Case Studies in Advanced Thermostat Control for Demand Response

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With updates (2008)

Introduction

- **More Demand for Demand Response Programs!**
  - **Utilities no longer control supply in many states due to deregulation**
  - **Need for more flexibility and "distributed" options like demand-side peak reduction**
  - **Regulators, consumers concerned about shortages and price spikes**
  - **Transmission constraints**

Introduction

- **What are the best options for proven demand response?**
  - **In Summer-peaking systems, air conditioning loads are the primary driver of peaks**
  - **Air conditioning is somewhat discretionary**
  - **New homes have a high degree of air conditioning**
  - **Nearly all businesses have air conditioning**

Air Conditioning Demand Response

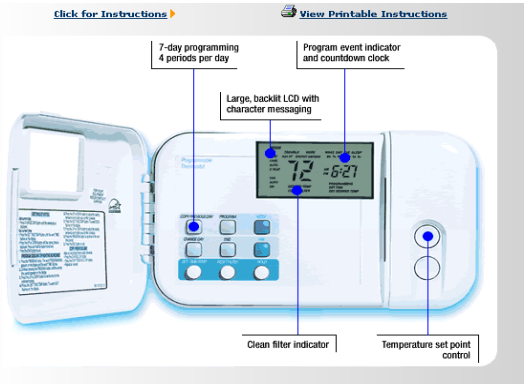
- **Historically, implemented with one-way switches on central A/C systems**
- **New generation of electronic thermostats now available and used by many utilities:**
  - **Two-way communications, which ensures verification of signal reception**
  - **Monitoring and control capability**
  - **Internet access**
  - **Interval data (runtime and temperature) available for virtually all sites**
  - **Customer overrides can be tracked/time-stamped**

Case Studies

- AEG experience with six utilities:
  - LIPA (NY), Southern California Edison, Consolidated Edison, Aquila, Colorado Springs Utilities, FPL Energy
  - Use the same technology electronic programmable thermostats with override
  - Thermostat with two-way communications and data access via public pager networks
  - Control of either duty cycle or temperature
  - Internet access
  - Hourly runtime and temperature data available for virtually all sites
  - Actual programming (7-day, 4-period setpoints), mode (auto, cool, heat) and status (hold on/off: programming used/not) available

Controllable Thermostat

Programmable thermostat with 2-way pager access



Case Studies

- **Long Island Power Authority (LIPA)**
  - **Since 2001, Central A/C units in over 20,000 residential, 3,000 small commercial**
  - **Free thermostat and $25 (one-time)**
  - **Customers have thermostat access over Internet**
  - **LIPA can control up to 7 days from 2-6 pm**
  - **Customer can override without penalty**

Case Studies

- **Consolidated Edison Company of NY**
  - **Since 2002, now over 15,000 thermostats at residential sites**
  - **Free thermostat and $25 (one-time)**
  - **Thermostat access over Internet**
  - **Controls when NY ISO requests (typically peak summer days 1-6 pm)**
  - **Customer can override without penalty**
  - **Small Commercial Pilot Program (2004)**
    - **Same terms except scalable one-time incentive ($25 per 3 ton increment)**
    - **By 2008, over 6,000 thermostats**

Case Studies

- **Southern California Edison (SCE)**
  - **Since 2002; target of 5,000 small commercial sites (achieved in 2003); approved for 2004**
  - **Free thermostat plus $300 annual incentive, with $5 penalty for each override**
  - **Control varies from 1-6 pm; in 2003 up to 20 control days allowed**
  - **Logger data on sample confirmed runtime data accuracy (within 3%)**

Thermostat Control Options

- **Duty Cycle Control**
  - **Limits runtime to a fixed percentage (e.g. 50% control limits to 15 minutes off per half-hour)**
  - **LIPA and Con Edison typically used 50% duty cycle control**
- **Setpoint Temperature Control**
  - **Increase current A/C thermostat setpoint by a specific value (e.g. 4 degrees)**
  - **SCE typically used 4 degree temperature control**

