

Smart Meters, In-Home Displays, Communications and Equipment that Facilitates Customer Usage Modification

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Customer Usage Modification

- Can A Smart Grid Influence Customers' Usage?
- Are Time Differentiated Rates Enough by Themselves?
- What Technologies are Available?
- What Results Have We Seen?
- What Are We Trying to Accomplish?

What Are We Trying to Accomplish

I believe that forward thinking utilities wish to empower customers with the information to make informed decisions on their energy use, and provide tools for those customers to be able to better manage their usage.

Improving load shape is one of the main keys to customers and utilities creating a benefit for both.

Customer Usage Modification

- **Energy Efficiency**
 - May not improve load factor
- **Load Control – utility-centric**
 - A/C, water heater, pool pump, irrigation cycling
- **Time Differentiated Rates – customer-centric**
 - Time of Use (TOU)
 - Critical Peak Pricing (CPP)
- **Both Result In Demand Reduction**
 - Load Shifting
 - Peak Load Shedding
 - Energy Efficiency

What Is Load Control

- **Duty Cycling of Consumer Equipment**
 - 100% control of an electric water heater or pool pump for 4 hours
 - 50% control of an air conditioner – i.e. the compressor is allowed to run only 15 minutes out of each 30 minute period over the 4 hour peak
 - Results in demand reduction
 - A/C ~1Kw
 - Water heater ~.4 Kw summer or 1 Kw winter
 - Control of electric resistance backup heat strips on a heat pump
 - The utility “has their finger on the button”
 - Customers usually receive a bill credit
- **Load control has been around since the late 1970's**
 - One way paging, VHF or 900 Mhz
 - Power Line Carrier

What Is TOU/CPP

- Electricity prices are time differentiated
 - TOU Rates are a published schedule with times and rates
 - Generally a 2 tier or 3 tier rate
 - Critical Peak Pricing takes a TOU rate and adds a real time component
 - The Critical Period will be at times of system peak
 - Generally lasting 1 – 4 hours
 - Often capped, i.e. maximum of 80 hours per year
- TOU has not been used widely because customers need to take action to reduce usage during higher price periods
- Current TOU and CPP rates are often accompanied by “enabling” technology
 - Programmable communicating thermostats, appliance switches, in home energy use displays, and consumer portals
- The customer incentive is in the form of the ability to automate the shifting of usage from high price periods to lower price periods, resulting in bill savings

Customer Incentives – What's in it for Me?

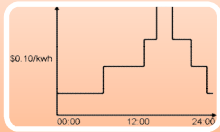
Bill credit for load control

- Typical
 - \$5/ summer month per a/c
 - \$2/ month electric water heater/pool pump

TOU/CPP Rate Structure

- Rate structure “rewards” customer for moving usage from high demand periods to lower demand periods
 - High price period cannot be too long – 4-5 hour max
 - Differential between rate tiers should be high enough to send a strong pricing signal
 - Critical period should be a minimum of 5 times the low price

Utility-Centric Solutions – Load Control



Consumer choice is usually limited, possibly a choice between switch and thermostat



Consumer response is dictated by the utility



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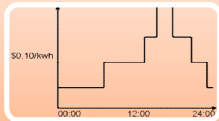
Little or no consumer feed back



M&V can be expensive and cumbersome

Consumer-Centric Solutions – TOU/CPP

Empowering consumers with tariffs and technologies can increase adoption and improve conservation



