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RETRO-COMMISSIONING
Examples and Ongoing Commissioning

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Who – Retro-Commissioning (RCx) Example I

- Energy Management Team (EMT) tasked to determine
  - effectiveness of RCx in their buildings
- Chose Building 6585 as the test case ~ 10 years old
- Electricity use looked normal, summer gas high
- Decided to contract with Energy Systems Laboratory (ESL) to implement RCx in Building 6585

Building 6585 – Technology Support Center

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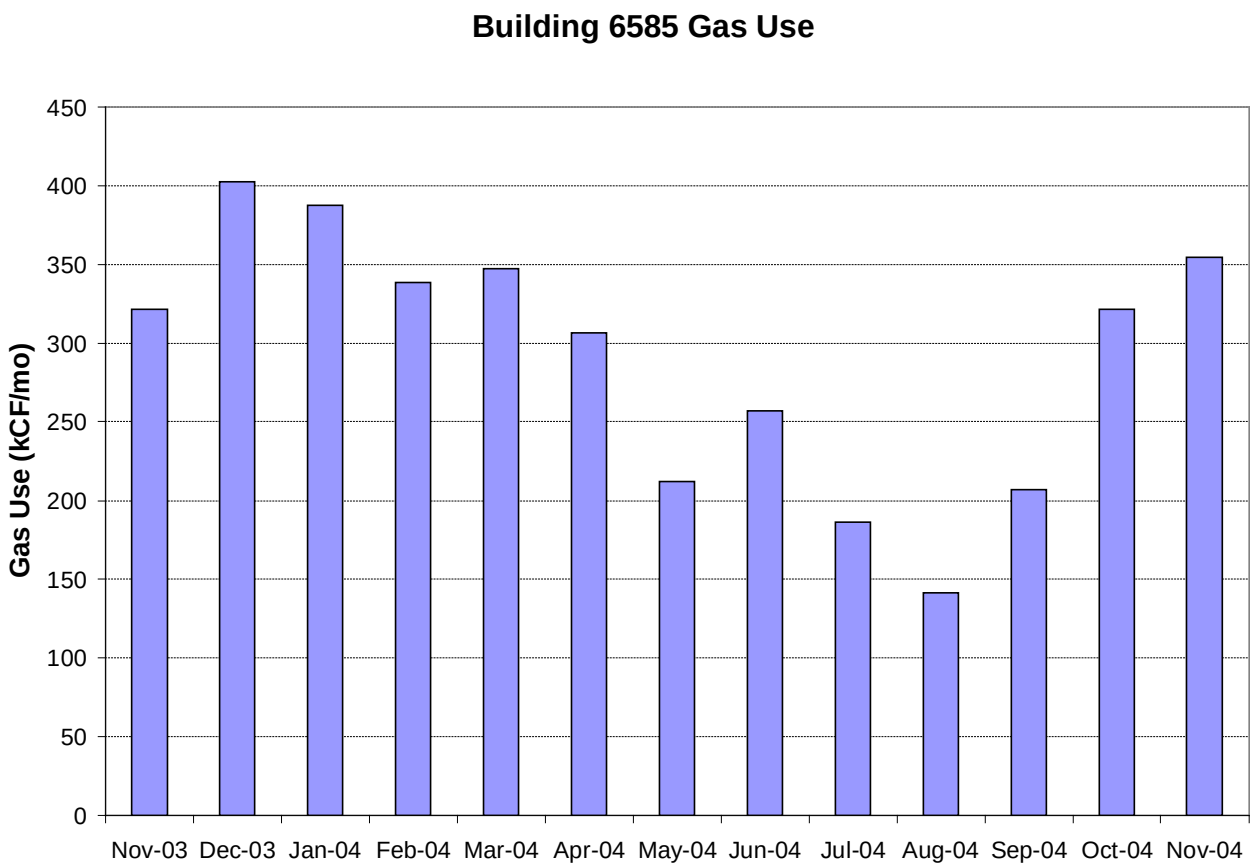
Building Characteristics

- 2-story bldg with basement + HVAC penthouse
- Conditioned space is 99,579 ft^2
- Two 4 MMBtu/hr hot water boilers
- Three 225 ton electric screw chillers
- Five single duct VAV AHUs with reheat
- Direct and indirect evaporative cooling provide all cooling for 6+ months per year
- Siemens Apogee EMCS

