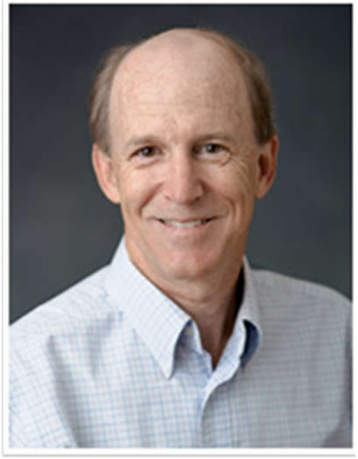
RETRO-COMMISSIONING (RCX)

7TH ANNUAL SUMMER CONFERENCE
STASMO

MARK WARREN, PE

R3Tr0-Commissioning

Presenter



Mark Warren, PE
Director of Commissioning
Ethos Engineering

Ethos Engineering

Texas * North Carolina

The Duke's Castle, Uzes, France

retro-Commissioning

Learning Objectives

- UNDERSTAND WHAT RCX IS AND WHAT IT CAN DO FOR YOU
- UNDERSTAND WHAT THE MOST RCX COMMON ISSUES ARE
- FIGURE OUT HOW TO DO SOME RCX YOURSELF
- LEARN TO LOVE CASTLES

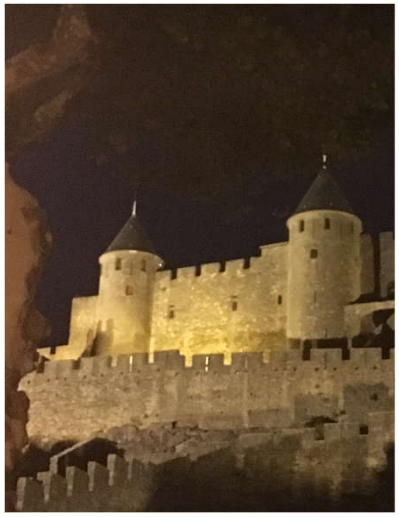
Wretro-Commissioning

Carcassonne, France

WHAT IS RETRO-CX?

Pretty much like Commissioning,

except for existing facilities



Carcassonne, France

Jethro-Commissioning

SO, WHAT IS COMMISSIONING?

A systematic process to ensure that a facility is operating and maintained to meet the needs of users.

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BENEFITS OF RCX

- BETTER OCCUPANT COMFORT AND HEALTH
- LOWER ENERGY BILLS (OFTEN)
  - Comfort & Health often at Odds with Low Energy Bills
- LONGER LIFE OF EQUIPMENT
- FEWER MAINTENANCE HEADACHES

Retreaux-Commissioning

WHY IS RETRO-CX NEEDED?

1. FACILITY WAS NEVER PROPERLY CX'D IN THE FIRST PLACE
2. SYSTEMS GET OUT OF WHACK (WACK?) AFTER YEARS OF OPERATION

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FACILITY WAS NEVER PROPERLY CX'D IN THE FIRST PLACE

- Most facilities were never CX'd
- Some facilities that were CX'd were not CX'd properly
- Most facilities that were *not* CX'd were left with numerous deficiencies
  - Sometimes Blatant – Known to exist, but can do nothing about it
  - Often Latent – If no one is screaming, no one knows problems exist
  - Almost always Irritating – what problem *isn't* irritating?

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SYSTEMS GET OUT OF WACK

1. Maintenance staff often fixes problem by the Band Aid method
2. Maintenance staff doesn't understand systems, so doesn't operate or maintain them properly
3. Maintenance staff does not have time, tools, expertise – nor the $$$ - to investigate problems
4. Sensors get out of calibration – and no one knows

Ritro-Commissioning

EXAMPLES OF FIXING PROBLEMS WITH BANDAIDS

- AC won't cool down a room: set the thermostat to 60F
- AC won't cool down a room: force the CHW valve to Open
- Rooms not 'cool' enough in morning when staff arrives: start cooling at 5AM; or leave AC on 24/7
- Hot complaints: lower the room temperature setpoint from the standard

Ritro-Commissioning

EXAMPLES OF FIXING PROBLEMS WITH BANDAIDS

- Hot complaints: force VAV box damper open
- Not sure if staff will work on weekend: leave the AC on 24/7
- AC won't cool down a room: shut the outside air damper
- Rooms too humid: shut the outside air damper
- Need to lower energy bills: shut the outside air damper
- ANYthing goes wrong: shut the outside air damper

