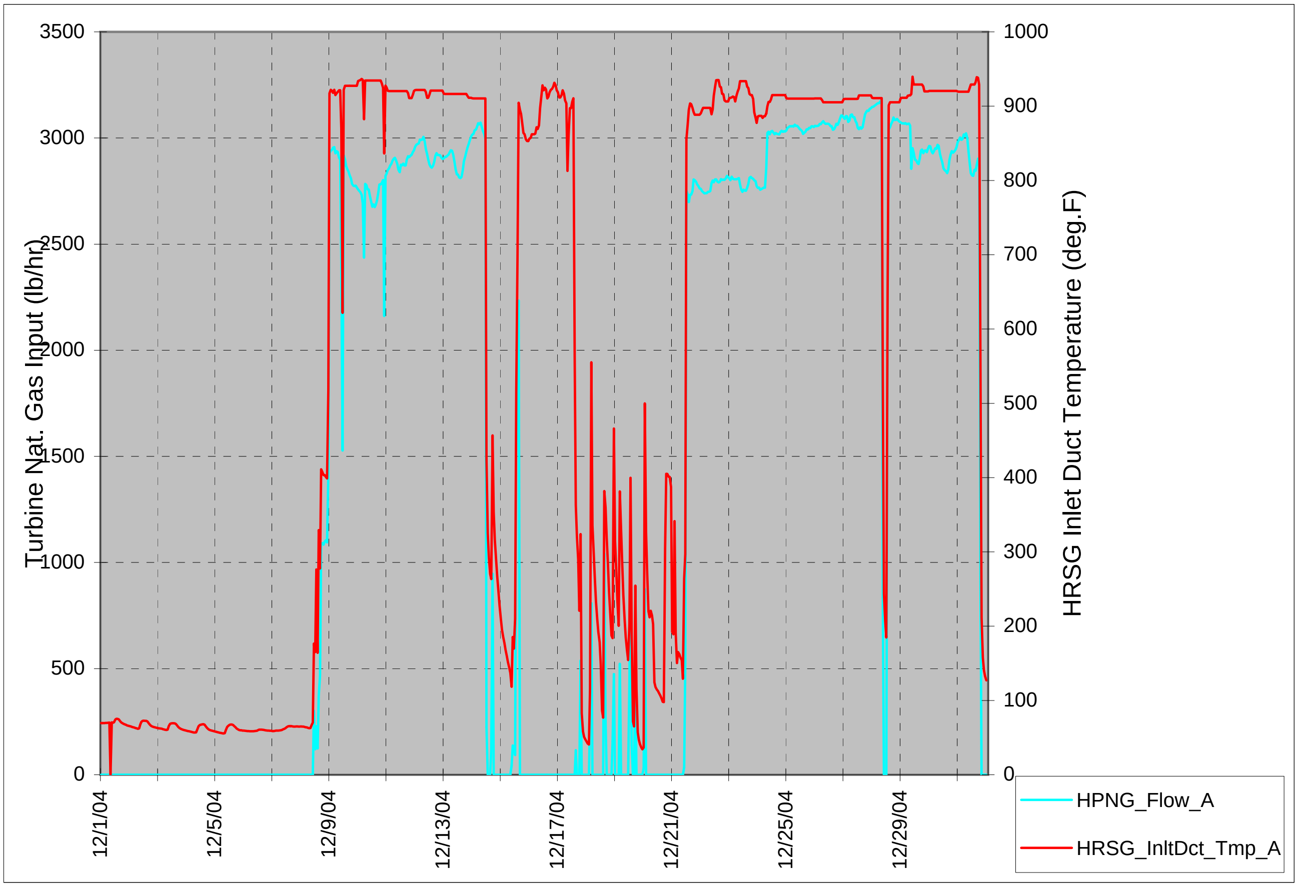


HRSG Diverter Damper Postion (%Open)
Aux. Boiler#5 Run Status
100
90
80
70
60
50
40
30
20
10
0
1
0
12/1/04
12/5/04
12/9/04
12/13/04
12/17/04
12/21/04
12/25/04
12/29/04
HRSG_Div_Dmpr
Boiler_5_Status