Building Characteristics and Operation

One Year of Monthly Gas Consumption in Building 6585



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Building Characteristics and Operation

Baseline Energy Use/Cost

Type/Use	Annual Use	Cost ($/yr)
Electricity	3,070,189 kWh	$124,957
Gas	3,464 MCF	$ 24,248
Baseline Cost		$149,205
Chiller	224,400 kWh	$ 9,135
Fans & Pumps	475,000 kWh	$ 19,337
Total HVAC		$ 52,720

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RCx Assessment

- Meeting between RCx engineers and EMT discussed
  - Basic systems and control practices
  - Known problems
  - Review of consumption data
- EMCS screens examined
  - Operating conditions/status of AHUs, chillers, boilers, towers, pumps

RCx Assessment (continued)

- Walkthrough of building
  - Detailed examination of HVAC systems
  - Spot measurements of key temps, pressures, flows
- Analysis of data
  - Develop list of preliminary RCx measures
  - Estimate savings from RCx implementation

Key Observations from Walk-Through

- AHUs
  - AHU 1 operated continuously
  - AHUs 2-5 operated 4 or 5am-6pm M-F
  - Constant static pressure set-points
- VAV Boxes
  - Average minimum flow settings >0.5 cfm/sq.ft.
- Loop Balancing
  - Numerous manual CHW valves 50% closed
  - HW pump VFD at 100%

Major Assessment Recommendations/Findings

- Check VAV boxes, determine required minimum flows and reduce where appropriate
- Develop and implement optimum start-stop strategy for each AHU
- Optimize static pressure settings for each AHU
- Optimize chilled and hot water secondary loop performance
- Optimize the preheat control strategy

Major Assessment Recommendations/Findings (continued)

- Measure minimum outside air flow settings and change as needed
- Examine and optimize combined economizer/tower cooling control strategy and operation
- Evaluate and optimize the supply temperature reset strategy
- Expected savings of at least $23,000/year

RCx Investigation and Implementation

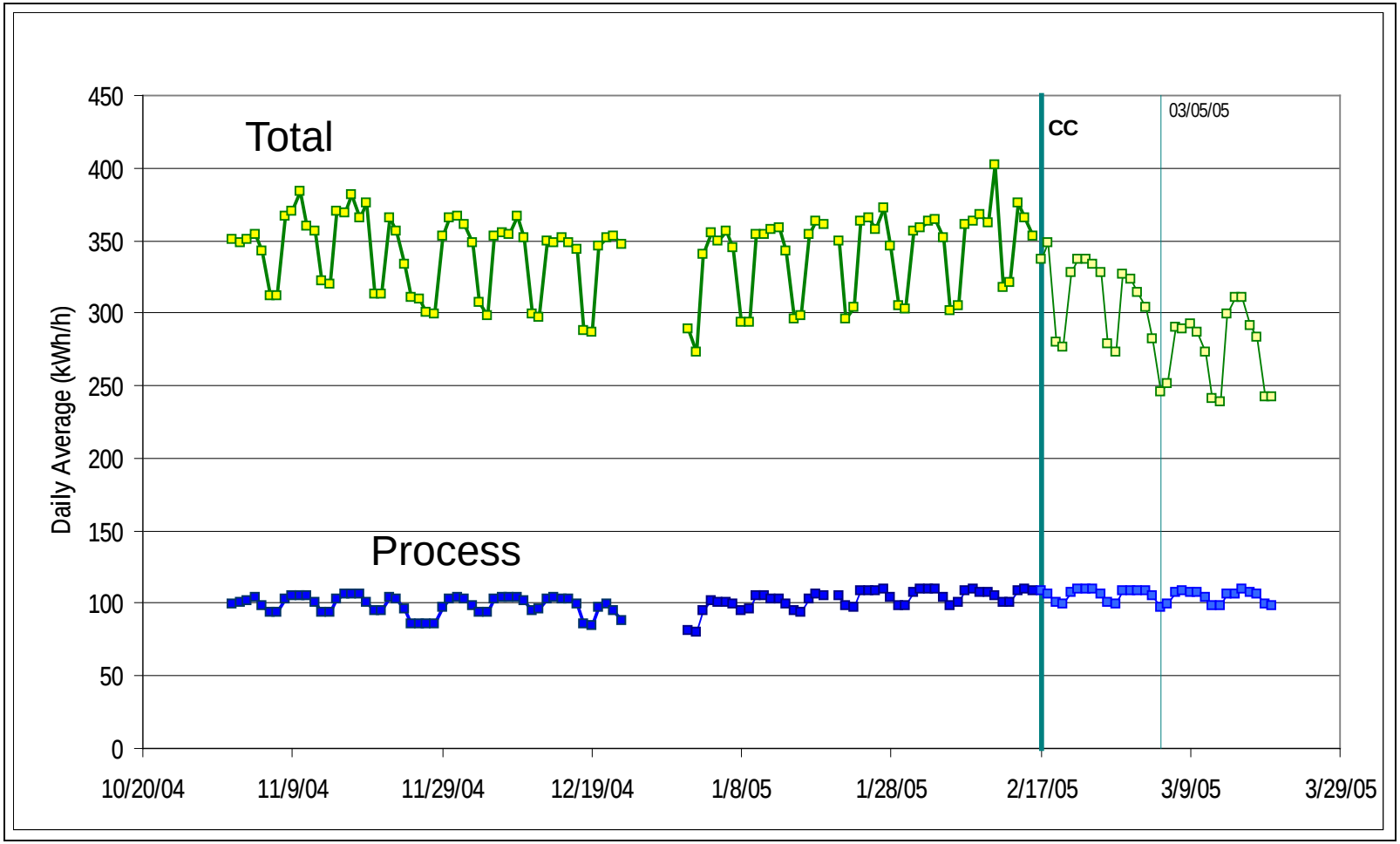
- Determined and implemented:
- Optimum start-stop strategy for each AHU (e.g. start at 6 am instead of 4 am)
- ~0.25 cfm/ft^2 terminal box minimum flows
- Static pressure settings ~ 0.5 inWG for each AHU
- Optimum chilled and hot water secondary loop performance DP values and valve positions