Consumer choice allows each family to pick the right level of activity



Consumer preferences enable price-responsive device behavior



Multiple touch points increase the available load and the influence on behavior



AMI solution provides built-in M&V and reduces the cost of a program

Elements of a Smart Grid Network

UnitySuite™ Head-End Enterprise Software



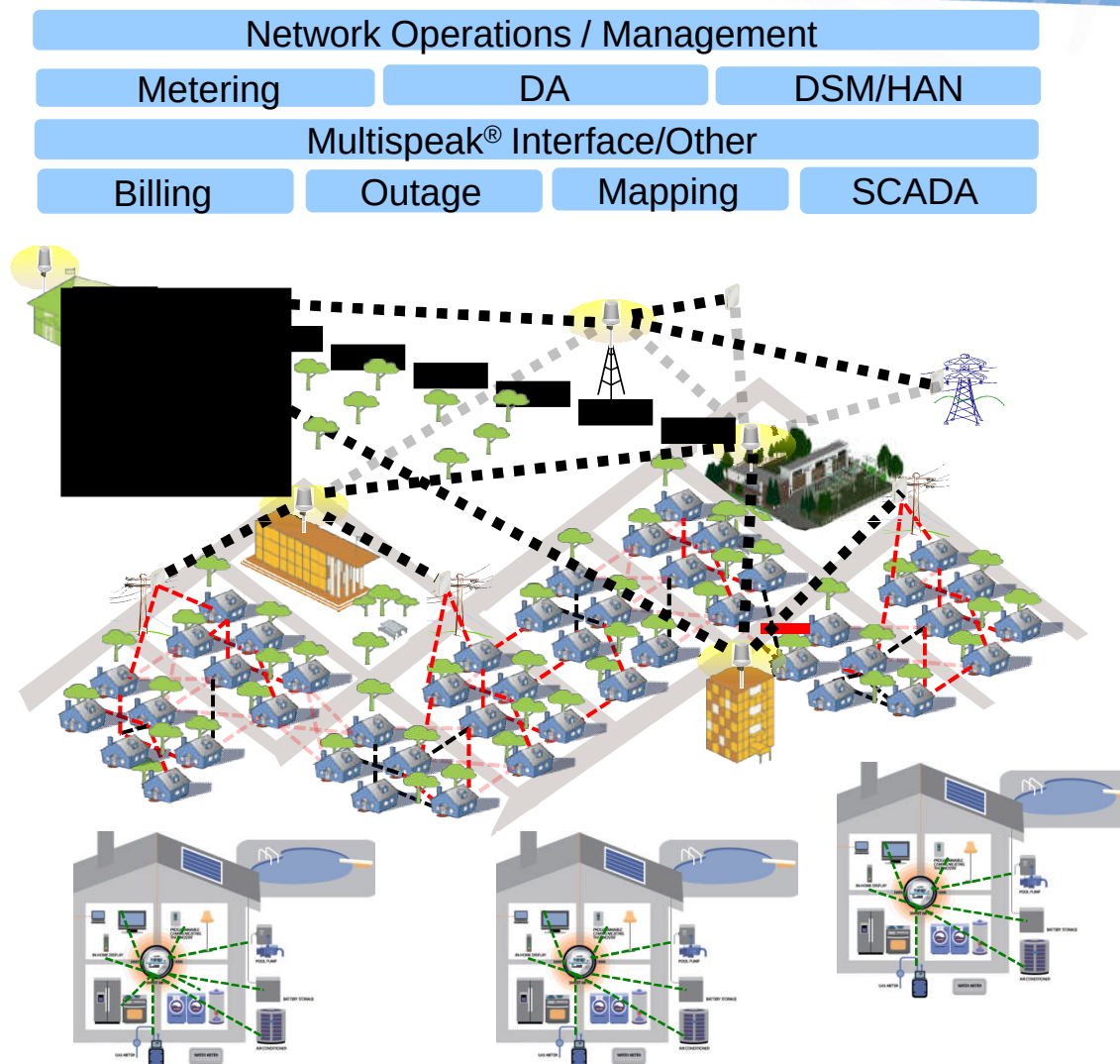
SecureMesh™ Wide Area Network (WAN - 5.9 GHz)



SecureMesh Neighborhood Area Network (NAN - 2.4 GHz)