Wetwo-Commissioning

CO2 AND RELATIVE HUMIDITY CONTROL ARE THE MAIN ISSUES IN HVAC OPERATION AND DESIGN (….in S. Texas)

GOOD CO2 LEVELS AND LOW ENERGY BILLS ARE AT ODDS WITH ONE ANOTHER

OPTIMUM CONTROL OF OA INTAKE AND RH CONTROLWILL BE A MAIN FOCUS OF RCX

Wetwo-Commissioning

CO2: IMPACTS ON HEALTH, PERFORMANCE

- CO2 IS PROXY FOR INDOOR AIR QUALITY ("HUMAN BIO-EFFLUENTS)
- ERGO - LOW CO2 DOES NOT NECESSARILY MEAN GOOD INDOOR AIR QUALITY
- LOW OUTSIDE AIR INTAKE CAN RESULT IN HIGH CO2 AND/OR OTHER CONTAMINANTS
- HIGH CO2 MIGHT IMPAIR MENTAL PERFORMANCE – COGNITIVE FUNCTIONALITY (MULTIPLE STUDIES)

Wetwo-Commissioning

CO2: IMPACTS ON HEALTH, PERFORMANCE

Lawrence Berkeley National Laboratory / 2012:

"On nine scales of decision-making performance, test subjects showed significant reductions on six of the scales at CO_2 levels of 1,000 parts per million (ppm) and large reductions on seven of the scales at 2,500 ppm."

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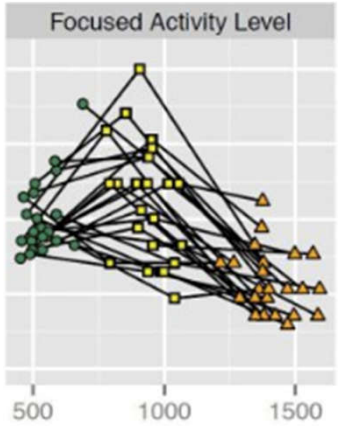
CO2: IMPACTS ON HEALTH, PERFORMANCE

Harvard School of Public Health / 2015: "carbon dioxide (CO2) has a direct and negative impact on human cognition and decision-making"



Other studies show CO2 levels need to be extremely high to be harmful to human health. For Example → → → →

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CO2: IMPACTS ON HEALTH, PERFORMANCE

- National Research Council: "Data collected on nine nuclear-powered ballistic missile submarines indicate an average CO2 concentration of 3,500 ppm with a range of 0-10,600 ppm…data collected on 10 nuclear-powered attack submarines indicate an average CO2 concentration of 4,100 ppm with a range of 300-11,300 ppm"

Wetwo-Commissioning

BOTTOM LINE:

1. HIGH CO2 LIKELY WON'T IMPACT HEALTH NEGATIVELY BUT MAY MODERATELY IMPACT LEARNING ABILITY
2. CO2 BEING A PROXY, IT IS WISE TO KEEP 'LOW' CO2 REGARDLESS
3. CODE CALLS FOR 700 PPM ABOVE AMBIENT – ASHRAE:

"Comfort (odor) criteria with respect to human bioeffluents are likely to be satisfied if the ventilation results in indoor CO2 concentrations less than 700 ppm above the outdoor air concentration."

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QUIZ

What is the 'back-ground' CO2 level in the world?

1. 257 ppm
2. 411 ppm
3. 686 ppm
4. All of the above

This is the highest level in *at least* how many years?

1. 200 years
2. 1,500 years
3. 100,000 years
4. 600,000 years

Where is 'back-ground' CO2 level measured?

1. Timbuktu, Mali
2. Downtown NYC
3. A mountaintop in Hawaii
4. All of the above

Wetwo-Commissioning

INDOOR RELATIVE HUMIDITY

- RCXA MAY RECOMMEND INCREASED OA INTAKE TO COMBAT HIGH CO2, RESULTING IN HIGHER ENERGY COST
- FRESH OUTSIDE AIR IS VERY EXPENSIVE TO DEHUMIDIFY
  - TONS OF AC TO COOL 1000 CFM TO 55/54 db/wb:
  - 98Fdb/78Fwb OUTSIDE AIR: 7.1 TONS
  - 75F / 50% RH INDOOR AIR: 2.1 TONS

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TEMPERATURE: IMPACTS ON HEALTH, PERFORMANCE

- ROOMS TOO WARM
  - 2018 HARVARD STUDY OF 71F v. 80F: 13 percent lower performance on basic arithmetic tests, and nearly a 10 percent reduction in the number of correct responses per minute
  - 2006 LAWRENCE BERKELY NAT'L LAB STUDY: Worker performance drops off when office temperatures rise above the mid-70s.

