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AABC Commissioning Group

AIA Provider Number 50111116



## Implementation of a Strategic Campus Sustainability and Energy Plan

Course Number: CXENERGY1903



***Nate Boyd, P.E., BEAP, CPMP, LEED AP***

***University of Central Florida***

***Wade Conlan, P.E., CxA, CPMP, LEED AP***

***Hanson Professional Services, Inc.***

April 17, 2019

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# Implementation of a Strategic Campus Sustainability and Energy Plan

AT THE UNIVERSITY OF CENTRAL FLORIDA



# AIA Disclaimer

# Presenters

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**Nate Boyd, P.E., BEAP, LEED AP**  
**Associate Director, Energy Services**  
University of Central Florida

- BS Mechanical Engineering at UCF
- 21+ years BAS industry experience
- CSE 40 Under 40
- UCF MAE Industry Advisory Board
- Valencia EMCT Industry Advisory Board
- Former City of Orlando Energy Manager



**Wade Conlan, P.E., CxA, LEED AP**  
**Commissioning Discipline Manager**  
Hanson Professional Services

- BS Architectural Engineering at PSU
- 23+ years Mechanical Design & Cx
- CSE 40 Under 40
- Chair of UCF MAE Industrial Advisory Board
- UCF Projects include Tri-gen Study, Multiple Bldg. Audit, CREOL Expansion, Energy Plant RetroCx and DEP IV Design Reviews

# Agenda

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- University Background
- University Plans and Progress
- Tools for Achieving the Plan
  - Commissioning
  - Existing Building Projects
- Carbon Neutrality
- Smart Grid
- Renewables
- Results
- Conclusions

# The University of Central Florida

**\$32 million per year in utilities**  
**793 million kBTU per year**



With more than 68,000 students, UCF is the biggest university in Florida, and one of the biggest in the nation. But being big goes beyond our size. Big is diverse and inclusive. Big is promising and powerful. Big attracts the brightest minds and boldest opportunities. So go on, Knights — dream big. Because big is just the beginning.



**1,440 Acre Main Campus**  
**180 Buildings**

# Utilities & Energy Services'

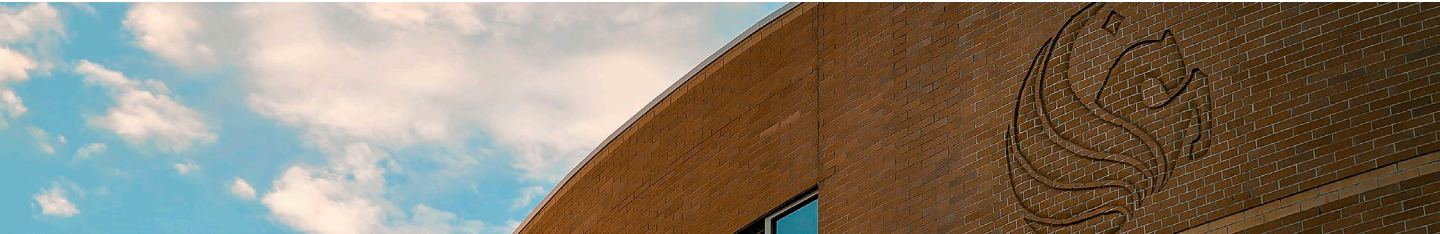
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# Vision.

*To obtain energy efficient buildings through the production, delivery, optimization, and management of **safe, reliable, and efficient** utility and energy systems to reduce the university's impact on the environment.*

## Collective Impact Strategic Plan

- Innovate academic, operational, and financial models to transform higher education.
- Define and achieve favorable sustainability comparison against other analogous and aspirational universities.





## **Smart Infrastructure**

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- Building automation
- GIS and mapping
- Billing and metering
- Analytics

## **Energy Services**

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- Energy audits
- EEM & modernization projects
- High performance buildings
- Renewables
- Commissioning
- Retro commissioning

## **Utility Production & Distribution**

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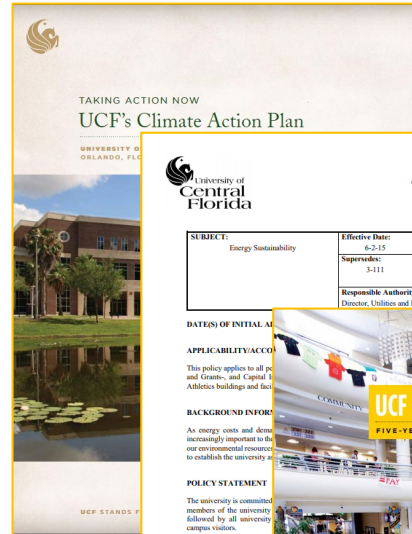
- Electric
- Chilled water
- Natural gas
- Water & waste water

**Our Departmental**  
**Structure.**



# Energy Plans & Policies

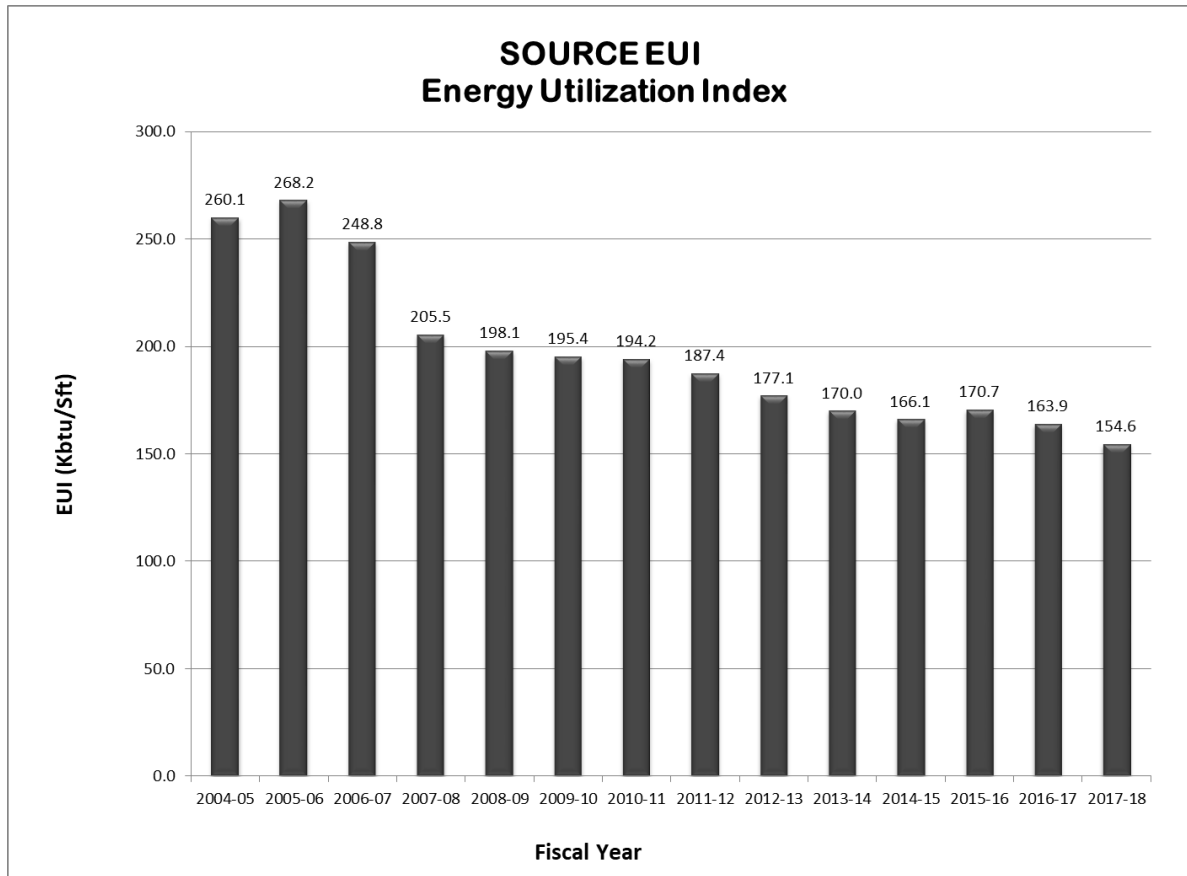
- Collective Impact Strategic Plan
- Campus Master Plan
- Climate Action Plan
  - American College and University President's Climate Commitment
- Energy & Sustainability Policy



