



# Retrocommissioning (RCx)

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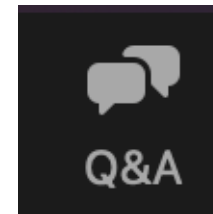
NEW HAMPSHIRE  
Electric Co-op

Unitil



## We look forward to hearing from you

Please put all your questions into the panel with the Q&A icon.



# Agenda

1

## **Strategic Partnerships and Opportunity**

NHSaves utility partners value partnership to drive energy efficiency projects

2

## **Controls Overview and RCx Introduction**

Overview of EMS architecture and RCx opportunities

3

## **Case Studies**

Project examples highlighting how NHSaves utility partners can support your projects



# Benefits of Utility Strategic Partnerships

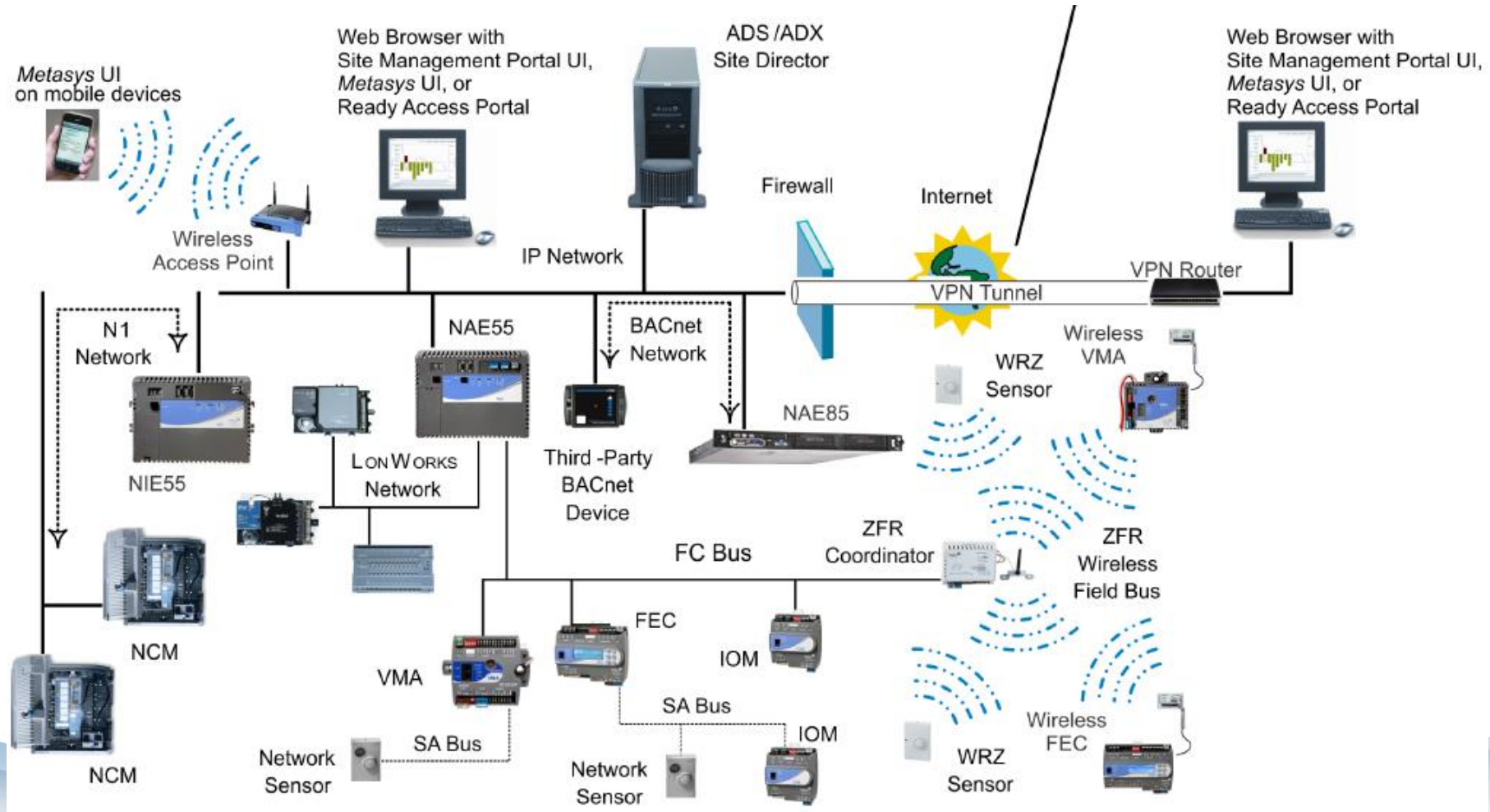
- Allows for a multifaceted approach in providing integrated solutions to C&I customers' unique needs
- Wealth of resources and expertise available, enabling your organization to develop more effective programs and strategies
- Provide access to incentives and funding opportunities to support your energy efficiency initiatives

# Opportunities with EMS

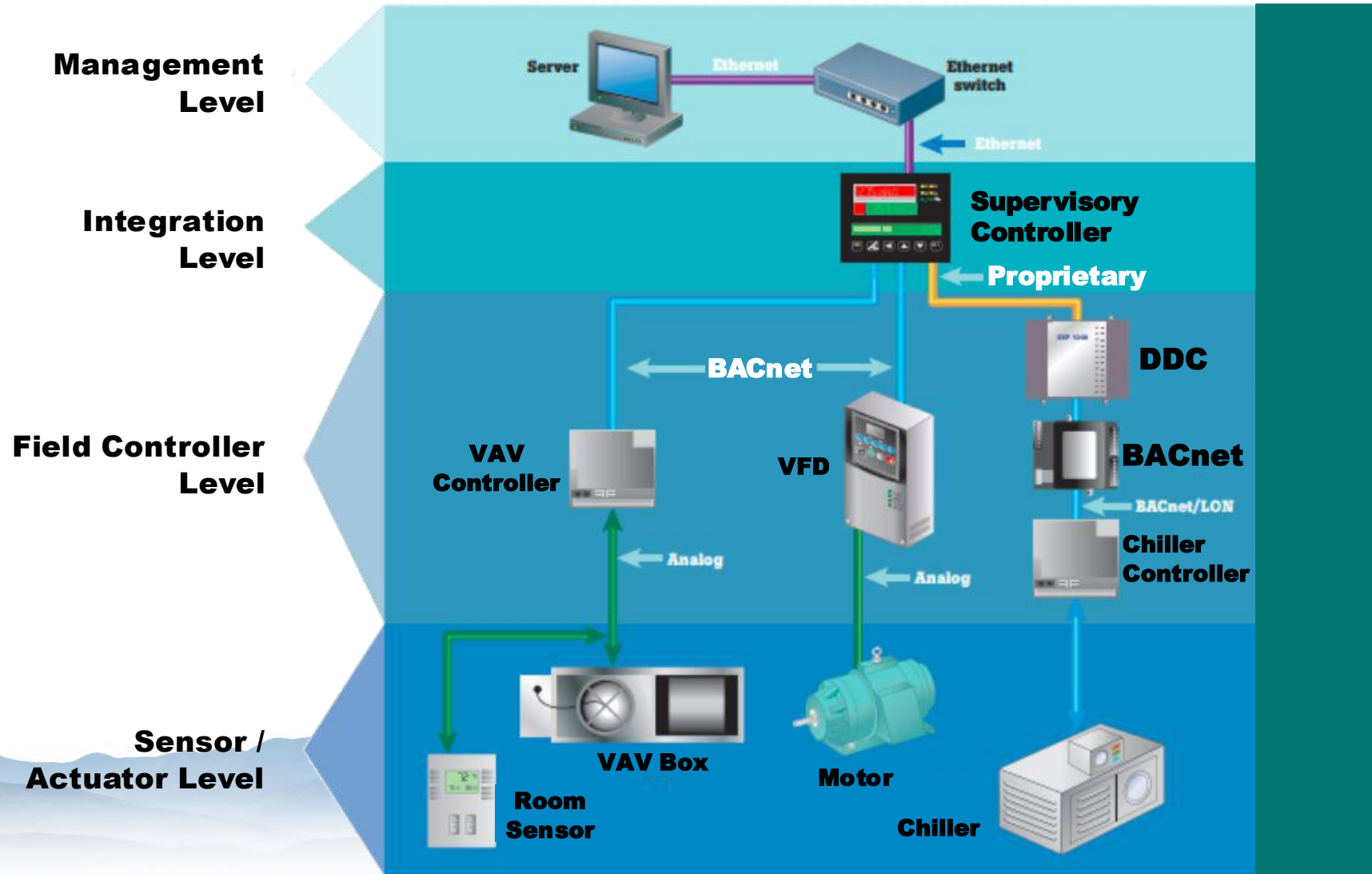
- EMS is the *new lighting* in terms of cost-effective and prevalent energy savings opportunity
- Often underutilized, lacking support/expertise, outdated and inefficient
- Potential opportunities
  - New construction systems
  - New systems with no pre-existing EMS
  - Existing systems:
    - *Complete replacement*
    - *Partial system replacement/upgrades*
    - *Component replacement*
    - *Add-on or expanding*
    - *Integration*
    - *Software or front-end updates*

