MAXIMIZING VENTILATION EFFECTIVENESS TO IMPROVE IAQ

BUILDING ENVELOPE EFFICIENCY, TOXICS, and INDOOR AIR QUALITY

TOXICS USE REDUCTION CONFERENCE

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RELEVANCE TO TOXIC USE REDUCTION

IN ADDTION TO MINIMIZING EXPOSURES TO TOXIC CONSTITUENTS IN BUILDING MATERIALS, IT CAN BE ASSUMED THAT FOSSIL FUEL USE, INCLUDING EXTRACTION, TRANSPORTATION, AND COMBUSTION, CAN BE CONSIDERED AS A TOXIC USE AS WELL. THEREFORE, TO TOXIC USE REDUCTION REQUIRES THAT VENTILATION NEEDS TO CONSUME AS LITTLE ENERGY AS POSSIBLE WHILE STILL PROVING HEALTHY INDOOR ENVIRONMENTS.

WHAT IS VENTILATION?

AIR MOVEMENT TO DILUTE AND REMOVE AIR CONTAMINANTS.

GOAL: MAKE THIS PROCESS NEED AS LITTLE EXTERNAL ENERGY AS POSSIBLE! (BOTH FOR CONDITIONING AND AIR MOVEMENT)

DESIGN DECISIONS

1) HOW MUCH VENTILATION TO PROVIDE?
2) HOW MUCH FILTRATION TO PROVIDE?
3) HOW MUCH HUMIDITY CONTROL TO PROVIDE?
4) HOW MUCH PRESSURIZATION TO PROVIDE?
5) HOW TO CONTROL THE AMOUNT OF VENTILATION?
6) WHETHER TO HAVE ENERGY RECOVERY?
7) WHERE SHOULD THE OA BE DRAWN FROM?
8) HOW RESILIENT IS THE DESIGN?

VENTILATION OPTIONS

1) DILUTION VENTILATION versus.
   LOCAL EXHAUST VENTILATION

2) MIXED-AIR SYSTEMS versus.
   DEDICATED OUTDOOR AIR SYSTEMS

2) WELL-MIXED VENTILATION versus
   DISPLACEMENT VENTILATION

2) MECHANICAL vs. NATURAL VENTILATION

5) TIME CLOCK vs. DEMAND-CONTROLLED VENTILATION

TYPES OF VENTILATION

DILUTION VENTILATION:

FOR CONTROLLING WIDELY DISPERSED SOURCES OF AIR CONTAMINANTS

LOCAL EXHAUST VENTILATION:

FOR CONTROLLING LOCALIZED SOURCES OF AIR CONTAMINANTS

TYPES OF VENTILATION

MIXED AIR SYSTEMS ATTEMPT TO PROVIDE BOTH DILUTION AND REMOVAL OF AIR CONTAMINANTS AS WELL AS THERMAL COMFORT

DEDICATED OUTDOOR AIR SYSTEMS (DOAS) SEPARATE DILUTION AND REMOVAL OF AIR CONTAMINANTS FROM PROVIDING THERMAL COMFORT

MIXED AIR HVAC SYSTEMS

1) DIFFICULT TO BALANCE COMPETING NEEDS FOR VENTILATION WITH THOSE FOR THERMAL COMFORT

2) CONTROL PARAMETER OF PERCENT OA IN THE SUPPLY AIR DIFFICULT TO MANAGE, ESPECIALLY IN VARIABLE AIR VOLUME (VAV) SYSTEMS

DEDICATED OUTDOOR AIR SYSTEMS (DOAS)

1) CAN BE MORE EFFICIENT AND CAN USE SMALLER DUCTS

2) MAY REQUIRE DEHUMIDIFICATION OF OUTDOOR AIR TO ACHIEVE DESIRED MOISTURE MANAGEMENT

3) MAY REQUIRE RADIANT HEATING AND/OR COOLING TO PROVIDE THERMAL COMFORT

VENTILATION ASSESSMENT

YOU CAN'T MANAGE WHAT YOU DON'T MEASURE

CARBON DIOXIDE (CO_2) MONITORING CAN BE A USEFUL TOOL FOR ASSESSING VENTILATION PERFORMANCE

VENTILATION ASSESSMENT

CUBIC FEET OF OUTDOOR AIR PER PERSON (CFM/Person):

CARBON DIOXIDE (CO_2) MONITORING DOES THIS WELL

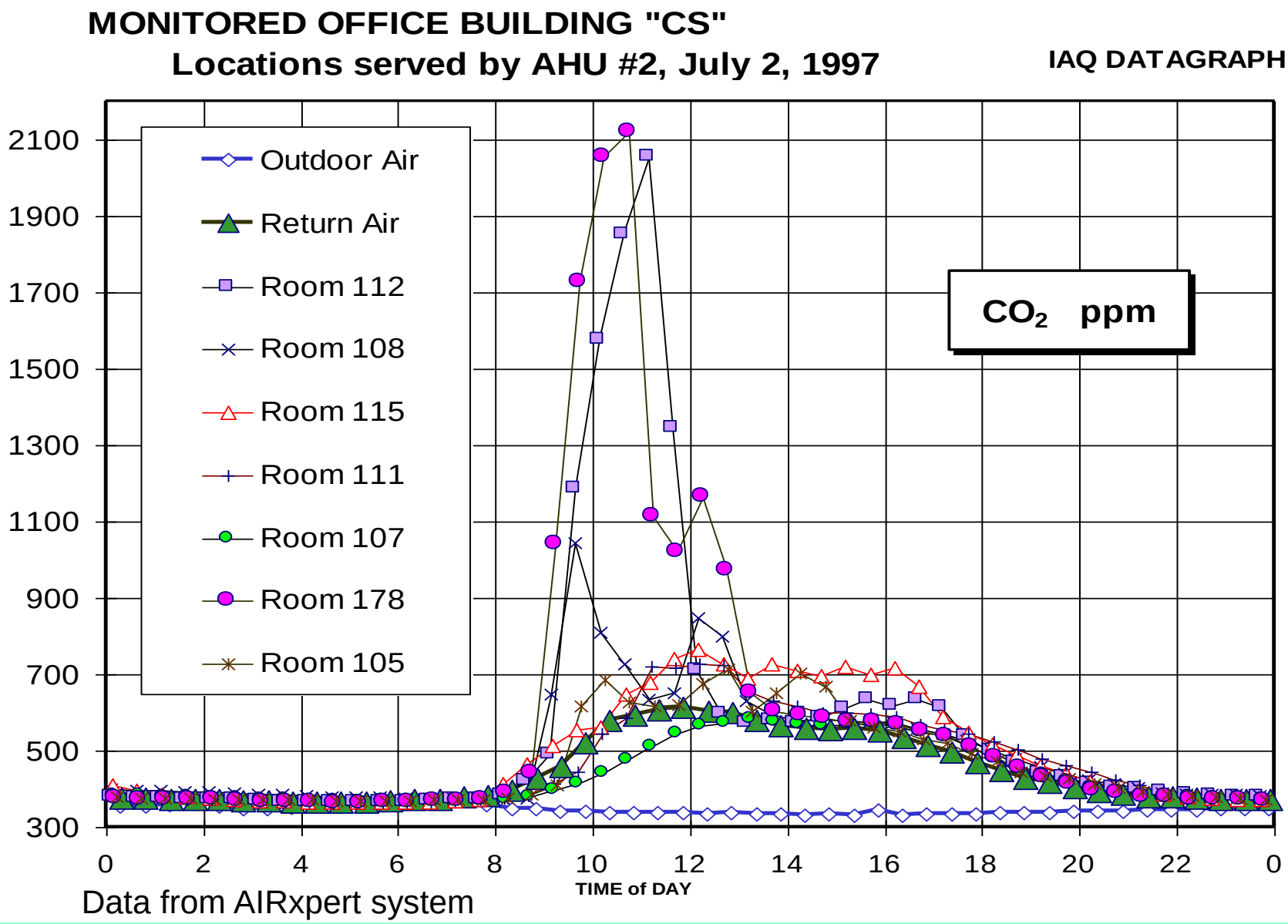
AIR CHANGES PER HOUR (ACH):