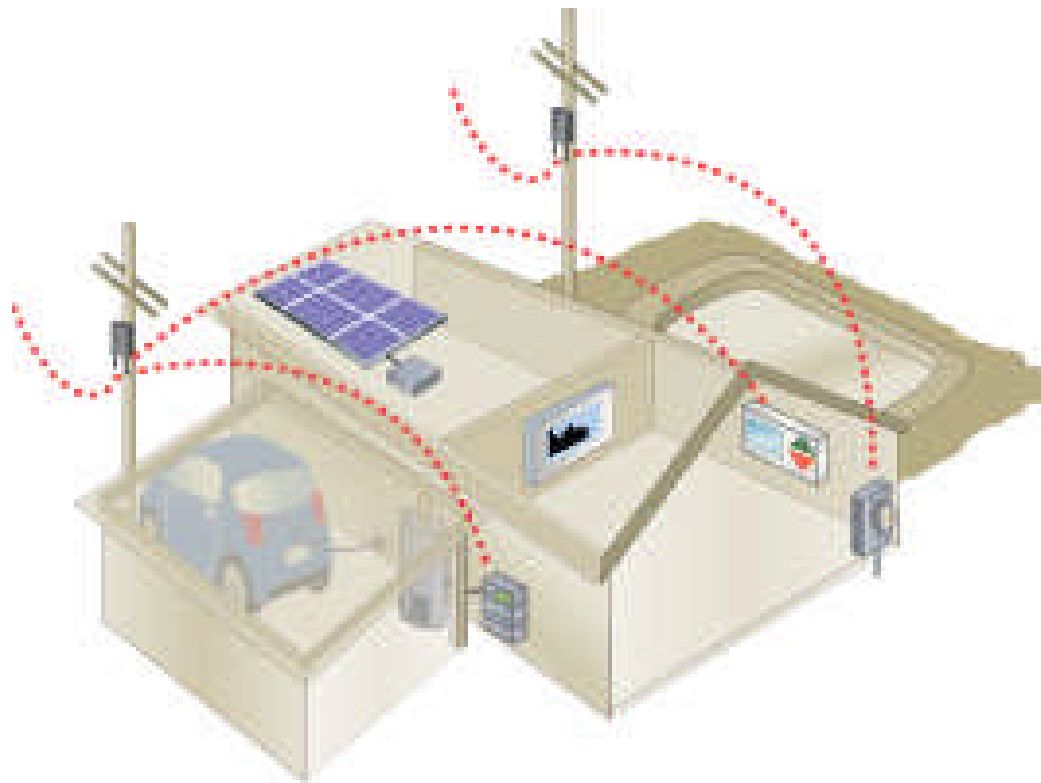


Home Area Network (HAN)



A multi-tier architecture for secure private networking

In-home devices directly connected to the AMI network.



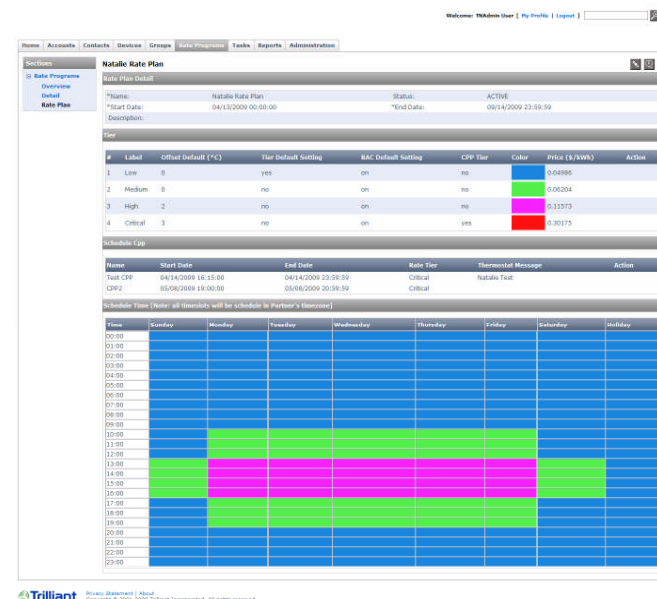
Home Area Network

Ability to provide customers with multiple offerings

- Traditional load control – duty cycle, set back
- Time-of-use rates
- Critical peak pricing
- Customer choices

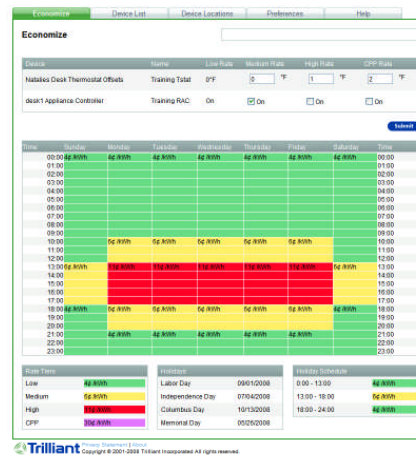
Advantage of two-way communications

- Confirmation of connectivity
- Confirmation of events being received
- Event logging – customer overrides, set point changes, etc.
- Firmware upgrades
- Ability to change functionality over the air

