Better Buildings Summit

HVAC Part 1: Life-Cycle Management Approach for Packaged HVAC

Michael Deru, NREL
Pat Hagan, Wawa
Brian Walser, BoA

May 28, 2015
1:30-3:00 pm EDT

Agenda

- Welcome and Introductions
- Project updates/announcements
  - Advanced RTU Campaign
  - Retailer Ventilation Guide
- Proactive Plan for HVAC: Pat Hagan, Wawa
- Smart Building Systems and Portfolio RTU management: Brian Walser, Bank of America
- Open discussion and new projects

Advanced Rooftop Unit Campaign (ARC)

High-efficiency RTU solutions

- High-efficiency RTUs
- Advanced RTU control retrofits
- Quality Installation and Quality Maintenance

Results:

- **193** ARC partners
- **40,000** high-efficiency RTUs
- **4** Trillion BTUs annual savings
- **$37** million annual savings

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RETAIL INDUSTRY LEADERS ASSOCIATION
Educate. Innovate. Advocate.

FEMP
Federal Energy Management Program

Better Buildings
U.S. DEPARTMENT OF ENERGY

www.advancedrtu.org

Advanced RTU Campaign Updates

- Congratulations to ARC award winners!
- New resources:
  - Walgreens case study
  - JCPenney case study
  - RTU Business case document (coming soon)


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Case Study: Walgreens RTU Replacement Program

Advanced RTU Campaign

Walgreens has developed a successful program to strategically retire RTUs prior to failure and replace them with high-efficiency units. In just 150 stores, Walgreens realized more than $1 million in savings from material and labor budgets. Walgreens planned RTU replacement model includes rightsizing equipment and optimizing replacements compared to an emergency replace upon failure mode. In one store, Walgreens reduced RTU energy consumption by more than 50% and energy costs by more than $14,000 annually.

Overview

Walgreens, the nation's largest drugstore chain, operates more than 8,200 drugstores across the United States. The company has a long-standing commitment to reduce energy consumption and expand its renewable energy initiatives. Through its partnership with the U.S. Department of Energy (DOE) Better Buildings Challenge, Walgreens is committed to reducing energy consumption by 20% by 2020 across its portfolio of 125 million square feet. To reach this commitment, Walgreens has initiated several energy efficiency programs and installed solar power at more than 150 locations.

Planned RTU replacement has been one of Walgreens' most successful initiatives. Before 2010, Walgreens only performed emergency replacements of failed RTUs. These replacements were expensive because of extra costs from overtime, expedited permitting and ordering, small purchase size, lack of rebates, and failure to address the potential for down-sizing. This run-to-fail model missed many opportunities that correspond to drastic opportunity cost savings at each building site.

Decision Process

In 2010, Walgreens developed a portfolio-wide planned RTU replacement model that resulted in significant energy and cost savings. The company evaluated their old reactive process of replace after failure against a proactive asset retirement approach to develop the business case for the new model. The risk and costs of not implementing the proactive program played a large role in securing capital to begin the program.

Organizational Profile	
Established	1901
Number of Facilities	8,200
Employees	240,000
Project Scope	Portfolio wide analysis and replacement plan


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Case Study: Variable Frequency Drive (VFD) Retrofit Upgrade on Rooftop Units

ADVANCED RTU CAMPAIGN

Overview

JCPenney is a major apparel and home furnishing retailer with approximately 1,060 locations throughout the United States. JCPenney integrates many opportunities for increased energy efficiency with electrical and mechanical systems, and their stores are equipped with modern monitoring and control equipment.

In response to the need to uncover inefficiencies and save money, JCPenney pursued a pilot program for RTU variable frequency drive (VFD) technology. Following the successful pilot program, JCPenney retrofitted 1,330 rooftop units in 130 additional stores with the VFD retrofit solution. The company recognized savings of as much as 47,800,000 kWh, a 22% reduction from before the VFD retrofit and a monetary savings of as much as $8 million.

Project Drivers

The management team at JCPenney was tasked with uncovering inefficiencies and pursuing projects that would save money. The engineering, energy management, facilities and maintenance teams identified 131 of their current prototype standalone stores as ideal candidates for these RTU retrofits. The sole purpose of the retrofit was simple: decrease energy consumption and maintain or increase occupant comfort and environmental conditions.

Prior to a national rollout program JCPenney chose a prototypical store in Flower Mound, Texas for a pilot test. Built in 2006, this store is approximately 100,000 square feet and conditioned with 12 RTUs. The retrofit package had an estimated simple payback of 1.7 years.

VFD Retrofit Results	
Energy Savings	47,800,000 kWh spread over 131 locations, a 22% reduction from before the VFD retrofit
Utility Savings	As much as $8 million in annual utility costs
Simple Payback	Less than one year.
Installation and Maintenance	Each RTU is equipped with a variable frequency drive and a control interface box that matches fan speed to each RTU's particular air flow requirements for cooling, heating and ventilating. During installation on each RTU, air flow measurements are used to determine the best air flow settings for each operation mode. VFDs perform a "soft start" on electric motors, extending motor and belt life.
Overall Performance	Additional energy savings were achieved with no compromise to customer comfort.


