Indoor Air Quality Challenges with Central DOAS and Opportunities for Demand Controlled Ventilation

Niloufar Ghazanfari, Georg Reichard

1 Doctoral Student, Building Construction, Virgina Tech University

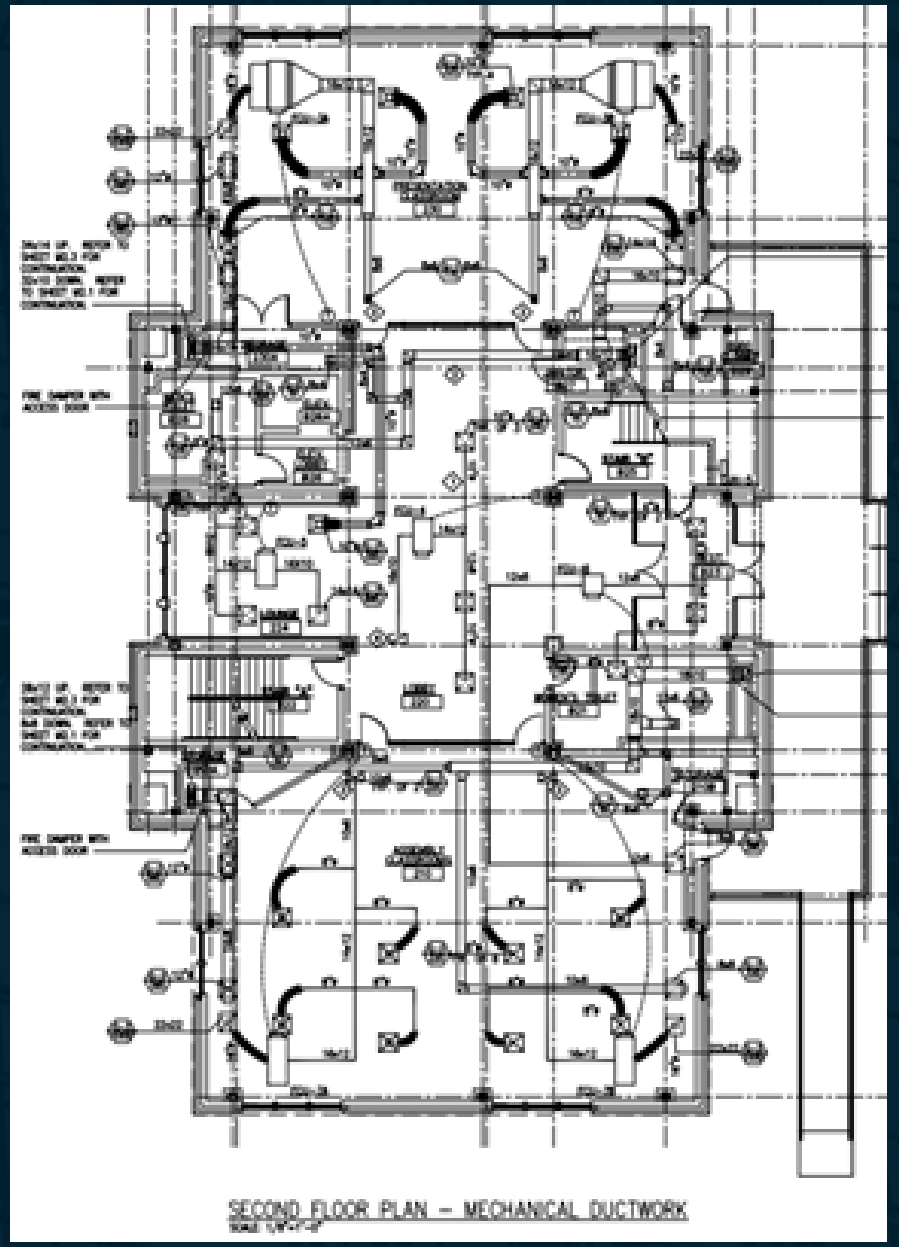
2 Professor and Department Head, Building Construction, Virgina Tech University

