# Retro Commissioning of Ventilation Systems

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# Agenda

- Why perform retro-commissioning
- Common RCx measures
- Functional testing
  - Basic equipment

# Commissioning and Retro-commissioning

- **Commissioning** vs. **Retro-Commissioning**
- **Retro-commissioning (RCx)** = commissioning of an existing building, typically looking to optimize existing systems and equipment for low cost
  - Focus on Low and No cost measures
- **Monitoring Based Commissioning** = A process that repeatedly looks at commissioning systems and equipment of a building/project. Typically done through a computerized process

# Why Should We Do This?

Shouldn't We Be Doing This Already?

- From millions of retro-commissioned square feet, we have found that NO facilities have the time, resources, or money to do this continually.
- Great opportunity to have a 3rd party who knows the process to review, test and tune-up all of the systems in your facility.
- Low Cost / High Impact Energy Savings

# RCx Examples of Optimization Measures

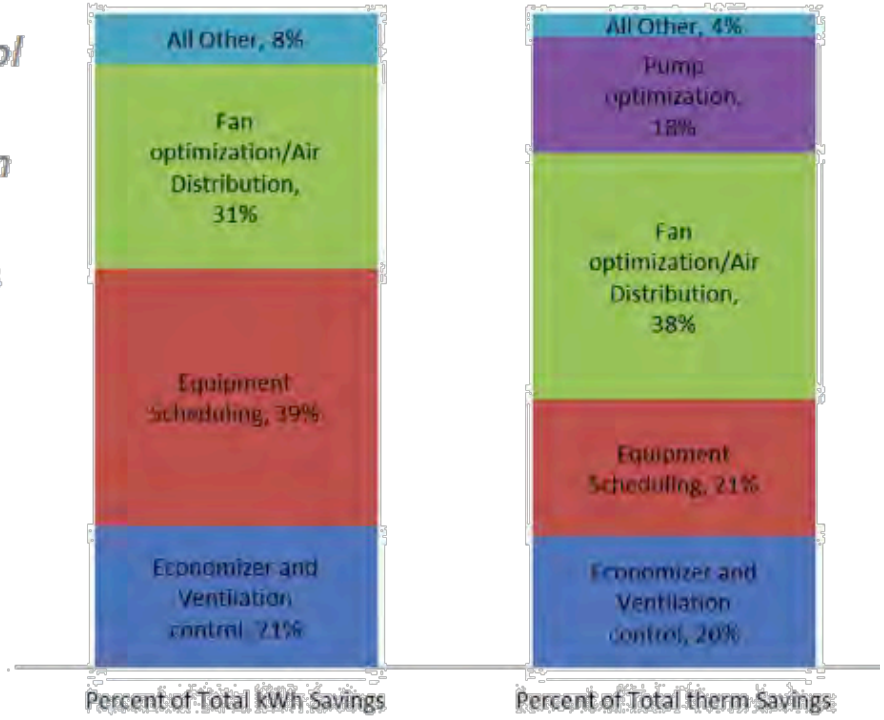
- Static Pressure Reset
- Discharge air temperature reset
- VAV box scheduling and CFM reset
- Air flow monitoring and control
- Demand control ventilation
- Improper ventilation (Too much OA)

# RCx Measures Cont.

Over 90% of the electrical savings, and 79% of the gas savings are from:

1. *Economizer & Ventilation Control*
2. *Equipment scheduling*
3. *Fan optimization/Air distribution*

- Fan optimization/Air distribution measures had the lowest simple payback (0.6 years).



# Top RCx Electric Savings Measures

| Measure | % of Total kWh Savings | Number of Measures (with Electric Savings) |
|---|---|---|
| Schedule AHU for space | 34% | 54 |
| Duct Static Pressure Reduce/Reset | 18% | 24 |
| Economizer and outdoor air control | 10% | 32 |
| Supply air temperature reset | 10% | 27 |
| Demand control ventilation | 4% | 6 |
| Condenser water temperature reset | 3% | 13 |
| Reduce Ventilation | 3% | 10 |
| Eliminate unnecessary fans | 3% | 1 |
| Utilize VFDs for fans | 2% | 3 |
| Schedule Fan Powered/VAV Boxes | 1% | 3 |
| Schedule heaters | 1% | 2 |
| Reduce pump differential pressure setpoint | 1% | 7 |
| Repair/replace dampers | 1% | 1 |
| Optimum start for AHU | 1% | 4 |
| Chilled water temperature reset | 0.9% | 9 |
| Schedule Pumps | 0.9% | 6 |
| Adjust freeze protection sequence for pumps | 0.7% | 3 |
| Schedule AHU and duct static pressure reset | 0.6% | 1 |

