

Case Studies in Advanced Thermostat Control for Demand Response

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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**
 - **Monitoring and control capability**
 - **Internet access**
 - **Interval data (runtime and temperature) available for virtually all sites**
 - **Customer overrides can be tracked**



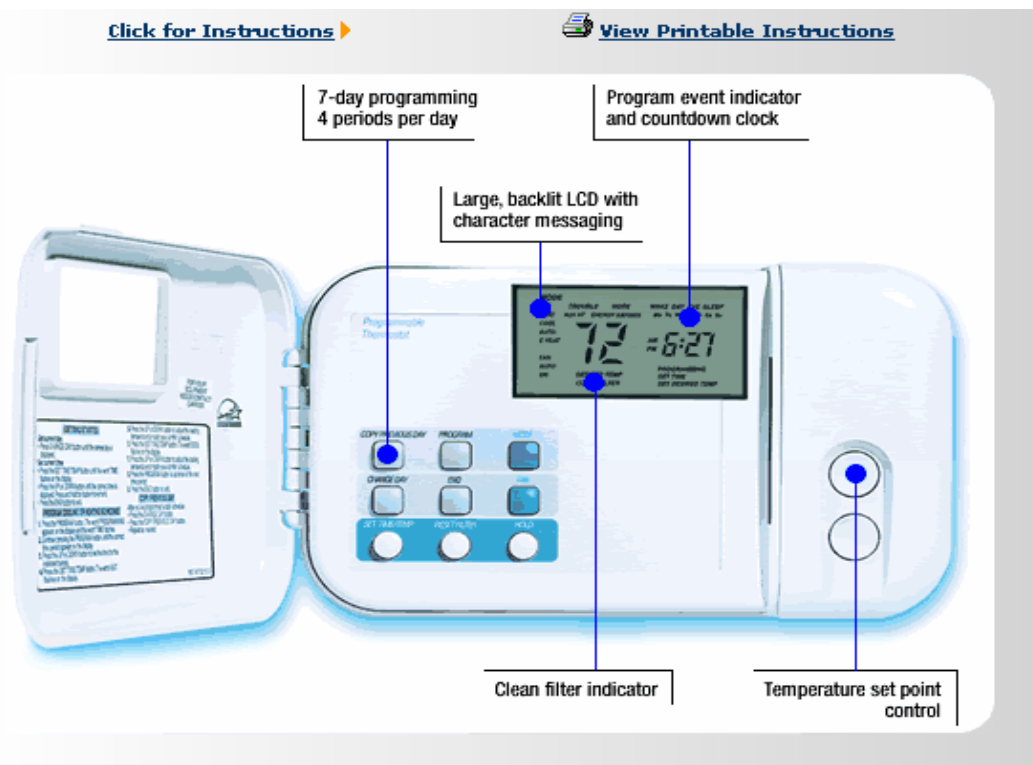
Case Studies

- **AEG experience with four utilities:**
 - **LIPA (NY), Southern California Edison, Consolidated Edison, Aquila (new for 2004)**
 - **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**



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 10,000 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)**



