Improving CO_2-DCV with Airflow Measurement

David S. Dougan, President

EBTRON®

Demand Control Ventilation

What is required to satisfy the requirements of ASHRAE Standard 62.1-2016 with dynamic reset?

ASHRAE 62.1-2016
Ventilation Rate Procedure (VRP)

6.2.7 Dynamic Reset. The system may be designed to reset the outdoor air intake flow (V_{ot}) and/or space or ventilation zone airflow (V_{oz}) as operating conditions change.

6.2.7.1 Demand Control Ventilation (DCV). DCV shall be permitted as an optional means of dynamic reset.

Exception: CO_2-based DCV shall not be applied in zones with indoor sources of CO_2 other than occupants or with CO_2 removal mechanisms such as gaseous air cleaners.

6.2.7.1.1 For DCV zones in the occupied mode, breathing zone outdoor airflow (V_{bz}) shall be reset in response to current population.

6.2.7.1.2 For DCV zones in the occupied mode, breathing zone outdoor airflow (V_{bz}) shall be not less than the building component ($R_a \times A_z$) for the zone.

ASHRAE 62.1-2016
Ventilation Rate Procedure (VRP)

6.2.2.1 Breathing Zone Outdoor Airflow. The outdoor airflow required in the breathing zone of the occupiable space or spaces in a *ventilation zone*, i.e., the breathing zone outdoor airflow (V_{bz}), shall be no less than the value determined in accordance with Equation 6.2.2.1.

$$V_{bz} = R_p \cdot P_z + R_a \cdot A_z \qquad (6.2.2.1)$$

where

R_p = outdoor airflow rate required per person from Table 6.2.2.1

P_z = the number of people in the ventilation zone during typical usage

R_a = outdoor airflow rate required per floor area from Table 6.2.2.1

A_z = zone floor area

ASHRAE 62.1-2016

Ventilation Rate Procedure (VRP)

6.2.2.1 Breathing Zone Outdoor Airflow. The outdoor airflow required in the breathing zone of the occupiable space or spaces in a *ventilation zone*, i.e., the breathing zone outdoor airflow (V_{bz}), shall be no less than the value determined in accordance with Equation 6.2.2.1.

$$V_{bz} = R_p \cdot P_z + R_a \cdot A_z \qquad (6.2.2.1)$$

where

R_p = outdoor airflow rate required per person from Table 6.2.2.1

P_z = the CURRENT population of the ventilation zone (as per 6.2.7.1.1)

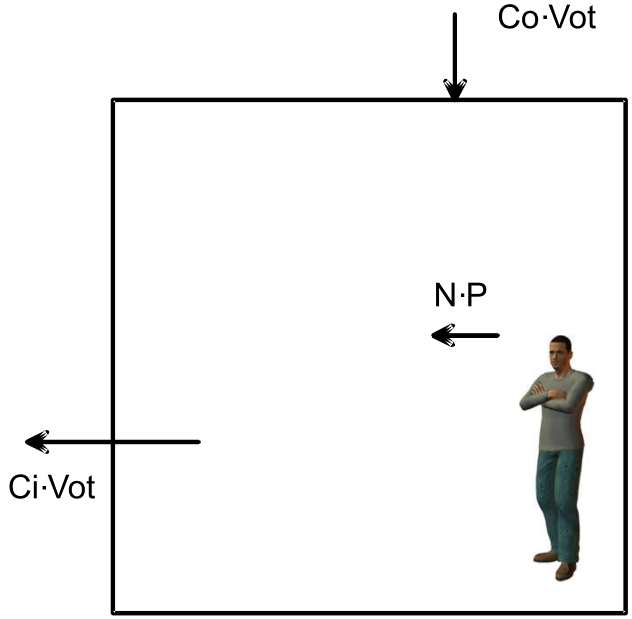
R_a = outdoor airflow rate required per floor area from Table 6.2.2.1

A_z = zone floor area

What about CO_2-DCV

Does CO_2-DCV satisfy the requirements of ASHRAE Standard 62.1-2016?

