



SmartPOWER
Critical Peak Pricing (CPP)

February 2008

APC SmartPOWER Pilot

What is SmartPOWER?

- ◆ SmartPOWER is an interactive energy management system that allows customers to program their heating and cooling system to automatically respond to varying prices
- ◆ Combines residential TOU rate with CPP (Critical Peak Pricing) rate rider component and one-way communicating programmable thermostat with web access capabilities
- ◆ Utilizes Sensus AMI network currently installed in the B'ham area as means of communicating with and reading meters
- ◆ APC conducted pilot programs in 2006 and 2007 to demonstrate feasibility of the technology and to collect data on the behavior of customers on the CPP rate

APC SmartPOWER Pilot

SmartPOWER Rate

SmartPOWER Pricing (Energy Only)

\$21.91 Customer Charge

Price per kWh

Off-peak	2.4505 cents	
Intermediate	5.6605 cents	Our standard rate (FD) costs about 6.176 cents per kWh.
On-peak	12.4918 cents	
Critical	29.9918 cents	

These kWh prices do not include base charge, fuel charges, NDR, or taxes.

SmartPOWER Time Periods

June-September

Weekdays:

Off-peak	9 p.m. - 10 a.m.
Intermediate	10 a.m. - 12 p.m and 7 p.m. - 9 p.m.
On-peak	12 p.m. - 7 p.m
Critical	12 p.m. - 7 p.m (5hrs. a day with a maximum of 120 hours a year)

October-May

Weekdays:

Off-peak	9 p.m. - 7 a.m.
Intermediate	7 a.m. - 9p.m.

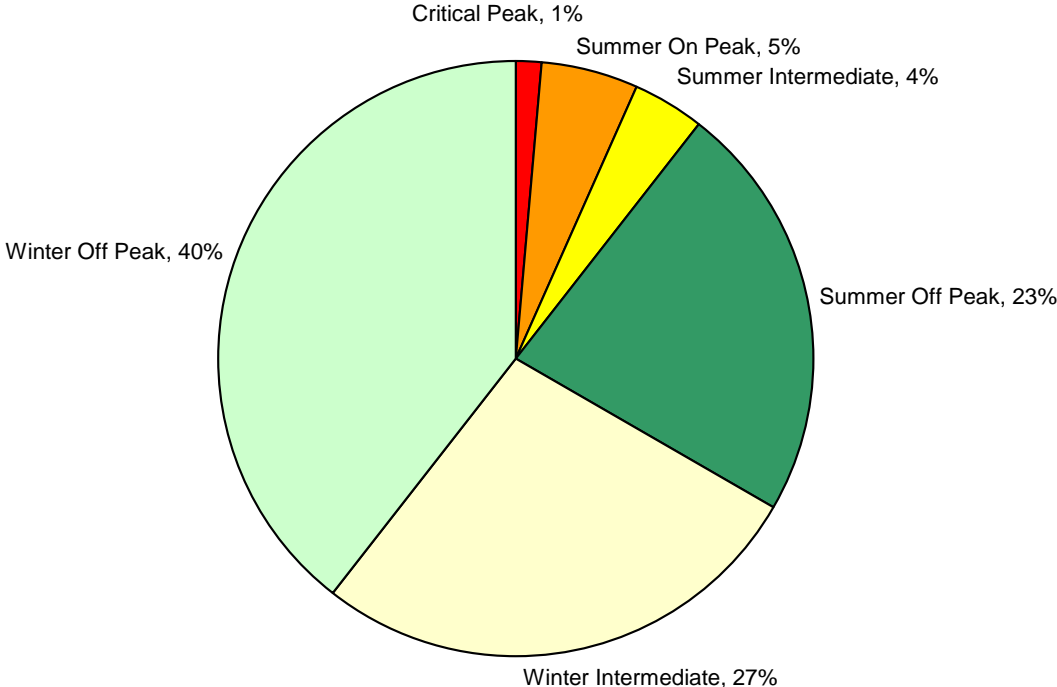
Weekends and holidays*:

Off-peak	24 hrs
----------	--------

**Holidays are defined as New Years Day, Independence Day, Labor Day, Thanksgiving Day, and Christmas Day. When any of these holidays fall on a Sunday, the Monday following is treated as a holiday.*

APC SmartPOWER Pilot

Rate FDT-CPP Price Availability



- Critical Peak
- Summer On Peak
- Summer Intermediate
- Summer Off Peak
- Winter Intermediate
- Winter Off Peak

APC SmartPOWER Pilot

How does it work “technically”?

- ◆ Customers have web access to control their thermostat settings
- ◆ Critical price signals are sent via the web to the thermostat using paging signals
- ◆ Signals are also sent to Sensus AMI meters telling them to create a new price period during a critical price event
- ◆ Customers are notified via e-mail (if they enroll) and at the thermostat during a critical price event

APC SmartPOWER Pilot

Why is it good for APC?

- ◆ This program encourages customers via the critical price to reduce their demand for electricity during times when load reduction is needed or when prices to produce electricity are higher than expected
- ◆ Customers pay rates based on APC's costs during specific hours of the day which encourages them to use more electricity during low cost periods and less during high cost periods

APC SmartPOWER Pilot

Why is it good for the customer?

- ◆ Customers can gain greater control over their electricity usage by having the ability to program their thermostats remotely or manually to suit their individual needs
- ◆ Customers can save money by shifting their electricity usage to lower cost periods

2006 Pilot Results

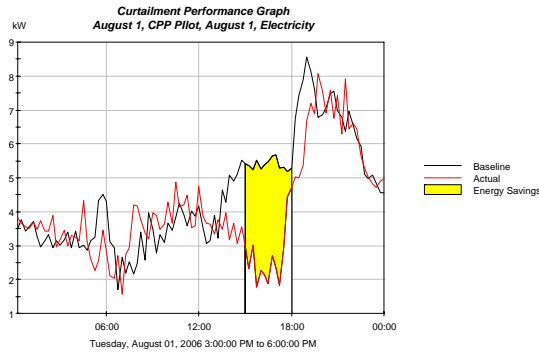
- ◆ Enrolled 16 employees in late July
- ◆ Called 4 critical price events
- ◆ Equipment performed as we expected and demand reduction was significant enough to warrant further testing in 2007 with a larger sample size

2006 Pilot Results

Tuesday, August 1, 2006

(Baseline Protocol: Matched Day Tuesday, August 8, 2006)

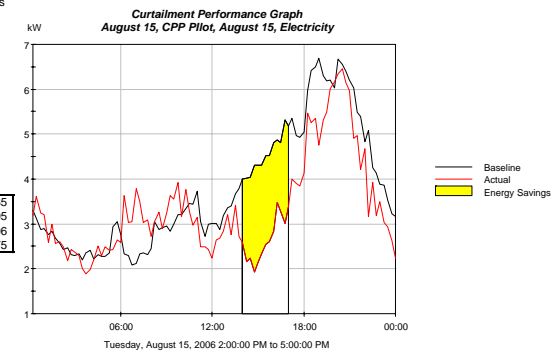
Hour Ending	Baseline	Actual	Savings
1am	3.56	3.64	
2am	3.27	3.58	
3am	3.11	3.36	
4am	3.23	3.24	
5am	2.99	3.29	
6am	4.10	2.77	
7am	2.60	2.10	
8am	2.34	3.52	
9am	3.36	3.58	
10am	3.21	3.82	
11am	3.87	4.22	
12Noon	3.92	4.08	
1pm	3.42	3.62	
2pm	4.30	3.60	
3pm	5.24	3.31	
4pm	5.34	2.34	2.99
5pm	5.54	2.26	3.28
6pm	5.27	3.48	1.80
7pm	7.66	5.52	
8pm	7.34	7.42	
9pm	7.27	7.17	
10pm	6.66	6.81	
11pm	5.54	5.59	
12Midnight	4.76	4.85	



Tuesday, August 15, 2006

(Baseline Protocol: Average August Weekday)

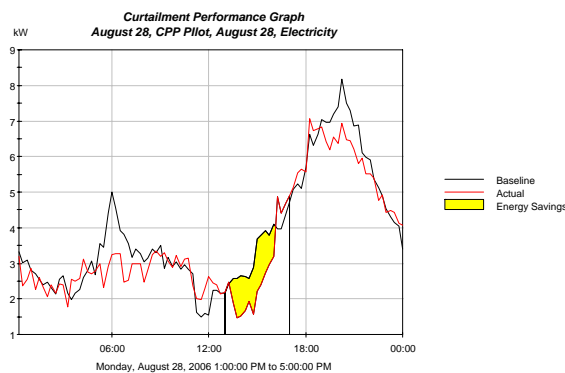
Hour Ending	Baseline	Actual	Savings
1am	3.05	3.31	
2am	2.71	2.69	
3am	2.38	2.37	
4am	2.32	2.05	
5am	2.27	2.38	
6am	2.78	2.52	
7am	2.21	3.37	
8am	2.36	3.08	
9am	2.95	3.11	
10am	3.06	3.56	
11am	3.49	3.29	
12Noon	2.94	2.41	
1pm	3.11	2.84	
2pm	3.71	2.87	0.85
3pm	4.17	2.12	2.05
4pm	4.54	2.58	1.96
5pm	5.04	3.29	1.75
6pm	5.08	3.97	
7pm	6.40	5.21	
8pm	6.19	5.75	
9pm	6.46	6.23	
10pm	5.43	4.70	
11pm	4.34	3.44	
12Midnight	3.45	2.70	



Monday, August 28, 2006

(Baseline Protocol: 5-Day September Average w/ True-Up)

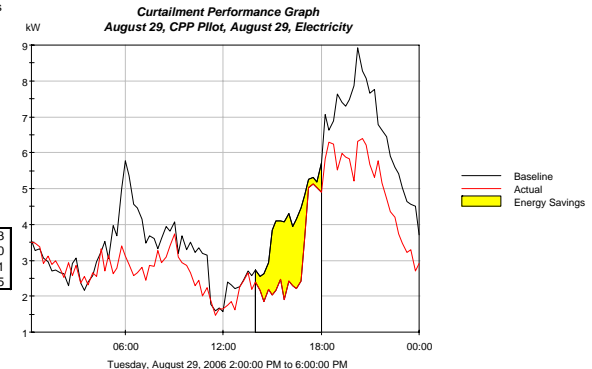
Hour Ending	Baseline	Actual	Savings
1am	3.06	2.74	
2am	2.52	2.32	
3am	2.42	2.35	
4am	2.14	2.35	
5am	2.78	2.84	
6am	4.10	2.86	
7am	3.96	2.88	
8am	3.22	2.86	
9am	3.34	3.14	
10am	2.99	3.11	
11am	2.84	2.88	
12Noon	1.56	2.22	
1pm	2.20	2.29	
2pm	2.55	1.83	0.72
3pm	2.95	1.84	1.10
4pm	3.90	2.82	1.08
5pm	4.25	4.71	(0.46)
6pm	5.28	5.47	
7pm	6.65	6.85	
8pm	7.13	6.38	
9pm	7.45	6.52	
10pm	6.21	5.70	
11pm	4.98	4.87	
12Midnight	3.98	4.27	



Tuesday, August 29, 2006

(Baseline Protocol: 5-Day September Average w/ True-Up)

Hour Ending	Baseline	Actual	Savings
1am	3.30	3.31	
2am	2.76	2.93	
3am	2.72	2.72	
4am	2.37	2.47	
5am	3.19	2.92	
6am	4.61	2.99	
7am	4.63	2.73	
8am	3.52	2.86	
9am	3.86	3.29	
10am	3.42	2.88	
11am	3.23	2.25	
12Noon	1.65	1.66	
1pm	2.30	1.87	
2pm	2.62	2.41	
3pm	2.99	2.06	0.93
4pm	4.14	2.24	1.90
5pm	4.35	2.64	1.71
6pm	5.37	5.02	0.35
7pm	7.06	5.98	
8pm	7.52	5.72	
9pm	8.23	6.15	
10pm	6.91	5.24	
11pm	5.48	3.94	
12Midnight	4.36	3.03	



2006 Pilot Results

Time	Event Day Reductions (kW)			
	8/1/2006	8/15/2006	8/28/2006	8/29/2006
2pm		0.85	0.72	
3pm		2.05	1.10	0.93
4pm	2.99	1.96	1.08	1.90
5pm	3.28	1.75	(0.46)	1.71
6pm	1.80			0.35
Average	2.69	1.65	0.61	1.22
Maximum	3.28	2.05	1.10	1.90
Total (kWh)	8.07	6.61	2.44	4.89

APC SmartPOWER 2007 Pilot

- ◆ Targeted customers in Birmingham area with AMI meters and usage between 11,612 kWh and 47,245 kWh annually
- ◆ Customers were solicited via outbound calls (Customer Link) and were offered a \$50 incentive to participate (\$25 at enrollment and \$25 in October)
- ◆ Utilized Comverge one-way communicating thermostats

APC SmartPOWER 2007 Pilot

Equipment



APC SmartPOWER 2007 Pilot

Web Control

SuperStat[®] Remote Programming Console
provided by 

LOGOUT

Heat Mode
SETTINGS

Cool Mode
SETTINGS

Vacation Mode
SETTINGS

Control Override
SETTINGS

SAVE

Start Times & Temperature Set Points

Use the form below to set the start time of each time period and input the desired Set Point

Primary Current Mode: Heat

Select a Day

Morning

Time : :

Set Point °F

Day

Time : :

Set Point °F

Evening

Time : :

Set Point °F

Night

Time : :