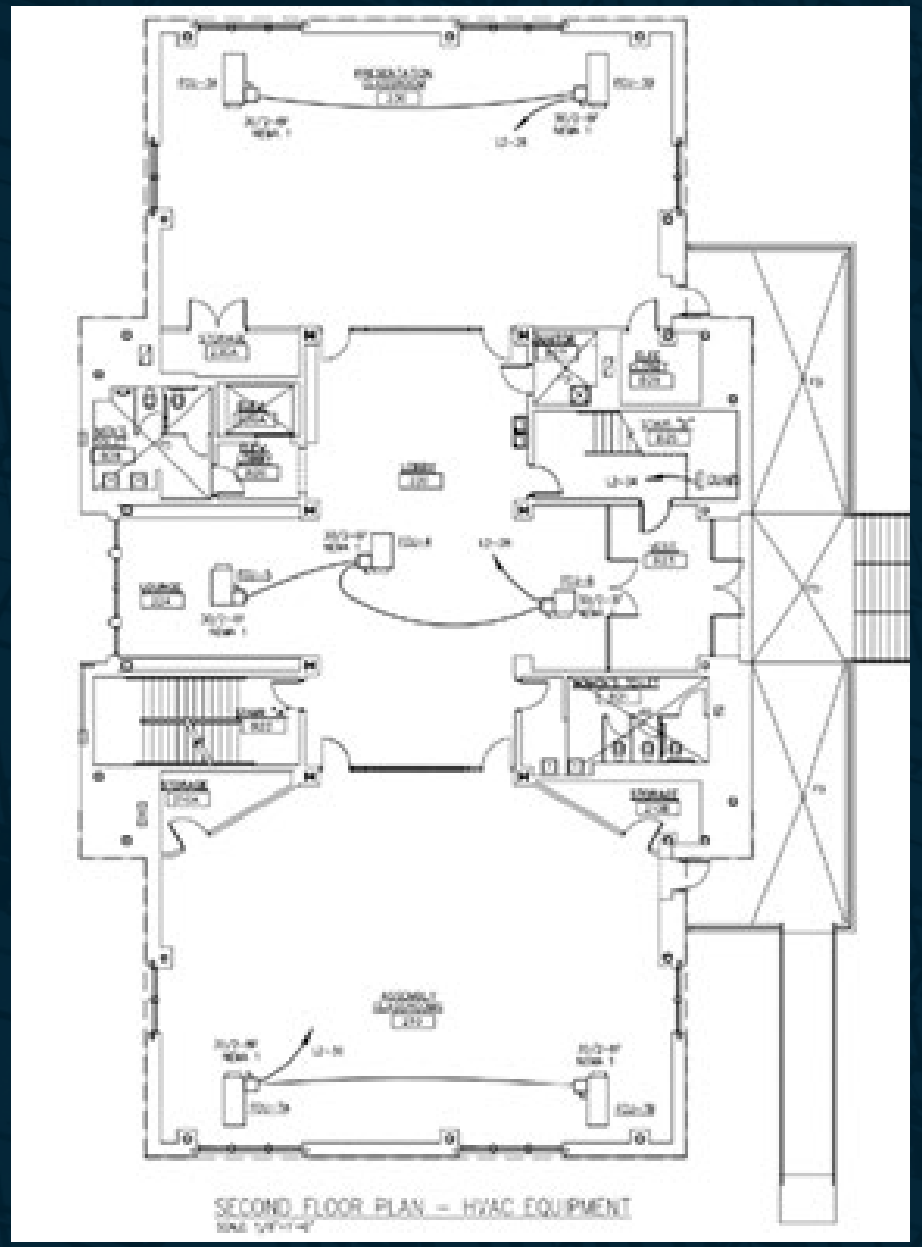
Case Study: Bishop-Favrao Hall (BFH), Classroom Hall 210

