

Ventilation for Acceptable Indoor Air Quality

Part 3 - Recognizing the Pitfalls of CO₂ Ventilation Control

David S. Dougan, President



Loris, South Carolina



TECHNICAL AIR SYSTEMS, INC.
A Comfortable Choice



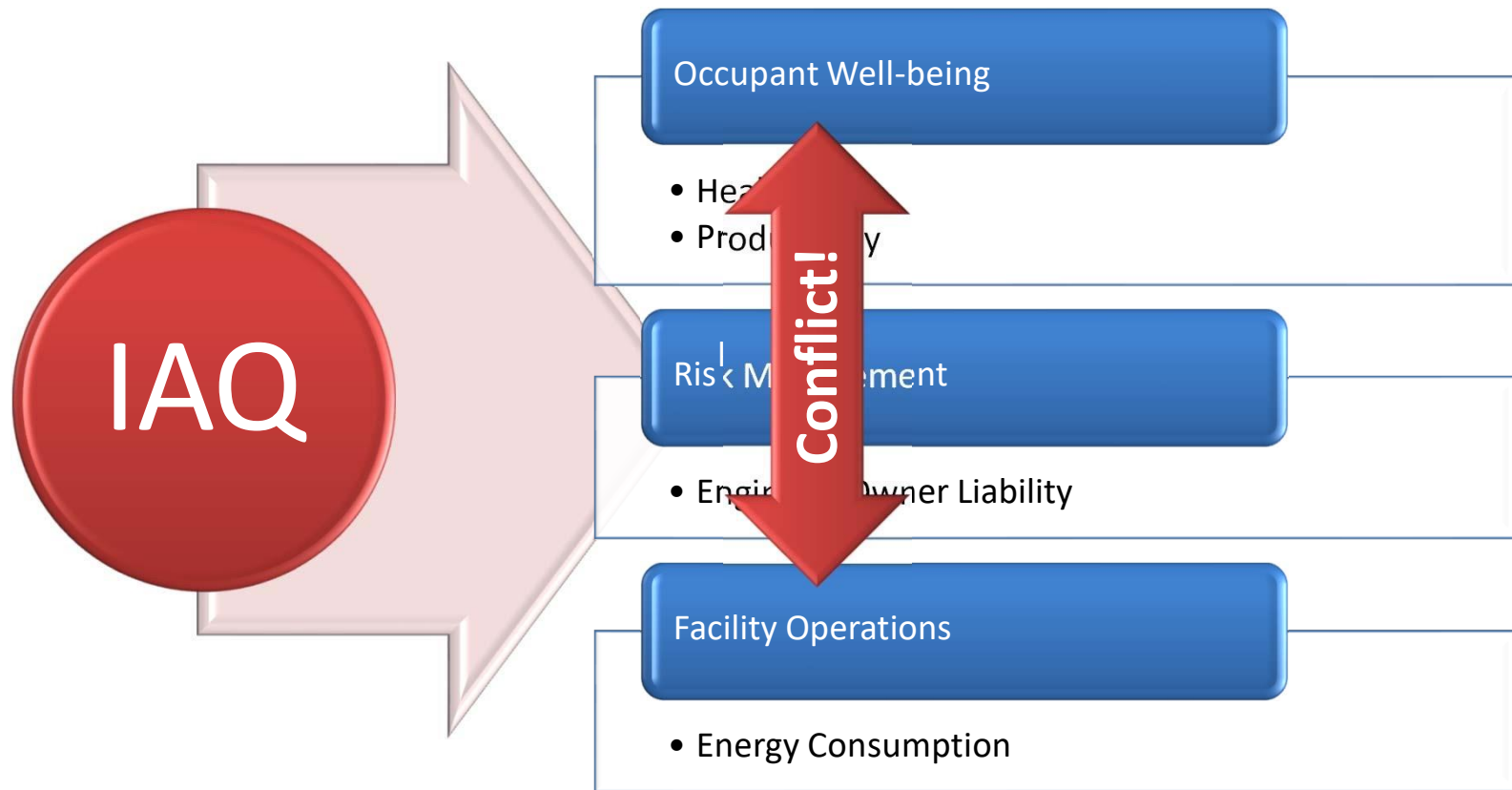


EBTRON®

TECHNICAL AIR SYSTEMS, INC.
A Comfortable Choice



Indoor Air Quality Affects ...