RCx Investigation and Implementation (continued)

- Optimum preheat control strategy
- Optimum supply temperature reset strategy
- Minimum outside air flow settings not changed – needed repairs not carried out
- Economizer/tower cooling control strategy and operation not optimized – insufficient time and low benefit

Results

Energy Impact of Initial RCx Implementation – Electric I



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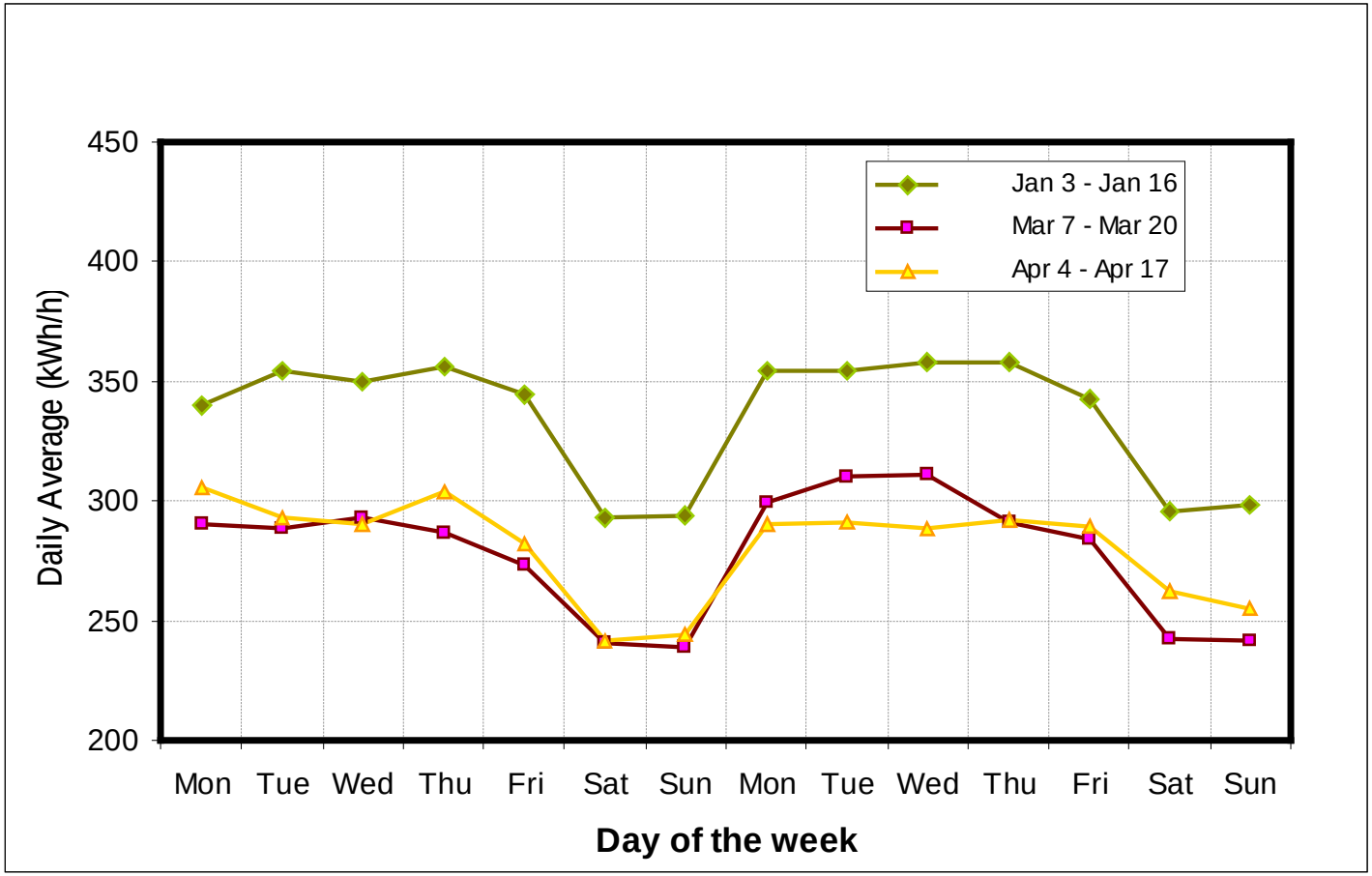
Results