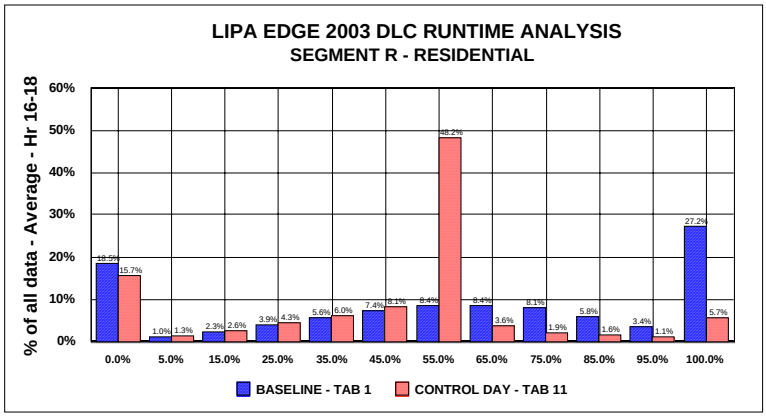
DLC Impact Evaluation

- **Hybrid Comparison Day Analysis**
  - **Use best comparison day, based on closest day with similar weather**
    - **Temperature, humidity, heat build-up**
    - **Patterns change over course of summer**
    - **Not cost-effective to collect every day**
  - **Compare baseline and control day**
    - **2-3 hours before control hour should match closely**
  - **Small Adjustment may be needed to match up**

Duty Cycle Control Case

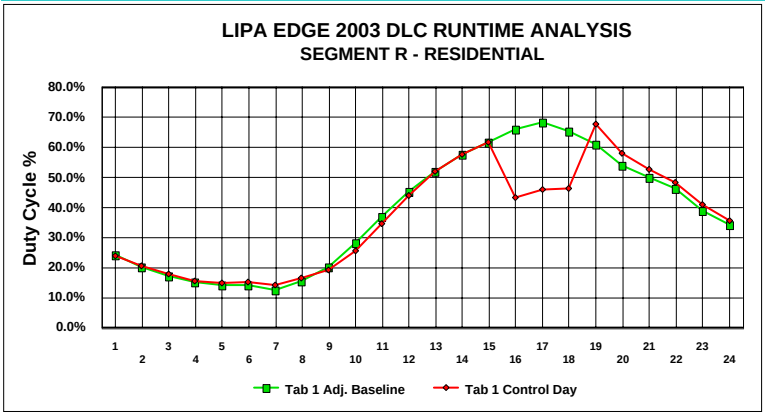
- **LIPA (NY) and Con Edison**
  - **Use 50% Duty Cycle Control**
  - **Both residential and commercial sites**
  - **Typically control during afternoon utility peak period (1-6 pm or 2-6 pm)**
  - **Allow overrides without penalty**
  - **Can confirm control and monitor overrides**

Duty Cycle Control Case



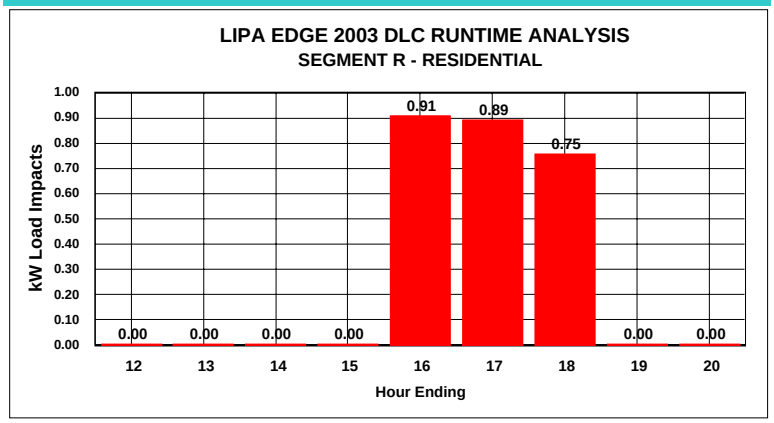
15-18% off; 25% of baseline @100%; only overrides over 55%