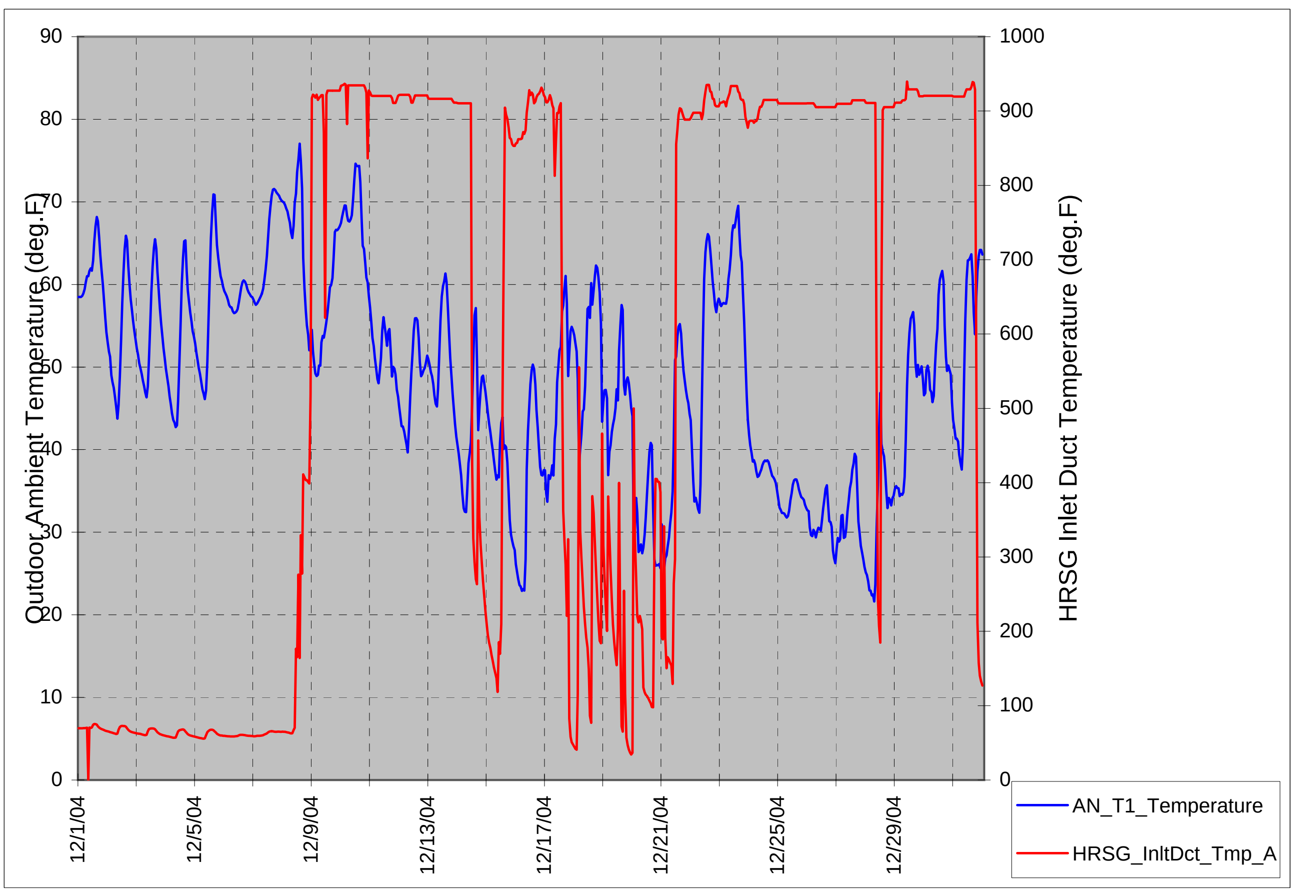


Steam Pressure (psig)
Deaerator Temperature (deg.F)
200
180
160
140
120
100
80
60
40
20
0
12/1/04
12/5/04
12/9/04
12/13/04
12/17/04
12/21/04
12/25/04
12/29/04
Boiler_Outlet_PSI
Deaerator_Temp