# Top RCx Gas Savings Measures

| Measure | % of Total therm Savings | Number of Measures (with NG savings) |
|---|---|---|
| Supply air temperature reset | 38% | 17 |
| Schedule AHU for space | 20% | 23 |
| Reduce pump differential pressure setpoint | 18% | 1 |
| Demand control ventilation | 8% | 3 |
| Economizer and outdoor air control | 5% | 5 |
| Reduce Ventilation | 3% | 3 |
| Duct Static Pressure Reduce/Reset | 2% | 1 |
| Improve valve control/ Replace/repair valve | 2% | 2 |
| CO-Based Ventilation Control | 1% | 1 |
| Optimize Snowmelt System | 0.9% | 1 |
| Reduce simultaneous heating and cooling | 0.7% | 3 |
| Optimum start for AHU | 0.5% | 1 |
| Low Flow Faucets | 0.4% | 1 |
| Improve CHW and HW flow control | 0.2% | 1 |
| Optimize supply fan performance | 0.1% | 1 |
| Reduce VAV Minimum Position | 0.04% | 1 |
| Schedule Fan Powered Boxes | 0.02% | 1 |

# #5 Static Pressure Reset

A 544,000 suburban office building is made up of a 21 story tower and two three story wings served by a central chilled water plant with a thermal storage capacity by making ice.

- The duct static pressure reset based on the chilled water valve position for E-01, T-05, T-06, W-07, and W-08. The maximum setpoint will be the current static pressure setpoint and minimum will be 1.00 IWC.
- Static pressure control of VAV air handling units is supposed to control the supply fan so that a pressure setpoint is maintained in the supply ductwork. As various VAV box dampers open and close, the pressure in the system will change and the fan will speed up or slow down to ensure there is enough pressure for the VAV boxes to work properly. This measure looks at adding static pressure reset to optimize the control of the fan speed.

| | Annual KW Saved | Annual kwh saved | Annual therms Saved | Annual Cost Savings | Project Cost | Payback |
|---|---|---|---|---|---|---|
| Static Pressure Reset | 17.5 | 153,102 | NA | $11,611 | $3,085 | .27 years |

# #5 Static Pressure Reset

A suburban office complex with 700,000 sf. Served by (30) air handling units, (4) water cooled chillers and (5) hot water boilers

- Install downstream static pressure sensors and reset static pressure setpoint based on chilled water valve position on units AHU-5,6 & 10

| | Annual kwh saved | Annual therms Saved | Annual Cost Savings | Project Cost | Payback |
|---|---|---|---|---|---|
| Duct Static Pressure Reset | 552,741 | NA | $32,181 | $6,658 | .21 years |

# #4 Economizer Optimization

An urban 35 story office tower with 1,224,500 gross square feet. There are (16) 2 MMBtuh natural gas boilers that provide heating water to the perimeter induction units and the interior core AHU's floor reheat coils. There are four (4) 900 ton Centrifugal chillers (R-134a) serving the building.

- Install enthalpy based economizers for units (12) air handling units.

| | Annual kwh saved | Annual therms Saved | Annual Cost Savings | Project Cost | Payback |
|---|---|---|---|---|---|
| Enthalpy Economizer | 126,886 | NA | $9,225 | $9,950 | 1.08 years |

# #4 Economizer Optimization

A suburban food manufacturer with a 200,000 sqft plant served by water cooled chillers, steam boilers and a mix of air handling units and makeup air units.

- Install enthalpy based economizers for (16) air handling units.

| | Annual KW Saved | Annual kwh saved | Annual therms Saved | Annual Cost Savings | Project Cost | Payback |
|---|---|---|---|---|---|---|
| Enthalpy Economizer | 230 | 1,821,682 | 113,731 | $168,473 | $45,492 | .27 years |

# #3 Demand Control Ventilation

A 50 story, 1,741,312 gross square feet urban office building.

