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Key Energy Savings Measures for Existing Building Commissioning (EBCx) Projects

Megan Wallace P. Eng., BPA
Eddy Cloutier P. Eng., BPA
Aurélie Verstraete P.Eng., BPA

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SAVE ON ENERGY POWER WHAT'S NEXT

Agenda

- Save on Energy program updates
- Reminders:
  - EBCx process
  - EBCx most common measures
- What to look for during the investigation?
  - How to spot the issues?
  - Case scenarios
  - EBCx key measure examples
- Q&A

Save on Energy Retrofit Program – fall 2023 changes

- Prescriptive incentives for most **non-lighting measures** have increased as of October 30, 2023
- Most non-lighting incentives have **doubled** and some have increased three- or fourfold, including air source heat pumps
- The last day to apply for **lighting** projects (prescriptive or custom) in the Retrofit program is **December 17, 2023**
- The **Instant Discounts Program** for lighting launches **December 18, 2023**
- In this program, incentives will be paid directly to distributors, enabling them to offer instant point-of-sale discounts on energy-efficiency lighting to customers

Visit the Retrofit program website for the updated measures and incentives.

Save on Energy Capability Building - EBCx resources

- Designed to enhance knowledge and develop skills in organizations and communities to increase awareness and participation in energy-efficiency opportunities across Ontario, including Save on Energy programs
- Our dedicated EBCx resources include:
  - webinars
  - practical guide for building owners and managers
  - info sheets: condos, medical buildings, office buildings and warehouses
  - incentives for ~20 training courses

EBCx resources on Save on Energy website

Save on Energy - EBCx Program

HOW DOES THE PROGRAM WORK?

The EBCx program has three phases with incentives for participants who complete each one.

1. INVESTIGATION PHASE

Hire a CP to investigate your facility and prepare a report setting out a commissioning plan.

INCENTIVE

Up to $0.06/sq. ft., up to $50,000 per facility and/or 75% of the cost of working with a CP

2. IMPLEMENTATION PHASE

Implement the energy-efficiency measures identified in the commissioning plan.

INCENTIVE

$0.03/KWh of confirmed energy savings, up to the lesser of 30% of facility annual electricity consumption or $50,000

3. PERSISTENCE PHASE

Receive training from your CP to maintain savings and monitor your systems for one year after implementation.

INCENTIVE

$0.03/KWh of confirmed persisting energy savings, up to the lesser of 30% of facility annual electricity consumption or $50,000

EBCx process

1	**PLANNING** • Owner selects a building and generates benchmarking score[1] • Owner selects EBCx provider and identifies team • Owner and provider define project objectives • Provider conducts interviews and performs walk through	EBCx Plan
2	**INVESTIGATION** • Provider reviews facility documentation • Provider performs diagnostic monitoring and testing • Provider and owner prioritize and select EBCx improvements	Findings Log Investigation Report
3	**IMPLEMENTATION** • Provider, building staff, or contractors implement selected operational improvements • Provider verifies results	Implementation Plan Implementation Report
4	**HAND-OFF** • Provider recommends persistence strategies • Provider conducts staff training • Provider holds hand-off meeting	EBCx Final Report

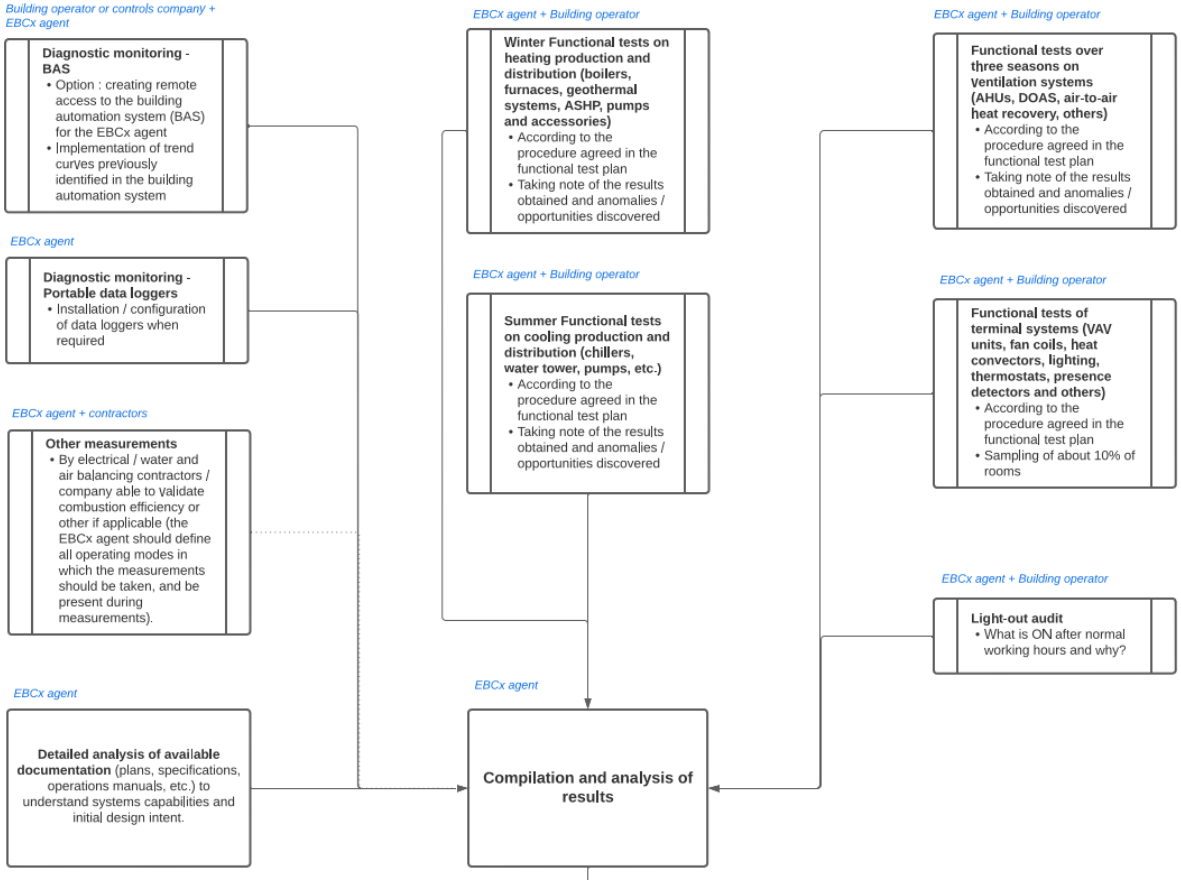
[1] The EnergyStar Portfolio Manager Program is a free benchmarking tool: https://portfoliomanager.energystar.gov/pm/login.html

Note: Save on Energy's EBCx program combines phase 1 and phase 2 into a single phase.

