

TECHNOLOGY OVERVIEW OF  
**THE CATALYST**

MARCH 16, 2016

Making smart...  simple





transformative wave  
CATALYST

US Patent # 8,515,584

**YALE**  
MECHANICAL

HVAC • PIPING • SHEET METAL • MILLWRIGHT • PLUMBING

# North America's Leading Efficiency Solution for Rooftop Packaged HVAC Systems

**Proven to reduce overall HVAC energy use by 25%-50%.**



PERFORMANCE & EFFICIENCY  
RETROFIT KIT  
PORTFOLIO ASSET MANAGEMENT  
COMPREHENSIVE VERIFICATION  
ADVANCED  
30-50% ENERGY SAVINGS  
PRE-PROGRAMMED  
70% FAN SAVINGS  
PREDICTABLE  
COST EFFECTIVE  
DOE VALIDATED  
OF DATA  
DCV  
70% FAN SAVINGS

# Third-party Validated Savings

PNNL study reports CATALYST produced an average, normalized energy savings of 57% on 66 RTUs across four US climate zones.

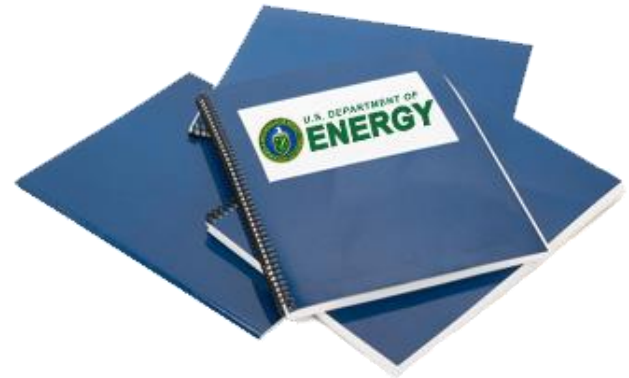


U.S. DEPARTMENT OF  
**ENERGY**



**Pacific Northwest**  
NATIONAL LABORATORY

*Proudly Operated by **Battelle** Since 1965*



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# Acknowledgements & Awards

- Named **#1 “Game-changing Technology of 2013”**
  - by E Source - the nation’s leading efficiency product evaluator.
- Named the **“Top Technology Deployment of the Year”**
  - by Association of Energy Service Providers.
- Two-time winner of the **Defense Energy Technology Challenge.**
- **Approved for Title 24** requirements in California utilities
- Selected as **exclusive product for field trials** conducted by two U.S. DOE Labs
- Withstood the scrutiny of numerous utility and **3rd-party trials.**



# Some of our Customers

- Whole Foods Markets
- BJ's Wholesale
- Rite Aid
- IKEA
- McDonalds
- Macerich Malls
- General Growth Properties
- Simon Properties
- Jones Lang LaSalle
- CBRE
- Walgreens
- Jack in the Box
- Kaiser Permanente
- Los Angeles Unified Schools
- Multiple CA Universities
- US Navy & Air Force
- Big Y Supermarkets
- Planet Fitness
- Bay Club Fitness
- Mor Furniture
- Ashley Furniture
- Dunkin Donuts
- Coast Guard
- Staples
- BE Aerospace
- BrandSmart
- Eli Lilly
- Microsoft
- Life Technologies
- YMCA
- Teledyne
- TJ Maxx
- Qualitel
- Caterpillar
- Goodwill Industries
- Holiday Inn





The CATALYST was one of 3 technologies evaluated in a pilot program by the MN Center for Energy and Environment (CEE) in a field test of Advanced Rooftop Controls.

A copy of the full report is available on CEE's website: <http://www.mncee.org/>





# Meet The Guys Who Dreamed This Up

## WASHINGTON GREEN 50



technology/cleantech  
(small company)

**Transformative Wave Technologies, Kent**

TWT retrofits existing HVAC systems to increase their energy and cost efficiency.