- Currently the main Air Handling Units that serve the office portion of the building are controlled based on ASHRAE 62.1 minimum ventilation rates. Based on building occupancy on any given day, due to factors such as sick days, the building not being fully occupied, and workers/ visitors coming and going at different times than are assumed leads to the building being overly ventilated a considerable portion of the time.
- Controlling Outdoor Air (OA) based on CO2 concentration of the exhaust air allows the ASHRAE 62.1 minimums to be reduced, provided that CO2 concentration in the exhaust air doesn't go above the Chicago Code maximum of 1000 ppm in the occupied spaces.

| | Annual kwh saved | Annual therms Saved | Annual Cost Savings | Project Cost | Payback |
|---|---|---|---|---|---|
| DCV | 245,694 | NA | $15,064 | $28,000 | 1.85 years |

# #3 Demand Control Ventilation

A 75,000 gross square feet urban manufacturing facility.

- Currently the Air Handling Units that serve the manufacturing floor provide 100% outdoor air to meet the code required ventilation rates.
- Controlling Outdoor Air (OA) based on CO2 concentration of the exhaust air allows the ASHRAE 62.1 minimums to be reduced, provided that CO2 concentration in the exhaust air doesn't go above the Chicago Code maximum of 1000 ppm in the occupied spaces.

| | Annual kwh saved | Annual therms Saved | Annual Cost Savings | Project Cost | Payback |
|---|---|---|---|---|---|
| DCV | 85,915 | 82,618 | $73,711 | $3,775 | 0.05 years |

# #2 Supply Air Temperature Reset

Suburban university campus with a main building approximately 411,000 square feet. The majority of the building was constructed in 1979, with additions in 1991 and 1997.

- Air handling unit 21 serves lecture rooms 1 and 2. During a site survey all the cold deck dampers were closed when the outdoor air temperature was 60F. This suggests that the spaces were overcooled. This measure looks at resetting the supply air temperature to reduce overcooling.

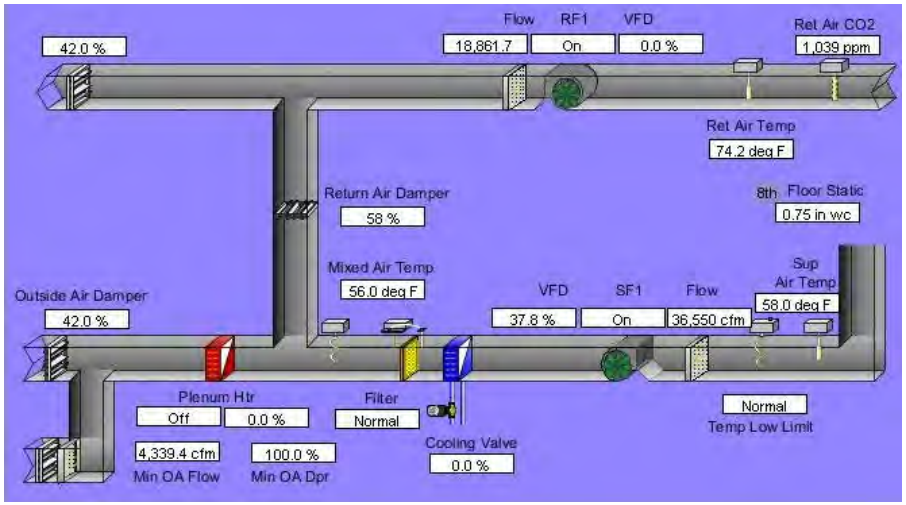
| | Annual kwh saved | Annual therms Saved | Annual Cost Savings | Project Cost | Payback |
|---|---|---|---|---|---|
| DAT Reset | 4,397 | 2,184 | $1,932 | $1,000 | .52 years |

# Testing Procedures & Equipment

- Calibrating sensors
- Damper modulation and actuation
- Economizer mode operation
- Review BAS graphics and trend data