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Rooftop Unit (RTU) Business Case Considerations for Proactive Replacement

May 2015

Retailer Ventilation Guide

- 62.1 and 90.1 are straight forward and easy to apply

Retailer Ventilation Guide

- ~~62.1 and 90.1 are straight forward and easy to apply~~
- Great opportunities for energy savings and equipment downsizing – but what is the best approach balance savings with good IAQ
- In review, expected publication – July 2015

Retailer Ventilation Best Practice Guide

Scott Williams
Williams Building Systems Engineering PC

Michael Deru
National Renewable Energy Laboratory

High-Impact Technology – Fans

- Fans are everywhere and consume ~ 140 billion kWh per year
- Opportunities for savings
  - Proper system design and sizing
  - Optimal control – off, VSDs
  - High-efficiency fans and motors
- What resources would be useful to help save energy?
  - Design and application guidance
  - Fan selection guidance
  - Specifications

HIT Special Session on Friday

High-Impact Technology Forum:
Harnessing American Ingenuity and Innovation

Amy Jiron will moderate three sessions from 9-2

Proactive Plan for HVAC
Pat Hagan, Wawa

U.S. DEPARTMENT OF ENERGY

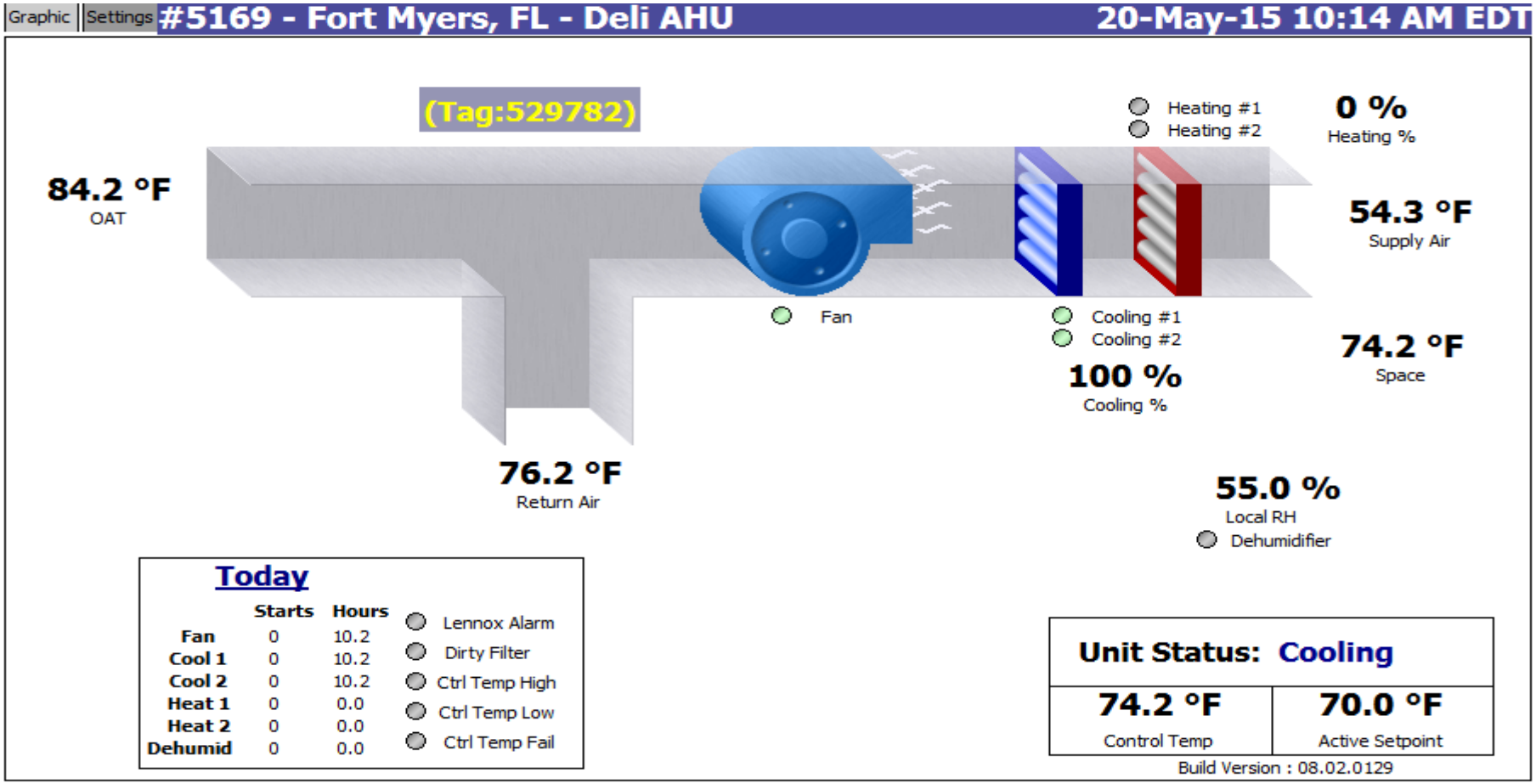
Proactive Plan for HVAC

May, 2015

Who is Wawa?

- Convenience store chain with over 650 locations, 400 + serving fuel (Mid-Atlantic and Florida)
- Store's age vary from 52 years to new
- Average sq. ft. range from 3000 to 7000
- Typical HVAC installation 2 to 4 units
- Primarily RTUs but splits and cassettes units also used.
- Energy load same as 40K sq ft building

Hot stores ?