***“ You cannot manage what you cannot measure (or trend)! ”***

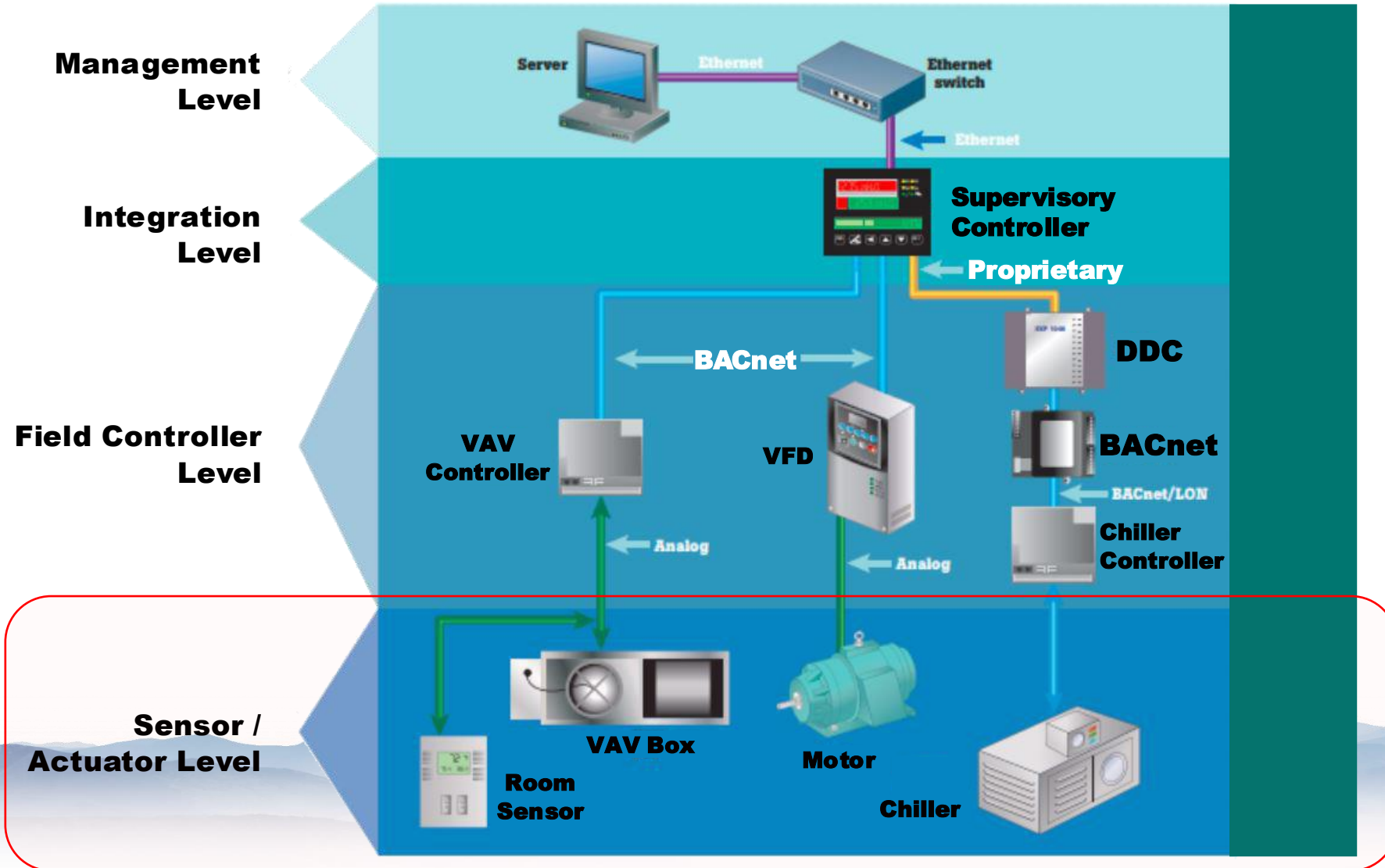
# EMS Architecture



# EMS Architecture

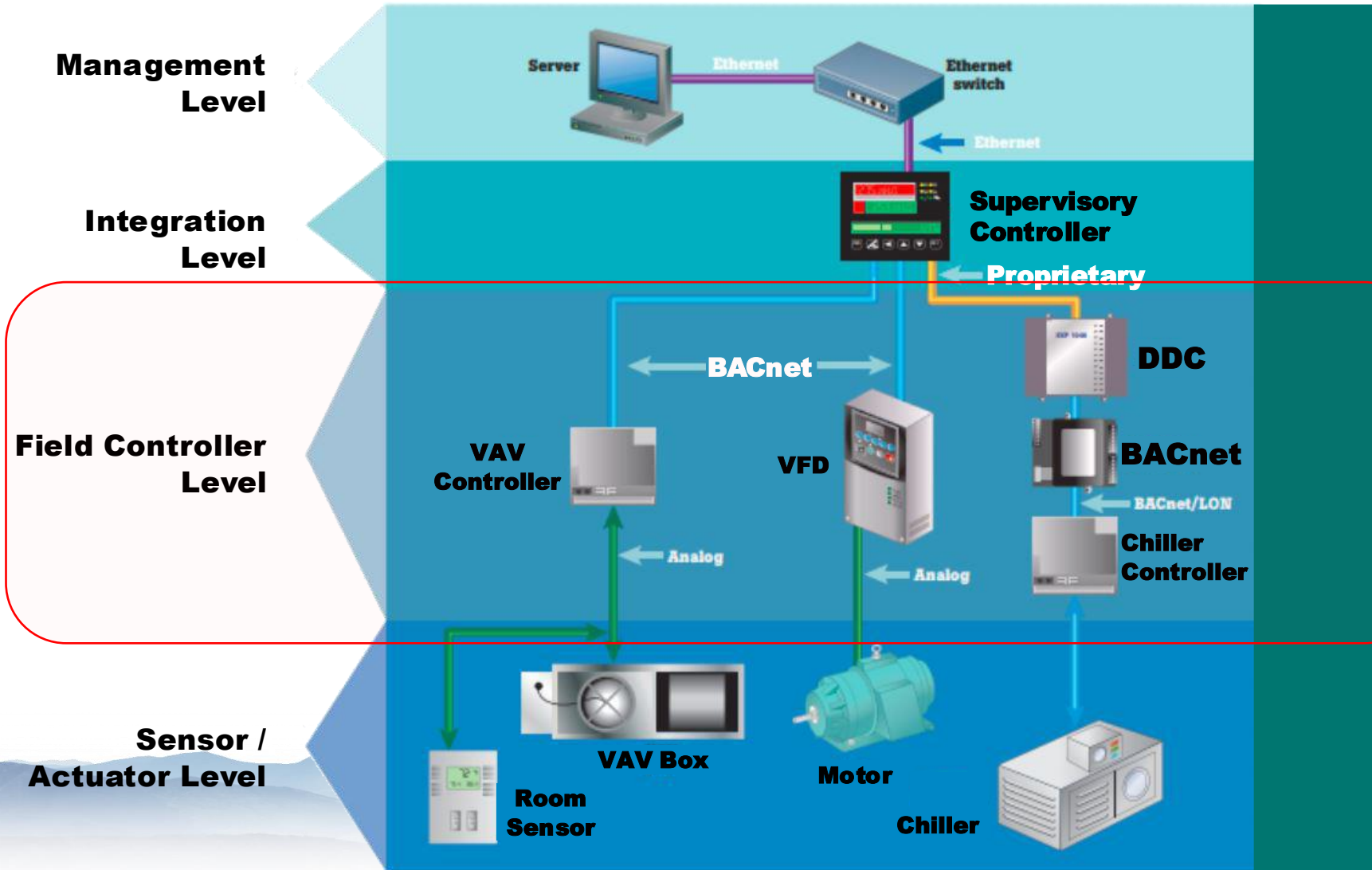


# EMS Architecture



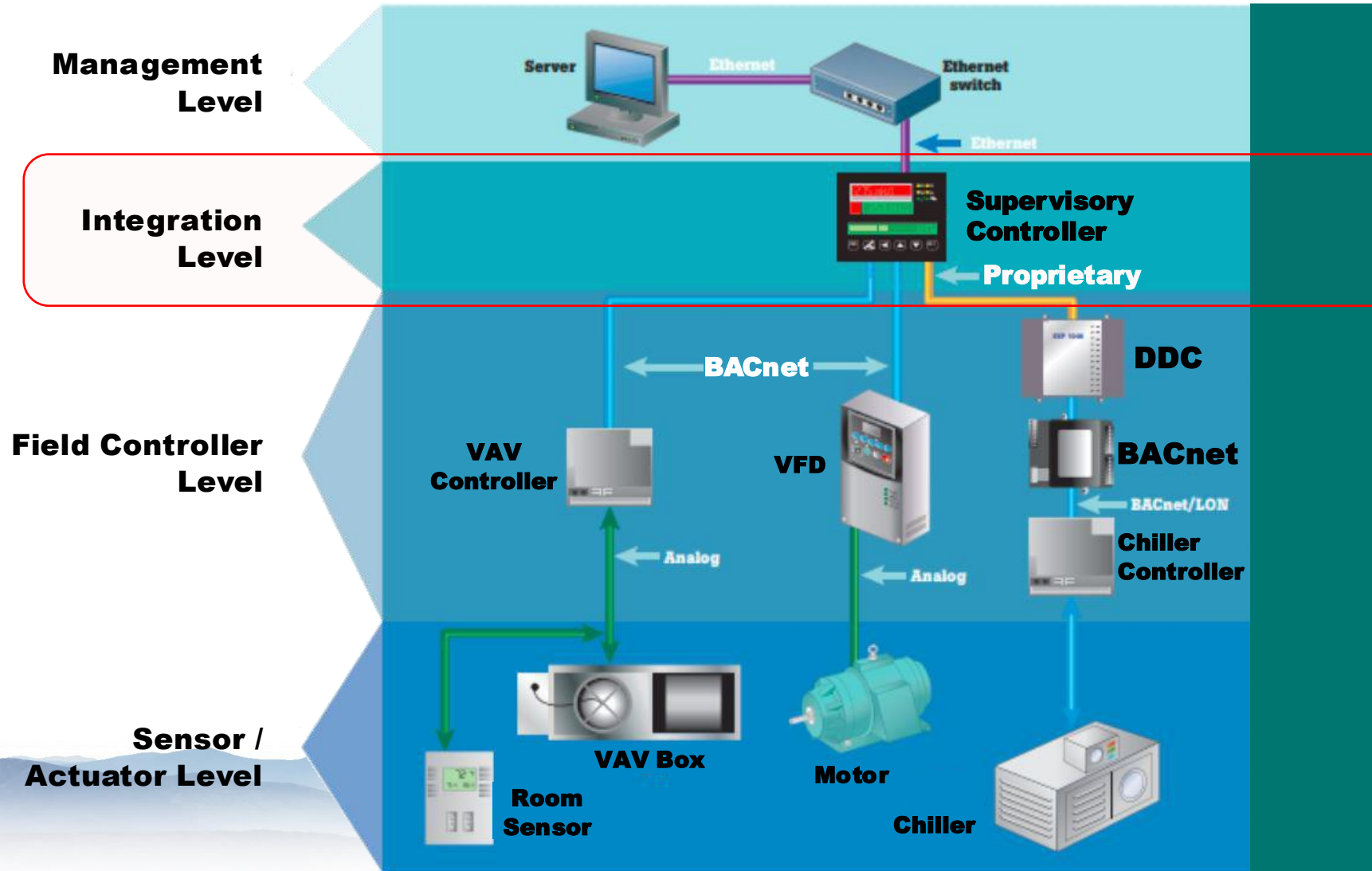
Input/Output Points:  
- End Devices  
- Sensors

# EMS Architecture



- Equipment Controllers:**
- Typically, 1 per system
  - Local programming/trends
  - Standalone Devices

# EMS Architecture



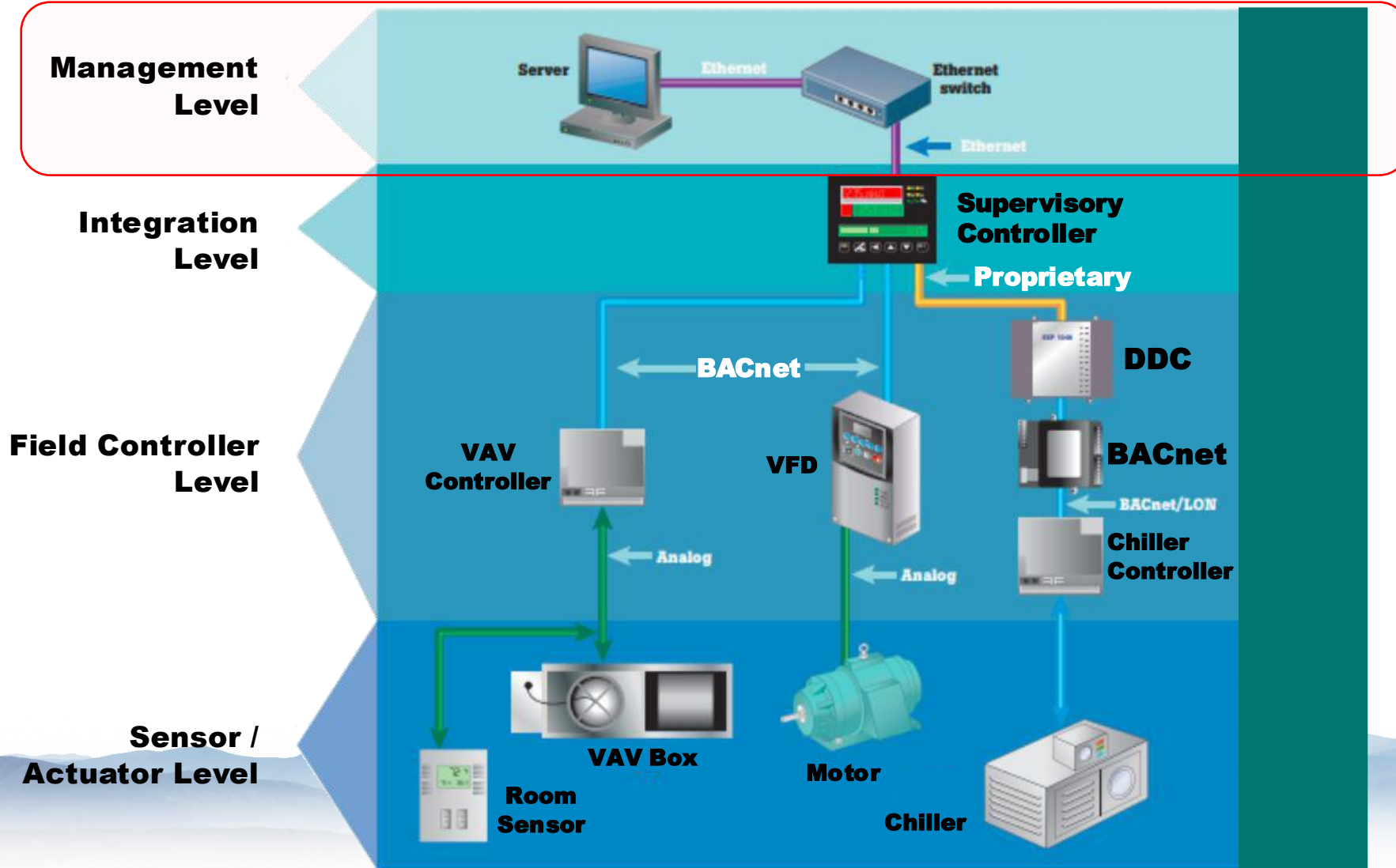
## Supervisory Controllers:

- Integrate equipment controllers
- Universal programming

## Communication

- BACnet
- Modbus
- Proprietary

# EMS Architecture



- Workstation/Server:**
- Manage operation
  - User interface/graphics
  - Change set-points
  - Create/collect trends

# Basic Components of EMS

**01**

INPUTS/OUTPUTS,  
SOFTWARE POINTS

**03**

GRAPHICS

**05**

TRENDING

**02**

MENU STRUCTURE

**04**

SCHEDULES

**06**

ALARMS

# Basic Components of EMS – Points

01

## INPUTS/OUTPUTS, SOFTWARE POINTS

### INPUTS

Signal from the sensor (CT, temperature) to the controller that provides information concerning changing conditions