Duty Cycle Control Case



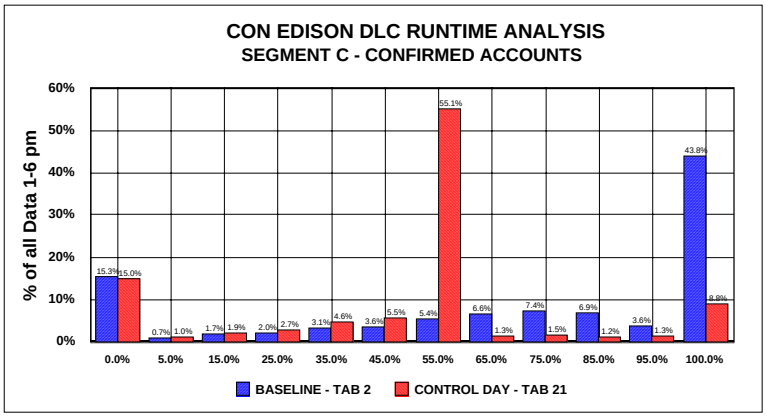
Control 3-6 pm; Some “payback” after control ends

Duty Cycle Control Case



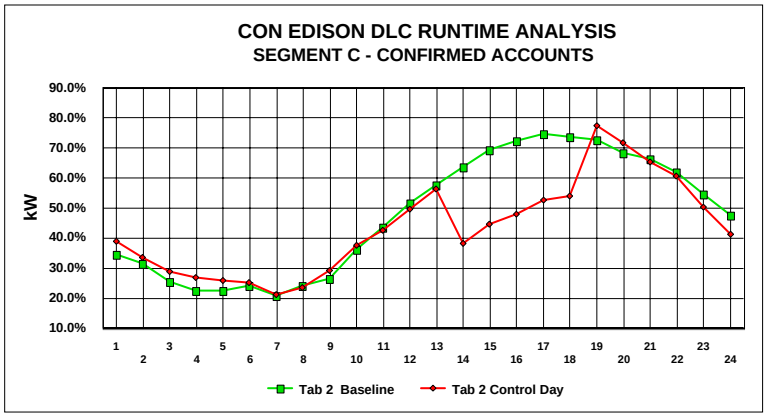
Impacts reduced over time mainly from increased overrides

Duty Cycle Control Case



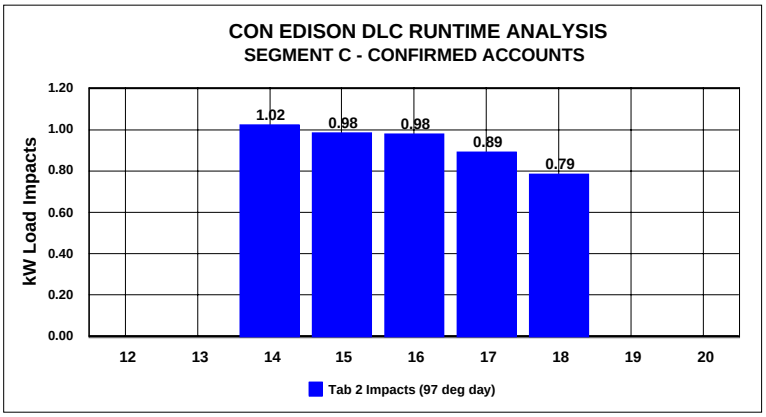
Residential: 15% off; 44% of baseline @100%