Investigation phase

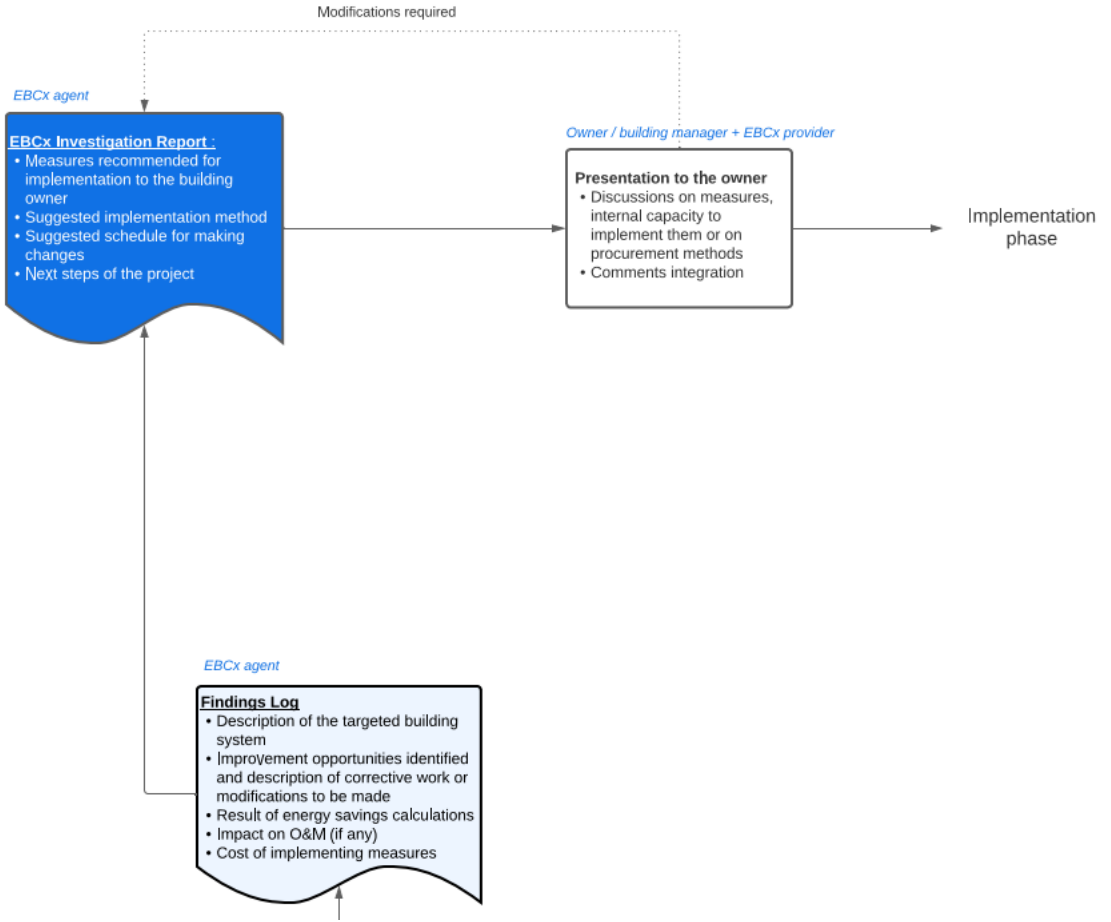
The investigation phase allows the EBCx team to analyze the system operations in detail, carry out diagnostic tests and propose measures to optimize operations. These measures are presented in the Findings Log, an integral part of the Investigation Report.

Investigation activities (1 of 2)



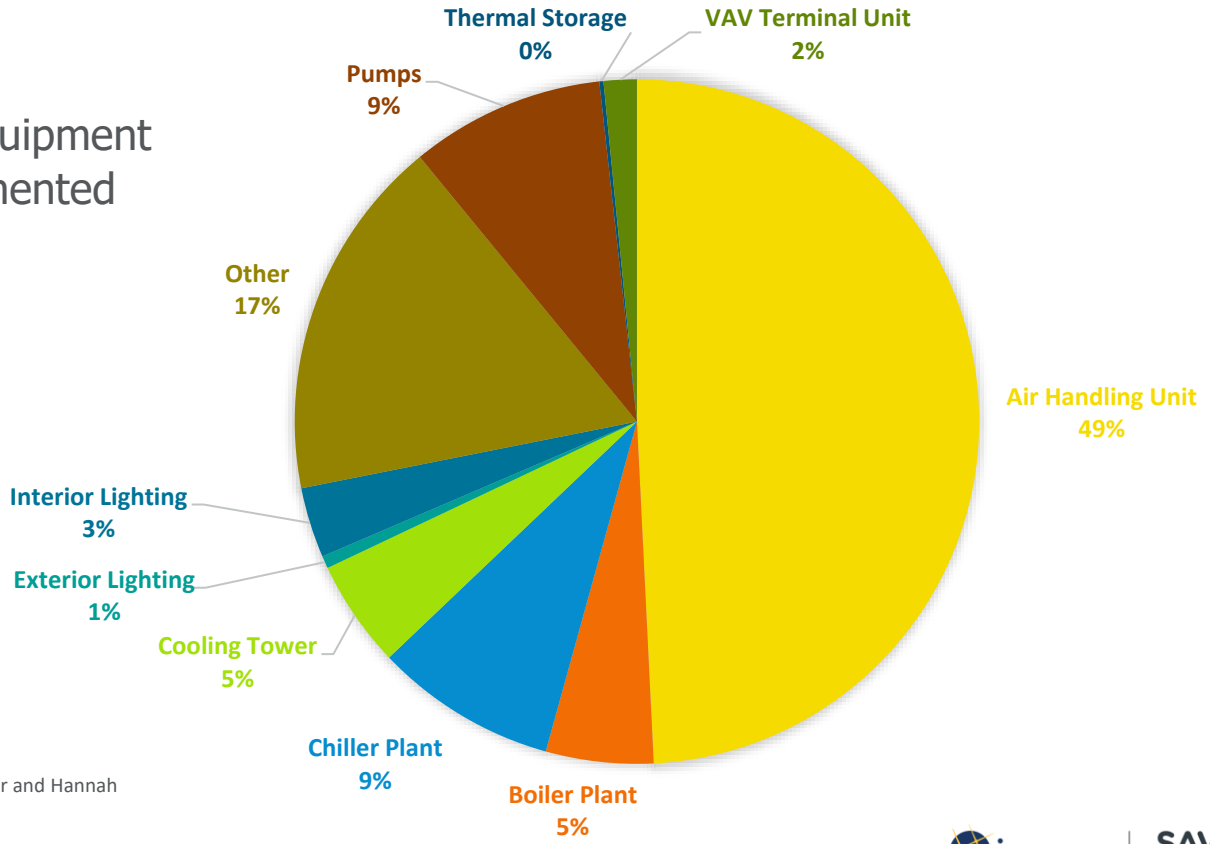
SAVE ON ENERGY
POWER WHAT'S NEXT

Investigation activities (2 of 2)



Statistics

Which systems and equipment are affected by implemented EBCx measures?



Reference : “The Right Measures” by Joann Effinger and Hannah Friedman, ASHRAE Journal, October 2010.