# Progress To Date

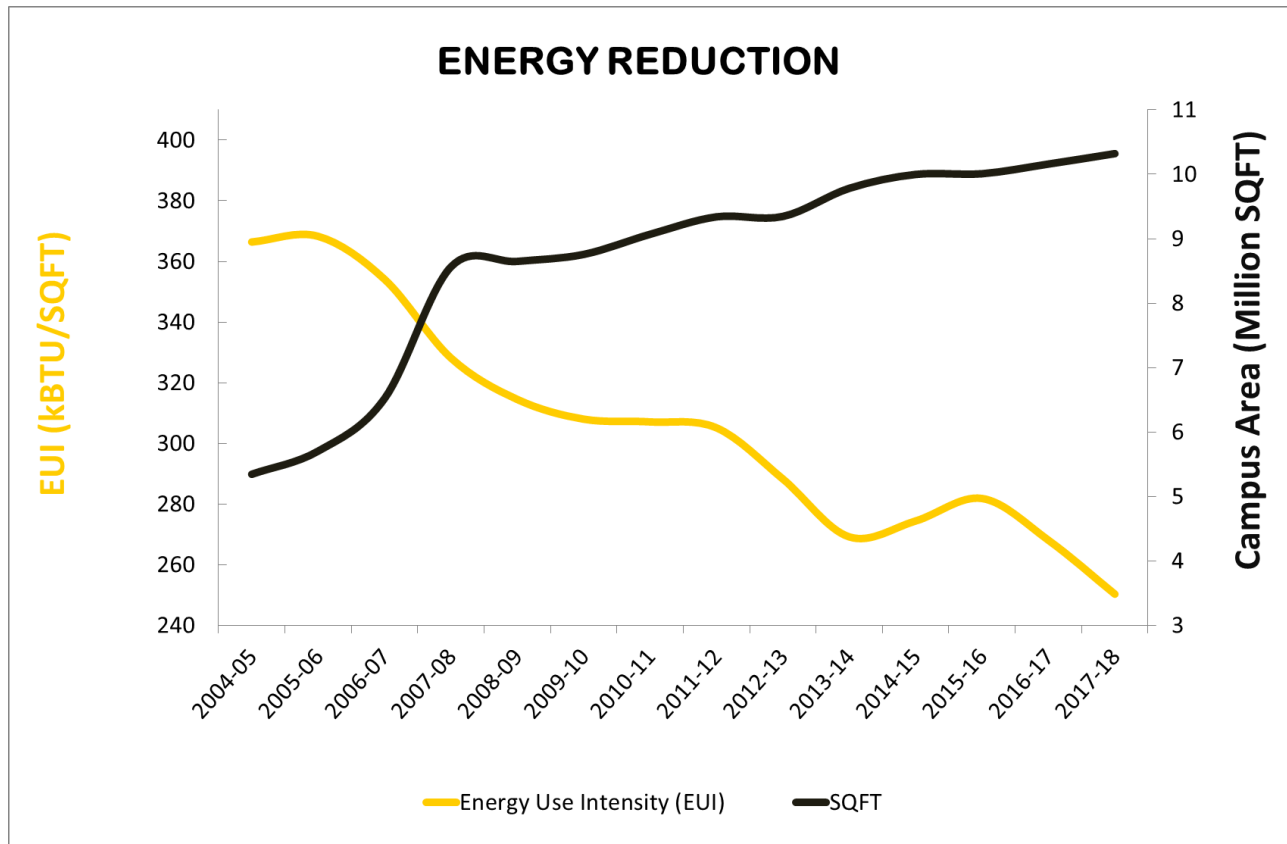
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*A decreasing Energy Use Intensity*



# Progress To Date

*A decreasing Energy Use Intensity*



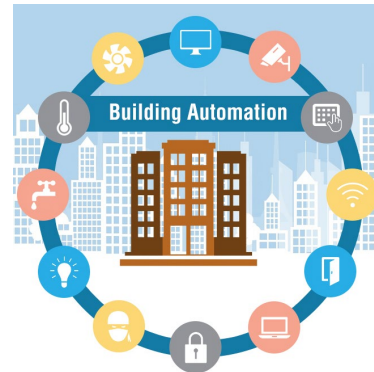
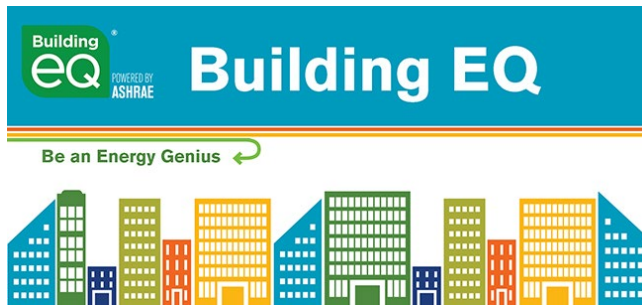
# Innovative Operation & Financial Models