Set Point °F

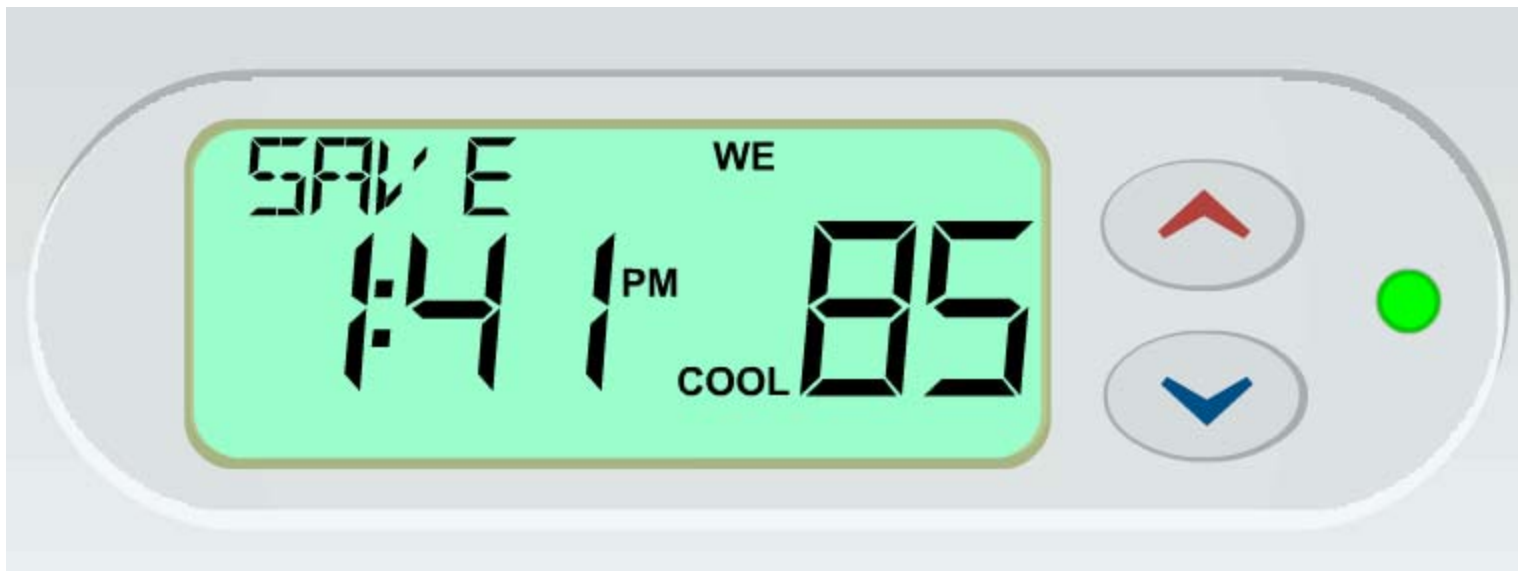
APC SmartPOWER 2007 Pilot

Control Strategy

- ◆ CPP events were triggered by marginal cost and critical need.
- ◆ When a CPP event is called thermostats will automatically enter a 70% cycling strategy (A/C will be cycled off 21 minutes of every 30 minutes or 42 minutes of each hour)
- ◆ Customers are notified via e-mail (if they choose) and at the stat
- ◆ Customers may opt out at the stat or via the web

APC SmartPOWER 2007 Pilot

- ◆ The Green LED is on during critical price periods when A/C is cycled off
- ◆ “SAVE” is displayed in the message window



APC SmartPOWER 2007 Pilot

Current Results

SmartPOWER Pilot Activity Summary	
Non-employees billing	65
Employees billing	19
Cancellations	3
Total billing	84

Data Challenges

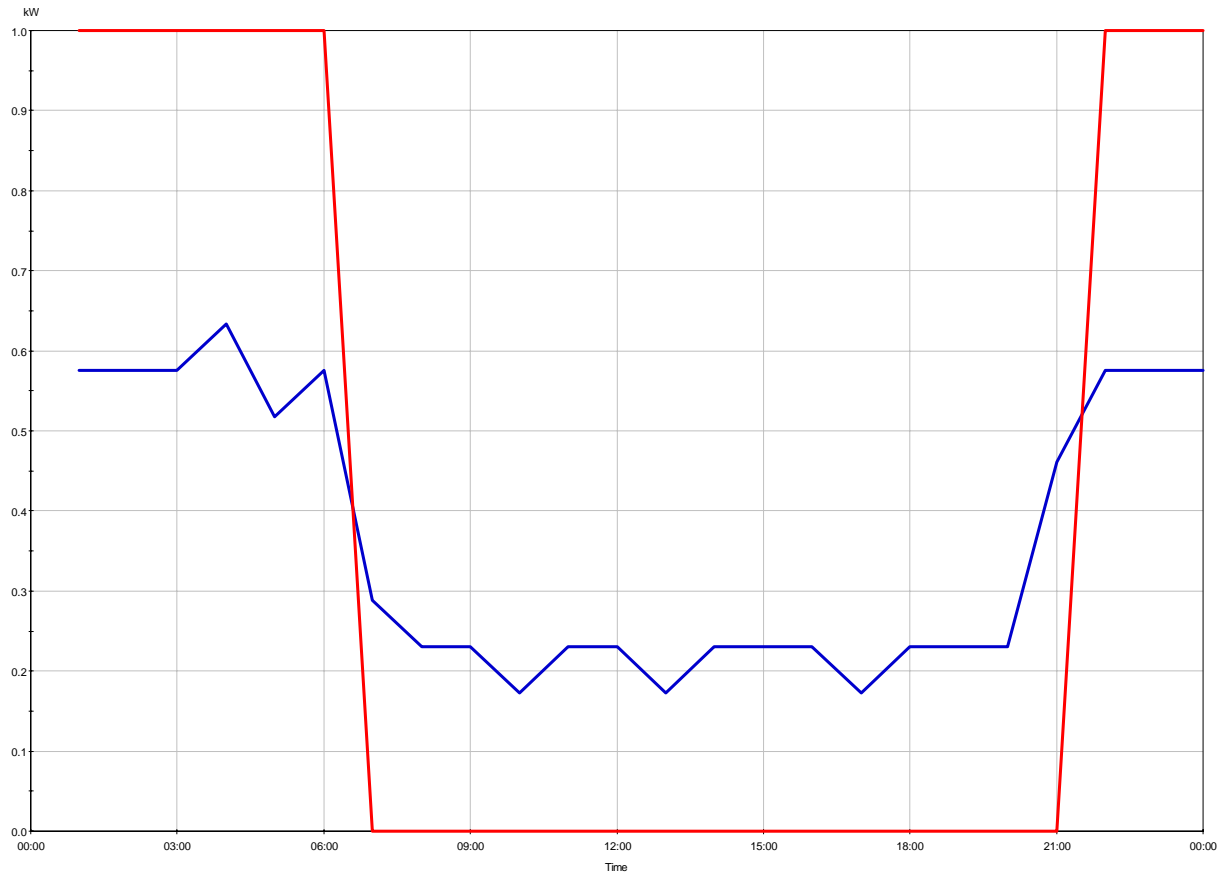
- ◆ Always worry about your data...no matter what IT tells you...sure we have hourly data...

WE0006	6/1/2007 0:00	2542
WE0006	6/1/2007 1:00	2544
WE0006	6/1/2007 2:00	2546
WE0006	6/1/2007 3:00	2548
WE0006	6/1/2007 4:00	2549
WE0006	6/1/2007 5:00	2550
WE0006	6/1/2007 6:00	2552
WE0006	6/1/2007 7:00	2554
WE0006	6/1/2007 8:00	2556
WE0006	6/1/2007 9:00	2558
WE0006	6/1/2007 10:00	2562
WE0006	6/1/2007 11:00	2566
WE0006	6/1/2007 12:00	2572
WE0006	6/1/2007 13:00	2577
WE0006	6/1/2007 14:00	2583
WE0006	6/1/2007 15:00	2591
WE0006	6/1/2007 16:00	2598
WE0006	6/1/2007 17:00	2604
WE0006	6/1/2007 18:00	2611
WE0006	6/1/2007 19:00	2617
WE0006	6/1/2007 20:00	2621

Uh Oh...Now What?

N=1

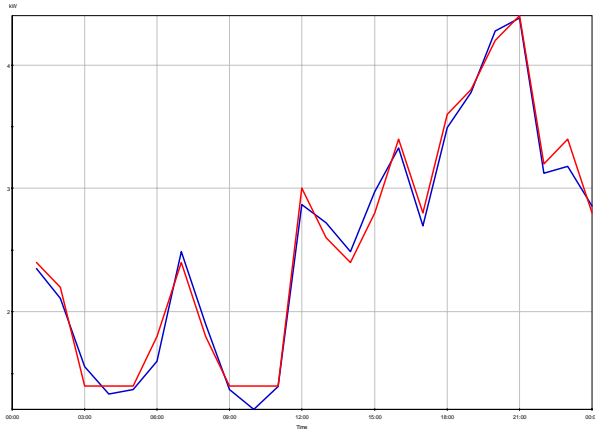
Thursday, August 03, 2006



Maybe It's Not So Bad...