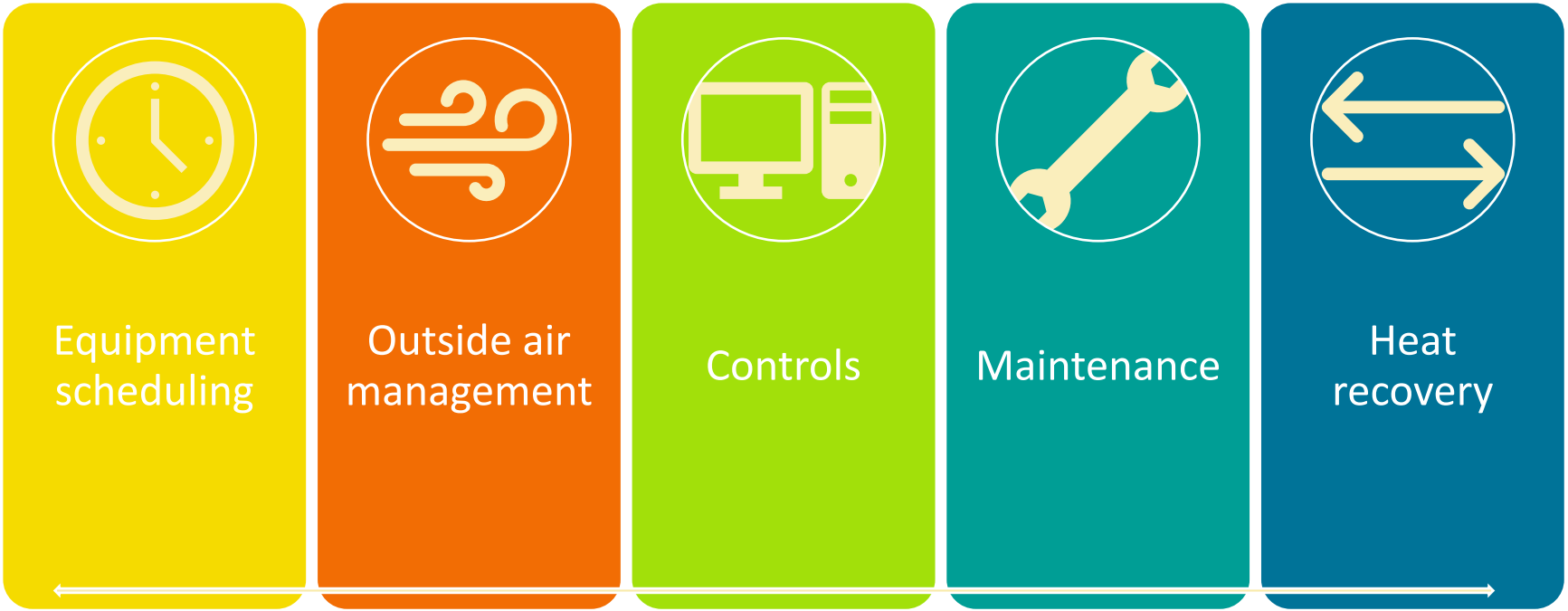
Statistics

- In this study, nine measures contribute to 75% of the total savings!

Key Measure Mix for EBCx	% of total savings
Revise control sequence	21%
Reduce equipment runtime	15%
Optimize airside economizer	12%
Add/Optimize supply air temperature reset	8%
Add VFD drive to pump	6%
Reduce coil leakage	4%
Reduce/Reset duct static pressure setpoint	4%
Add/Optimize Start/Stop	3%
Add/Optimize condenser water supply temperature reset	2%
Total	**75%**

Reference : "The Right Measures" by Joann Effinger and Hannah Friedman, ASHRAE Journal, October 2010.

What to look for during investigations?



Equipment scheduling – How to spot the issues?

- Review Building Automation System (BAS) schedules vs. actual occupancy schedules
- Review BAS and trend logs
- Perform on-site inspection (after hours if possible)
- Conduct interview with Operations staff
- Analyze energy data

Equipment scheduling – Air Handling Unit (AHU) schedule

Case scenario

- Office building occupied from 8 am–5 pm, Monday to Friday.
- AHUs schedule set from 3 am–8 pm, 7 days a week by operator after several thermal complaints on a Monday morning.

Time	M	T	W	T	F	S	S
00:00	OFF	OFF	OFF	OFF	OFF	OFF	OFF
01:00	OFF	OFF	OFF	OFF	OFF	OFF	OFF
02:00	OFF	OFF	OFF	OFF	OFF	OFF	OFF
03:00	ON	ON	ON	ON	ON	ON	ON
04:00	ON	ON	ON	ON	ON	ON	ON
05:00	ON	ON	ON	ON	ON	ON	ON
06:00	ON	ON	ON	ON	ON	ON	ON
07:00	ON	ON	ON	ON	ON	ON	ON
08:00	ON	ON	ON	ON	ON	ON	ON
09:00	ON	ON	ON	ON	ON	ON	ON
10:00	ON	ON	ON	ON	ON	ON	ON
11:00	ON	ON	ON	ON	ON	ON	ON
12:00	ON	ON	ON	ON	ON	ON	ON
13:00	ON	ON	ON	ON	ON	ON	ON
14:00	ON	ON	ON	ON	ON	ON	ON
15:00	ON	ON	ON	ON	ON	ON	ON
16:00	ON	ON	ON	ON	ON	ON	ON
17:00	ON	ON	ON	ON	ON	ON	ON
18:00	ON	ON	ON	ON	ON	ON	ON
19:00	ON	ON	ON	ON	ON	ON	ON
20:00	OFF	OFF	OFF	OFF	OFF	OFF	OFF
21:00	OFF	OFF	OFF	OFF	OFF	OFF	OFF
22:00	OFF	OFF	OFF	OFF	OFF	OFF	OFF
23:00	OFF	OFF	OFF	OFF	OFF	OFF	OFF

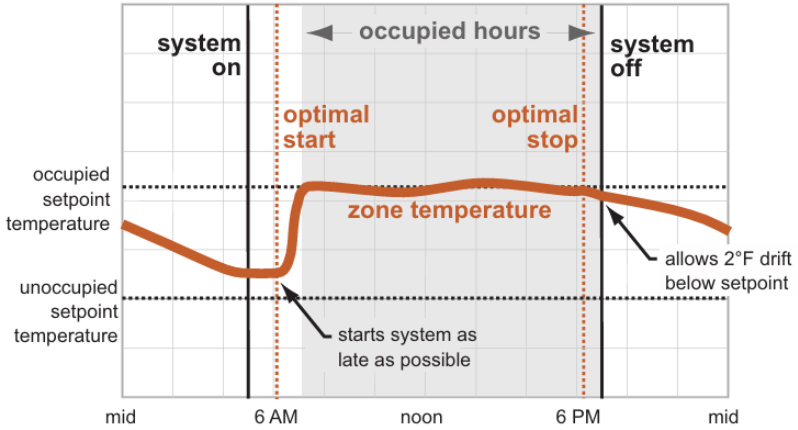
AHU schedule example

Equipment scheduling – Air Handling Unit schedule

EBCx measures:

- Modify schedule to reflect actual need
- Implement optimum start (OAT, indoor conditions)
- Train staff (schedule for special events, optimum start parameters, etc.)

Figure 1. Optimal start and optimal stop

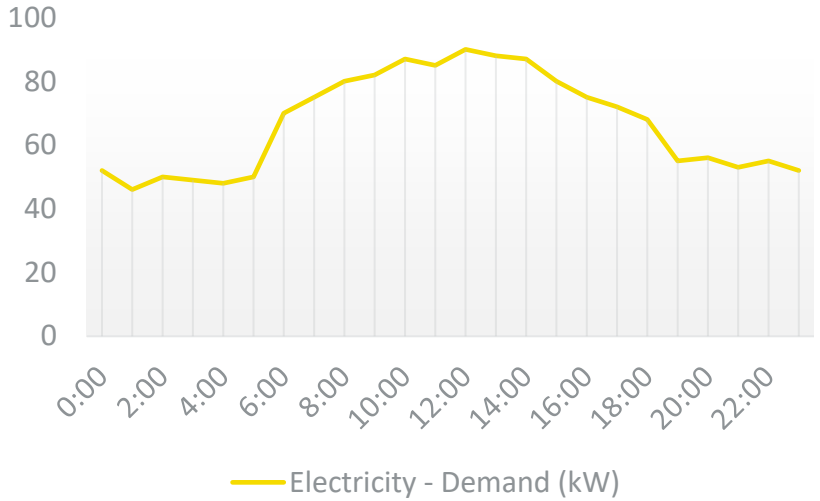


Ref. : TRANE engineers newsletter

Equipment scheduling – unoccupied mode

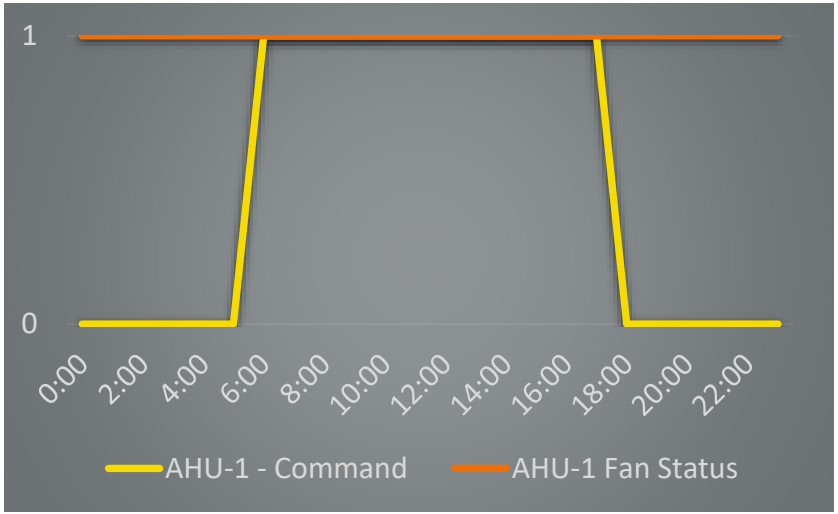
Case scenario

- HVAC schedules meet occupancy hours
- Operator does not receive any thermal complaints even on the coldest days
- But utility data (kW) shows a high baseload during unoccupied hours