Graphic
Settings
#5169 - Fort Myers, FL - Deli AHU
20-May-15 10:14 AM EDT
(Tag:529782)
Heating #1
Heating #2
0 %
Heating %
84.2 °F
OAT
54.3 °F
Supply Air
Fan
Cooling #1
Cooling #2
74.2 °F
Space
100 %
Cooling %
76.2 °F
Return Air
55.0 %
Local RH
Dehumidifier
Today
Starts
Hours
Fan 0 10.2
Cool 1 0 10.2
Cool 2 0 10.2
Heat 1 0 0.0
Heat 2 0 0.0
Dehumid 0 0.0
Lennox Alarm
Dirty Filter
Ctrl Temp High
Ctrl Temp Low
Ctrl Temp Fail
Unit Status: Cooling
74.2 °F
Control Temp
70.0 °F
Active Setpoint
Build Version : 08.02.0129

How you determine next steps?

- BAS provides:
- Proactive equipment monitoring
  - Provides real-time and historical information
- Provide a safe and comfortable work environment for our associates
- Minimize equipment downtime, repair costs, product spoilage, and energy consumption

- Determine the following:
  - Is it a single unit issue or entire store?
  - Door openings, recent deliveries, work being done at store
  - Recent repairs-unit out on parts
  - Vendor visit to check all connections and functions of unit.
  - Discuss options

Reactive vs. Proactive

- Replace as they break
  - More costly
  - Larger impact on store
  - Possible product and sales lose
  - Long term outages 3-5 days
- Scheduled replacement
  - Off season replacement
  - Less impact on store
  - Planned outage
  - Proper equipment installed according to needs.

How Many and When?

- Over 2000 units in operation today.
  - 750 less than 5 years old
  - 375 replaced since 2011
- Factors for change out
  - Age-8-10 + years old
  - Repair totals over 70% of cost of new
  - Run time avg. during cooling season
  - Remodel scheduled
- Recently explored changing all units out of locations depending on how close in age they were.

Financials

- Over the last three years Wawa has invested a little over $4M in HVAC replacements in 126 locations.
  - Wawa expectations
    - Lower annual maintenance HVAC budget by 15%
    - Increase lifecycle RTU from 10 years to 13-15 years
    - Test high efficiency units in new stores
    - Partner with BBA on next RTU campaign
    - Gain some energy benefits