### OUTPUTS

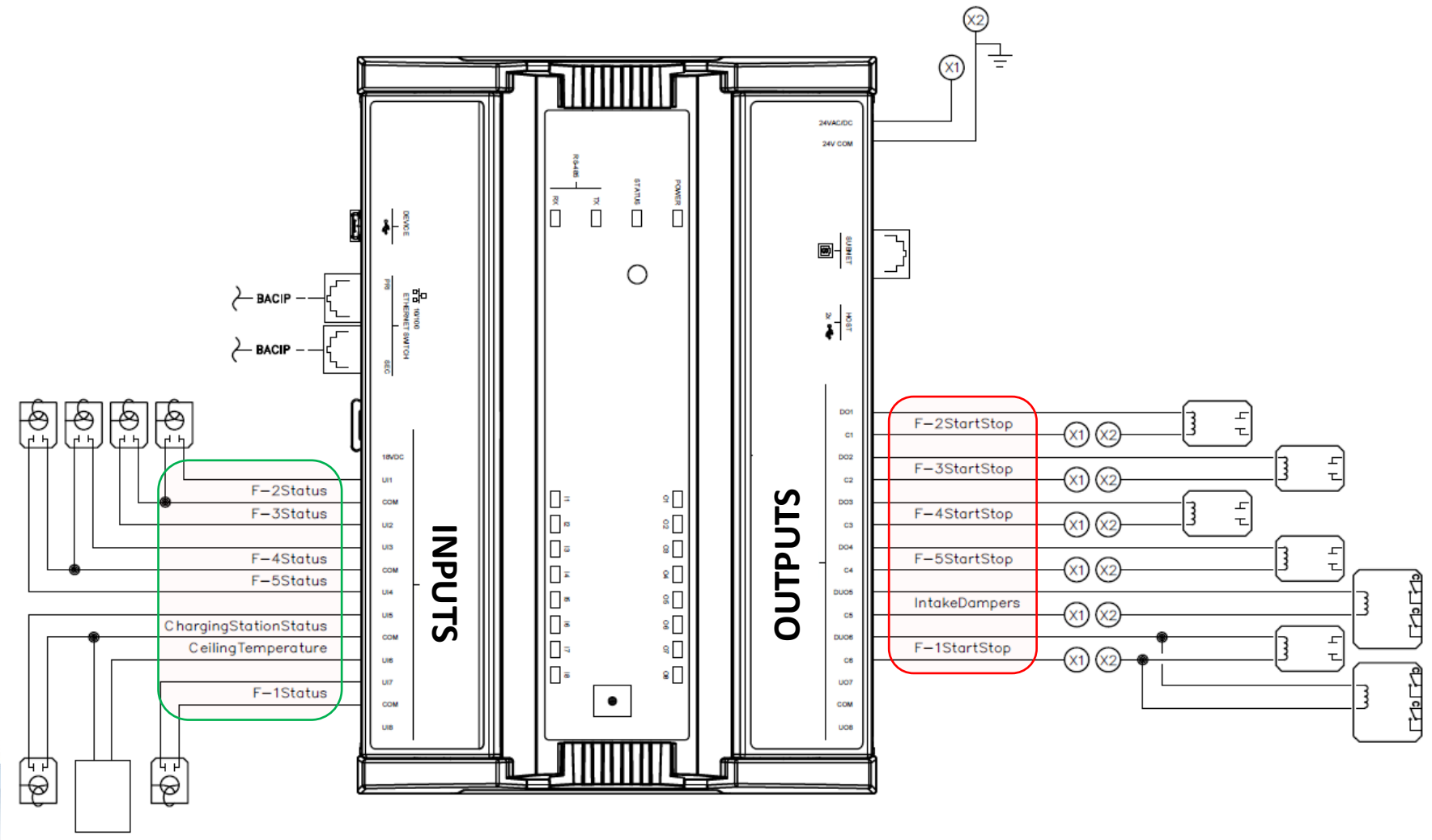
Signal from the controller to a component (relay, motor starter, actuator), that performs an action on an end-device (damper, valve)

### SOFTWARE (or Virtual)

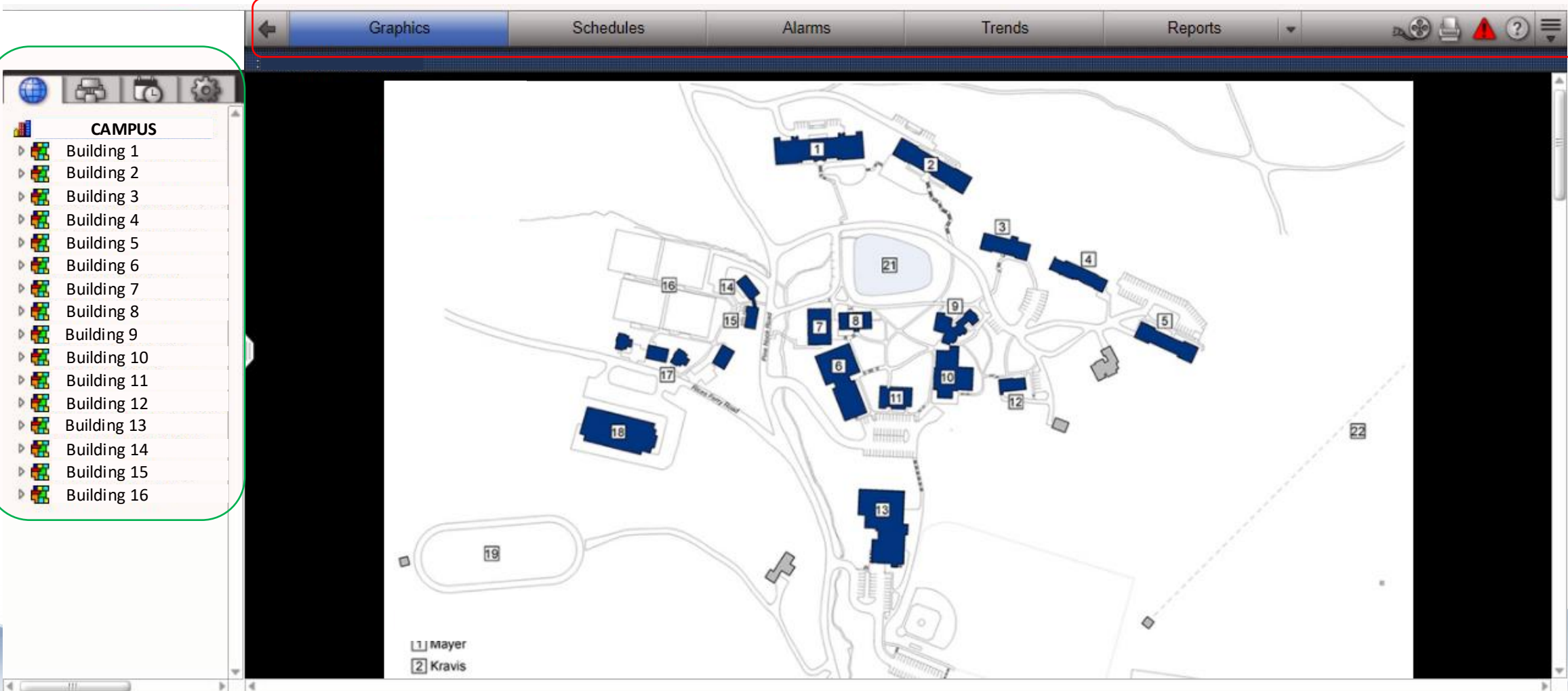
Calculated or passed through the controller, as opposed to hardwired physical points.

Points the controller aims to maintain (setpoints) or provide monitoring/diagnostics feedback (alarms)

# Basic Components of EMS – Points



# Basic Components of EMS – Menu Structure



# Basic Components of EMS – Menu Structure



### Misc Equipment

- Radiant Panel Listing
- Induction Unit Listing
- VAV Listing
- UH/CUH/EUH Listing
- Exhaust Fans
- KILN Systems
- FUME Exhausts
- Domestic Hot Water
- Ductless Splits



Outside Air Conditions	
Temperature	41.1 °F
Humidity	40.2 %Rh
Enthalpy	12.2

### Floor Plans

- First Floor Overview
- First Floor A
- First Floor B
- First Floor C
- First Floor D
- First Floor E
- Second Floor Overview
- Second Floor A
- Second Floor B
- Second Floor C
- Second Floor D

### Freezer Temp

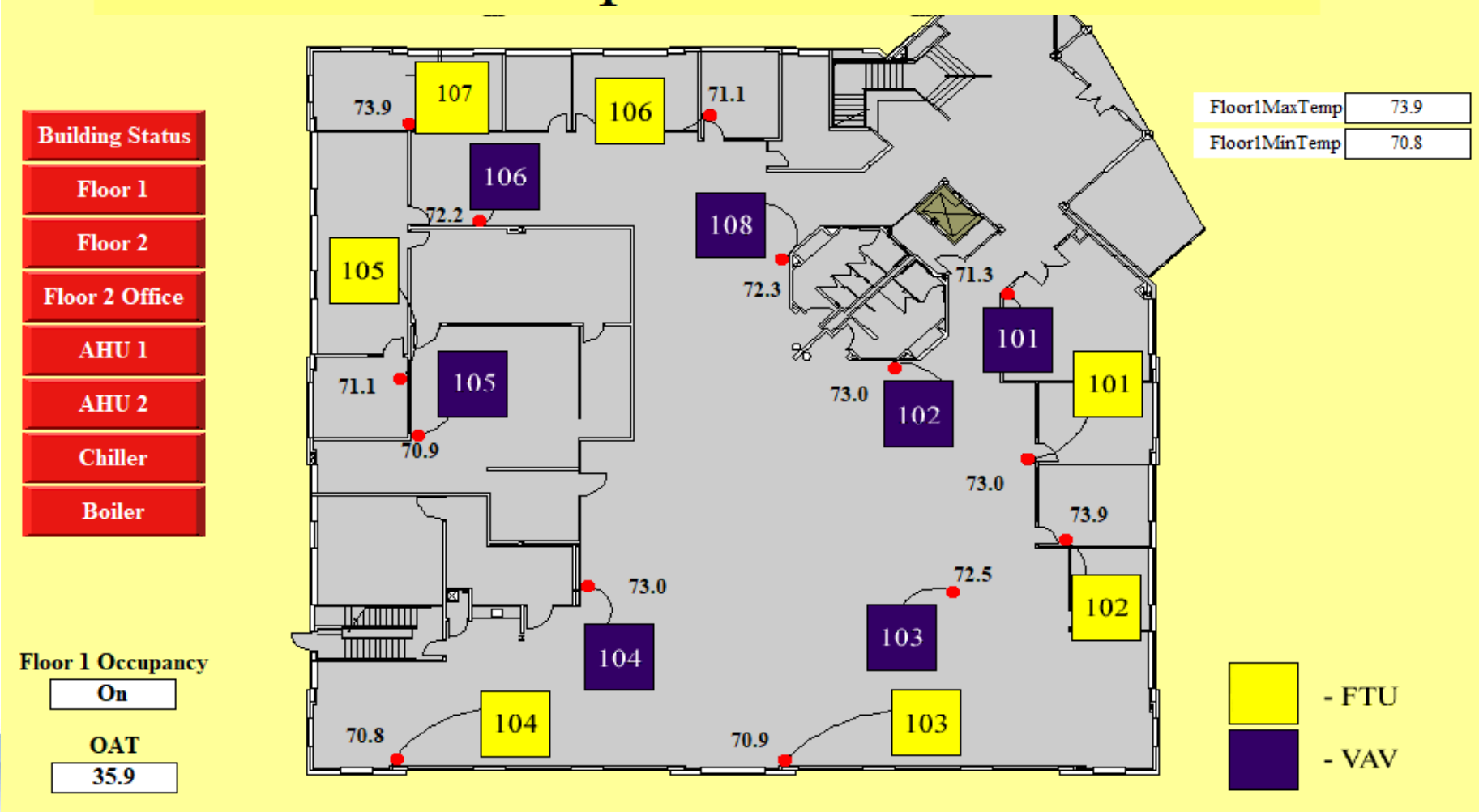
7 °F

### Energy Metering

Kitchen Gas Meter	14,501,600 CF
RTU's High Roof Gas Meter	10,919,150 CF
Boilers Gas Meter	6,314,270 CF
RTU's Lower Roof Gas Meter	6,199,840 CF
Water Heaters Gas Meter	205,736 CF
Main Electric Meter	9,688,244 kWh

Description	Supply Temp	Return Temp	Status
<input type="checkbox"/> Hot Water System	138 °F	134 °F	Active
<input type="checkbox"/> Chilled Water System	65 °F	79 °F	Inactive
<input type="checkbox"/> RTU-1	70 °F	72 °F	On
<input type="checkbox"/> RTU-2	72 °F	72 °F	On
<input type="checkbox"/> RTU-3	69 °F	73 °F	On
<input type="checkbox"/> RTU-4	71 °F	72 °F	On
<input type="checkbox"/> RTU-5	70 °F	73 °F	On
<input type="checkbox"/> RTU-6	71 °F	69 °F	On
<input type="checkbox"/> RTU-7	69 °F	74 °F	On
<input type="checkbox"/> RTU-8	72 °F	68 °F	On
<input type="checkbox"/> RTU-9	70 °F	67 °F	On
<input type="checkbox"/> RTU-10	71 °F	74 °F	On
<input type="checkbox"/> RTU-11	71 °F	70 °F	On
<input type="checkbox"/> RTU-12	70 °F	72 °F	On
<input type="checkbox"/> RTU-13	65 °F	72 °F	On
<input type="checkbox"/> RTU-14	69 °F	80 °F	On
<input type="checkbox"/> RTU-15	75 °F	74 °F	On
<input type="checkbox"/> RTU-16	75 °F	74 °F	On
<input type="checkbox"/> RTU-17	78 °F	72 °F	On
<input type="checkbox"/> RTU-18	72 °F	68 °F	On