Combined Heat & Power Plant  
passes 200,000 MWh of production



District Energy Plant IV opens





# High Performance Buildings

## 23 and counting



**UCF Recreation & Wellness Expansion**  
LEED® BD+C LEED 2.2  
LEED Gold®



**UCF Career Services**  
LEED® BD+C LEED 2.2  
LEED Gold®



**UCF Performing Arts Center**  
LEED® BD+C LEED 2.2  
LEED Gold®



**UCF Biomedical Science Building**  
LEED® BD+C LEED 2.2  
LEED Silver®



**UCF Student Union Expansion**  
LEED® BD+C LEED v4  
Registered



**UCF John C. Hitt Library Expansion**  
LEED® BD+C LEED v2009  
Registered



**UCF CREOL Expansion**  
LEED® BD+C LEED v2009  
Registered



**UCF Trevor Colbourn Hall**  
LEED® BD+C LEED v2009  
Registered



**UCF Classroom I**  
LEED® O+M LEED v4  
Registered



**UCF Downtown Future**  
LEED® BD+C LEED v4  
Future



**UCF Band Building**  
LEED® BD+C LEED v4  
Registered



**UCF Dining Facility**  
LEED® BD+C LEED v4  
Registered



**UCF District Energy Plant IV**  
LEED® BD+C LEED v2009  
LEED Gold®



**UCF Interdisciplinary Research & Incubator**  
LEED® BD+C LEED v2009  
Registered



**UCF Global**  
LEED® BD+C LEED v2009  
LEED Gold®



**UCF Alumni Center**  
LEED® O+M LEED v4  
LEED Gold®



**UCF Physical Science II**  
LEED® BD+C LEED 2.2  
LEED Gold®



**UCF Greek Life Center**  
LEED® BD+C LEED v2009  
LEED Silver®



**UCF College of Medicine**  
LEED® BD+C LEED 2.2  
LEED Silver®



**UCF Morgridge Intl Reading Center**  
LEED® BD+C LEED 2.2  
LEED Gold®



**UCF Wayne Densch Center for Student-Athlete Leadership**  
LEED® BD+C LEED v2009  
LEED Gold®



**UCF Academic Village Phase II**  
LEED® BD+C LEED v2009  
LEED Silver®



**UCF Visitor and Parking Information**  
LEED® BD+C LEED 2.2  
LEED Gold®



**UCF Classroom II**  
LEED® BD+C LEED v2009  
LEED Gold®



**UCF Greek House A**  
LEED 101 HOMES LEED  
LEED Gold®



**UCF Greek House B**  
LEED 101 HOMES LEED  
LEED Gold®



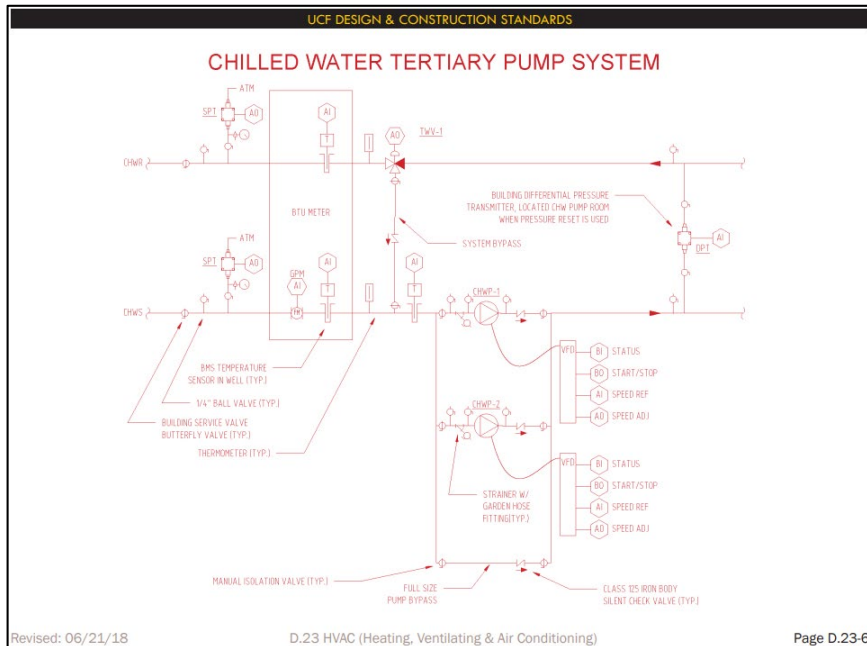
**UCF Partnership III**  
LEED® BD+C LEED 2.2  
LEED Silver®



**UCF Public Safety**  
LEED® BD+C LEED 2.2  
LEED Gold®

# Building Codes

- Design, Construction & Renovation Standards
- BAS specifications – ASHRAE Guideline 13 & 36 based
- LEED Gold minimum







**BUILDING  
DESIGN AND  
CONSTRUCTION**

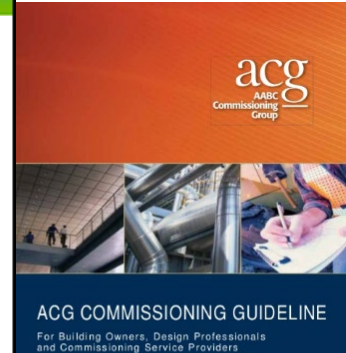
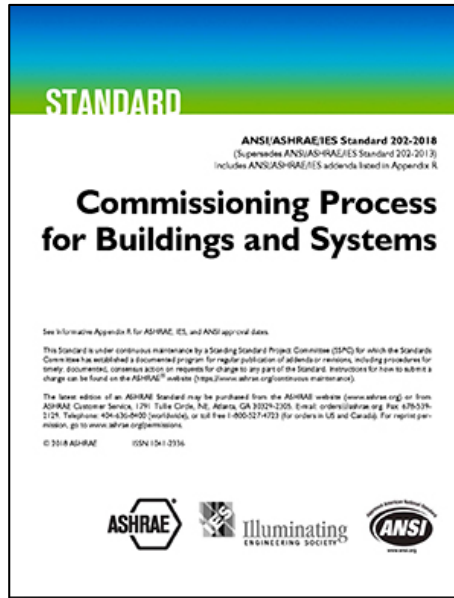


**BUILDING  
OPERATIONS AND  
MAINTENANCE**



# Commissioning – New Buildings & Renovations

- ASHRAE Standard 202-2013
  - (Revising to '18)
- ASHRAE Guideline 0
- ACG Cx Guidelines



Required for all projects



# Commissioning – New Buildings & Renovations

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- Owner's Project Requirements



## OWNER PROJECT REQUIREMENTS

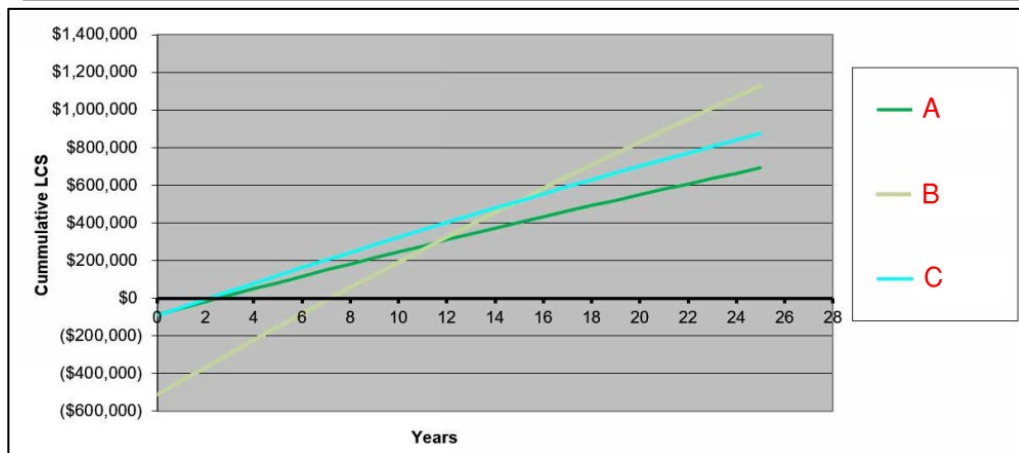
UCF 586  
DOWNTOWN CENTRAL ENERGY PLANT  
January 30, 2018  
Rev 2