[catalystteec.com](http://catalystteec.com)



# Common Commercial HVAC Systems

- Chilled Water / Boiler Plants
  - High Rise Office; Campuses, Hospitals, Large Office Buildings, Mixed-Use
- Variable Air Volume (VAV)
  - Mid-rise, Medium Office
- Water Source Heat Pumps
  - Small to mid size office
- Split Systems; Variable Refrigerant Flow
- **Most Common: Rooftop Package Units (RTU's)**

# RTU Basics





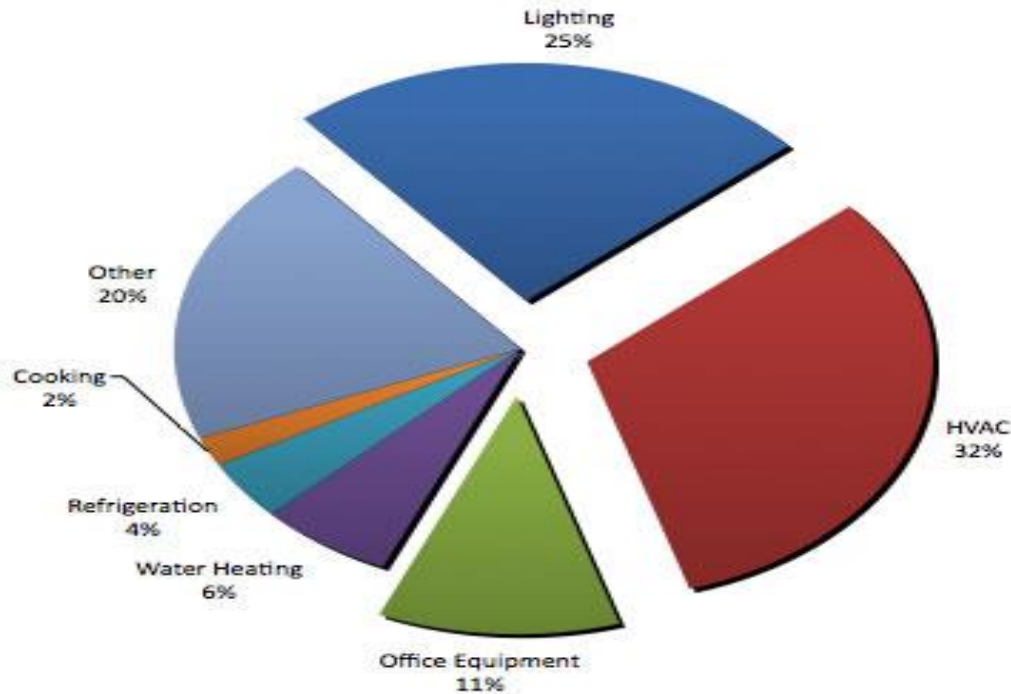


# RTU Energy Usage

- RTUs use more energy than any other cooling technology
- Annual energy consumption exceeds 2.1 quads
  - 1 quad = 8 billion gallons of gasoline
- RTUs operate at a low efficiency level because:
  - Oversized
  - Unintelligent
  - Under-Maintained
  - Often Ignored
  - Lack Accountability



# HVAC Accounts For an Average of 30% to 35% of Building Energy Use





# What Can Be Done?

## Status Quo

- Constant Speed Fan
- Single-point change-over economizer
- Fixed ventilation based on max occupancy

## Advance Rooftop Controls

- Variable Speed Fan
  - 60-65% of the savings
- Differential Economizer
  - CA Title 24 Fault Detection
- Demand Control Ventilation (DCV)





## ...but wait – There’s More!

- Automatic Airflow Adjustments to Protect Equipment
- Maintains Comfort & IAQ
- Solves Power Exhaust Problems
- Demand-Response Capable
- Built In Measurement and Verification Sequence
- Proven Track record of Reducing Overall Energy Use by 25%-50%



**“In over 40 years of experience in the HVAC industry, this is the best product I have ever seen for Packaged Rooftop Units.”**

- John Morgan, Owner, Bay Air Systems

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# Six Little-Known Facts That Support RTU Retrofit Solutions:

1. Lighting upgrades undermine humidity control through the HVAC system
2. Simply adding a VFD to RTUs can undermine proper ventilation / IAQ
3. Traditional Demand Control Ventilation (DCV) increases electric usage
4. Nearly 80% of all RTU economizers are dysfunctional
  - Client receives little or no benefit
5. Power exhaust fans can erase the benefit of an economizer
6. EER Efficiency Ratings are not an indication of overall energy efficiency