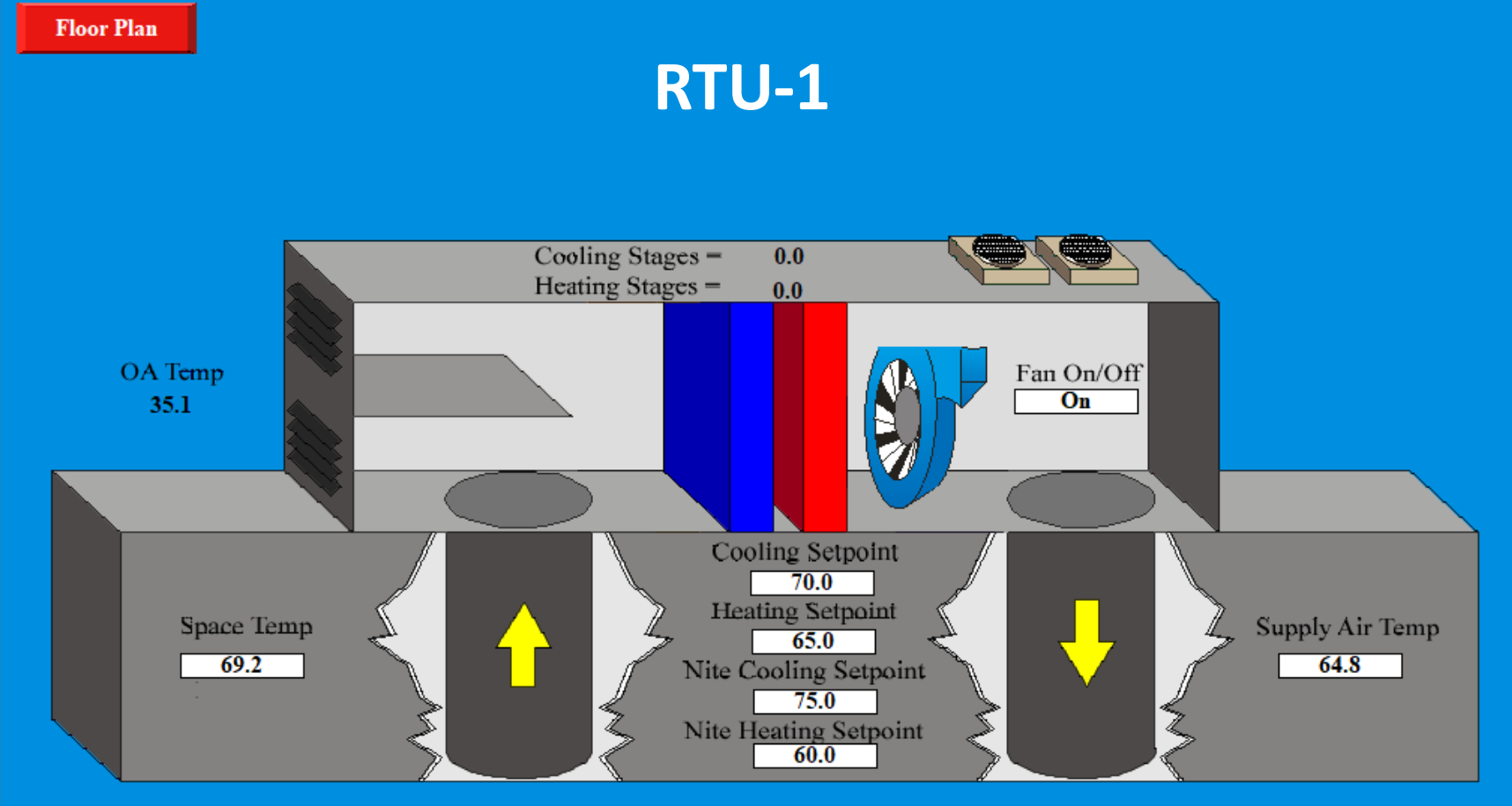
# Graphics – Floor Plan



# Graphics – Floor Plan



# Graphics - HVAC



# Graphics - HVAC

## RTU-2

RTU 2 Zones    \*\*Duct Static Pressure will reset itself based on VAV  
\*\*Damper positions, Should be between 1.0 and 2.5

Return Air Humidity: 35.9 %    Return Fan Speed Command: 65.6 %  
Return Air Temperature: 69.2 °F

Unit Shutdown Override

Diagnostic Reset     Reset     Off

Duct Static Pressure Sp: 2.000 in.W.C.	Override
Discharge Air Humidity High Limit:	95.0 °F
Economizer Enable Sp:	60.0 °F
Space Dehumidification Sp:	55.0 %
Space Humidification Sp:	25.0 %
Discharge Air Sp At 20 Degree OAT:	65.0 °F
Discharge Air Sp At 60 Degree OAT:	55.0 °F
Discharge Air Temperature Sp Active:	61.2 °F
Minimum/Unocc Supply Fan Speed:	33.0 %

Mixed Air Damper Command: 64.3 %

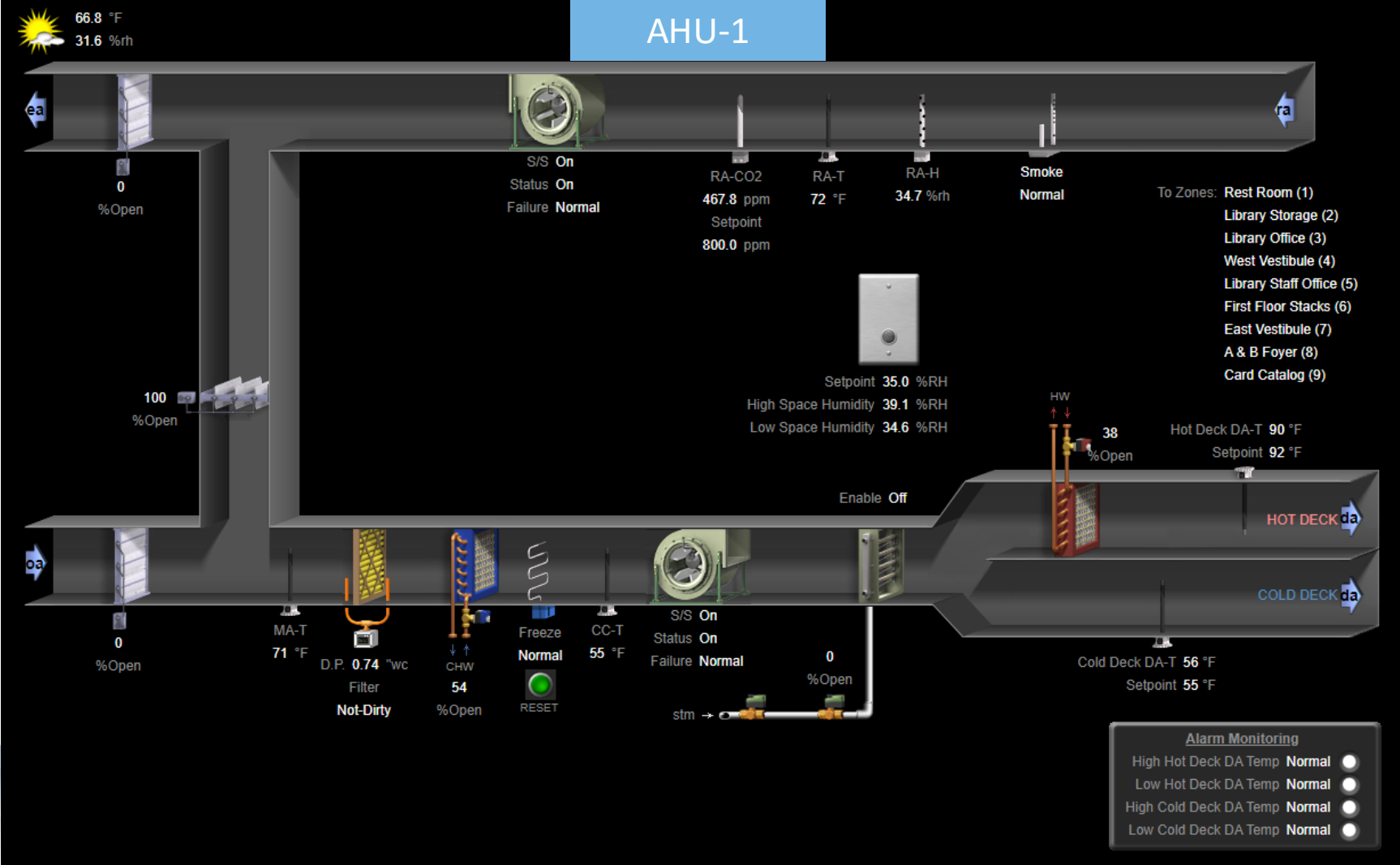
Mixed Air Temperature: 54.8 °F

CHW Valve Command: 0.0 %    HW Valve Command: 0.0 %

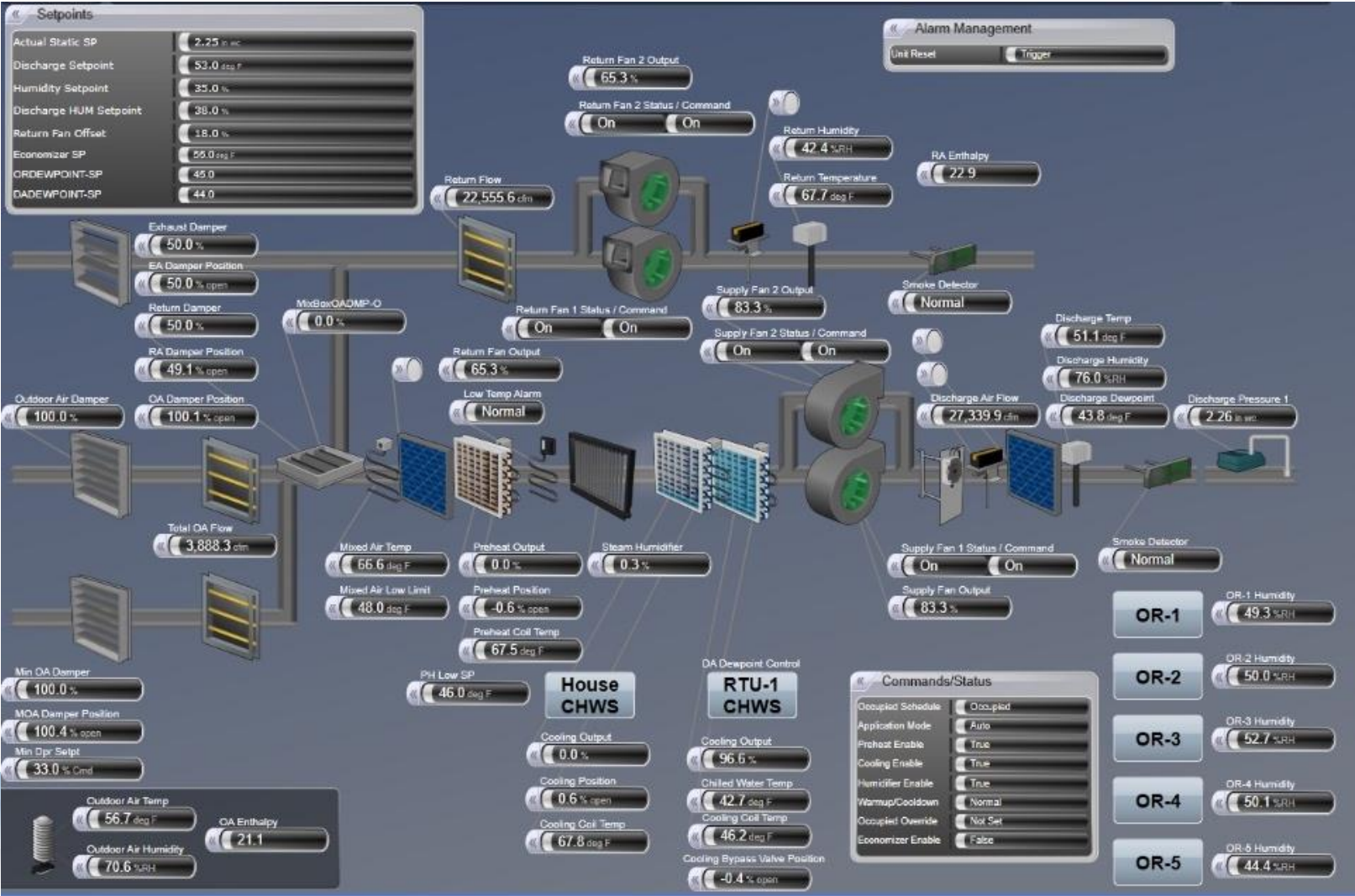
Discharge Air Humidity: 61.9 %  
Discharge Air Temperature: 62.0 °F  
Duct Static: 1.970 in.W.C.