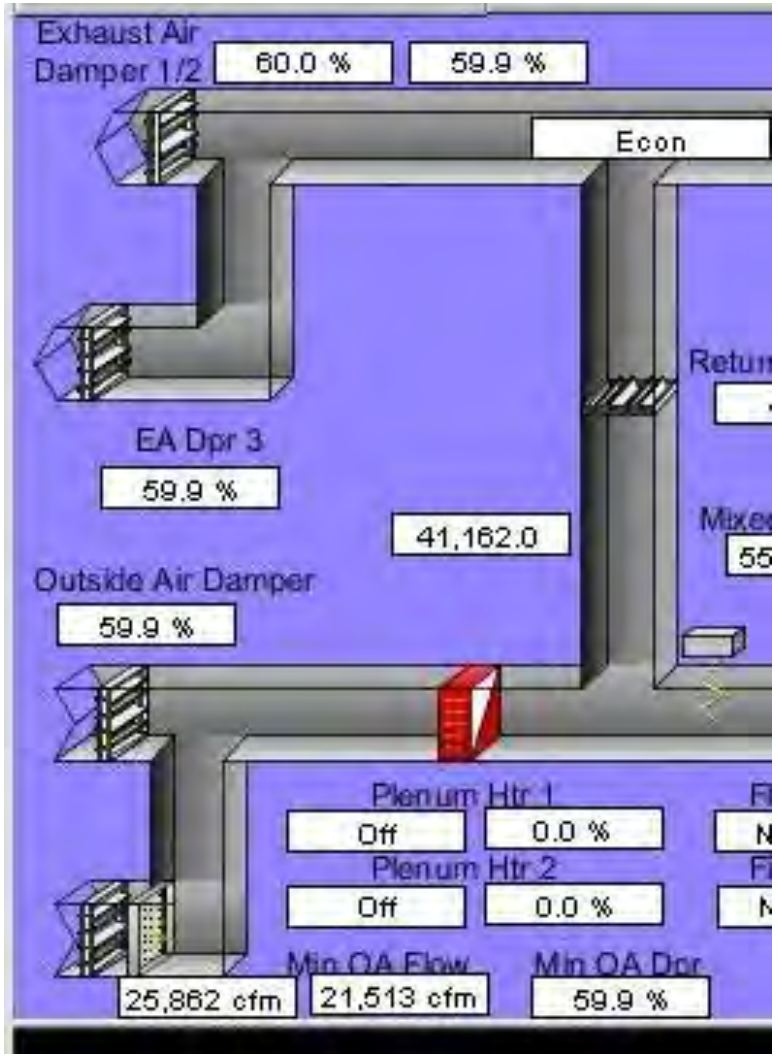
# Calibrating Sensors

- Airflow monitoring stations
- Temperature sensors




# Damper Modulation

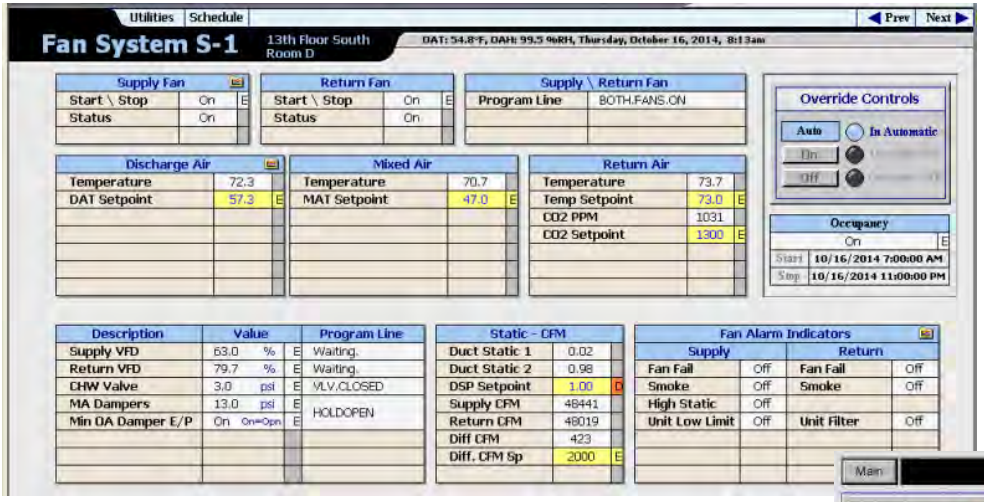
- Command dampers from BAS
- Field verify position visually and using temperature calculations
  - (RAT-MAT)/(RAT-OAT)