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**

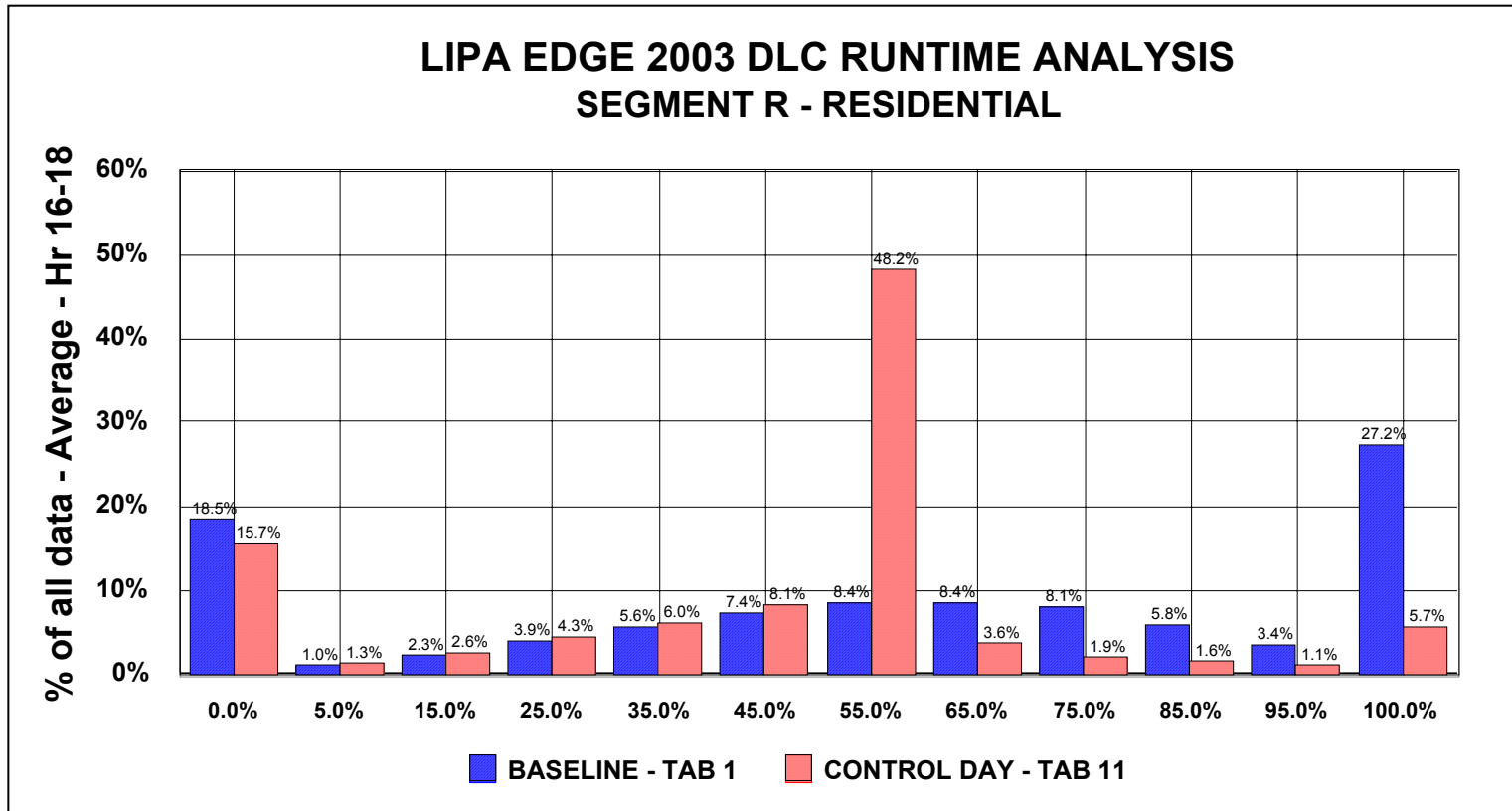


Duty Cycle Control Case

- **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**



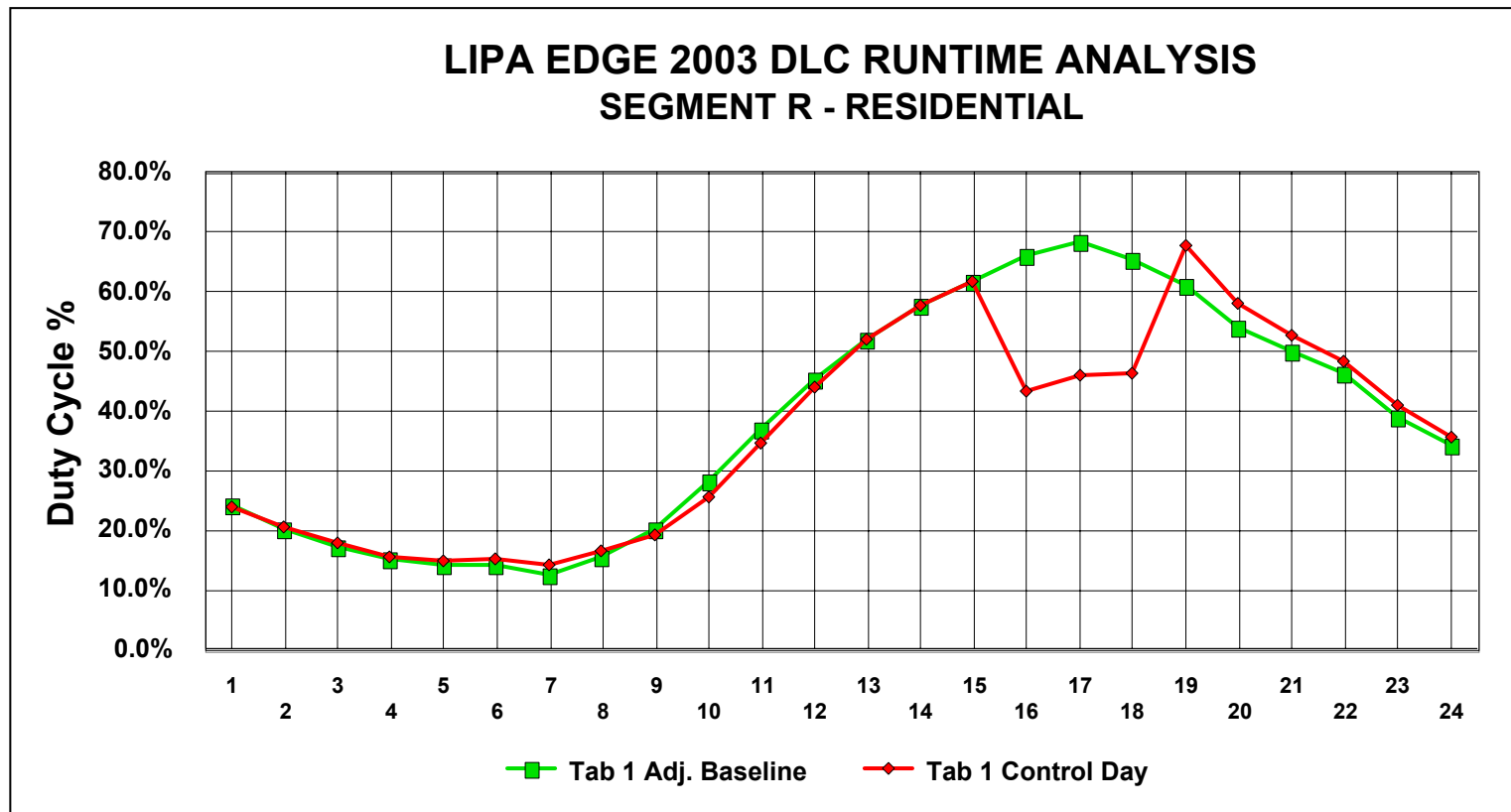
Duty Cycle Control Case