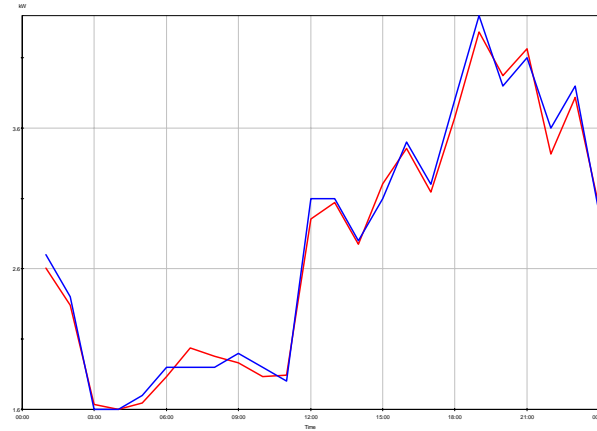
N=5

Thursday, August 03, 2006



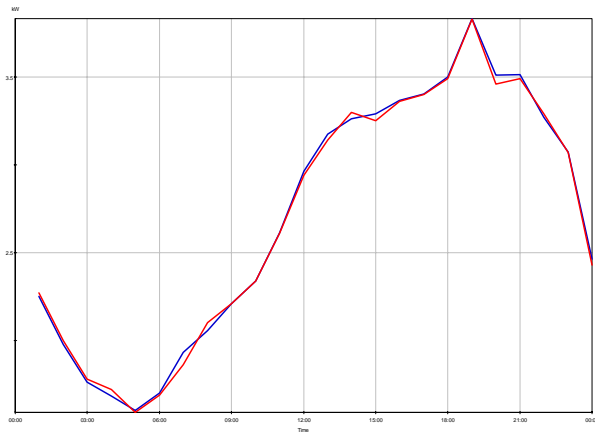
N=10

Thursday, August 03, 2006



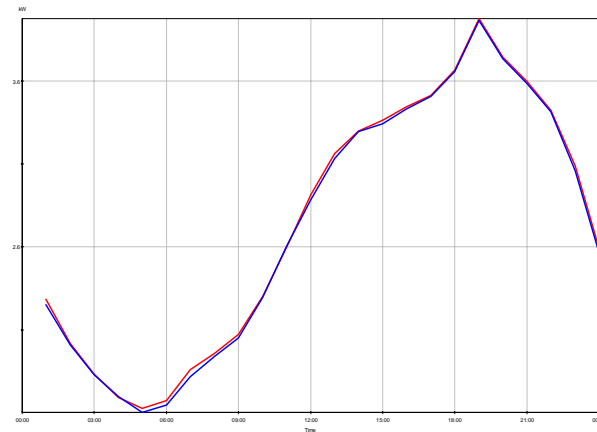
N=100

Thursday, August 03, 2006



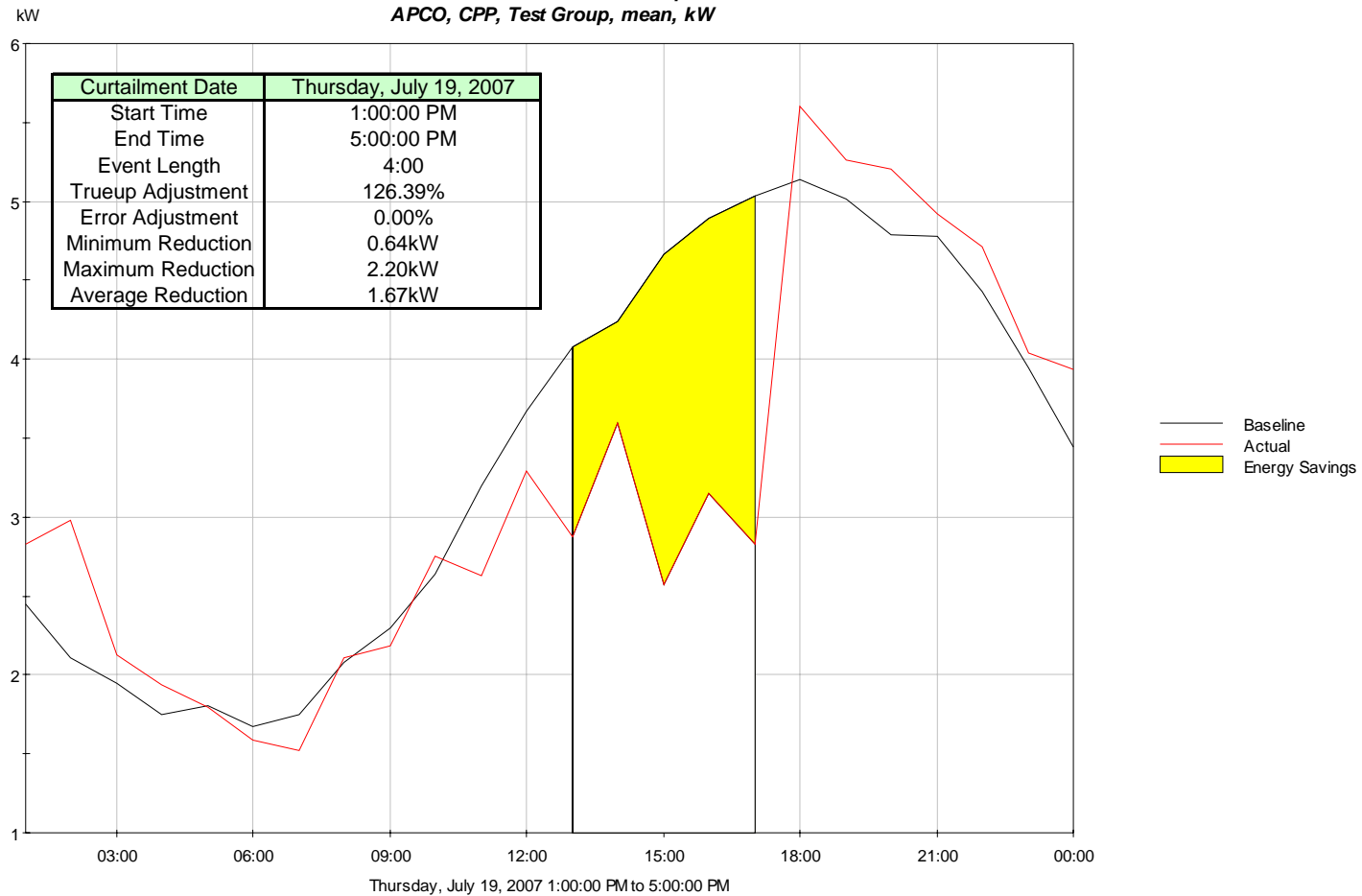
N=500

Thursday, August 03, 2006



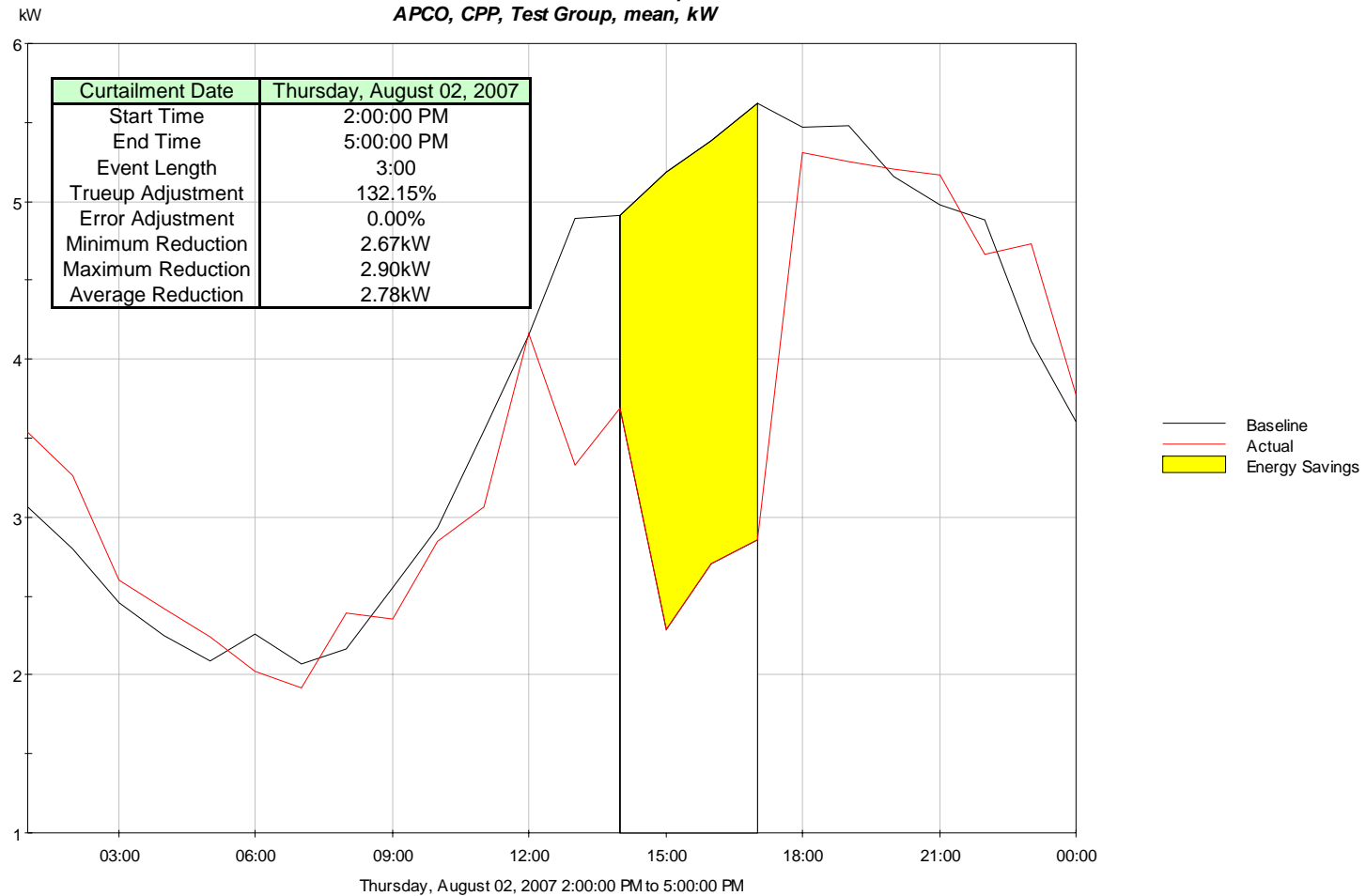
Thursday, July 19, 2007

Curtailment Performance Graph
APCO, CPP, Test Group, mean, kW



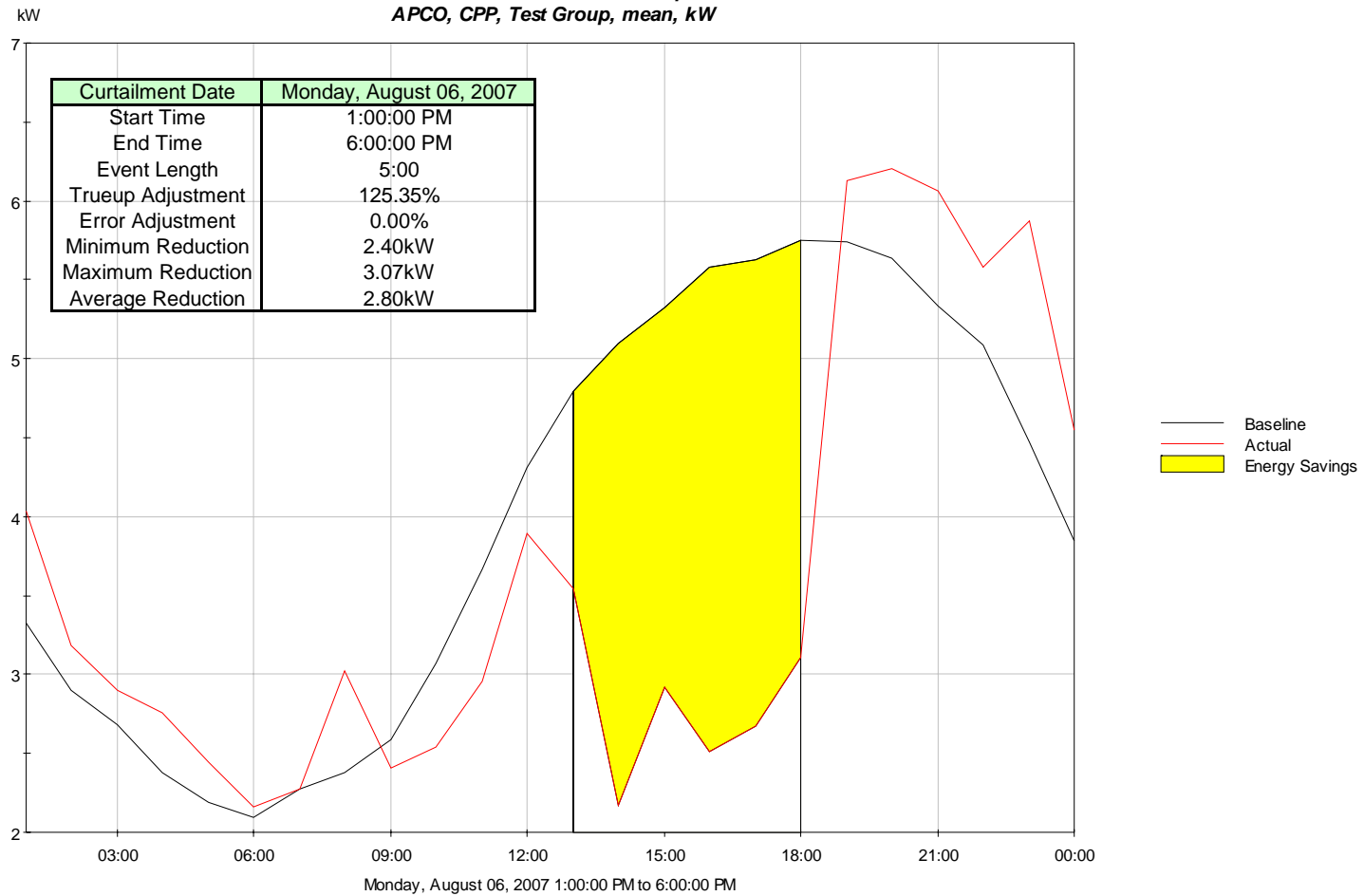
Thursday, August 2, 2007

Curtailment Performance Graph
APCO, CPP, Test Group, mean, kW

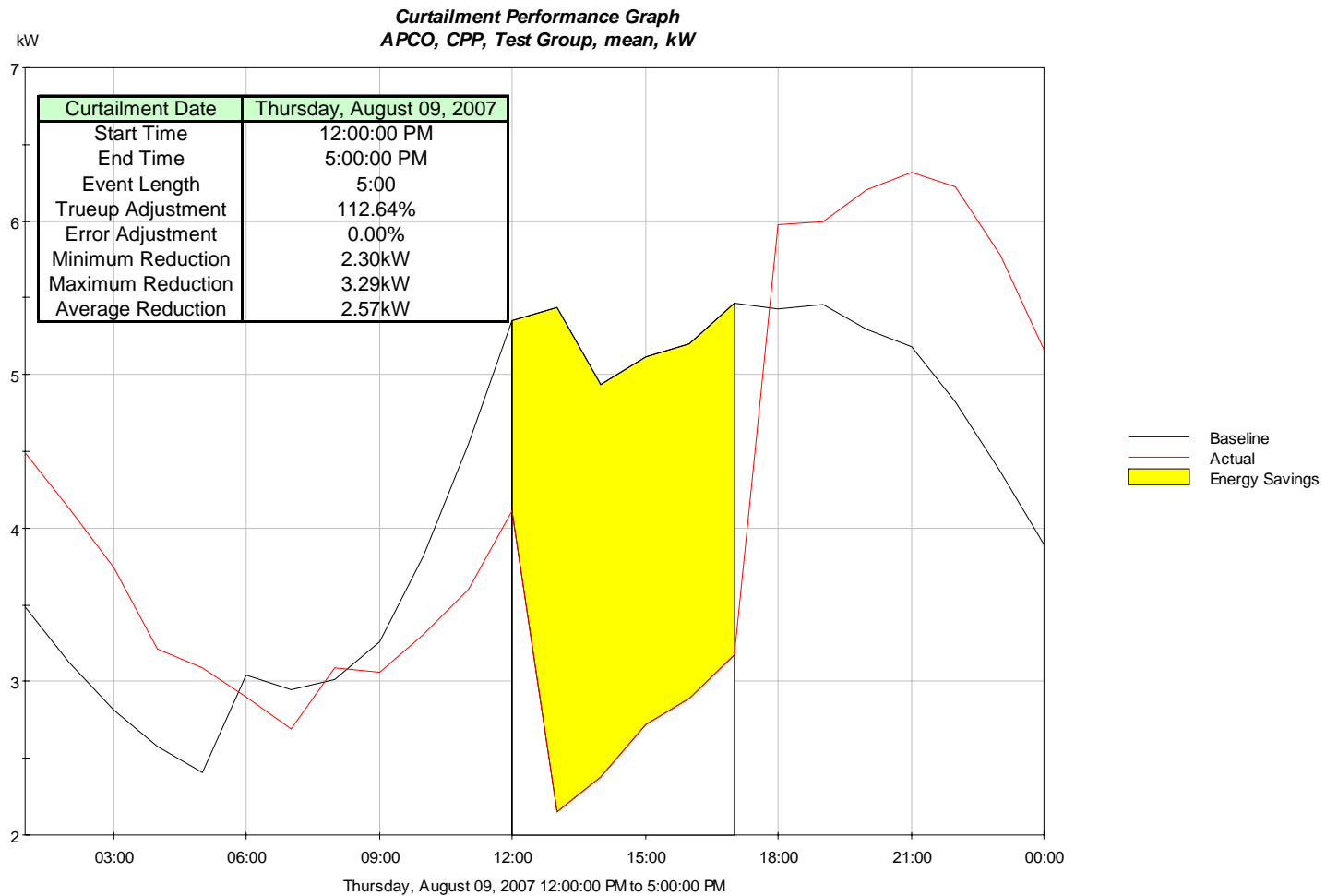


Monday, August 6, 2007

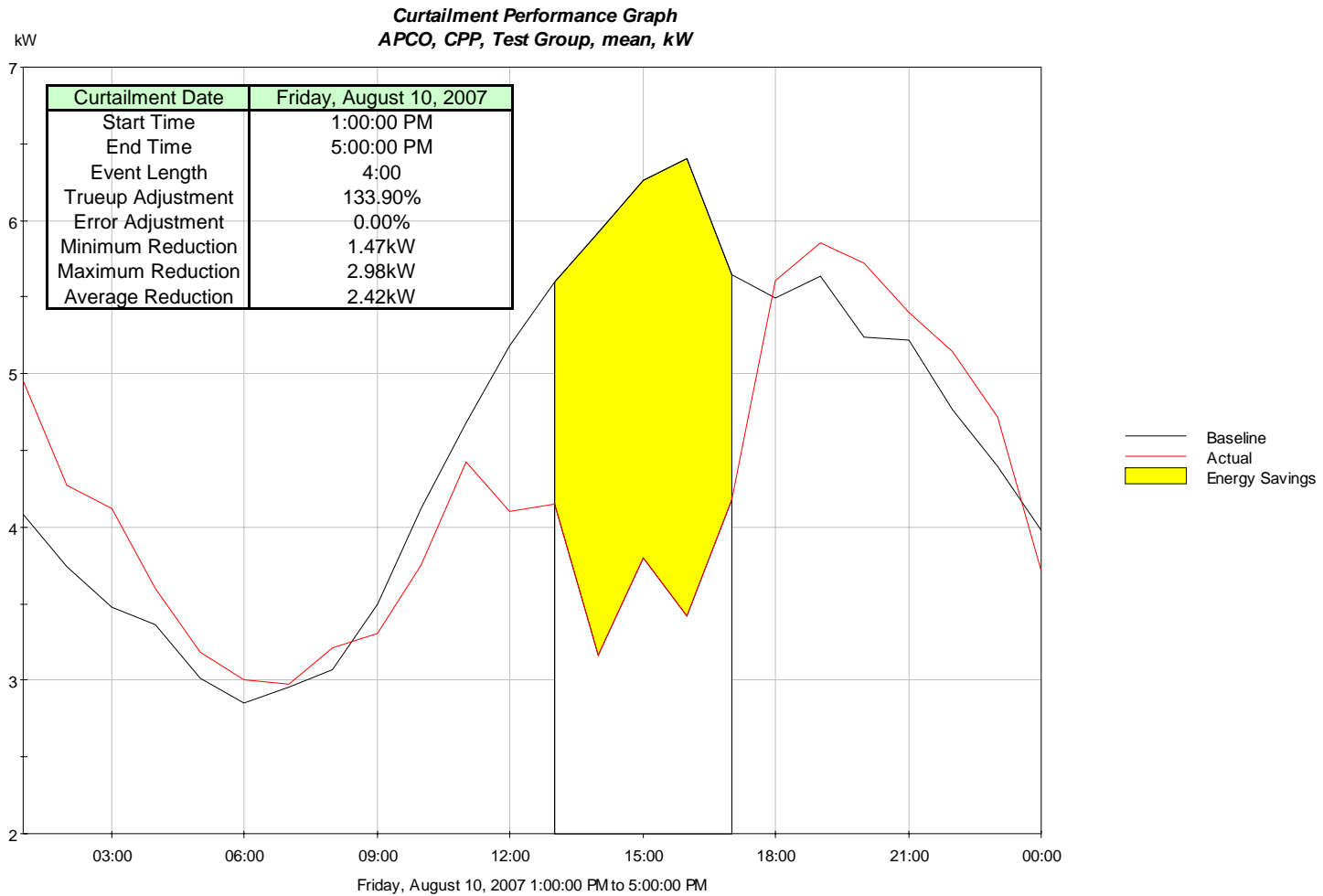
Curtailment Performance Graph
APCO, CPP, Test Group, mean, kW