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TEMPERATURE: IMPACTS ON HEALTH, PERFORMANCE

- ROOMS TOO COLD
  - ELECTRIC SPACE HEATERS DRIVE UP YOUR ENERGY COSTS
  - ELECTRIC SPACE HEATERS USED AS MUCH IN WARM WEATHER AS IN COLD

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ENOUGH ABOUT CO2 AND TEMPERATURE

EXAMPLES OF
STAFF NOT UNDERSTANDING SYSTEMS

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- RE-HEAT FOR DEHUMIDIFICATION
  - A small-ish, un-named University in College Station, TX
    - Maintenance person thought you need to heat air to dehumidify it
  - XYZ un-named University in Houston, TX
    - Pre-heating outside air in summer
- MOTOR OPERATION
  - Amps do not equate to power
- POWER FACTOR PENALTY – KNOW YOUR ELECTRIC RATE
  - Whaaaaa…..???

Leonardo da Vinci burial place, Amboise Castle

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STAFF DOESN'T HAVE THE TIME TO INVESTIGATE

- E.g., facility manager at Unnamed School fixes everything that goes wrong, plus directs traffic 2x/day, acts as volleyball coach.
- Maintenance funding always seems to get short end of the stick.
  - A client added hundreds of 1000's of sq ft of buildings, cut maintenance 25%

SENSORS OUT OF CALIBRATION

Inaccurate sensors cost you big time – either in poor comfort, undesirable indoor environmental conditions, or energy cost

Examples

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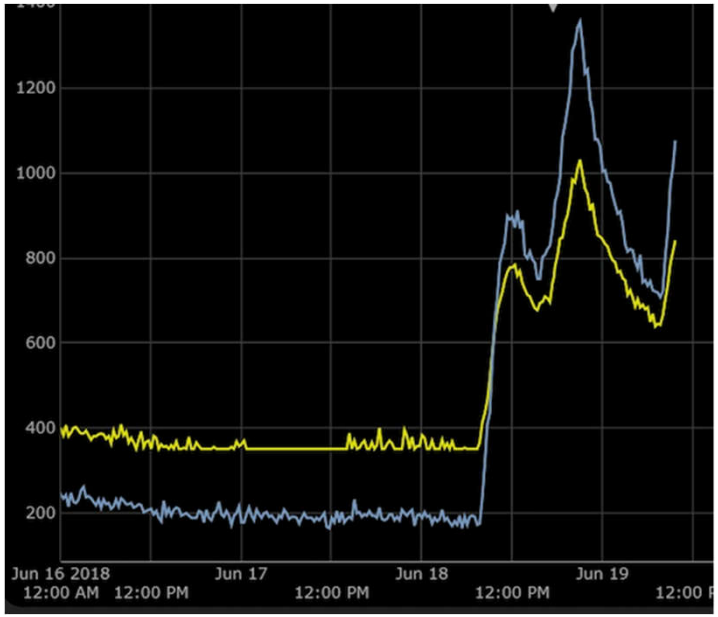
INACCURATE CO2 SENSOR

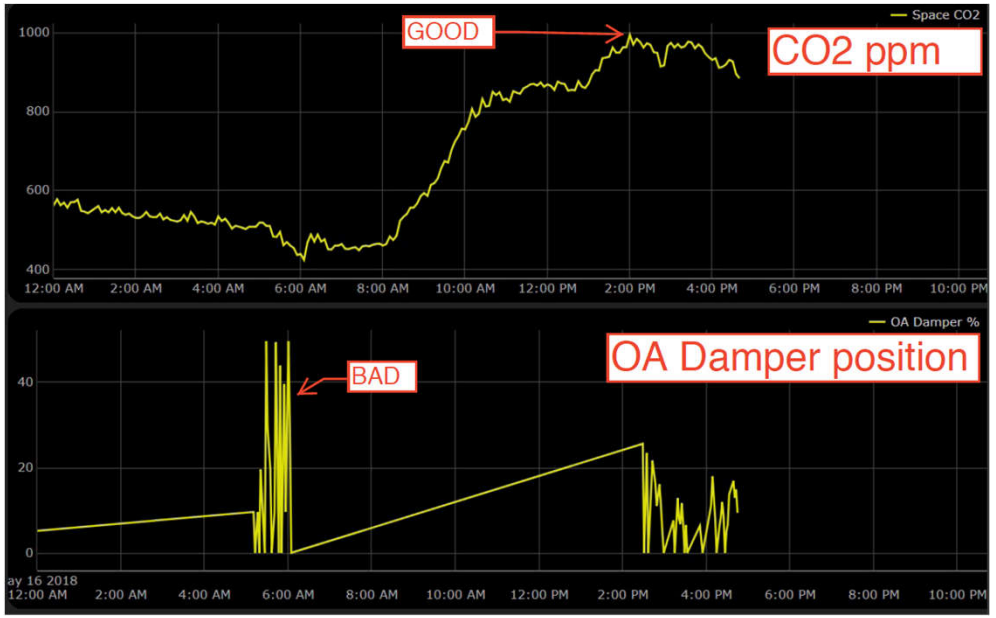
- CO2 SENSOR READING TOO HIGH
  - BAS will bring in more outside air than necessary, causing energy bills to increase.
- CO2 SENSOR READING TOO LOW
  - BAS will bring in less outside air than necessary, resulting in high CO2 concentration in rooms.
    - Ambient air CO2 is a minimum of 411 ppm
    - Max desired CO2 in a classroom is ±1100 ppm