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



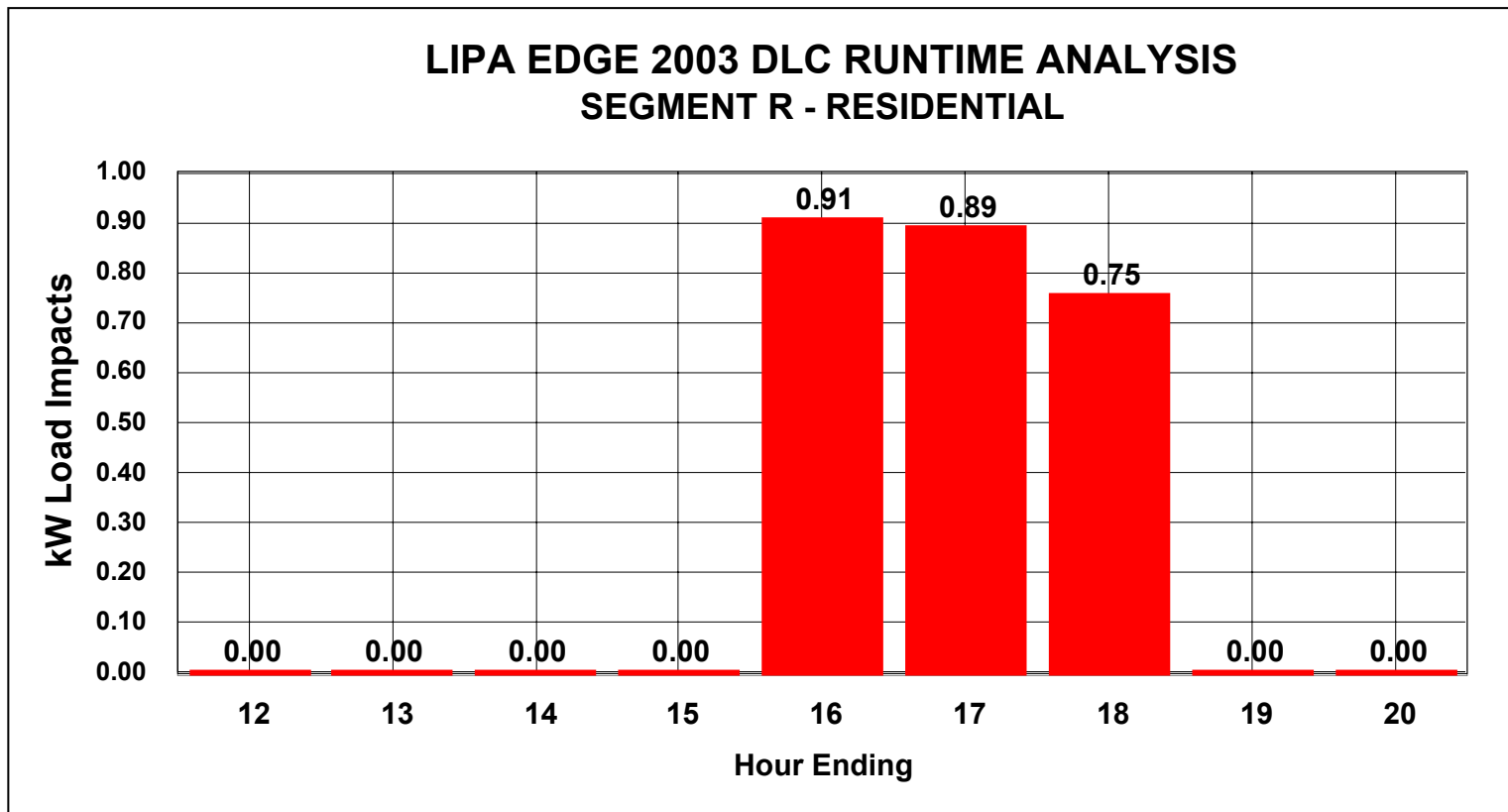
Duty Cycle Control Case



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



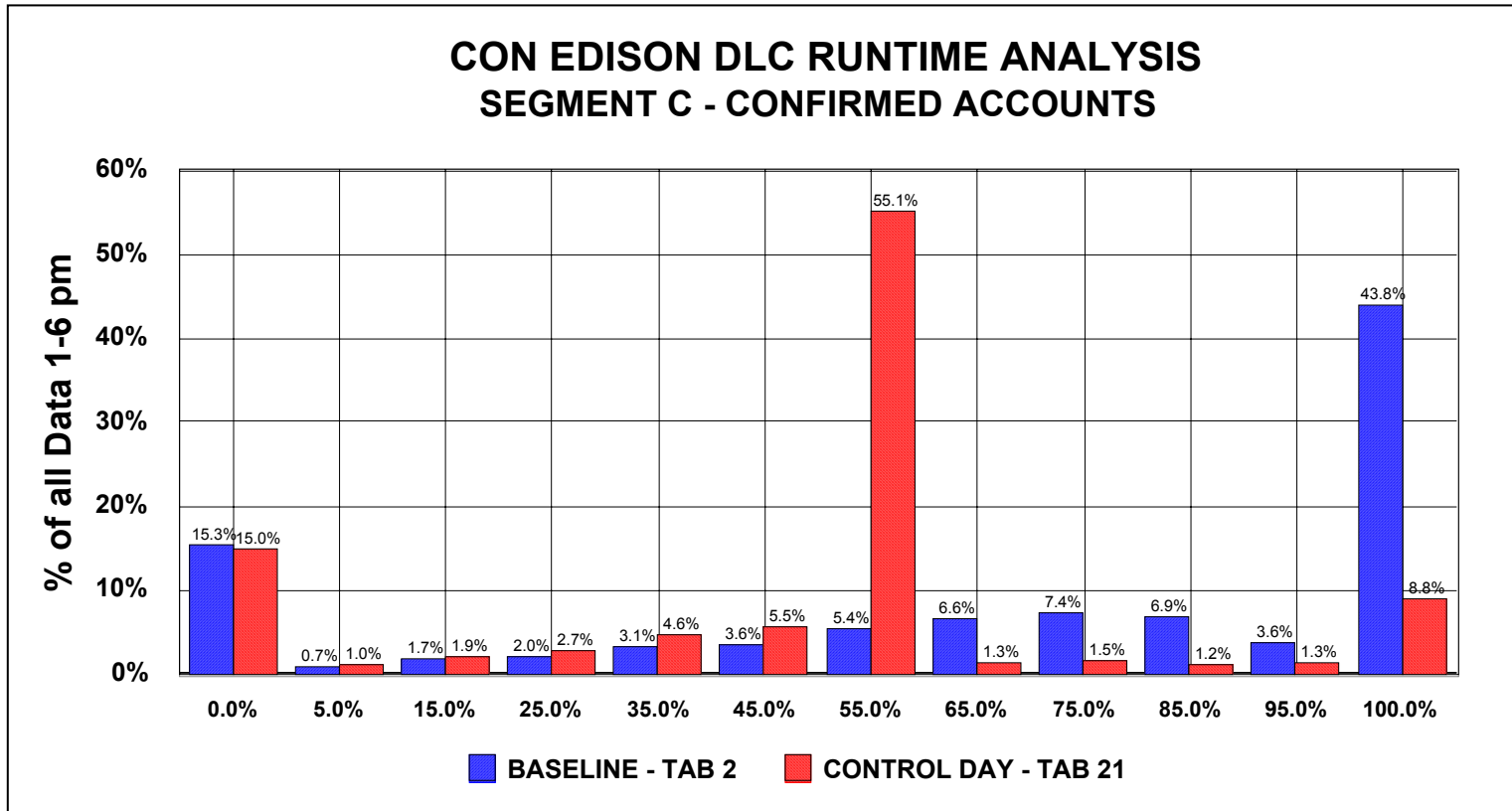
Duty Cycle Control Case



Impacts reduced over time mainly from increased overrides