BEST6

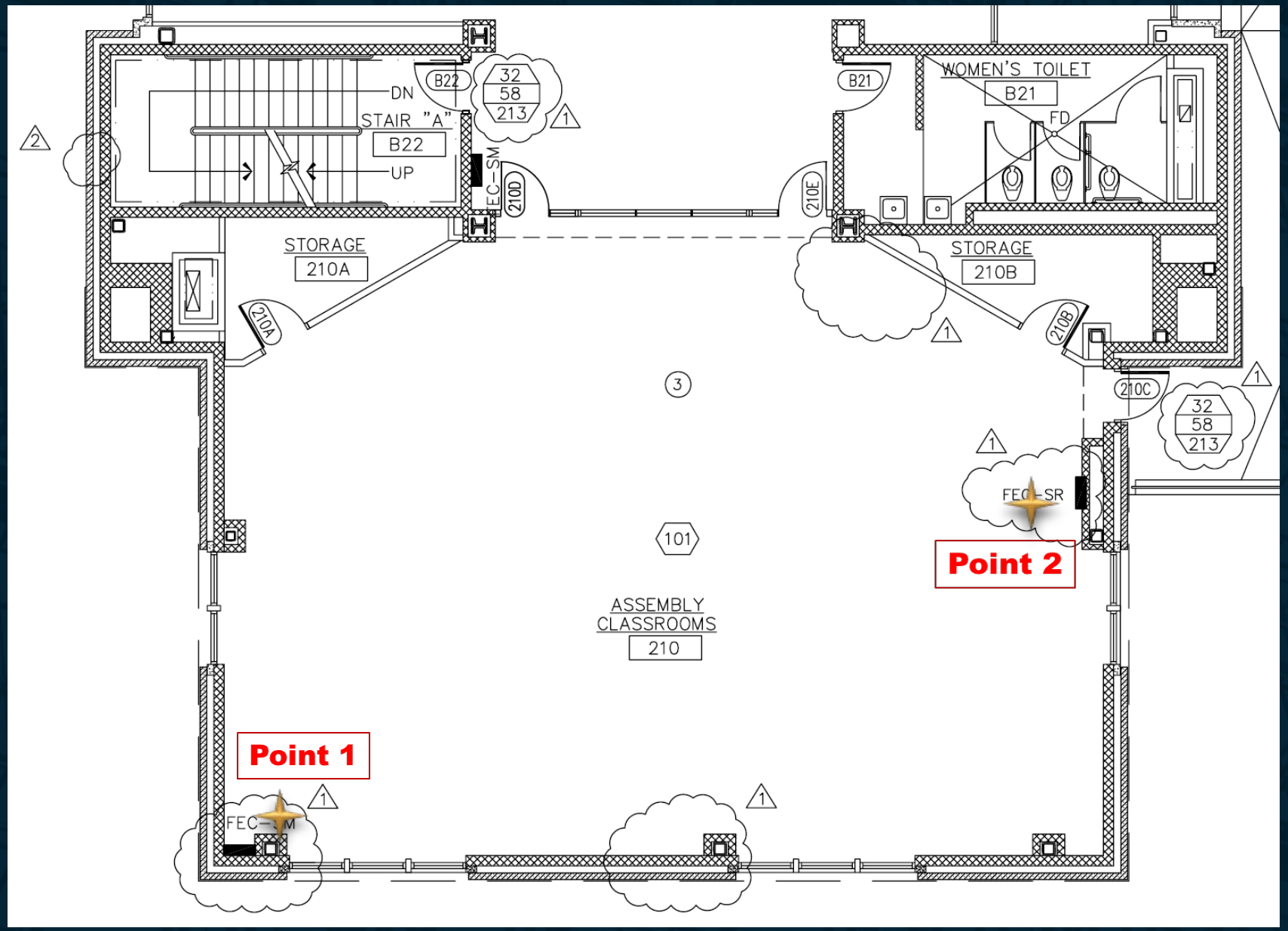
Floor Plans

Bishop-Favrao Hall Classrooms





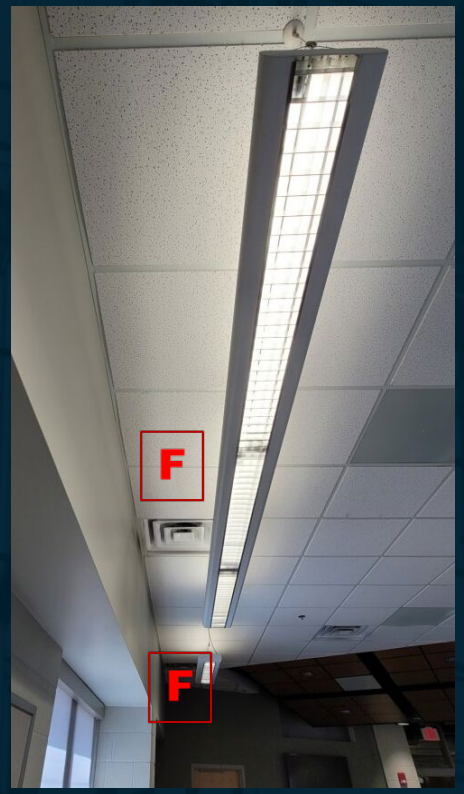
Designated Points of CO2 Concentration Measurement



Floor Plans

Bishop-Favrao Hall Classrooms