Commissioning

Bad sensor



Decent CO2 Control



INACCURATE ROOM HUMIDITY SENSOR

- RH SENSOR READING TOO HIGH
  - Unit will operate in dehumidification mode, causing energy bills to increase
- RH SENSOR READING TOO LOW
  - RH will be higher than desirable – possible mold growth, possible occupant discomfort

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What is the Scope of Work for RCX?

Whatever you want it to be.

TYPICAL RCX

- HVAC & Controls

NOT TYPICAL RCX

- Plumbing, Lighting, Electrical

Burg Eltz, Germany

WetRow-Commissioning

THE FULL WORKS

INITIAL INSPECTION / DISCUSSION WITH STAFF

IDENTIFY OPPORTUNITIES

GATHER / ANALIZE UTILITY BILLS

DOCUMENT SYSTEMS INFO

RUN GLOBAL REPORTS

REVIEW CONTROL SEQUENCES

SET UP TREND LOGS

STAFF TRAINING

IDENTIFY ‘HIGH’-COST MEASURES

MEASUREMENT & VERIFICATION

WetRow-Commissioning

MAIN THINGS RCXA WILL LOOK AT

OPERATING SCHEDULES

ROOM TEMP & RH SETPOINTS

OPTIMAL CONTROL SEQUENCES

OUTSIDE / CO2 AIR CONTROL

ACCURACY OF SENSORS

DEVICES (VALVES, DAMPERS, FANS…) RESPOND TO COMMAND PROPERLY

CONDITION OF EQUIPMENT

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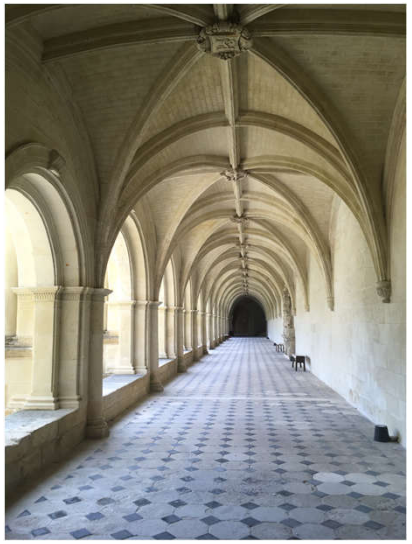
CONTROLS ARE EVERYTHING!

- GRAPHICS CORRECT
- SETPOINTS ARE APPROPRIATE
- OPERATING SCHEDULES ARE APPROPRIATE
- SEQUENCES AS SPEC'D OR APPROPRIATE
- OUTSIDE AIR INTAKE
- SENSOR ACCURACY
- ALARMS WORK (non-nuisance)



Corridors where Eleanor of Aquitaine roamed

Retro-Commissioning

TRENDING AND GLOBAL REPORTS

"YOU CAN OBSERVE A LOT JUST BY WATCHING" – YOGI BERRA

BAS TRENDING AND GLOBAL REPORTS ARE THE MOST POWERFUL TOOLS YOU HAVE

- MOMENT-IN-TIME SNAPSHOTS CAN BE MISLEADING OR INCOMPLETE
- LEARN HOW TO SET UP TRENDS & DO GLOBAL REPORTS – USE THEM INTENSIVELY