RATIO OF AIR VOLUME IN DIVIDED BY VOLUME OF SPACE

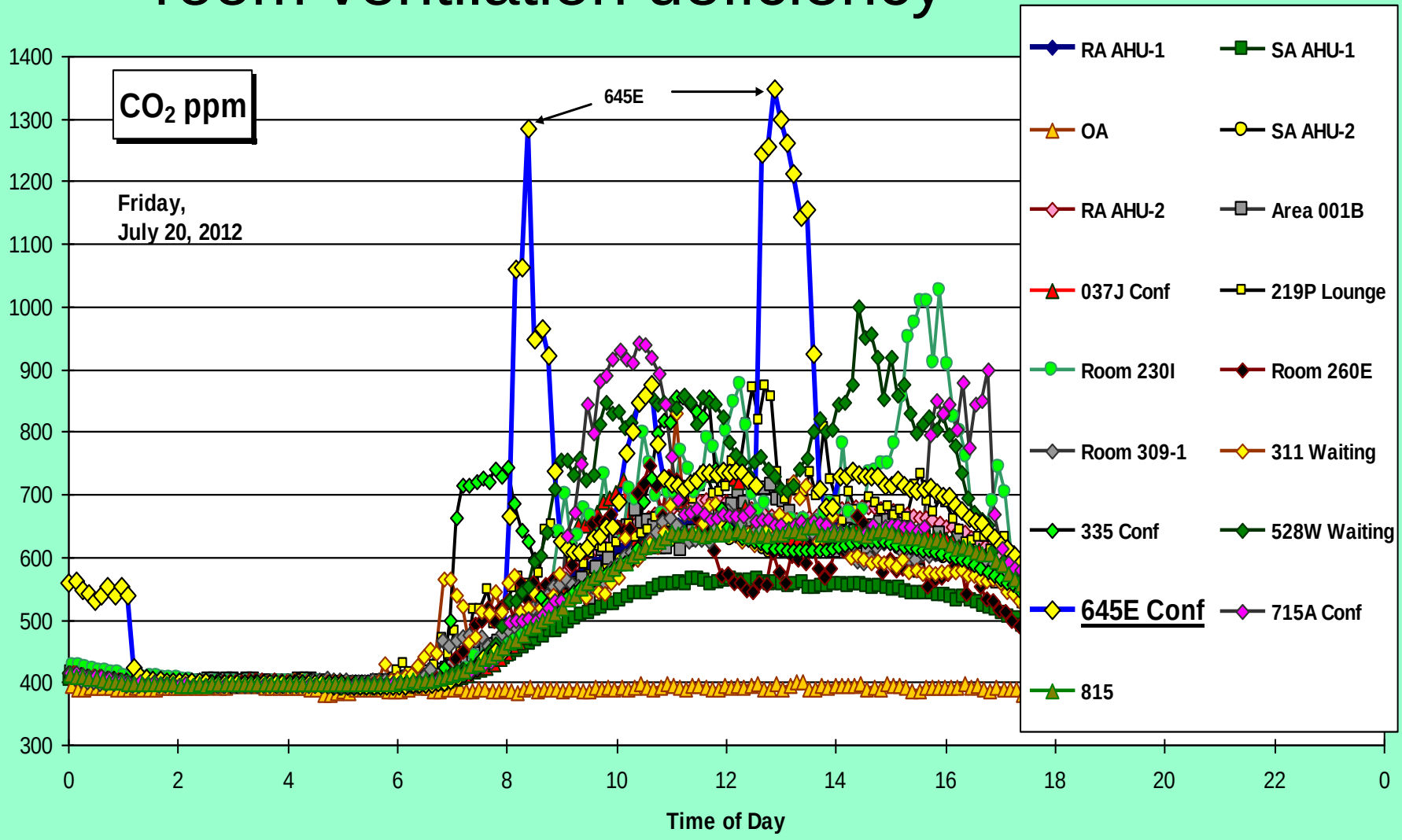
AIR CHANGES PER HOUR (ACH):

IN WELL-MIXED SPACE, THE SLOPE OF TRACER DECAY LINE

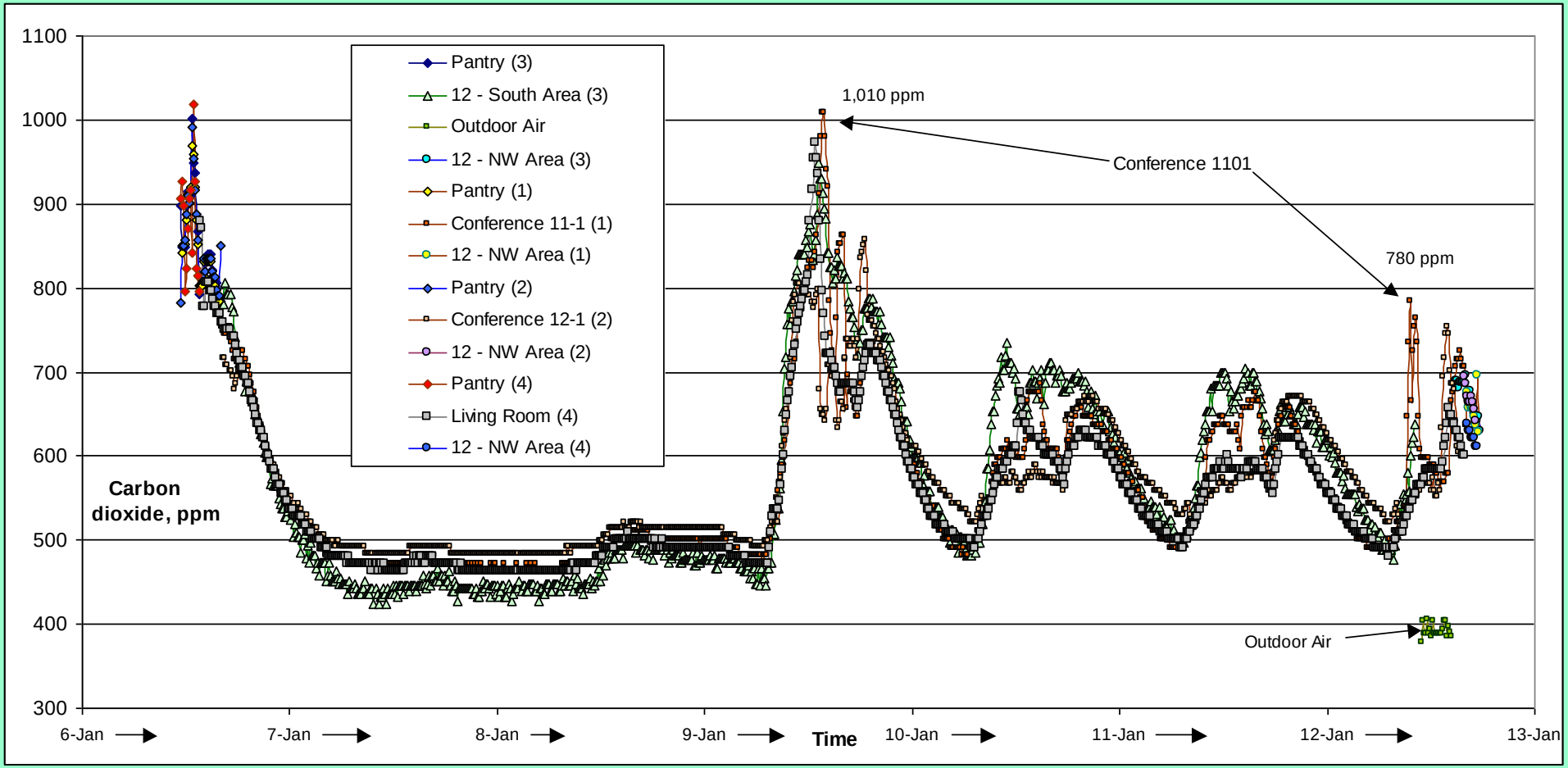
Ventilation Deficiency typical with Mixed Air System



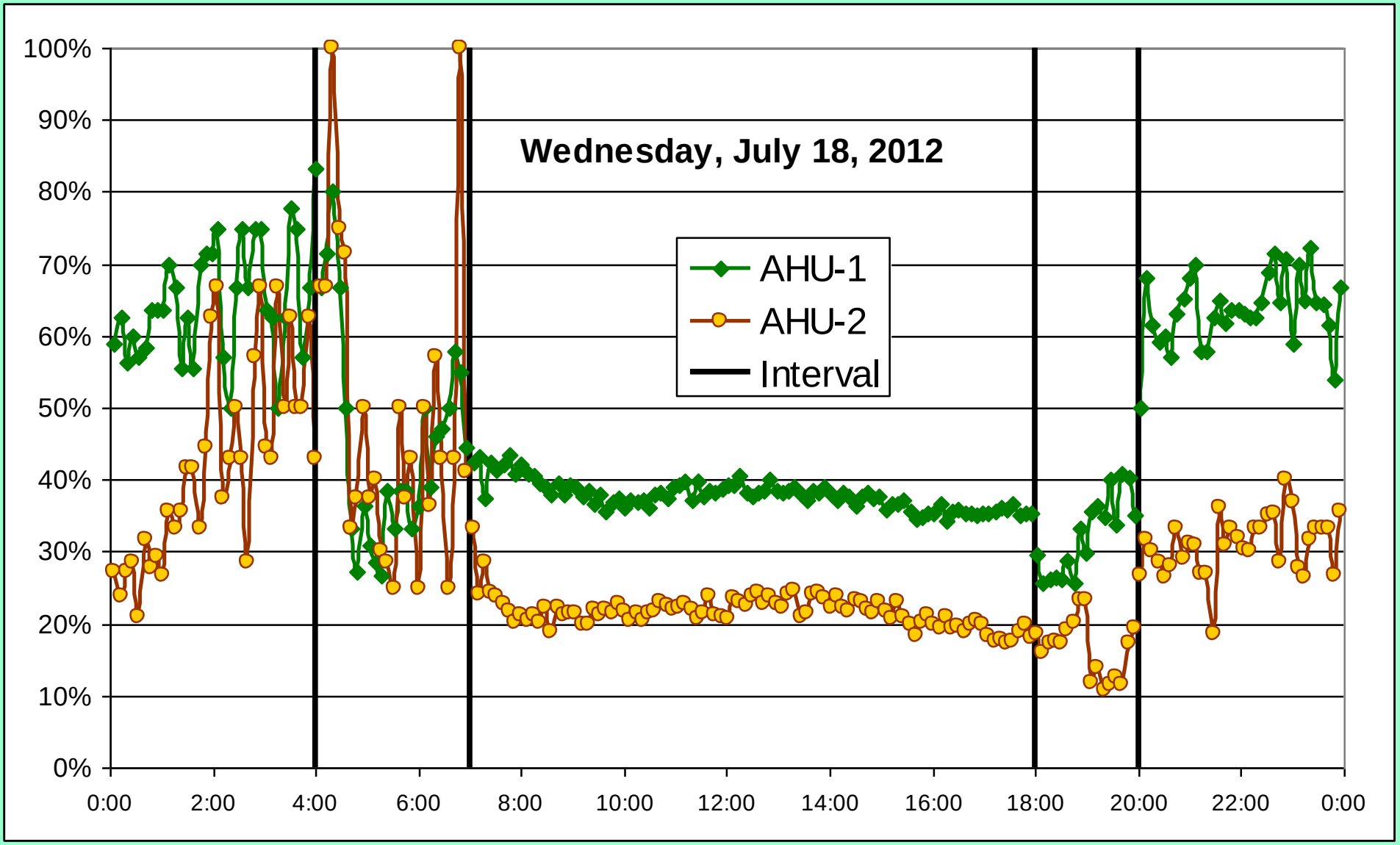
Recent example of conference room ventilation deficiency