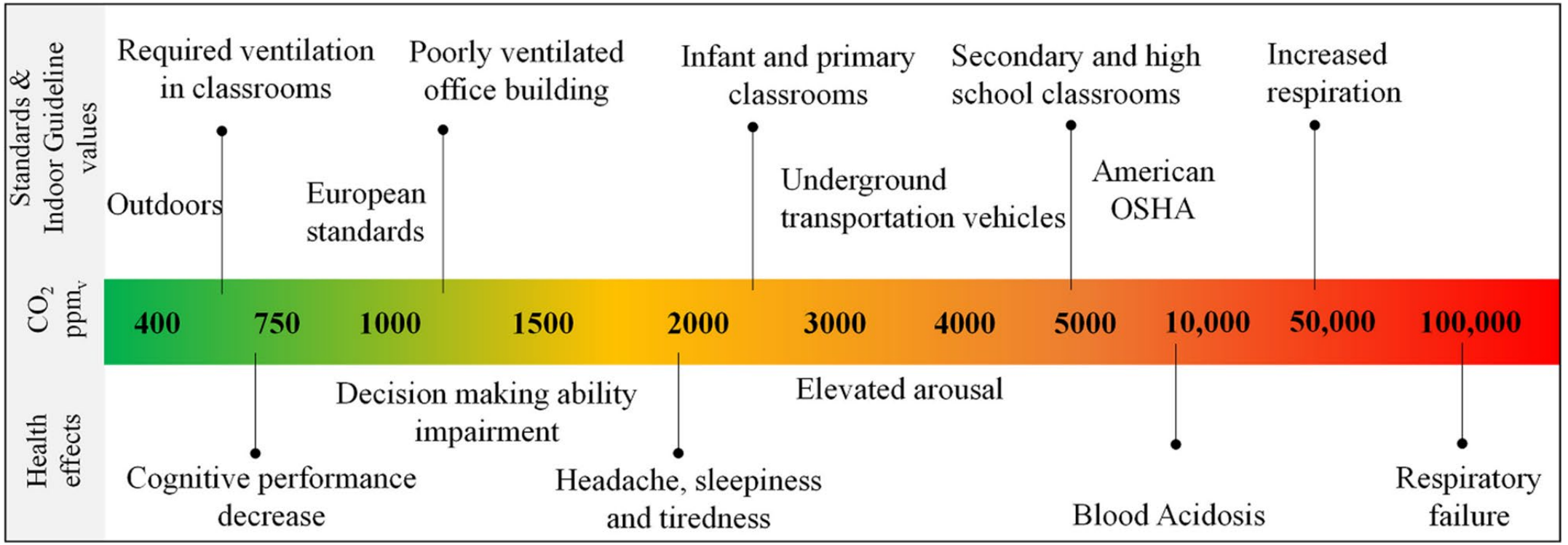
Air Ducts Distribution on Ceiling



Case Study: Bishop-Favrao Hall (BFH), Classroom Hall 210

Indoor Air Quality Guideline Values for CO2 vs Health Effects

(López et al., 2023)

