



SmartPOWER

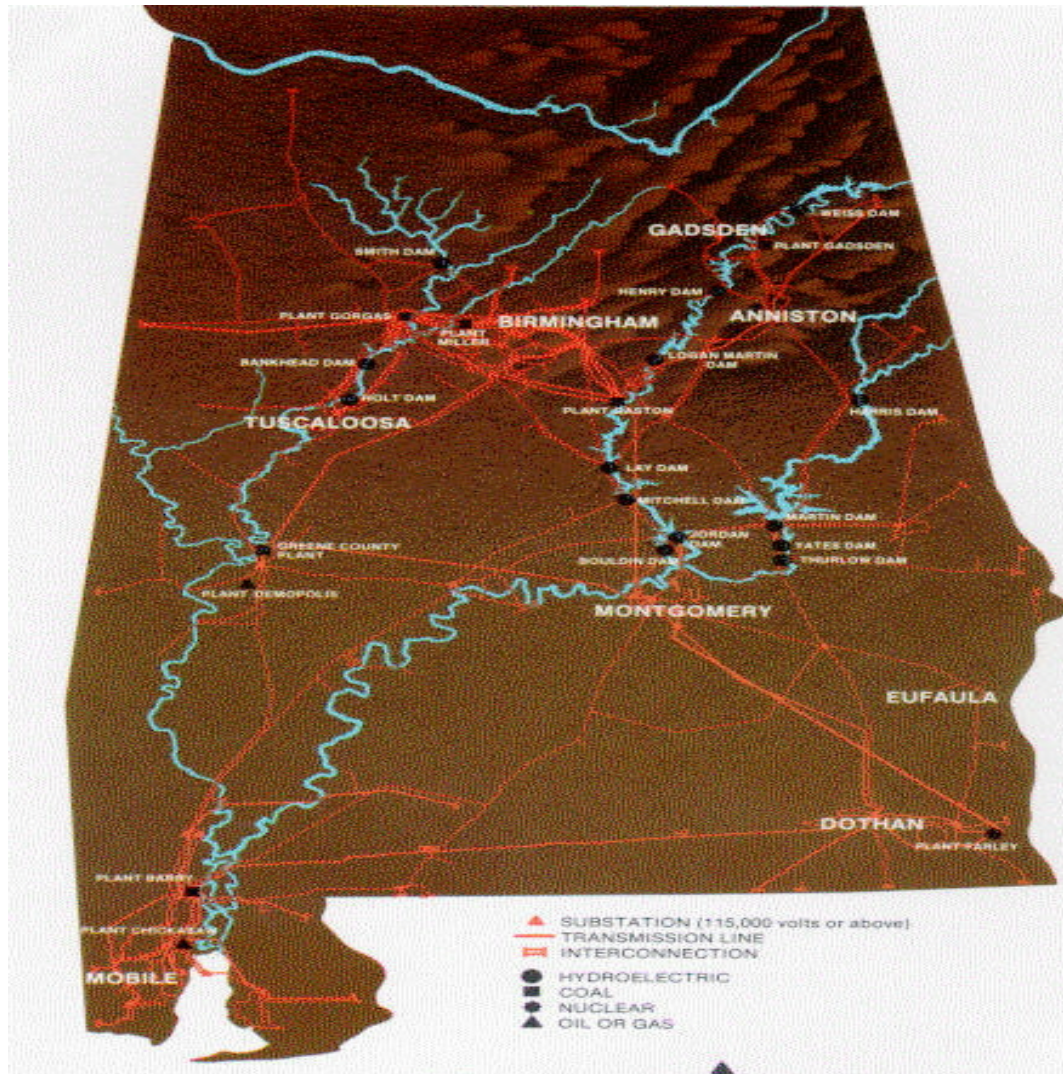
Critical Peak Pricing (CPP)

Pilot

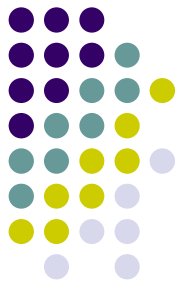
AEIC Load Research Workshop
May 21, 2007
Boston, MA

Wilbur Johnson, Alabama Power Company
Curt Puckett, *RLW Analytics*

Alabama Power Company Service Area



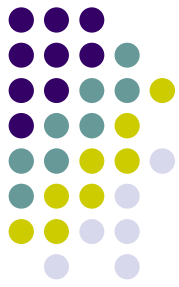
APC SmartPOWER Pilot



What is SmartPOWER?

- **Combines TOU rate with CPP component and one-way communicating programmable thermostats with web access capabilities**
- **Utilizes AMI network currently installed within the B'ham area as means of communicating with and reading meters**
- **Pilot to demonstrate feasibility of the technology and allow APC to collect data on the behavior of customers on the CPP rate**

APC SmartPOWER Pilot



How does it work “technically”?

- **Customers have web access to control their thermostat settings and to choose a response to a critical price signal.**
- **Critical price signals are sent via the web to the thermostat using 900mhz paging signals**
- **Signal are also sent to AMI meters via two-way radio 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

SmartPOWER Rate

Standard FDT Rate

\$21.91 Customer Charge

Price per kWh

| | |
|--------------|---------------|
| Off-peak | 2.4505 cents |
| Intermediate | 5.6605 cents |
| On-peak | 17.3405 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

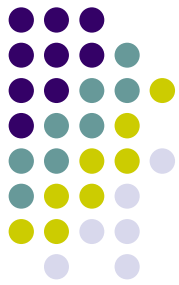
Weekdays:

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

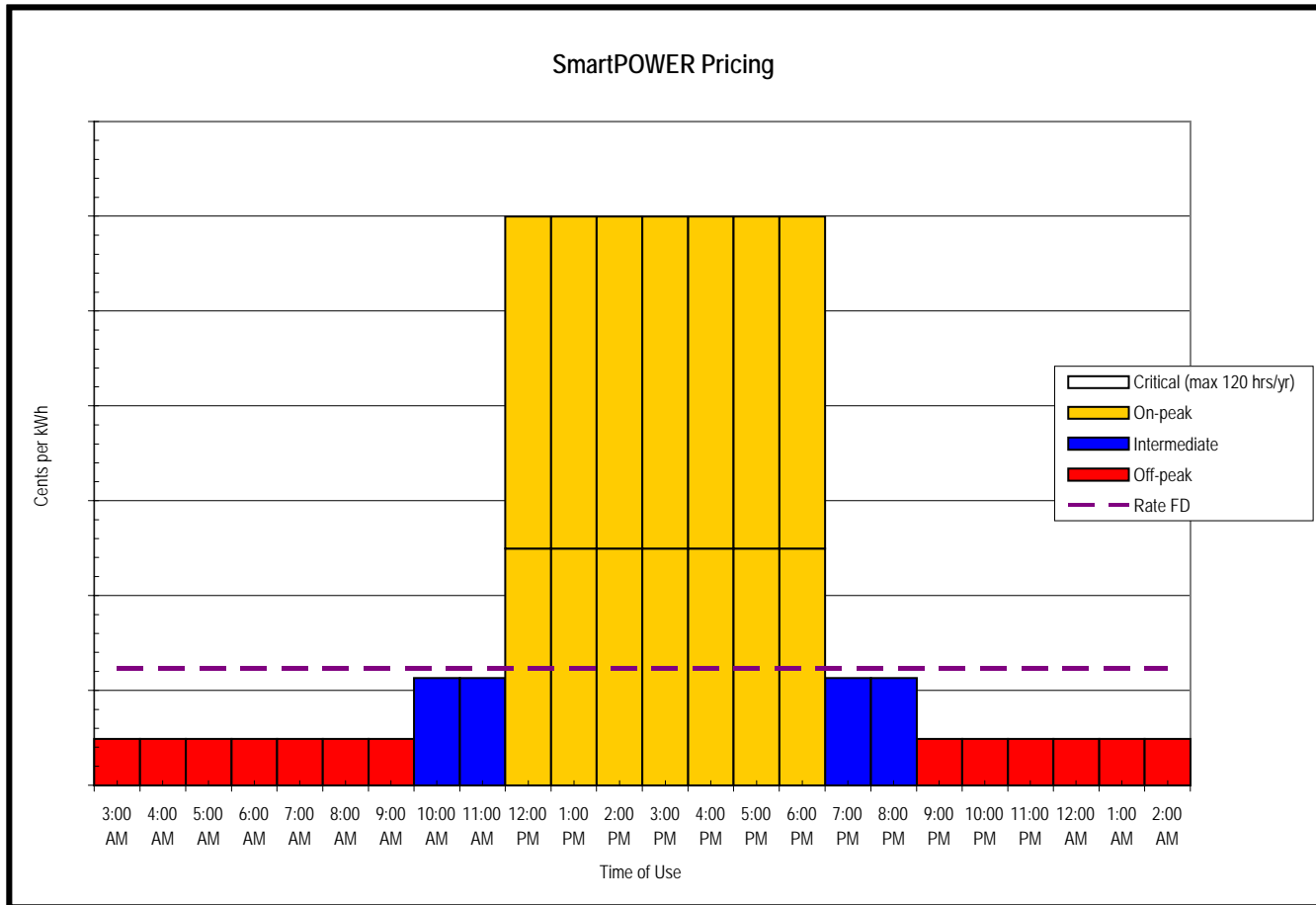
Weekends and holidays*:

| | |
|----------|--------|
| 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.*