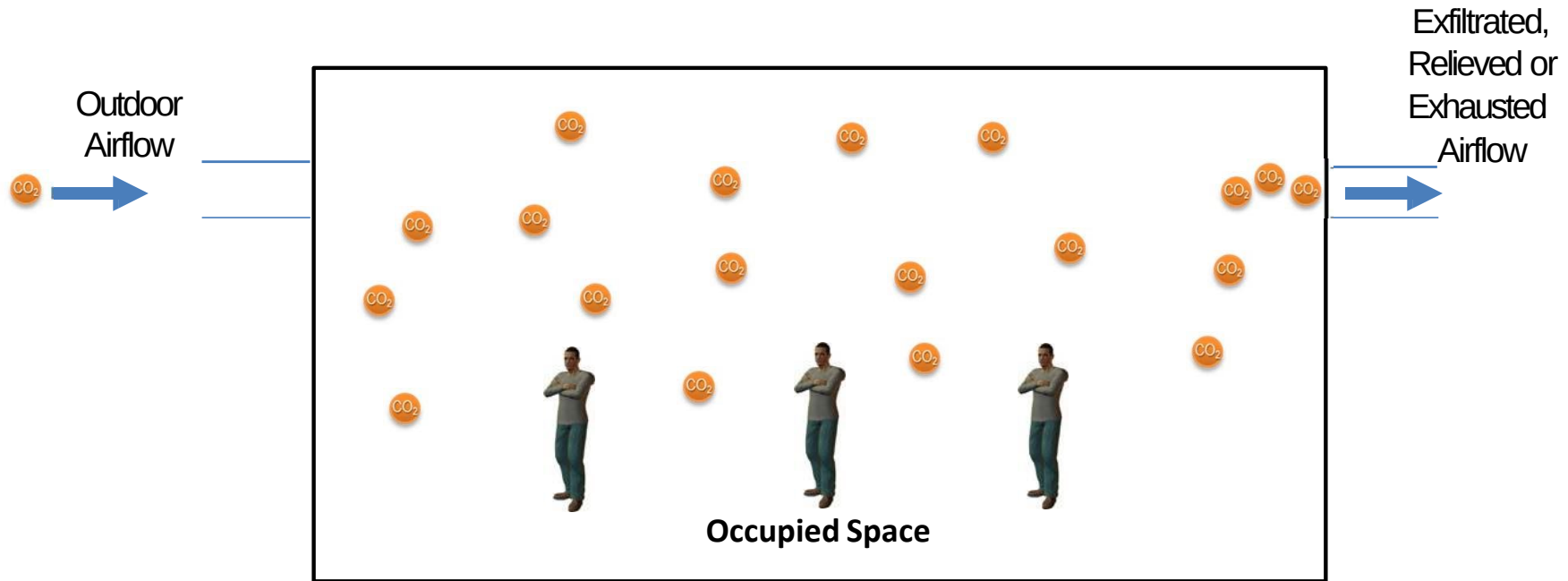
EBTRON

TECHNICAL AIR SYSTEMS, INC.
A Comfortable Choice



CO₂ and Ventilation - @ Steady State

Constant Outdoor Air Dilution Rate, Fixed Population

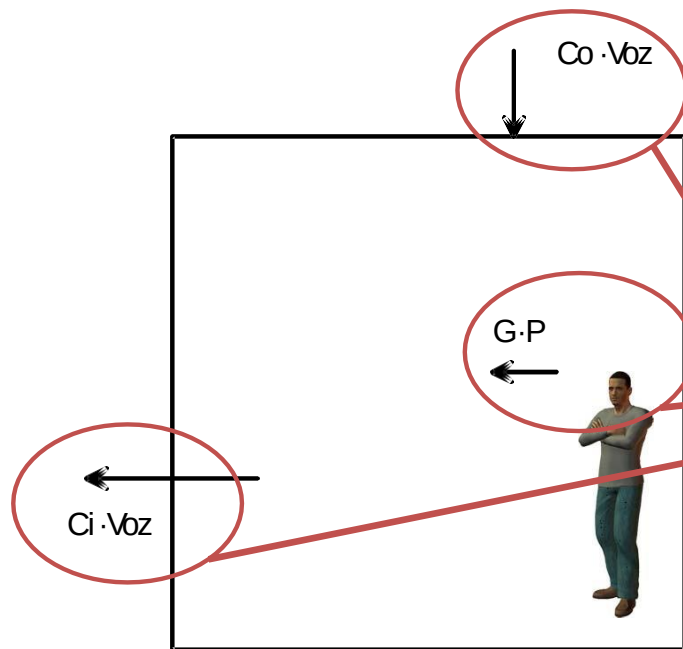


EBTRON[®]

TECHNICAL AIR SYSTEMS, INC.
A Comfortable Choice



CO₂ and Ventilation



C_o = Outdoor CO₂ concentration (ft³ CO₂/ft³ air)

C_i = Indoor CO₂ concentration (ft³ CO₂/ft³ air)

$V_{oz} = Q_{OA}$ = Outside Airflow Rate (ft³air/min)

V_o = Outside Airflow Rate/Person ((ft³air/min)/person)

G = CO₂ generation rate of the occupant (ft³ CO₂/min)

P = Number of occupants

Steady-state Mass Balance: In = Out

$$C_o \cdot V_{oz} + G \cdot P = C_i \cdot V_{oz}$$

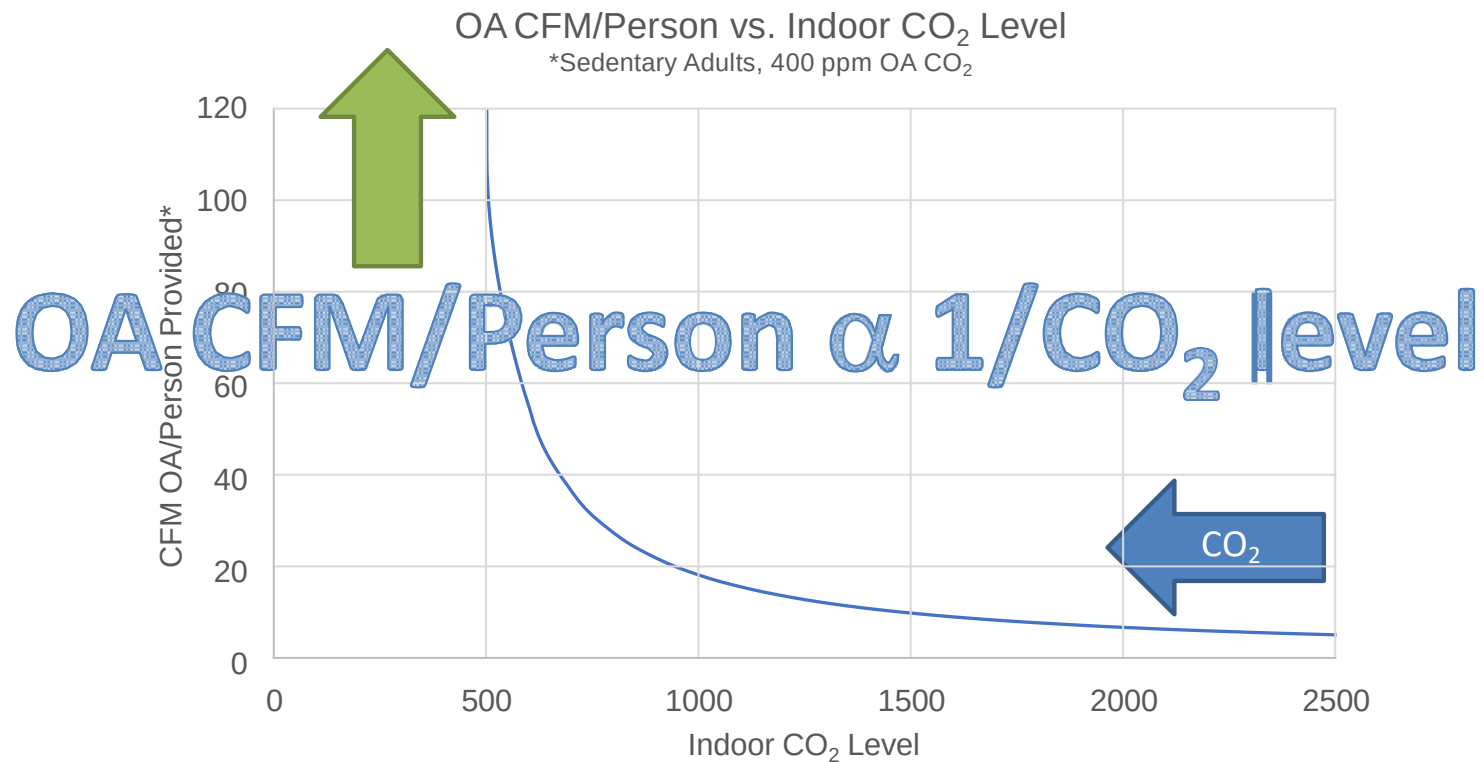
Can be rearranged as:

$$G / (C_i - C_o) = V_{oz} / P = V_o = \text{OA CFM/person}$$

EBTRON

TECHNICAL AIR SYSTEMS, INC.
A Comfortable Choice

CO₂ and Ventilation are Codependent



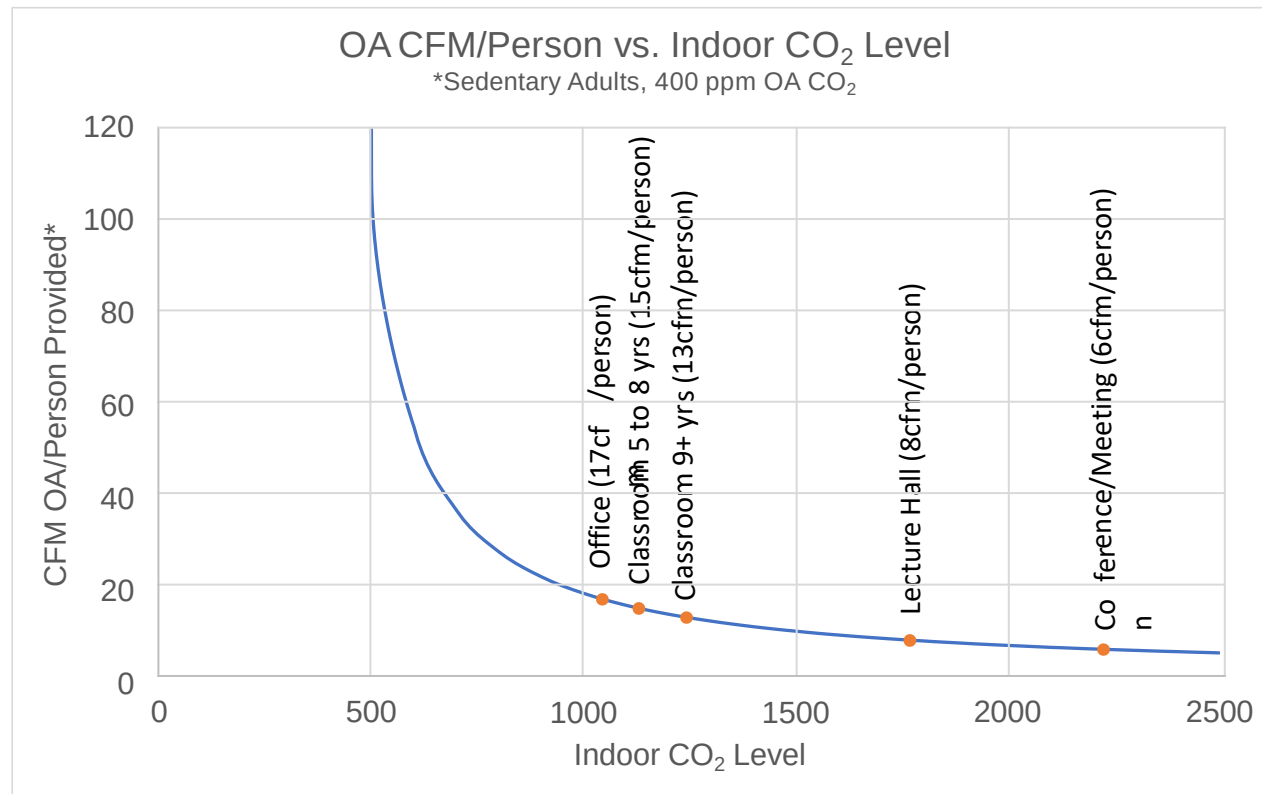
Note: G=0.0100 ft³ CO₂/min based on average male 20 to 60 years old @1.3 M (addendum ab)