Humidifier Valve Command: 0.0 %  
Supply Fan Speed Command: 93.7 %

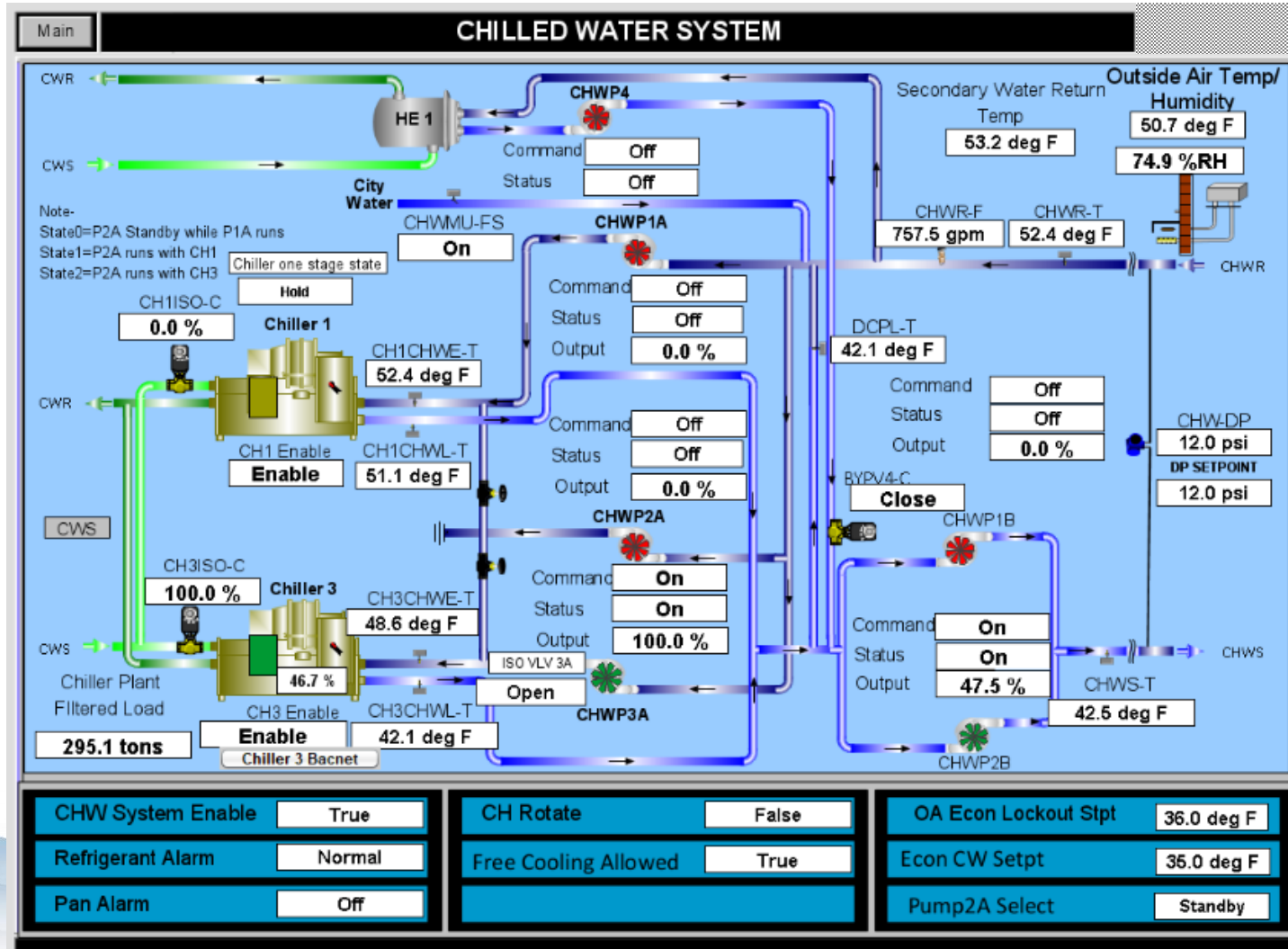
# Graphics - HVAC



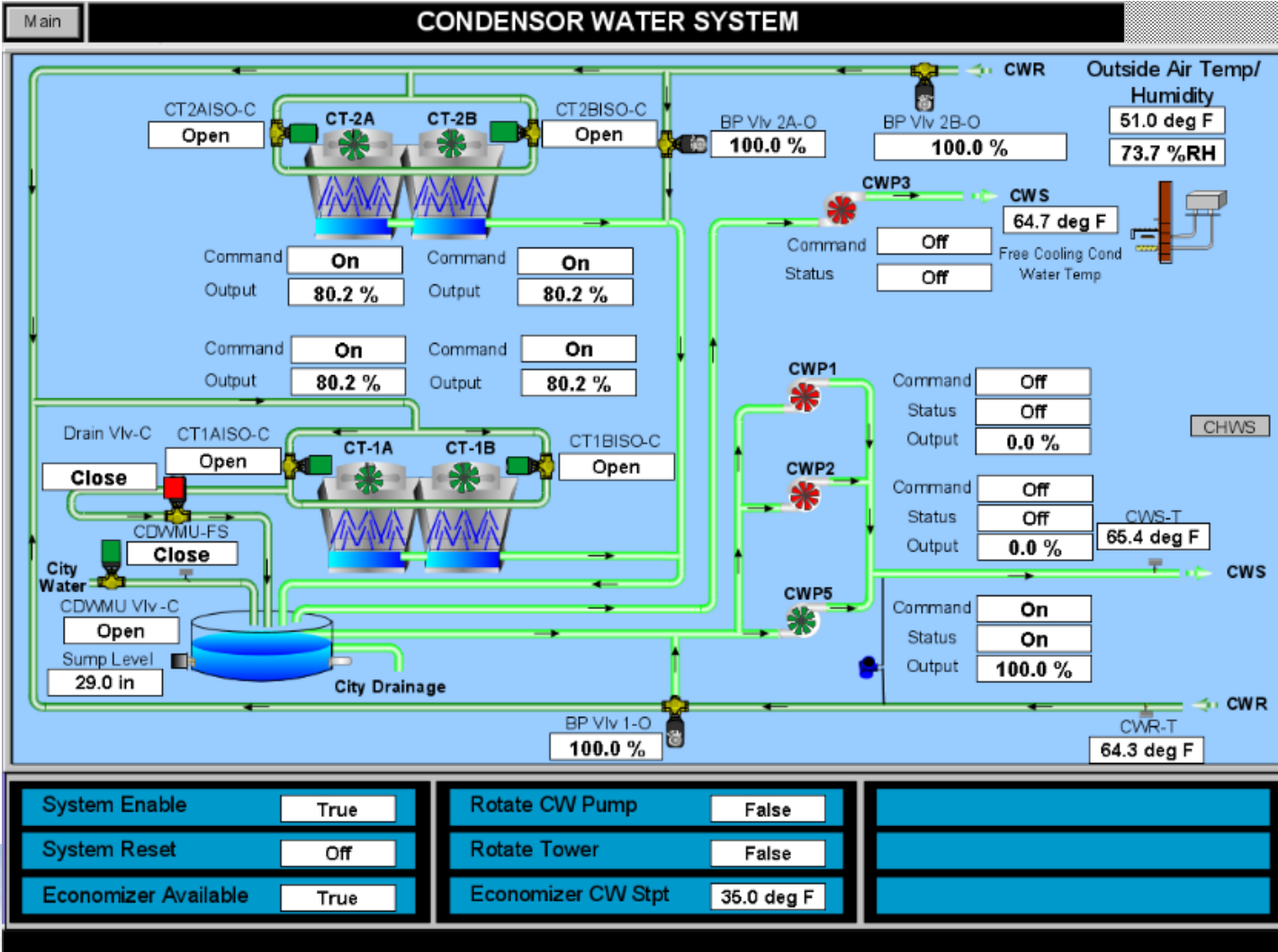
# Graphics - HVAC



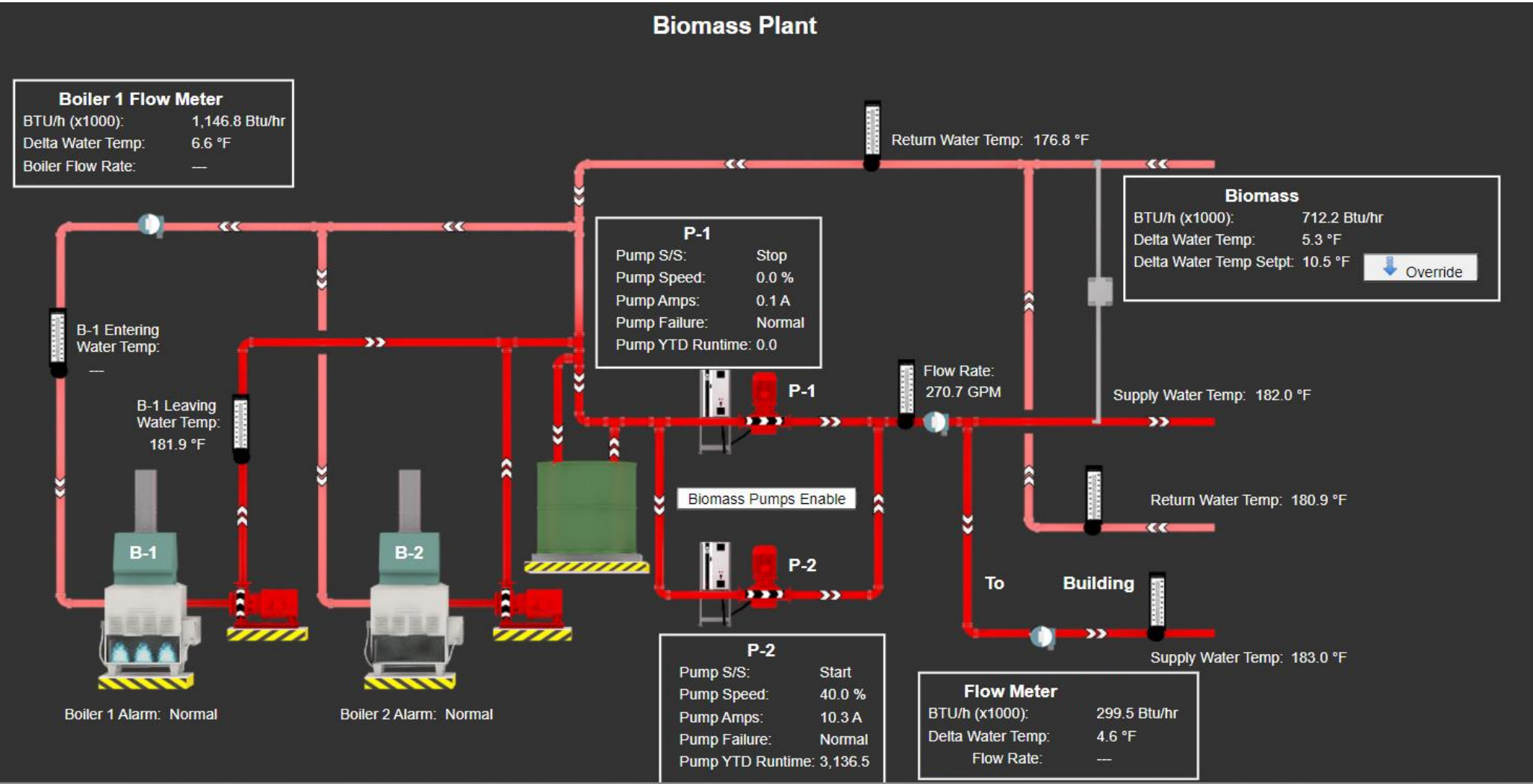
# Graphics – Chiller Plant



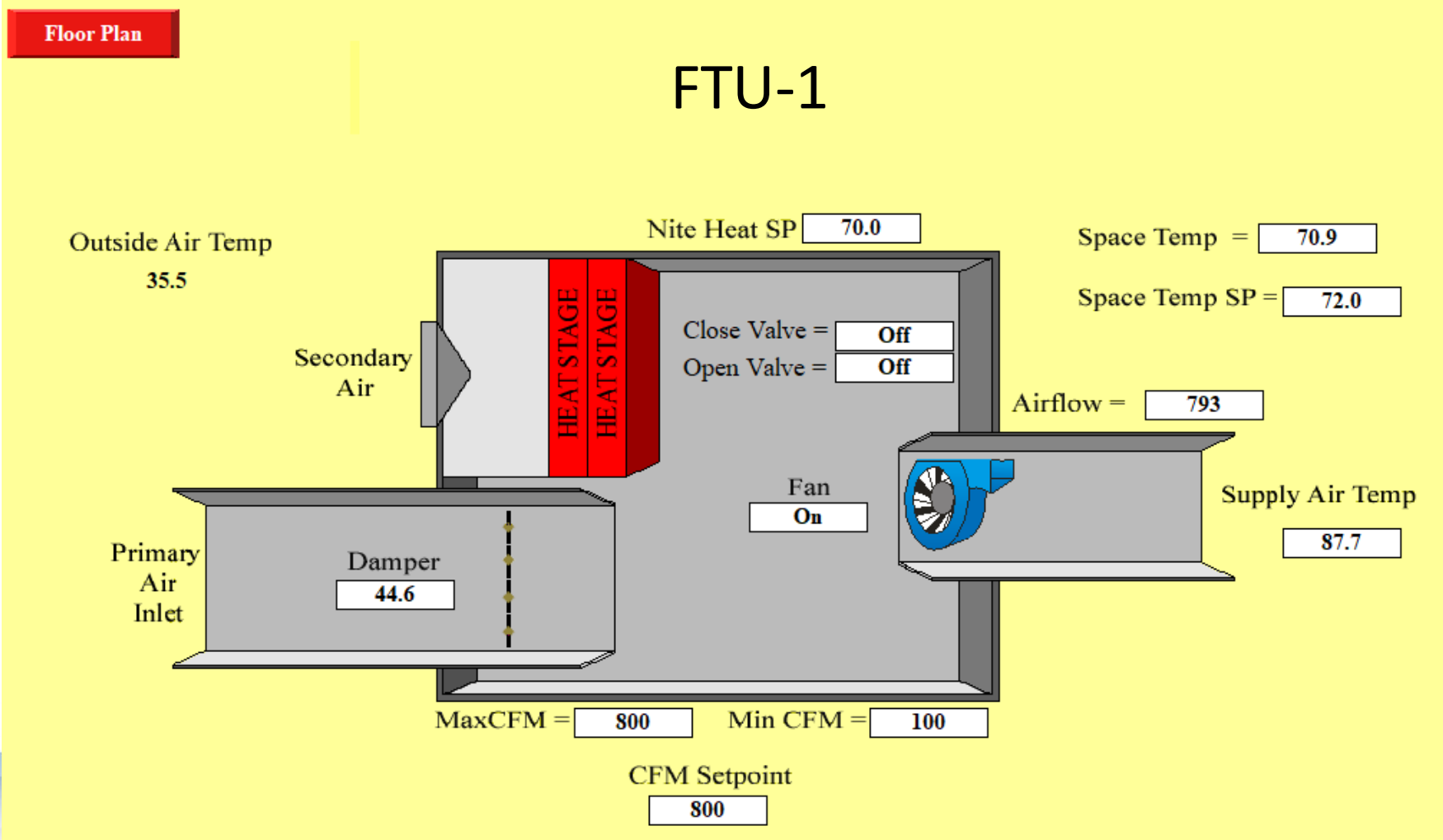
# Graphics – Chiller Plant



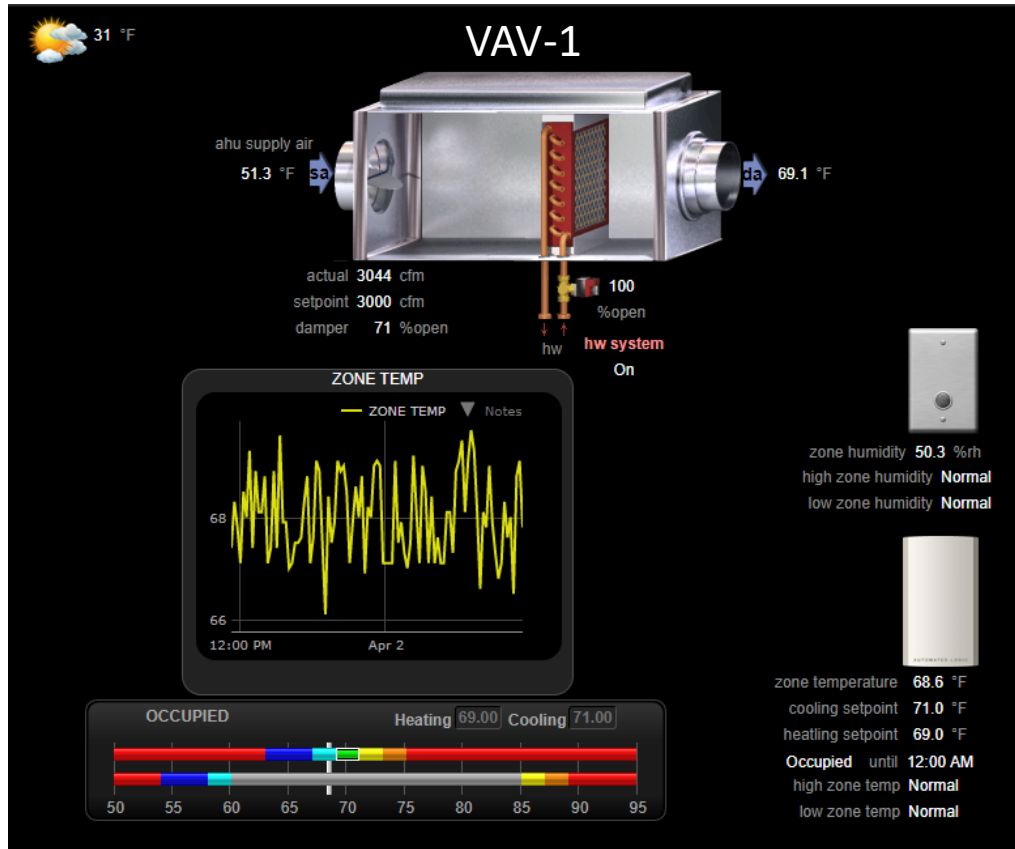
# Graphics – Boiler Plant



# Graphics – Terminal Units



# Graphics – Terminal Units



# Graphics – Equipment Summary

Induction Unit Summary Screen

Induction Unit	Space Temp	Space Hum	Space CO2	Occ Setpoint	Unoc Htg. Stpt	Unoc Clg. Stpt	Min Setpoint	Max Setpoint	Heat Setpoint	Cool Setpoint	Htg Valve Pos	Clg Valve Pos
	73.5 °F	28 %RH	446 PPM	73.5 °F	65.0 °F	85.0 °F	68.0 °F	74.0 °F	72.5 °F	74.5 °F	0 %	0 %
	71.5 °F	31 %RH		68.0 °F	65.0 °F	85.0 °F	68.0 °F	74.0 °F	67.0 °F	69.0 °F	0 %	0 %
	70.0 °F	31 %RH		74.0 °F	65.0 °F	90.0 °F	68.0 °F	74.0 °F	73.0 °F	75.0 °F	0 %	0 %
	68.5 °F	32 %RH		74.0 °F	70.0 °F	90.0 °F	68.0 °F	74.0 °F	73.0 °F	75.0 °F	0 %	0 %
	71.5 °F	28 %RH		70.0 °F	58.0 °F	85.0 °F	68.0 °F	74.0 °F	69.0 °F	71.0 °F	0 %	0 %
	71.5 °F	27 %RH		74.0 °F	65.0 °F	85.0 °F	68.0 °F	74.0 °F	73.0 °F	75.0 °F	0 %	0 %
	70.0 °F	26 %RH		69.0 °F	65.0 °F	85.0 °F	68.0 °F	74.0 °F	68.0 °F	70.0 °F	0 %	0 %
	72.0 °F	25 %RH		74.0 °F	65.0 °F	99.0 °F	68.0 °F	74.0 °F	73.0 °F	75.0 °F	0 %	0 %
	71.0 °F	27 %RH		70.0 °F	65.0 °F	85.0 °F	68.0 °F	74.0 °F	69.5 °F	70.5 °F	0 %	0 %
	68.5 °F	30 %RH		68.0 °F	65.0 °F	85.0 °F	68.0 °F	74.0 °F	67.0 °F	69.0 °F	0 %	0 %
	71.0 °F	29 %RH		74.0 °F	65.0 °F	85.0 °F	68.0 °F	74.0 °F	73.0 °F	75.0 °F	0 %	0 %
	72.0 °F	26 %RH		74.0 °F	65.0 °F	85.0 °F	68.0 °F	74.0 °F	73.0 °F	75.0 °F	0 %	0 %
	72.0 °F	26 %RH		72.0 °F	65.0 °F	85.0 °F	68.0 °F	74.0 °F	71.0 °F	73.0 °F	0 %	0 %