# Commissioning – New Buildings & Renovations

- LCCAs

Performance Data	Chiller Selections			
	Florida Baseline	A	B	C
Full Load Efficiency (KW/ton)	0.585	Centrifugal 0.5522	Mag Bearing 0.5568	Centrifugal 0.535
Part Load efficiency NPLV (KW/ton)	0.38	0.3625	0.3383	0.341
Condenser Pressure Drop (Ft/H2O)	20	16.2	11.6	21
Evaporator Pressure Drop (Ft H2O)	20	9.73	14	21
Costs per machine (\$)				
Total costs for 6 chillers (\$)				
Simple Payback (yrs)		2.5	6.9	2.1
Cumulative Life Cycle Savings (\$)		\$691,753	\$1,128,035	\$877,532
Savings to Investment Ratio (SIR)		8.8	3.2	10.4
Adjusted Internal Rate of Return (AIRR)		12.40%	7.90%	13.10%



# Commissioning – New Buildings & Renovations

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- Good Lab Pressurization



# Commissioning – New Buildings & Renovations

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- Variable Kitchen Hood



# Commissioning – New Buildings & Renovations

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- Duct Pressure Testing



Tube Name Plate above photo. Below is chart for Tube 6693-5



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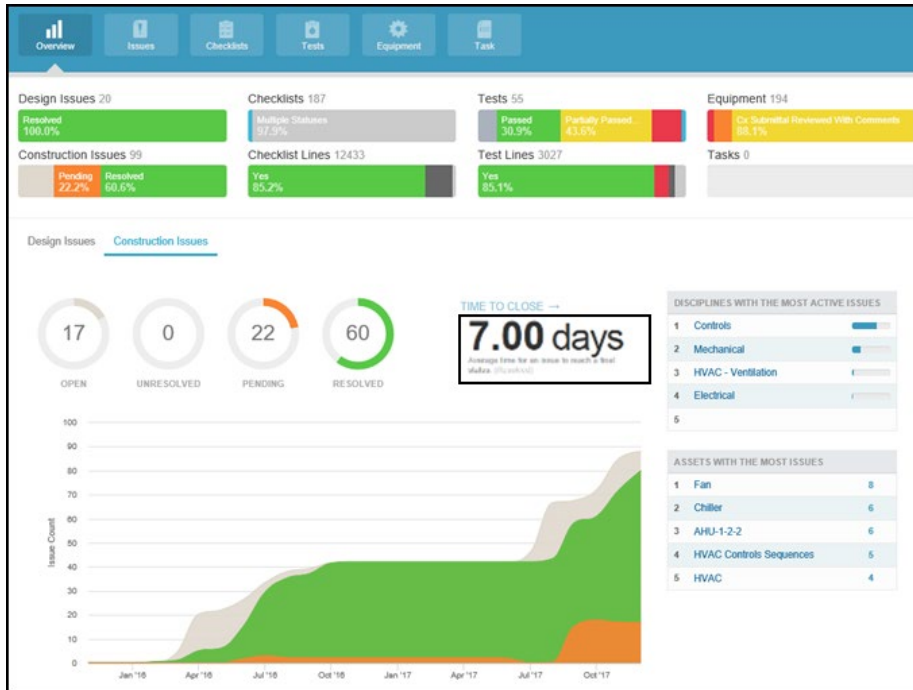
- Controls Integration Matrix

[illegible]



# Commissioning – New Buildings & Renovations

- Communication via CxAlloy

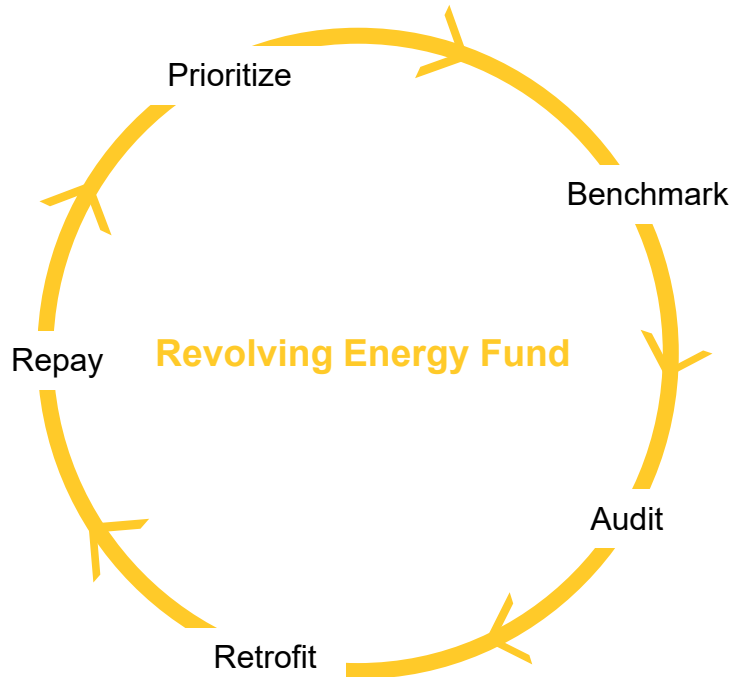




# Energy Services

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- Reduce campus utility consumption
- Manage Continuing Service Contracts for BAS, TAB and Cx

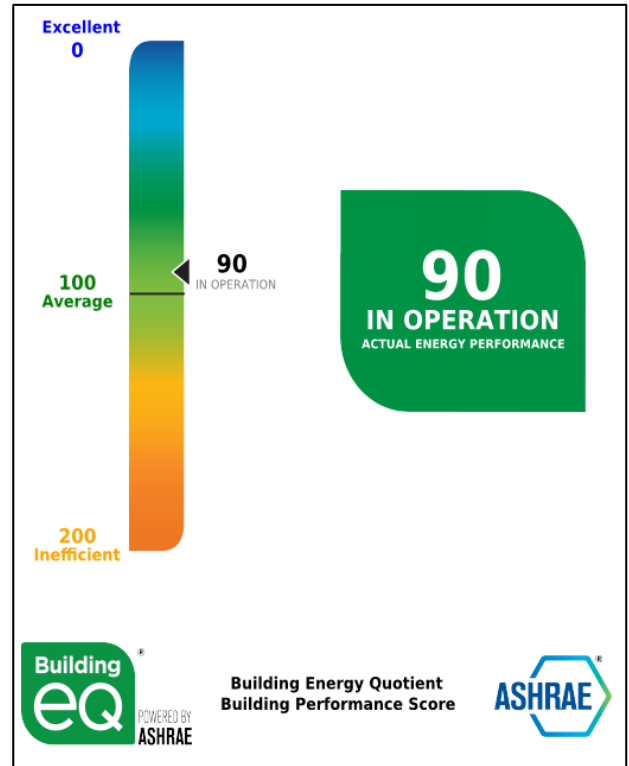






# Benchmarking Buildings

- Which platform?