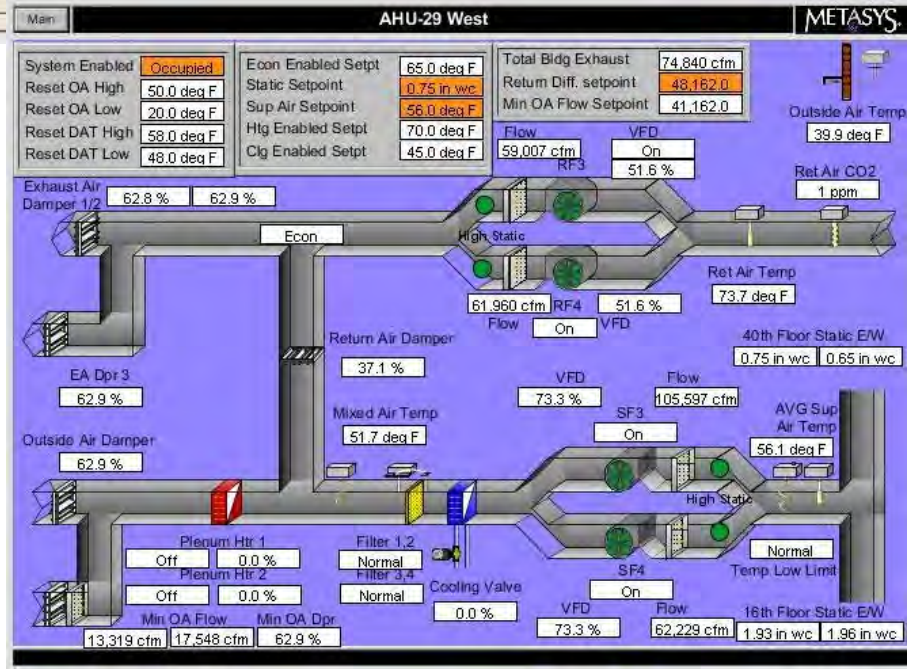


# Economizer Mode Operation

- Manipulate controls for economizer mode
- Verify operation in “Summer” and ‘Winter” modes