	72.7 °F	28 %RH		72.0 °F	65.0 °F	85.0 °F	68.0 °F	74.0 °F	71.0 °F	73.0 °F	0 %	0 %
	72.6 °F	26 %RH		74.0 °F	65.0 °F	85.0 °F	68.0 °F	74.0 °F	73.0 °F	75.0 °F	0 %	0 %
	73.3 °F	28 %RH		70.0 °F	65.0 °F	85.0 °F	68.0 °F	74.0 °F	69.0 °F	71.0 °F	0 %	0 %
	73.4 °F	26 %RH		74.0 °F	65.0 °F	85.0 °F	68.0 °F	74.0 °F	73.0 °F	75.0 °F	0 %	0 %
	72.7 °F	26 %RH		74.0 °F	70.0 °F	86.0 °F	68.0 °F	74.0 °F	73.0 °F	75.0 °F	0 %	0 %
	71.1 °F	28 %RH		68.0 °F	65.0 °F	85.0 °F	68.0 °F	74.0 °F	67.0 °F	69.0 °F	0 %	0 %
	71.3 °F	30 %RH		74.0 °F	65.0 °F	85.0 °F	68.0 °F	74.0 °F	73.0 °F	75.0 °F	0 %	0 %
	69.7 °F	30 %RH		69.0 °F	65.0 °F	85.0 °F	68.0 °F	74.0 °F	68.0 °F	70.0 °F	0 %	0 %
	70.3 °F	28 %RH		72.0 °F	65.0 °F	85.0 °F	68.0 °F	74.0 °F	71.0 °F	73.0 °F	0 %	0 %
	71.1 °F	29 %RH		68.0 °F	65.0 °F	85.0 °F	68.0 °F	74.0 °F	67.0 °F	69.0 °F	0 %	0 %
	70.3 °F	28 %RH		74.0 °F	65.0 °F	85.0 °F	68.0 °F	74.0 °F	73.0 °F	75.0 °F	0 %	0 %
	67.3 °F	32 %RH		72.0 °F	65.0 °F	85.0 °F	68.0 °F	74.0 °F	71.0 °F	73.0 °F	0 %	0 %
	70.4 °F	28 %RH		74.0 °F	65.0 °F	85.0 °F	68.0 °F	74.0 °F	73.0 °F	75.0 °F	0 %	0 %
	70.4 °F	28 %RH		70.0 °F	70.0 °F	85.0 °F	68.0 °F	74.0 °F	69.0 °F	71.0 °F	0 %	0 %
	69.2 °F	29 %RH		74.0 °F	70.0 °F	88.0 °F	68.0 °F	74.0 °F	73.0 °F	75.0 °F	0 %	0 %
	70.1 °F	26 %RH		72.0 °F	58.0 °F	85.0 °F	68.0 °F	74.0 °F	71.0 °F	73.0 °F	0 %	0 %

# Graphics – Lab Hoods

**Science Center**

System Details			
Timeclock	DAY	Total Exhaust Flow	846 cfm
Control Mode	HEAT	Lab Flow Differential	-76 cfm
Occupancy Status	OCC	Common Hood Alarm	NORMAL

**Makeup Air Valve**

- 800 cfm (setpoint)
- 781 cfm (actual)
- 47% (status)
- 27% (status)
- Airflow From Air Handling Unit AHU-1

**Hood 1 Valve**

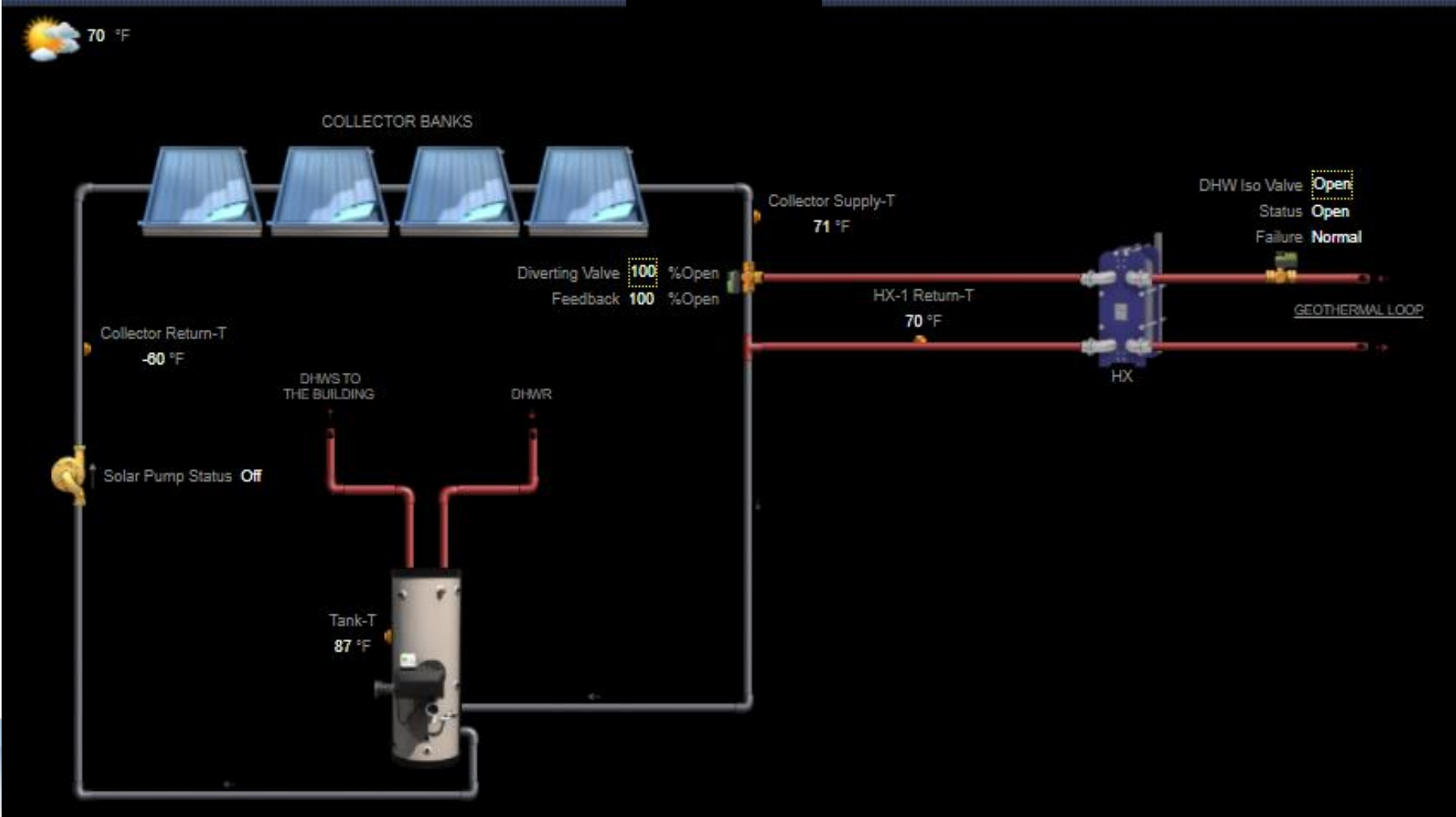
- 0 cfm (setpoint)
- 0 cfm (actual)
- 1% (status)