Smart Building Systems and Portfolio RTU management

Brian Walser, Bank of America

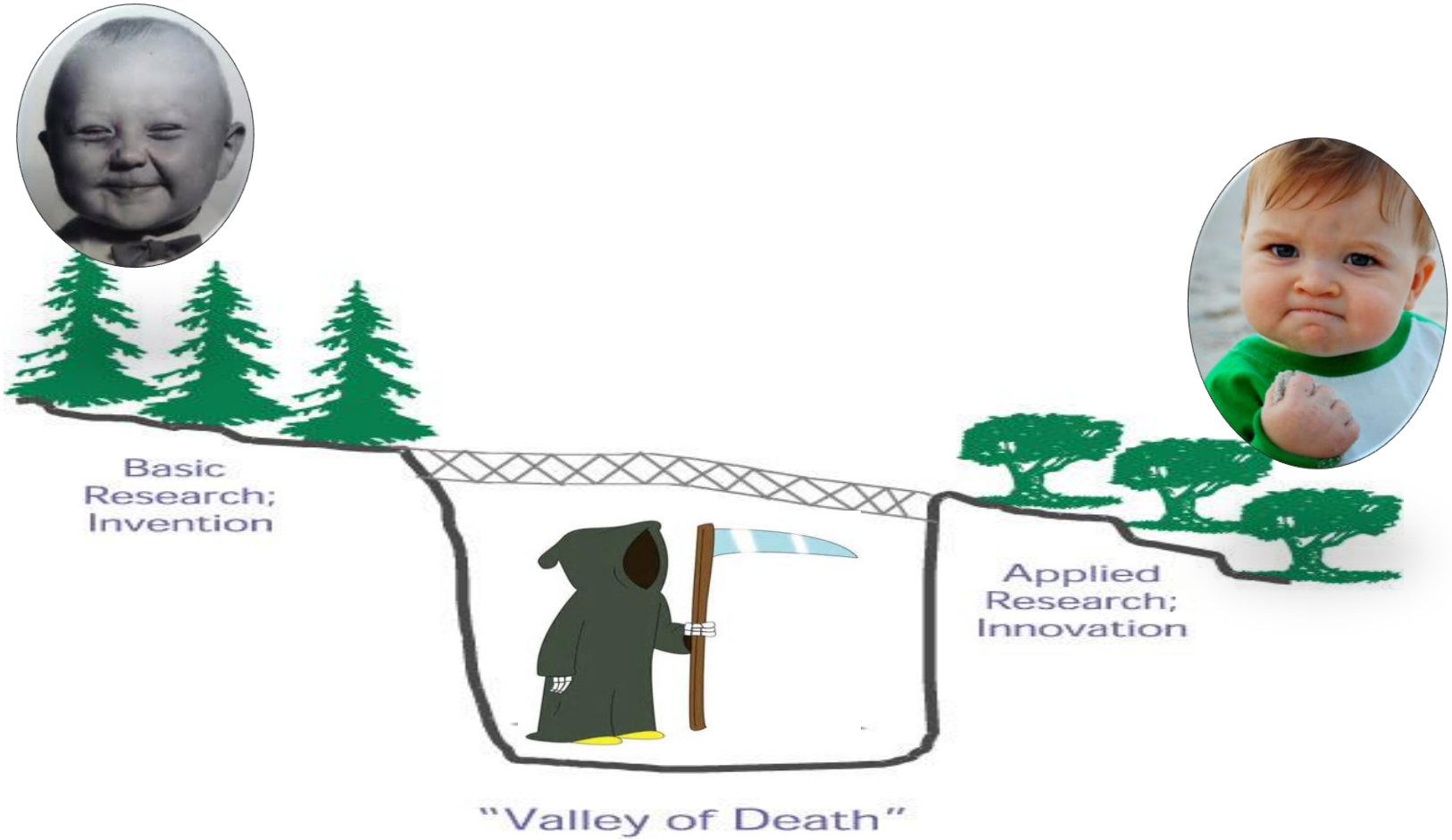
U.S. DEPARTMENT OF ENERGY

Smart Building Systems- *iC*^{3}

Lessons learned from the installation of a 3,500 location smart building control system.

Brian Walser - Director of Energy and Sustainability

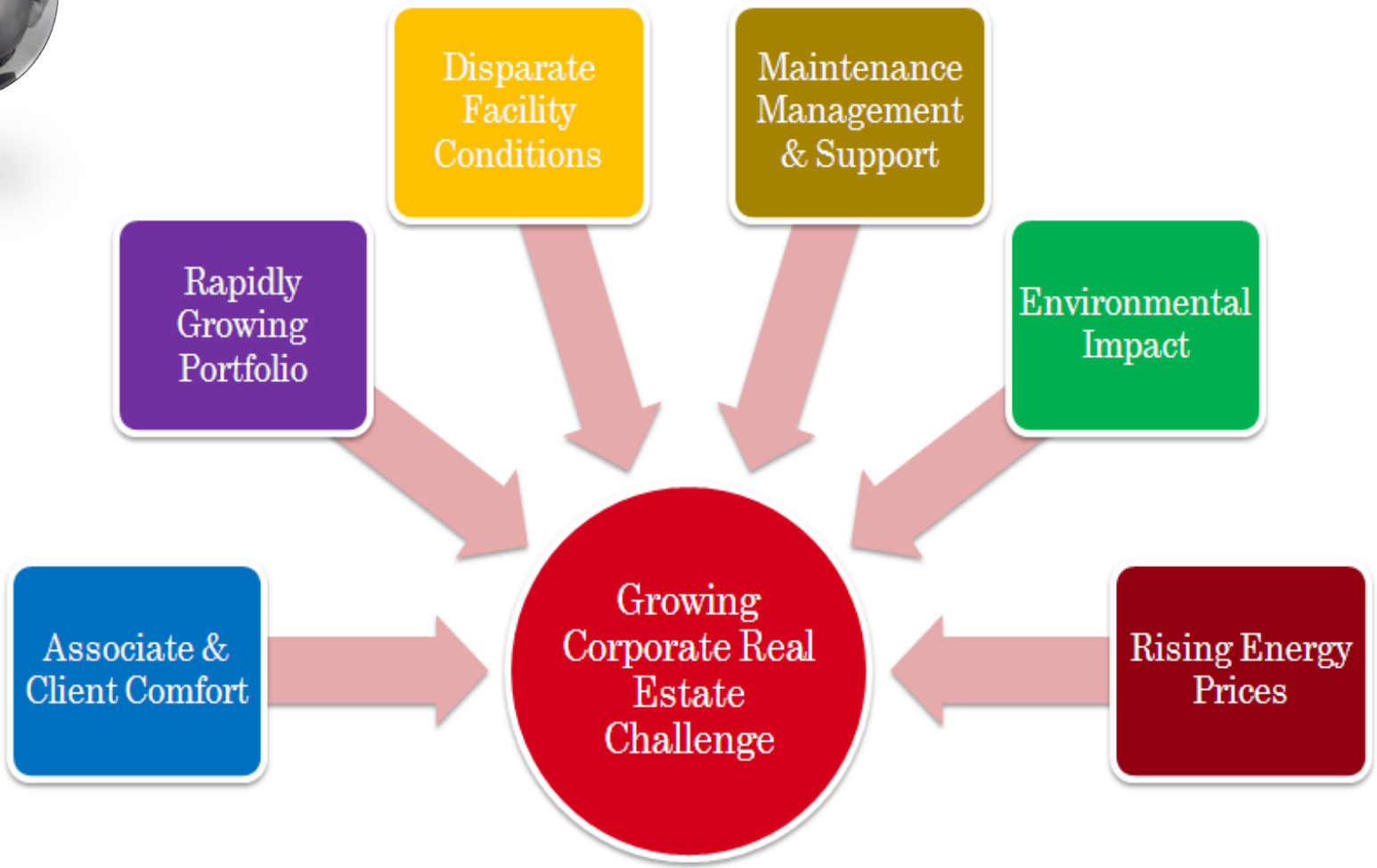
Our iC³ Journey



Gerald Adolph (Booz Allen & Hamilton) --- *"I would define [the] Valley of Death [as occurring] when the amount of money you're starting to ask for—the bill—starts to add up to the point where management says, 'What are you guys up to, what are you doing, and what am I going to get out of it?' But yet it is sufficiently early in the process that you don't feel you can answer that question. If you are fortunate enough that the questions come when you have an answer, you, in fact, have scooted over the Valley. If not, you are squarely in that Valley."*

http://www.atp.nist.gov/eao/gcr02-841/chapt2.htm Graphic adapted from Congressman Vern Ehlers

The CRE Business Challenge



The iC³ Vision

Traditional EMS operations stop here...