CO_2 and Ventilation



Co = Outdoor CO_2 concentration (ft^3 CO_2/ft^3 air)
Ci = Indoor CO_2 concentration (ft^3 CO_2/ft^3 air)
Vot = Outside Airflow Rate (ft^3/min)
Vo=Outside Airflow Rate/Person ((ft^3/min)/person
N = CO_2 production of occupant (ft^3 CO_2/min)
P = Number of occupants

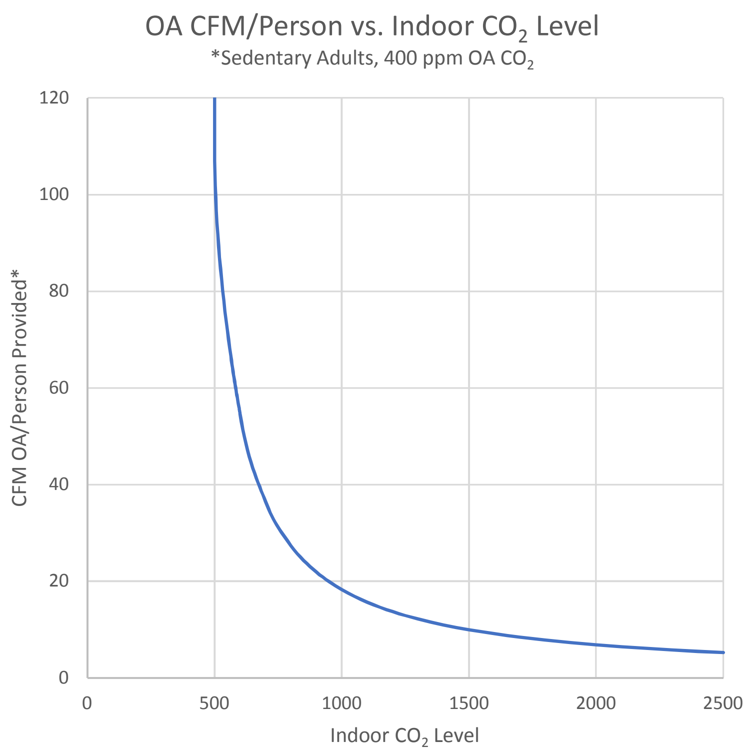
Steady-state Mass Balance: In = Out

Co·Vot + N·P = Ci·Vot

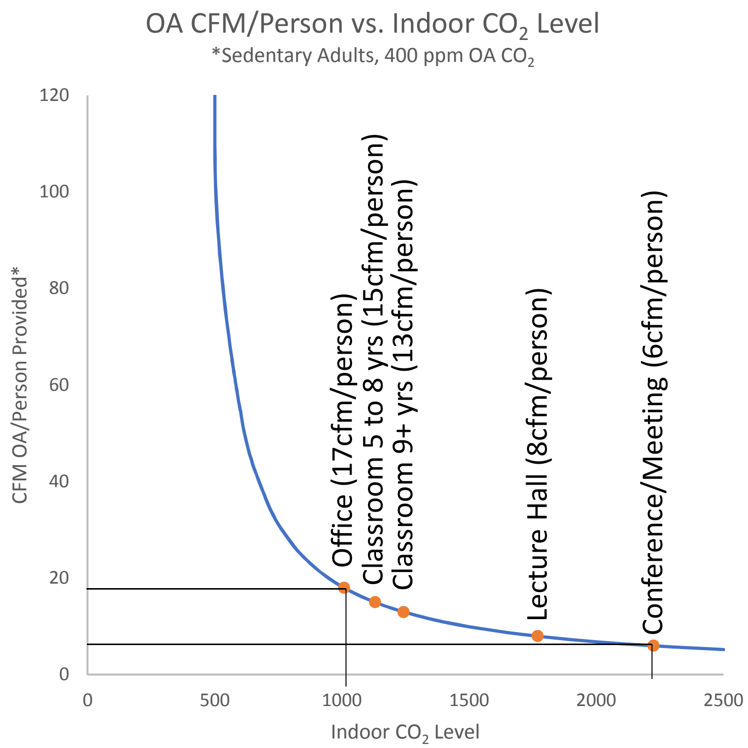
Can be rearranged as:

N / (Ci – Co) = Vot/P = Vo = **OA CFM/person**

Relationship between the indoor CO_2 level and OA Ventilation

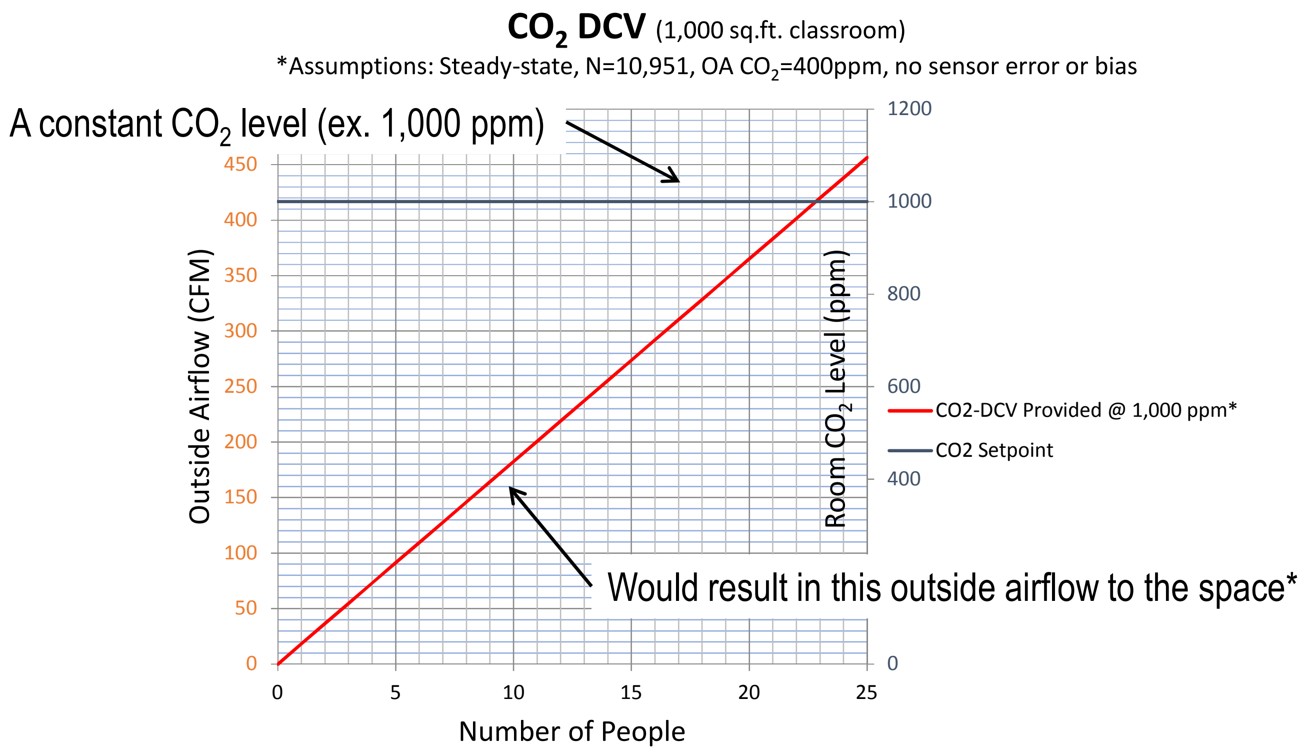


CO_2 and Ventilation are Codependent

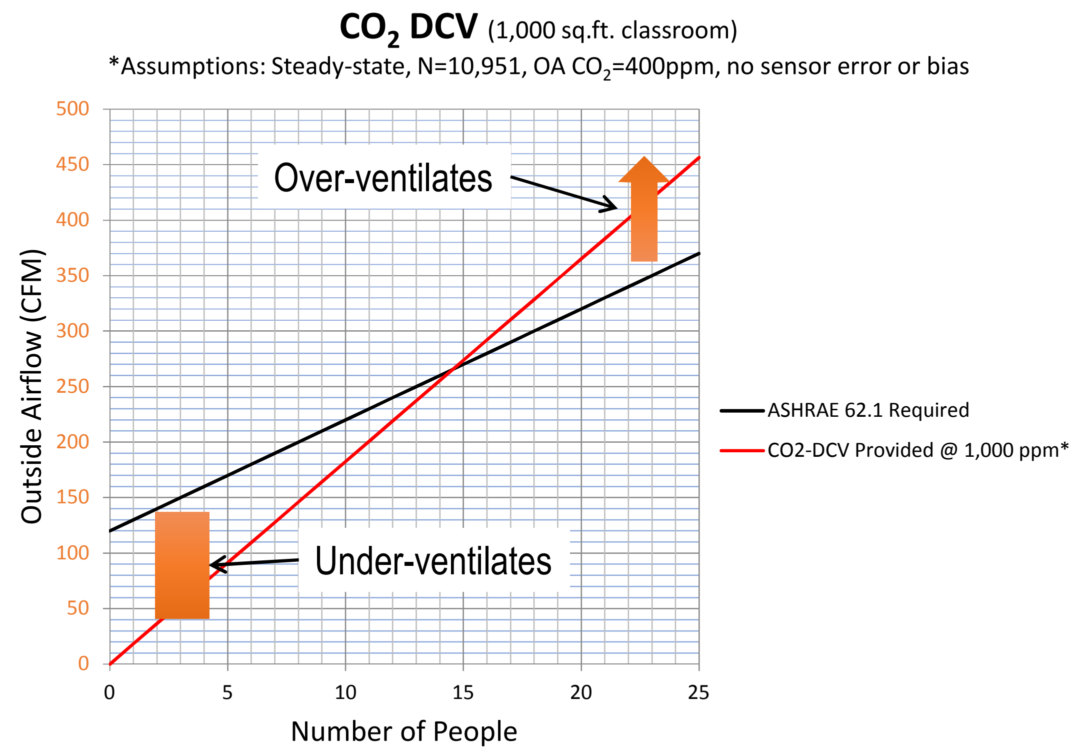


Operate: 18 CFM/person

Design: 6 CFM/person



CO2 DCV (1,000 sq.ft. classroom)
*Assumptions: Steady-state, N=10,951, OA CO2=400ppm, no sensor error or bias
A constant CO2 level (ex. 1,000 ppm)
Would result in this outside airflow to the space*
Outside Airflow (CFM)