EBTRON

TECHNICAL AIR SYSTEMS, INC.
A Comfortable Choice



CO₂ Levels and the IMC/ASHRAE 62.1



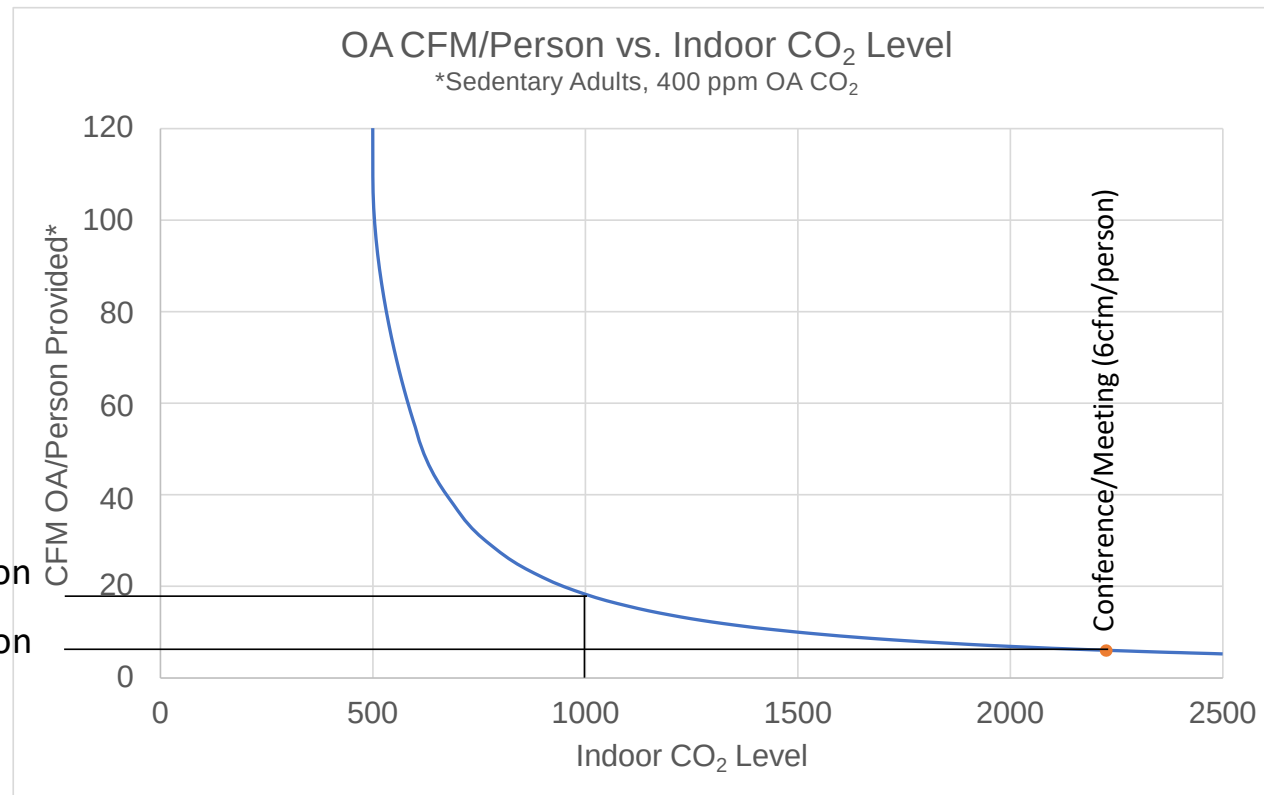
Note: G=0.0100 ft³ CO₂/min based on average male 20 to 60 years old @1.3 M (addendum ab)



TECHNICAL AIR SYSTEMS, INC.
A Comfortable Choice



Design to 62.1/IMC – Operate @ 1,000 ppm



Operate: $\approx$ 17 CFM/person

Design: 6 CFM/person

EBTRON

TECHNICAL AIR SYSTEMS, INC.
A Comfortable Choice



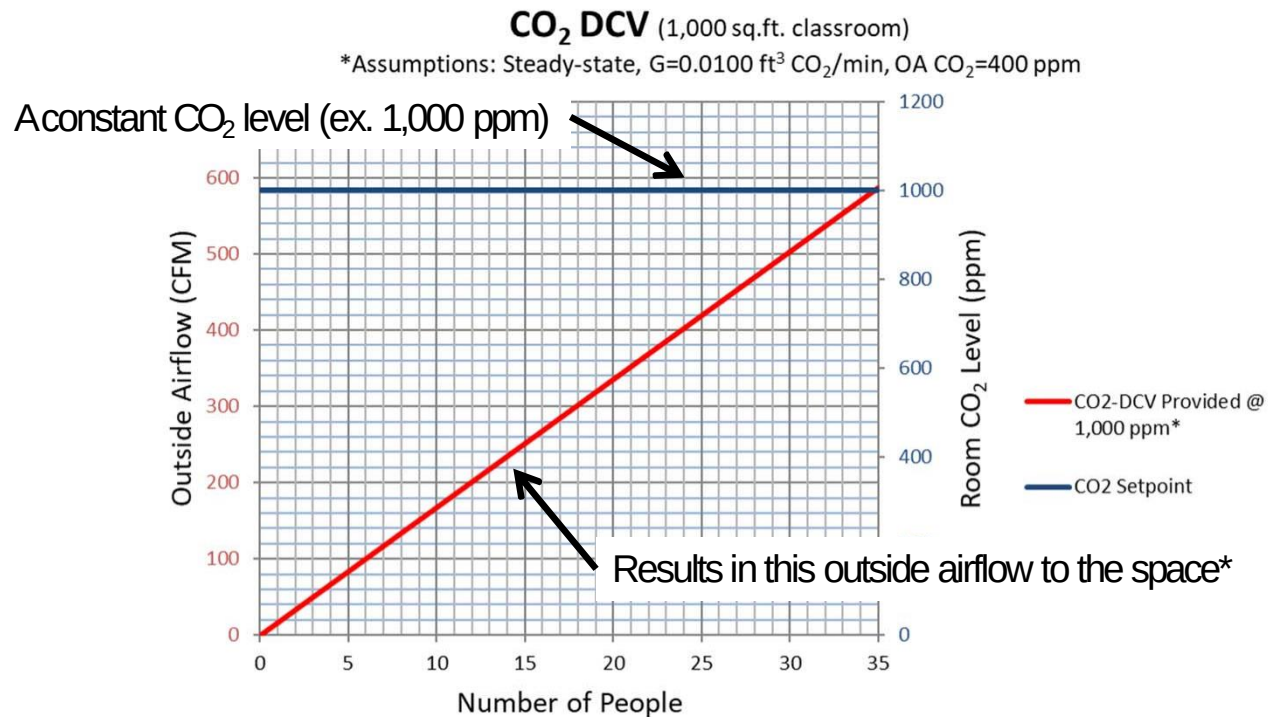


EBTRON[®]