The iC3 Solution

Reactive
- Call driven
- Simple fixes
- Field Support

Detection
- Alarm driven
- Trending analysis
- Field support

Predictive
- Condition monitoring
- Planned work
- Intelligent field support

Game Changing!

System Design – Facility Level

Control Capabilities

Interior lights
(on/off)

Exterior lights
(on/off) & (Amps)

Building Health
(Space Temp) (RH) (CO2)
(Utility kWh)
Override Button(s)

HVAC Controller
- Discharge Air Temp
- Amps
- All Controller points

Implementation

Key Deployment Statistics

- Over 3200 sites installed across 32 states
- Average of 125+ sites installed per month.
- Installations took 1 to 3 days to complete.
- Multi-layered quality control process minimizes installation defects and ensures quality.
- Commissioning process bring sites online to realize same day benefits.

Single Site

3-4 HVAC units
Avg 5500 SF
2-3 day install

All Sites

3200 sites
34 states
17.5MMsf
12,000 HVAC systems

Enterprise Software

Commissioning tool
BMS Screens
Alarm Mgt tool
Case Mgt Software
Fault Detection Software

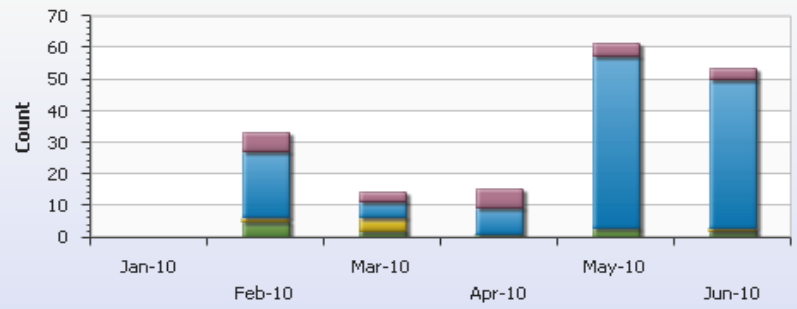
Nirvana!

FDSI INSIGHT

Home | Site Acceptance | Fault Detection | Case Tracking | Energy Usage | Optimal Setpoints | Reports/Lists | Settings and Admin