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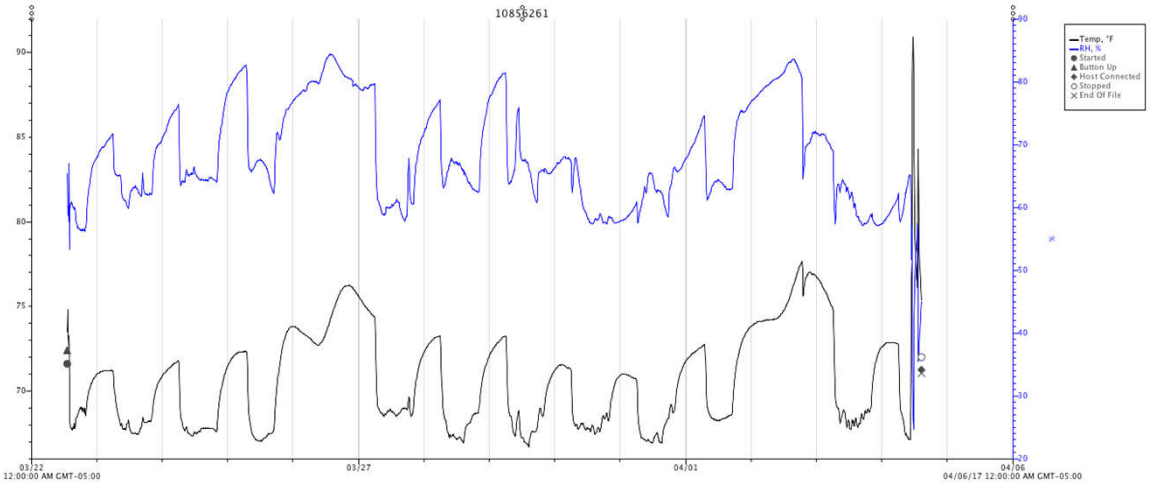
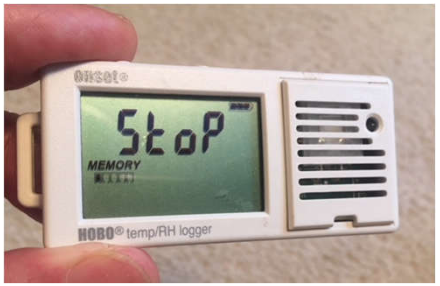
IF YOU HAVE NO BAS SENSOR, USE HOBOS (by Onset corp.)

A Hobo graph



A HOBO - this one logs temp & RH



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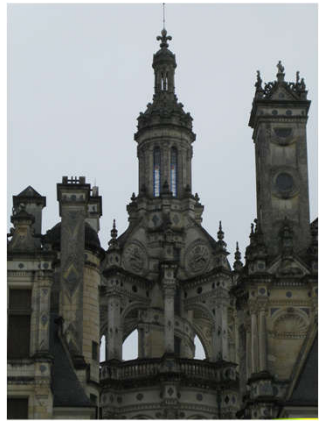
TREND LOG