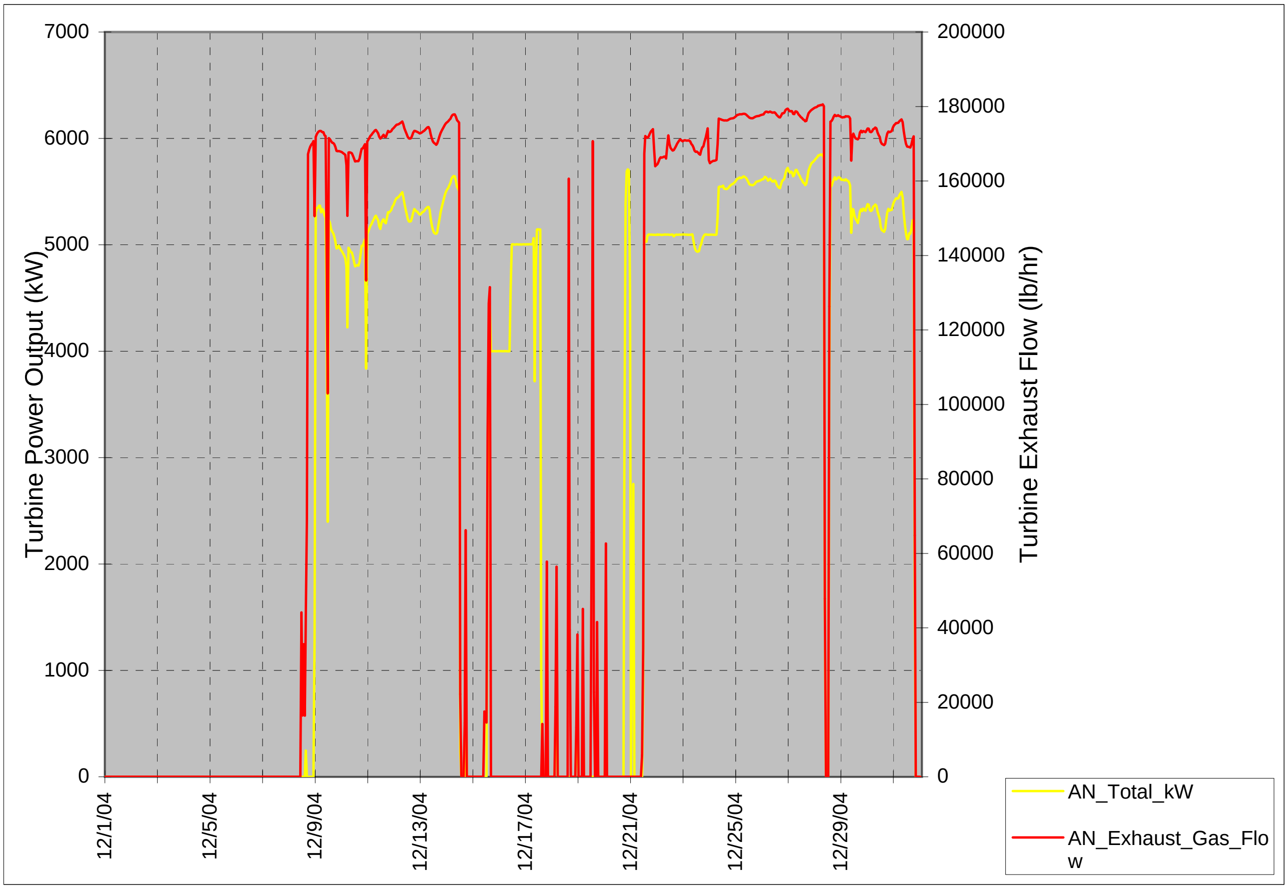
Misc. Plots



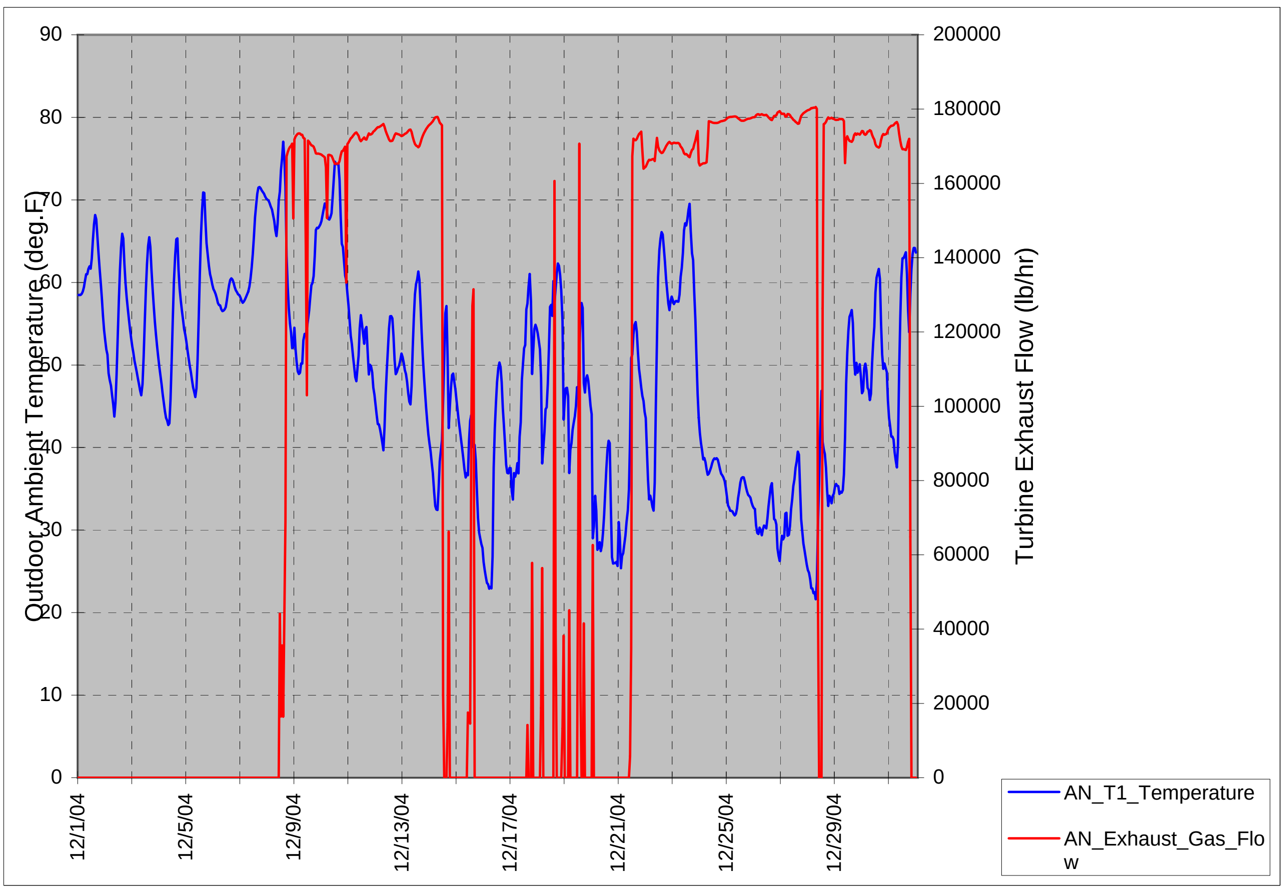
3500
3000
2500
2000
1500
1000
500
0
Turbine Nat. Gas Input (lb/hr)
1000
900
800
700
600
500
400
300
200
100
0
HRSG Inlet Duct Temperature (deg.F)
12/1/04
12/5/04
12/9/04
12/13/04
12/17/04
12/21/04
12/25/04
12/29/04
HPNG_Flow_A
HRSG_InltDct_Tmp_A



90
80
70
60
50
40
30
20
10
0
Outdoor Ambient Temperature (deg.F)
1000
900
800
700
600
500
400
300
200
100
0
HRSG Inlet Duct Temperature (deg.F)
12/1/04
12/5/04
12/9/04
12/13/04
12/17/04
12/21/04
12/25/04
12/29/04
AN_T1_Temperature
HRSG_InltDct_Tmp_A



7000
6000
5000
4000
3000
2000
1000
0
Turbine Power Output (kW)
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Turbine Exhaust Flow (lb/hr)
12/1/04
12/5/04
12/9/04
12/13/04
12/17/04
12/21/04
12/25/04
12/29/04
AN_Total_kW
AN_Exhaust_Gas_Flow



90
80
70
60
50
40
30
20
10
0
Outdoor Ambient Temperature (deg.F)
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Turbine Exhaust Flow (lb/hr)
12/1/04
12/5/04
12/9/04
12/13/04
12/17/04
12/21/04
12/25/04
12/29/04
AN_T1_Temperature
AN_Exhaust_Gas_Flow