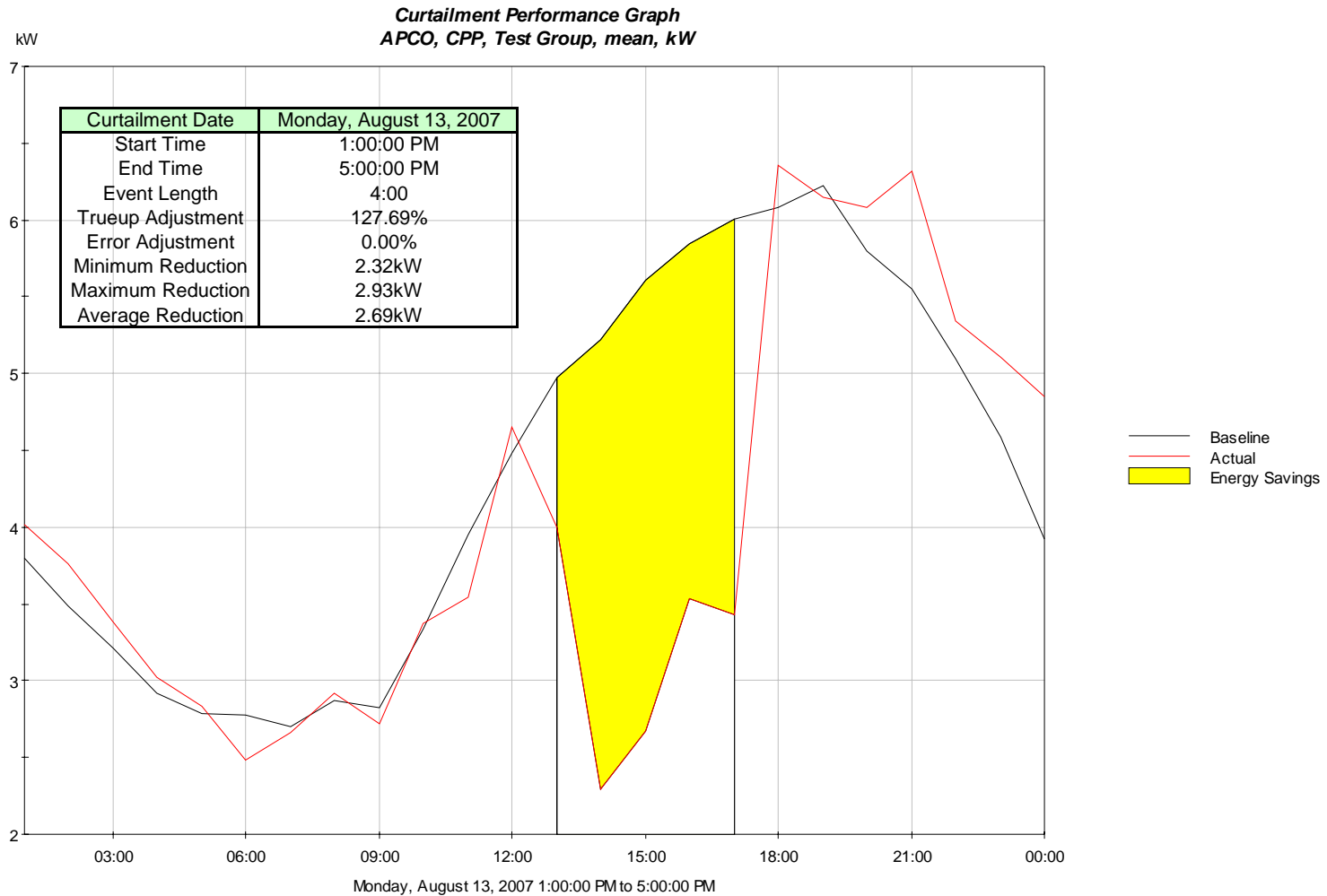
Thursday, August 9, 2007



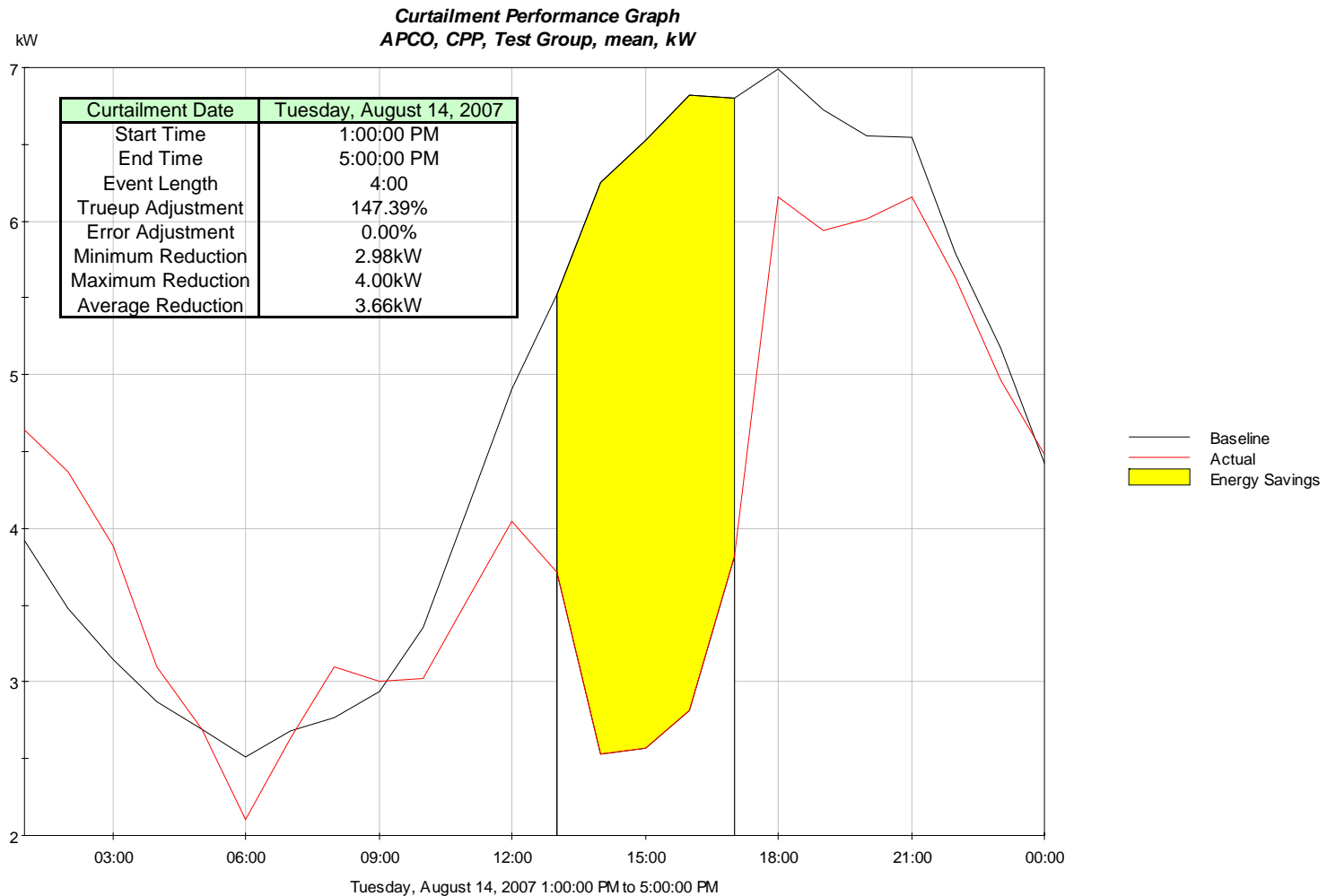
Friday, August 10, 2007



Monday, August 13, 2007

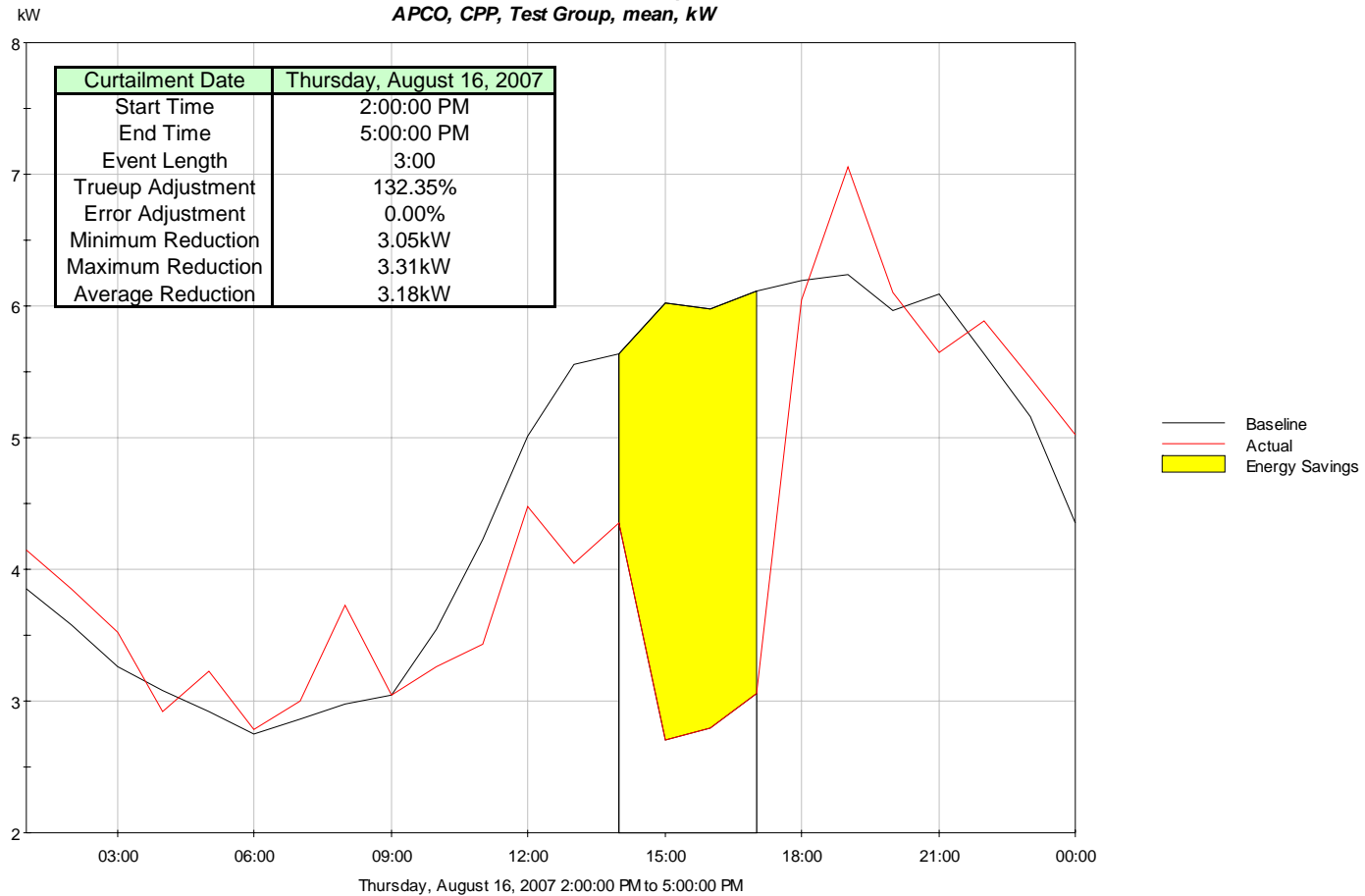


Tuesday, August 14, 2007



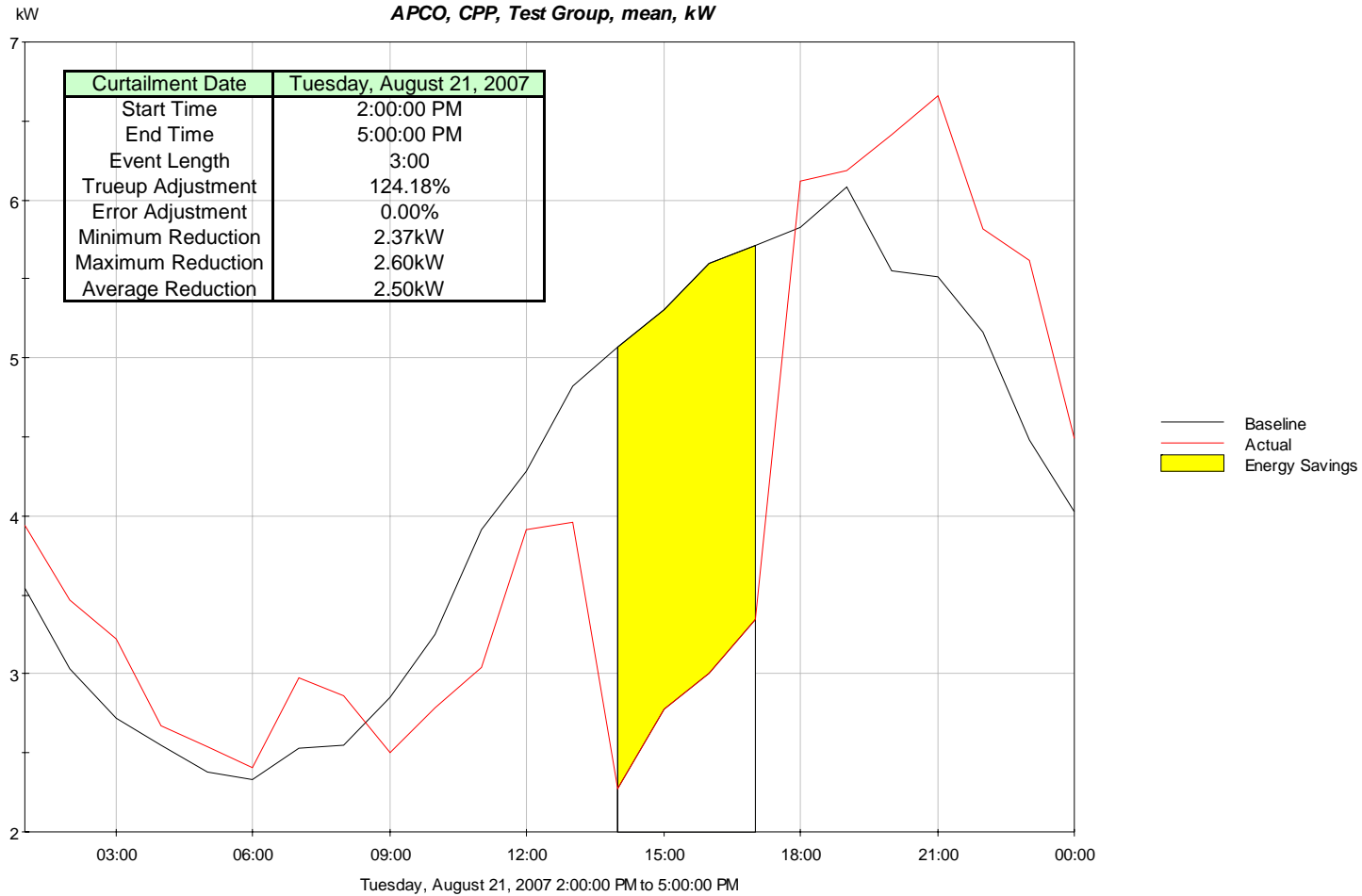
Thursday, August 16, 2007

Curtailment Performance Graph
APCO, CPP, Test Group, mean, kW

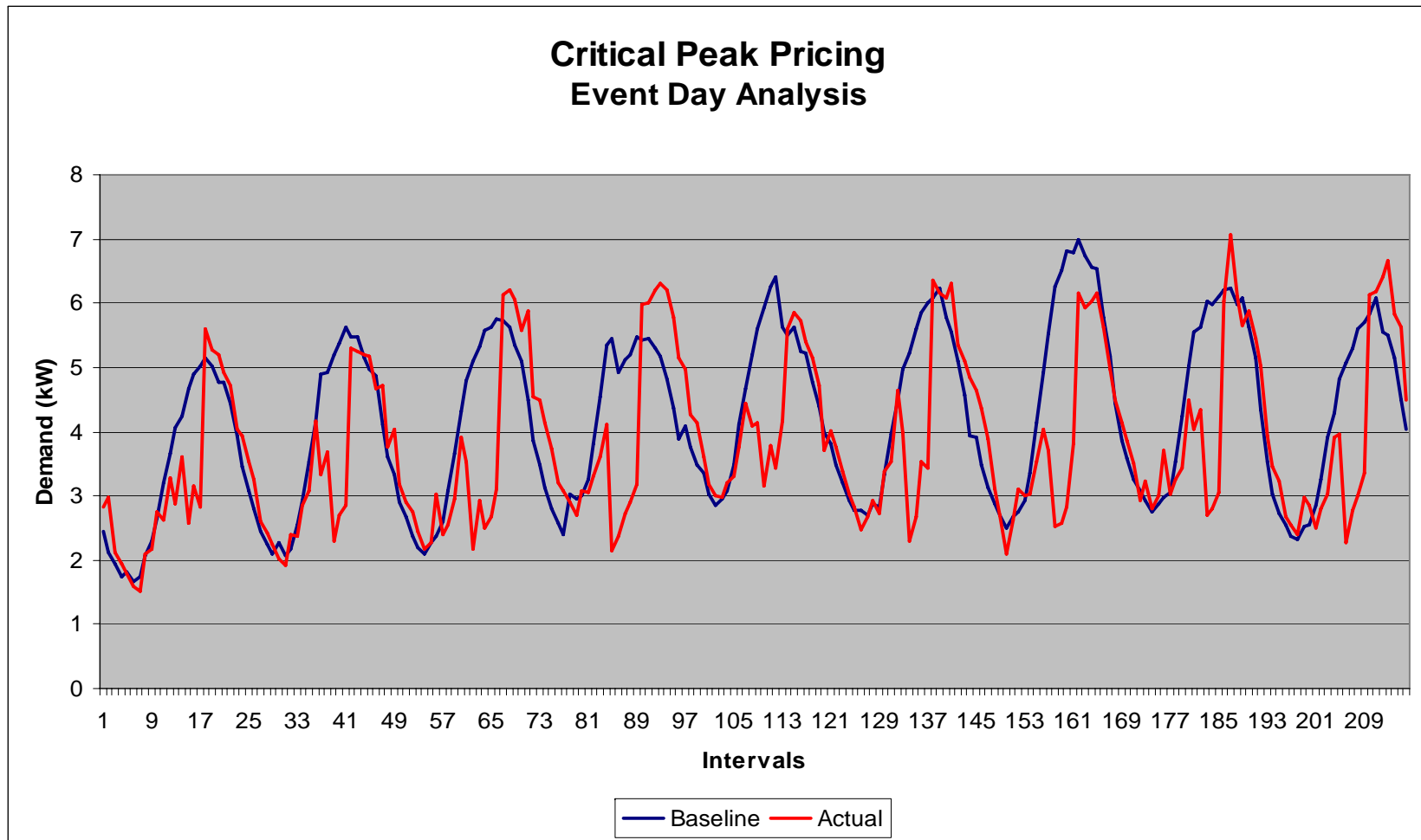


Tuesday, August 21, 2007

Curtailment Performance Graph
APCO, CPP, Test Group, mean, kW



Event Day Analysis



Event Summaries

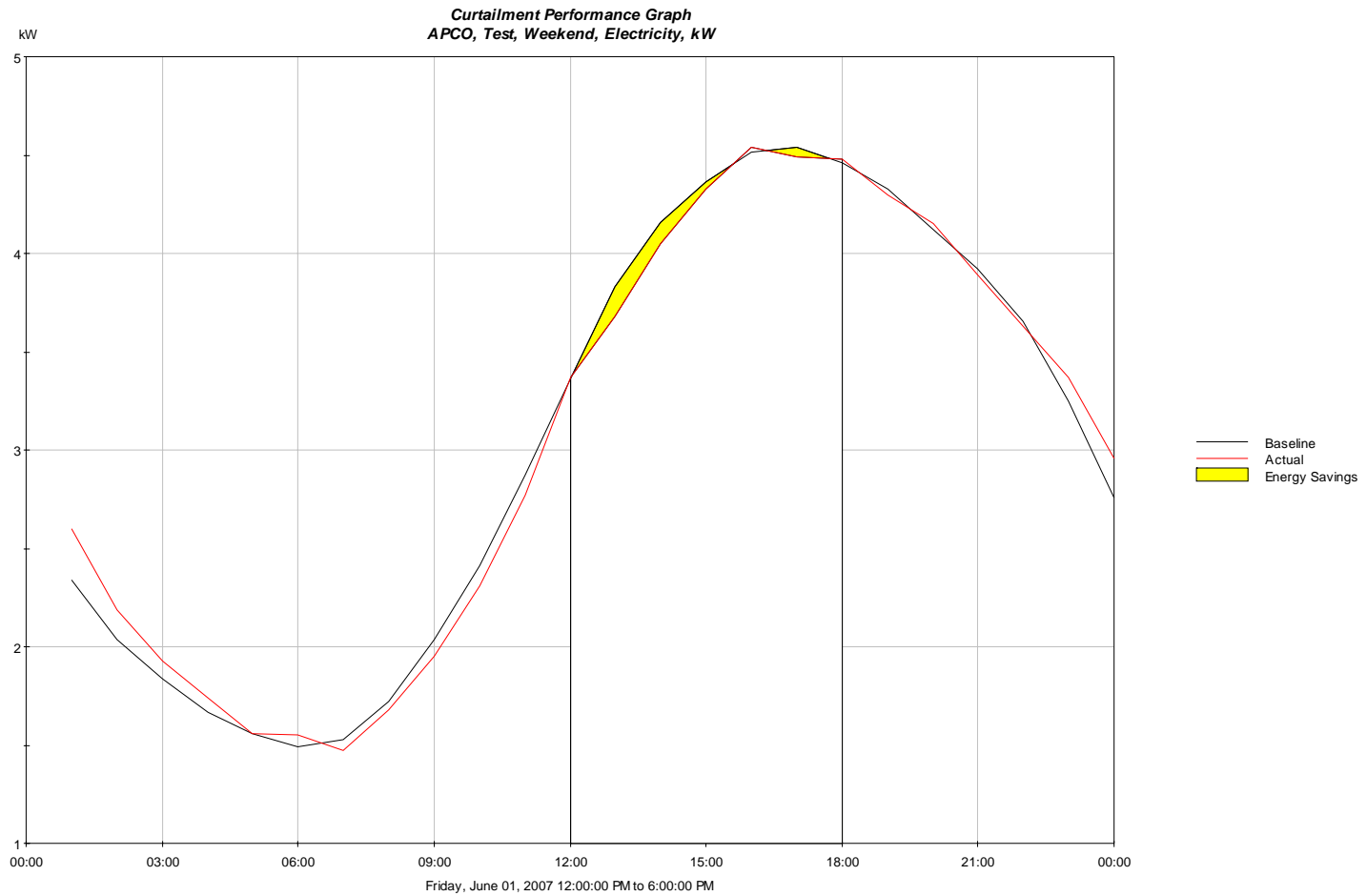
- ◆ Average reductions ranged from a low of 1.67 kW to a high of 3.66 kW
- ◆ Maximum reductions ranged up to 4.00 kW

Event Date	Event Time		Length Hours	In-Period Reduction			
	Start	End		Min	Max	Average	Energy
Thursday, July 19, 2007	1:00 PM	5:00 PM	4:00	0.64kW	2.20kW	1.67kW	6.68kWh