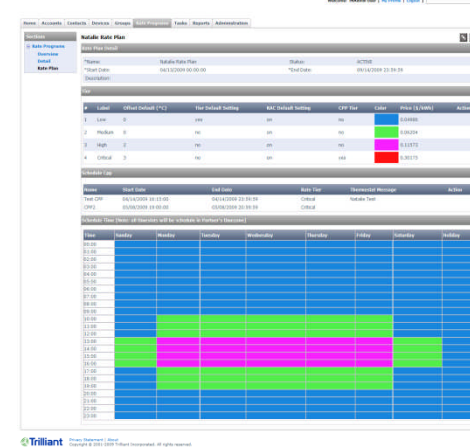


TOU/CPP Enablers

Consumer Portal



Utility Dashboard



In-Home Displays



Programmable Communicating Thermostats



Load Control Switches



Communicating Thermostat

Typical device features

- Price signals
- Load Control (overridable and non-overridable)
- Messages (up to 89 characters)
- Real-time device status
- Real-time remote control (HVAC mode changes, temporary holds)
- Consumer settings; e.g., temperature unit display (C or F)
- Alarm reports (increases device up-time)
- Over-the-air firmware upgradable

Local device features

- Occupancy schedules
 - Energy Star default settings: Wake, Leave, Return, Sleep
 - Up-to six programmable transitions for the day
 - Week schedules for either 5-2, 5-1-1, and 7
- Consumer settings
 - Language (English and Spanish)
 - 12- or 24-hour time display
 - Change / clean filter reminder (months)

Other features

- State-of-the-art climate control algorithms
- Optional auxiliary switch to save installation costs
- Optional color-matched wall-plate



Load Control Switch

End-to-end features

- Controls appliances with load control commands (e.g., Open, Close)
- Open relays immediately
- Close relays immediately
- Schedule load shedding events
- Specific dates/times (e.g., on 5 May 2010 at 14h00)
- Specific durations (e.g., for 2 hours)
- Specific duty cycle (e.g., 40% off)
- Over-the-air firmware upgradable (SecureMesh only)

Relays

- One 30 Amp / 240V relay
- Two 5 Amp / 120V relays



In-Home Display

End-to-end capabilities

- CPP events
- TOU current rate
- Rate plan updates
- Over-the-air firmware upgradable



Device features

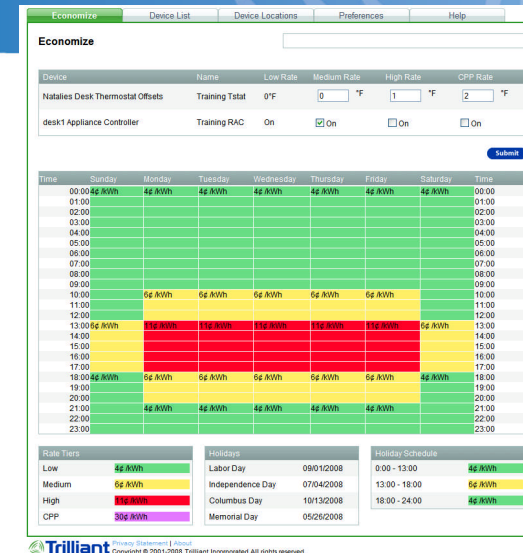
- Communicates directly to associated meter for energy use
- Displays current rate or usage
- Displays historical usage and cost
- Lightbar indicates current rate and usage