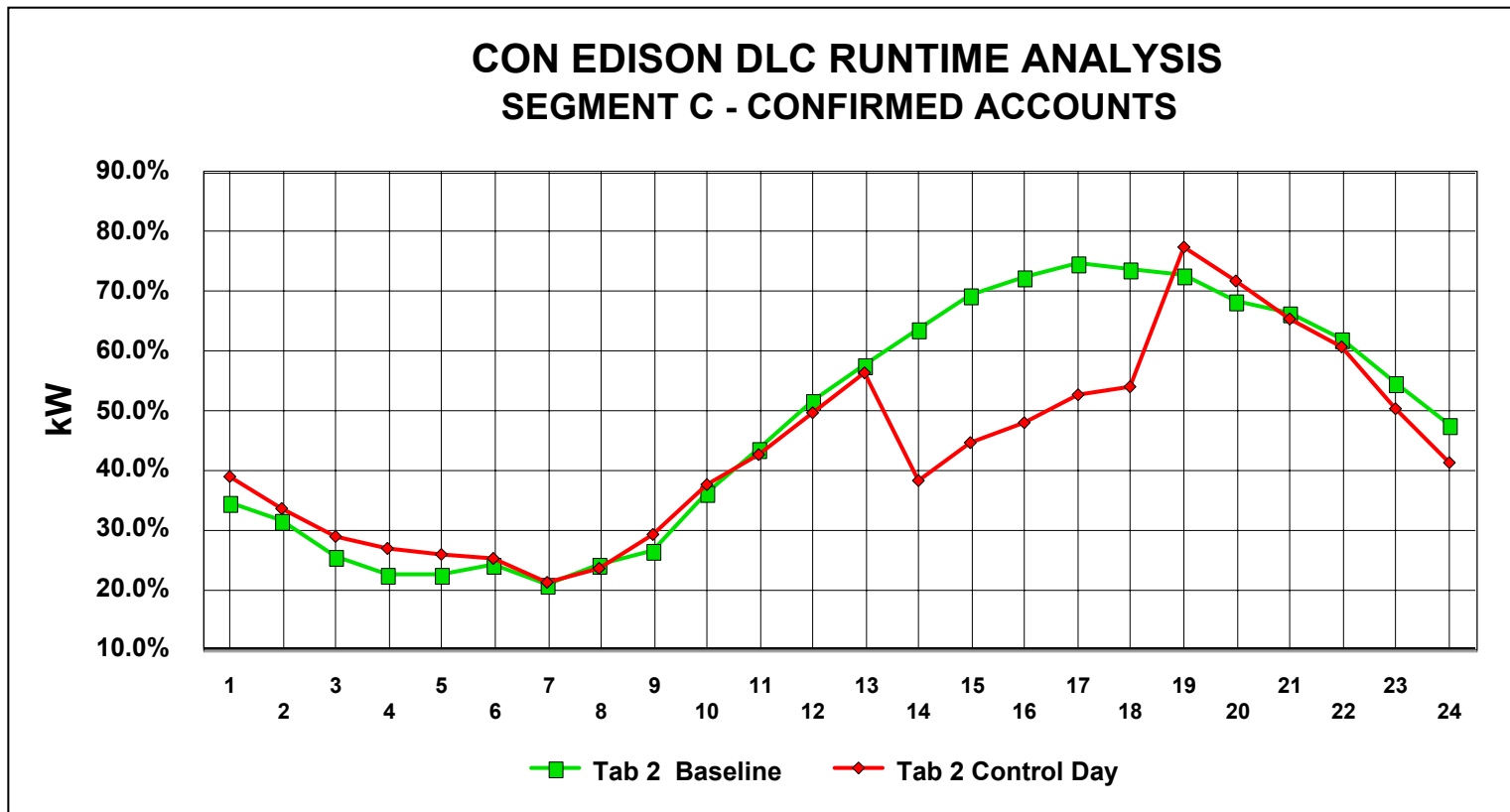
Duty Cycle Control Case



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



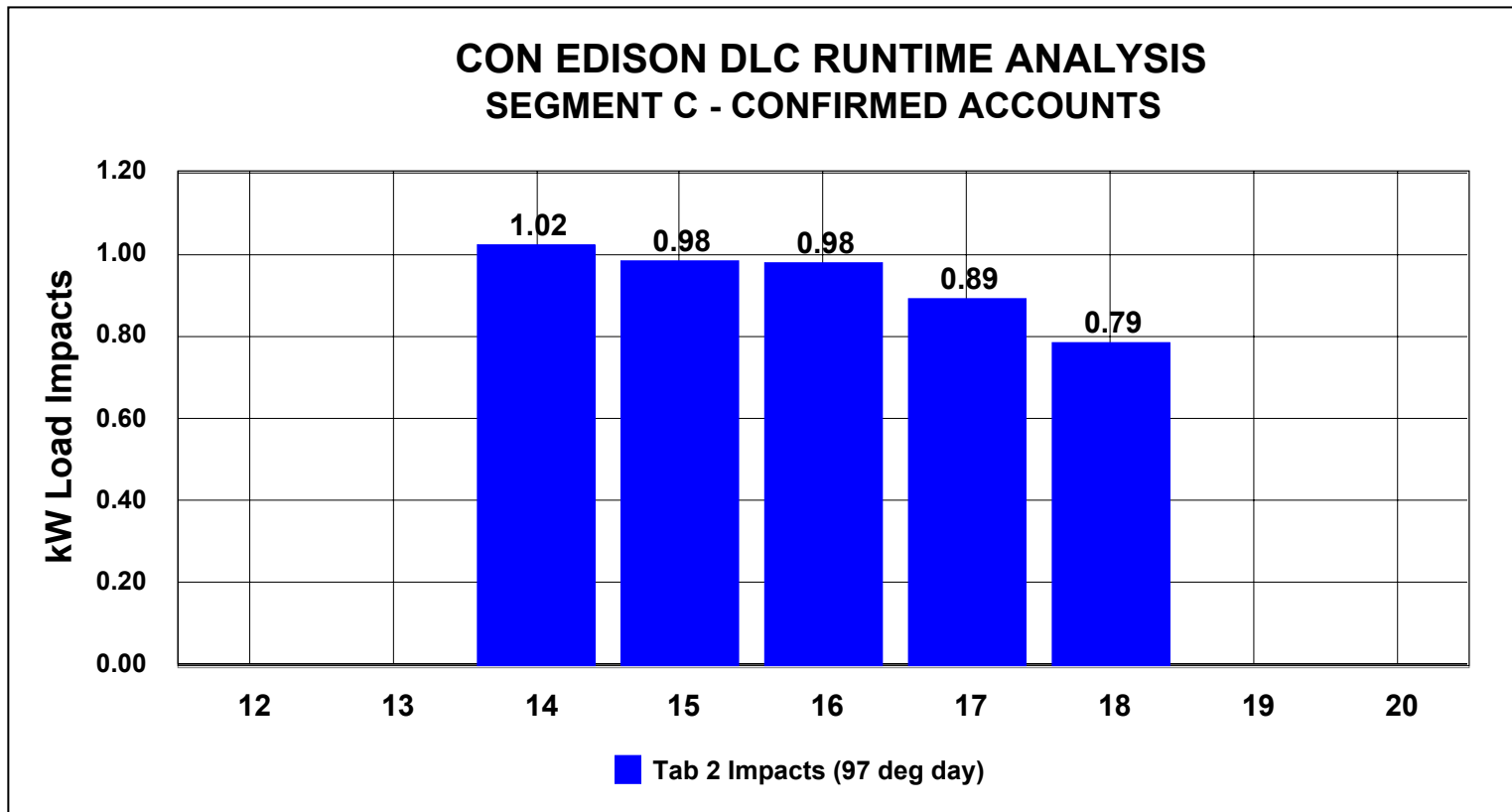
Duty Cycle Control Case



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