**Temperature and Humidity**

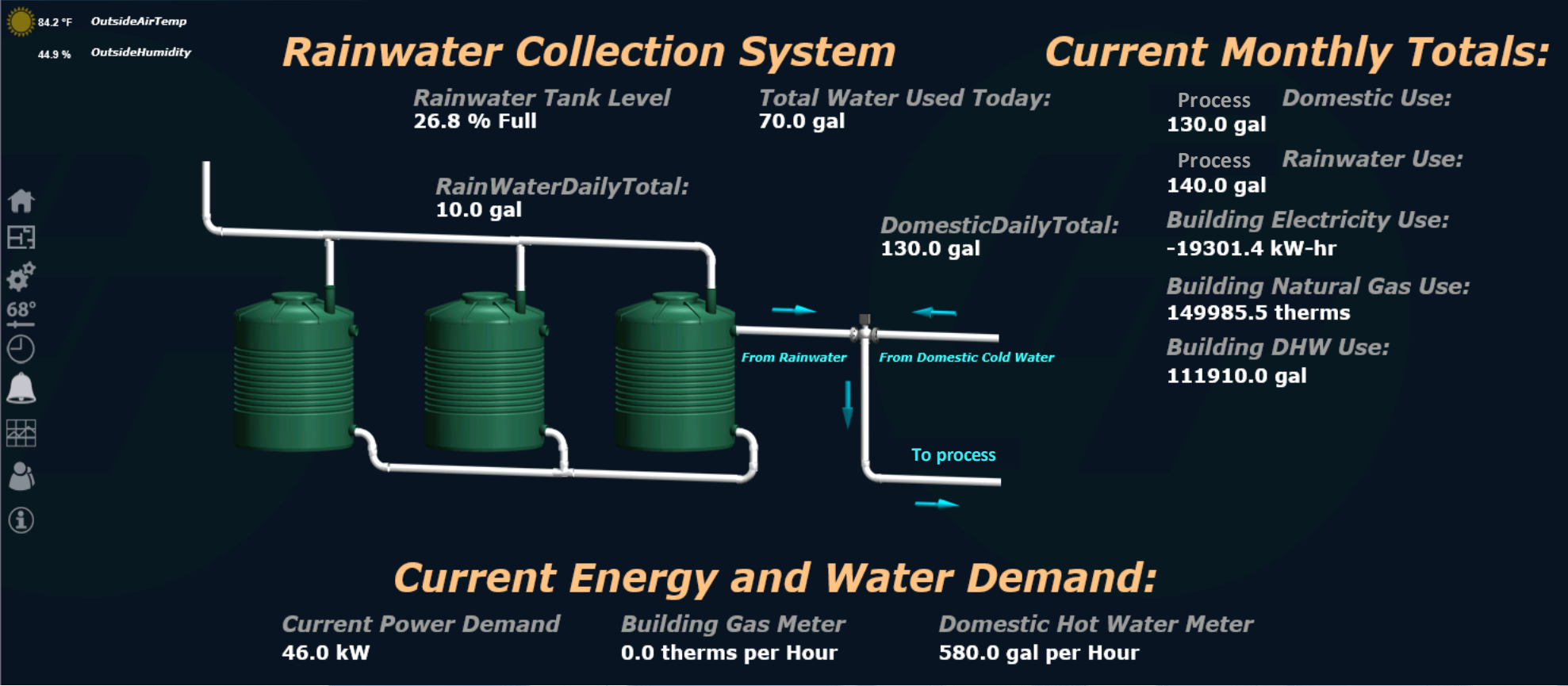
- 70.0 °F (setpoint)
- 69.9 °F (actual)
- 36.9% (status)

FLAMMABLE  
KEEP FIRE AWAY

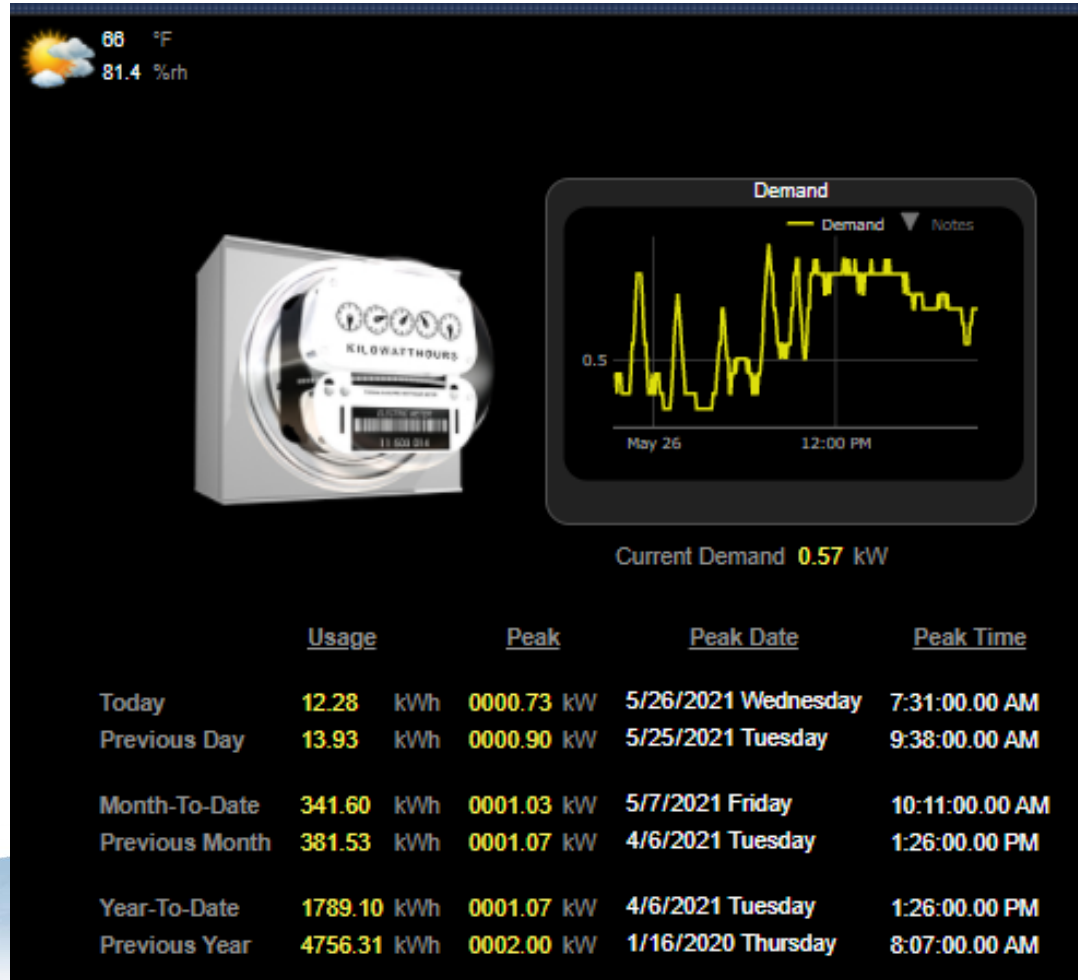
# Graphics – Solar Thermal Hot Water



# Graphics – Rainwater Collection/Metering

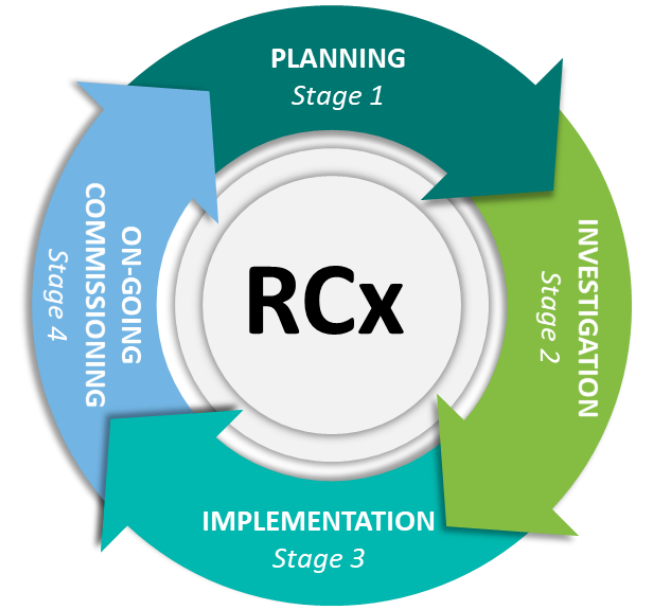


# Graphics – Metering



# Retrocommissioning (RCx)

- Systematic process of assessing and improving the EMS sequences of operation
- Identifying and repairing hardware deficiencies
- Ensure systems operate efficiently and per an optimized design intent.
- Scope could include
  - *Reviewing setpoints and temperature resets*
  - *Confirming optimized outdoor air rates*
  - *Performing hardware functional testing*
  - *Developing deficiencies list*
  - *Identify energy efficiency control sequences*



**Original design intent is often ineffective/inefficient. Newer sequences may be more beneficial.**

# Typical Energy Savings Opportunities

## AIR SIDE

- ❑ Schedule and setback optimization
- ❑ Outside air optimization
- ❑ Economizer optimization
- ❑ Supply air temperature reset
- ❑ Demand controlled ventilation
- ❑ Variable volume conversion
- ❑ Optimize fan speed
- ❑ Static pressure optimization and reset
- ❑ Optimize building pressure control
- ❑ Exhaust fan control
- ❑ Terminal unit optimization

# Typical Energy Savings Opportunities

## CHILLED WATER

- ❑ Chiller staging
- ❑ Chilled water reset
- ❑ Condenser water reset
- ❑ Variable speed chilled water
- ❑ Variable speed condenser flow
- ❑ Variable primary flow
- ❑ Differential pressure reset
- ❑ Cooling tower optimization
- ❑ Waterside economizer optimization

# Typical Energy Savings Opportunities

## HOT WATER

- ❑ Boiler staging
- ❑ Hot water reset
- ❑ Variable speed hot water
- ❑ Variable primary flow
- ❑ Differential pressure reset and optimization

# Common RCx Targets

Overridden  
Setpoints

Simultaneous  
Heating &  
Cooling

Lack of  
Optimal  
Start/Stop

Excess  
Outside Air

Inefficient  
Economizer  
Sequence

Building  
Pressurization  
Issues

Underutilized  
Reset  
Sequences

Overridden  
Variable Speed  
Drives

Poorly Located  
or Failed  
Sensors

Altered  
Occupancy  
Schedules

No Setback  
Temperatures

# Sequence Example: Supply Air Reset

The controller shall monitor the supply air temperature and shall maintain a supply air temperature setpoint reset based on zone cooling and heating requirements

**The supply air temperature setpoint shall be reset for cooling based on zone cooling requirements as follows:**

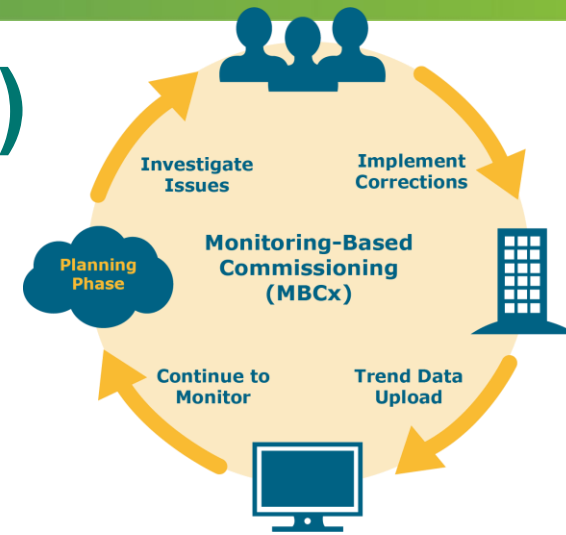
- The initial supply air temperature setpoint shall be **55°F** (adj.).
- As cooling demand increases, the setpoint shall incrementally reset down to a minimum of **53°F** (adj.).
- As cooling demand decreases, the setpoint shall incrementally reset up to a maximum of **72°F** (adj.).

**If more zones need heating than cooling, then the supply air temperature setpoint shall be reset for heating as follows:**

- The initial supply air temperature setpoint shall be **82°F** (adj.).
- As heating demand increases, the setpoint shall incrementally reset up to a maximum of **95°F** (adj.).
- As heating demand decreases, the setpoint shall incrementally reset down to a minimum of **72°F** (adj.).