Thursday, August 02, 2007	2:00 PM	5:00 PM	3:00	2.67kW	2.90kW	2.78kW	8.34kWh
Monday, August 06, 2007	1:00 PM	6:00 PM	5:00	2.40kW	3.07kW	2.80kW	14.00kWh
Thursday, August 09, 2007	12:00 PM	5:00 PM	5:00	2.30kW	3.29kW	2.57kW	12.83kWh
Friday, August 10, 2007	1:00 PM	5:00 PM	4:00	1.47kW	2.98kW	2.42kW	9.67kWh
Monday, August 13, 2007	1:00 PM	5:00 PM	4:00	2.32kW	2.93kW	2.69kW	10.75kWh
Tuesday, August 14, 2007	1:00 PM	5:00 PM	4:00	2.98kW	4.00kW	3.66kW	14.65kWh
Thursday, August 16, 2007	2:00 PM	5:00 PM	3:00	3.05kW	3.31kW	3.18kW	9.55kWh
Tuesday, August 21, 2007	2:00 PM	5:00 PM	3:00	2.37kW	2.60kW	2.50kW	7.49kWh

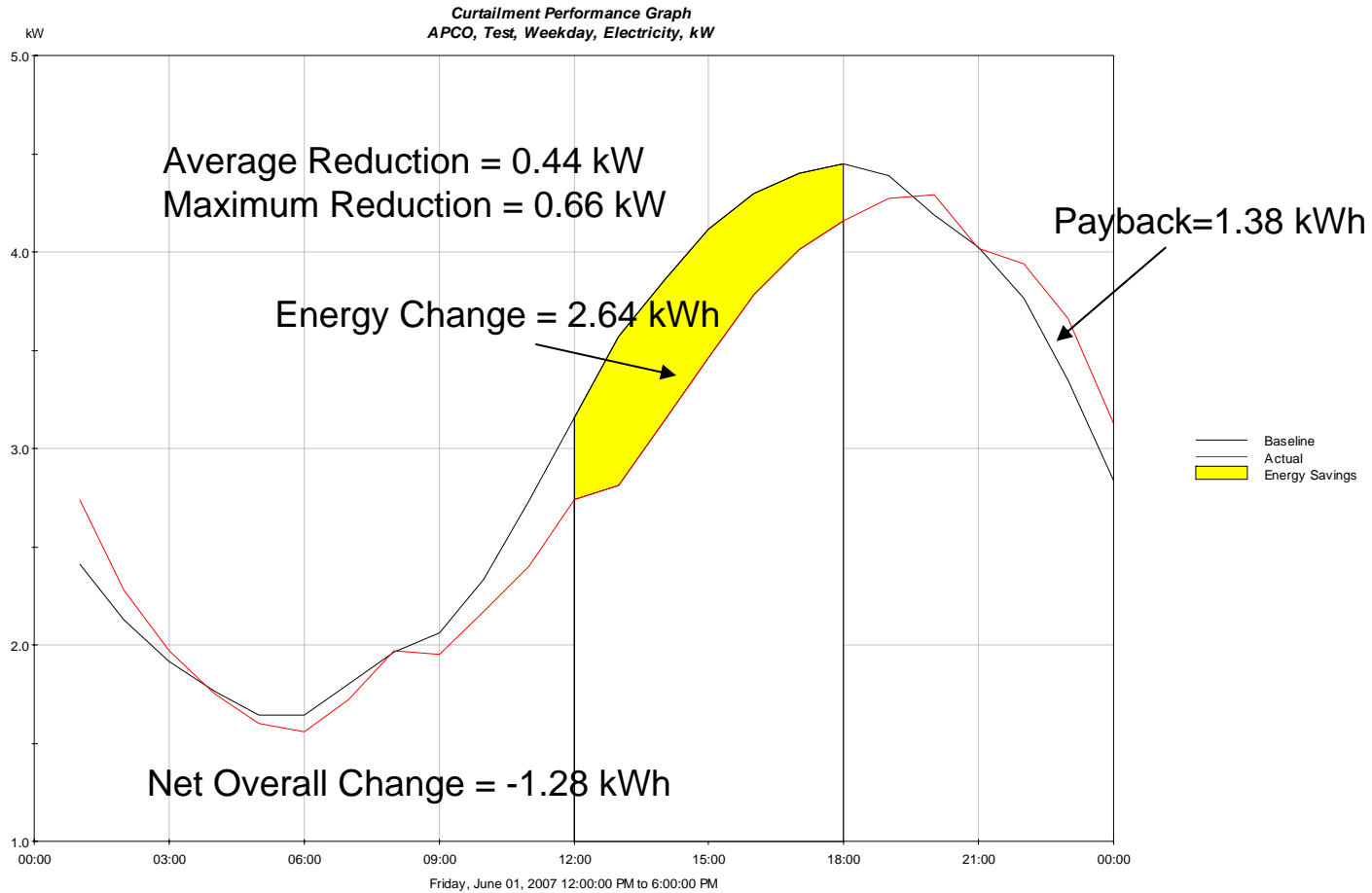
Energy Shift/Savings

- ◆ **Examined non-event days to estimate load changes occurring as a result of installing the enabling technologies**
 - 📄 **Very similar patterns on weekends**
 - 📄 **Drastically different patterns on weekdays**