# Review BAS Graphics and Trends



# Review BAS Graphics and Trends

H17 =AVERAGEIFS(H$22:H$4069,$C$22:$C$4069,">= &$A17,$C$22:$C$4069,"<

| | A | B | C | D | G | H | I | J |
|---|---|---|---|---|---|---|---|---|
| 1 | OAT Low | OAT High | | | | | | |
| 8 | 55 | 60 | | 53.53 | 53.68 | 98.21 | 73.66 | 22.49 |
| 9 | 50 | 55 | | 53.42 | 51.83 | 87.07 | 73.50 | 22.11 |
| 10 | 45 | 50 | | 53.55 | 50.58 | 109.10 | 73.64 | 4.12 |
| 11 | 40 | 45 | | 54.50 | 50.21 | 94.66 | 73.28 | 0.22 |
| 12 | 35 | 40 | 0 | 53.92 | 49.63 | 101.67 | 73.29 | 0.02 |
| 13 | 30 | 35 | 0 | 55.53 | 51.33 | 102.17 | 73.20 | 0.02 |
| 14 | 25 | 30 | 0 | 54.91 | 51.03 | 99.11 | 73.42 | 0.33 |
| 15 | 20 | 25 | 0 | 57.17 | 52.98 | 101.98 | 73.55 | 0.03 |
| 16 | 15 | 20 | 0 | 58.04 | 55.01 | 116.96 | 73.35 | 0.03 |
| 17 | 10 | 15 | 0 | 57.94 | 55.03 | 121.43 | 72.92 | 0.00 |
| 18 | 5 | 10 | 0 | 59.14 | 55.91 | 112.07 | 72.81 | 0.00 |
| 20 | | | | | | | | |
| 21 | Time | | AHU-29WEST.OA-T.Trend - | AHU-29WEST.DAT- | AHU-29WEST.MAT.AHU- | AHU-29WEST.RAQ.AHU- | AHU-29WEST.RAT.AHU- | AHU-29WEST.CLGO.AHU29W- |
| 22 | 3/10/2014 | 17:00 | 59.87479 | 53.95472 | 54.59246 | 46.56632 | 73.71262 | 13.89576 |
| 23 | 3/10/2014 | 17:15 | 59.63162 | 53.95472 | 54.59873 | 8.356351 | 73.71262 | 14.13534 |
| 24 | 3/10/2014 | 16:45 | 59.41961 | 53.95472 | 54.77645 | 37.11998 | 73.71262 | 14.44498 |
| 25 | 3/10/2014 | 17:30 | 59.38989 | 53.95472 | 54.18458 | 439.9351 | 73.71262 | 13. |
| 26 | 3/10/2014 | 18:00 | 59.22658 | 52.68929 | 54.16907 | ??? -1.230601 | 73.71262 | 7.9 |
| 27 | 3/10/2014 | 17:45 | 59.09045 | 53.95472 | 53.96053 | 141.1717 | 73.71262 | 13. |
| 28 | 3/10/2014 | 16:30 | 58.73352 | 53.95472 | 55.19249 | 137.0294 | 73.71262 | 14. |
| 29 | 3/10/2014 | 16:15 | 58.04793 | 53.96951 | 55.19001 | 394.7258 | 73.71262 | 14. |
| 30 | 3/10/2014 | 18:30 | 58.01532 | 53.96206 | 54.14558 | 1.962824 | 73.71262 | 8.4 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 13 | 4 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 14 | 5 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 15 | 6 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 16 | 7 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 17 | Hrs per wk | 168 | | | | | | | |
| 18 | Total hrs selected | 8760 | | | | | | | |
| 19 | Total bin hrs | 8760 | | | | | | | |
| 20 | High bin temp. | 105 | | | | | | | |
| 21 | Bin increment | 5 | deg.DB | | | | | | |
| 22 | Max DB | 105 | 100 | 95 | 90 | 85 | 80 | 75 | 70 |
| 23 | Min DB | 100 | 95 | 90 | 85 | 80 | 75 | 70 | 65 |
| 24 | Avg bin DB | 102.5 | 97.5 | 92.5 | 87.5 | 82.5 | 77.5 | 72.5 | 67.5 |
| 25 | Count (hrs) | 0 | 1 | 26 | 160 | 428 | 531 | 538 | 767 |
| 26 | Count (hrs) - Low Rise AHUs only | 0 | 1 | 26 | 155 | 364 | 373 | 350 | 376 |
| 27 | Mean WBT | #DIV/0! | 77.4 | 77.7 | 72.3 | 69.2 | 66.9 | 65.0 | 62.0 |
| 28 | Max WBT | 0.0 | 77.4 | 80.4 | 79.6 | 79.0 | 76.8 | 73.9 | 70.0 |
| 29 | Mean Enth. | #DIV/0! | 41.2 | 41.6 | 36.6 | 33.8 | 32.0 | 30.5 | 28.2 |
| 30 | | | | | | | | | |
| 31 | | | | | | | | | |
| 32 | Total Unit CFM | AHU-29E, W | 650658 | 618125 | 585592 | 562819 | 540046 | 517273 | 494500 | 471727 |
| 33 | | AHU-3E, W | 129600 | 129600 | 129600 | 129600 | 129600 | 129600 | 129600 | 224656 |
| 34 | | AHU-3HC | 8400 | 8400 | 7560 | 7224 | 6888 | 6552 | 6216 | 5880 |
| 35 | | AHU-3CC | 4900 | 4900 | 4410 | 4209 | 4008 | 3807 | 3606 | 3406 |
| 36 | | | | | | | | | |
| 37 | | | | | | | | | |
| 38 | | | | | | | | | |
| 39 | | | | | | | | | |
| 40 | | | Current SP | | New Low Setpoint | | New High Setpoint | | |
| 41 | Unit Static Pressure | AHU-29E, W | 0.75 | "w.c. | 0.55 | "w.c. | 0.75 | "w.c. | |
| 42 | | AHU-3E, W | 0.75 | "w.c. | 0.55 | "w.c. | 0.75 | "w.c. | |
| 43 | | AHU-3HC | 1.50 | "w.c. | 1.00 | "w.c. | 1.50 | "w.c. | |
| 44 | | AHU-3CC | 1.75 | "w.c. | 1.00 | "w.c. | 1.75 | "w.c. | |
| 45 | | | | | | | | | |

# Questions?