Incomplete Overnight Purge of Air Contaminants



VARIATIONS IN %OA DURING THE DAY



VENTILATION CHALLENGES

PRESSURIZING THE BUILDING

CO2 MONITORING, DATA ACCURACY

HUMIDITY CONTROL

MYTH: CO_2 SENSORS DON'T NEED CALIBRATION VERIFICATION

Data logging and review as part of Re-Commissioning

Figure 1.1-A

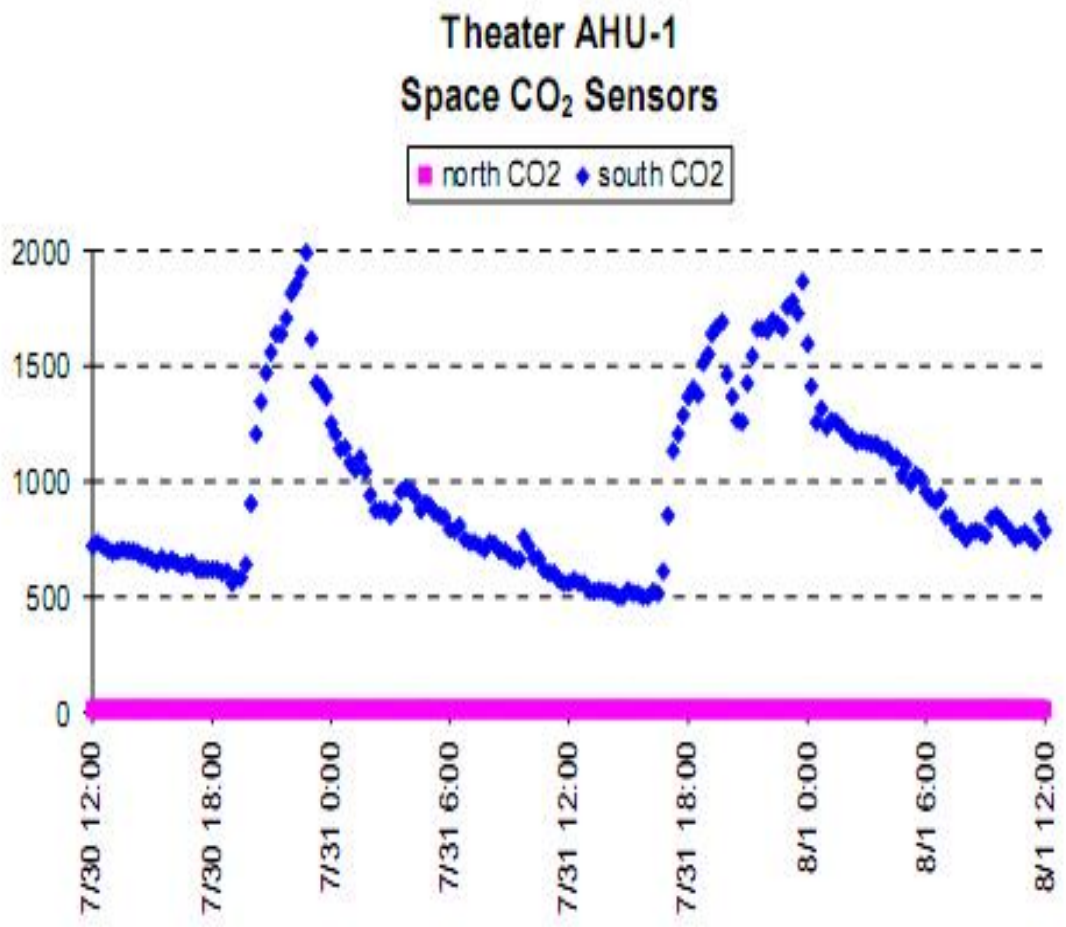
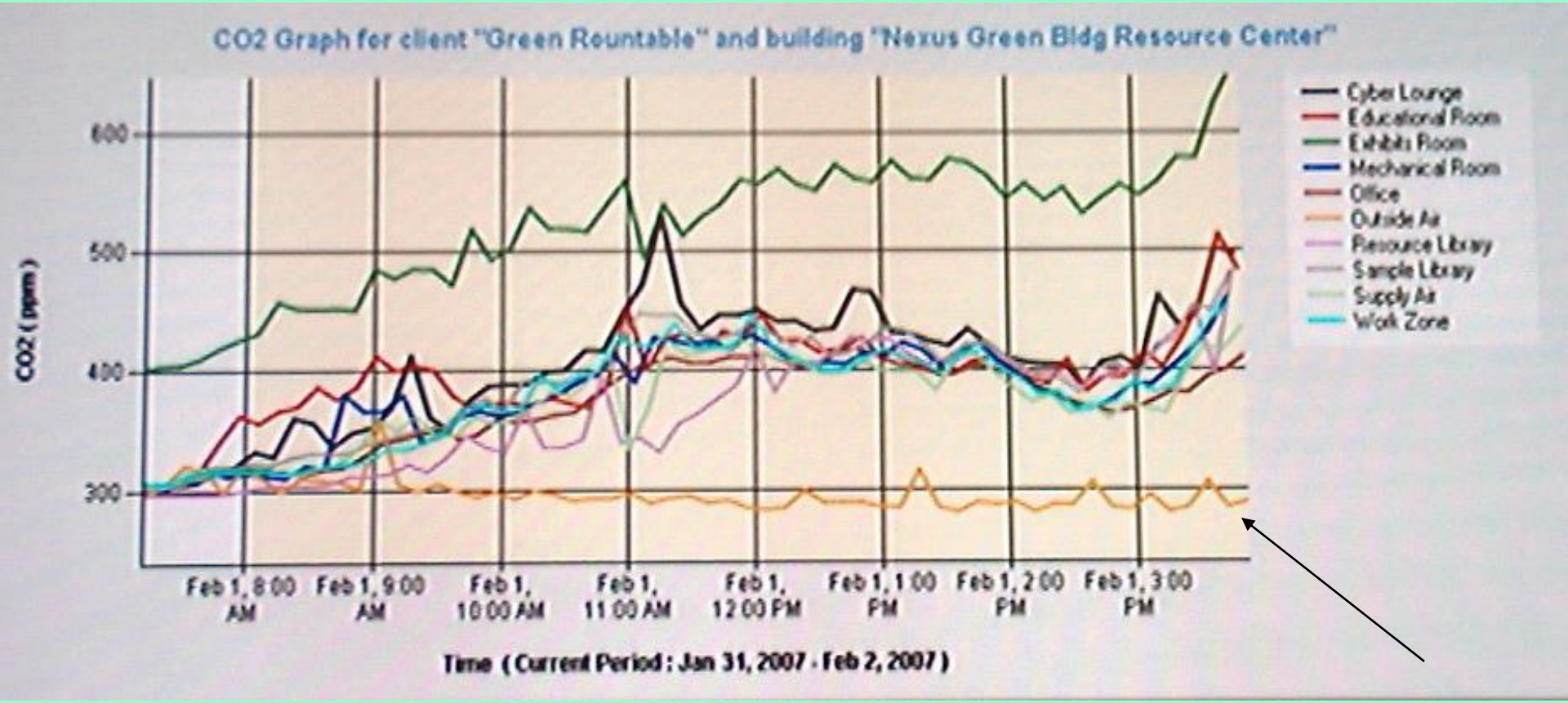