Room CO2 Level (ppm)
Number of People
0
50
100
150
200
250
300
350
400
450
0
400
600
800
1000
1200
0
5
10
15
20
25
CO2-DCV Provided @ 1,000 ppm*
CO2 Setpoint



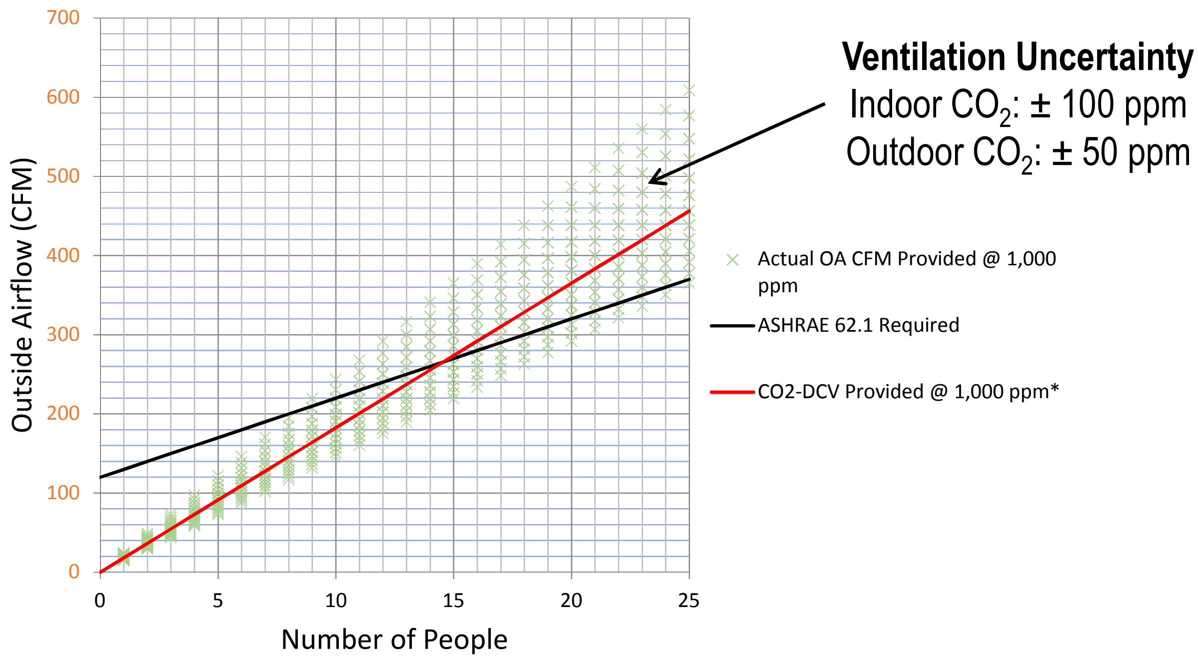
CO2 DCV (1,000 sq.ft. classroom)
*Assumptions: Steady-state, N=10,951, OA CO2=400ppm, no sensor error or bias
Over-ventilates
Under-ventilates
Outside Airflow (CFM)
Number of People
0
50
100
150
200
250
300
350
400
450
500
0
5
10
15
20
25
ASHRAE 62.1 Required
CO2-DCV Provided @ 1,000 ppm*