# Benchmarking Buildings

- Pilot Study using bEQ

## Standard Operating Procedure:

UCF Building Energy Audit and Performance Rating Procedures using the  
ASHRAE Building Energy Quotient (bEQ) Program

### **Purpose:**

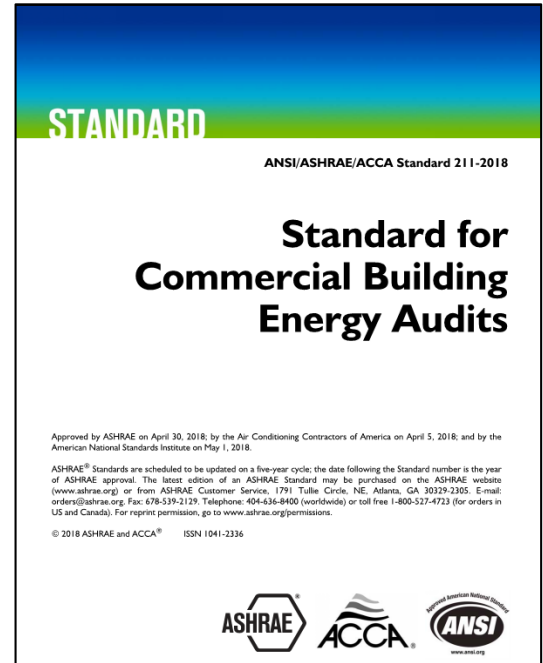
To provide UCF students and staff established guidelines for using the ASHRAE Building Energy Quotient (bEQ) tool effectively to conduct ASHRAE Level 1 energy audits and building benchmarking.

- Plan Forward
  - 20+ buildings per year get bEQ rankings
  - Results determine next step
    - Modernization project (includes Level 2 Audit) or
    - Retro-Cx



# Modernization Projects

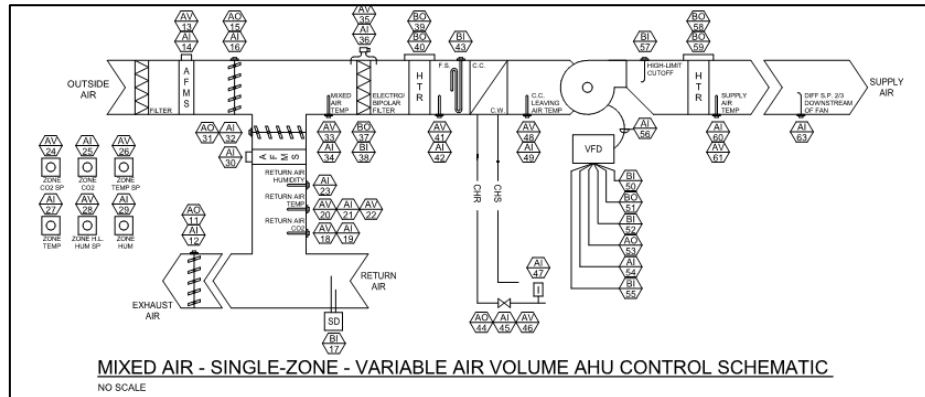
- Perform ASHRAE Level II Energy Audits
  - BAS & CxA involvement
  - Auditor does design docs
  - Goal is 3 to 6 per year



*BAS-centric audits* ← → *RCx SOW*

# Modernization Projects

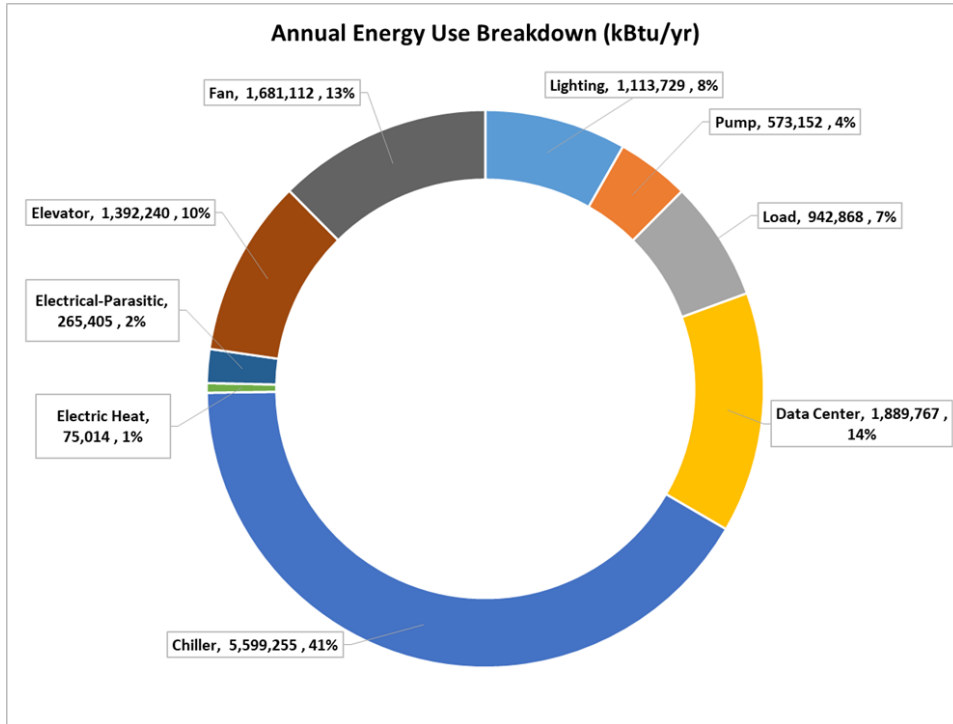
- Design documents result in:
  - BAS, Cx & TAB proposals - direct to owner
  - HVAC major equipment - Owner Direct Purchase
  - Continuing services mechanical, electrical, etc. bids.
- Project focus:
  - Control diagrams
  - Sequences
  - BAS GUI
  - Trends
  - Alarms
  - Data for FDD