Energy Impact of Initial CC Implementation – Electric II



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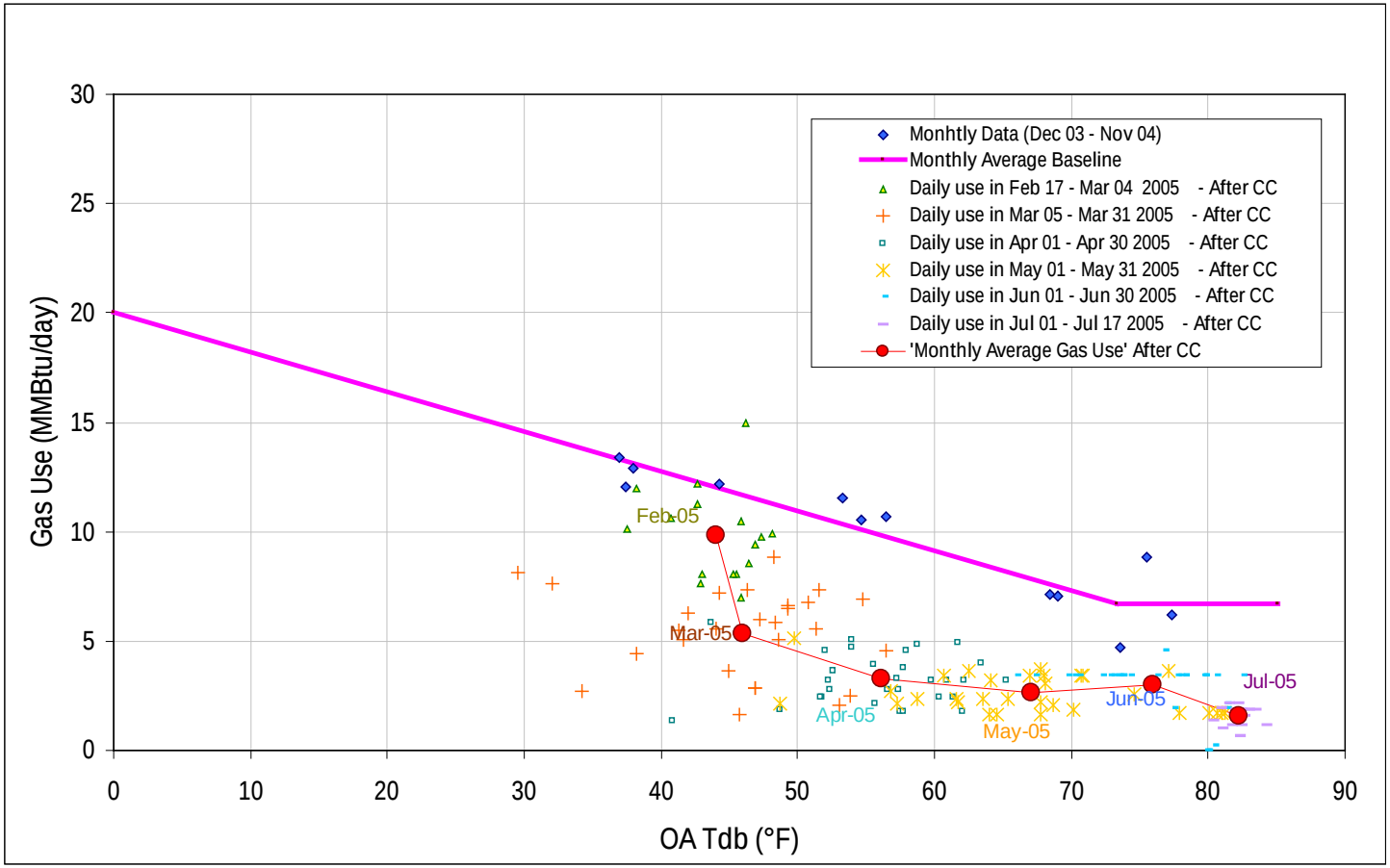
Results