Electricity – utility data

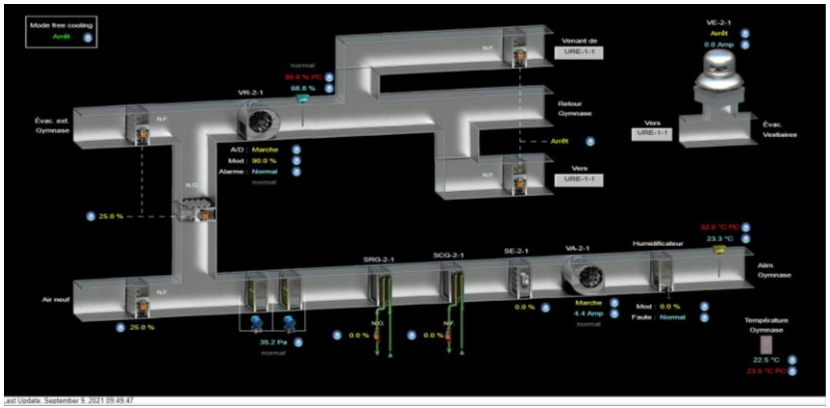
Equipment scheduling – unoccupied mode



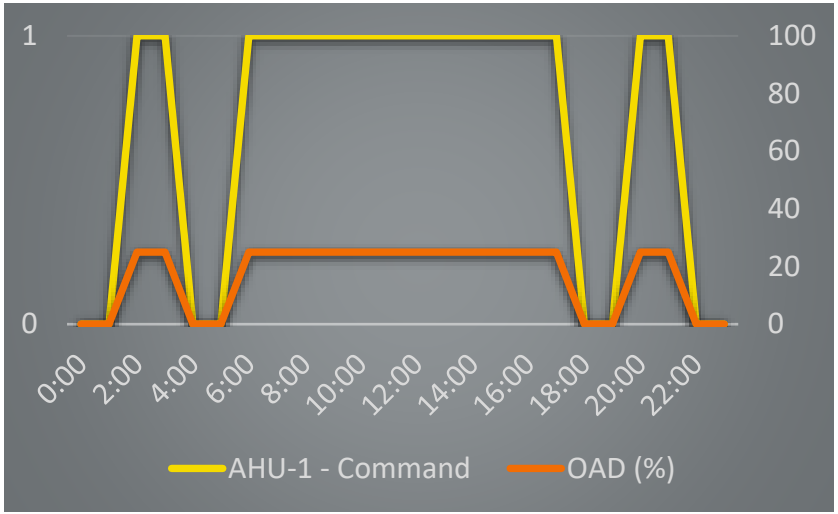
Trend log - Fan status versus Command

Electric panel control – Manual override

Equipment scheduling – unoccupied mode



Building automation system (BAS) graphic - AHU



Trend log – OA damper position

Equipment scheduling – unoccupied mode

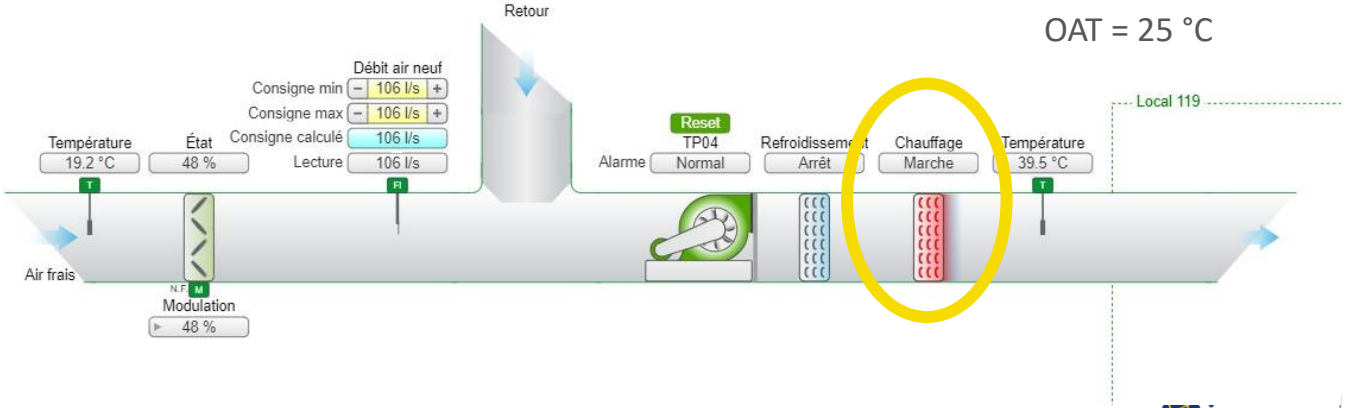
EBCx measures:

- Program dedicated control sequences for HVAC operation during unoccupied hours
  - Authorize AHU and perimeter heating to start during unoccupied hours
  - Night setback to maintain minimum/maximum room T°
  - Special attention to OAD and exhaust fan control
  - Pre-heating "warmup" mode
- Staff training to avoid future manual override

Equipment scheduling – equipment lockout

Case scenario

- Energy consumption is high, even during mid-season
- Operator reports thermal complaints (hot/cold)
- Simultaneous heating/cooling



Equipment scheduling – equipment lockout

EBCx measures:

- Establish boiler lockout during summer
- Establish terminal heating/perimeter heating lockout during summer
- Establish cooling coil valve lockout during winter
- Review control sequences to reduce simultaneous heating and cooling during mid-season

Equipment scheduling – lighting controls

Case scenario

- A night walk-through reveals interior lighting is ON despite lighting controls

Photo taken at 10:30 p.m. on a Tuesday: over 60% of occupancy sensors failed!

Equipment enabling – lighting controls

EBCx measures:

- Verify existing lighting controls and sensors (occupancy sensors, luminosity sensors, etc.)
- Optimize lighting control schedule
- Engage security staff, janitor and cleaning staff
- Set up "Occupant Awareness" program

Equipment scheduling – key measures

- **Optimize HVAC schedule to match occupancy / load**
  - AHU, RTU, thermostats, VAV boxes, chiller, boiler, pumps, exhaust fans, etc.
  - During occupied hours (optimum start, fresh air/exhaust)
  - During unoccupied hours (night setback, "warm-up" mode)
  - Interlock fresh air and exhaust/relief fans
- **Optimize lighting schedule to match occupancy**
- **Review equipment selection** (efficiency of chiller plant, heat pump/boiler)
- **Implement seasonal lockout** (boiler/chiller plant, chilled/hot water valves, perimeter heating/room reheat)

Outside air management – How to spot the issue?