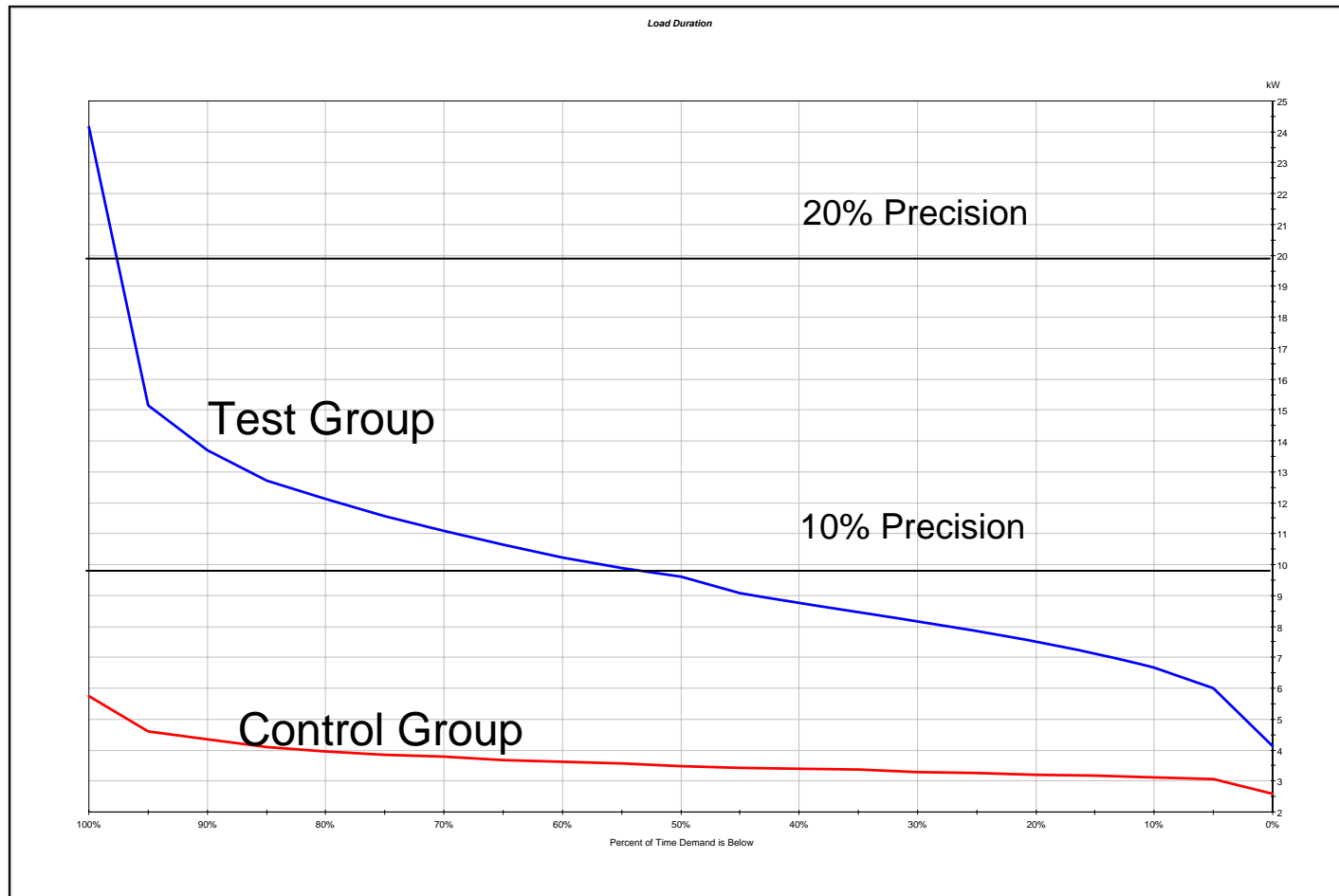
Non-Event Day Weekend Comparison



Non-Event Day Weekday Comparison



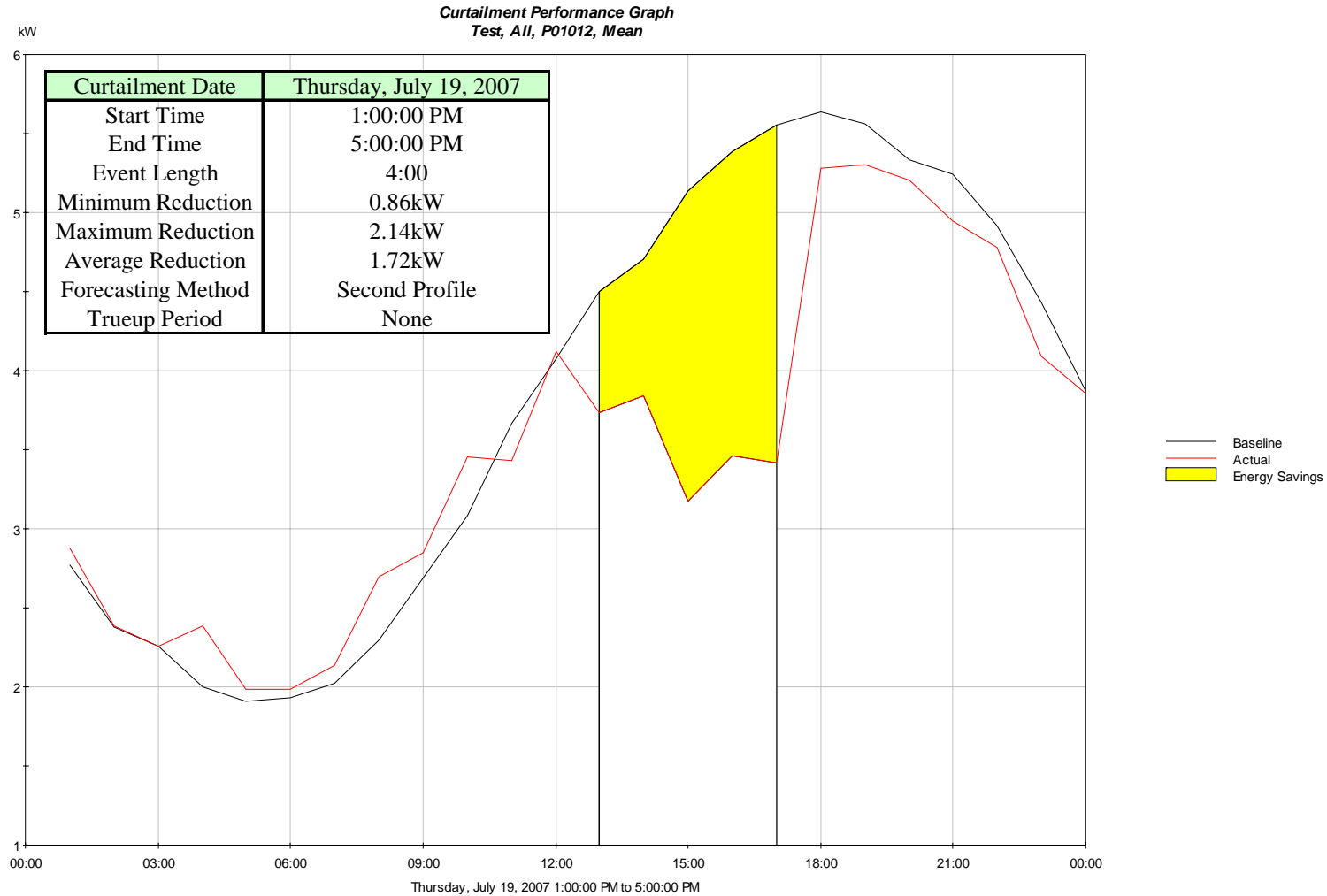
Estimated Precision (Hours from 12 Noon to 6pm)



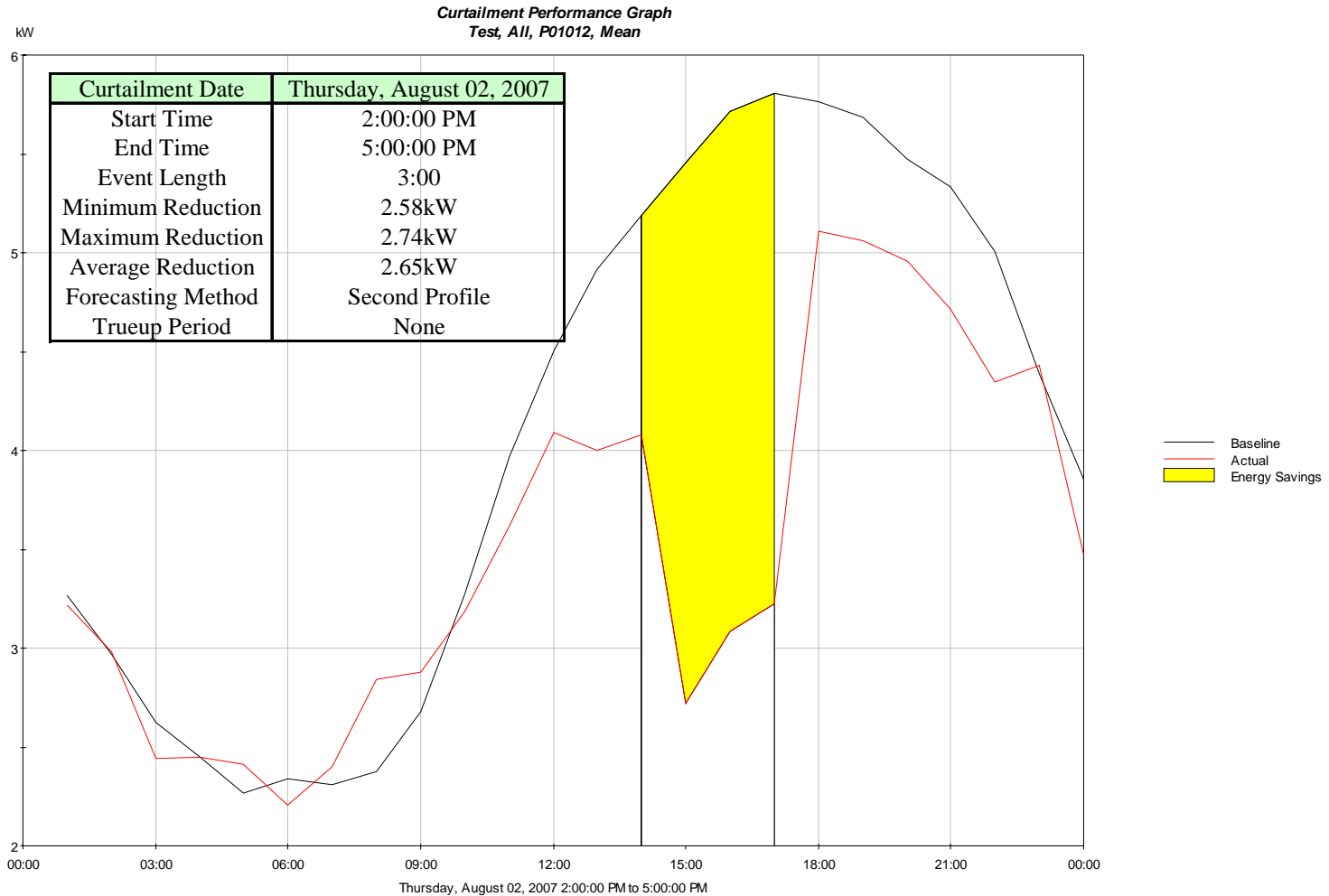
Weighted Analysis

class	Stratum	Maximum	Accounts	kWh	Sample_Max	Weight_Max	Module	Last_Change
Control	1	15,312	4,006	51,591,846	212	20.54	M6100	1/30/2008
Control	2	18,908	3,193	54,489,652	72	49.12	M6100	1/30/2008
Control	3	22,926	2,727	56,667,839	79	42.61	M6100	1/30/2008
Control	4	29,168	2,307	59,106,467	64	45.24	M6100	1/30/2008
Control	5	69,898	1,750	63,535,382	36	72.92	M6100	1/30/2008
Test	6	15,312	4,006	51,591,846	24	801.20	M6100	1/30/2008
Test	7	18,908	3,193	54,489,652	14	3,193.00	M6100	1/30/2008
Test	8	22,926	2,727	56,667,839	10	1,363.50	M6100	1/30/2008
Test	9	29,168	2,307	59,106,467	11	2,307.00	M6100	1/30/2008
Test	10	69,898	1,750	63,535,382	4	1,750.00	M6100	1/30/2008