Figure 1.1-B

Calibration performed off-site



Calibration questionable as CO_2 value drops below 300 ppm

Aircuity data

CO_2 SENSOR ON THE WALL IN THE BREATHING ZONE

MYTH: CO_2 SENSORS SHOULD BE 3' TO 6' OFF THE FLOOR TO ACHIEVE A REPRESENTATIVE READING

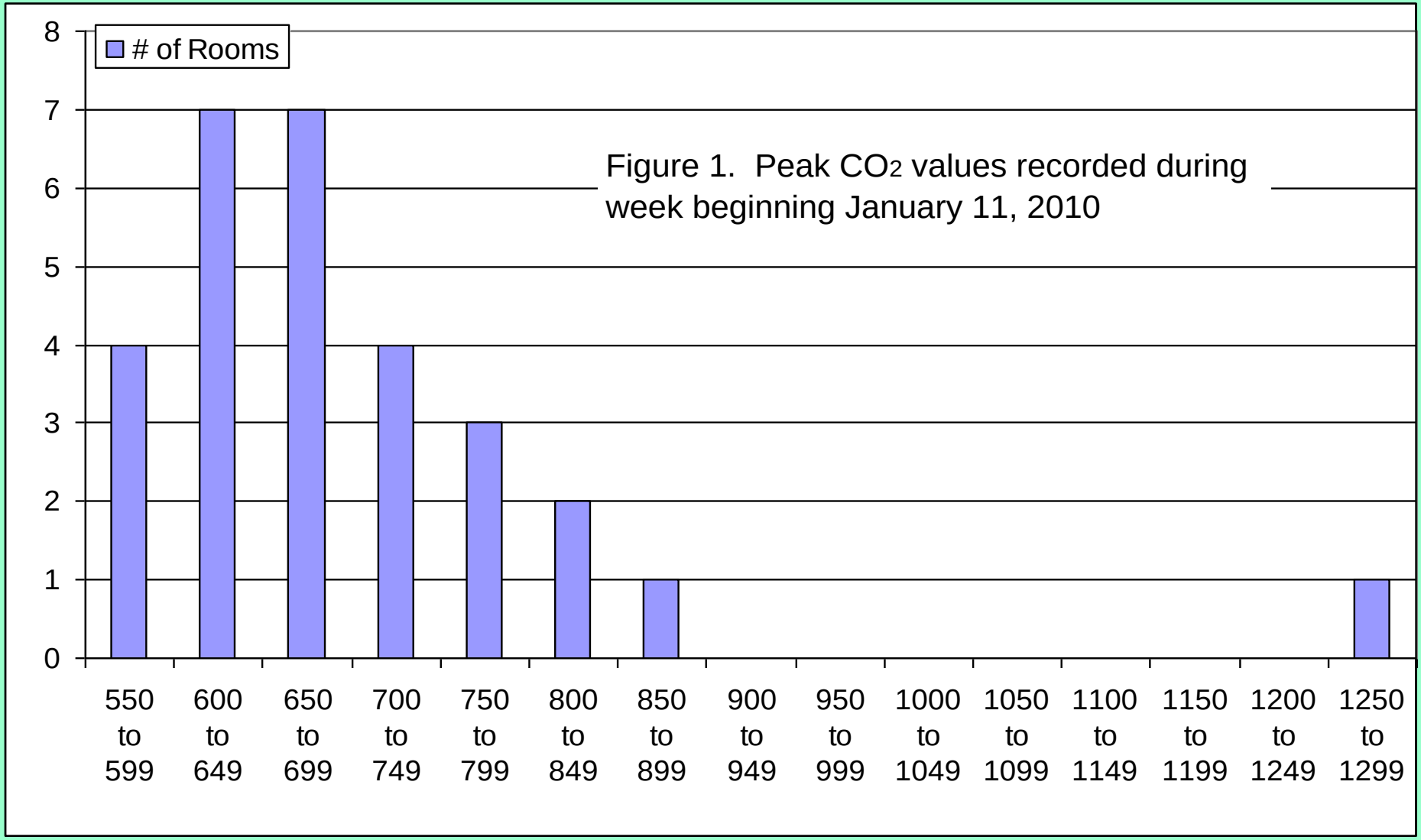


Figure 1. Peak CO_2 values recorded during week beginning January 11, 2010

REPRESENTATIVE SAMPLING LOCATION

TYPES OF VENTILATION

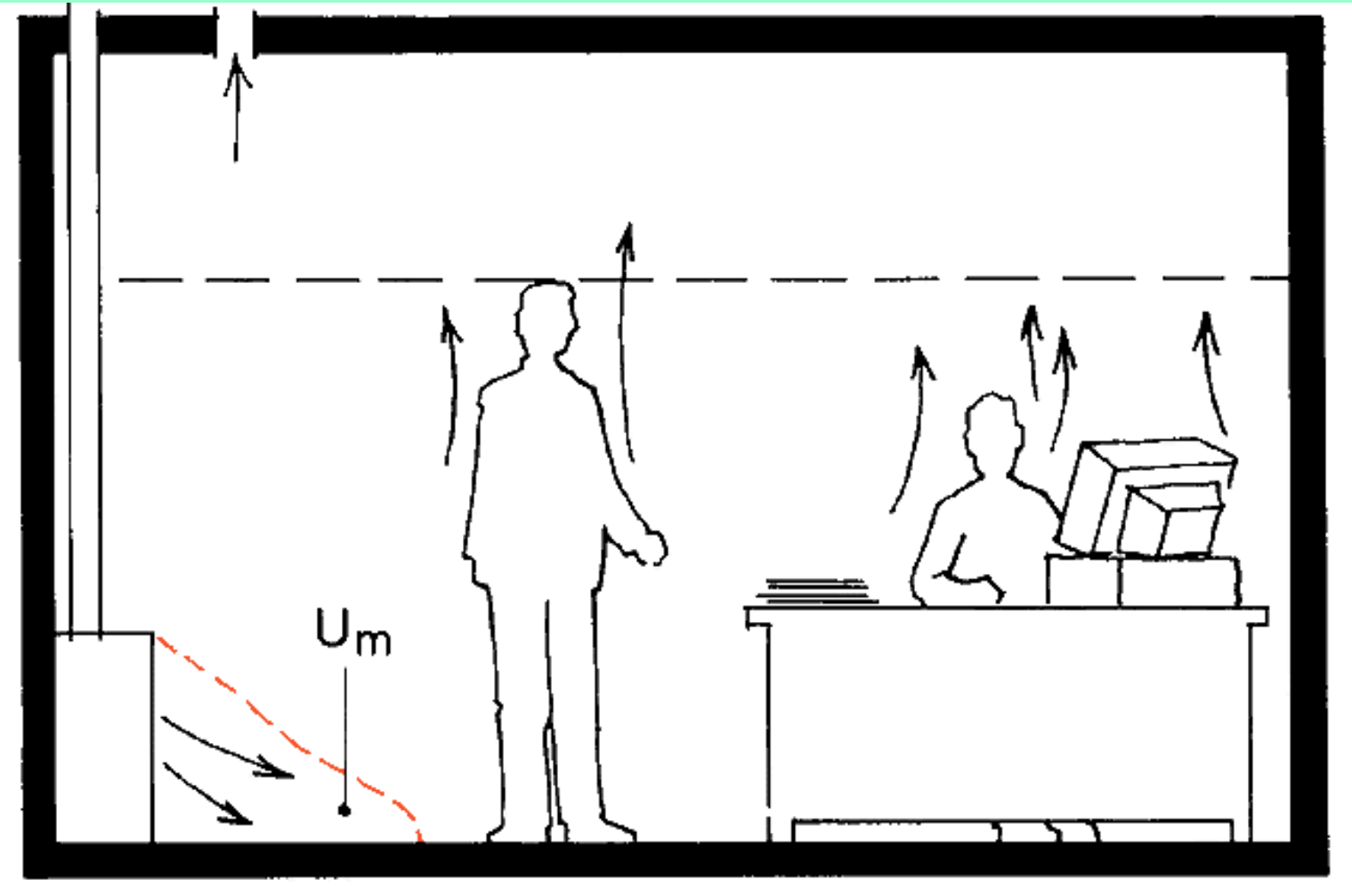
WELL-MIXED VENTILATION:

ABLE TO ACHIEVE UNIFORM TEMPERATURE PROFILE ACROSS SPACE BUT POOR AT PROVIDING EFFECTIVE REMOVAL OF AIR CONTAMINANTS

DISPLACEMENT VENTILATION:

MUCH HIGHER VENTILATION EFFECTIVENESS AND GREATER ISOLATION OF PEOPLE FROM EACH OTHER

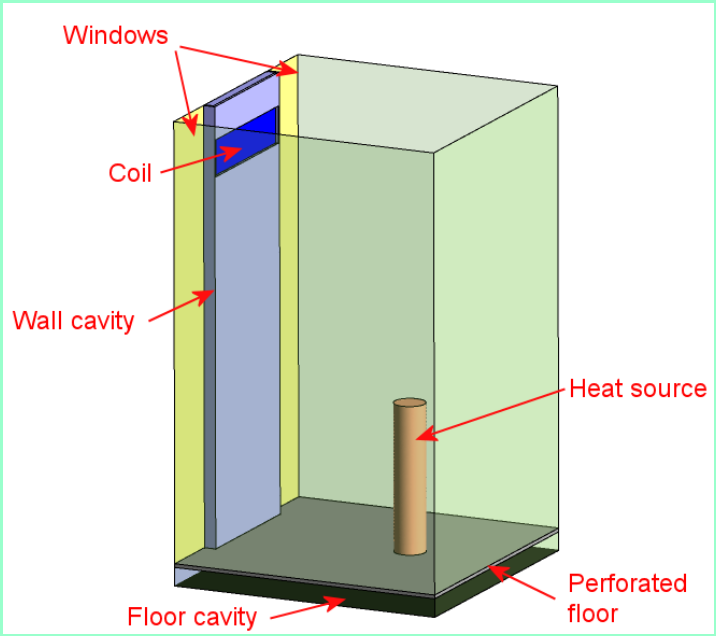
DISPLACMENT VENTILATION



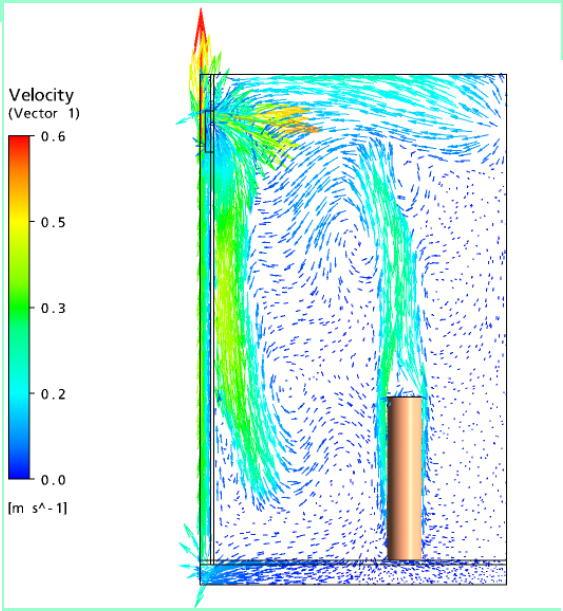
Capitalizing on Warm Air Rising

Passive Ventilation

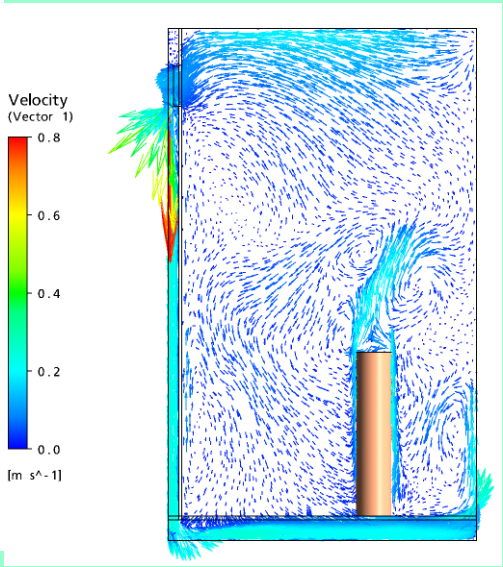
Floor displacement flow by passive air ventilation: cooling coil, wall and floor cavities, perforated floor



Room model



Cavity wall not insulated (40 W/m²) on wall



Cavity wall insulated

Velocity vectors in a vertical plane across the middle of the model perpendicular to the external cavity wall with cooling coil

TYPES OF VENTILATION

MECHANICAL VENTILATION DESIGN:
REQUIRES FAN ENERGY TO MOVE AIR THROUGH THE BUILDING

NATURAL VENTILATION DESIGN:

TAKES ADVANTAGE OF NATURAL FORCES TO MOVE AIR THROUGH THE BUILDING

HYBRID VENTILATION DESIGN:

COMBINATION OF THE TWO

NATURAL VENTILATION

AIRFLOW IS DUE TO THE DRIVING FORCES OF BUOYANCY AND WIND

STACK EFFECT VENTILATION:
BOUYANCY DRIVEN

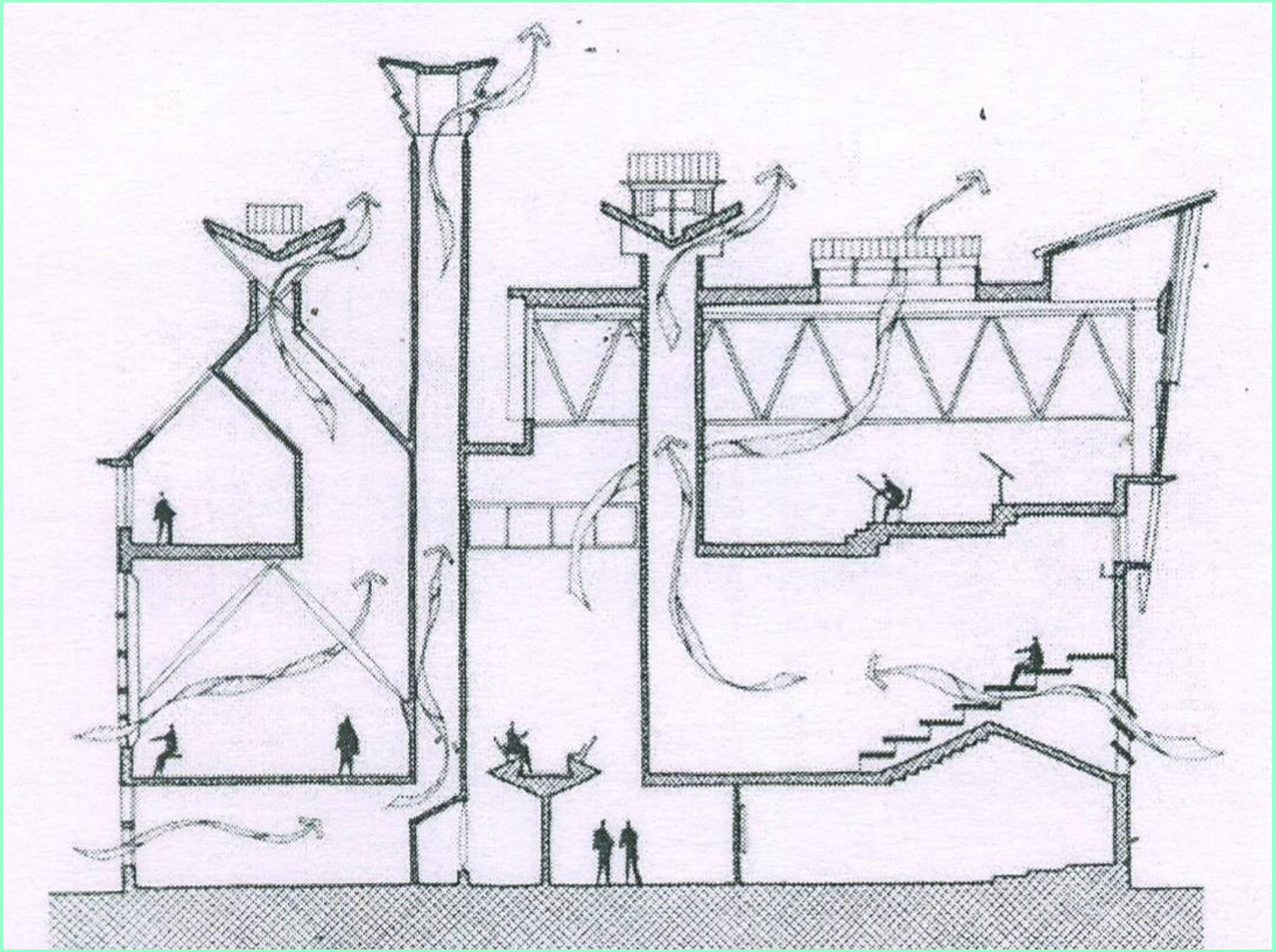
SINGLE-SIDED VENTILATION:
LIMITED TO ZONES CLOSE TO THE OPENINGS

CROSS-VENTILATION:
OPENINGS ON OPPOSITE WALLS FOR LARGER ZONES

WINDCATCHERS: WIND & BOUYANCY

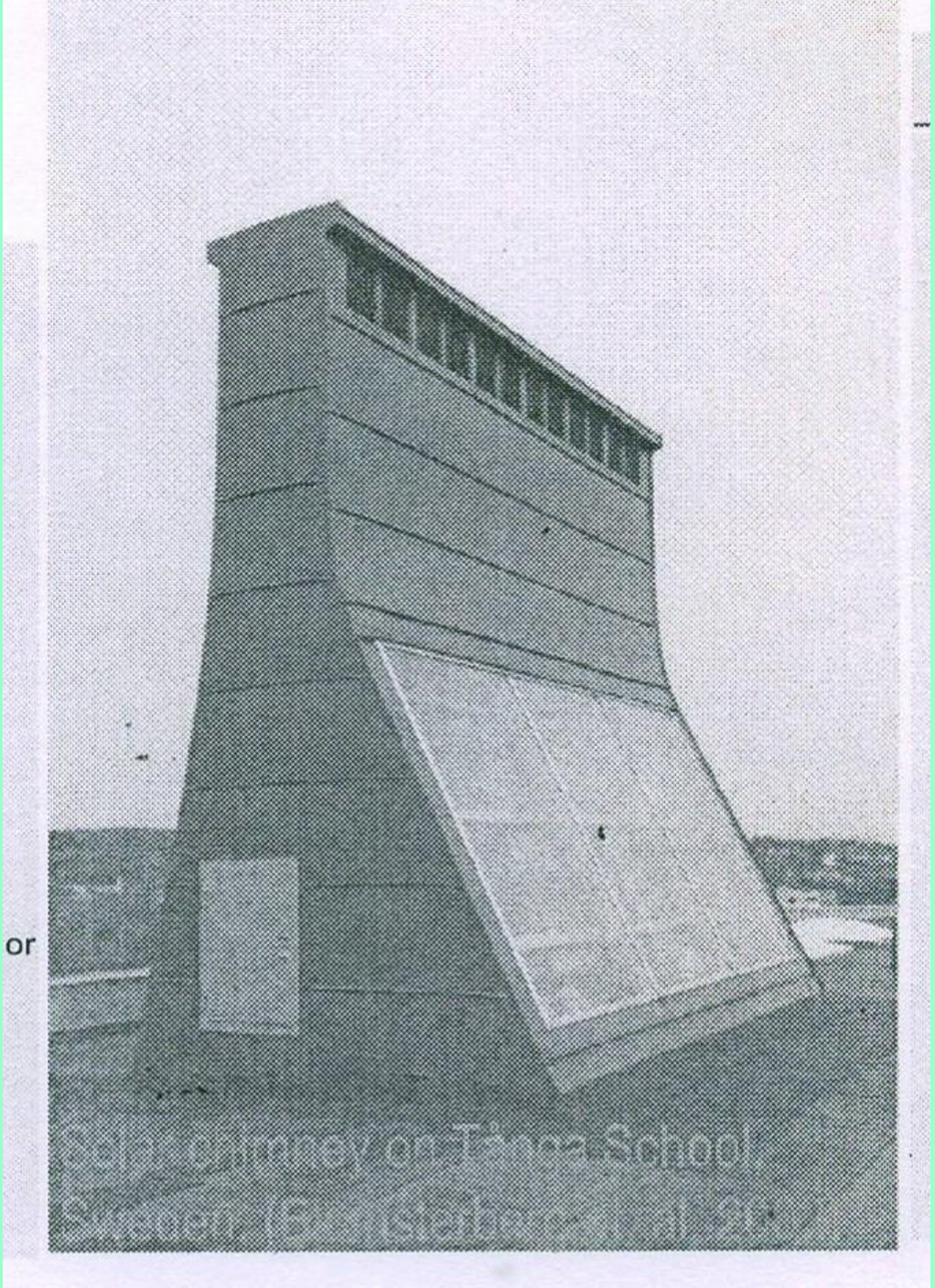
SOLAR-INDUCED VENTILATION:
USES THE SUN TO INCREASE BOUYANCY

STACK EFFECT: QUEEN'S BUILDING, DE MONTFORT UNIVERSITY



SOLAR-INDUCED VENTILATION:

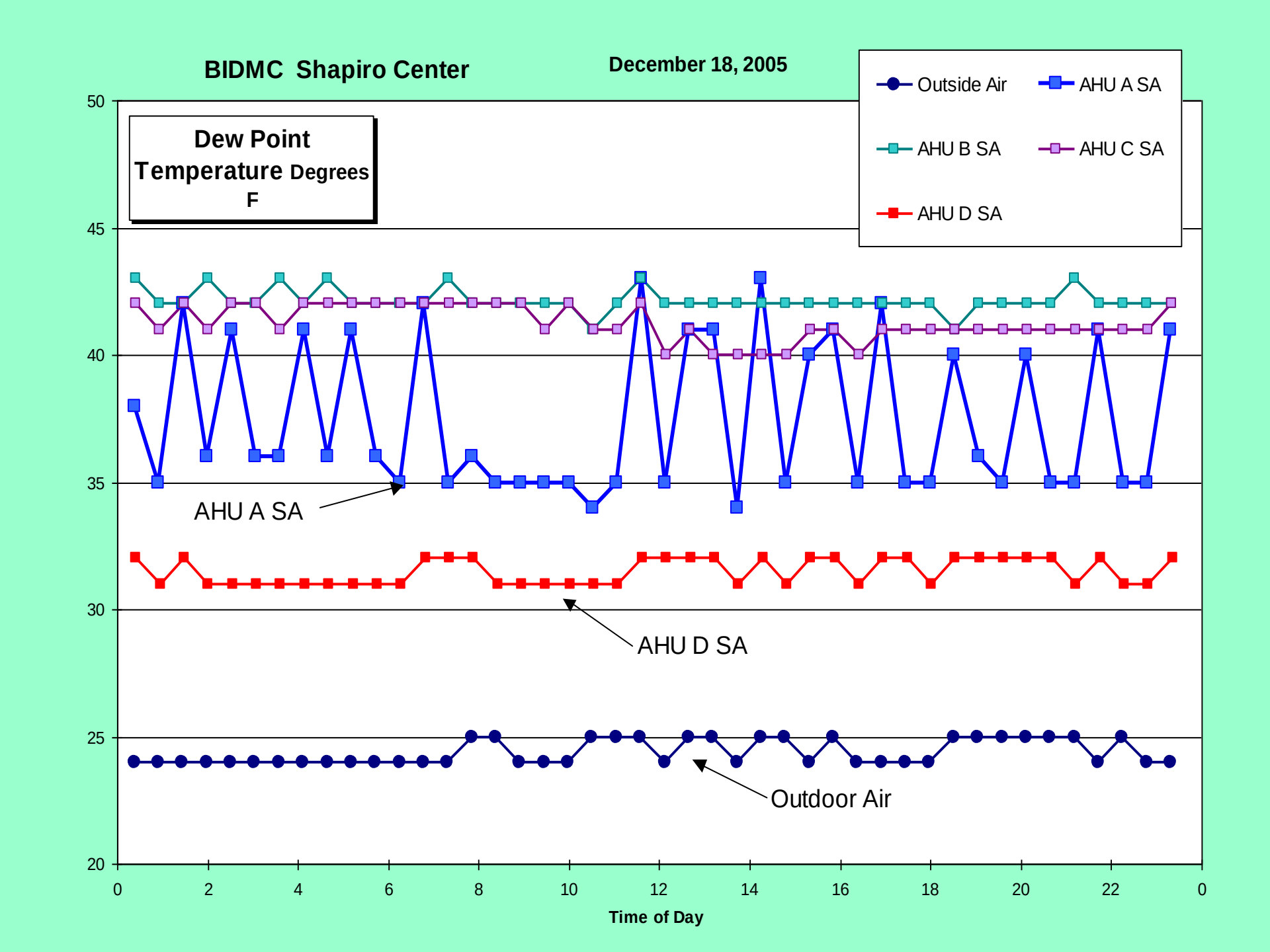
SOLAR CHIMNEY

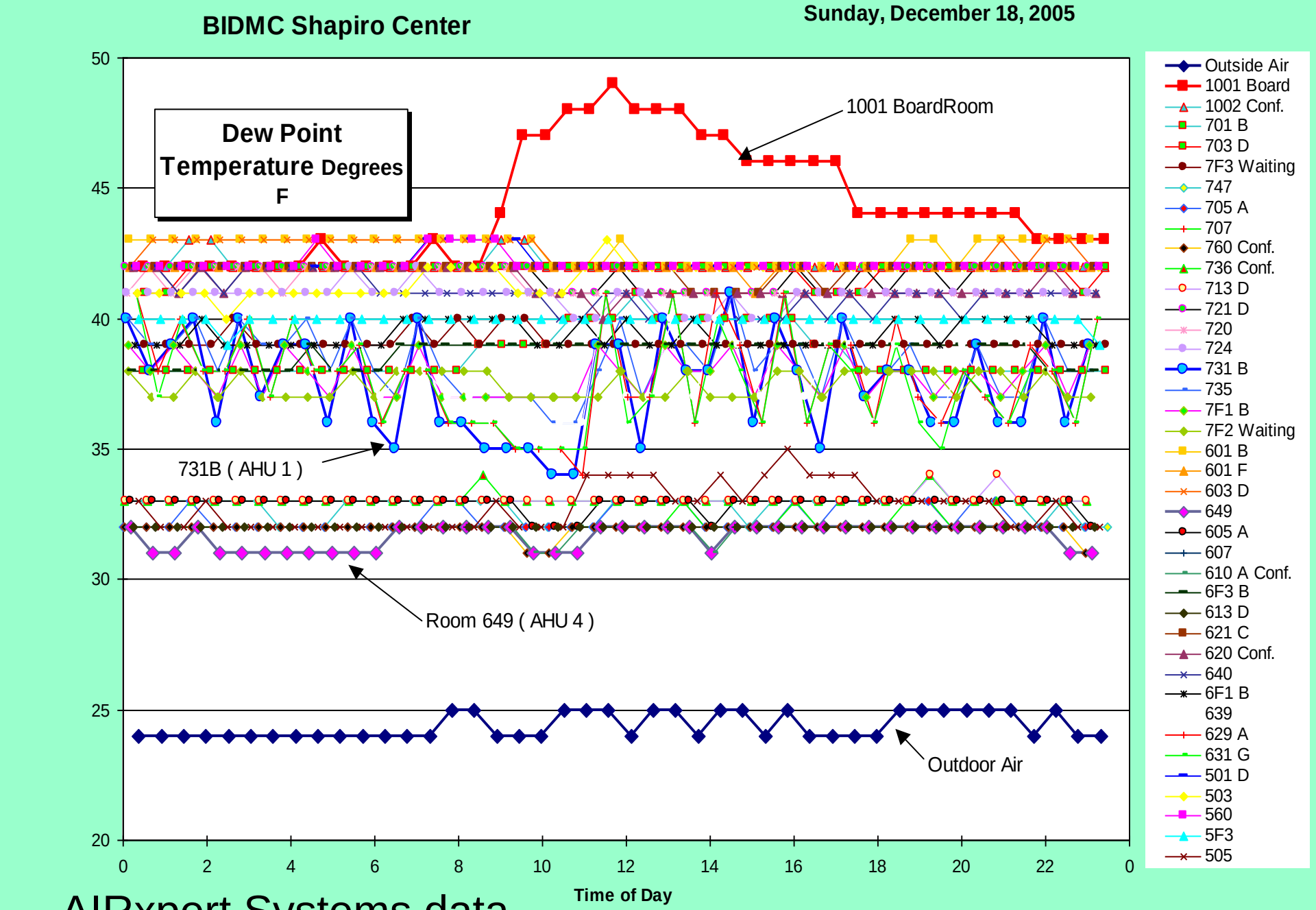


VENTILATION REQUIREMENT

CONDITIONING OF OUTDOOR AIR BEFORE DELIVERY TO OCCUPIED SPACES: HEATING / COOLING

MOISTURE MANAGEMENT

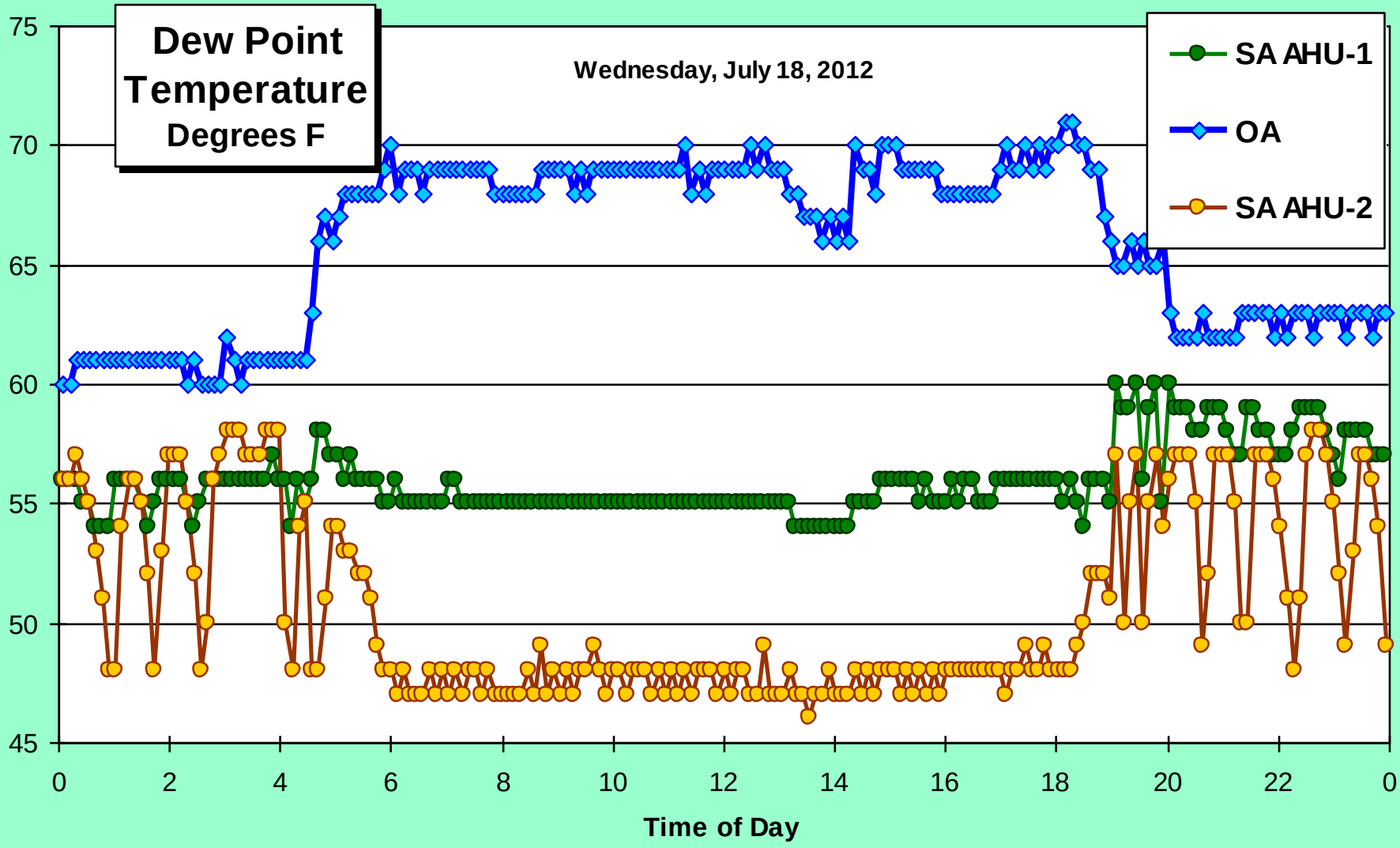

BIDMC Shapiro Center
December 18, 2005
Dew Point Temperature Degrees F
Outside Air
AHU A SA
AHU B SA
AHU C SA
AHU D SA
AHU A SA
AHU D SA
Outdoor Air
50
45
40
35
30
25
20
0
2
4
6
8
10
12
14
16
18
20
22
0
Time of Day



AIRxpert Systems data

RESULT OF POOR MOISTURE MANAGEMENT

VARIATIONS IN DEHUMIDIFICATION



VENTILATION ASSESSMENT

CUBIC FEET OF OUTDOOR AIR PER PERSON (CFM/Person):