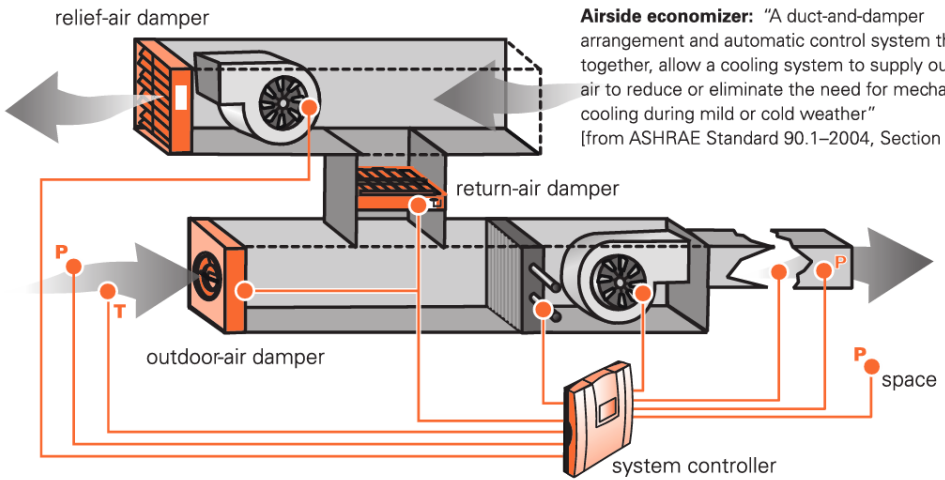
- Review HVAC schedules
- Review BAS trend log (OAD, VAV box operation)
- Review CO_2 level monitoring (zones, return air)
- Perform on-site inspection and functional testing
- Interview with operations staff/operational problems (anti-freeze alarms)
- Compare minimum OA requirements to actual OA supply
- Review initial TAB reports and/or perform measurements with Balancing Team

Outside air management – economizer control

Case scenario

- Economizer control is not optimal.
- During mid-season, mechanical cooling is used before outside air damper is 100% open.

Figure 1. Typical air handler



Airside economizer: "A duct-and-damper arrangement and automatic control system that, together, allow a cooling system to supply outdoor air to reduce or eliminate the need for mechanical cooling during mild or cold weather" [from ASHRAE Standard 90.1–2004, Section 3]

Ref. : TRANE engineers newsletter

Outside air management – economizer control

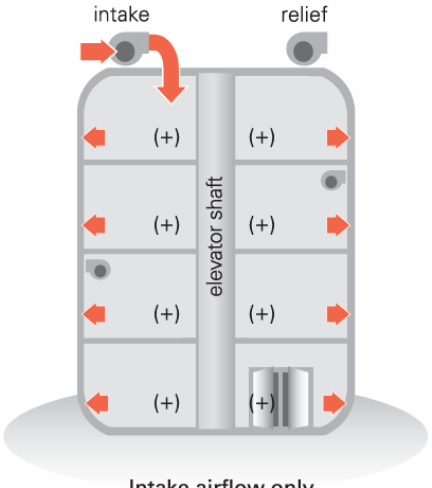
EBCx measures:

- Restore / Optimize airside economizer
  - Economizer sequenced with the mechanical cooling equipment
- Consider dehumidification load
  - Differential enthalpy with fixed dry-bulb control with high-limit shut-off
  - High limit example : hOA >hRA and TOA > 70°F (21°C)
- Building with heat recovery chillers = mechanical cooling should be prioritized when there is a heating demand.

Outside air management – minimum outdoor air

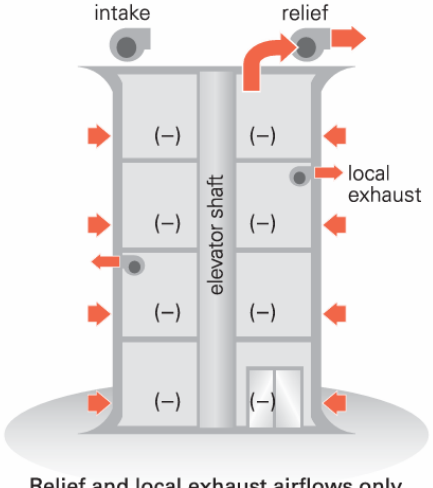
Case scenario

- Doors do not close/open!
- Building pressurization problems



Intake airflow only

- Outward-swinging doors may stand open
- During winter, exfiltrating indoor air drives moisture into building envelope



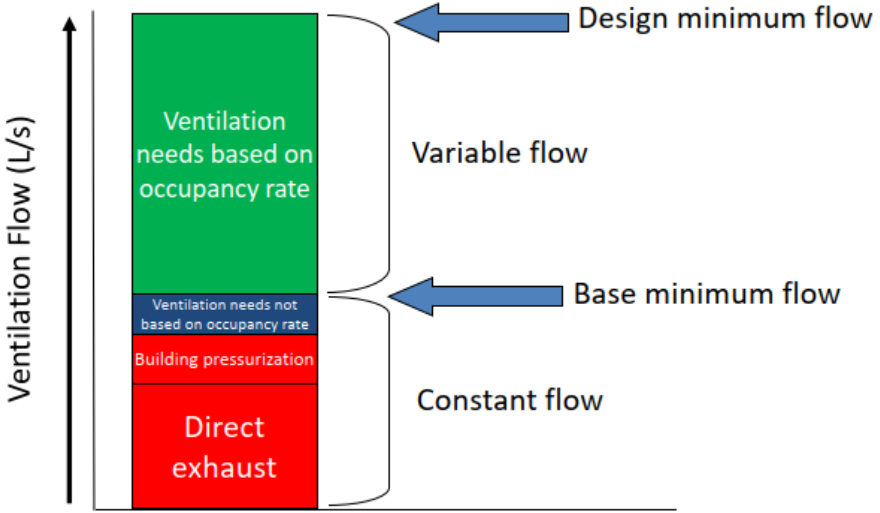
Relief and local exhaust airflows only

- Inward-swinging doors may not latch
- During summer, infiltrating outdoor air drives moisture into building envelope

Ref. : TRANE engineers newsletter

Outside air management – requirements

- Calculate OA requirements (ASHRAE 62.1)

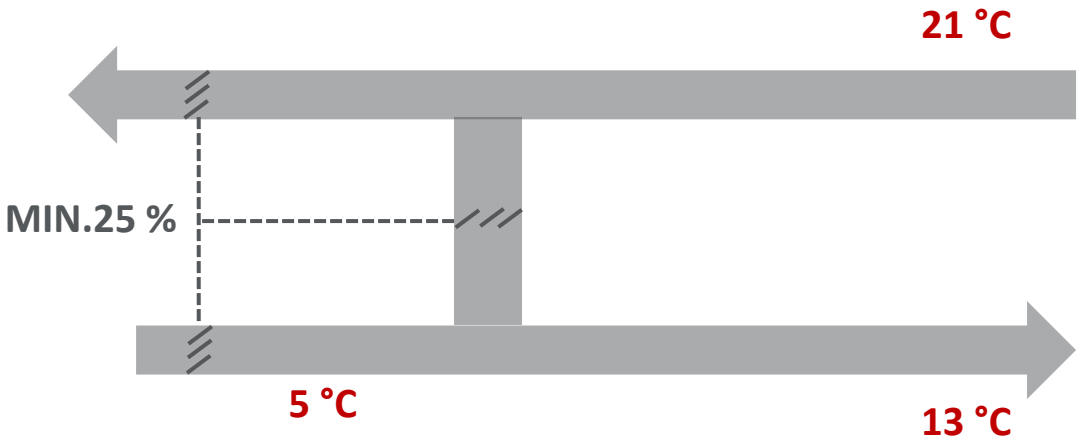


Reference : Advanced Course on EBCx – Natural Resources Canada

Outside air management – minimum outdoor air

- Calculate OAF (outdoor air fraction) entering the building - when the AHU is not in economizer mode:

OAF = (RAT-MAT) / (RAT-OAT)



OAF = 50 % !