Duty Cycle Control Case



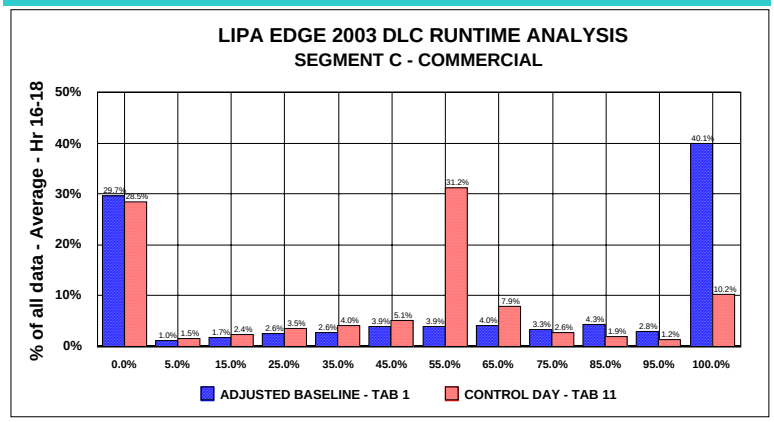
Residential 1-6 pm control - some “payback” after control ends

Duty Cycle Control Case



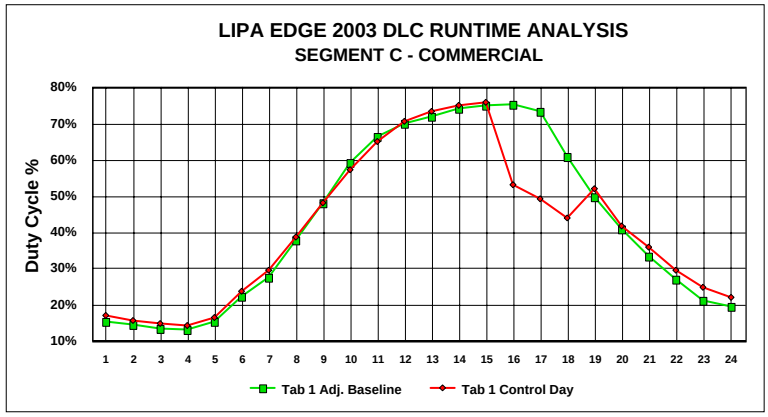
Impacts reduced over time mainly from increased overrides

Duty Cycle Control Case



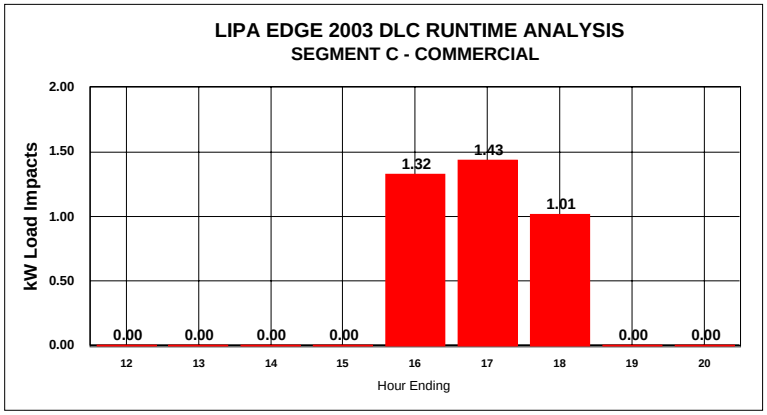
Commercial: About 40% @100%, nearly 30% of units were off