TECHNICAL AIR SYSTEMS, INC.
A Comfortable Choice



Fixed Setpoint CO₂-DCV



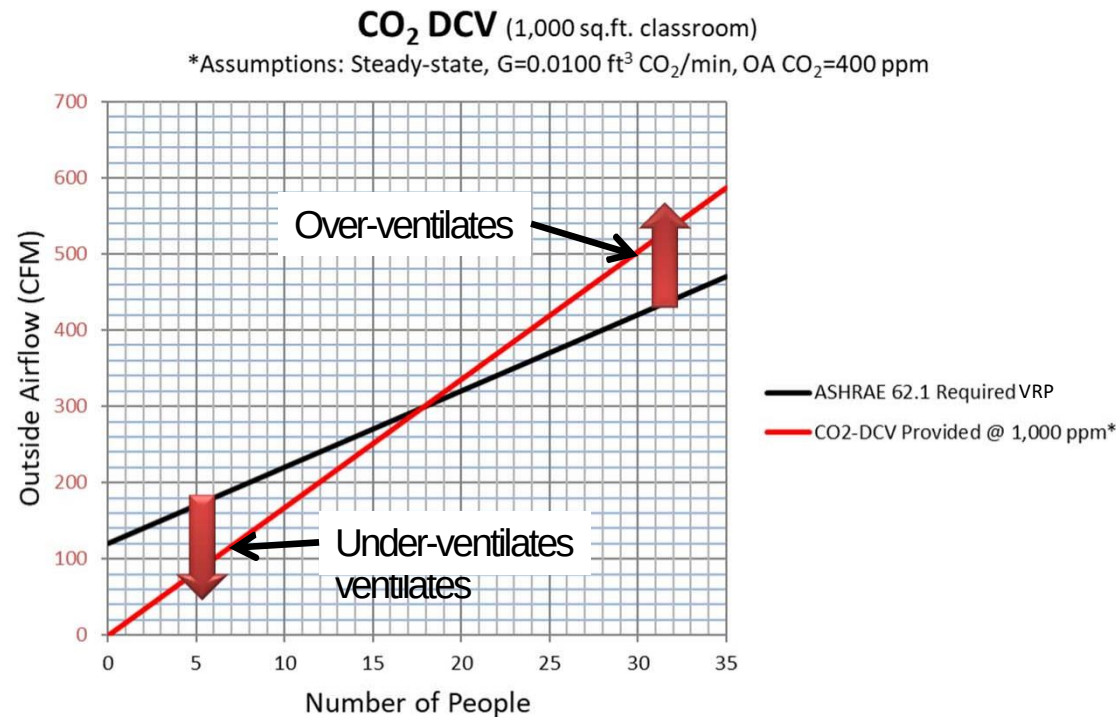
Note: $G=0.0100 \text{ ft}^3 \text{ CO}_2/\text{min}$ based on average male 20 to 60 years old @1.3 M (addendum ab)

EBTRON

TECHNICAL AIR SYSTEMS, INC.
A Comfortable Choice



Fixed Setpoint CO₂-DCV vs. ASHRAE 62.1



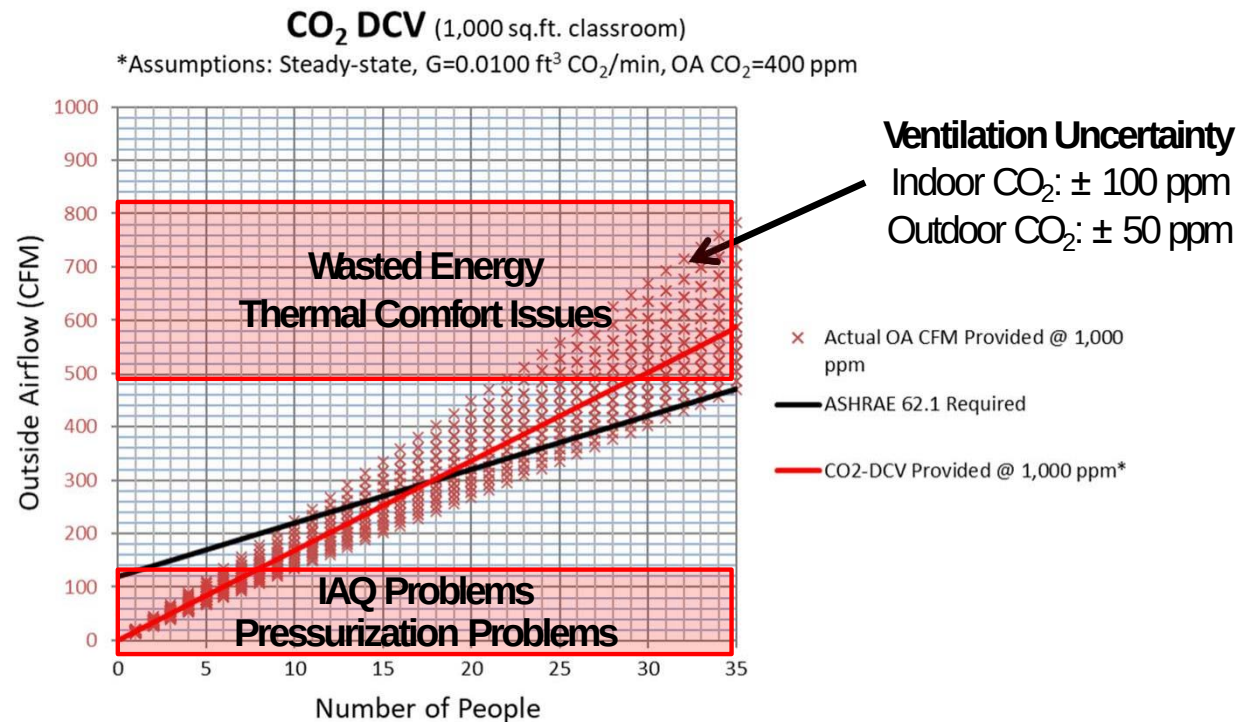
Note: $G=0.0100 \text{ ft}^3 \text{ CO}_2/\text{min}$ based on average male 20 to 60 years old @1.3 M (addendum ab)

EBTRON

TECHNICAL AIR SYSTEMS, INC.
A Comfortable Choice



CO₂-DCV Ventilation Uncertainty



Note: G=0.0100 ft³ CO₂/min based on average male 20 to 60 years old @1.3 M (addendum ab)