# Modernization Projects

- Energy Scores and Consumption





# Modernization Projects

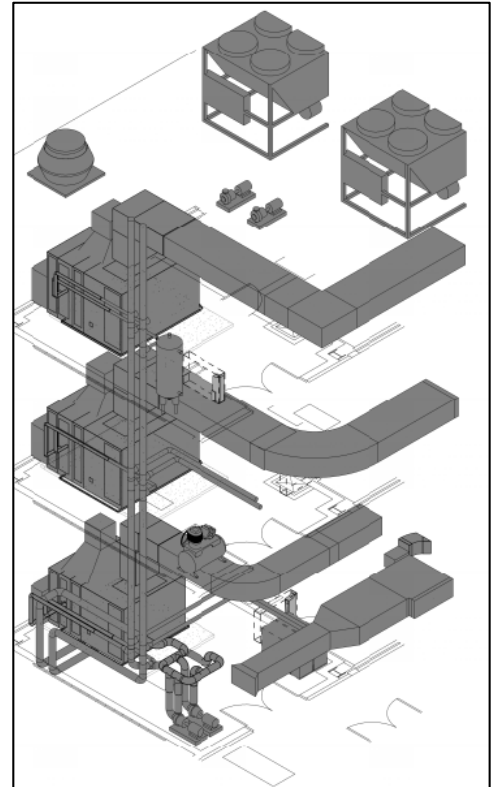
- Facility Improvement Measures

Recommended BAS Upgrades					
Tag	Measure Description	Implementation Costs	Annual Savings	Simple Payback (years)	Comments and Recommendations
1.1	Replace antiquated LonTalk BAS with native BACnet BAS	\$ 209,000.0	\$ 53,000	5.2	
1.2	Implement optimal start routine	Included in FIM 1.1	\$ 12,800	Included in FIM 1.1	Requires FIM 1.1
1.3	Reduce minimum flow settings in VAV terminals	Included in FIM 1.1	\$ 5,300	Included in FIM 1.1	Requires FIM 1.1
1.4	Eliminate OA ventilation during morning warm-up/cool-down modes	Included in FIM 1.1	\$ 3,500	Included in FIM 1.1	Requires FIM 1.1
1.5	Implement OA economizer mode	Included in FIM 1.1	\$ 700	Included in FIM 1.1	Requires FIM 1.1
1.6	Implement dynamic SA duct static pressure setpoint reset	Included in FIM 1.1	\$ 7,200	Included in FIM 1.1	Requires FIM 1.1
1.7	Tune VFD and actuator PID loops to match span range	Included in FIM 1.1	\$ 700	Included in FIM 1.1	Requires FIM 1.1
1.8	Implement demand-control ventilation	Included in FIM 1.1	\$ 8,400	Included in FIM 1.1	Requires FIM 1.1
1.9	Implement supply air temperature setpoint reset	Included in FIM 1.1	\$ 4,000	Included in FIM 1.1	Requires FIM 1.1. Implementation cost assumes two zone relative humidity sensors per AHU
1.10	Install occupancy sensors and integrate with the BAS to relax zone temperature setpoints	Included in FIM 1.1	\$ 8,900	Included in FIM 1.1	This FIM overlaps with Lighting FIM 2.3. Requires installation of dual-mode PIR and ultrasonic occupancy sensors.
1.12	Check hydronic valves and airside damper actuators are operating properly	Included in FIM 1.1	\$ 1,800	Included in FIM 1.1	If the OAD damper is commanded to anything less than 100% VFD speed can be reduced by reducing the total static pressure across the unit.

# Modernization Projects

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- Sample Project
  - Replacing control system
  - Replacing PIU w/ separate heat
  - Replacing three AHUs
  - Replacing OA Dampers
  - Replacing RA Dampers
  - Updating tie to campus CHW
  - Fixing back-up chillers SOO
  - Implement dynamic reset SOO
  - Implement DCV



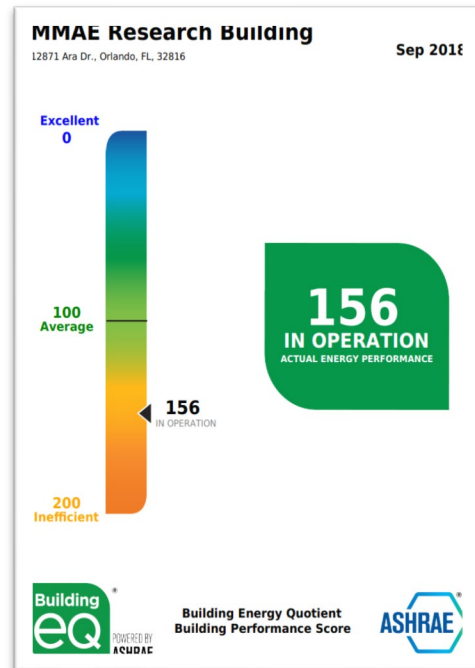


# Retro-Commissioning

- 5 to 10 RCx efforts per year

## Retro-commissioning Conditions

Energy Performance	Less than AVERAGE
BAS	Native BACnet
HVAC	FAIR
Work order history	Neglected
Alarms	Numerous





# Retro-Cx Projects

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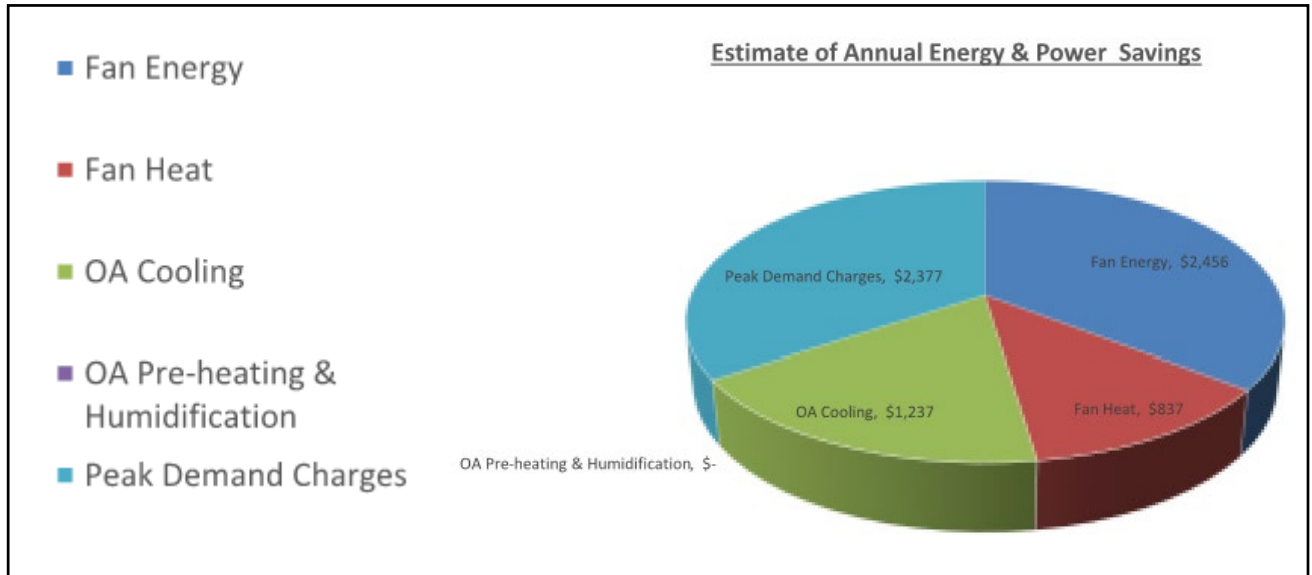
- Existing Chiller Plants Retro-Commissioning
  - Satellite Plants has four 2,000 ton chillers
  - Main Plant has four 2,000 ton chillers (plus an absorption)
  - 3 million gallon thermal storage tank