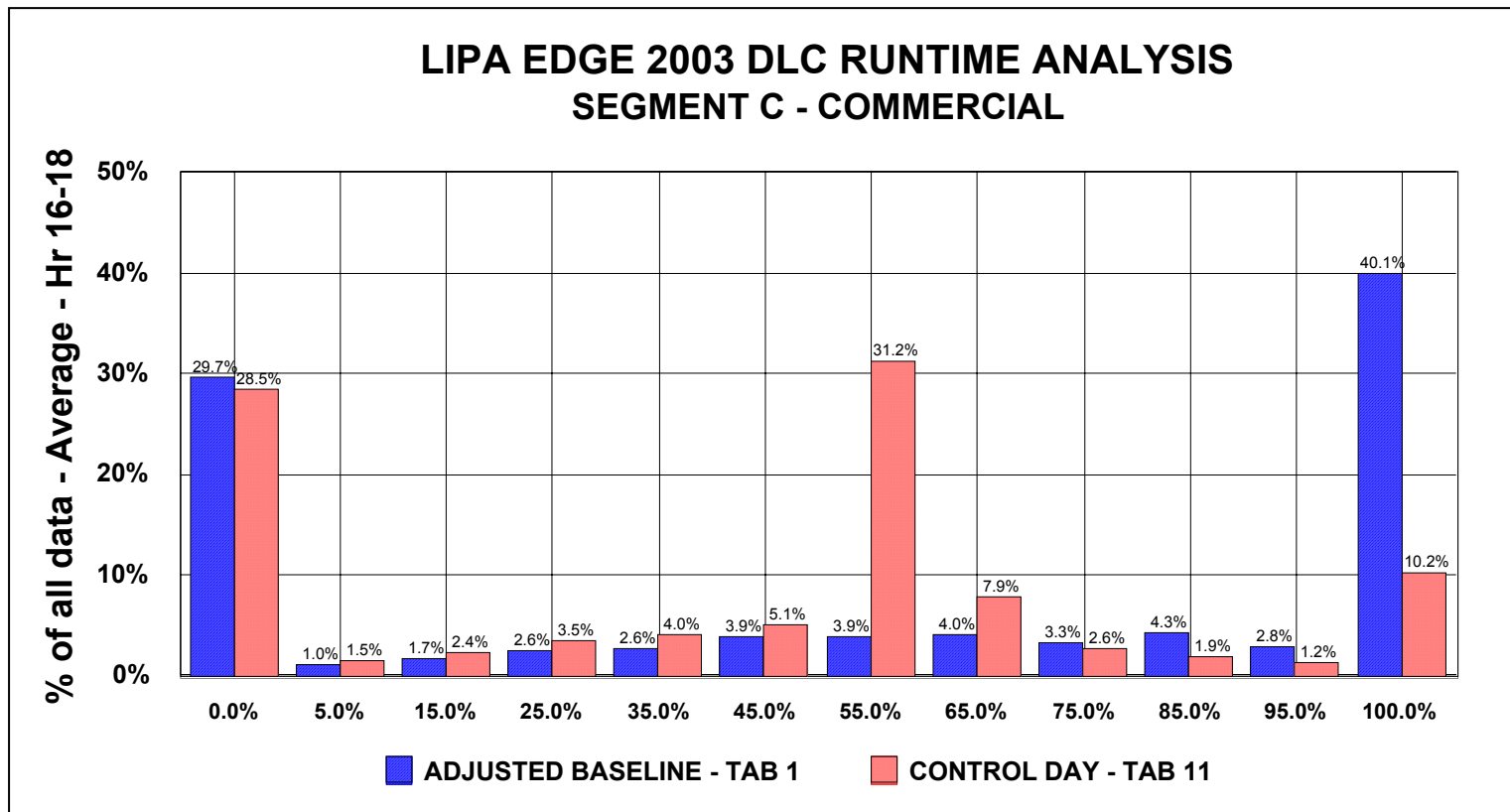
Duty Cycle Control Case



Impacts reduced over time mainly from increased overrides



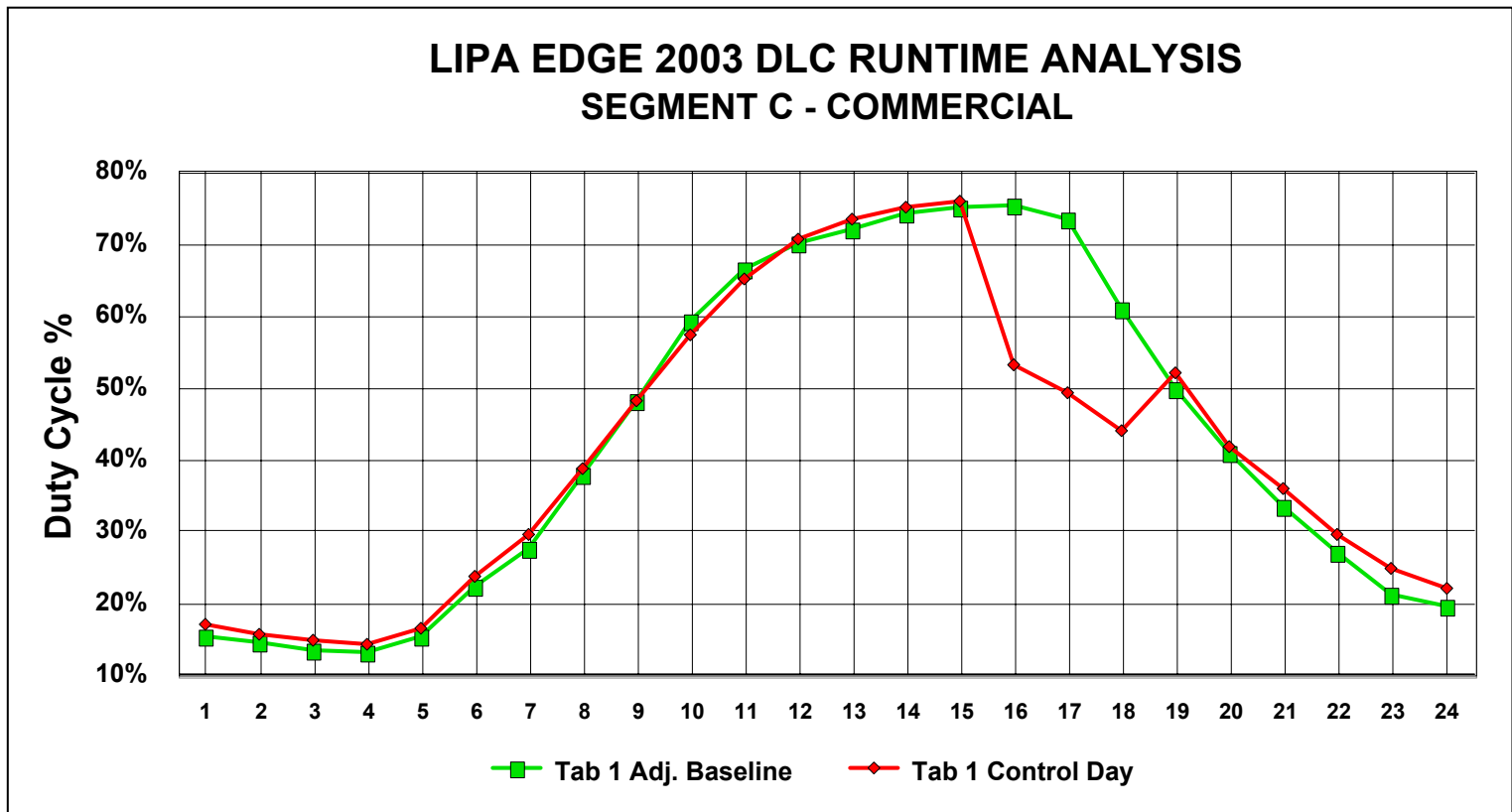
Duty Cycle Control Case



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