Age vs. CO₂ Generation Rates and Corresponding OA CFM for Ci-Co=600 ppm

Normative Appendix D Calculations (Addendum ab)										
Age	Sex	RQ Assumed	BMR Calc. Coef. Table D1.2.2.		Mass (kg) Table D1.2.3.	BMR eq. D1.2.6.1.	M Table 1.2.4.1.	G= RQ·BMR·M·k L/S CFM		OA CFM @Ci-Co=600
5	M	0.85	0.095	2.110	18.6	3.877	1.3	0.0024	0.0052	8.6
10	M	0.85	0.095	2.110	31.8	5.131	1.3	0.0032	0.0068	11.4
15	M	0.85	0.074	2.754	56.8	6.957	1.3	0.0044	0.0093	15.4
20	M	0.85	0.063	2.896	71.6	7.407	1.3	0.0047	0.0099	16.4
30	M	0.85	0.048	3.653	78.4	7.416	1.3	0.0047	0.0099	16.5
40	M	0.85	0.048	3.653	83.6	7.666	1.3	0.0048	0.0102	17.0
50	M	0.85	0.048	3.653	83.4	7.656	1.3	0.0048	0.0102	17.0
60	M	0.85	0.048	3.653	82.6	7.618	1.3	0.0048	0.0101	16.9
Avg. 20 to 60	M							0.0047	0.0101	16.8

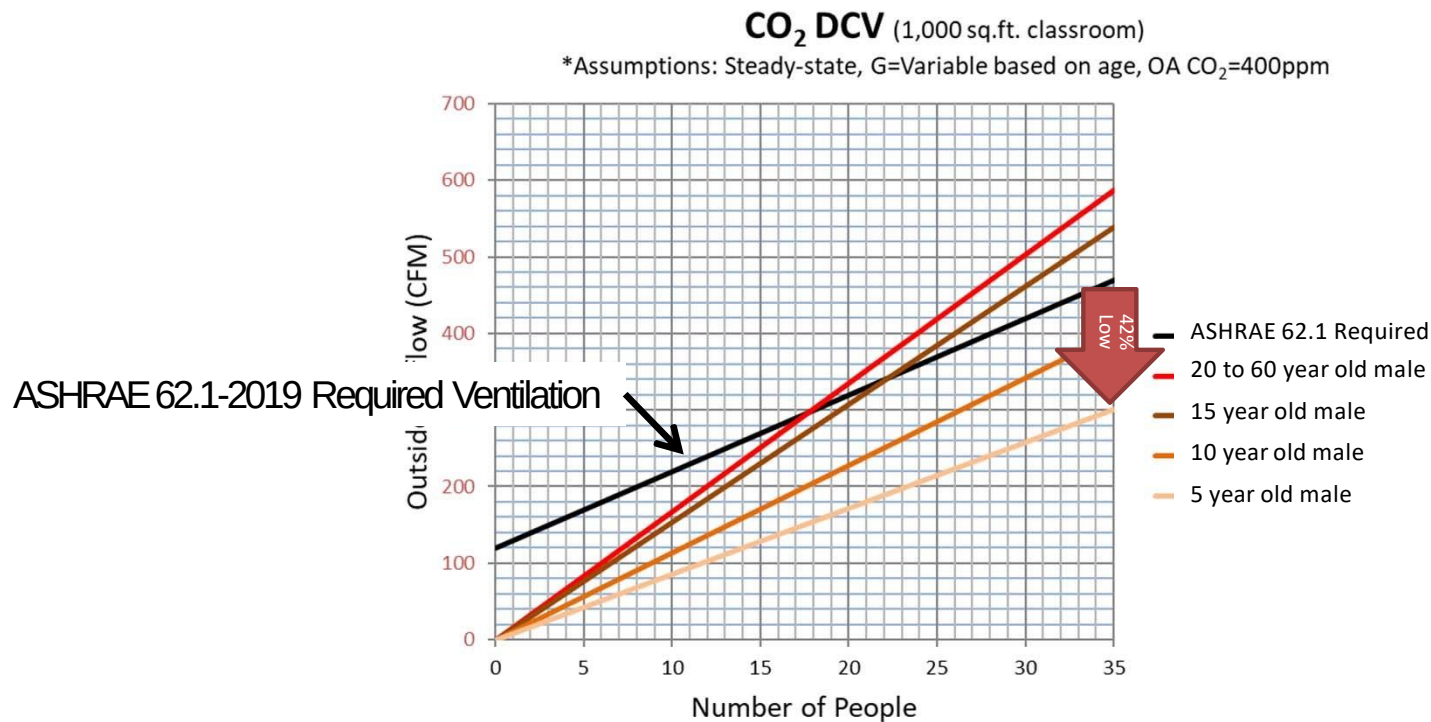
Source: ASHRAE 62.1 Normative Appendix D (proposed addendum ab)



TECHNICAL AIR SYSTEMS, INC.
A Comfortable Choice



Fixed Setpoint CO₂-DCV and Occupant Age



Note: G based on various age males @1.3 M (addendum ab)



Activity vs. OA CFM/person

Table 1.2.4.1. *M* values for various activities ⁵

Activity	Males		Females	
	Average <i>M</i>	<i>M</i> Range	Average <i>M</i>	<i>M</i> Range
Aerobic dancing – low intensity	3.51		4.24	
Aerobic dancing – high intensity	7.93		8.31	
Calisthenics	5.44			
Child care (unspecified)			2.5	
Climbing stairs	5.0			
Dancing	5.0		5.09	
Eating and drinking	1.4		1.6	
Housework (unspecified)			2.8	2.5 to 3.0
Office worker – Filing	1.3		1.5	
Office worker – Reading	1.3		1.5	
Office worker – Sitting at desk	1.3			
Office worker – Standing/moving around	1.6			
Office worker – Typing	1.8		1.8	
Office worker – Writing	1.4		1.4	
Reading	1.22		1.25	
Sleeping	1.0		1.0	
Sitting quietly	1.2		1.2	
Sitting on a bus/train	1.2			
Standing	1.4		1.5	
Walking around/strolling	2.1	2.0 to 2.2	2.5	2.1 to 2.9
Walking quickly	3.8			
Walking slowly	2.8	2.8 to 3.0	3.0	

Table 1.2.4.2. Values of physical activity levels (*M*) ⁴

Activity	<i>M</i>	Range
Calisthenics – light effort	2.8	
Calisthenics – moderate effort	2.8	
Calisthenics – vigorous effort	8.0	
Child care		2.0 to 3.0
Cleaning, sweeping – moderate effort	3.8	
Custodial work – light	2.3	
Dancing – aerobic, general	7.3	
Dancing – general	7.8	
Health club exercise classes – general	5.0	
Kitchen activity – moderate effort	3.3	
Lying or sitting quietly		1.0 to 1.3
Sitting reading, writing, typing	1.3	
Sitting at sporting event as spectator	1.5	
Sitting tasks, light effort (e.g. office work)	1.5	
Sitting quietly in religious service	1.3	
Sleeping	0.95	
Standing quietly	1.3	
Standing tasks, light effort (e.g. store clerk, filing)	3.0	
Walking, less than 2 mph, level surface, very slow	2.0	
Walking, 2.8 mph to 3.2 mph, level surface, moderate pace	3.5	