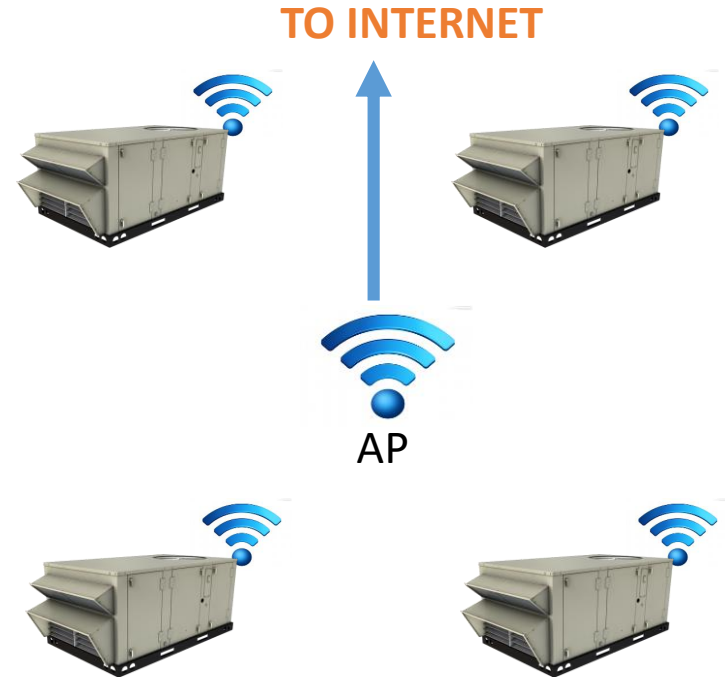




# transformative**wave** eIQ Platform

## Wireless Rooftop Network

- Secure/Non-Discoverable Network
  - 802.11a 5 GHz
- Hub – Spoke Deployment
  - To Central Access Point “AP”
- Line-of -Sight Preferred
- Can Support Wired CAT5 Network