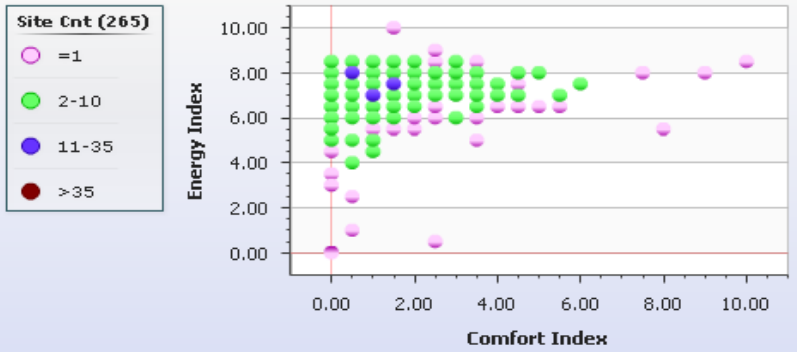
Home Log Out

Cases by Category

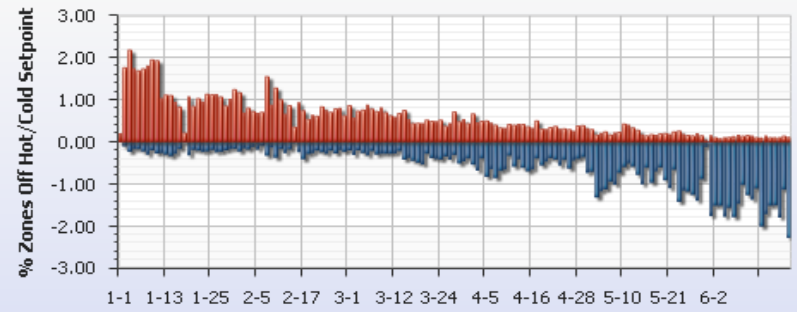


Case breakdown from: Jan 2010 to Jun 2010

Comfort Index vs. Energy Index

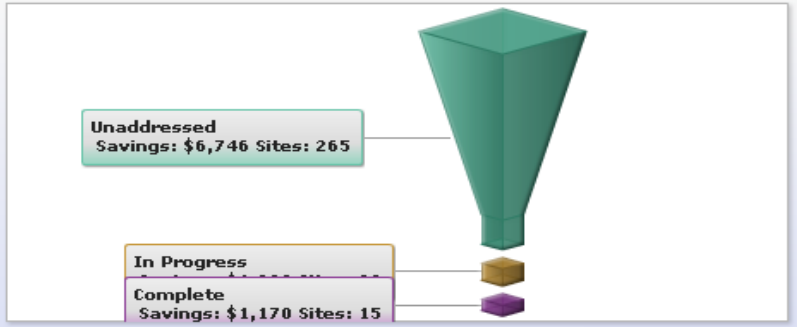


ZTC Portfolio Score



Usage from Jan 2010 to Jun 2010 Daily Monthly

Sites With Savings Potential

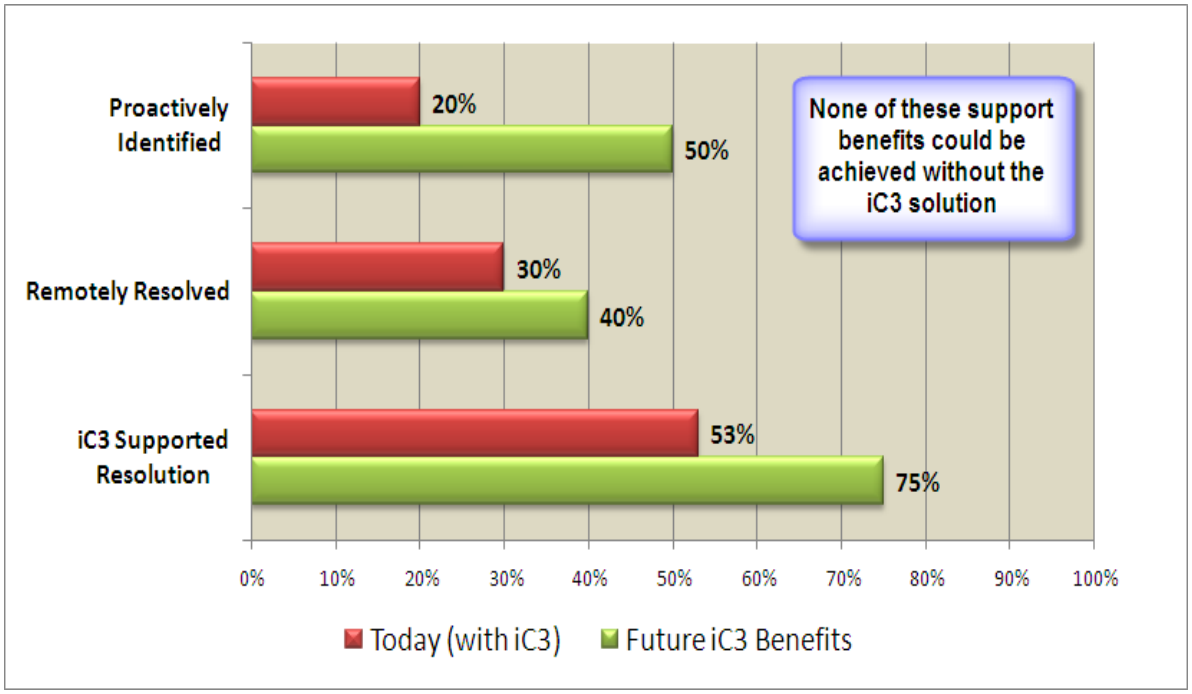


Problem Type Category: Lighting

Some Success!

HVAC Event Identification → Remote Troubleshooting → Dispatch Mobile Tech → Validation of Repairs