Software

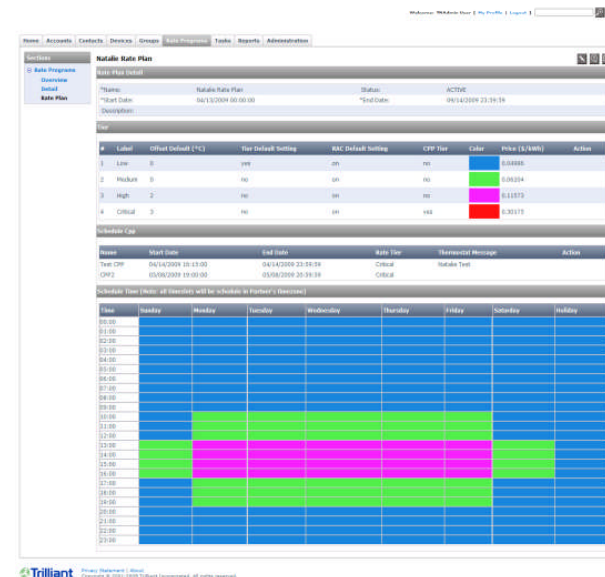
Consumer Portal

- TOU rates and schedule
- Customer preferences
- Customer control & scheduling

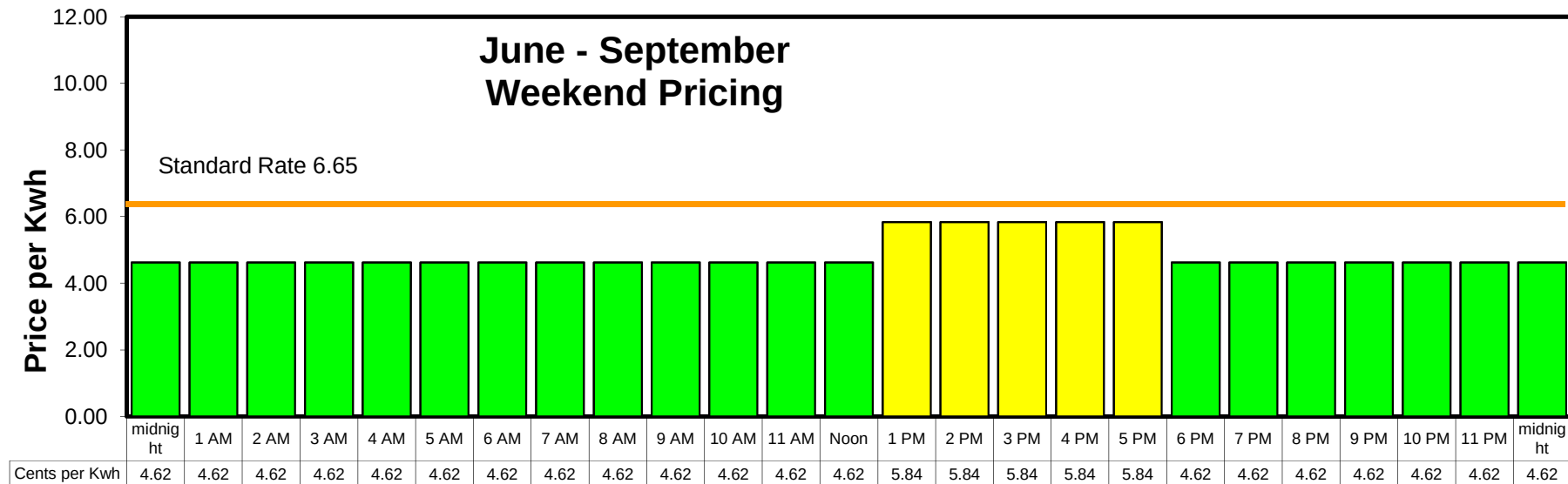
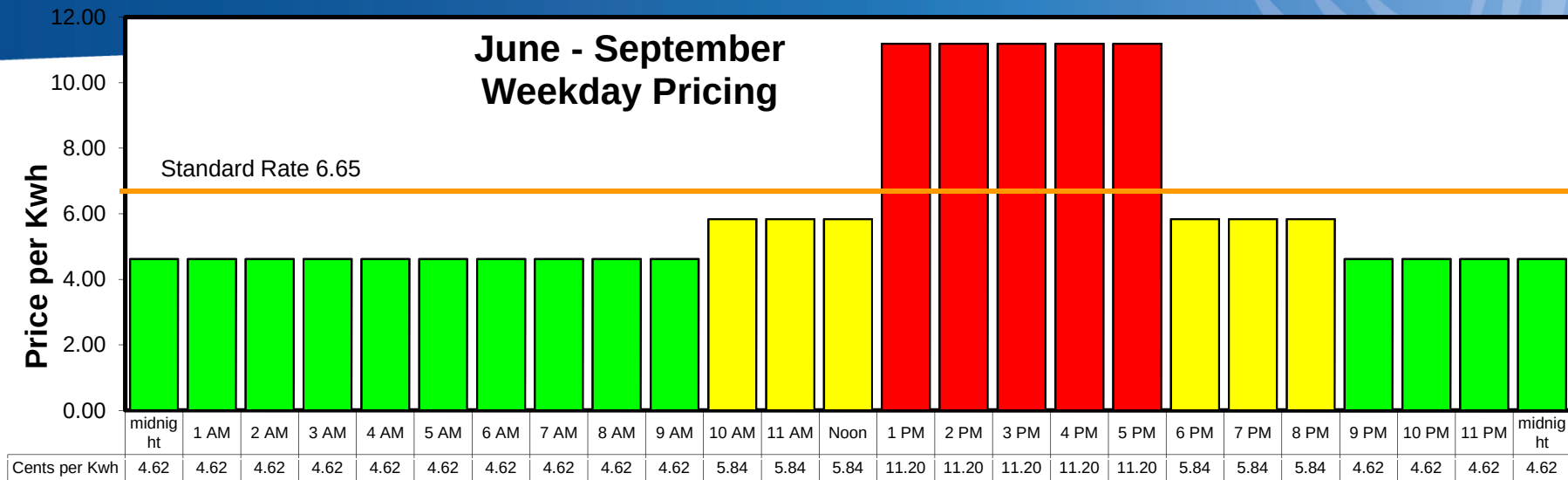