Fan speed in Yellow

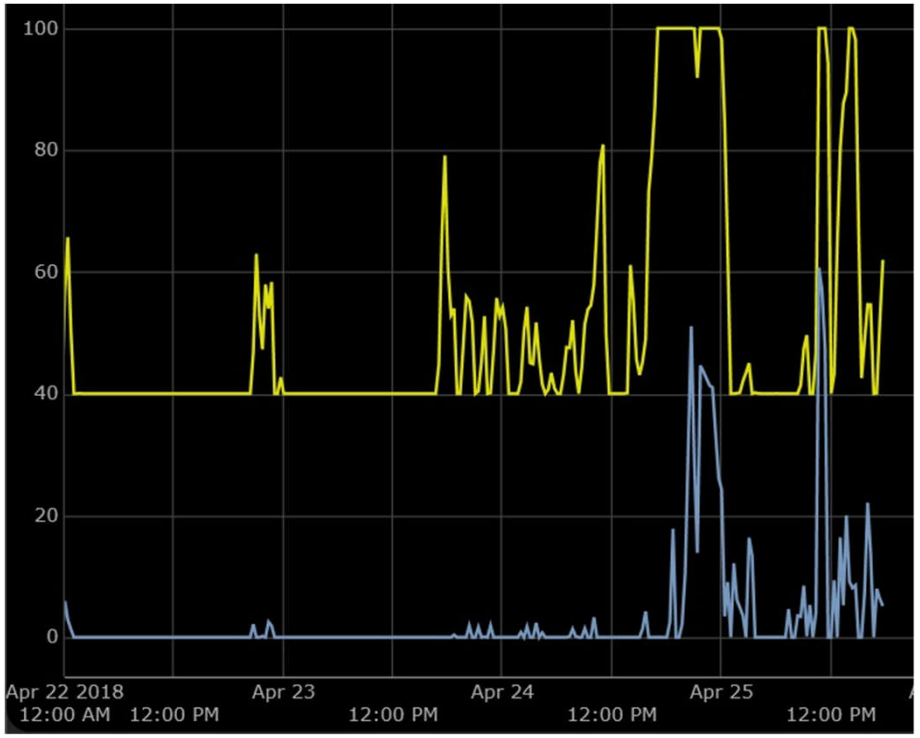
CHW valve in Blue



Chambord Castle

Francois 1st

440 rooms,
282 fireplaces,
84 staircases



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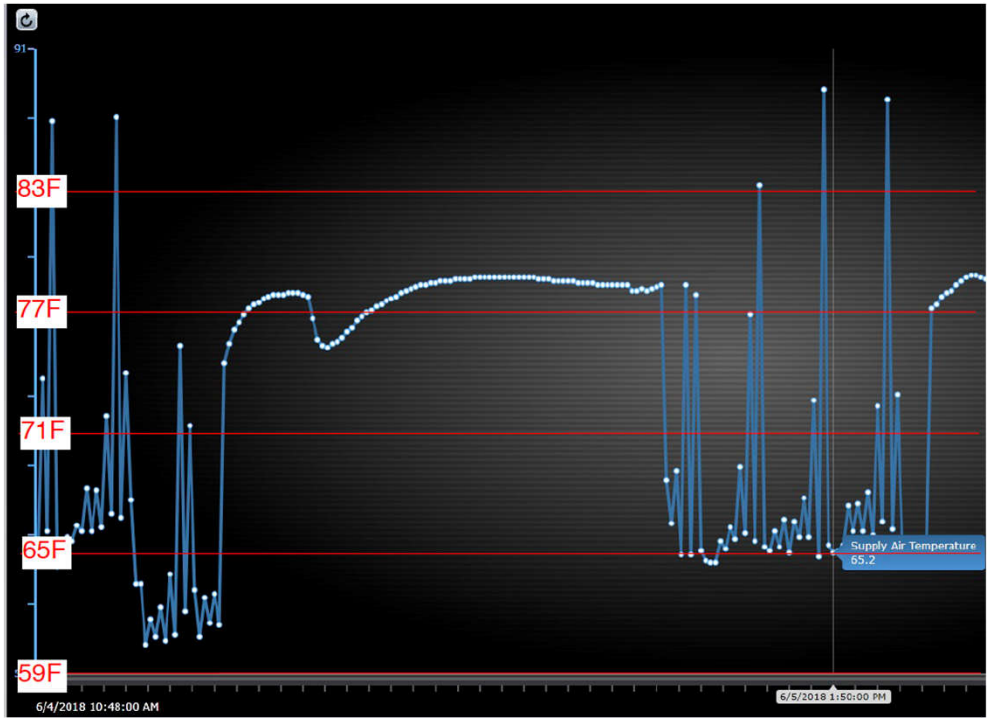
TREND LOG