CO_2-DCV

How does indoor/outdoor CO_2 uncertainty affect the ventilation provided by CO_2-DCV?

CO_2 DCV (1,000 sq.ft. classroom)

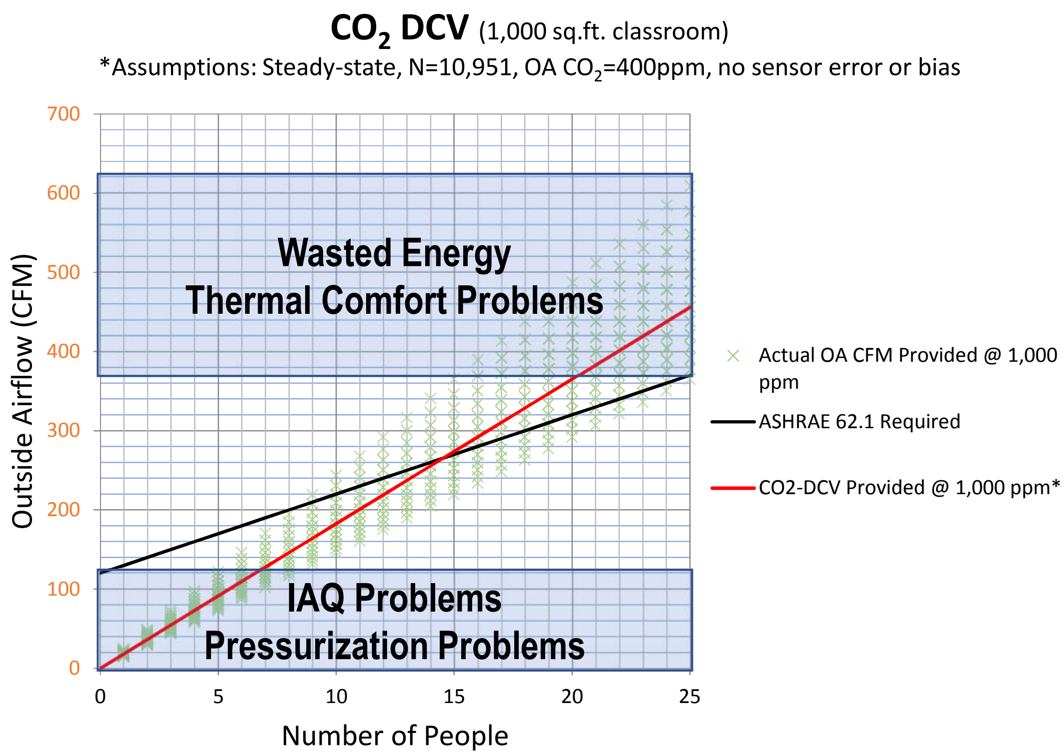
*Assumptions: Steady-state, N=10,951, OA CO_2=400ppm, no sensor error or bias