## No wiring in the space or on rooftop

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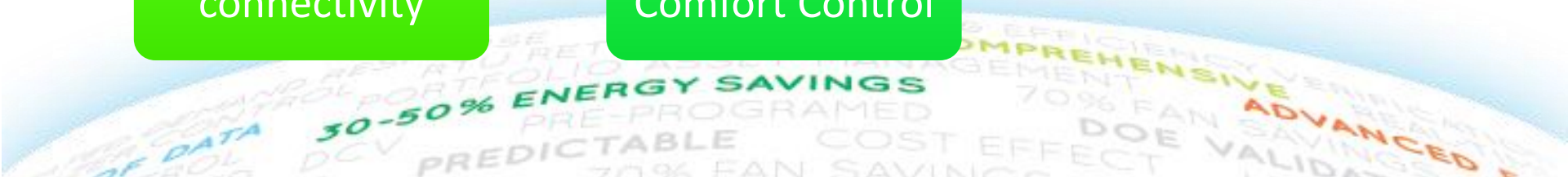
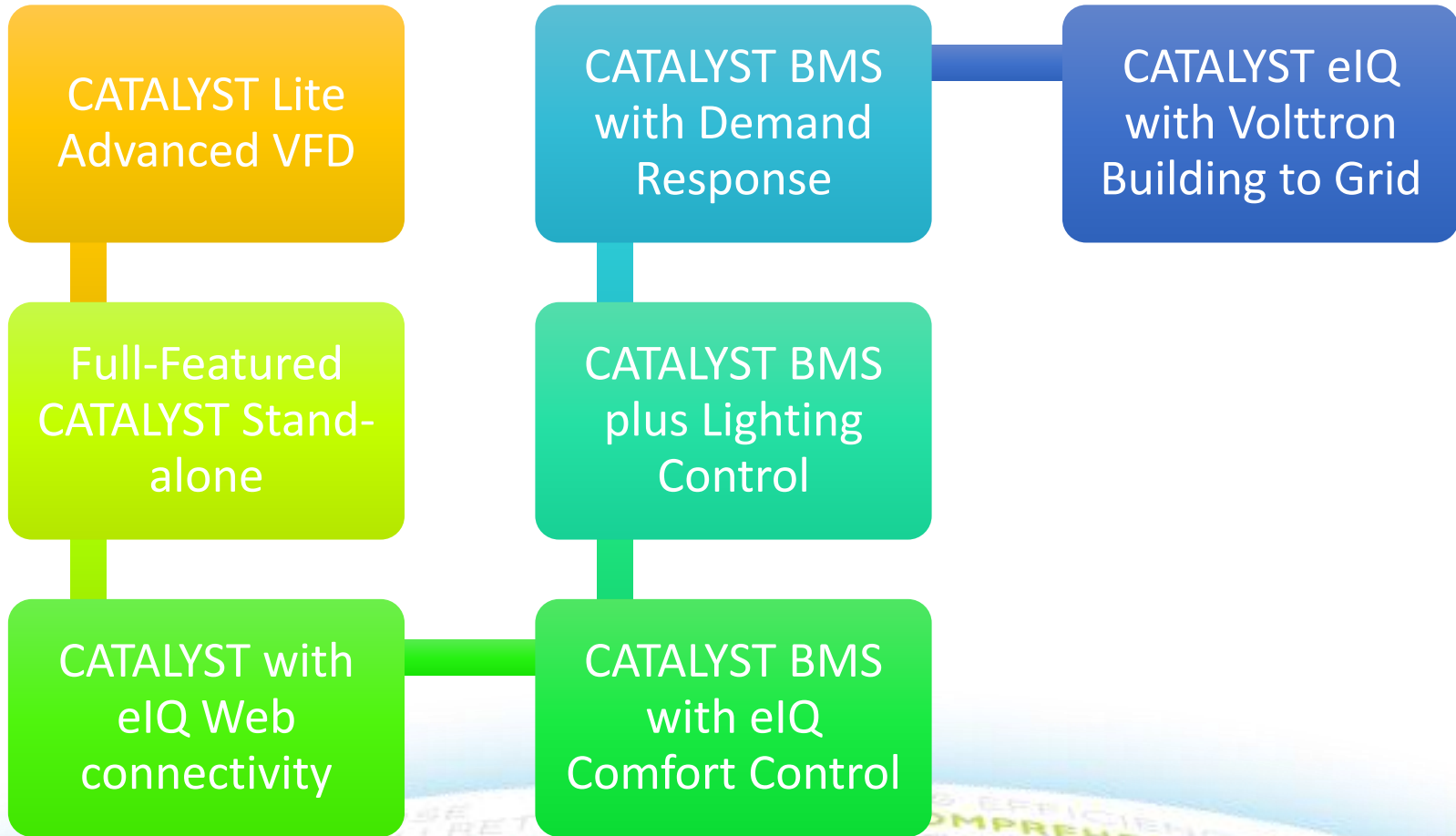
# CATALYST Service Switch

- A multi-position selectable switch for service personnel use. This will enable techs to operate the system in any mode of operation for maintenance purposes.
- The use of the service switch will suppress data collection by the eIQ Platform to avoid negative impact on fault detection and analytics.

Empowers contractors to easily perform preventative maintenance and verify economizer functions without undermining the CATALYST installation



# Our Solution Stack

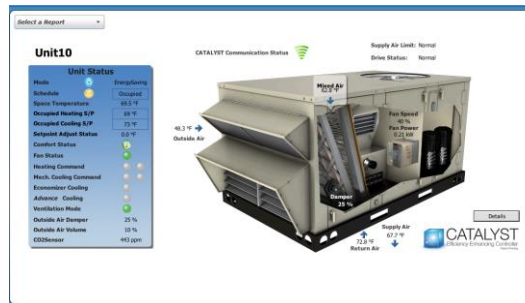




# transformativewave eIQ Platform

# YALE MECHANICAL

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Mor Furniture - Kent Site Report