Discharge air temperature from dedicated OA unit

Rajesh's Home In France

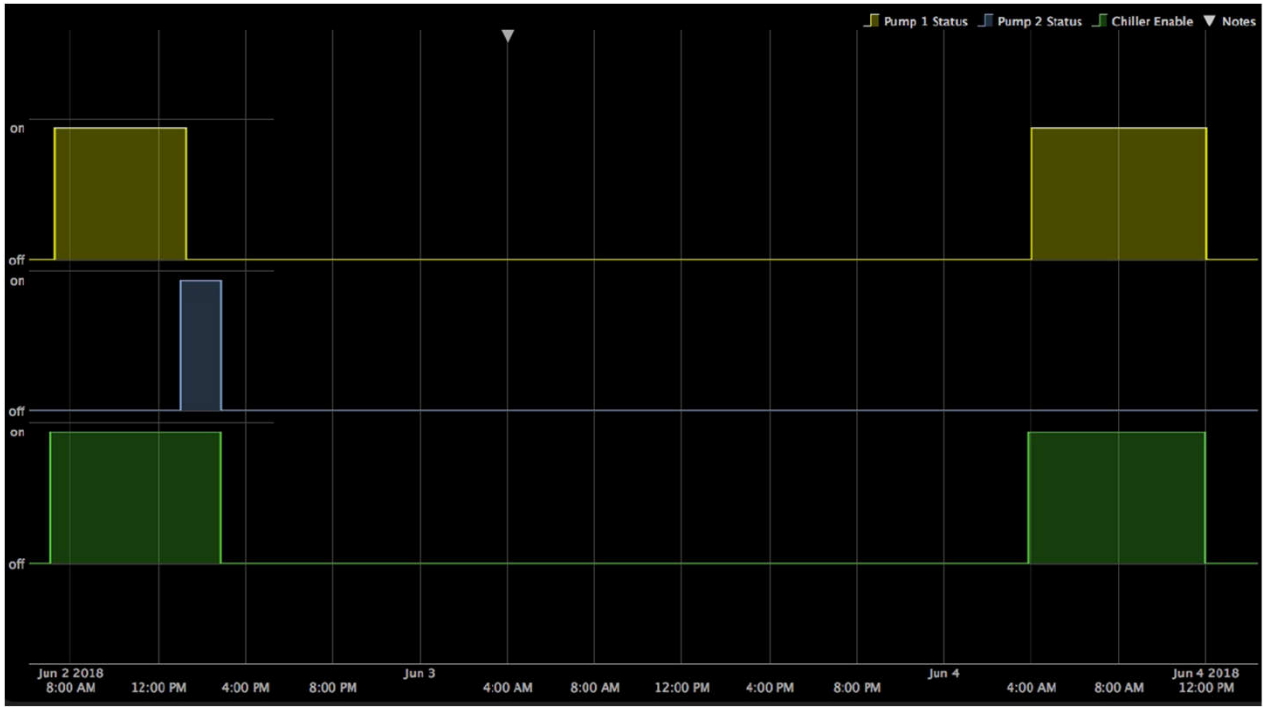


Retro-CX'g

TREND LOG

Check the REAL equipment operating hours

Azay le Rideau
France



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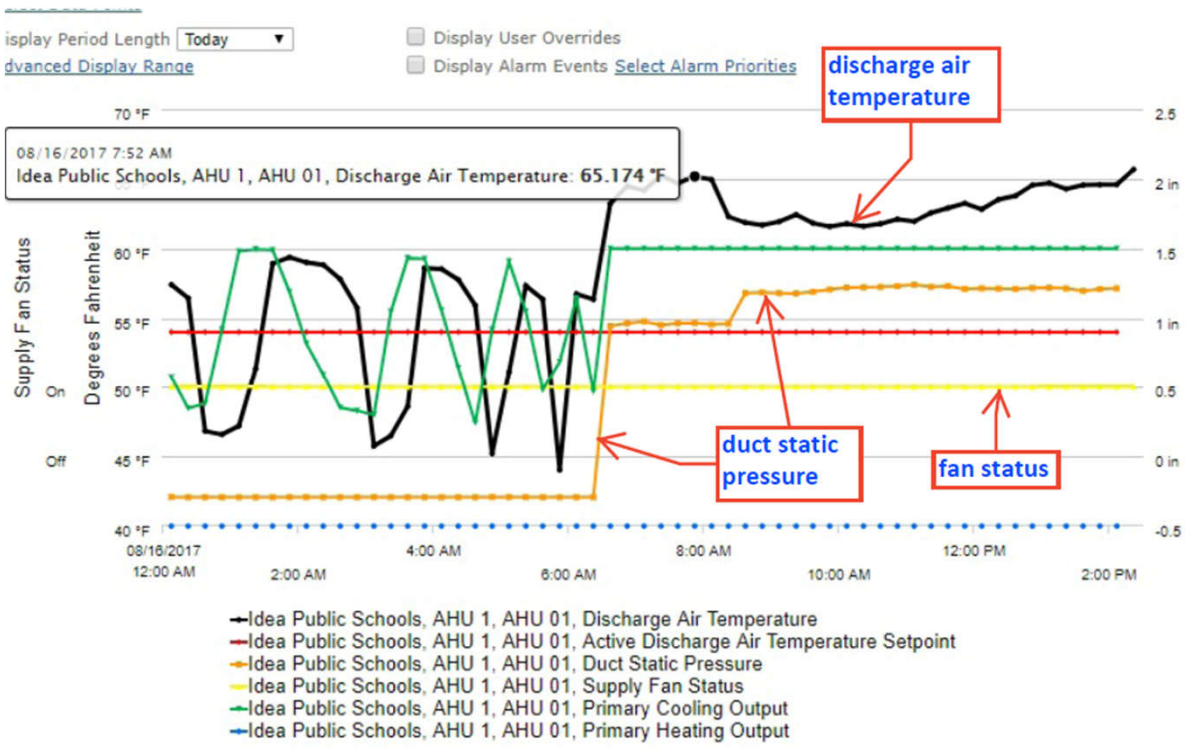
TREND LOG

What can this tell you?