> 6X

$$G / (C_i - C_o) = V_o = \text{OA CFM/person}$$

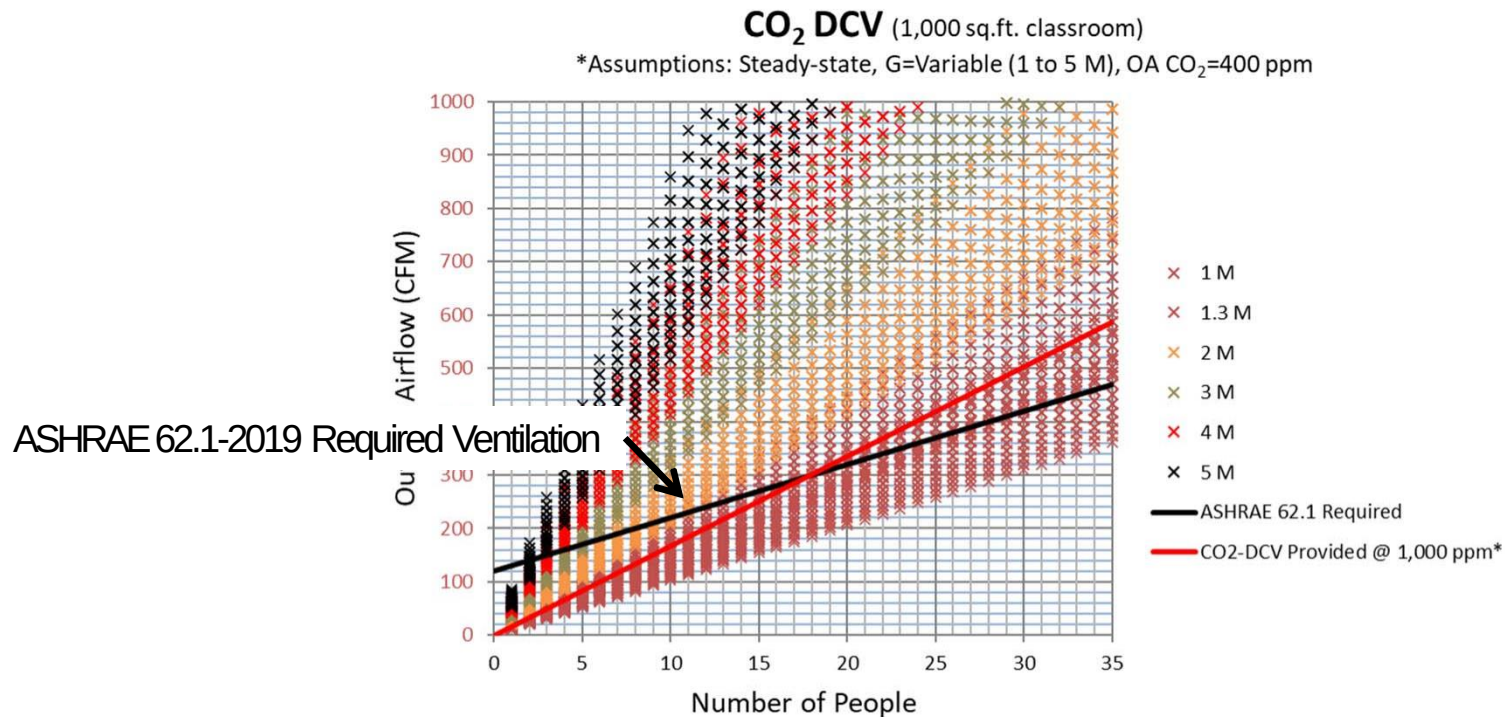
$$M \propto G \propto \text{OA CFM/person!}$$

EBTRON

TECHNICAL AIR SYSTEMS, INC.
A Comfortable Choice



Activity Level Adds More Uncertainty



Note: G based on average male 20 to 60 years old (addendum ab)



Fixed Setpoint CO₂-DCV vs. ASHRAE 62.1



EBTRON[®]

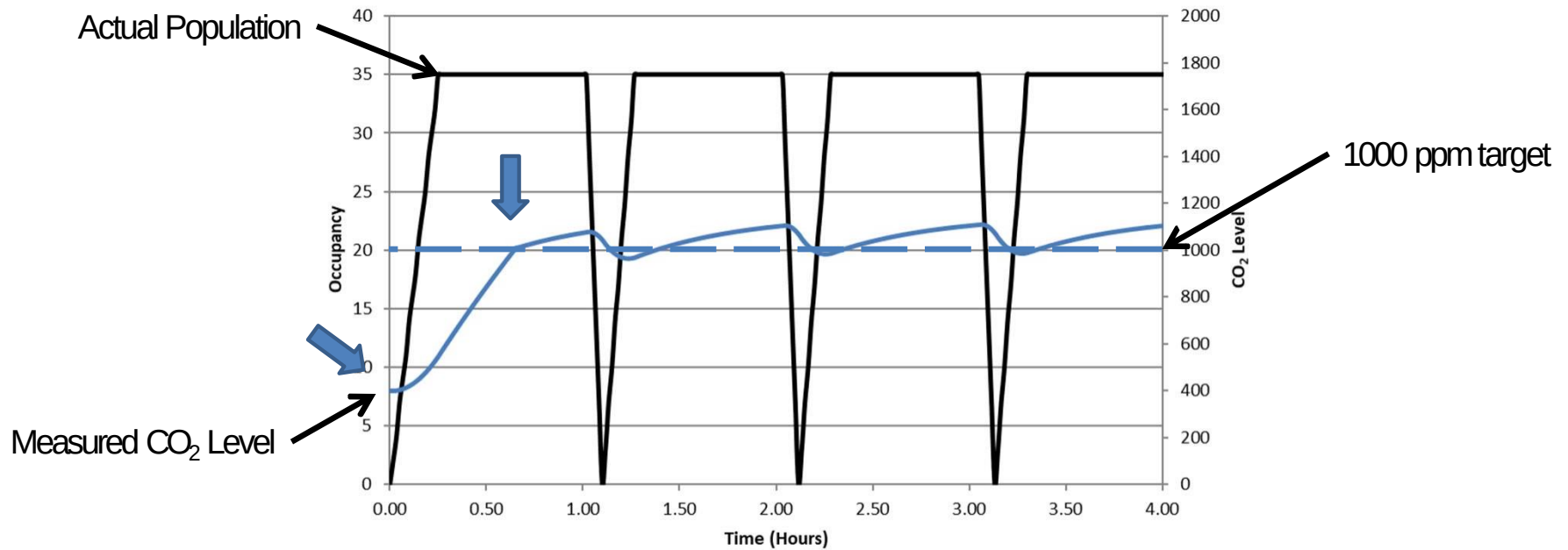
TECHNICAL AIR SYSTEMS, INC.
A Comfortable Choice



Good or Bad IAQ?

2-POS CO₂-DCV LAG (1,000 sq.ft. classroom)

Az=1,000 sq ft, Design Occupancy=35, Actual Occupancy = 35
45 minute classes, 15 minutes between periods