# Retro-Cx Projects

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- Duct Sealing
  - 4 AHUs leaking 19,475 CFM out of 126,250 CFM Supply Air




# Re-Commissioning

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- Key to lowering OPEX
  - BAS response team hours in FY 17-18 was 66% due to hot / cold calls
- RCx can get in front of:
  - Maintenance burdens
  - Reducing deferred maintenance backlog
  - Information transfer to Operations



# BAS Point to Point



Utilities and Energy Services

UNIVERSITY OF CENTRAL FLORIDA

Re-CX Issues Log

Bldg. 0003 Main Chiller Plant

				Issue	Resolution				
Issue Reference	Date	Discipline	Assoc. Equipment	Comments / Observation	Action By	Corrective Action	Date Resolved	Status	
1	1/29/19	CHWP - 2	CH-2	Suction PT line clogged. Unable to verify Ft Head across pump. Test ports are installed I correctly. Factory supplied ports should be used. Evap GPM total verified by barrel pd.	CHW Dept.	Review with Saul		Open	
2	1/29/19	CHWP - 3	CH-3	Test ports are installed I correctly. Factory supplied ports should be used. Evap GPM total verified by barrel pd.	CHW Dept.	Review with Saul		Open	
3	1/29/19	CH-3	CH-3	Condenser return has Onicon flow Meter installed. No AI shown on BAS. Further investigation required.	Controls	Need to review with Nicole.		Open	
4	1/29/19	CH-3	Evap.	Evap wet DP out of Cal. W.O # 10614384	CHW Dept.	Jose to replace Wednesday morning. Will retest to Verify. Wet dp has been replaced.BAS 2.77 PSID meter reading 2.71 PSID. Calibrated.	1/30/19	Closed	
5	1/30/19	BTU meter EVAP	CH-4	BTU meter appears to be out of calibration. Measured GPM 3816, BTU meter 3564 GPM.	Keith	Spoke with Keith about verifying finding. Wednesday feb.6. Last calibration Date 6/30/2014		open	
6	1/30/19	BTU meter EVAP	CH-5	BTU meter appears to be out of calibration. Measured GPM 3775, BTU meter 3360 GPM. 2.4 degree difference between measured and BTU temp Lev water temp. Measured 44.3, BAS 43.3 and BTU Meter 41.9.	Keith	Spoke with Keith about verifying finding. Wednesday feb.6. Last calibration Date 4/28/2015		open	
7	1/30/19	Condenser Water GPM.	CH-4	Measured condenser water GPM 6173 @ 6.67 FT.BAS reading 5.73 Ft @ 5757 GPM.		Need to replace Dp sensor. 116% (16%) difference between measured and BAS.		open	
8	1/30/19	Condenser Water GPM.	CH-5	No proper test port for testing dp across chiller Cond barrel.	CHW Dept.	Spoke with Saul and Eddy. They will have a test port installed on Thursday 1/31/2019.		open	

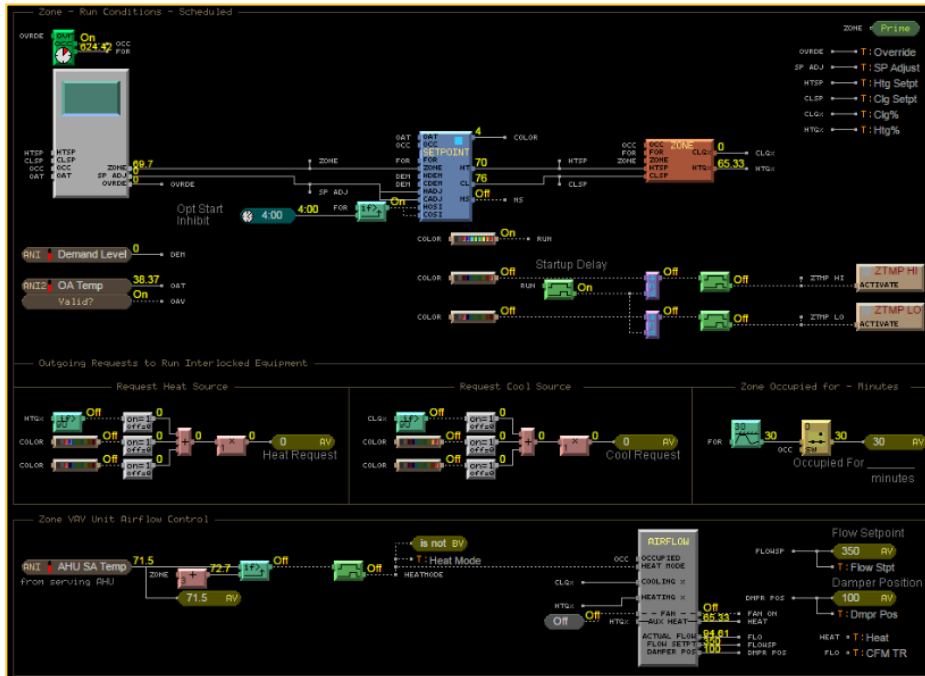
# TAB

- Re-TAB
  - Calibrates the BAS
  - Returns HVAC to design parameters & records performance degradation
  - Restores BTUs, CFMs and GPMs
- BAS now provides trustworthy telemetry

PUMP TEST REPORT				
Job Name: Retro Cx- UES 0003 Main Chiller Plant				DATE:
PUMP DATA				
Pump Designation	SCHWMTR-1	SCHWMTR-2	SCHWMTR-3	SCHWMTR-4
Pump Manufacturer	ARMSTRONG	ARMSTRONG	ARMSTRONG	ARMSTRONG
	12X12X17 /	12X12X17 /	12X12X17 /	12X12X17 /
Model Number	43TCZ	43TCZ	43TCZ	43TCZ
Impeller Size				1800 / 1762
RPM	1800	1800	1800	Tested
Design GPM	5300	5300	5300	5300
Design Head	180	180	180	180
System Fill Pressure				
MOTOR DATA				
Motor Manufacturer	TECO / 449TCZ	BALDOR / 445TCZ	BALDOR / 445TCZ	BALDOR / 445TCZ
Horsepower	300	300	300	300
RPM	1788	1780	1780	1780
Voltage	460	460	460	460
Phase	3	3	3	3
Amperage				
Rated	332.0	335.0	346.0	346.0
Corrected for Voltage				
TEST RESULTS - FINAL				
Suction	42.1	Punch	43.7	41.0
Discharge	79.2		81.2	80.4
Pressure Differential	37.1	#VALUE!	37.5	39.4
Head in Feet	85.7		86.6	91.0
Final GPM	7681		7641	7454
Test Voltage	NA	NA	NA	NA
	NA	NA	NA	NA
	NA	NA	NA	NA
Running Amperage	332.1		282.2	332.5
	VFD		VFD	VFD