Fan staying on all night

Unit cooling all night

Unit not cooling well in day (60F-65F supply air)



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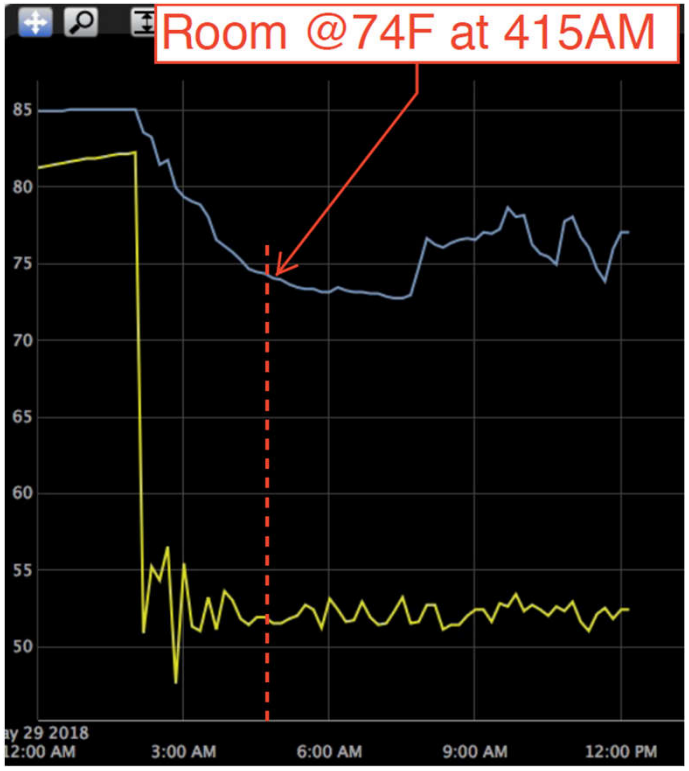
TREND LOG

Optimum Start-Stop



R.-Commissioning

QUIZ

Who Owned This Shack?

a. Marie Antoinette
b. Melania Trump
c. Diane de Poitiers
d. Catherine de Medici
e. All of the above

Chenonceau, France

Rx-Commissioning

GLOBAL REPORTS

Look for outliers

Space Temp

Equipment	Current Value
Wing #8 Second Floor / FCU-8201A	72.7
Wing #8 Second Floor / FCU-8201B	72.5
Wing #8 Second Floor / FCU-8202	68.9
Wing #8 Second Floor / FCU-8203B	72.8
Wing #8 Second Floor / FCU-8203A	73.7
Wing #8 Second Floor / FCU-8204A	74.9
Wing #8 Second Floor / FCU-8204B	72.3
Wing #8 Second Floor / FCU-8205	72.5
Wing #8 Second Floor / FCU-8206B	72.5
Wing #8 Second Floor / FCU-8206A	72.5
Wing #8 Second Floor / FCU-8207	70.9
Wing #8 Second Floor / FCU-8208	71.5
Wing #8 Second Floor / FCU-8209A	71.2
Wing #8 Second Floor / FCU-8209B	71.6
Wing #8 Second Floor / FCU-8210	70.5

Space RH

HI TEST	LO TEST
66	40
65	65
60	60
63	63
64	64
56	56
?	?
48	48
53	53
53	53
74	74
55	55
65	65
61	61
88	88
54	54
55	55

RetroCommissioning

QUIZ

Who Owned This Castle?

1. Walt Disney
2. The Mad King Ludwig
3. The Mad Bill Gates
4. The Mad Hatter
5. All of the above

Why was he mad?

1. Didn't have enough money
2. He wasn't; he was just eccentric
3. Too many steps to climb
4. Chloroform poisoning

Retreaux Commissioning

Cost of RCX

WHATEVER: Tailor it to the size, complexity, and energy costs of facility

- As little as 1 day on site, < 1 day report write
- As much as weeks-long process

Meteora, Greece

Technically not a castle

RCX

QUESTIONS ?

PREGUNTAS ?

FRAGEN ?

Ερωτήσεις ?