Utility Dashboard

- Establish rates and rate periods
- Schedule CPP or DLC events
- Provide customer service



Typical Rate Structure



Economize

Device List

Device Locations

Preferences

Help

Economize

Device	Location	Low	Medium	High	Critical
Thermostat Offsets		0°F	0°F	2°F	4°F
Appliance Controller		On	On	On Off	On Off

Submit

Time	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Time
00:00	5¢ /kWh	5¢ /kWh	5¢ /kWh	5¢ /kWh	5¢ /kWh	5¢ /kWh	5¢ /kWh	00:00
01:00								01:00
02:00								02:00
03:00								03:00
04:00								04:00
05:00								05:00
06:00								06:00
07:00								07:00
08:00		6¢ /kWh	6¢ /kWh	6¢ /kWh	6¢ /kWh	6¢ /kWh		08:00
09:00								09:00
10:00								10:00
11:00								11:00
12:00								12:00
13:00								13:00
14:00								14:00
15:00								15:00
16:00								16:00
17:00								17:00
18:00	6¢ /kWh	12¢ /kWh	12¢ /kWh	12¢ /kWh	12¢ /kWh	12¢ /kWh	5¢ /kWh	18:00
19:00								19:00
20:00								20:00
21:00								21:00
22:00	5¢ /kWh	5¢ /kWh	5¢ /kWh	5¢ /kWh	5¢ /kWh	5¢ /kWh	5¢ /kWh	22:00
23:00								23:00

Rate Tiers

Low	5¢ /kWh
Medium	6¢ /kWh
High	12¢ /kWh
Critical	12¢ /kWh

Holidays

Not Applicable

Holiday Schedule

0:00 - 24:00 5¢ /kWh

[Economize](#)[Device List](#)[Device Locations](#)[Preferences](#)[Help](#)

Device List

Device	Name	Location	State	HVAC Mode	Temperature	Set Points	Fan	
Thermostat	NCIB00000676		Normal	Heat ▼	72 °F	71 - 74	Auto ▼	Refresh

Device	Name	Location	Power State	Control	
Appliance Controller	NCCA00000029		On	Change ▼	Refresh

Device	Name	Location	Reading	
Electric Meter	000833933		26,699.70 kWh	Refresh

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Individual device control & interrogation – M&V

Device Commands



Temperature:	75	Mandatory Load Shedding:	false
Temperature Scale Displayed:	Fahrenheit	Event Disabled by User:	false
Fan Mode:	On	Event Cancelled by User:	false
Fan Operation:	On	New Message:	false
Heat Set Point:	60	Configuration Error:	false
Cool Set Point:	80	Output Short Circuit:	false
Control Mode:	Heating	Heat Pump Fault:	false
Equipment Operating Mode:	Heat Only	Filter Fault:	false
Equipment Type:	Furnace and Air Conditioner	Low Battery:	false
Number of Stages Engaged:	No Stage Engaged	Heat Pump Disabled:	false
Price Event in Progress:	false	Hold Type:	No Hold
Load Shedding in Progress:	false		

Refresh

Thermostat Hold Control

Hold Type:

Set Hold

Thermostat Mode Control

Equipment Operating Mode:

Fan Mode:

Set Mode

Device Commands



Current Power Mode: Enabled

☒ Enable ☐ Disable

Refresh Send Change

CPP Event Results

Load reduction of 13% - 36% observed

- CPP event compared to regression results, assuming the same population, the same temperature, and the same rate structure
- Days with higher temperatures resulted in larger load drops