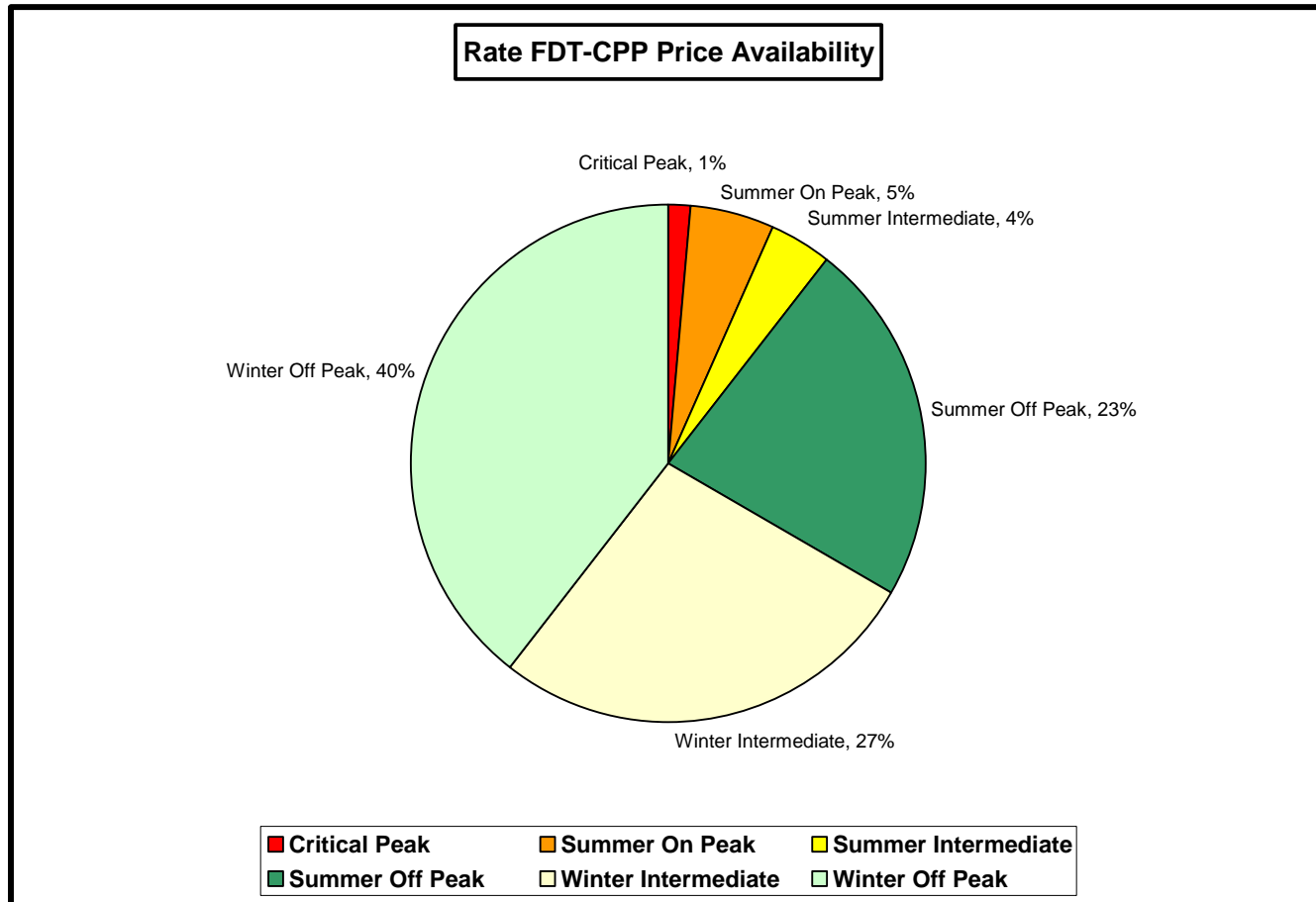


APC SmartPOWER Pilot





APC SmartPOWER Pilot

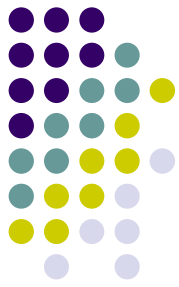




2006 – Proof of Concept

- Instrumentation deployed on sixteen employees
- Limited data available for first event
- Various strategies deployed to establish customer baseline

| Data Start Date | Account | Event Days | | | |
|-----------------|-------------|------------|-----------|-----------|-----------|
| | | 8/1/2006 | 8/15/2006 | 8/28/2006 | 8/29/2006 |
| 3-Aug | 36672-81024 | | X | X | X |
| 18-Jul | 48022-71025 | X | X | X | X |
| NA | 04203-58023 | | | X | X |
| 3-Aug | 52913-01057 | | X | X | X |
| 22-Jul | 85812-20026 | | X | X | X |
| 8-Jul | 85142-25004 | X | X | X | X |
| 19-Jul | 59232-97013 | X | X | X | X |
| NA | 34433-68002 | | | X | X |
| 2-Aug | 90303-01028 | X | X | X | X |
| 21-Jul | 39542-70013 | | X | X | |
| 8-Jul | 69362-71015 | | X | X | X |
| 3-Aug | 98252-78018 | | X | X | X |
| 13-Jun | 15752-80000 | X | X | X | X |
| 17-Jul | 48293-01013 | X | X | X | X |
| 27-Aug | 29015-06056 | X | X | X | X |
| 26-Aug | 85672-99001 | X | X | X | X |
| Active Accounts | | 8 | 14 | 16 | 15 |