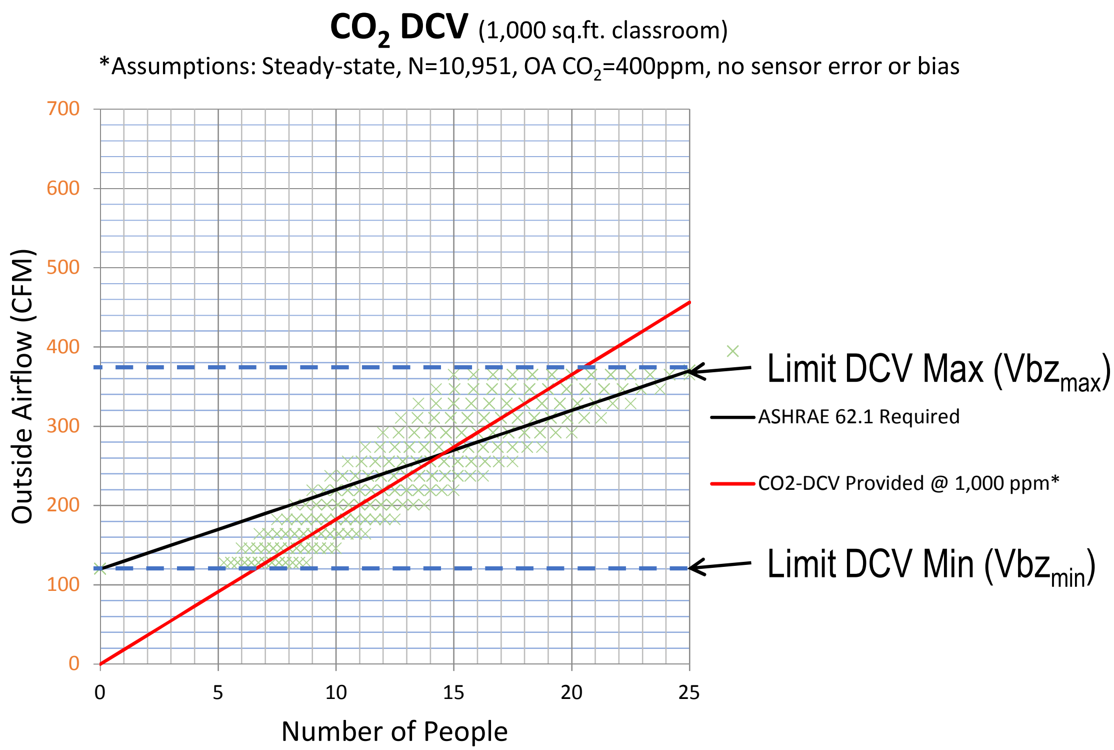


Improved CO_2-DCV

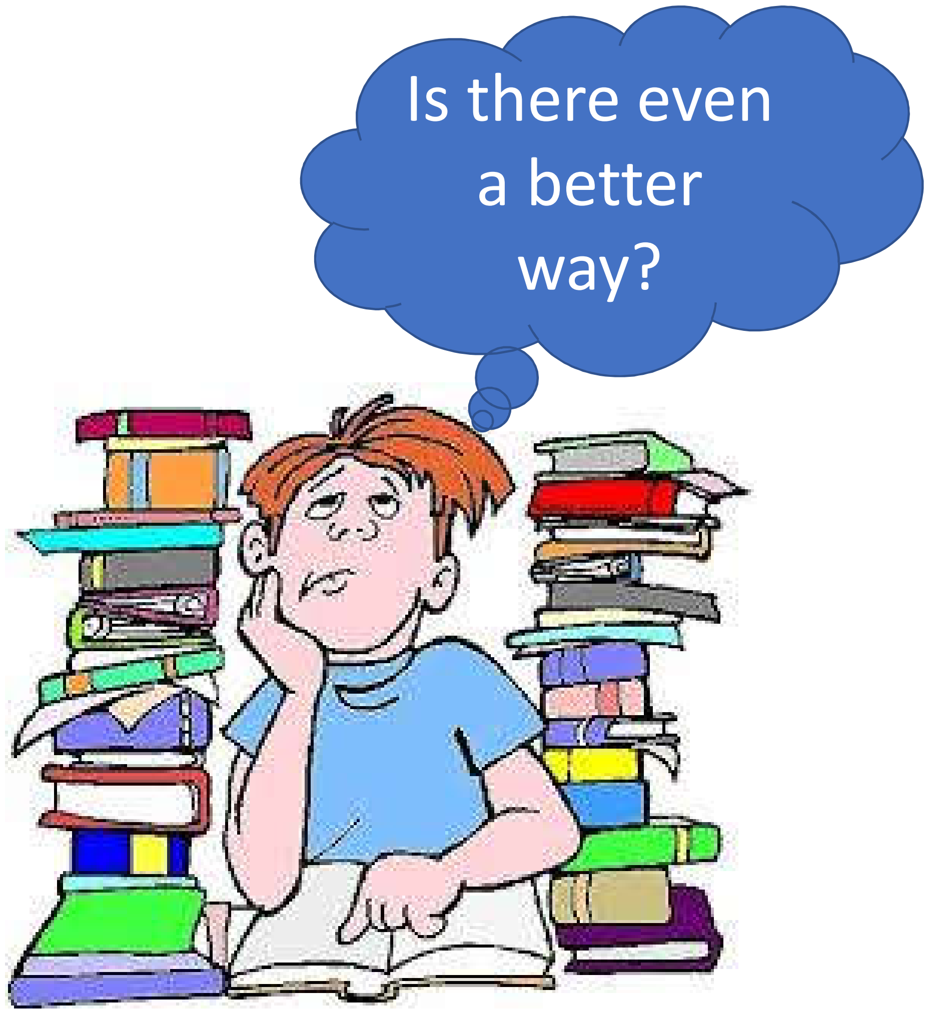
Can I improve traditional CO_2-DCV performance?