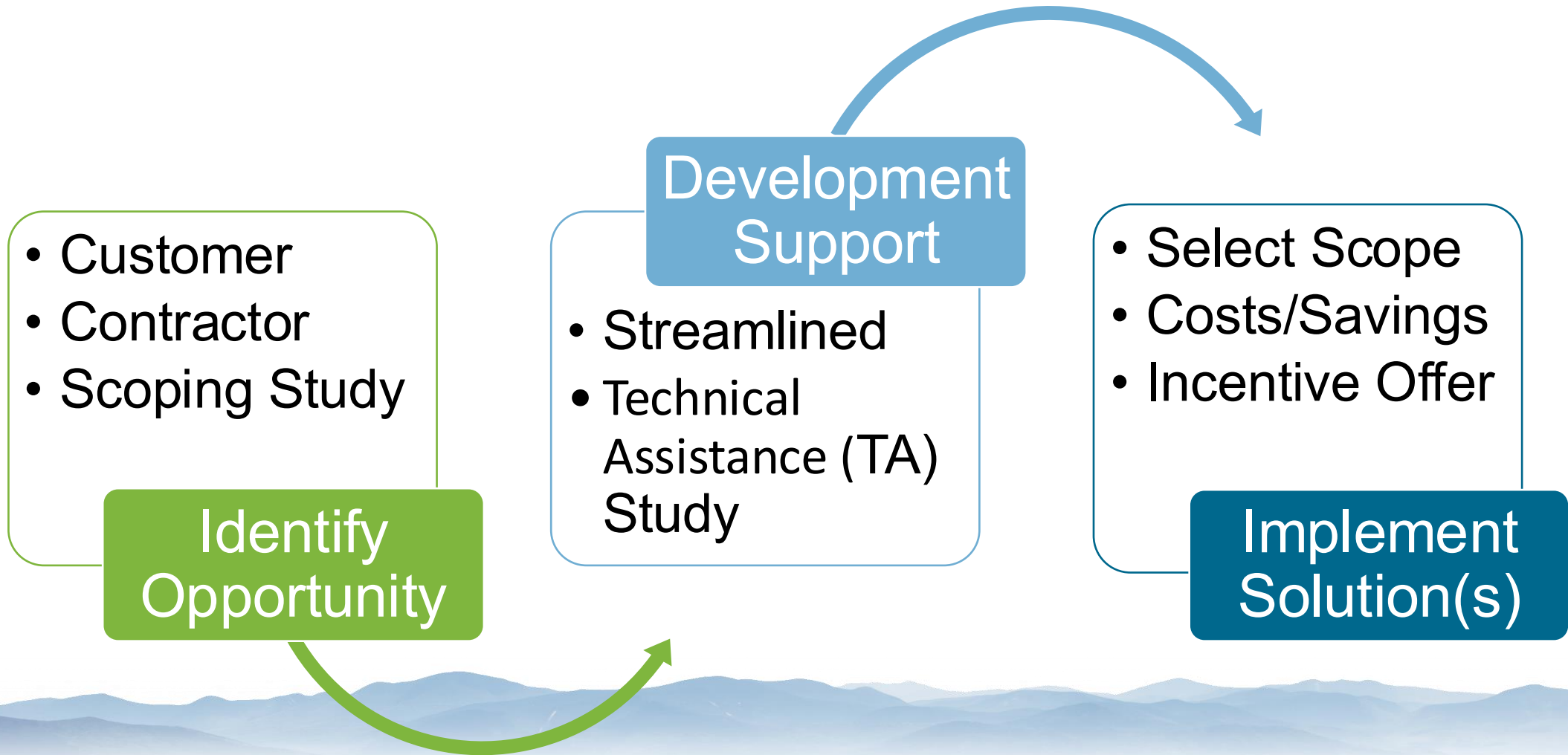
# Monitoring Based Commissioning (BMCx)

- ❑ Ongoing commissioning process to maintain and continuously improve building performance
- ❑ Continuously monitoring and analyzing large amounts of trend data
- ❑ Fault detection and diagnostics
- ❑ Often leverages separate analytics platform



Site	Rule	Duration	Cost	Equips
Carytown	① AHU Fan Failure	51.25hr		① Carytown RTU-1
	① Lights On and Unoccupied	68.75hr	\$165	① Carytown Main Lights
	① Temp Sensor Failure	672hr		① Carytown RTU-1
Gaithersburg	① AHU Cool Failure	5.25hr		① Gaithersburg RTU-1
	① AHU Heat-Cool Mode Cycling	32.5hr		① Gaithersburg RTU-1
	① AHU Fan Short Cycling	73hr		① x 2
Metal Forming	① AHU On and Fan Off	35min		① Metal Forming RTU-1
	① Bay Lighting On and Unoccupied	7.98hr	\$19	① Main Lights
	① Heat Treat Temp Out of Range	8.5hr		① x2
	① Heat Treat Temp Too High	2.25hr		① Heat Treating
	① Heat Treat Temp Too Low	6.25hr		① x2
	① Units Down 10%	24hr		① Metal Forming 1
Short Pump	① Daily Consumption Limit	3.5hr		① Flow Meter

# Project Development Approach



NHSaves utility partners offer support at each stage to streamline the process.

# Program Funded Scoping Study

Identify Efficiency Opportunities



Perform high level onsite walkthrough



Identify energy conservation measures (ECMs)



Discuss ECM opportunities with customer



Define project development next steps

# Program Co-Funded TA Study

## Project Development Support



Perform detailed energy assessment



Partner with contractors/vendors to develop scope



Develop costs and savings for ECMs



Provide program documentation for incentive offer

# RCx Project Example



Large electronics  
manufacturing  
facility

Strategic partnership with the customer's sustainability team.

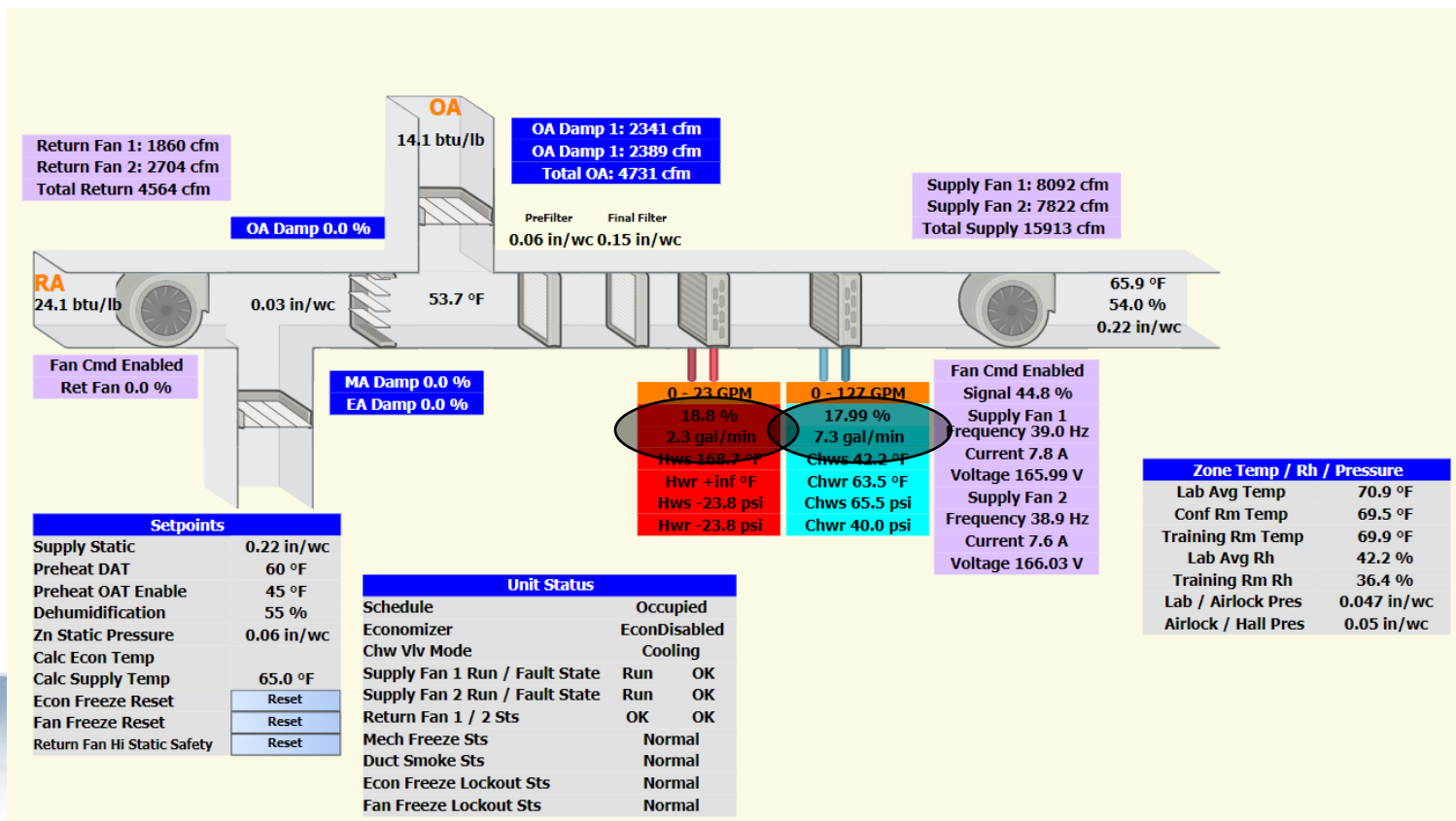
500,000 ft<sup>2</sup> industrial facility

Laboratories, clean rooms, testing and manufacturing areas

TA study focusing on 28,000 ft<sup>2</sup> lab area with 5 large AHUs

# RCx Project Example

Identified several sequences of operation in partnership with customers internal team and controls contractor.



Preheating and cooling simultaneously because of inefficient sequence and setpoints

# RCx Sequences of Operation

Unit	1. SAT Reset	2. Leaking CHW Valve	3. Airflow Turndown	4. Airflow Balancing	5. Static Press. Opt.	6. AHU Rebalancing	7. Economizer	8. OA Reduction	9. PH Pump Control	10. RH Optimization	11. PH Optimization	12. Zone Double Cooling
AHU-1	X	X	X		X	X		X		X		
AHU-2	X		X		X	X		X		X		
AHU-3	X			X			X	X	X	X	X	
AHU-4	X			X			X	X	X	X	X	X
AHU-5				X			X	X	X	X	X	

# RCx Results

Significant energy savings from only 5 AHUs

ECM Name	Cost	Annual Electric Savings (kWh)	Annual Gas Savings (Therms)	Incentive Offer	Annual Cost Savings	Simple Payback (years)
ECM-1: Retrocommissioning	\$199,216	747,432	95,037	\$64,448	\$223,051	0.6

Customer is performing similar RCx across other AHUs

# RCx Project Example



Critical access hospital

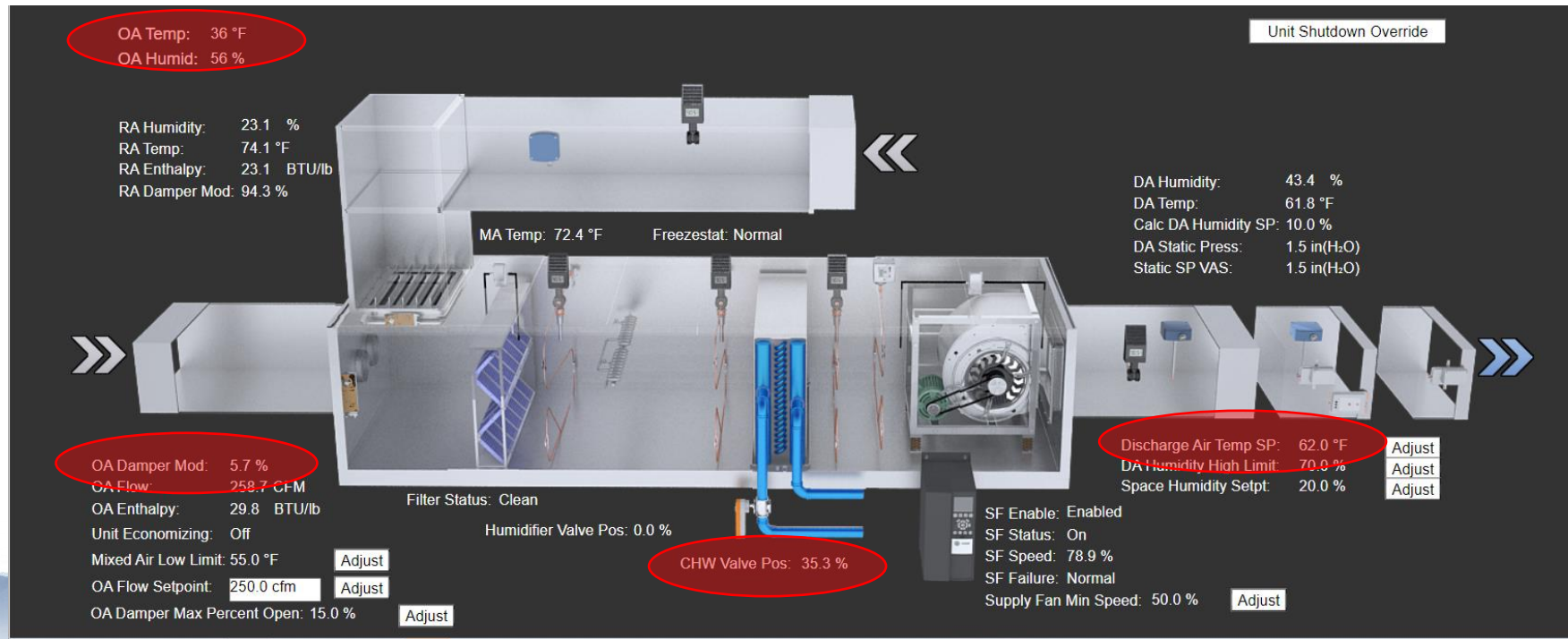
156,000 ft<sup>2</sup> facility

Emergency, surgical, and intensive care services

TA study focusing on RCx for HVAC systems

# RCx Project Example

Identified several sequences of operation in partnership with facilities team and controls contractor



**Mechanical cooling enabled when outside air temperature is 36°F. Unit should be economizing**

# TA Study RCx Sequences of Operation

Unit	1. SAT Reset	2. Static Pressure Opt.	3. DCV	4. Economizer	5. Bldg. Pressure Control	6. Schedules/Setbacks	7. Interlock EF and RTU	8. CHW Flow and dP Opt.	9. CHW Reset	10. Primary Pump Control	11. OR Occupancy Controls
RTUs/AHUs	X	X	X	X		X	X				X
Boiler Plant										X	
Chiller Plant								X	X		
Exhaust Fans					X		X				
VAVs/FCUs						X					

# TA Study RCx Results

Customer leveraged three measures (lighting, controls, HVAC) at the same time

ECM Name	Cost	Annual Electric Savings (kWh)	Woodchip Savings (tons)	Incentive Offer	Annual Cost Savings	Simple Payback (years)
ECM-1: Retrocommissioning	\$79,133	96,906	175	\$58,162	\$22,395	0.94

Project also included server room free cooling and integration of exhaust and server equipment.