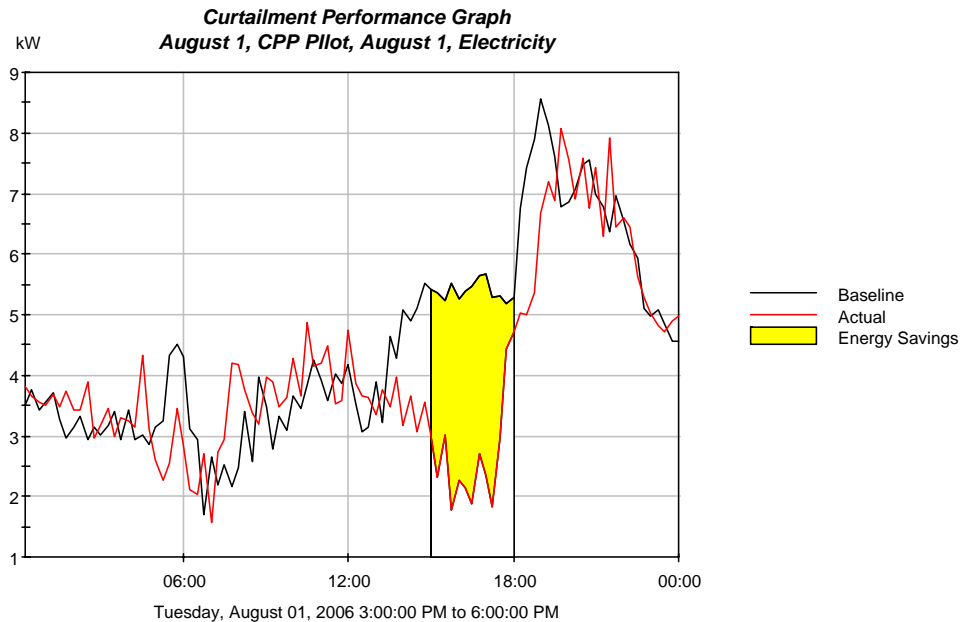


Event Day Performance

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 | |



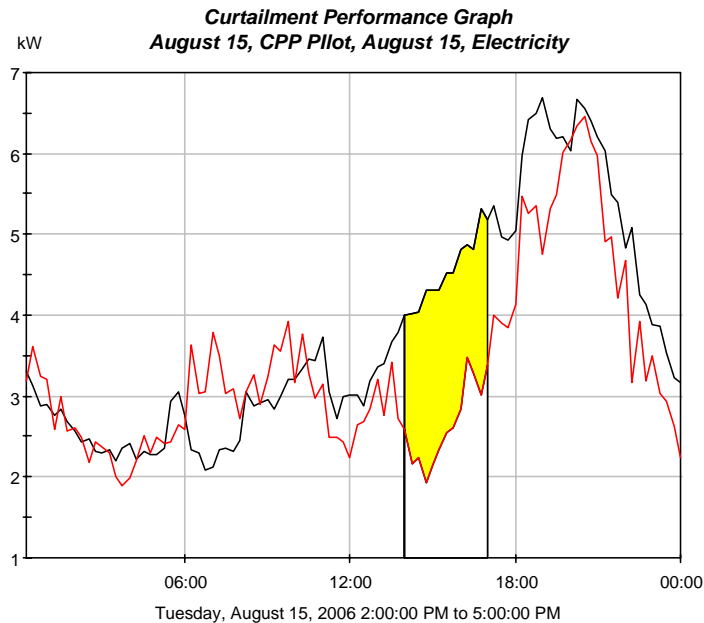


Event Day Performance

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 | |



— Baseline
— Actual
■ Energy Savings

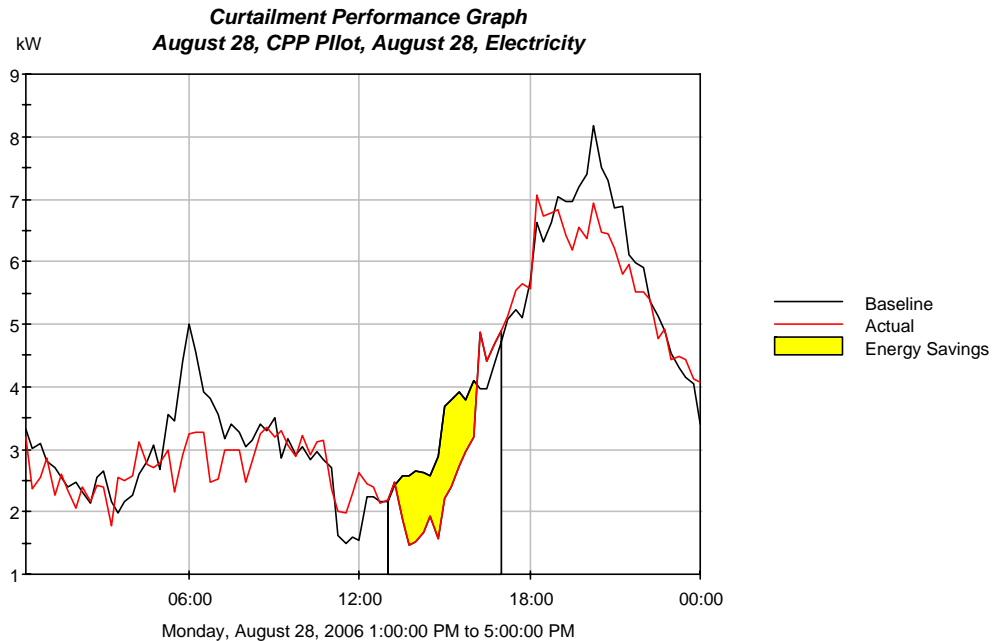


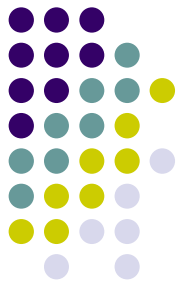
Event Day Performance

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 | |



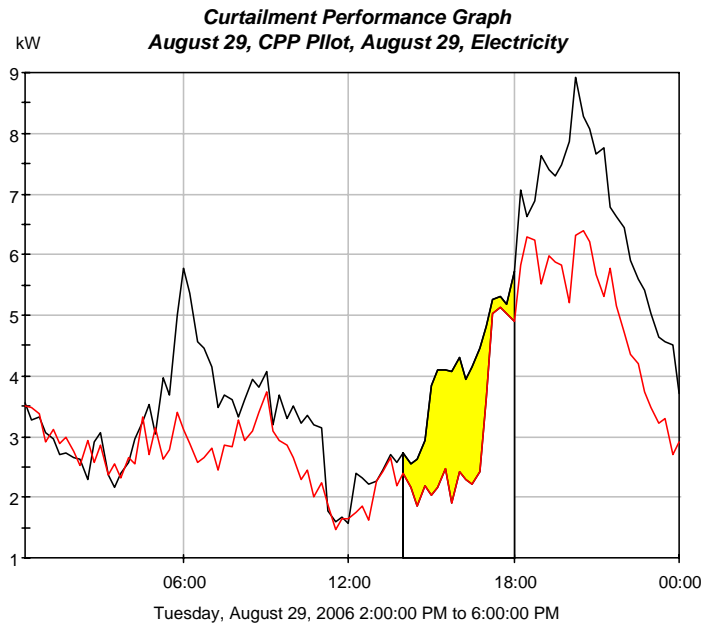


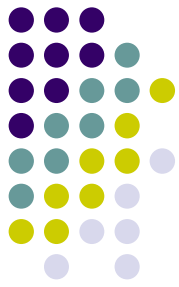
Event Day Performance

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 | |

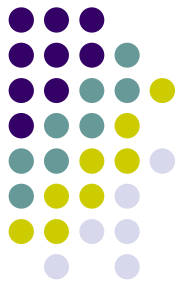




Load Impact Summary

- Plausible estimates developed for each of the four events
- Demand reductions ranged from 1.1 kW to 3.28 kW

| 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 |



Anatomy of a Plan

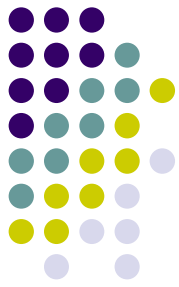
- Purpose
- Goals and Objectives
- Project Duration
- Experimental Rate Offering
- Enabling Technology
- Experimental Design
- Geographical Constraints
- Target Population
- Sample Design
- Customer Recruitment
- Event Trigger
- Control Strategy
- Customer Notification
- Customer Billing
- Analysis Plan