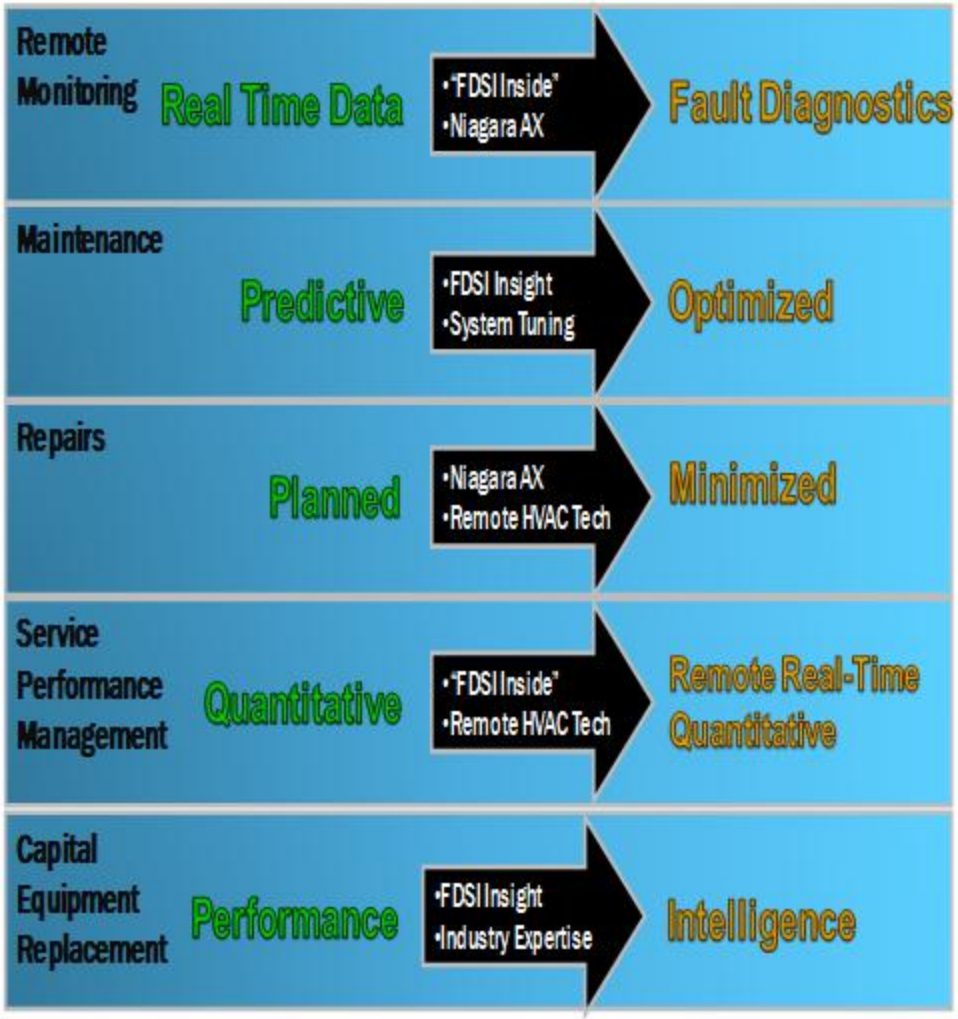
iC3 Operations Highlights



- 11-17% energy savings
- 30% of events resolved remotely, avoiding costly technician dispatches to facilities
- 20% of events proactively identified
- 53% iC3 supported issues get solved faster and right the first time
- Enabled to support disaster recovery efforts

Slipping! More Value Needed!

Evolution of EMMS from Generation 1 to Generation 2



Associated Benefits

- ✓ Leverage technology to use real-time facility data and to develop fault diagnostics.
- ✓ Develop real-time diagnostic tools to predict system faults

- ✓ Progress from "Predictive" to "Optimized" maintenance planning.
- ✓ Combine predictability with intelligent maintenance routines.

- ✓ Reduce repair events through optimized maintenance and real-time monitoring.
- ✓ Enable remote technicians to repair and correct system issues.

- ✓ Develop technologies to conduct real-time, ongoing HVAC commissioning.
- ✓ Minimize routine servicing costs and maximize system efficiency.

- ✓ Extend the life of capital assets and minimize ongoing, expensive capital replacement projects.
- ✓ Use data analytics to evaluate and improve capital planning budgeting.

The Valley!

- Hard savings not as great as anticipated, and hard to prove R&M savings
- Installation and data quality issues, erodes confidence
- Unnoticed installation cost overruns
- Pushback from field engineers
- The pace of change was faster than the culture could adapt
- Hard to recruit top tier command center employees
- Proactive resolution eliminates the “hero euphoria” of being reactive
- Corporate culture not ready/sold on proactive HVAC management
- Financial collapse, kills all innovation

Climbing out of the valley!

Focused on highest value, incremental changes

- **Kept BMS technology in place**
- **Kept data collection happening**
- **Built a dashboard for mobile technicians**
- **Strategically started to use fault detection again**
  - Can't heat/cool report
  - Runtime Faults
  - IAQ (RH/CO2)
  - Energy disaggregation
  - Power Outage
  - What HVAC equipment needs replacing.
- **Reduced Truck Roles –** Remote equipment schedule management
- **Optimization**
  - Unit Coordination
  - Price response
  - Outside Air Management
- **New HVAC Unit Virtual Quality Control**
  - More consistent quality control and commissioning when HVAC equipment is replaced.

Mobile Dashboard

HVAC Performance Data

- Three primary graphs
  - Heating, cooling and space info
  - Supply temperature, Amperage and with heating and cooling commands
  - Humidity and CO2 Levels
- 24 or 7 day trend information