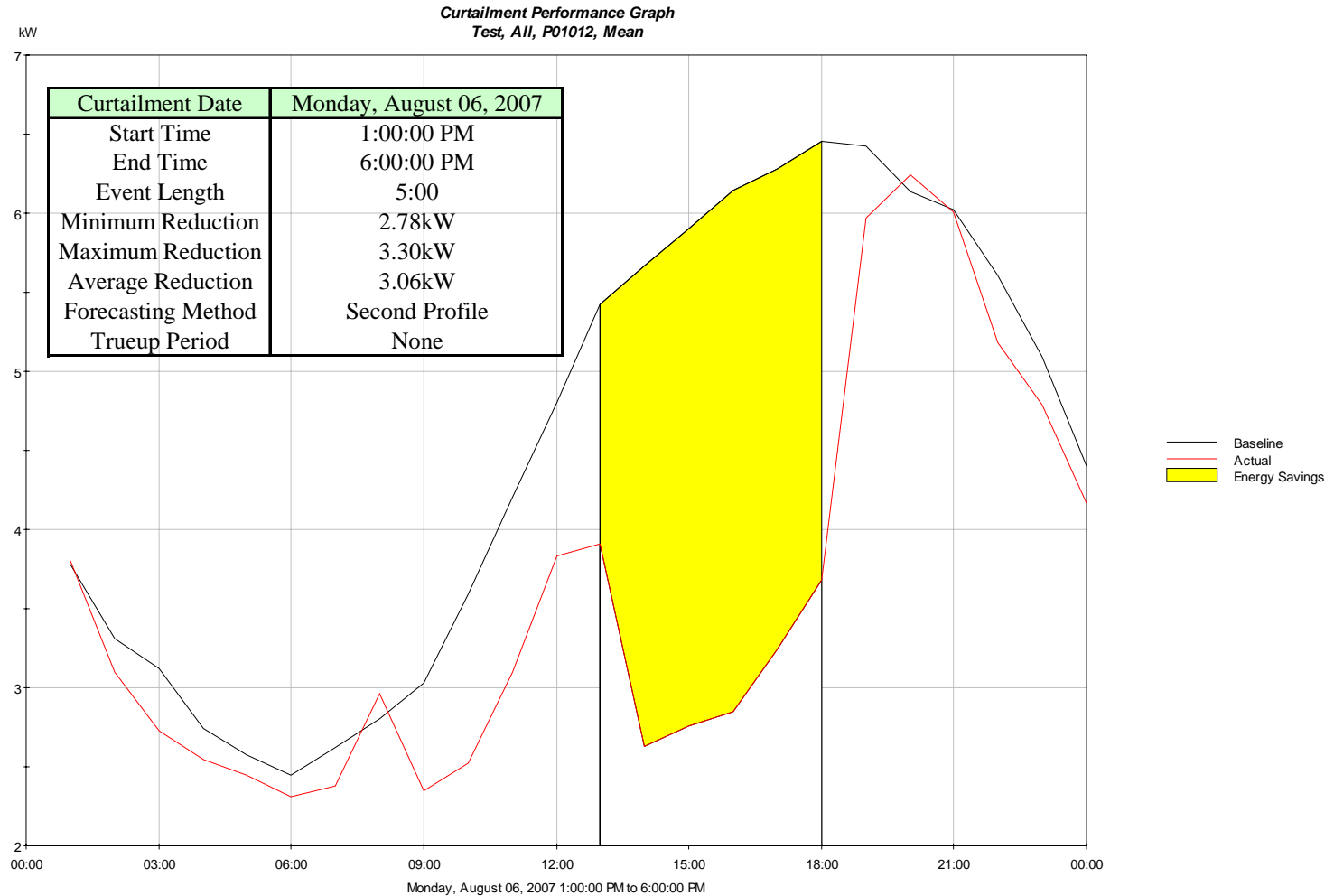
Thursday, July 19, 2007



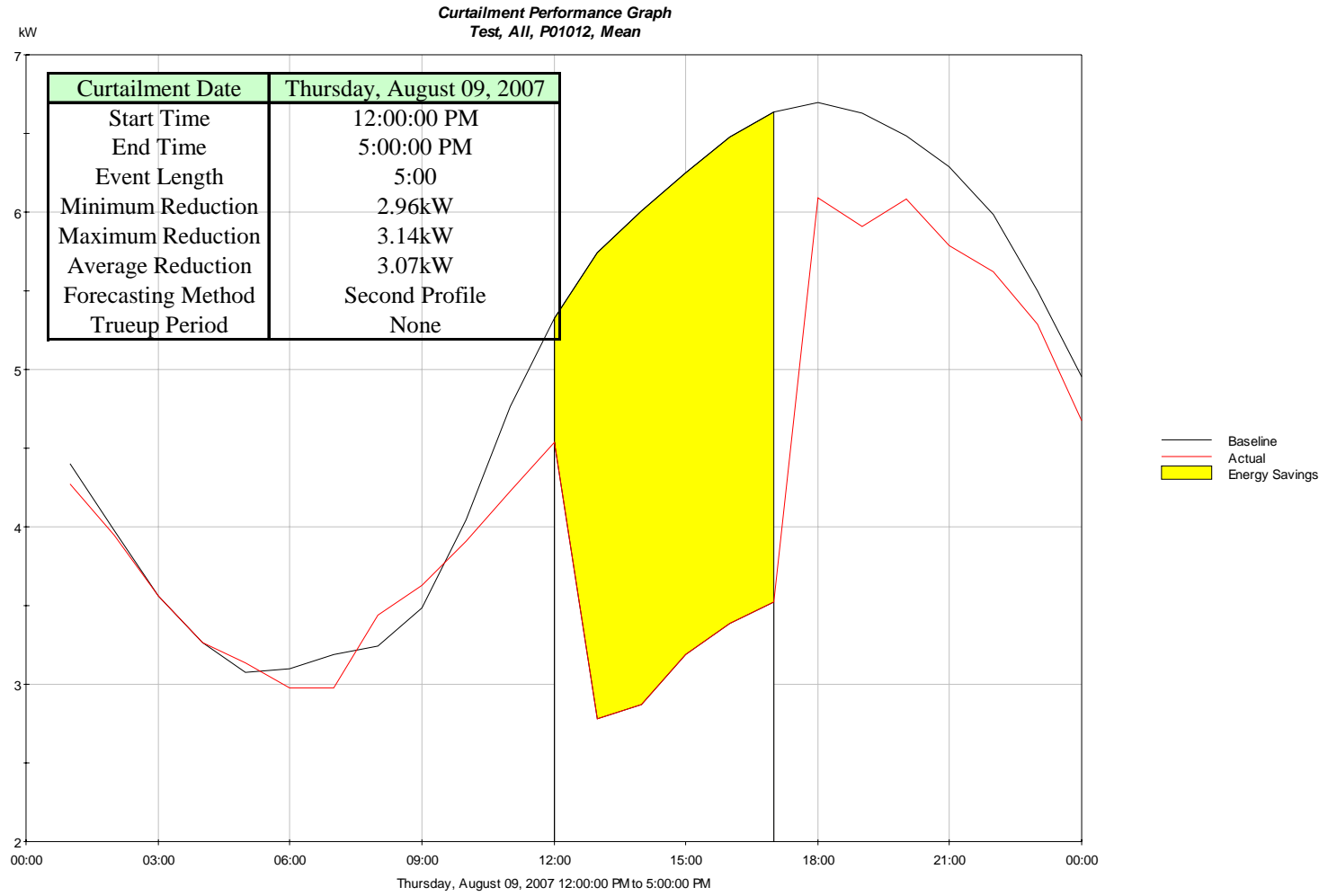
Thursday, August 2, 2007



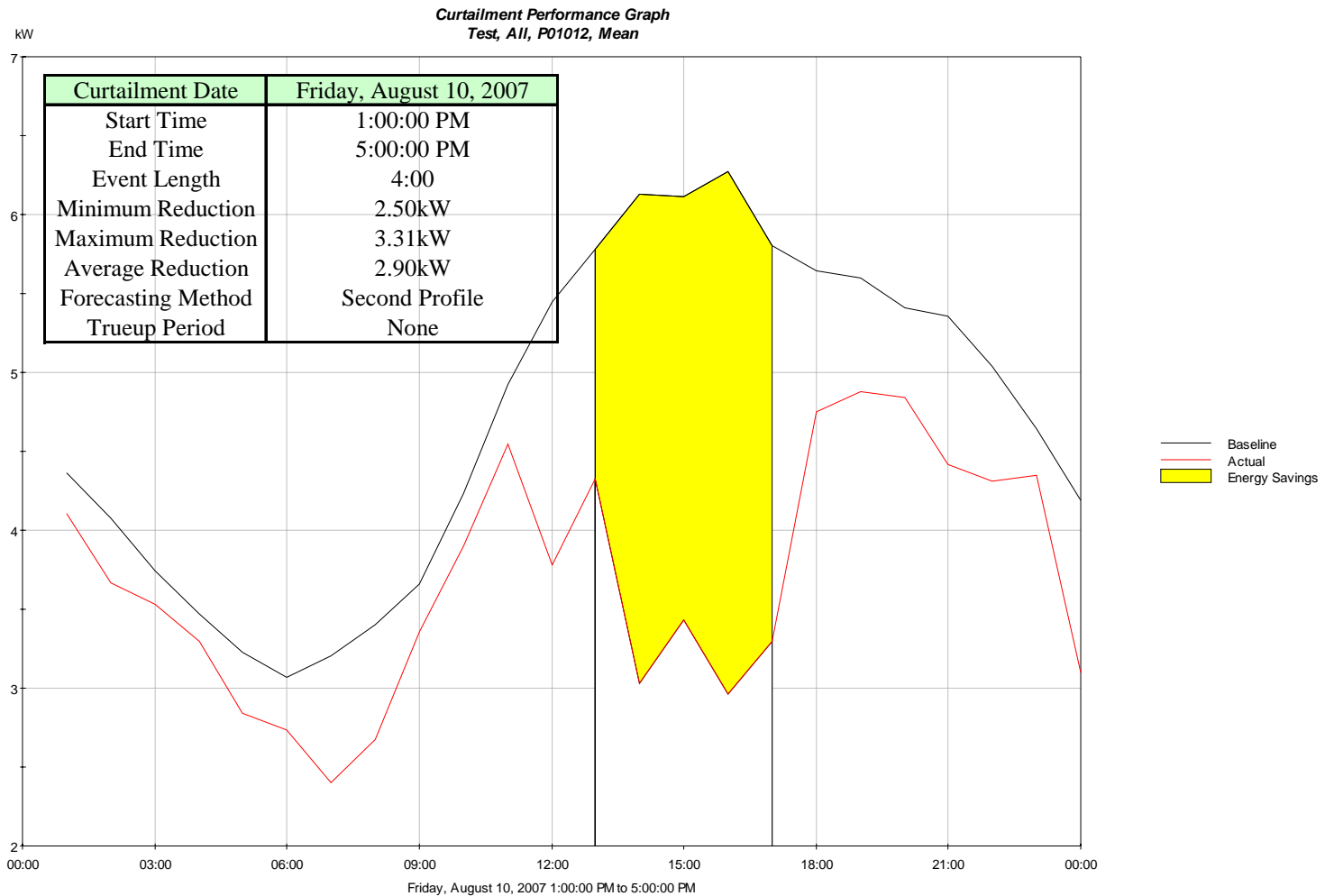
Monday, August 6, 2007



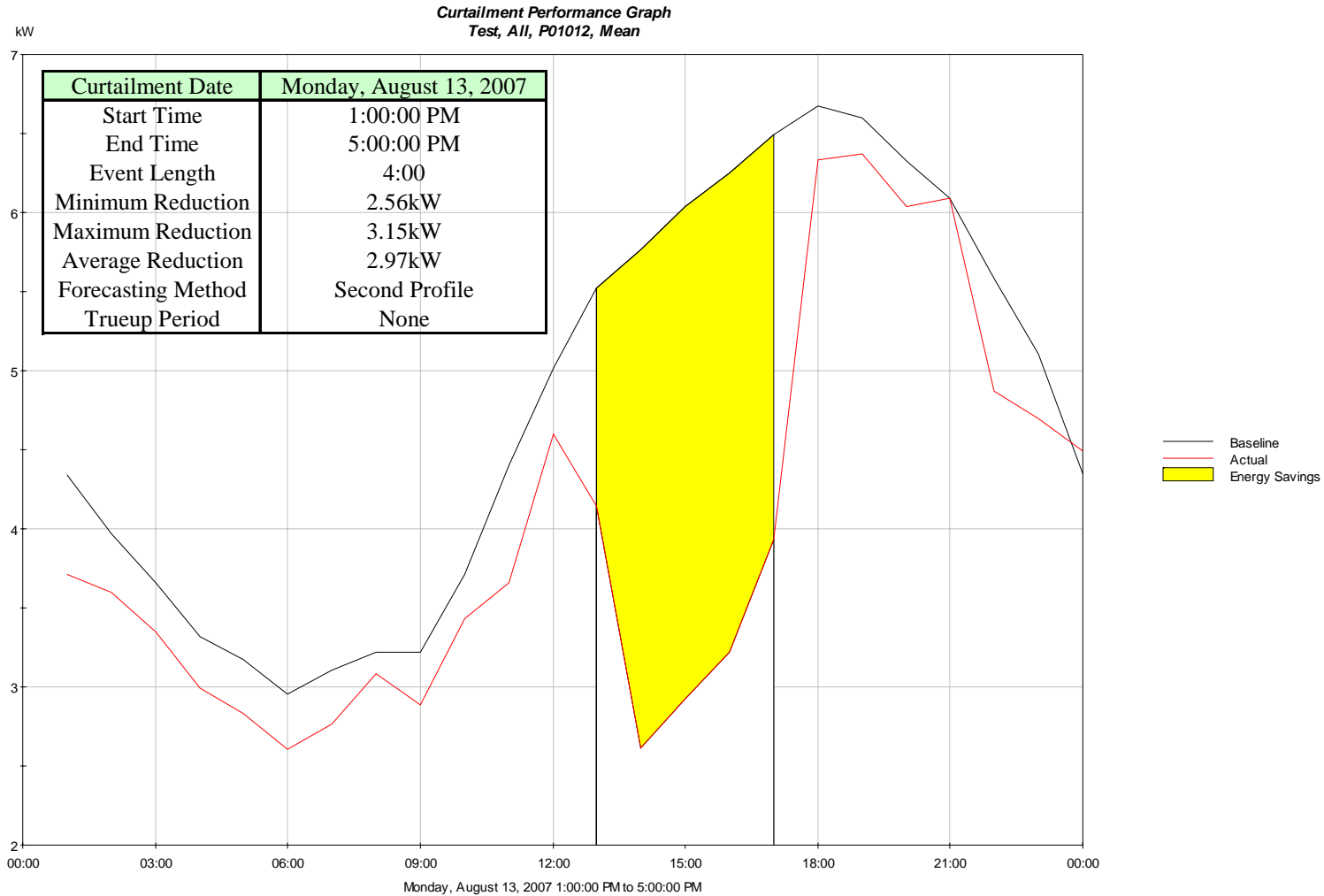
Thursday, August 9, 2007



Friday, August 10, 2007

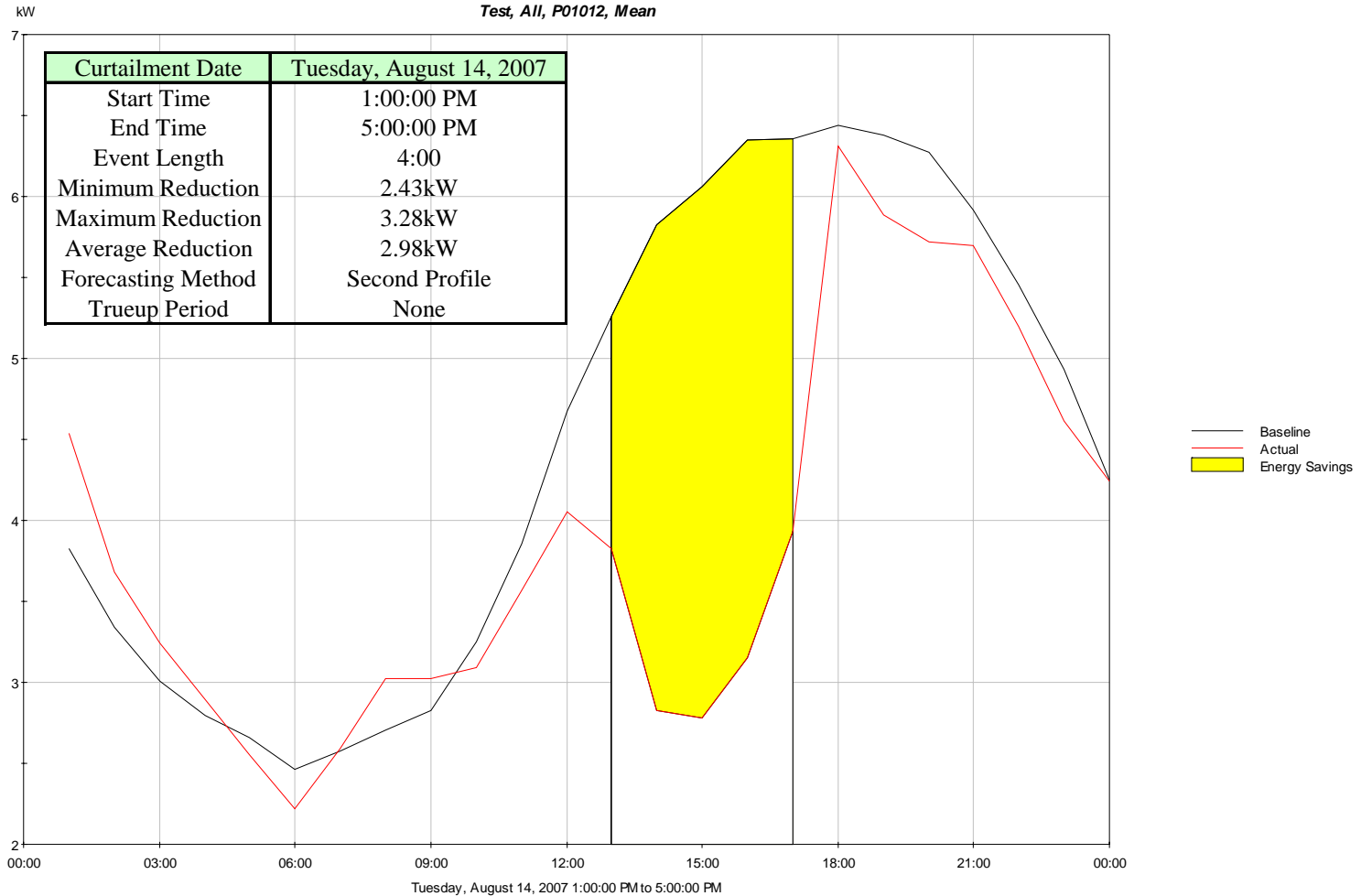


Monday, August 13, 2007

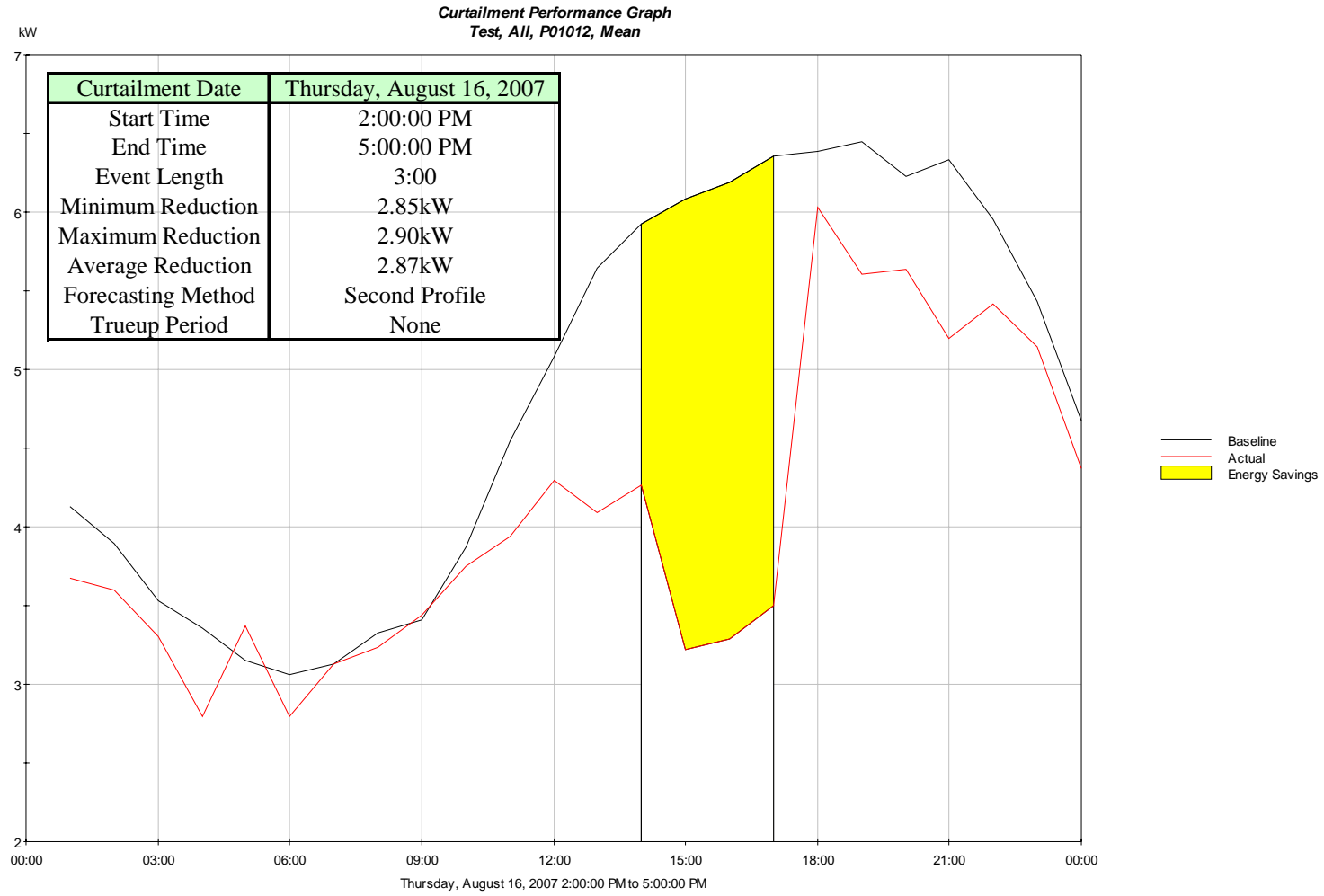


Tuesday, August 14, 2007

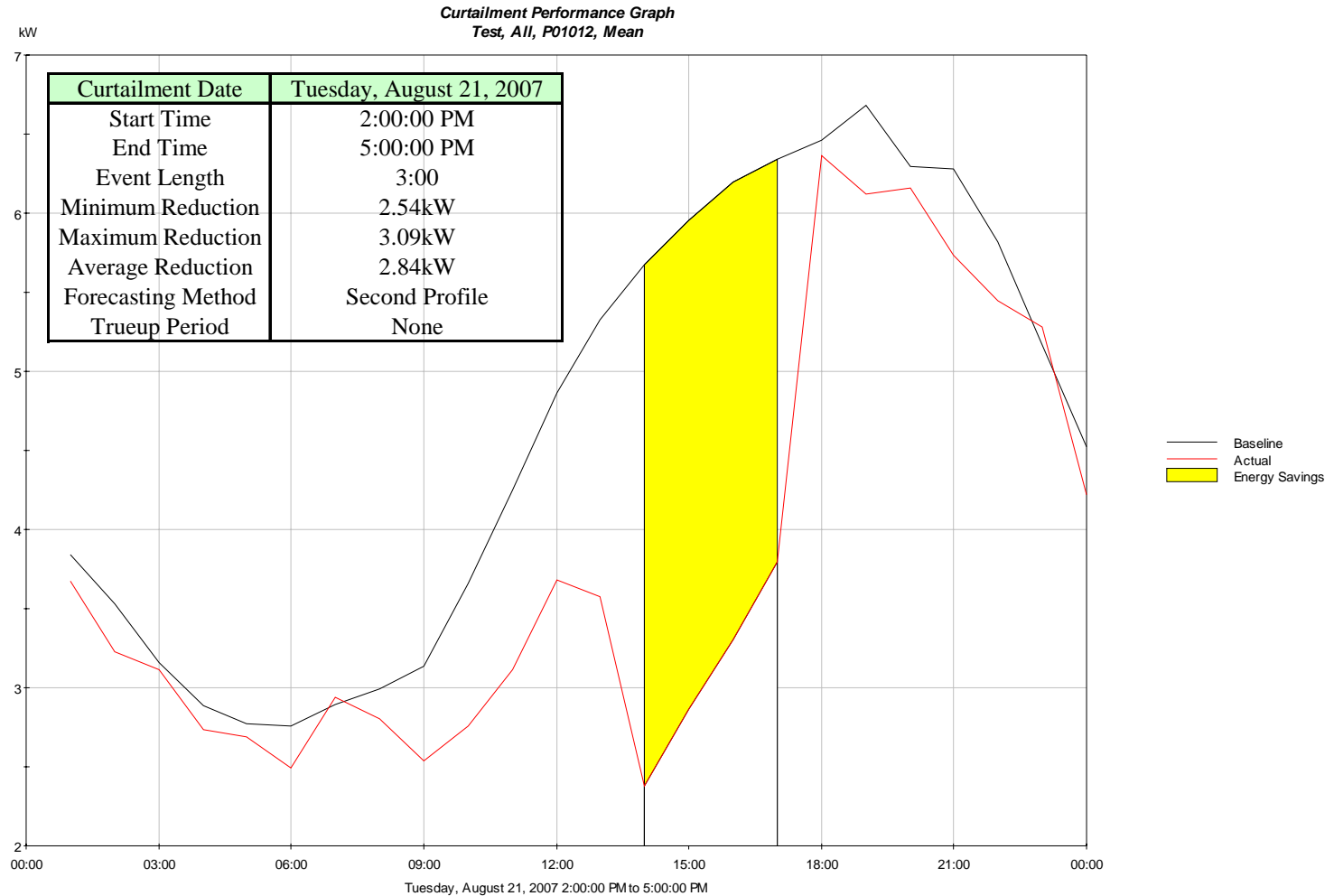
Curtailment Performance Graph
Test, All, P01012, Mean



Thursday, August 16, 2007



Tuesday, August 21, 2007



Event Summaries

- ◆ Average reductions ranged from a low of 1.72 kW to a high of 3.07 kW
- ◆ Maximum reductions ranged up to 3.31 kW

Event Date	Event Time		Length Hours	In-Period Reduction			
	Start	End		Min	Max	Average	Energy
Thursday, July 19, 2007	1:00 PM	5:00 PM	4:00	0.86kW	2.14kW	1.72kW	6.88kWh
Thursday, August 02, 2007	2:00 PM	5:00 PM	3:00	2.58kW	2.74kW	2.65kW	7.95kWh
Monday, August 06, 2007	1:00 PM	6:00 PM	5:00	2.78kW	3.30kW	3.06kW	15.28kWh
Thursday, August 09, 2007	12:00 PM	5:00 PM	5:00	2.96kW	3.14kW	3.07kW	15.36kWh