Address Fixed Damper Error

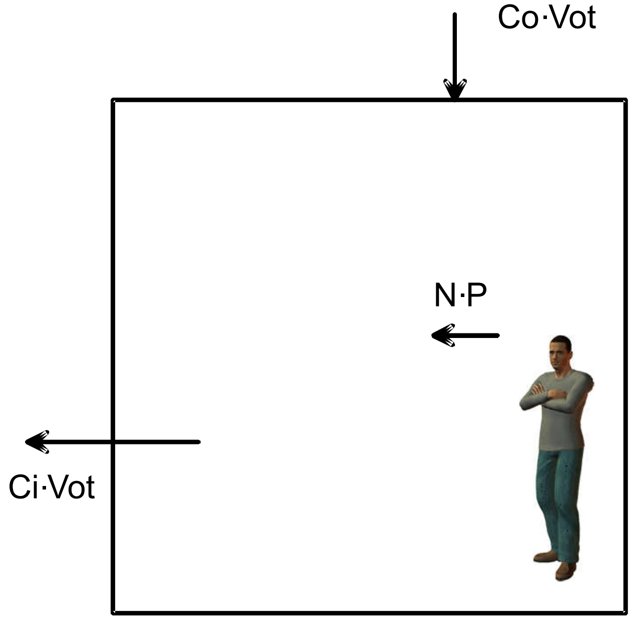




CO_2 DCV (1,000 sq.ft. classroom)
*Assumptions: Steady-state, N=10,951, OA CO_2=400ppm, no sensor error or bias
Outside Airflow (CFM)
700
600
500
400
300
200
100
0
0
5
10
15
20
25
Number of People
Limit DCV Max (Vbz_{max})
ASHRAE 62.1 Required
CO2-DCV Provided @ 1,000 ppm*
Limit DCV Min (Vbz_{min})


Is there even a better way?

CO_2 and Ventilation



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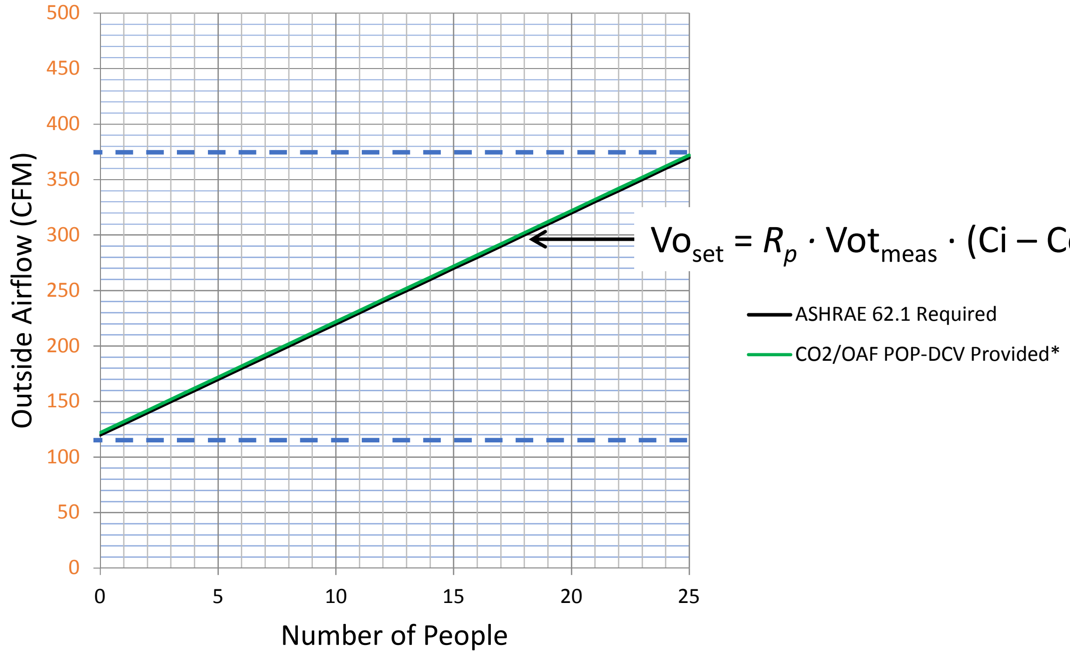
Ci = Indoor CO_2 concentration (ft^3 CO_2/ft^3 air)
Vot = Outside Airflow Rate (ft^3/min)
Vo=Outside Airflow Rate/Person ((ft^3/min)/person
N = CO_2 production of occupant (ft^3 CO_2/min)
P = Number of occupants