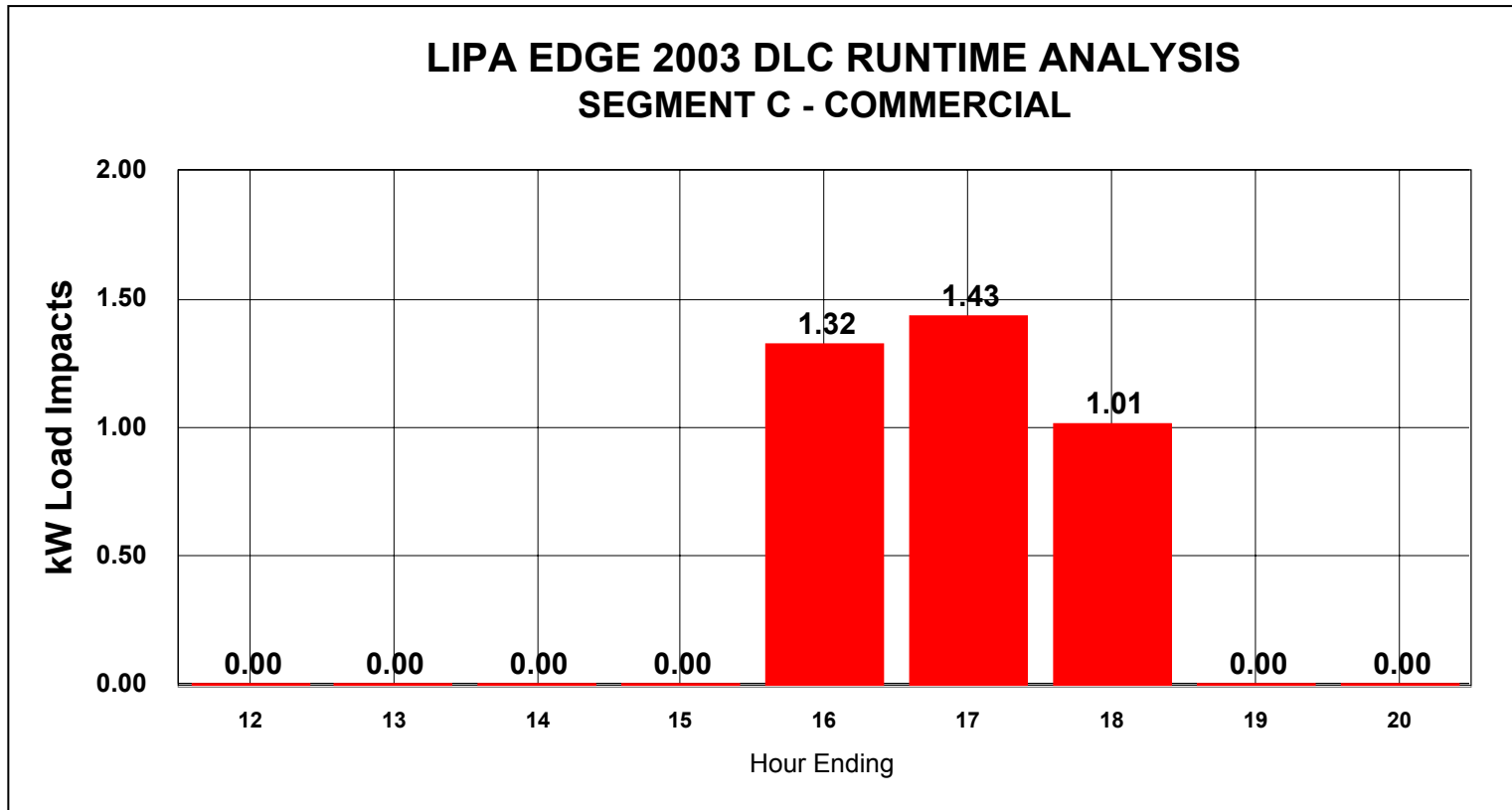
Duty Cycle Control Case



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**

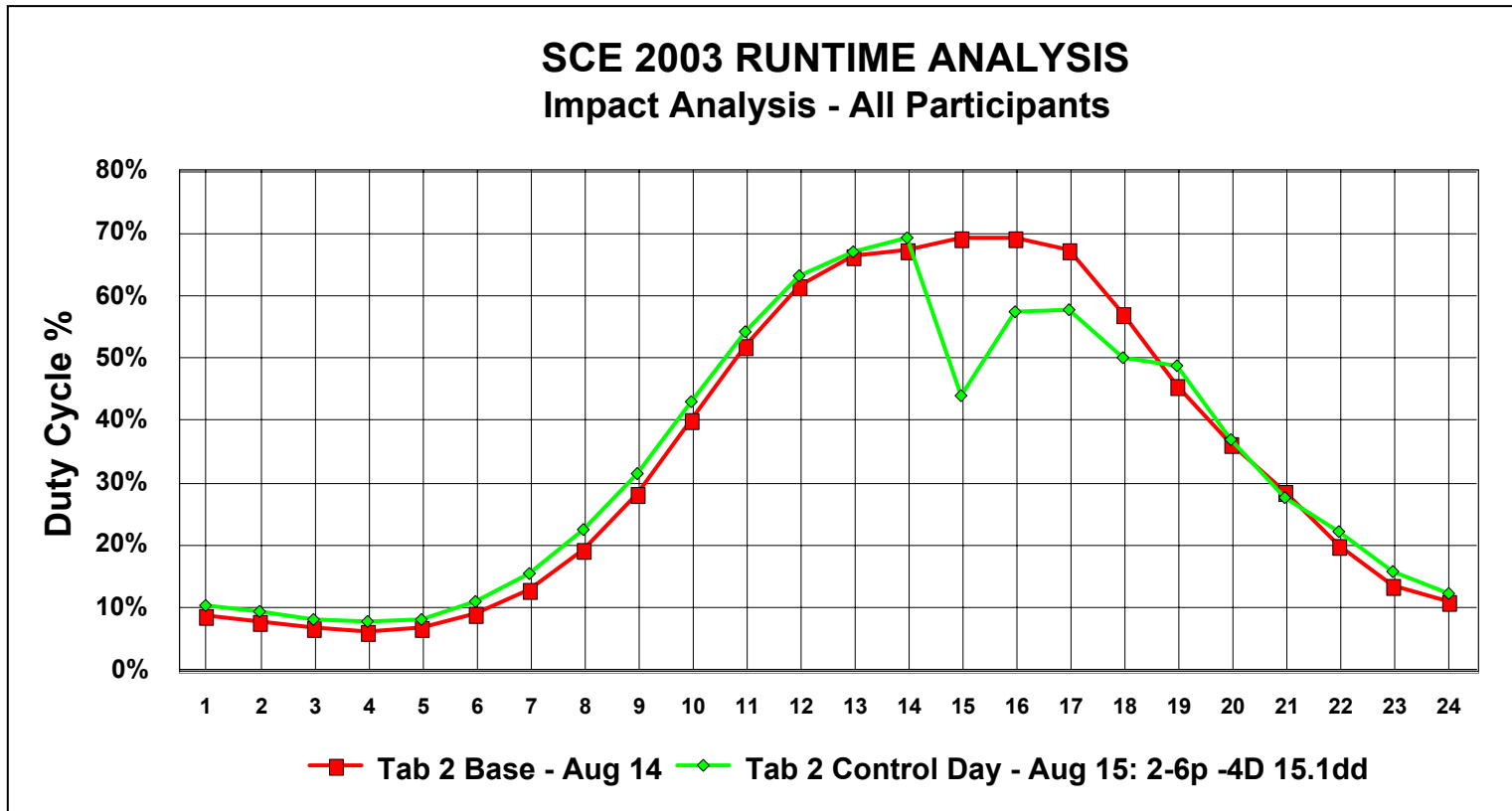


Setpoint Temperature Control Cases

- **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)**