Friday, August 10, 2007	1:00 PM	5:00 PM	4:00	2.50kW	3.31kW	2.90kW	11.60kWh
Monday, August 13, 2007	1:00 PM	5:00 PM	4:00	2.56kW	3.15kW	2.97kW	11.86kWh
Tuesday, August 14, 2007	1:00 PM	5:00 PM	4:00	2.43kW	3.28kW	2.98kW	11.91kWh
Thursday, August 16, 2007	2:00 PM	5:00 PM	3:00	2.85kW	2.90kW	2.87kW	8.62kWh
Tuesday, August 21, 2007	2:00 PM	5:00 PM	3:00	2.54kW	3.09kW	2.84kW	8.53kWh

APC SmartPOWER 2007 Pilot

Focus Group Results

- ◆ Conducted focus group research following the summer period with 21 non-employee participants
- ◆ When asked if they would recommend the program on a 1-10 scale (1 being definitely not and 10 being definitely would) no one gave a rating lower than 7 and half gave a 9 or 10
- ◆ Customers were pleased with the program and felt they saved money (average bill savings of 6% was observed for the group).

APC SmartPOWER 2007 Pilot

Future Plans

- ◆ Explore utilizing Sensus two-way communications in thermostats (would provide confirmation that T'stats receive CPP event signals)
- ◆ Add 500 additional customers during the summer of 2008
- ◆ Plan to add a few thousand customers during 2009 (following AMI implementation)