Steady-state Mass Balance: In = Out
Co·Vot + N·P = Ci·Vot

Can be rearranged as:
Vot·(Ci-Co) / N = **P = People!**

CO_2 / Airflow DCV (1,000 sq.ft. classroom)

*Assumptions: Steady-state, N=10,951, OA CO_2=400ppm, no sensor error or bias



$$Vo_{set} = R_p \cdot Vot_{meas} \cdot (Ci - Co)/ N + R_a \cdot A_z$$

CO_2 / Airflow DCV (1,000 sq.ft. classroom)

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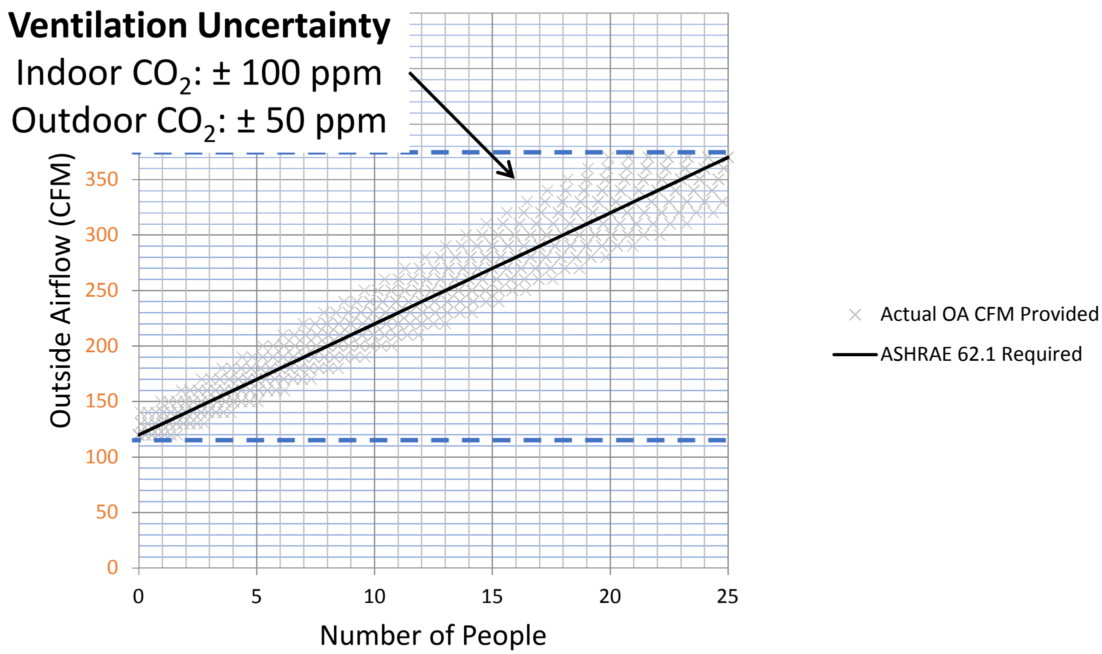

The bottom line on CO_2-DCV…

- Can over- and under-ventilate for a given population.
- May not meet the requirements of ASHRAE 62.1.
- Can be **improved** by limiting min and max ventilation limits using direct outdoor airflow measurement.
- Can **estimate the population** using airflow measurement.

Thank You!

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