Anatomy of a Plan

The SmartPower Plan

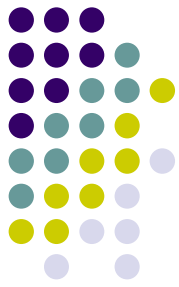


- Project Purpose:
 - Establish a global purpose
 - *Obtain information needed to determine if and how residential time-of-use rates can be made beneficial to Alabama*



Project Goals and Objectives

- Estimate the energy and demand savings associated with customers moved from the standard residential rate (FD) to the experimental time-of-use with the critical peak pricing (CPP) component
 - The magnitude of load reduction during the on-peak period
 - The magnitude of the load reduction during the CPP periods
 - The amount of energy shifted from on-peak to mid-peak or off-peak periods



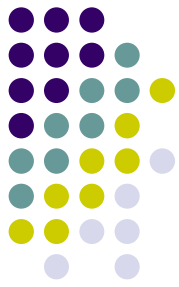
Project Goals and Objectives

- Examine the impact of coupling the experimental TOU rate with the CPP component with enabling technology
- Survey program participants to determine ways to improve on the offering and determine if participation has a positive impact on conservation awareness
- Examine the cost-effectiveness of this type of program



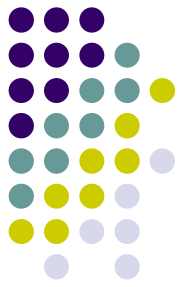
Experimental Rate Offering

- **Summer: June 1 through September 30**
 - On-Peak hours defined as the seven hour period (12pm to 7pm) during weekdays;
 - Intermediate-Peak hours defined as the four hour period (10am to 12pm and 7pm to 9pm) during weekdays;
 - Off-Peak hours defined as the remaining 13 hour weekday period (9pm to 10am) and all hours during weekends and holidays.
 - Critical peaks can be called during the on-peak hours for up to five continuous hours but not for more than 120 hours during the summer.



Experimental Rate Offering

- **Winter: October 1 through June 1**
 - Intermediate-Peak hours defined as the 14 hour weekday period (7am to 9pm) and all hours during weekends and holidays.
 - Off-Peak hours defined as the remaining 10 hour weekday period (9pm to 7am) and all hours during weekends and holidays.

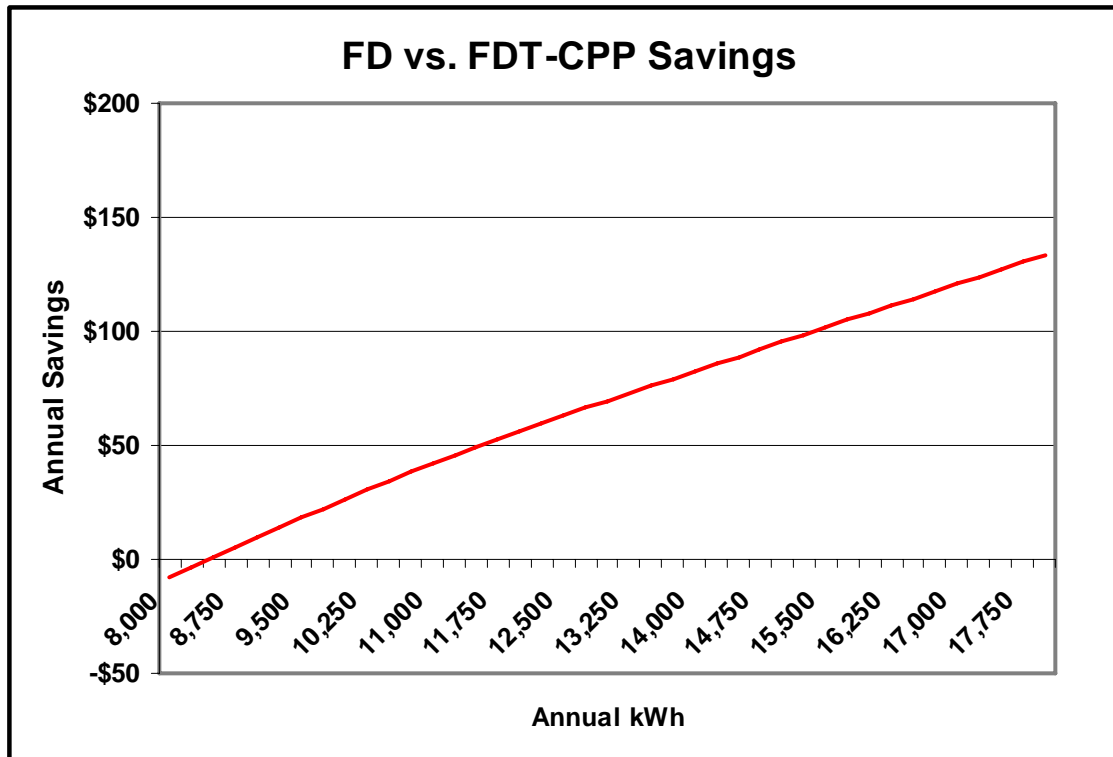


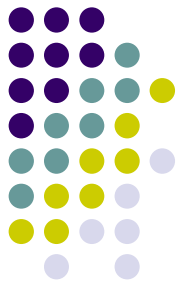
Energy Pricing Component

- **The energy pricing component is as follows:**
 - \$0.299918/kWh for critical peak hours;
 - \$0.124918/kWh for on-peak hours;
 - \$0.056518/kWh for intermediate-peak hours; and
 - \$0.024418/kWh for off-peak hours.