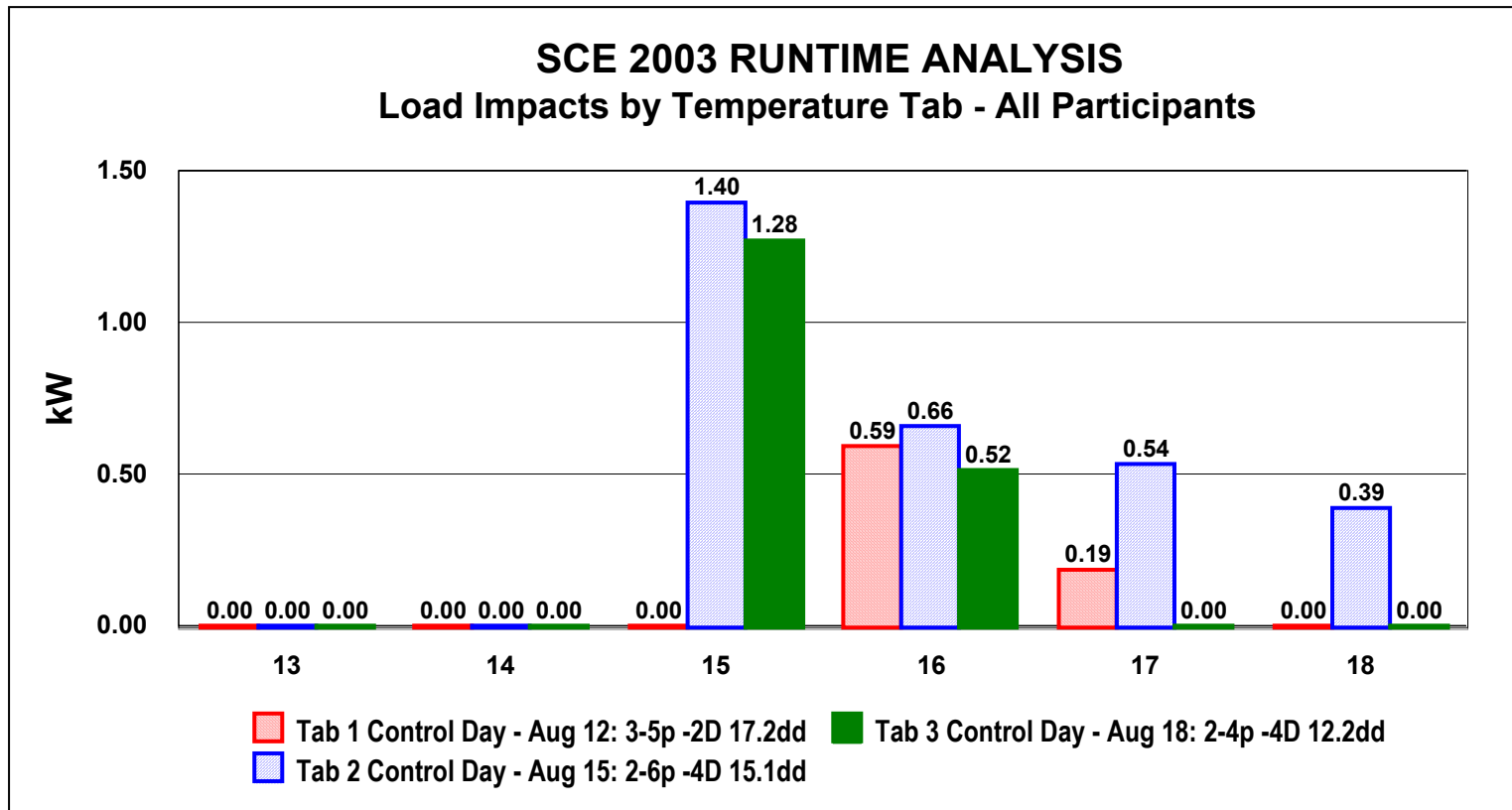
Setpoint Temperature Control Cases



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



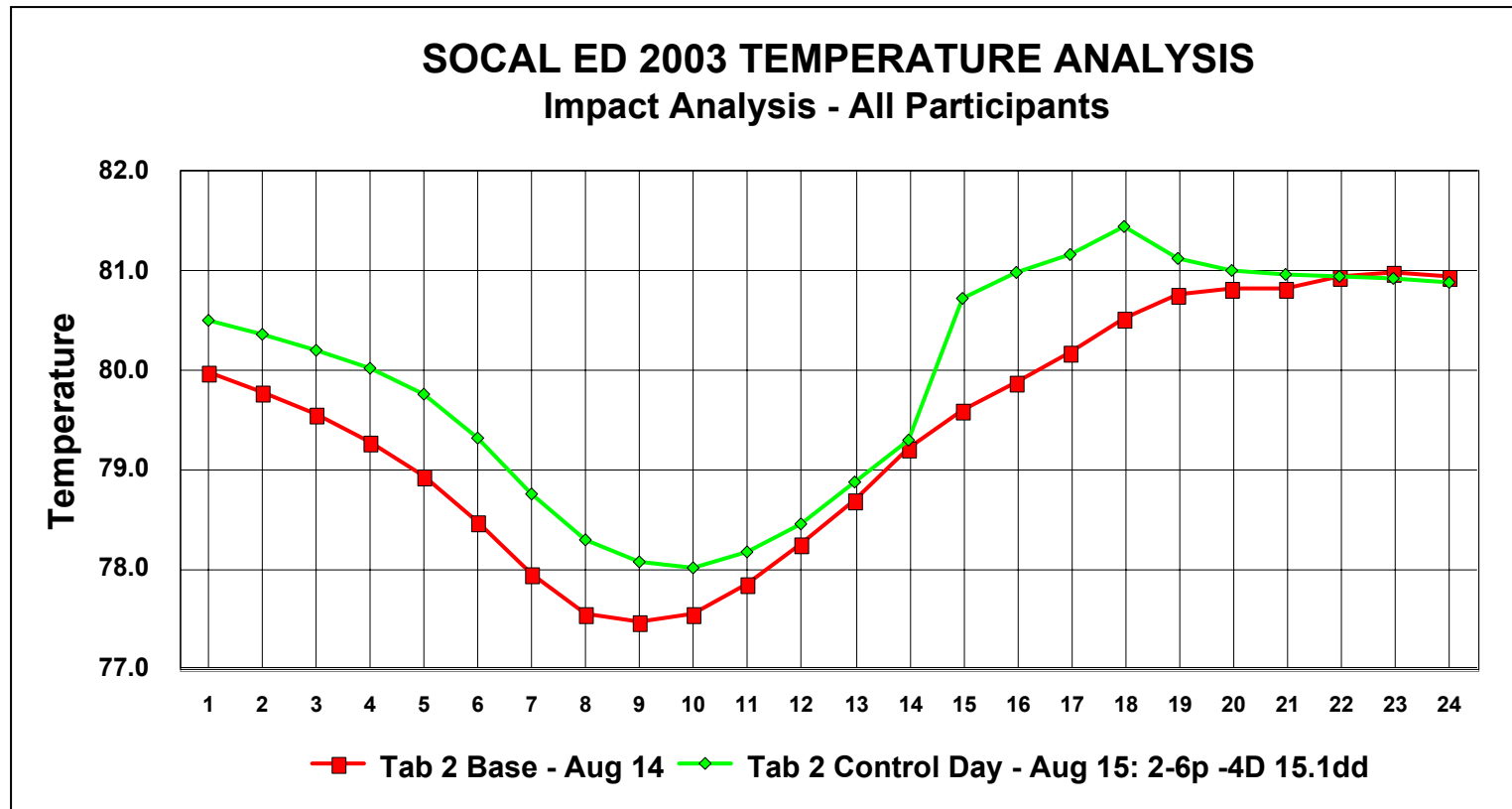
Setpoint Temperature Control Cases



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