# Functional Testing

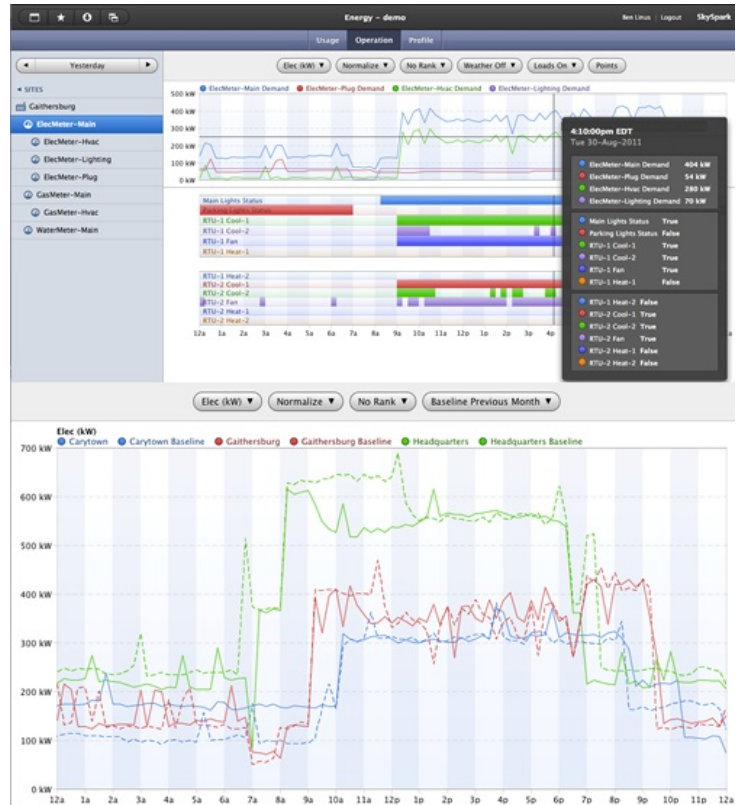
- Sequences of Operations tested
- Sequence enhancements programmed and tested
- Systems Manual updated (and into CMMS and GUI)





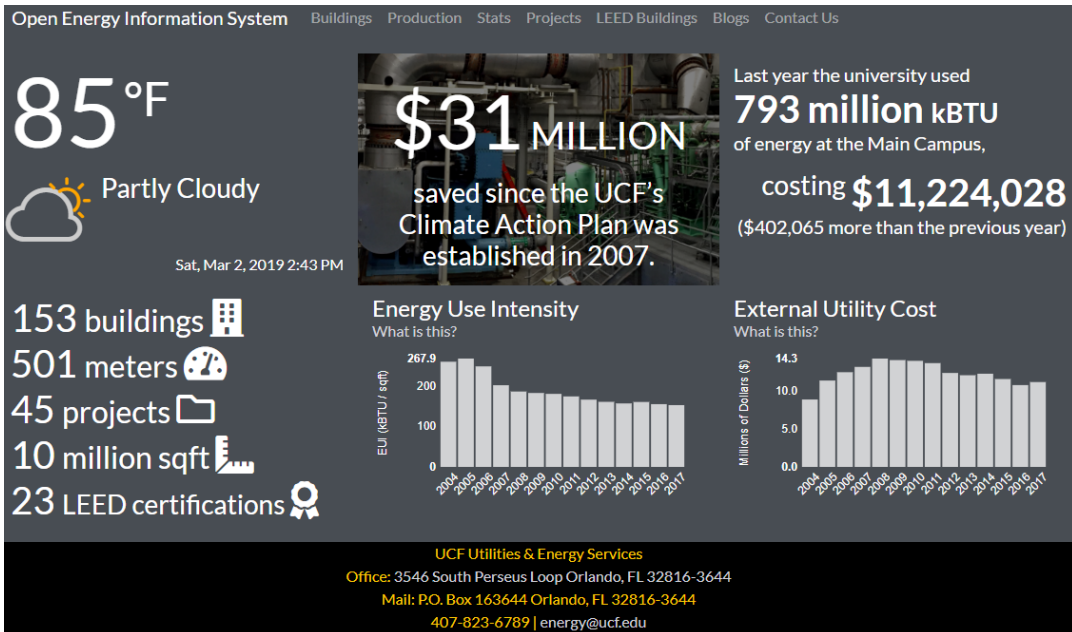
# Monitoring-Based Cx

- Map ReCx project BAS points into Monitoring-Based Cx FDD
- “Human” intervention of FDD faults initially
- If Confidence is  $> 95\%$ , then FDD faults result in actual work orders.



# Carbon Neutrality

- UCF's goal is carbon neutrality by 2050.
- What will our carbon impact look like by then?
- What does it look like now?





# Carbon Neutrality

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- Demand Response = approximately 30% average energy savings
- For 2018, campus reduced from 793 million kBTU to 555 million kBTU
- How much PV is needed to generate 555 million kBTU?
  - 136 MW = 25% coverage (362 of 1,440 acres)
  - Not realistic, and doesn't account for growth
- Peak electrical demand = approximately 30 MW
- Is it legal/safe to export 100+ MW on peak?
- Is it cost effective to store it?



# Smart Grid Plans

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- DG via PV, hydrokinetic, waste-to-energy, co-gen, tri-gen.
- 140 kW grid-connected PV currently
- Energy Storage
- BAS infrastructure for dynamic demand response
- Advanced AMI utility metering and BAS utility sub metering
- Power Systems degrees collaborating with UES and Siemens
  - Digital grid lab
  - Smart buildings lab



# Renewable Energy

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- Only 140kW installed currently
- Ground mount – lowest \$/W, needed for 2020 goal
- Rooftop – prioritize by size, verify structural, simulate grid, deploy
- Parking Garage
- Surface Parking
- Floating Arrays
- Other sources
  - Hydrokinetic turbines (reclaim pressure reduction) = ~12 kW
  - Waste-to-Energy bio-digester = waste audit needed





# By The Numbers.

Avoided **\$30.5 million** in utility expenditures.

**23 buildings** are certified under LEED.

**\$25.4 million** in infrastructure improvements since 2014.

Reduced campus Energy Use Intensity by **42.4%** since 2007.



# Conclusions

- Dedicated, yet diverse, team with aligned purpose
- Strong, transparent working relationships
- Living documents and easily accessible records
- Academia eager for collaboration with operations
- Have a plan