Rate Impact: Cross Over





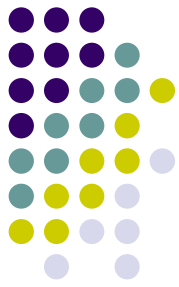
Project Duration

- *APCO agreed to fund the Residential TOU CPP Pilot Study through September 2007*



Experimental Design

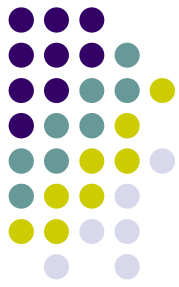
- Test/Control Experimental Design
 - The customers recruited into treatment group number two will be given a Smart thermostat and placed on the time-of-day rate that includes the experimental critical peak pricing component.
 - The cost of monitoring additional control group customers is low due to the AMI infrastructure, we selected a relatively large (5:1) independent control group for the test group.



Enabling Technology

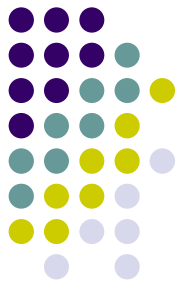
- *The Comverge SuperStat™ thermostat will be used in the Pilot Program.*





Enabling Technology

- **Comverge Advantages**
 - **Auto changeover**
 - **Backlit display**
 - **Handles 2 stages of heating and cooling**
 - **Fewer power “stealing” issues**
 - **Better signal reception (VHF signal)**
 - **Compatible with gas or electric systems**



Web Control

SuperStat® Remote Programming Console
provided by **comverge**

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

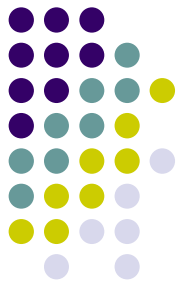
Time :

Set Point °F

Night

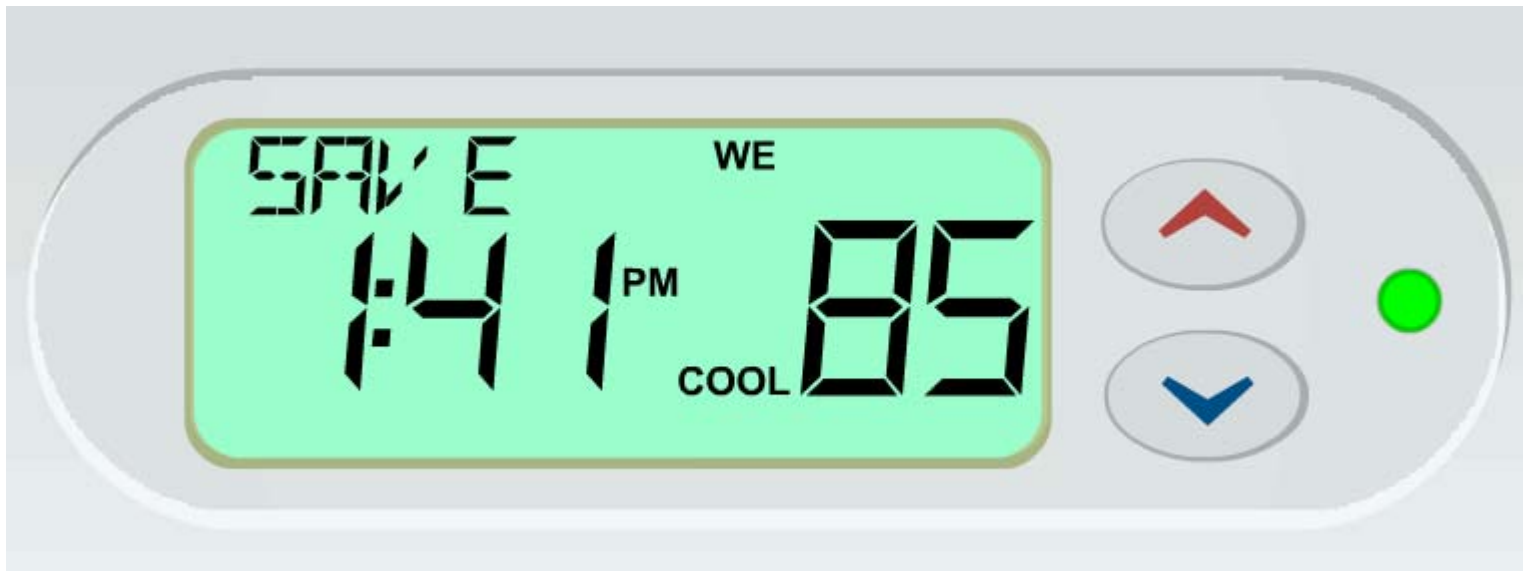
Time :