Energy Impact of Initial RCx Implementation – Gas



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Example I Results

Cost Savings from RCx Implementation

Energy Type	Savings Period	Savings	Percent Savings
Electricity (kWh)	1 year	$16,018 (393,570)	13%
Gas (MCF)	1 year	$14,251 (2,036)	59%
Total Savings Project Cost		$30,269 $55,000	20% 1.8 yr payback

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RCx Example II
Airport Terminal D Overview

- Opened in 2005
- 1.9 million sq.ft.
- 27 aviation gates
- 60 retail spaces
- 99 ticket positions
- 91 elevators, 59 escalators, 34 moving sidewalks
- 6 miles of baggage belts
- 52 million kWh/yr

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Terminal D HVAC System

- Over 90 major AHUs serving the terminal
  - ~30 CV AHUs for concourse areas
  - ~60 VAV AHUs serving ~1400 terminal reheat boxes
  - 4 outside air AHUs

Terminal D HVAC System (continued)

- Hot water system
  - 2 pump rooms which can be isolated
  - Each can serve the entire terminal
  - Each has two pumps with VFDs
  - Each has a steam to hot water heat exchanger
- Chilled water
  - Supplied by Central Utility Plant (CUP)

Hardware/Control Issues Identified

- A few fans commanded “on” were actually off
- Some supply air fan VFDs in “hand”
- Some AHUs showed “offline” due to a faulty Network controller
- Missing space temperature sensor for an AHU

Hardware/Control Issues Identified
(continued)

- Significant supply air leak at the air duct connection to an AHU
- Existing AHU static pressure reset program didn't control properly because the control point had been deleted
- Some VAV boxes had their hot water manual valve closed
- Zone temperature setpoint as low as 50ºF

Hardware/Control Issues Identified
(continued)

- A terminal box without hot water valve actuator and no space temperature sensor
- A fan-powered terminal box with a failed fan motor.
- Some terminal boxes with plugged filters
- Several terminal box reheat valves and/or volume dampers were operating backwards

Hardware/Control Issues Identified
(continued)

- Some wireless zone temperature sensors were reading zero due to low battery level, causing the units to operate in the heating mode
- Short cycling of heating water pumps

RCx Efficiency Measures

- Occupancy schedule for AHUs
- Reduce outside air during low occupancy period
- Standardize heating and cooling setpoints to eliminate simultaneous heating and cooling
- Adjust terminal box minimum air flow setpoints
- Convert large constant volume AHUs to VAV operation Optimize supply air temp, duct static pressure, and return fan speed
- Reset HW temperature and ΔP setpoints

Challenges and Approach

- Programming of discontinued terminal box controller
  - Attended a week-long special training session
- Cooperation from building operators
  - Provided workshop to operators
- High turnover with maintenance staff
  - Concern for persistence of savings
  - Addressed by discussing changes with operators and providing them with written instructions