34.0 °F Cloudy Connection Status: Online

Unit Name	Serves	Comm. Mode	Health	OC	Control	Space	Actual	Fan	Power	1	2	3	Supply	Return	CO2	Volume
UNIT01 Conference rm						64.5 °F	68 °F	73 °F	130 %	0.45 kW			68.3 °F	64.3 °F	358 ppm	3 %
UNIT02 Mail Room W						71.2 °F	72 °F	73 °F	75 %	0.33 kW			69.5 °F	73.1 °F	489 ppm	12 %
UNIT03 Mail Room E						71.5 °F	72 °F	73 °F	75 %	0.46 kW			64.5 °F	72.1 °F	489 ppm	4 %
UNIT04 Breakroom						68.4 °F	69 °F	73 °F	100 %	0.48 kW			71.5 °F	75.3 °F	489 ppm	5 %
UNIT05 N.W. Show						64.1 °F	69 °F	73 °F	75 %	0.87 kW			124.5 °F	74.8 °F	499 ppm	14 %
UNIT06 N.E. Show						62.4 °F	69 °F	73 °F	75 %	0.76 kW			66.7 °F	64.5 °F	536 ppm	27 %
UNIT07 R. Show						64.1 °F	69 °F	73 °F	90 %	1.45 kW			119.0 °F	75.9 °F	499 ppm	14 %
UNIT08 Central show						65.2 °F	69 °F	73 °F	45 %	0.19 kW			64.2 °F	71.8 °F	474 ppm	14 %
UNIT09 Control room						69.2 °F	70 °F	73 °F	90 %	2.24 kW			124.0 °F	74.4 °F	466 ppm	15 %
UNIT10 W. Show						65.2 °F	69 °F	73 °F	45 %	0.23 kW			67.4 °F	72.4 °F	442 ppm	10 %
UNIT11 Finance						64.4 °F	69 °F	73 °F	40 %	0.26 kW			74.4 °F	72.4 °F	445 ppm	8 %
UNIT12 E.W. Show						69.2 °F	69 °F	73 °F	40 %	0.22 kW			67.4 °F	70.4 °F	439 ppm	16 %
UNIT13 E. Show						69.2 °F	69 °F	73 °F	40 %	0.20 kW			67.9 °F	71.4 °F	445 ppm	19 %
UNIT14 S. Show						70.2 °F	69 °F	73 °F	40 %	0.20 kW			67.4 °F	71.4 °F	439 ppm	18 %
UNIT15 S.E. Show						70.1 °F	69 °F	73 °F	40 %	0.17 kW			67.3 °F	70.3 °F	431 ppm	14 %

## Web-accessible control & visualization

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# Portfolio Prioritization Tools

Bartell Drugs  
Washington Region

transformativewave  
eIQ Platform

**Energy**

! Energy Alerts (4)

- Bartell #12 - Bothell
- Bartell #18 - Kirkland
- Bartell #38 - Seattle
- Bartell #40 - Bellevue
- Bartell #66 - Seattle

🔊 Energy Warnings (5)

- Bartell #06 - Redmond
- Bartell #23 - Seattle
- Bartell #38 - Seattle
- Bartell #62 - Shoreline
- Bartell #68 - Renton

**Health**

🔊 Health Warnings (9)

- Bartell #06 - Redmond
- Bartell #07 - Issaquah
- Bartell #32 - Des Moines
- Bartell #42 - Queen Anne
- Bartell #47 - Maple Valley
- Bartell #51 - Marysville
- Bartell #53 - Lynnwood
- Bartell #54 - Tacoma
- Bartell #66 - Seattle

**Comfort**

🔊 Comfort Warnings (2)

- Bartell #23 - Seattle
- Bartell #54 - Tacoma

! 5   🗑️ 5   ✓ 42

! Alerts (0)   🗑️ 9   ✓ 41

! Alerts (0)   🗑️ 2   ✓ 42

# Quick Access to Detailed Information

Unit Name	Serves	Comm	Mode	Health	Occ	Fan	Cooling		Heating		Fan Status	Fan Speed	Fan Power	Cooling		Hea
							1	2	1	2				1	2	1
Unit01	N.W. Hygene											40 %	0.32 kW			
Unit02	Northwest											40 %	0.33 kW			
Unit03	Southwest											40 %	0.34 kW			
Unit04	S.W. Corner											75 %	2.11 kW			
Unit05	S.E. Corner											75 %	1.79 kW			
Unit06	Southeast											40 %	0.33 kW			
Unit07	Northeast											40 %	0.33 kW			
Unit08	N.E. Corner											40 %	0.26 kW			