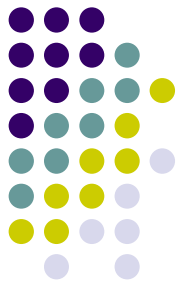
Set Point °F



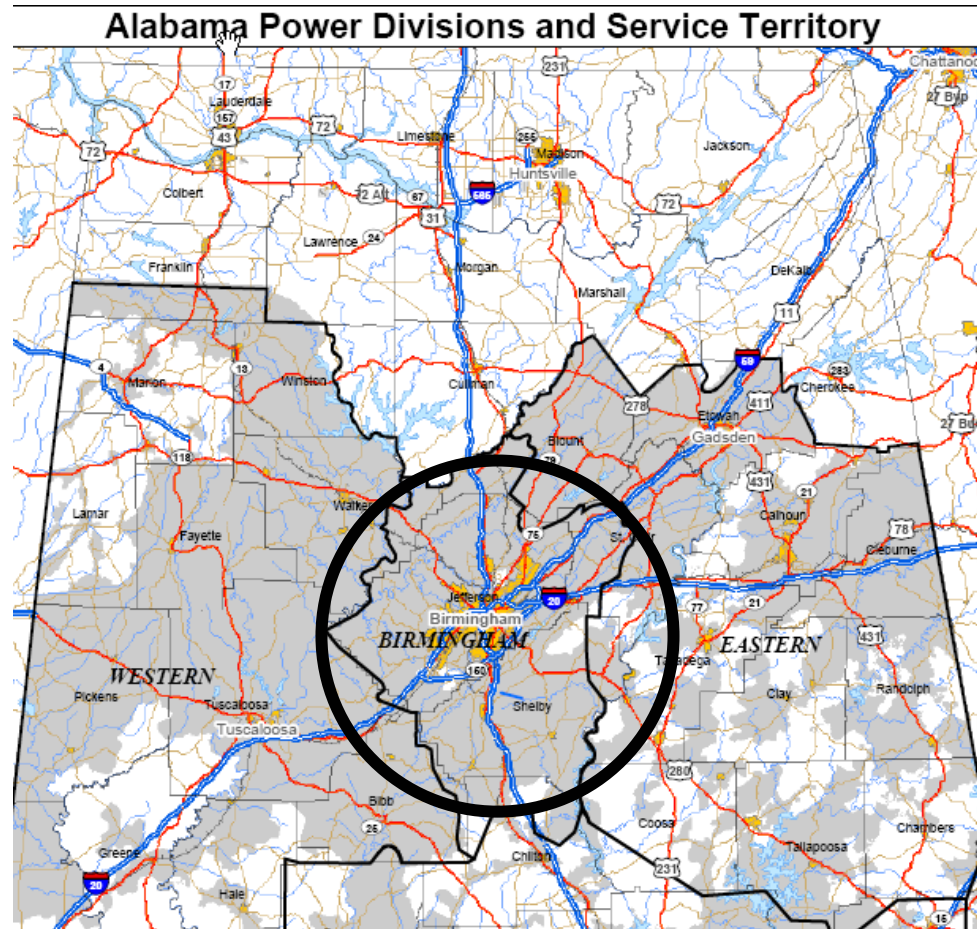
Enabling Technology

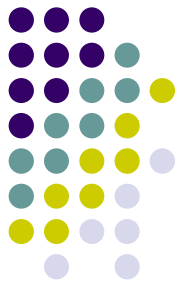
- The Green LED is on during curtailment event
- “SAVE” is displayed in the message window





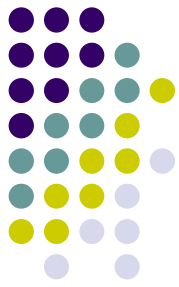
Geographical Constraint





Geographical Constraint

- **Benefits**
 - Minimizes the cost incurred implementing the enabling technology, i.e., the “smart” thermostats by limiting the licenses required for the paging technology
 - Limiting the study to Birmingham Division, reduces the training needed of APCO Metering System personnel and Call Center personnel to implement the program.
 - Reduces the cost of installing and subsequent follow-ups (if needed) on the “smart” thermostats.
 - Thermostat installers will have less distance between installations by limiting the geographic area, thus expediting the installations.



Target Population

- *High Summer Use Residential Customers are the target population*
 - *Geographically constrained to the 45,000 customers in the AMI area*
 - Target population was screened for single family, non-rental customers not on the flat rate with at least 350 days of billing history within the AMI infrastructure area yielding 19,000 potential participants



Usage Statistics

- Customers in first quartile were excluded leaving approximately 14,000 customers with the potential to save at least \$50 annually

| Annual Energy Use Statistics | | | | | | | | |
|------------------------------|-----------|--------|-----------------|--------------|--------|--------------|-----------------|-----------------|
| Rate | Count (N) | Mean | 10th Percentile | 1st Quartile | Median | 3rd Quartile | 90th Percentile | 99th Percentile |
| FD | 18,660 | 18,253 | 8,297 | 11,612 | 16,374 | 22,732 | 29,483 | 55,234 |
| FDE | 207 | 29,236 | 14,488 | 18,328 | 25,649 | 33,000 | 45,178 | 115,858 |
| FT | 23 | 21,050 | 11,322 | 14,317 | 19,807 | 26,239 | 32,439 | 40,938 |
| Summer Use Statistics | | | | | | | | |
| Rate | Count (N) | Mean | 10th Percentile | 1st Quartile | Median | 3rd Quartile | 90th Percentile | 99th Percentile |
| FD | 18,660 | 9,116 | 4,194 | 5,969 | 8,350 | 11,243 | 14,682 | 25,789 |
| FDE | 207 | 12,129 | 5,473 | 7,493 | 10,505 | 13,932 | 23,703 | 49,550 |
| FT | 23 | 9,104 | 4,369 | 7,388 | 8,520 | 10,484 | 13,358 | 17,134 |
| August Use Statistics | | | | | | | | |
| Rate | Count (N) | Mean | 10th Percentile | 1st Quartile | Median | 3rd Quartile | 90th Percentile | 99th Percentile |
| FD | 18,660 | 2,469 | 1,143 | 1,633 | 2,267 | 3,045 | 3,956 | 4,708 |
| FDE | 207 | 3,251 | 1,442 | 1,973 | 2,826 | 3,620 | 5,472 | 11,796 |
| FT | 23 | 2,451 | 1,519 | 1,975 | 2,377 | 3,089 | 3,277 | 4,220 |