Duty Cycle Control Case



Control 3-6pm; No observed payback

Duty Cycle Control Case



Impacts reduced over time mainly from declining loads

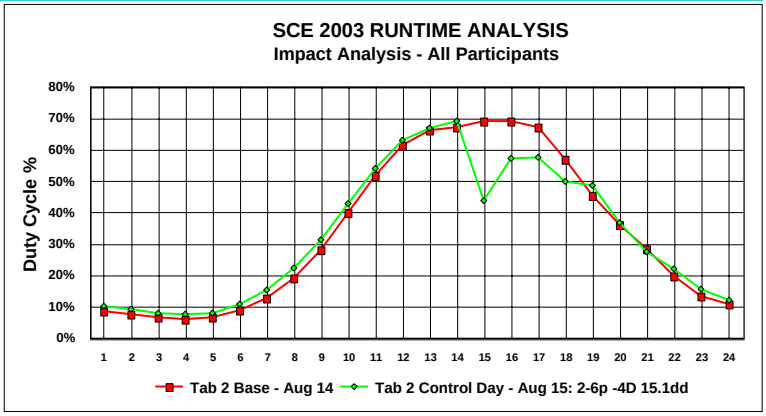
Duty Cycle Control

- **Only effective on customers whose base duty cycle (runtime) exceeds limit (e.g. 50%)**
- **Impacts are larger on more severe days as more customers exceed the duty cycle limit – more suited to emergency operation**
- **Impacts are more consistent and maintained for a longer period**
- **Potentially more severe on some customers than others, such as those with undersized systems**
- **Easy to identify overrides from runtime data**

Setpoint Temperature Control Cases

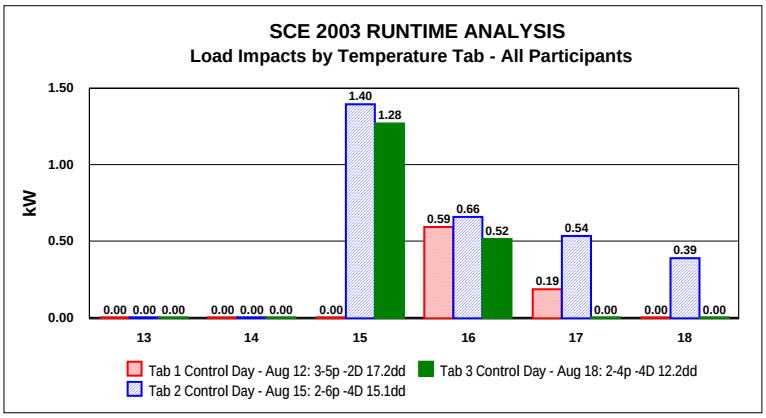
- **Southern California Edison (2003)**
  - **Thermostat setpoint increased**
    - **#1: Aug 12 (3-5, 2 deg.) – 96 degrees max**
    - **#2: Aug 15 (2-6, 4 deg.) – 98 degrees max**
    - **#3: Aug 18 (2-4, 4 deg.) – 88 degrees max**
  - **About 4,400 runtime data points each day (all commercial sites)**

Setpoint Temperature Control Cases



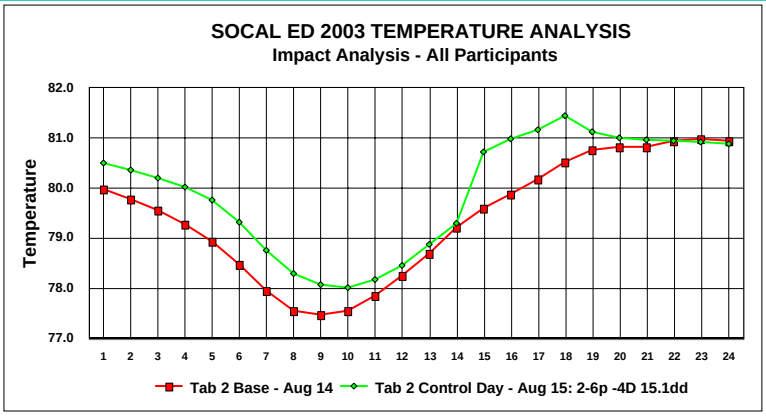
98° max day; 4° setpoint change 2-6pm, no payback

Setpoint Temperature Control Cases



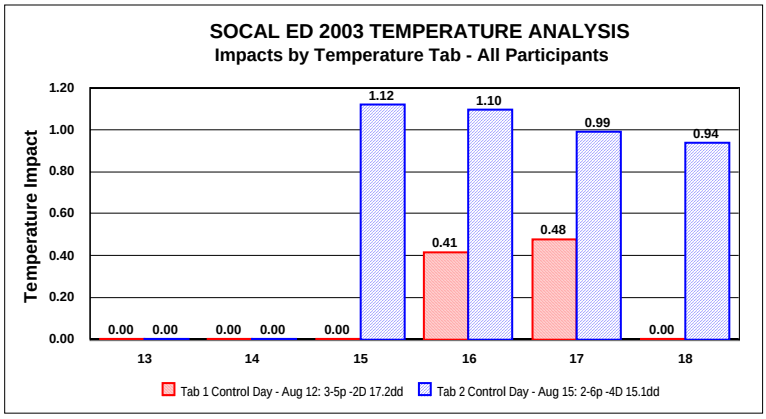
RED (96° max) 3-5pm, 2° control; BLUE (98°) 2-6pm, 4° control; GREEN (88° max) 2-4pm, 4° control