UnitHealth = Fan Belt/ Motor Adjustment {ok}

Specific Fault is enunciated via a text description when user holds cursor over the Health Icon

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# Visualize Real-Time Performance

AC02B Bar/Restaurant

Summary

CATALYST Mode



Space Temperature  
70.4 °F

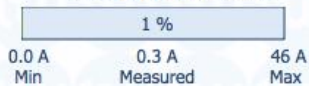
Actual Cooling  
Setpoint  
71 °F

70 °F  
Actual Heating  
Setpoint



- Heat 3
- Heat 1
- Emergency
- Advanced Cool
- Ventilation Mode
- Heat 2
- Heat 4

Total Unit Power %



Outside Air  
45.7 °F  
5 %  
OSA Volume



Fan Speed  
40 %  
Fan Power  
0.13 kW

OSA Damper  
12 %

**!** Damper Fault  
Improper Operation

Supply Air  
58.6 °F  
Normal

Return Air  
71.6 °F  
512 ppm

STATUS

SETTINGS

PERFORMANCE



# Drill Down to Unit Details

AC01A South Casino Floor

Summary

### Drive

Drive Status: Normal

Drive Reset:

### Occupancy

Occupancy Status: Occupied

Occupancy Schedule Selector: Schedule 1

Unoccupied Override Time	-	60 min	+
Optimum Start Maximum	-	45 min	+
Optimum Stop Time	-	30 min	+
Optimum Stop Setpoint Offset	-	2 °F	+

### Demand Control Ventilation

CO2 Setpoint:

DCV Max Air Volume:

### Space Setpoints

Space Temperature: 69.3 °F

Actual Heating Setpoint: 70 °F

Actual Cooling Setpoint: 72 °F

Occupied Heating S/P:

Occupied Cooling S/P:

Unoccupied Heating S/P:

Unoccupied Cooling S/P:

Setpoint Adjust Range:

Setpoint Adjust Status: 0.0 °F

### Economizer

OSA Damper: 7 %

Base Econ Setpoint:

Econ Standard Min:

ESM OSA Minimum\*:

Power Exhaust SP\*:

Power Exh. Command: Stop

Allow Compressor if Economizer Fails:

### Supply Limit

Supply Air Temp: 110.4 °F

Supply Air Limit: Normal

Low Limit Alert S/P:

Low Limit Alarm S/P:

High Limit Alert S/P:

High Limit Alarm S/P:

### Fan Speeds

Vent Mode Speed:

Full Speed Setpoint:

Heat 1 Speed:

Heat 2 Speed:

Cool 1 Speed:

Cool 2 Speed:

### Service Switch

Status: Auto

Soft Switch:

Fan Status:

Heating Command:

Mech. Cooling Command:

Fan Speed: 75 %

Fan Power: 0.99 kW

OSA Damper: 7 %

\*Calculated Outside Air volume utilizing fan speed multiplied by Outside Air Damper position.

STATUS SETTINGS PERFORMANCE



# Remote Control Capability

AC01A South Casino Floor

Summary

### Drive

Drive Status: Normal

Drive Reset:

### Occupancy

Occupancy Status: Occupied

Occupancy Schedule Selector: Schedule 1

Unoccupied Override Time: - 60 min +

Optimum Start Maximum: - 45 min +

Optimum Stop Time: - 30 min +

Optimum Stop Setpoint Offset: - 2 °F +

### Demand Control Ventilation

CO2 Setpoint: - 1000 ppm +

DCV Max Air Volume: - 30 % +

### Space Setpoints

Space Temperature: 69.3 °F

Actual Heating Setpoint: 70 °F

Actual Cooling Setpoint: 72 °F

Occupied Heating S/P: - 70 °F +

Occupied Cooling S/P: - 72 °F +

Unoccupied Heating S/P: - 60 °F +

Unoccupied Cooling S/P: - 80 °F +

Setpoint Adjust Range: - 0.0 °F +

Setpoint Adjust Status: 0.0 °F

### Economizer

OSA Damper: 7 %

Base Econ Setpoint: - 65 °F +

Econ Standard Min: - 15 % +

ESM OSA Minimum\*: - 5 % +

Power Exhaust SP\*: - 85 % +

Power Exh. Command: Stop

Allow Compressor if Economizer Fails:  No

### Supply Limit

Supply Air Limit:

Supply Air Limit:

Low Limit A:

Low Limit B:

High Limit A:

High Limit B:

### Fan Speeds

Vent Mode Speed: - 40 % +

Full Speed Setpoint: - 100 % +

Heat 1 Speed: - 75 % +

Heat 2 Speed: - 90 % +

Cool 1 Speed: - 75 % +

Cool 2 Speed: - 90 % +

### Service Switch

Status: Auto

Soft Switch:

Fan Status:

Heating Command:

Mech. Cooling Command:

Fan Speed: 75 %

Fan Power: 1.01 kW

OSA Damper: 7 %

STATUS

SETTINGS

PERFORMANCE

\*Calculated Outside Air volume utilizing fan speed and Outside Air Damper position.



# Remote Test Sequence for Economizer, Cooling, & Heating

AC01A South Casino Floor

Summary

### Economizer

Normal

OSA Volume @ 100% OSA **84.0 %**  
Setpoint 60.0 %

OSA Volume @ Minimum 5 % **10.3 %**  
Setpoint +/- 5.0 %

Leakage When OSA Closed **2.2 %**  
Setpoint 10.0 %

### Economizer Test

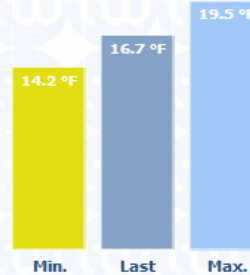
High OSA Setpoint	100.0 °F
Low OSA Setpoint	50.0 °F
OSA / Return Differential S/P	10.0 °F
OSA Temperature	57.7 °F
Return Temperature	72.2 °F

Conditions Suitable ●  
Test in Progress ●

Start Test

These tests will override the unit for 45 minutes and modulate the OSA Damper fully open, to minimum and fully closed.

### Mechanical Cooling



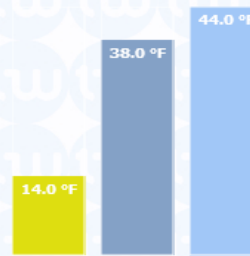
Cooling Capacity °F

Maximum Recorded Unit Amps  
Measured Cooling Amps



Cooling Power

### Heating



Heating Capacity °F

### Heating & Cooling Tests

Supply Air 69.0 °F

Test Mechanical Cooling

Passed

Reset Cooling Data



Test Heating

Passed

Reset Heating Data



These tests will override the unit for 30 minutes and operate the heating/cooling continuously for 15 minutes.