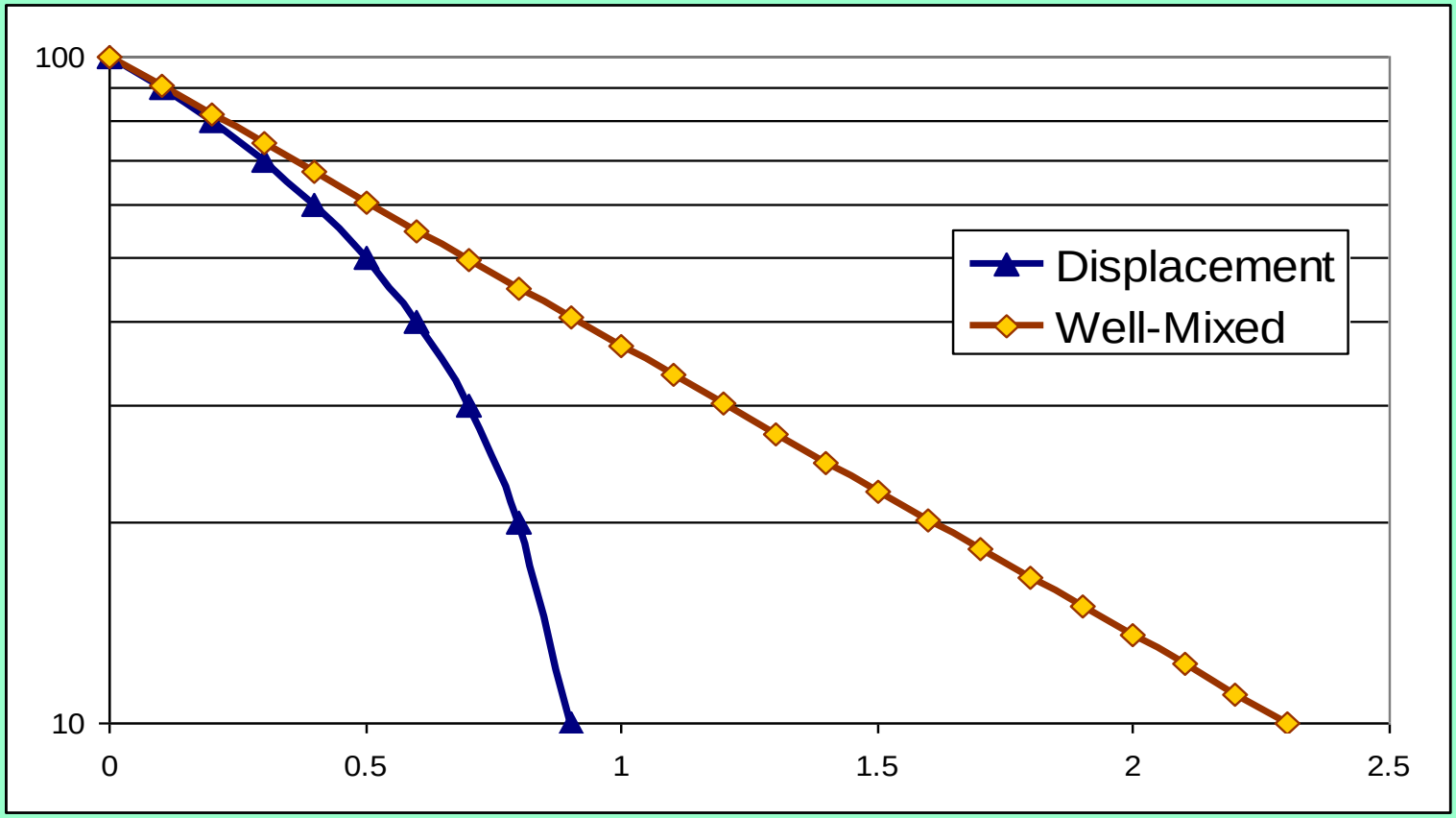
CFM/Person = CO_2 Generation / Δ CO_2

20 CFM/P = 10,600 / 930 ppm $_{in}$ – 400 ppm $_{OA}$

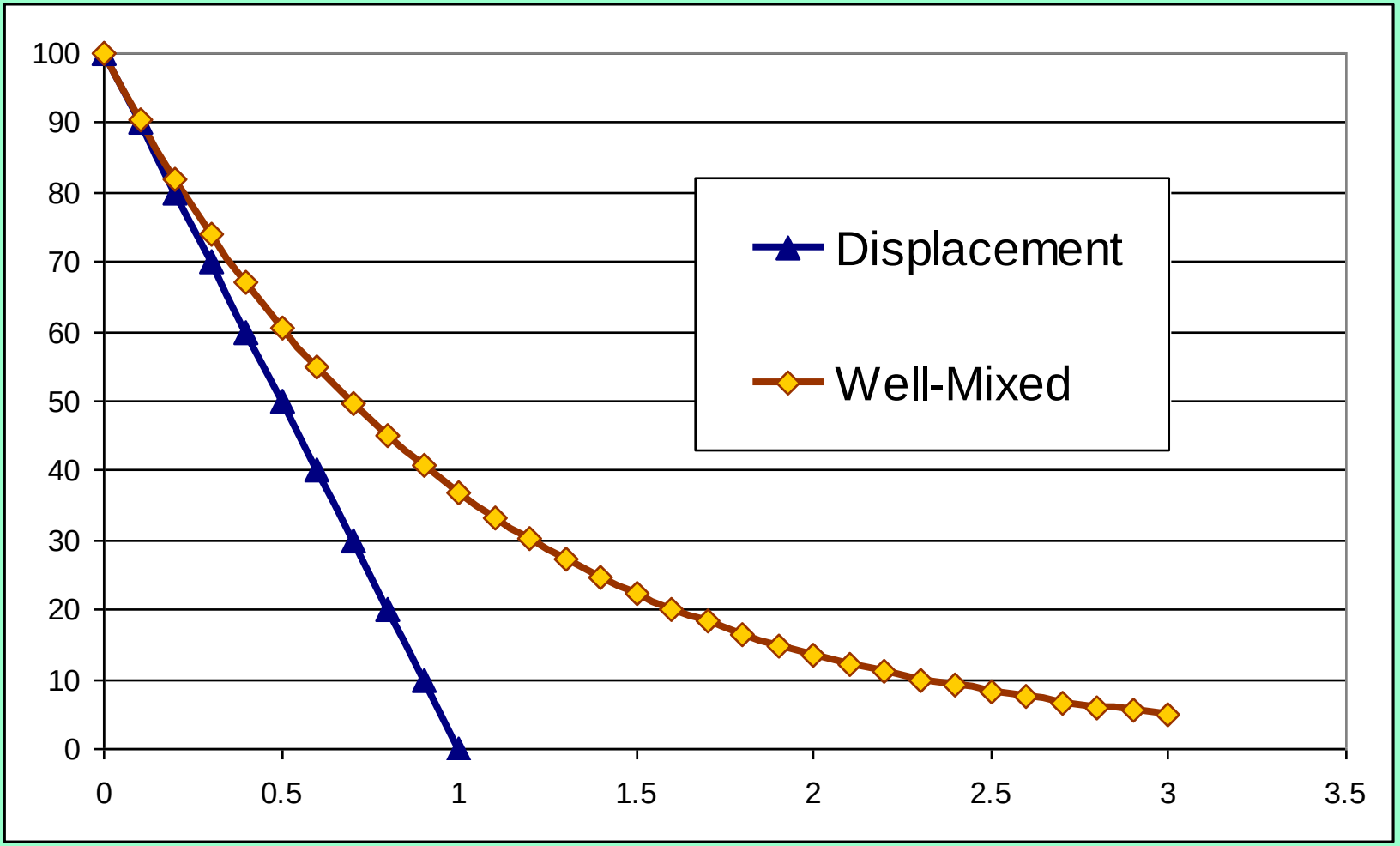
20 CFM/Person = 10,600 / 530 ppm $_{difference}$

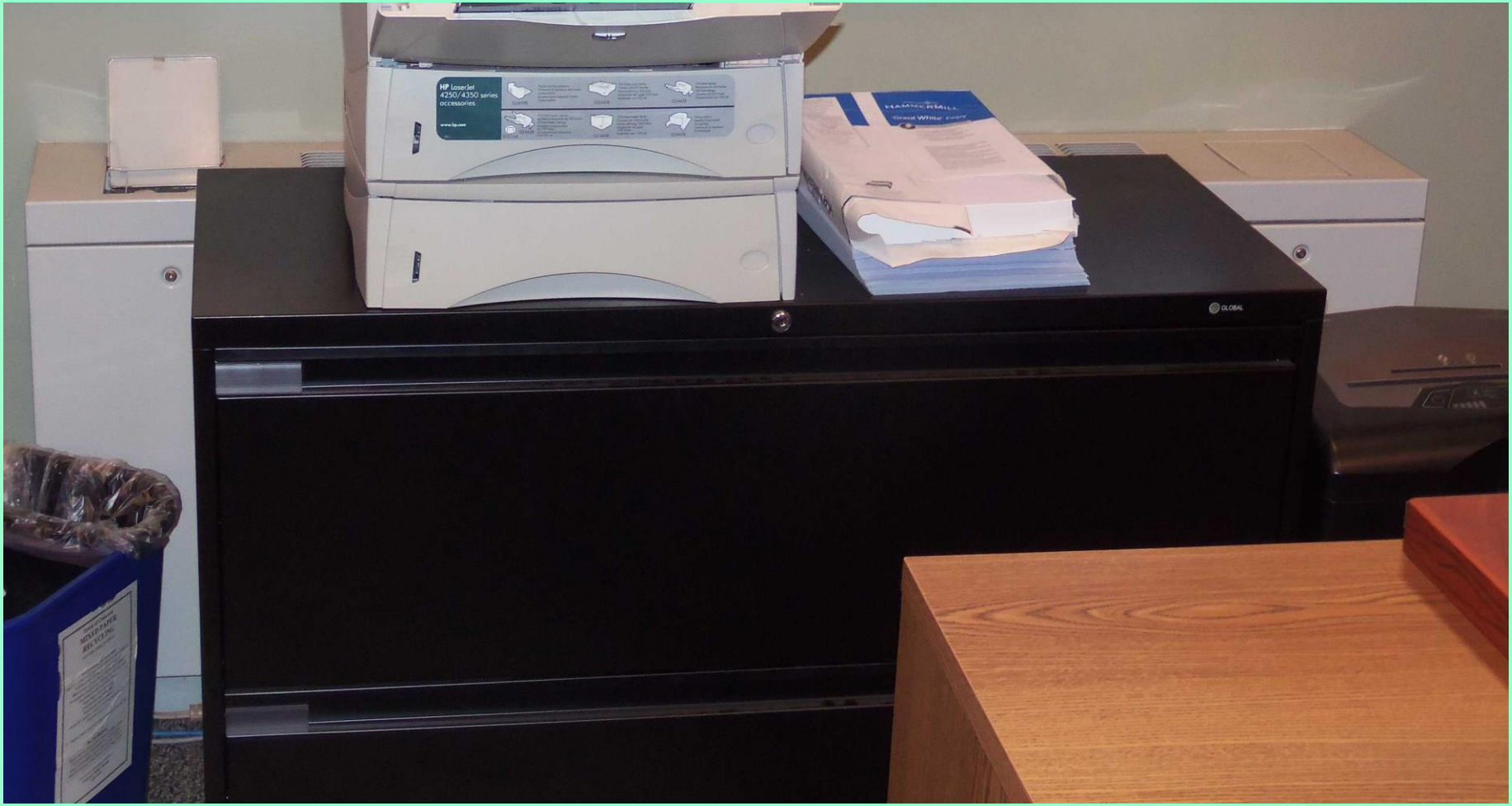
NOTE: 10,600 = 0.0106 CFM/Person x 1,000,000

COMPARISON OF AIR CONTAMINANT REMOVAL RATES FOR 1 ACH, ON SEMI-LOG PLOT



COMPARISON OF AIR CONTAMINANT REMOVAL RATES, 1 ACH





What’s wrong in this picture?

What’s wrong in this picture?


Remember, the HVAC
system really does NOT
always perform as intended