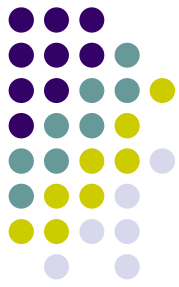
Sample Design

- Planned sample size must allow for “meaningful” results

| Scenario | Error Ratio | Desired Rel Prec | Required Sample | Scenario | Error Ratio | Desired Rel Prec | Required Sample | Scenario | Error Ratio | Desired Rel Prec | Required Sample |
|----------|-------------|------------------|-----------------|----------|-------------|------------------|-----------------|----------|-------------|------------------|-----------------|
| 1 | 0.50 | ±10.0% | 67 | 13 | 0.60 | ±10.0% | 97 | 25 | 0.70 | ±10.0% | 131 |
| 2 | 0.50 | ±11.0% | 56 | 14 | 0.60 | ±11.0% | 80 | 26 | 0.70 | ±11.0% | 109 |
| 3 | 0.50 | ±12.0% | 47 | 15 | 0.60 | ±12.0% | 67 | 27 | 0.70 | ±12.0% | 91 |
| 4 | 0.50 | ±13.0% | 40 | 16 | 0.60 | ±13.0% | 57 | 28 | 0.70 | ±13.0% | 78 |
| 5 | 0.50 | ±14.0% | 34 | 17 | 0.60 | ±14.0% | 50 | 29 | 0.70 | ±14.0% | 67 |
| 6 | 0.50 | ±15.0% | 30 | 18 | 0.60 | ±15.0% | 43 | 30 | 0.70 | ±15.0% | 59 |
| 7 | 0.55 | ±10.0% | 81 | 19 | 0.65 | ±10.0% | 113 | 31 | 0.75 | ±10.0% | 151 |
| 8 | 0.55 | ±11.0% | 67 | 20 | 0.65 | ±11.0% | 94 | 32 | 0.75 | ±11.0% | 125 |
| 9 | 0.55 | ±12.0% | 57 | 21 | 0.65 | ±12.0% | 79 | 33 | 0.75 | ±12.0% | 105 |
| 10 | 0.55 | ±13.0% | 48 | 22 | 0.65 | ±13.0% | 67 | 34 | 0.75 | ±13.0% | 89 |
| 11 | 0.55 | ±14.0% | 42 | 23 | 0.65 | ±14.0% | 58 | 35 | 0.75 | ±14.0% | 77 |
| 12 | 0.55 | ±15.0% | 36 | 24 | 0.65 | ±15.0% | 51 | 36 | 0.75 | ±15.0% | 67 |

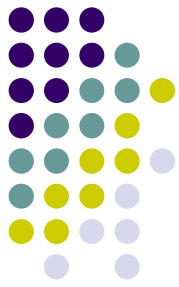
- Already constrained by consumption allows for a simple random sample to be drawn

| Error Ratio | Sample Size | Number of Stratum | Expected Rel Prec |
|-------------|-------------|-------------------|-------------------|
| 0.7 | 75 | 1 | ±13.8% |
| 0.7 | 75 | 2 | ±13.4% |
| 0.7 | 75 | 3 | ±13.4% |
| 0.7 | 75 | 5 | ±13.3% |



Customer Recruitment

- *APCO is using an outbound call center to recruit customers into the Pilot*

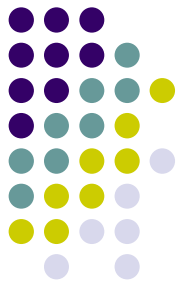


Event Trigger

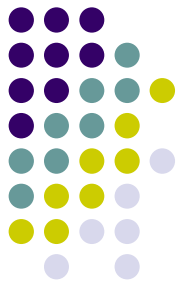
- **Event Trigger**

- **Heat Index of 95 degrees or greater and RTP-H pricing will be used as triggers**

Control Strategy & Customer Notification



- **When a CPP event is called thermostats will enter a 70% cycling strategy**
 - **Customers are notified *day of event* via e-mail (if they choose) and at the T-stat**
 - **Customers may opt out at the T-stat or via the Web**



Customer Billing

- *Customers will be billed from the interval load data collected for the evaluation*



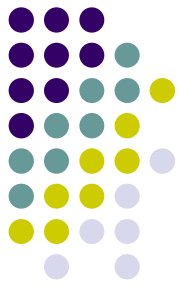
Analysis Plan

- Analysis Matrix

| Study Group | Rate Options | Sample Size | Average CPP Demand | System Peak Demand | Time-of-Use On-peak | Time-of-Use Mid Peak | Time-of-Use Off Peak | Average Summer Use |
|---------------|------------------------------|-------------|--------------------|--------------------|---------------------|----------------------|----------------------|--------------------|
| Control Group | Standard Residential | 500 | Mean Variance | Mean Variance | Mean Variance | Mean Variance | Mean Variance | Mean Variance |
| Test Group | TOU/ CPP w/ Smart Thermostat | 100 | Mean Variance | Mean Variance | Mean Variance | Mean Variance | Mean Variance | Mean Variance |

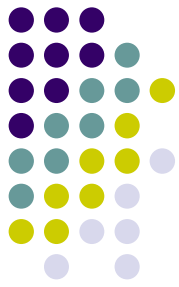
- Two Sample Comparisons

| Statistic | Test Group | Control Group | Difference |
|--------------------|------------|---------------|------------|
| Demand at Peak | 2.80 | 4.20 | 1.40 |
| Relative Precision | 21.0% | 18.9% | |
| Error Bound | 0.59 | 0.79 | 0.99 |



Analysis Plan

- Bill Comparisons
- Weather Normalized Results
- Final Report



Final Report

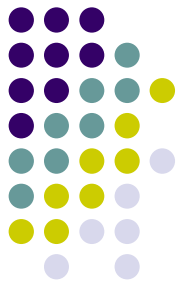
- Executive Summary
 - Overview
 - Analysis Summary
 - General Conclusions
- Introduction
 - Background
 - Goals and Objectives
- Project Design
 - Experimental Design
 - Enabling Technologies
 - Residential TOU/CPP Rate Design
 - Customer Recruitment
- Project Design (continued)
 - CPP Customer Notification
 - Customer Billing
 - CPP Event Calls
 - Test and Control Groups
- Project Analysis
 - Analysis of Test Group: TOU/CPP
 - Impact Analysis
 - Bill Comparison
 - Supplemental Analysis
 - Weather Normalized
- Appendices
 - Event Day Graphs



2007 Pilot Differences

Key Differences Between 2006 and 2007 Pilots

| | 2006 | 2007 |
|--------------------------------|---------------------|---------------|
| Customers | Employees | Non-employees |
| # of Customers | 16 | 100 |
| Equipment | Cannon | Comverge |
| Load Reduction Strategy | Temperature Ramping | Cycling |



Acknowledgements

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