STATUS

SETTINGS

PERFORMANCE





Advanced  
Fault  
Detection &  
Remote  
Diagnostics

Energy  
Saving  
Hardware  
Upgrade

Efficiency &  
Performance  
Verification  
Tools

**CATALYST** *with eIQ*  
comprehensive solution

M&V Data  
Collection  
Mechanism

Demand  
Response  
Technology

Building  
Control  
System





# transformative wave eIQ Platform

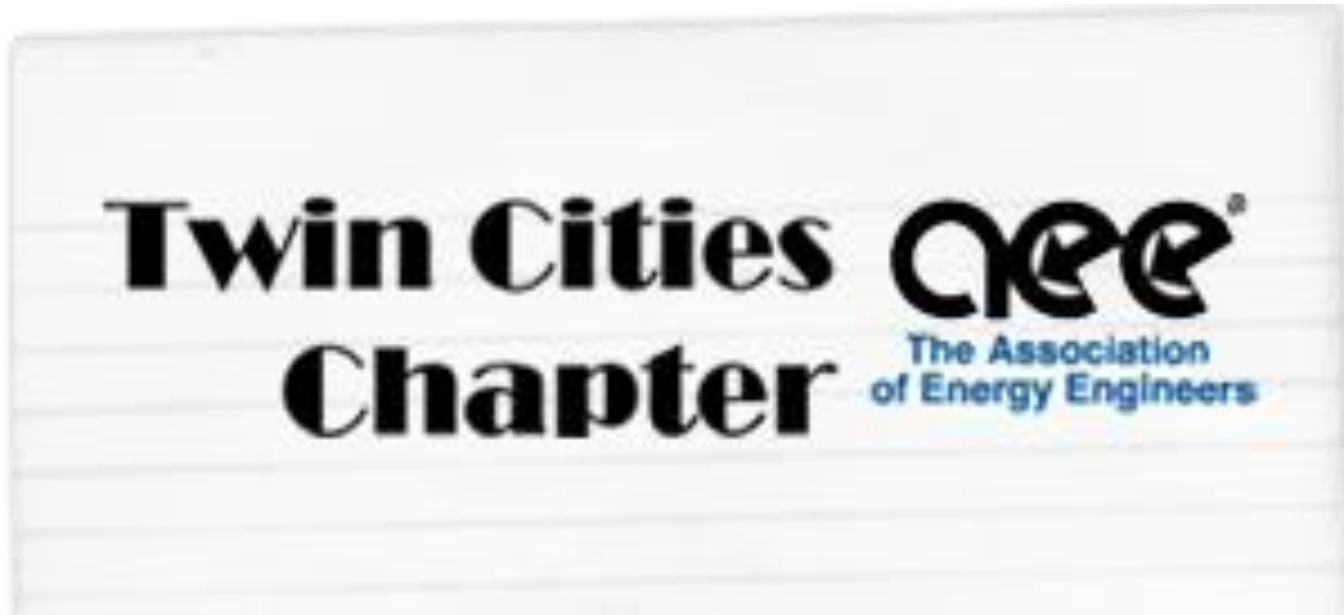
## Live Demonstration



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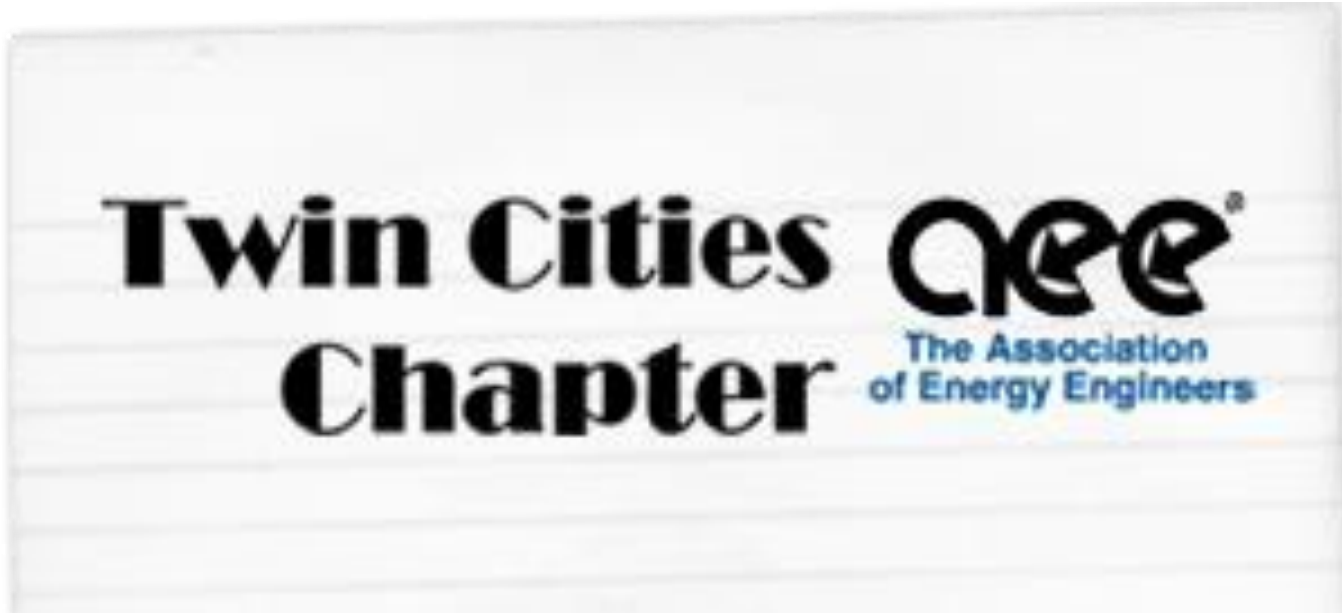




# QUESTIONS?

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**THANK YOU!**

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