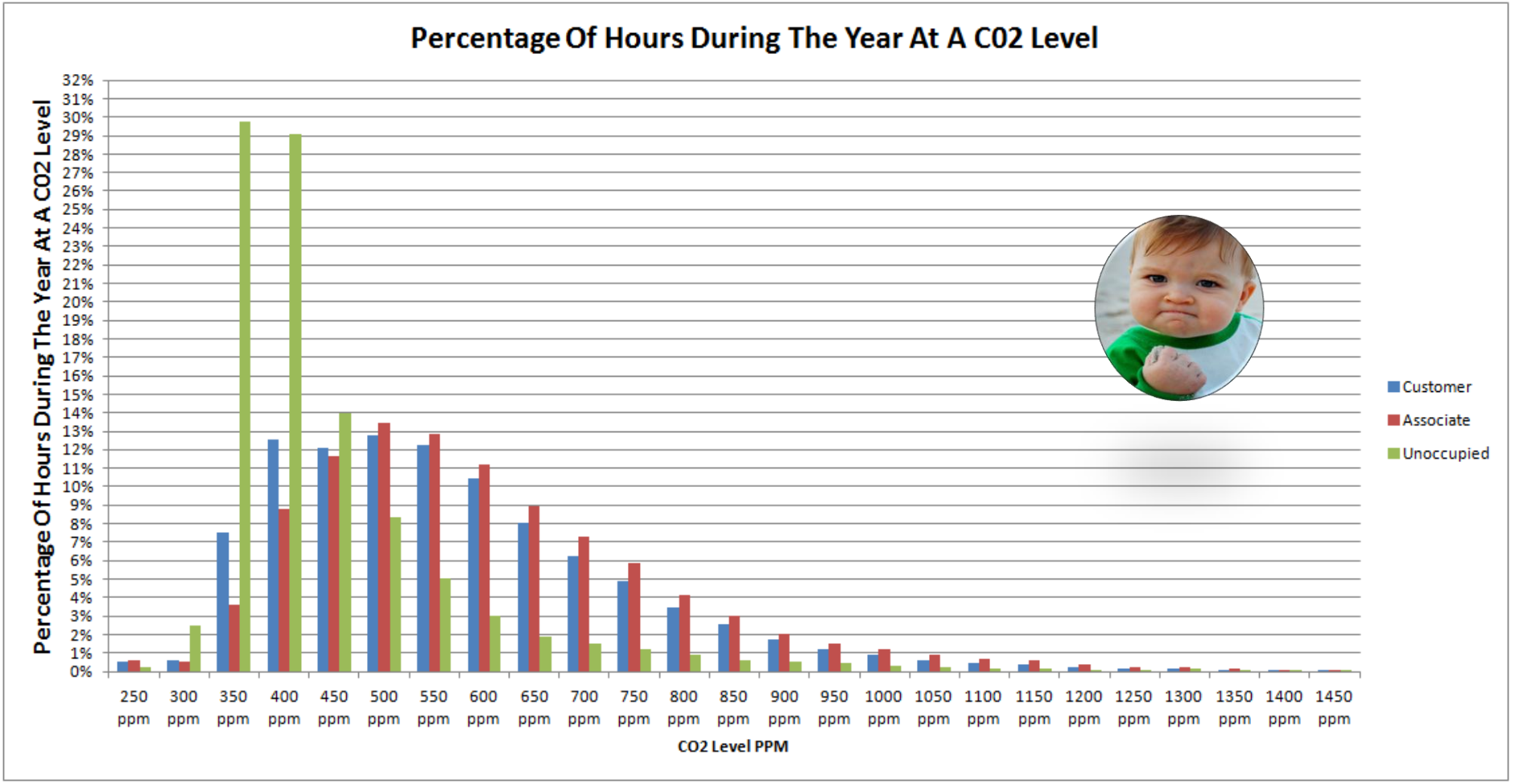
Lighting Runtime Data

- Lighting Graphs
- Lighting Runtime tables

Accessible via mobile device as well!

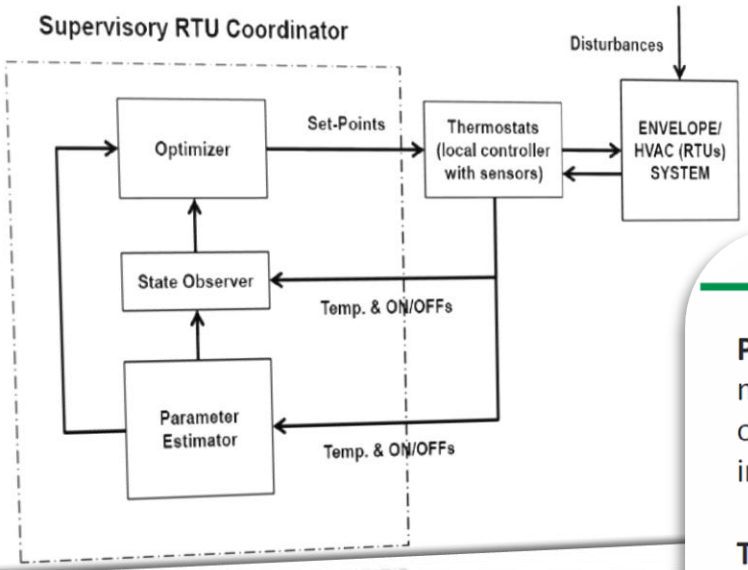
Allows engineers to "self serve" a wealth of knowledge of the current and historical performance of a sites HVAC or lighting

CO^2 Reporting



Optimization - Unit Coordination

- Learns relationship between thermostat temperatures and RTU on/off staging (no other measurements required)
- Determines RTU staging to minimize energy (based on RTU rated power or measurements if available)



CBEI - Coordinating RTUs in Small & Medium Sized Commercial Buildings

2015 Building Technologies Office Peer Review

thermostat ● supply diffuser ■ RTU

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Jim Braun, jbraun@purdue.edu
CBEI/Purdue University

Purpose and Objectives

Problem Statement: Advanced controls for SMSCBs (small and medium-size commercial buildings) are rarely implemented because of poor overall economics. Low-touch, low-cost control implementations are needed.

Target Market and Audience:

- Market is SMCBs that utilize RTUs for cooling.
- RTUs serve about 60% of commercial floor space & account for ~150 TWh of annual electrical usage (~1.56 Quads primary energy for cooling) & ~$15B in electric bills.
- Audience is companies that can build successful businesses to deliver advanced RTU controls for SMSCBs.

Lessons Learned

- Start with the end in mind, how will the new system affect your current or adapted process?
- Make sure your organization is ready for change.
- The control system features and functions are not nearly as important as how and if you will use those features and functions to save cost.
- The contractor that you use is not nearly as important as having a quality control and acceptance process in place.
- Spend the time necessary to develop a good point naming, and trend set-up, standards.
- Make sure that you have expertise in-house to manage the project, negotiate change orders, and ensure quality.
- Plan to slow/stop implementation after 5%-15% of the sites have been completed and refine your design & install process.
- Use a tune-up tool like FDSI's tune-up tool to check unit performance before installation of control system.
- Don't expect that your savings percentage will be the same as projects implemented by other organizations. Estimate you savings based on how you will change your operations. Only "benchmark" information to make sure your savings estimates are reasonable.

What's next?

- What is your most exciting new project?
- What is your biggest challenge?
- Possible future activities
  - Fan application guidance and specs
  - System level metrics for performance tracking
  - Cold climate HPs
  - VRFs (Can they be cost effective?)
  - Evaporative cooling (Is it ready for prime time?)
  - Other?