Occupancy Schedule Optimization

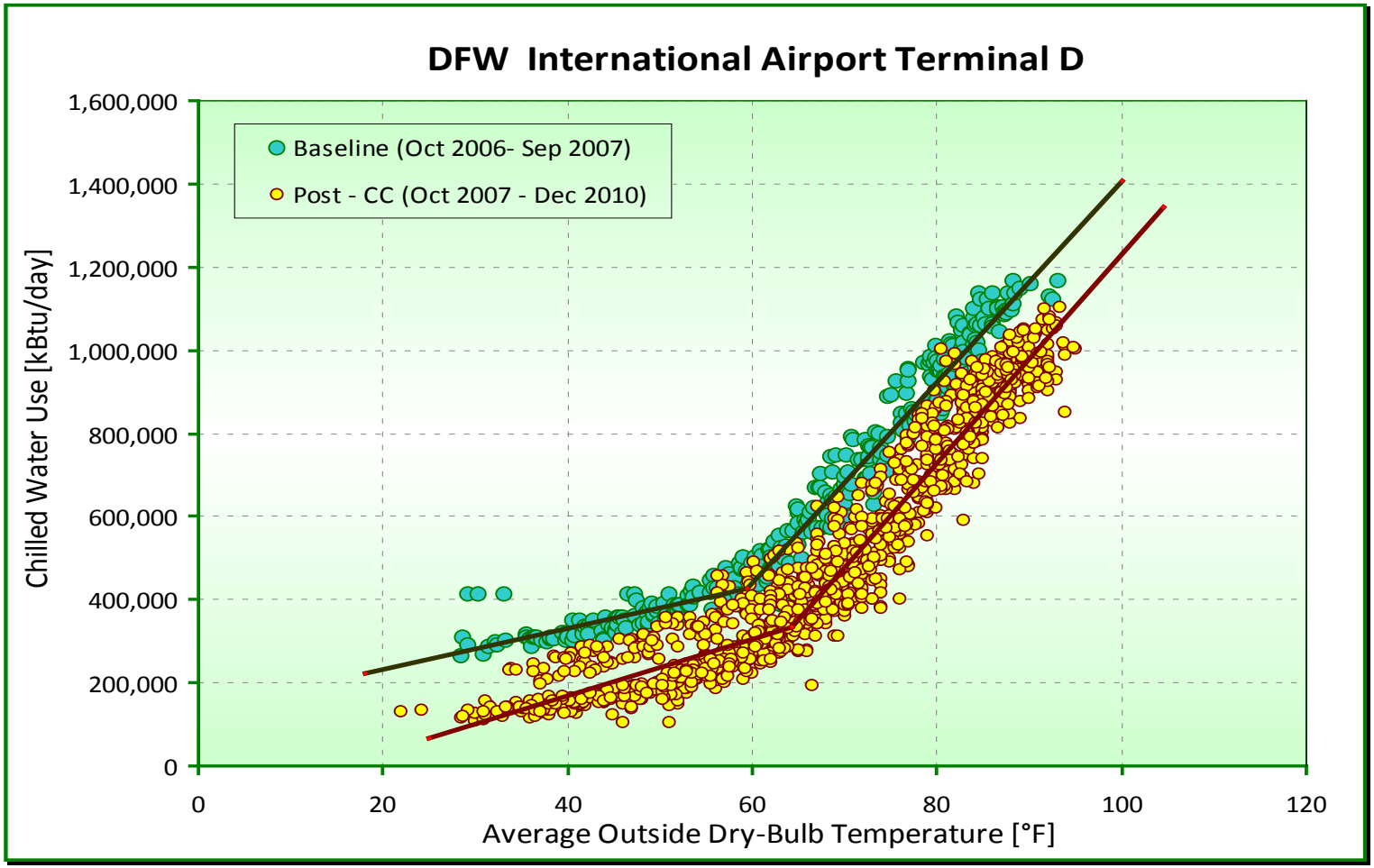
- Occupancy schedule implemented for the majority of HVAC systems
- Occupied period is 5:00am to 10:00pm
  - Cooling set point is 73 F
  - Heating set point is 70 F

Occupancy Schedule Optimization
(continued)

- During lightly occupied period
  - Reduce air flow rates
  - Cooling set point is 76 F
  - Heating set point is 68 F
- Provide schedule override capability for operators
- DETAIL ON OTHER MEASURES IMPLEMENTED NOT PROVIDED

RCx Impact

Chilled Water Savings (25% reduction)