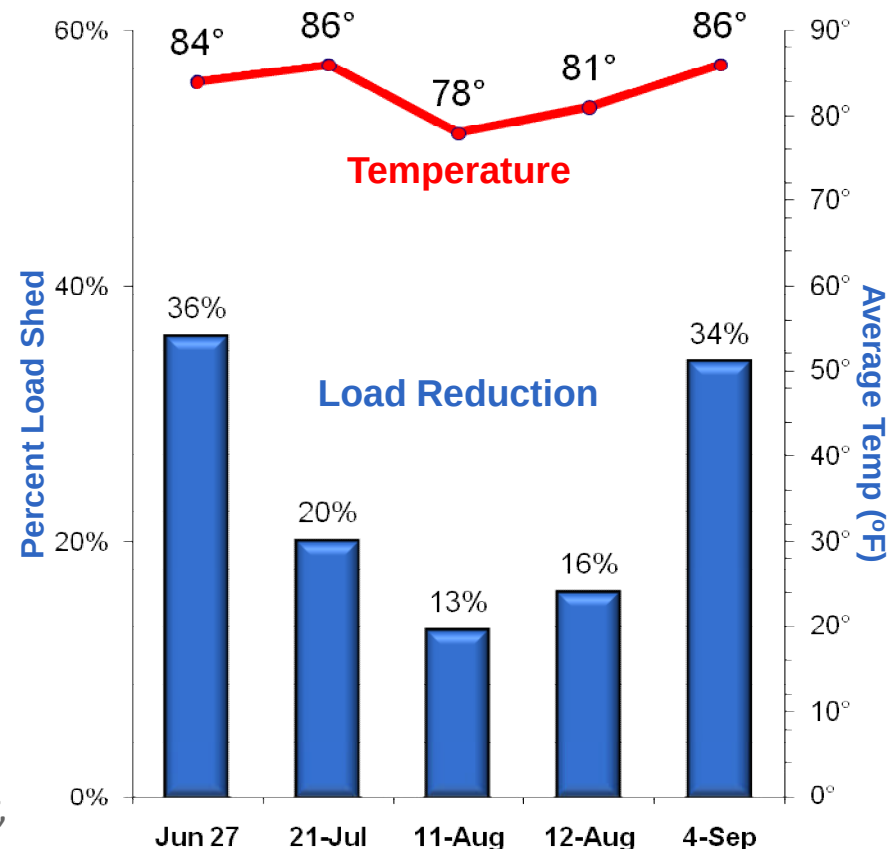
Largest reductions from use of PCT

- PCT-only gave average 27% drop
- IHD-only contributed the least (10%)