Setpoint Temperature Control Cases



98° Day (2-6pm, 4° control) hourly indoor temperature impacts

Setpoint Temperature Control Cases



RED (96° max) 3-5pm, 2° control; BLUE (98°) 2-6pm, 4° control – Indoor Temperature Impacts

Setpoint Temperature Control

- **Affects all customers equally in terms of relative comfort**
- **Impacts are consistent across a range of weather conditions – more suited to frequent use as a load reduction option**
- **Impacts are more pronounced in first hour and decline in subsequent hours**
- **Potential for customers to pre-cool and reduce impact achieved**
- **Could penalize customers already conserving**
- **Difficult to identify overrides from runtime data, but should see fewer overrides**

Duty Cycle vs. Setpoint Control

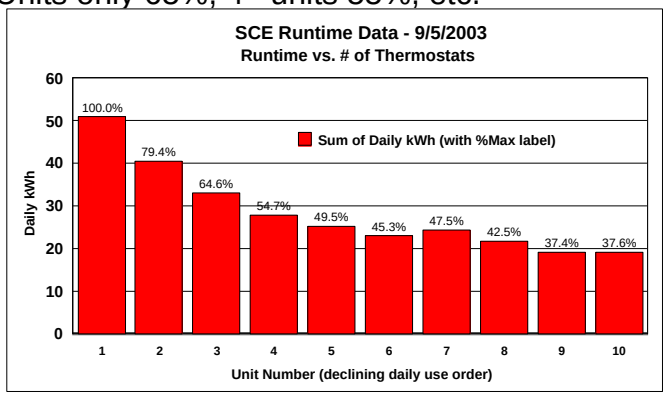
- Duty Cycle Control
  - More effective for longer periods
  - More suited to residential
- Temperature Setpoint Control
  - More consistent across participants
  - Higher initial hour impacts
  - More suited to commercial (declining PM loads)

Free Riders

- Some Participants off during control period:
  - App. 15-18% of residential units off on hot days
    - Mostly people not home, on vacation or prefer not using their A/C
    - Some multiple units (e.g. 2nd Floors) are 31% of LIPA; 81% of all units are single/1st
  - App. 22-30% of comm. units off on hot days
    - Multiple units are 60% of all units in SCE; 60% of units are single/1st; 21% are 2nd units

Free Riders: Multiple Units

Commercial: 2nd Units use only 79% of Primary Units; 3rd Units only 65%, 4th units 55%, etc.



Free Riders

- **Could only be reduced by pre-qualifying units at a site to increase average impacts**
  - **Potential Discrimination Issue**
  - **Minimum summer use billing increment level**
  - **Residential sites could exclude 2nd floor if only bedrooms (lower use and less coincident)**
  - **Commercial sites would require evaluation of likelihood of little-used units**
- **Free Riders are generally unavoidable, but must be factored into any assessment of potential impacts and costs**

SUMMARY

- For Residential programs
  - Duty cycle control works best, especially for only a few control days per season
  - Could reduce free riders by target marketing to higher summer use customers
  - Temperature setpoint control would work best for energy conservation improvements (by utility or customer)
  - Most customers (77%) use programmable features of thermostats themselves

SUMMARY

- For Commercial programs
  - Temperature setpoint control works best if many control days or short-duration curtailments – should also reduce overrides
  - Duty Cycle control works best for more hours of sustained load reduction
  - Runtime data could provide good source of baseline A/C load profiles by business type
  - Targeting specific business types would be advisable