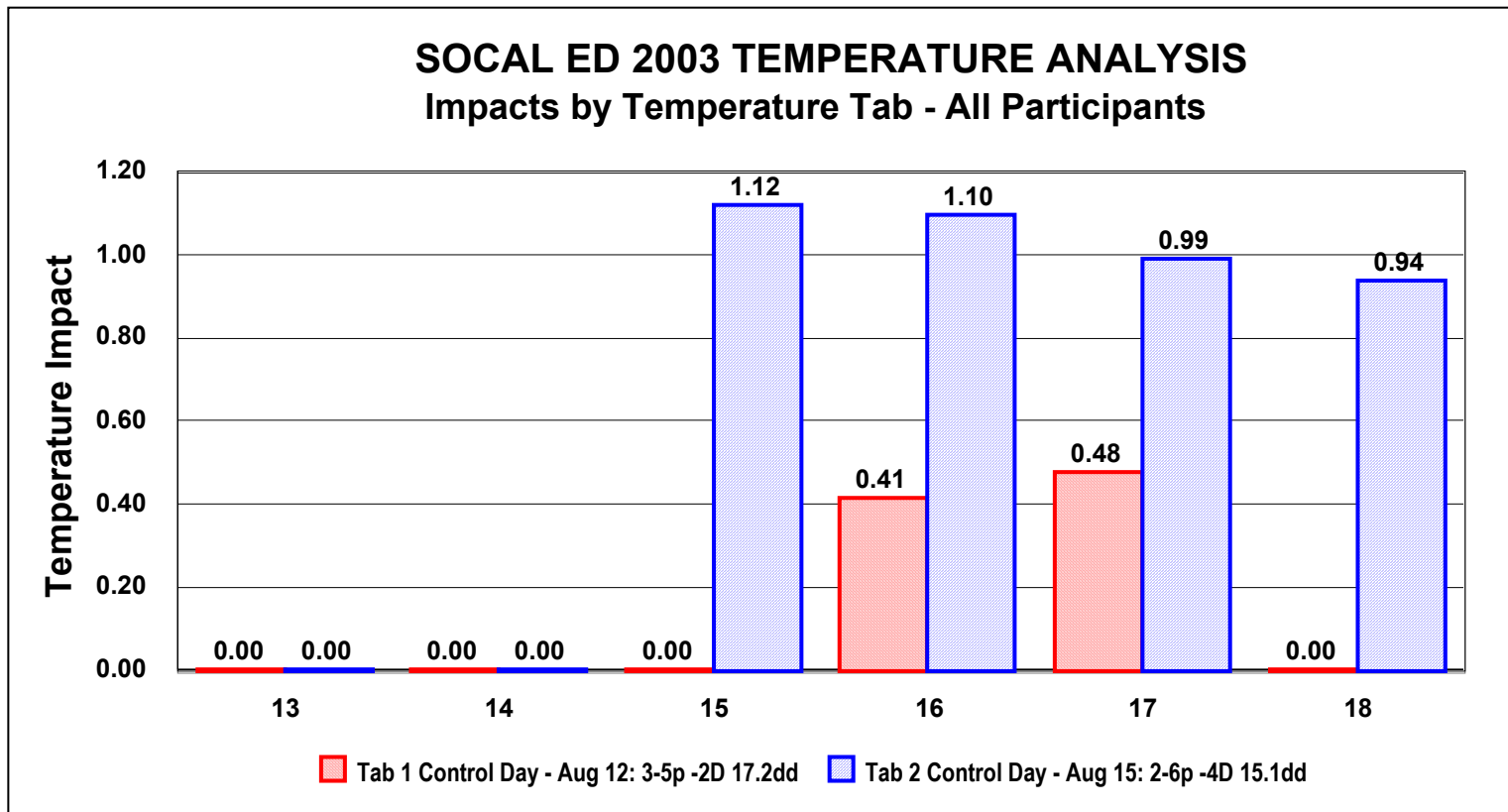
Setpoint Temperature Control Cases



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)



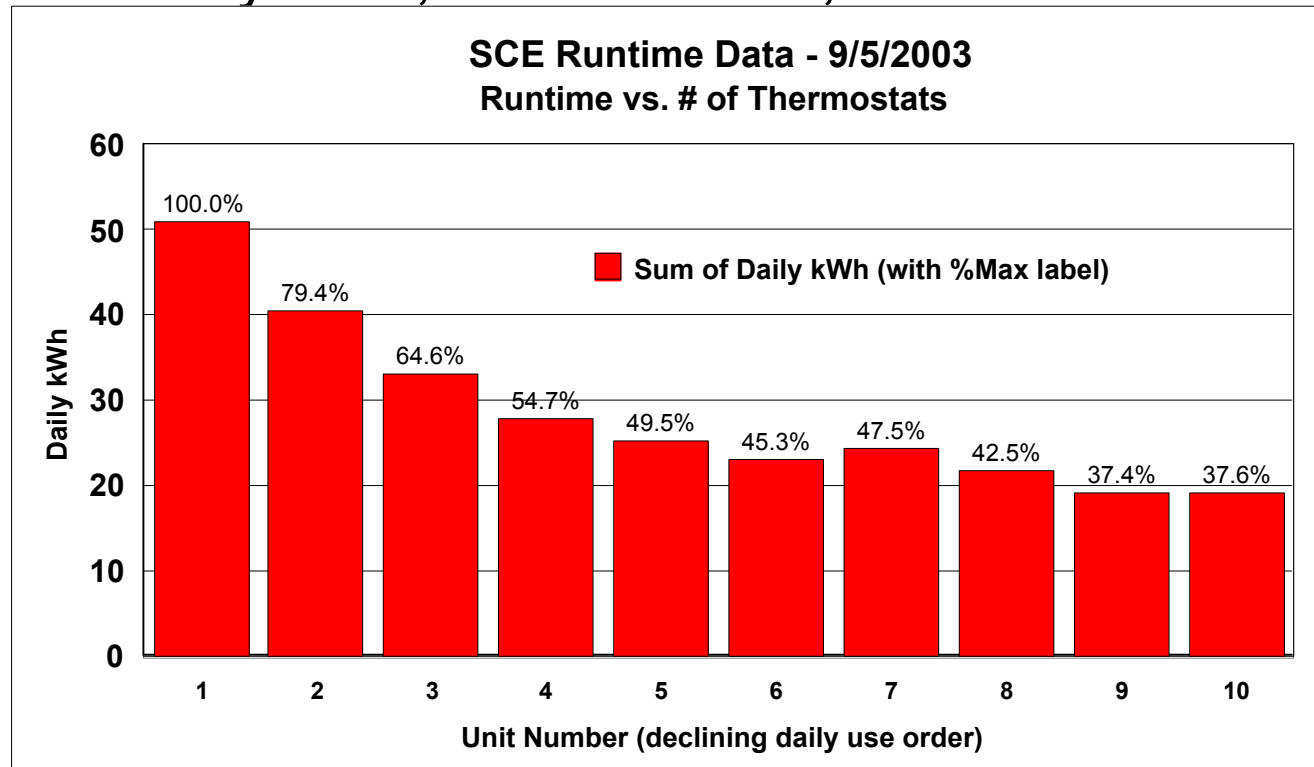
Free Riders

- **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**



NOTES



Notes