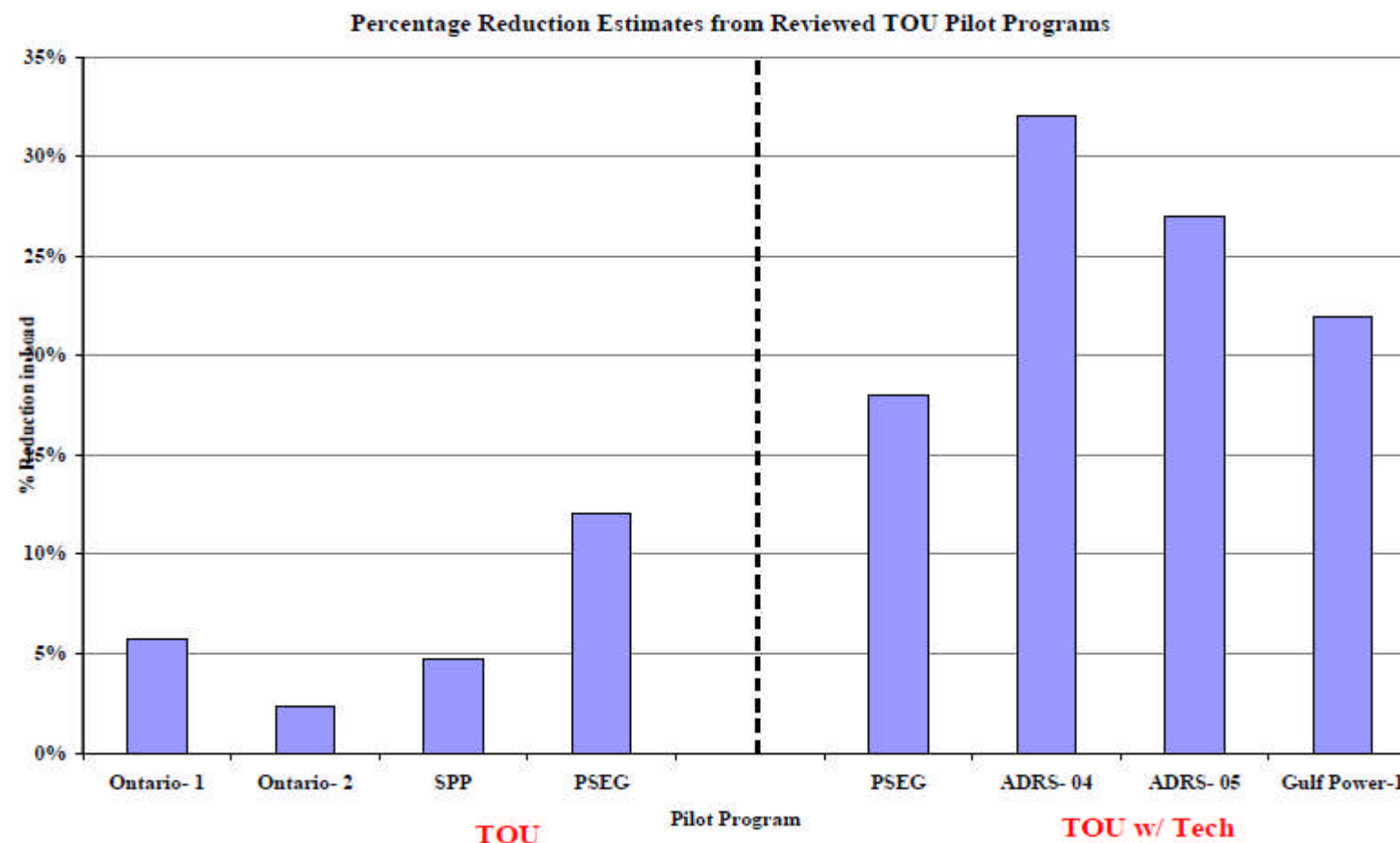
Highest reduction seen during 1st hour

- On average, the first hour of the CPP event showed 24% higher drop than the second
- In practice, the first-hour drop could be even higher: CPP events were not started simultaneously for all customers
- A higher temperature offset would likely add additional load reduction during the first hour, while decreasing the reduction in the second

Total Cumulative Load Reduction Over Two-Hour CPP Event



Across these pilots, there is compelling evidence of demand response



CPP Event Results

Gulf Power CPP Results

- 3.8% conservation results
- Average demand reduction during peak period was 2.1 KW
- Average demand reduction during critical period was 2.75 KW

California Statewide Pilot

- Average peak-period energy use reduced by 13%

Ameren UE – CPP Pilot

- No technology - average demand reduction during critical period was .61 KW
- With technology - average demand reduction during critical period was 1.87 KW

PowerCentsDC

- CPP – Peak reduction – summer 34%, winter 13%
- CPR - Peak reduction – summer 13%, winter 5%
- HP - Peak reduction – summer 4%, winter 2%

Connexus Energy

- Average 18% summer peak load reduction

Puget Sound TOU

- TOU - Peak reduction 4%
- Increased consumer bills

Observations from Informal Customer Interviews

Customers like the IHD

- In particular, they like (and use!) the lightbar
- After nearly a year, all devices were still plugged in (not in a drawer)
- General use was to shift dishwashing, washing/drying clothes, etc. to off-peak
- **Important tool for customer involvement and satisfaction**

IHDs do an excellent job of raising customer awareness

- Especially family-wide: kids see the red lightbar and will turn lights off, etc.

Thermostats were infrequently updated

- Most users set it and forget it – it will do it's job
- To ensure maximum energy savings and customer satisfaction, utilities should set a realistic initial schedule

Water heater switches

- Out of site – out of mind, as long as the high period was no too long
- The ability to override when necessary

Customer Behavior

Customers shifted usage

- In most cases customers did not use fewer Kwh
- Customers used Kwh at different times of the day
- Customer bills reduced by 12% - 30%

Consumer Portals

- 20 – 60 – 20
- Needed to establish preferences or to override
- Educate customers on their usage patterns

Customer surveys

- Very high satisfaction rates
- Most would recommend the rate
- Few reverted to the flat rate
- Customers like to be in control

Customer Demographics

- Residential customer response to offerings was higher than expected
- Environmental leaning customers
- High tech customers
- Many older/retired customers signed on
- Low income participation lagged
- Commercial customer response was low

Anecdotes

- Initial customer thoughts, “I don’t want to wash my clothes at 2 AM”
 - Customers liked being “in control”, having information
 - Customers must have a rate structure “they can live with”
 - Customers will innovate on their own, i.e. pre-cool, etc
 - Customers wanted to be able to make informed decisions on energy use
-
- Just don’t use the clothes dryer during the high period
 - Red light time
 - One family has “red light time”, during which the whole family has to conserve
 - Electricity Dictator
 - One man became the “Electricity Dictator” (according to his wife) after receiving the IHD
 - When he ceased his efforts, their bill went up significantly

Questions