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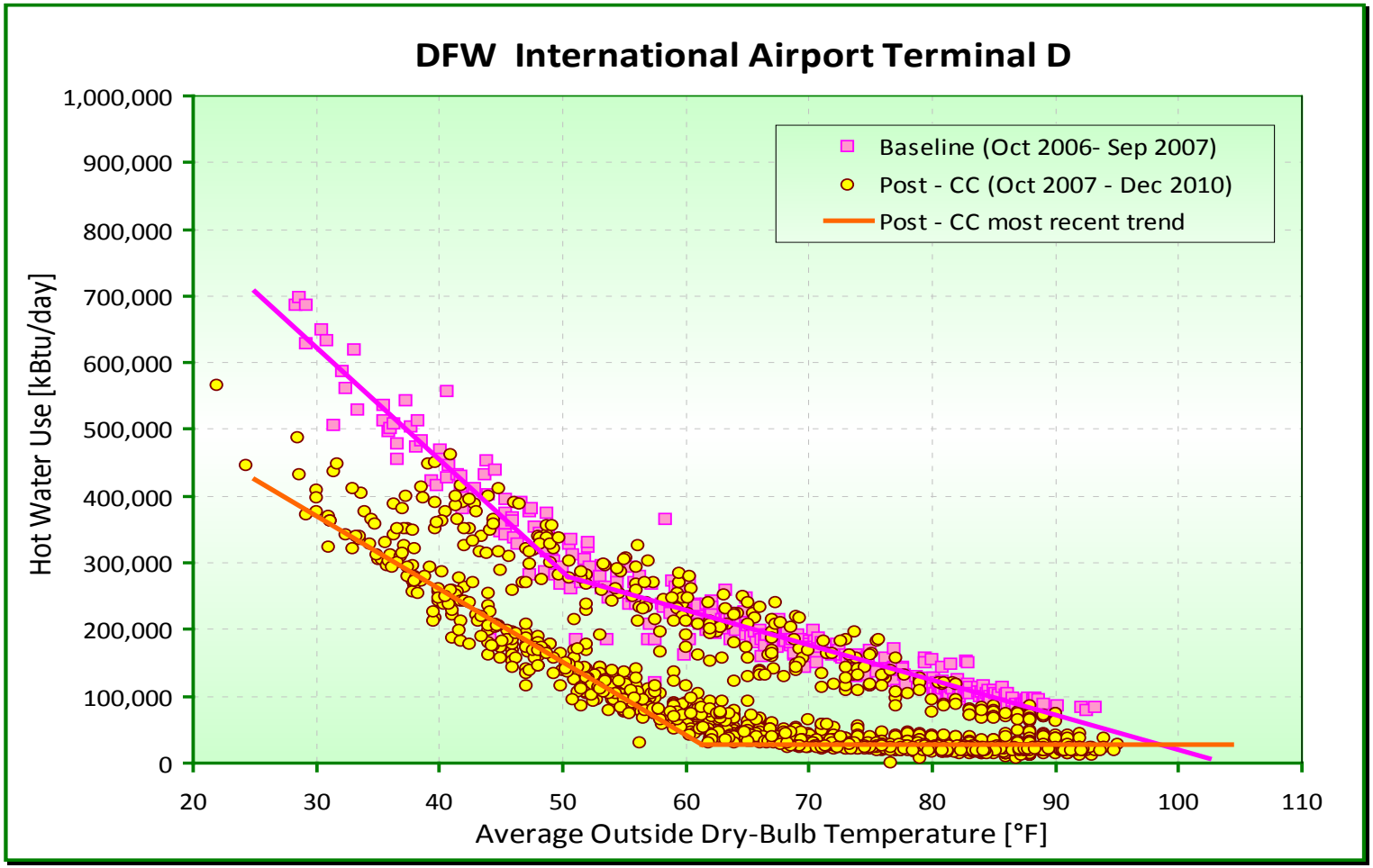
RCx Impact

Hot Water Savings (49% reduction)