EBTRON

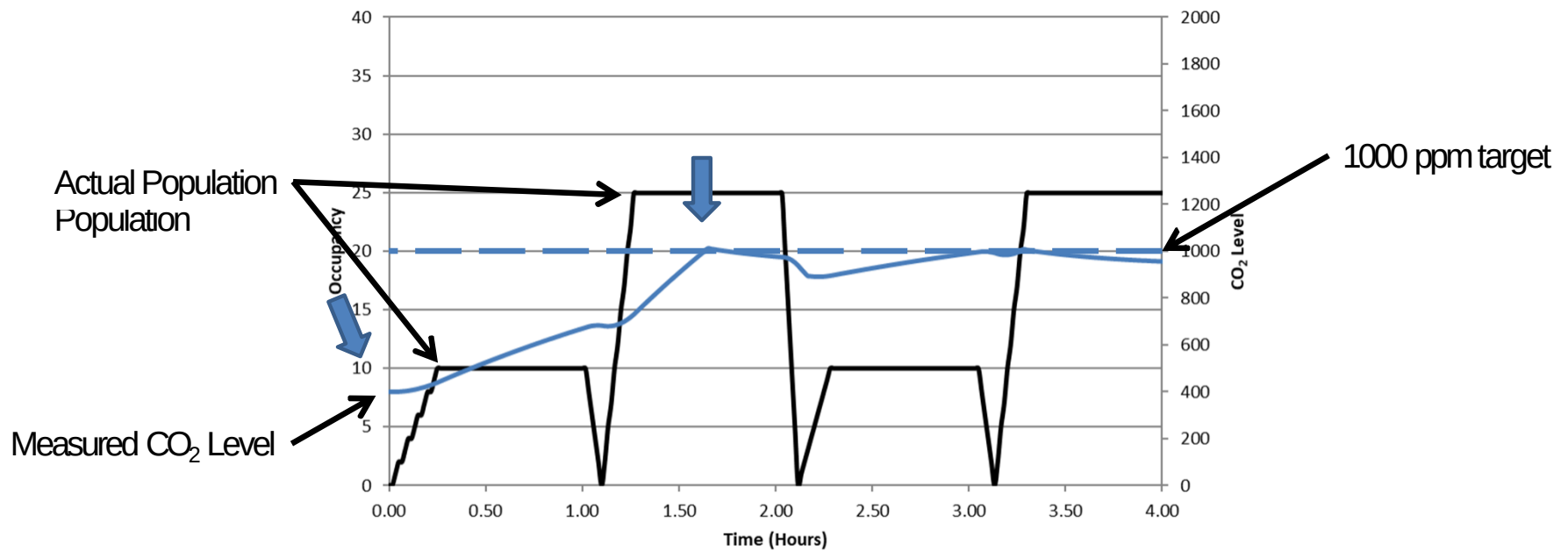
TECHNICAL AIR SYSTEMS, INC.
A Comfortable Choice



Better or Worse?

2-POS CO₂-DCV LAG (1,000 sq.ft. classroom)

Az=1,000 sq ft, Design Occupancy=35, Actual Occupancy = 10 to 25
45 minute classes, 15 minutes between periods



EBTRON

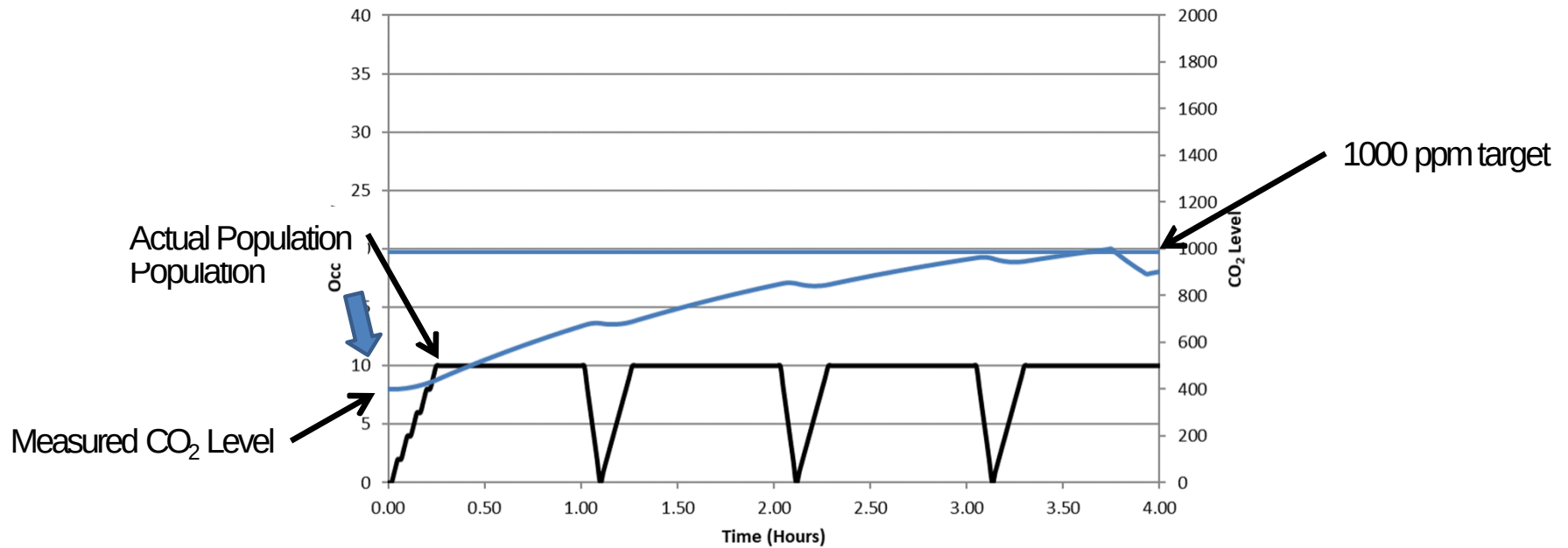
TECHNICAL AIR SYSTEMS, INC.
A Comfortable Choice



Best or Worst?

2-POS CO₂-DCV LAG (1,000 sq.ft. classroom)

Az=1,000 sq ft, Design Occupancy=35, Actual Occupancy = 10
45 minute classes, 15 minutes between periods



EBTRON

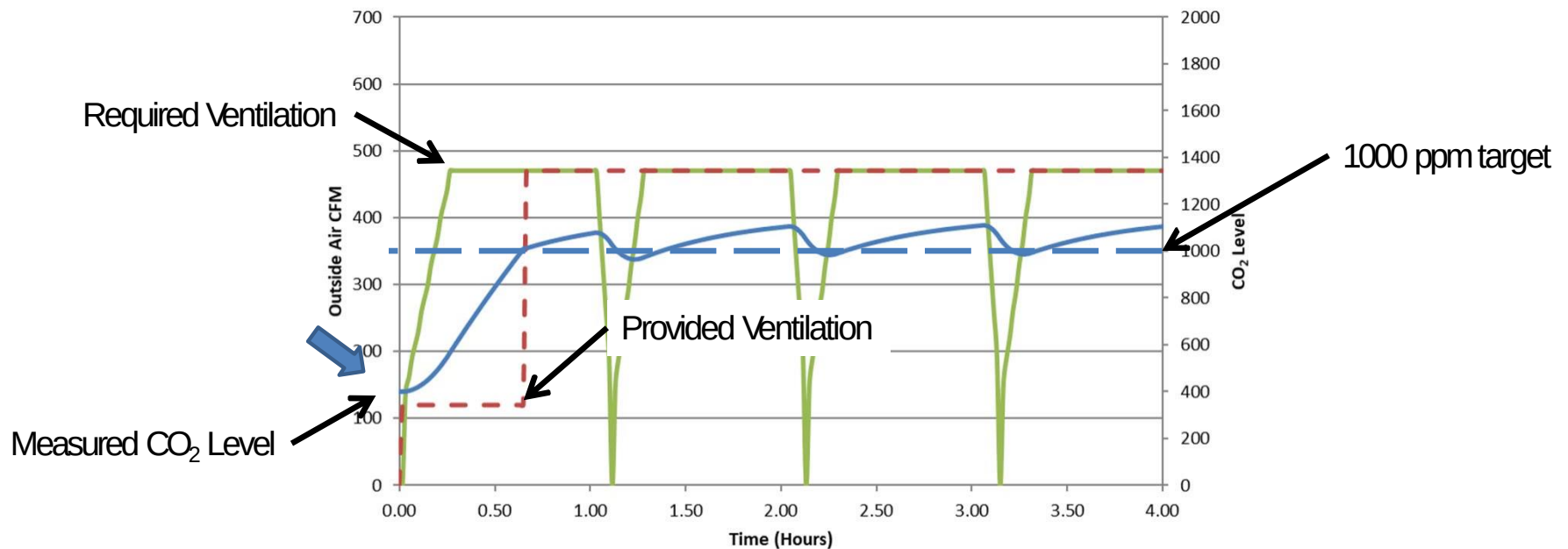
TECHNICAL AIR SYSTEMS, INC.
A Comfortable Choice

Good or Bad IAQ?