Outside air management – minimum outdoor air

EBCx measures:

- Review minimum outdoor air flow requirements (design vs. actual occupancy rate)
- Review OA damper operation
- Review direct exhaust control

Outside air management – demand control ventilation

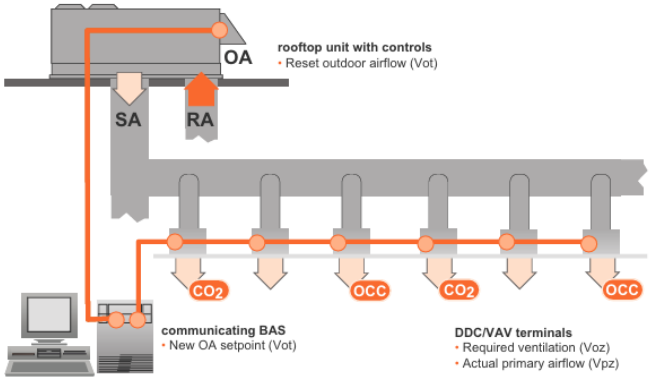
EBCx measures:

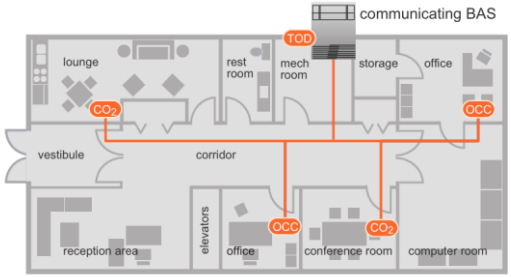
- Reduce ventilation air flow rate as occupancy levels decrease
- CO_2 level is used as an indicator of occupancy rate
- ASHRAE 62.1 : MAX (Outdoor_CO_2 + 700 ppm ; 1100 ppm)

Outside air management – DCV

Control strategies:

- CO_2 sensor in Return Air (does not consider diversity, etc.)
- CO_2 sensor in Critical Zones (OAF is high for one particular zone?)
- Minimum air flow rate still required for mechanical reasons (diffuser distribution, reheat, VAV box operation)
- Give priority to the economizer!





Ref. : TRANE engineers newsletter

Outside air management – key measures

- **Optimize economizer control strategy**
  - Free cooling versus humidification/dehumidification
- **Review outside air admission versus requirements**
  - Minimum outside air
  - Airflow balancing/pressurization
  - Outside air damper control
- **Implement Demand Control Ventilation (DCV)**

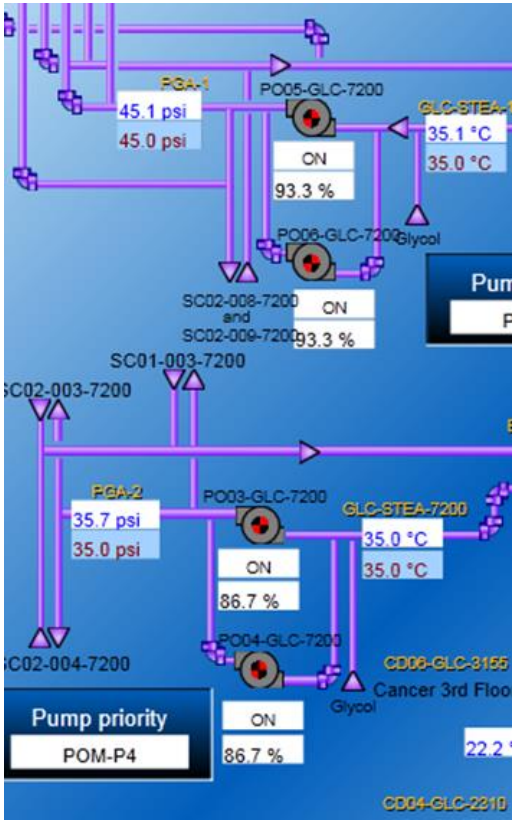
Controls – How to spot the issue?

- Review BAS graphics
- Review trend log
- Perform on-site inspection and functional test
- Interview operations staff/thermal complaints register

Pump VFD controls

Case scenario

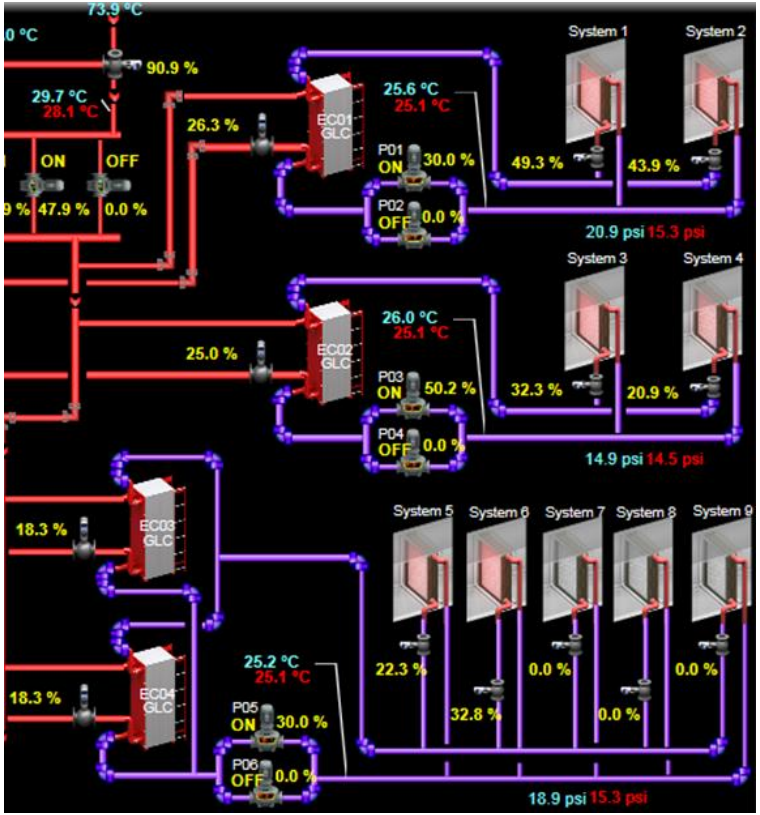
- Trend logs show pumps running at high speed at all times
- The original design did not specify setpoints, and the system was commissioned with high fixed pressure setpoints
- Redundant pumps operate in parallel



Pump VFD controls

EBCx measure description

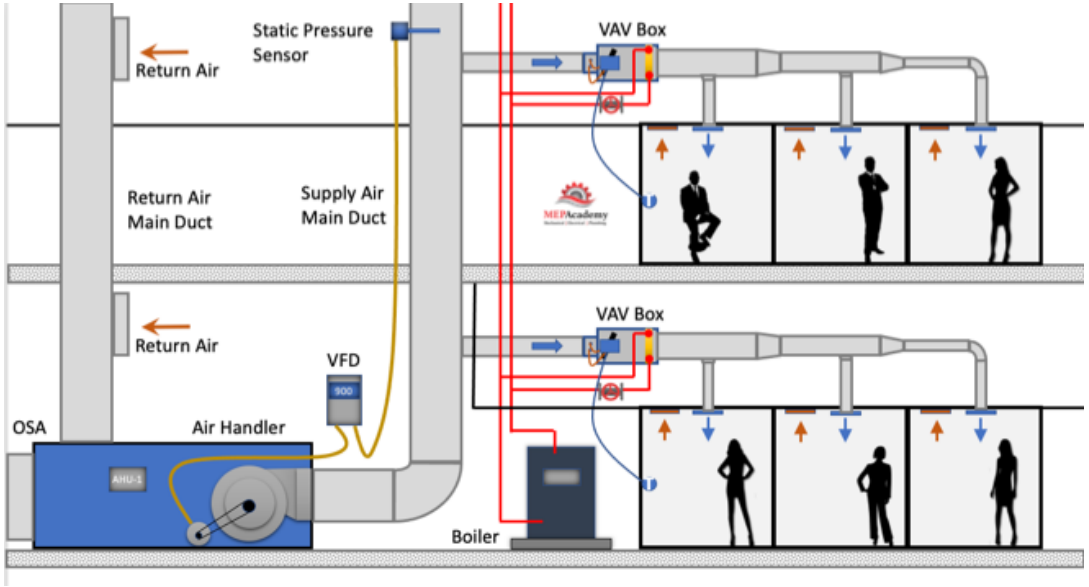
- Dynamic adjustment of setpoint pressure to network demand
- There are various methods of dynamic adjustment, but for example, in the case of a network supplying heating or cooling coils, you can adjust according to the control valve most in demand (open)