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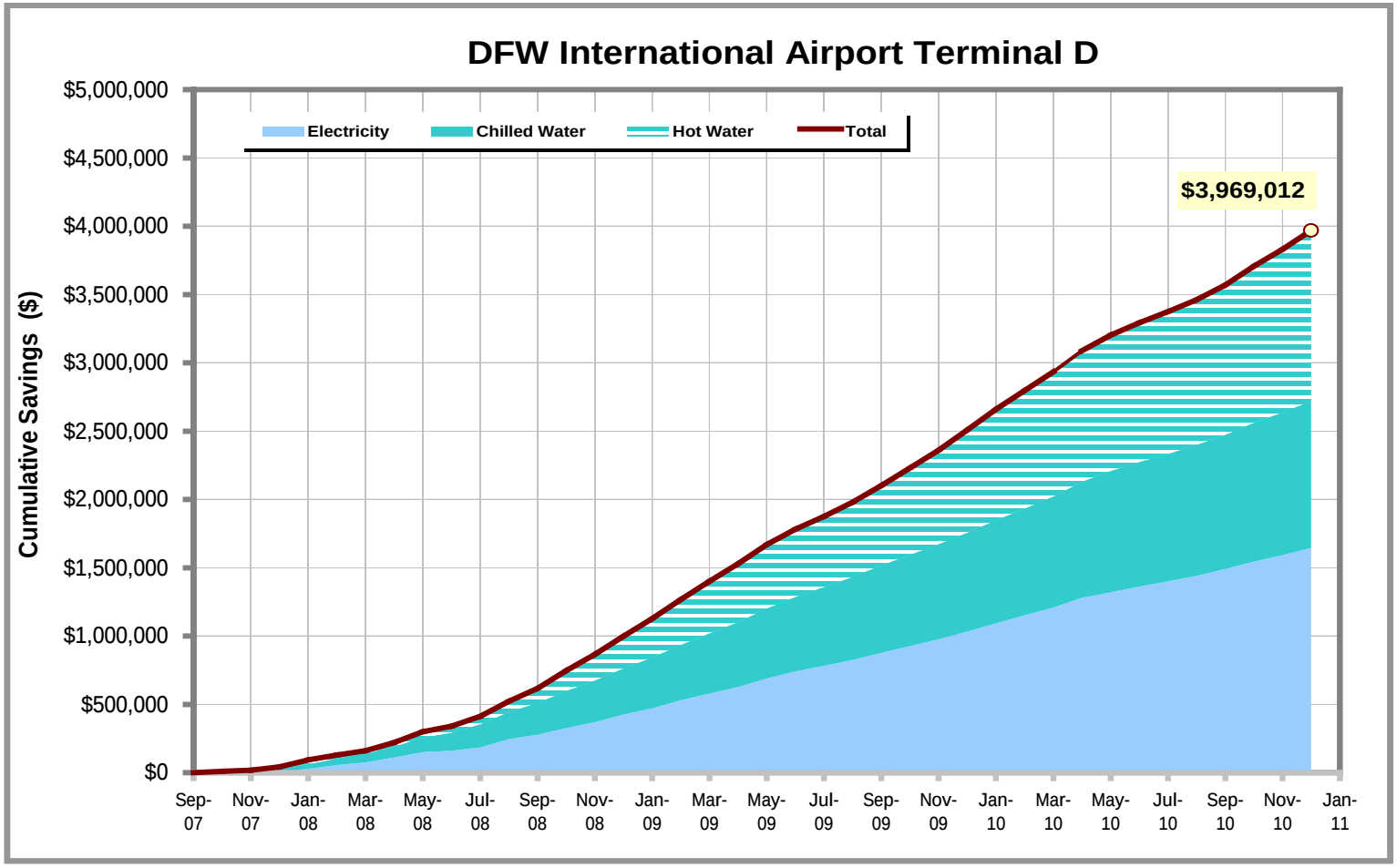
RCx Impact

Cumulative Energy Cost Savings



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Overall RCx Impact

- Improved building comfort
- Reduced maintenance calls
- Enhanced operator skills
- Cumulative cost savings of nearly $4 million in 3 years
- Simple payback of 15 months

Ongoing Commissioning (OCx): Strongly Recommended

- TYPICALLY with NO OCx: 20% savings will be 15% savings in 3-4 years
- BUT
  - 20% savings may be 20% after 4 years Bldg 1
  - 20% savings may be 10% after 2 years Bldg 2
- OCx has maintained savings in some buildings for 10+ years

Ongoing Commissioning Approaches

- Periodic manual review of energy use, EMCS parameters and trend data
- Use Tracking Software to alert to increased consumption – then intervene
- Fault Detection and Diagnosis software alerts for problems – then intervene

Conclusions

- RCx typically provides 10-20% energy savings
- RCx typically has payback of 1-3 years
- Savings level depends on skill of provider
- Ongoing Commissioning recommended to maintain savings
- RCx can improve comfort