2-POS CO₂-DCV LAG (1,000 sq.ft. classroom)

Az=1,000 sq ft, Design Occupancy=35, Actual Occupancy = 35
45 minute classes, 15 minutes between periods



EBTRON

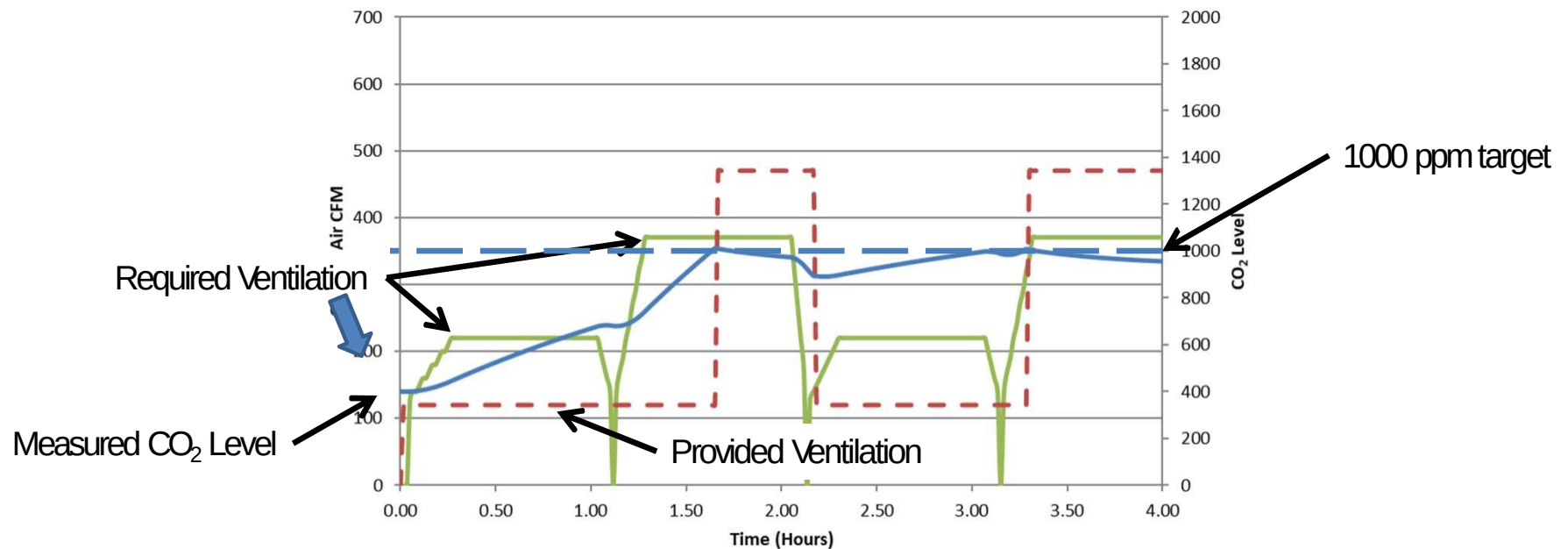
TECHNICAL AIR SYSTEMS, INC.
A Comfortable Choice

Better or Worse?



2-POS CO₂-DCV LAG (1,000 sq.ft. classroom)

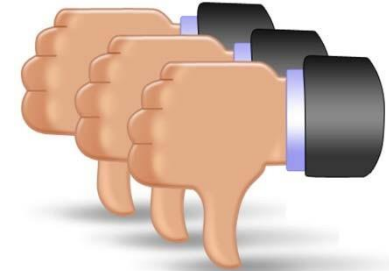
Az=1,000 sq ft, Design Occupancy=35, Actual Occupancy = 10 to 25
45 minute classes, 15 minutes between periods



EBTRON

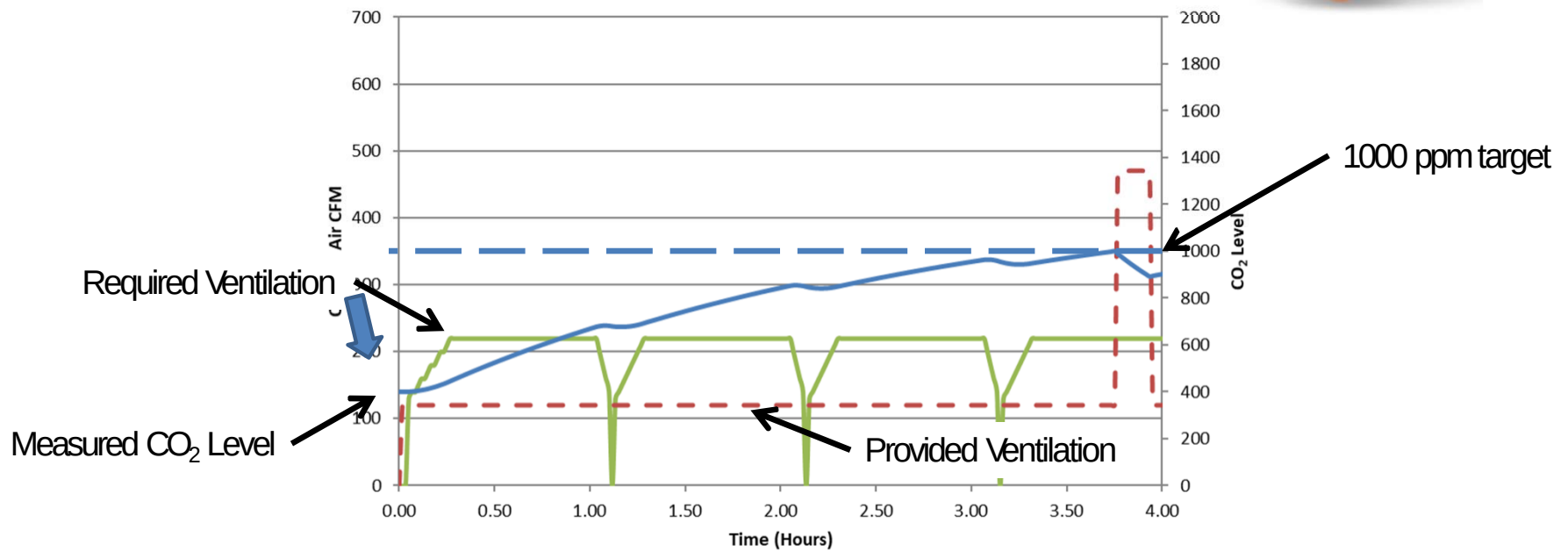
TECHNICAL AIR SYSTEMS, INC.
A Comfortable Choice

Best or Worst?



2-POS CO₂-DCV LAG (1,000 sq.ft. classroom)

Az=1,000 sq ft, Design Occupancy=35, Actual Occupancy = 10
45 minute classes, 15 minutes between periods



EBTRON

TECHNICAL AIR SYSTEMS, INC.
A Comfortable Choice



Why shouldn't I just
maintain CO₂ levels?

You do not know how much OA
ventilation you have provided!

EBTRON®

TECHNICAL AIR SYSTEMS, INC.
A Comfortable Choice



Thank You!

Questions? More information?

Contact Technical Air Systems, Inc.

NY/NJ EBTRON Representative

pscheele@technicalair.com

NY: 212-946-4935

NJ: 973-285-0333

The EBTRON logo features the word "EBTRON" in a bold, red, italicized sans-serif font. A registered trademark symbol (®) is located at the top right of the word.

TECHNICAL AIR SYSTEMS, INC.
A Comfortable Choice