AHU supply temperature control

Case scenario

- Supply temperature set at 13°C (55°F) at all times
- It has been observed at the control system that in many areas, VAV boxes operate at their minimum opening for long periods of the day, and the terminal reheat coils have to operate to avoid overcooling

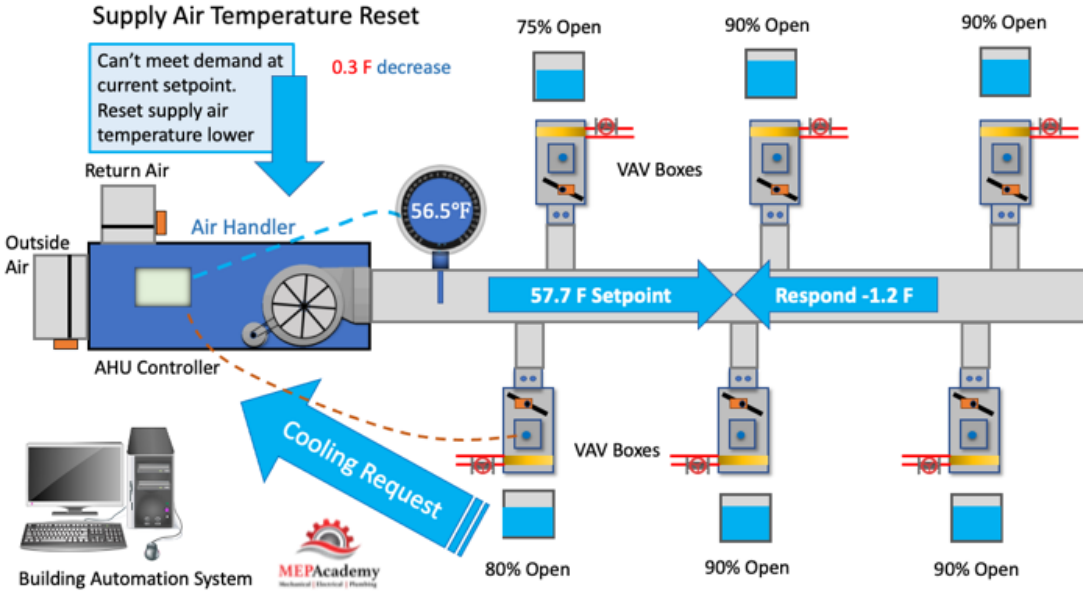


Credit : How a Variable Air Volume VAV System Works - MEP Academy

AHU supply temperature control

EBCx measure description

- Dynamic adjustment of supply air temperature according to demand
- Use of the "Trim and response" strategy: when VAV boxes are not in cooling demand, the supply temperature is gradually readjusted upwards over time (in increments of 0.5°F, for example). When some boxes are over 90% open, the movement is reversed



Credit : Top 6 HVAC Control Strategies to Save Energy - MEP Academy

Room temperature setpoints

Case scenario

- Based on the trend curves recorded at night, there is no temperature set-back in winter
- The operator says that wall insulation is minimal, and that this creates discomfort during the coldest weather. The temperature set-back sequence has been deactivated

Room temperature setpoints

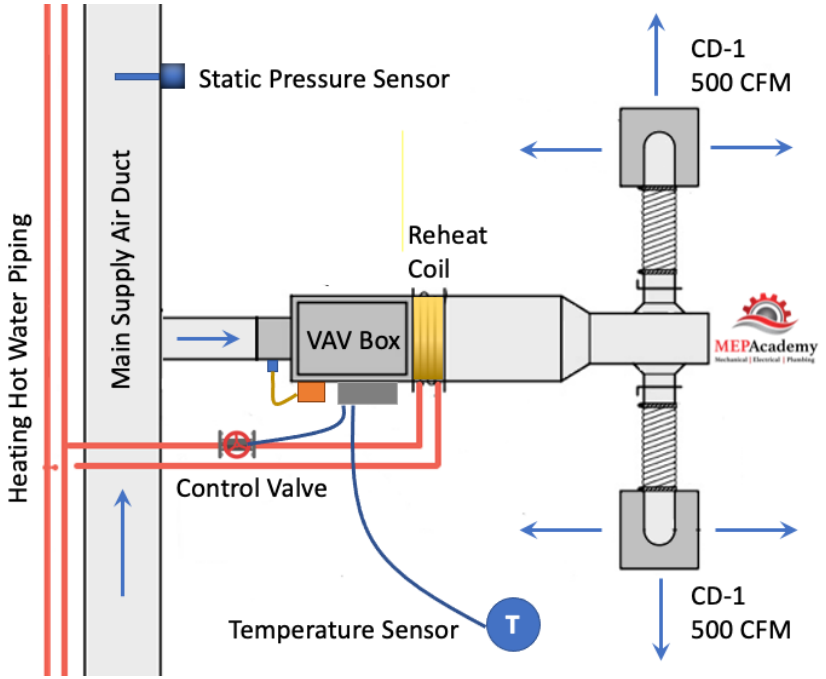
EBCx measure description

- Temperature setback to 18°C as soon as the occupancy schedule ends
- Programming of a sequence where the temperature set-back time is reduced below an outdoor temperature of -10°C, so that the room temperature is back to normal in time for the occupants' arrival (optimum start)
- Training the operator to make adjustments rather than disabling the setback sequence

VAV boxes minimum flow setpoints

Case scenario

- The minimum flow rates for VAV boxes are all set at 50% of the maximum flow rate. In the original design documents, no minimum was specified
- Complaints are common in some overcooled sectors. High heating consumption even in summer: high terminal reheating



Credit : How a Variable Air Volume VAV System Works - MEP Academy

Variable air volume box minimum flow setpoints

EBCx measure description

- Calculation of flow rates to be admitted into rooms in accordance with ASHRAE 62.1
- Adjustment of minimum VAV box flow rates to comply with ASHRAE 62.1 while limiting terminal reheat requirements
- Validation of minimum flow rates with a balancing contractor

Controls – Key measures

- **Resolve sensor problem** (calibration, relocation, replacement)
- **Review setpoints** (temperature, pressure, humidity)
  - Remove manual overrides
  - Dual room setpoints (cooling/heating), occupied/unoccupied setpoints.
- **Optimize equipment staging** (chillers, heat pumps, etc.)
- **Implement/optimize reset strategies**
  - Differential pressure reset for pumps and fans (based on terminal devices conditions)
  - Discharge air temperature reset (based on zone conditions / outdoor air temperature)
- **Review/Optimize VAV box minimum flow setpoints**

Maintenance – How to spot the issue?

- In-depth system inspection
- Functional tests
- Review of operators' contracts and maintenance tasks (are there any gaps?)
- Review of occupant complaints: complaints often conceal maintenance issues

Maintenance – leaking heating or cooling valve

Case scenario

- During an inspection of an air handling unit, the commissioning agent notices that the heating coil is operating at the same time as the cooling coil. However, at the BAS, the heating valve is at 0%
- The agent closes a manual valve to isolate the heating coil, and within seconds the situation is back to normal

Maintenance – leaking heating or cooling valve

EBCx measure description

- Depending on the type of valve, the operator or a contractor may or may not be able to repair it. In some cases, replacement may be required
- Energy savings are often very significant, since they impact several systems: heating energy, cooling energy, pumps, etc., as well as having an impact on comfort

Maintenance – key measures

- Eliminate simultaneous heating and cooling (leaky valves)
- Reduce losses in the ductwork (leaky ductwork, filters that need to be changed)
- Improve equipment performance (e.g., clogged boiler)
- Eliminate flow obstructions
- Review dampers / valves operation (e.g., broken linkage)

Heat recovery – How to spot the issues?

- Review mechanical drawings and expected efficiency
- Measure flow and temperature; calculate actual efficiency
- Review BAS trend log
- Review control sequences
- Perform functional testing under several operational conditions

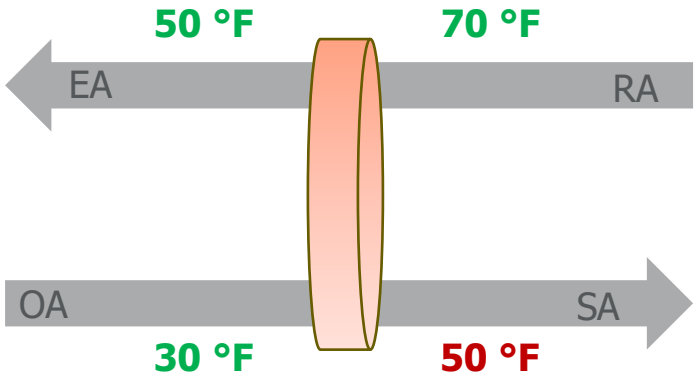
Heat recovery – air-to-air heat exchangers

Case scenario

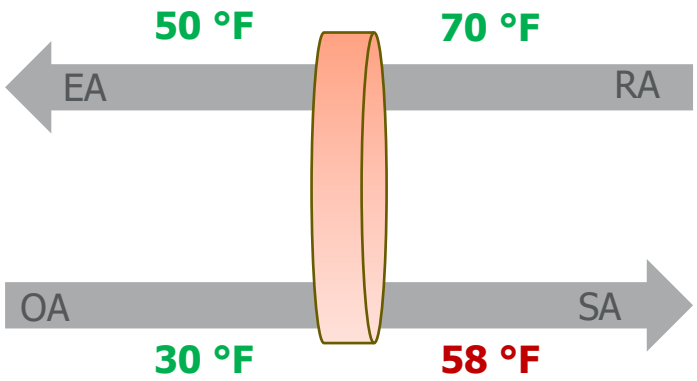
- Heat exchanger does not perform as well as expected
- Operator receives many alarms during winter
- Supplemental heating is required even during mid-season

Heat recovery – air-to-air – Thermal wheel

Is balancing optimal?



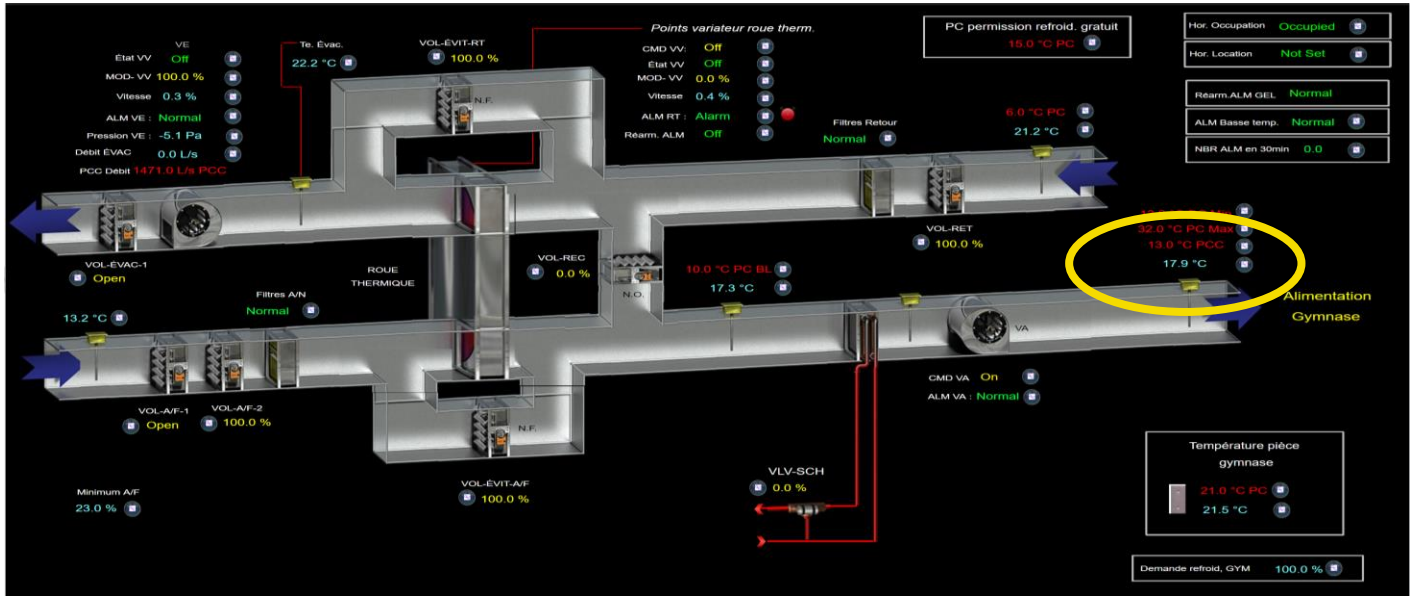
RA flow = 70% OA flow



RA flow = OA flow

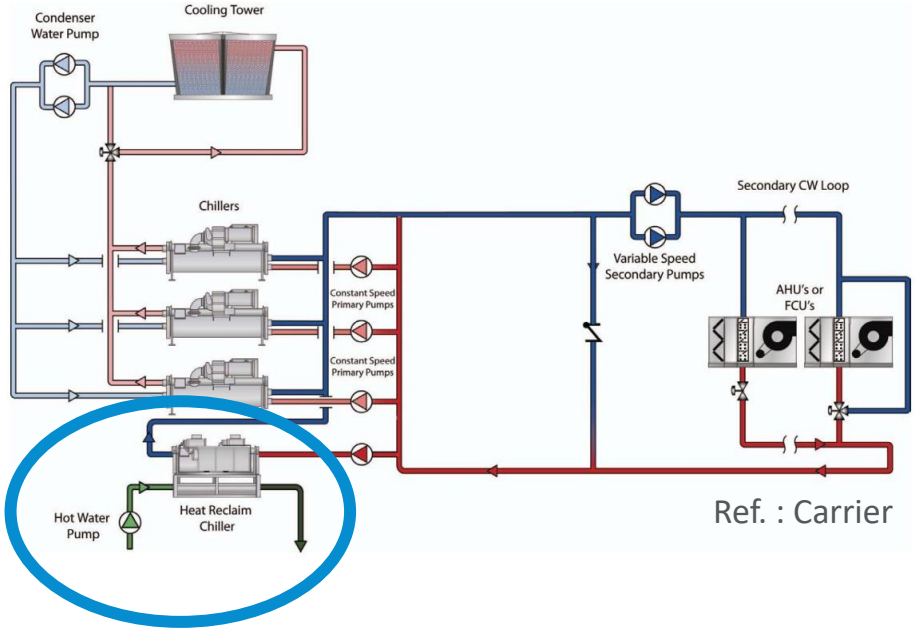
Heat recovery – air-to-air – Thermal wheel

Does overheating occur?



Heat recovery – heat recovery chiller

Is the HR chiller used at the right time and under the right conditions?



Heat recovery – key measures

- **Air-to-air heat recovery** (thermal wheel, plate type heat exchanger)
  - Optimize heat recovery control (HRC) strategy (enabling/disabling, bypass damper, etc.)
  - Establish / Optimize anti-freeze regulation
  - Review air balancing between fresh air and exhaust

- **Heat recovery chiller**
  - Prioritize heat recovery chiller when there are heating loads in the building
  - Optimize heating loop temperatures to benefit from HRC
  - Overheat air (with heat recovery) and use mechanical cooling

Discussion

Thank you for participating!

Questions: trainingandsupport@ieso.ca

Information, events, courses: https://saveonenergy.ca/For-Business-and-Industry/Training-and-support

EBCx program: https://saveonenergy.ca/For-Business-and-Industry/Programs-and-incentives/Existing-Building-Commissioning-Program

Thank you!

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trainingandsupport@ieso.ca

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