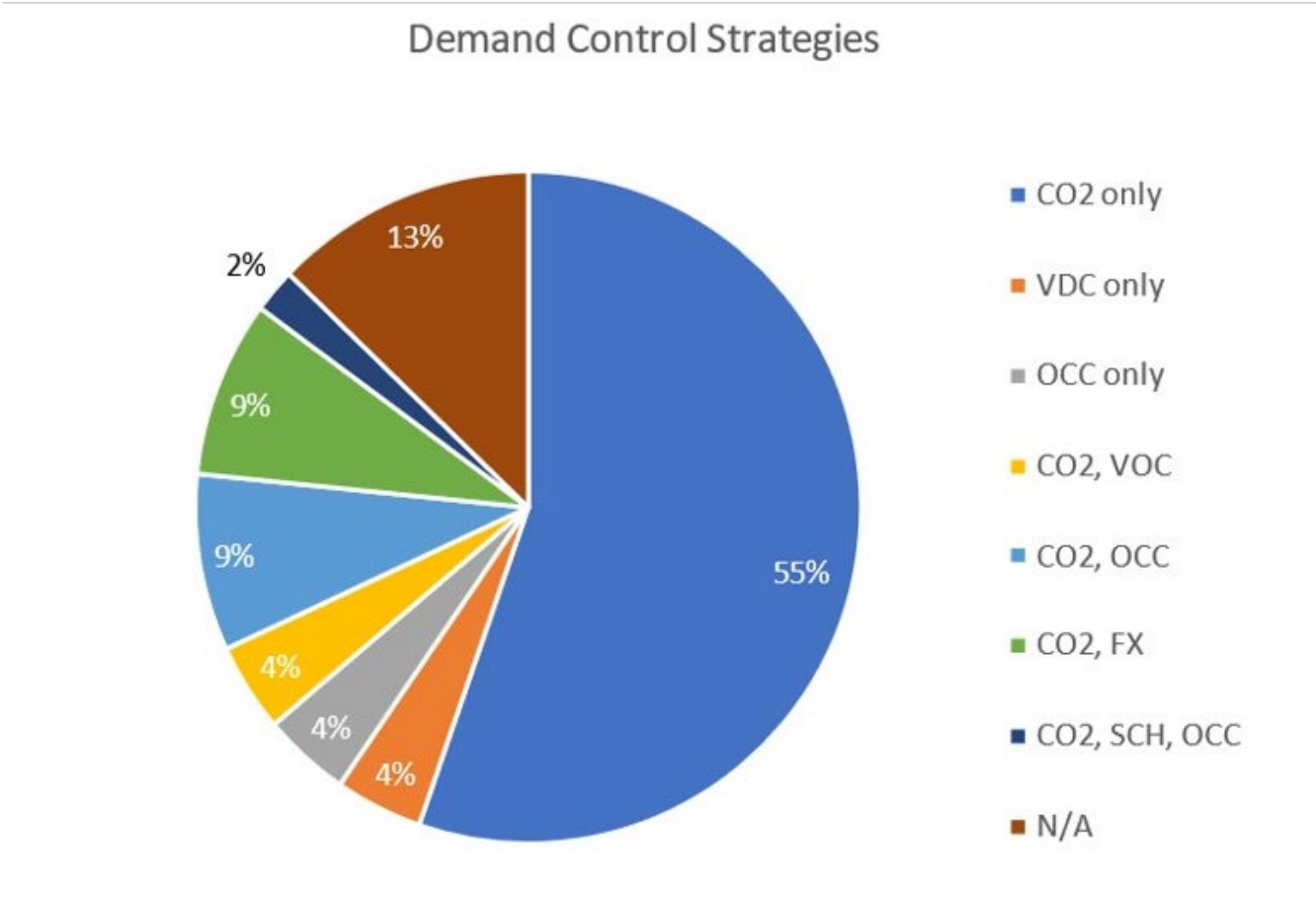


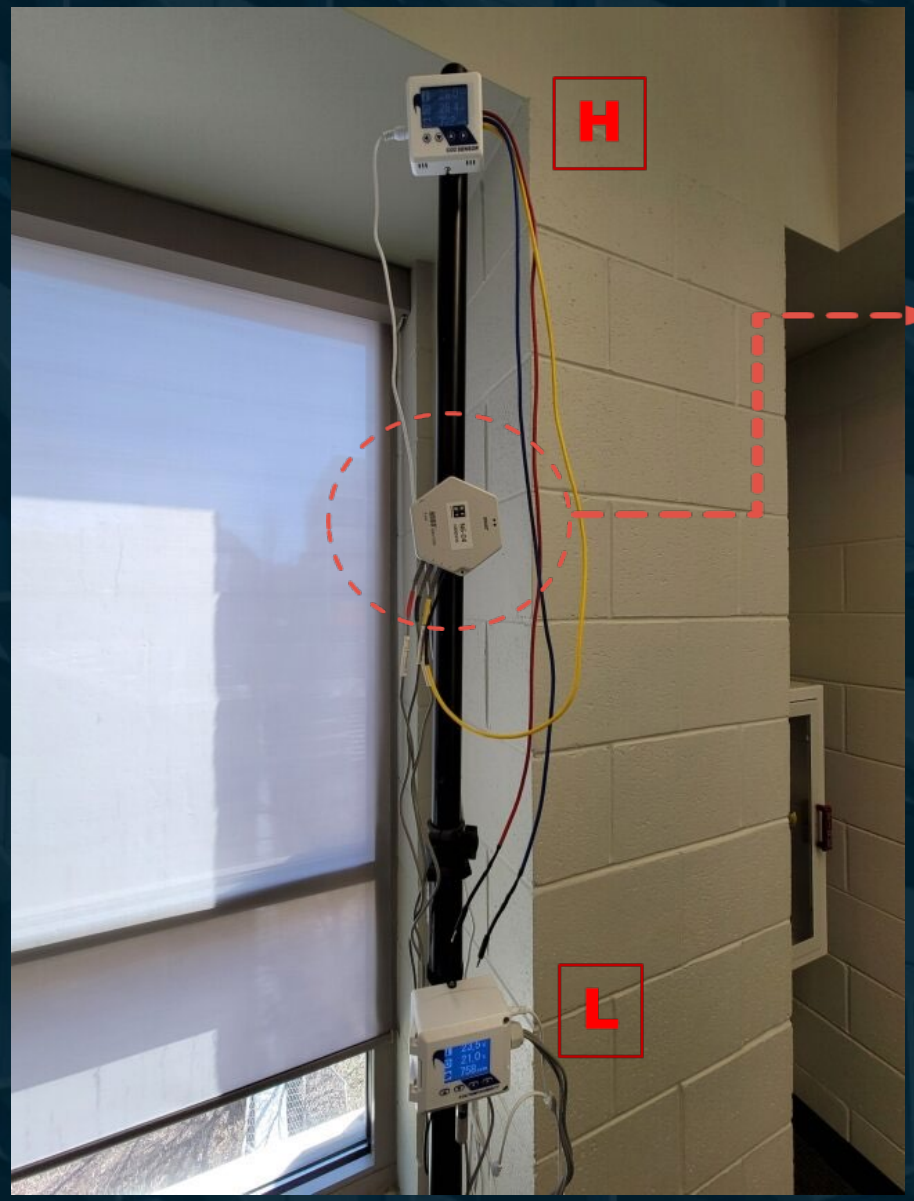
BEST6

Effective Healthy Ventilation Systems

The Most Energy-Efficient Ventilation Systems

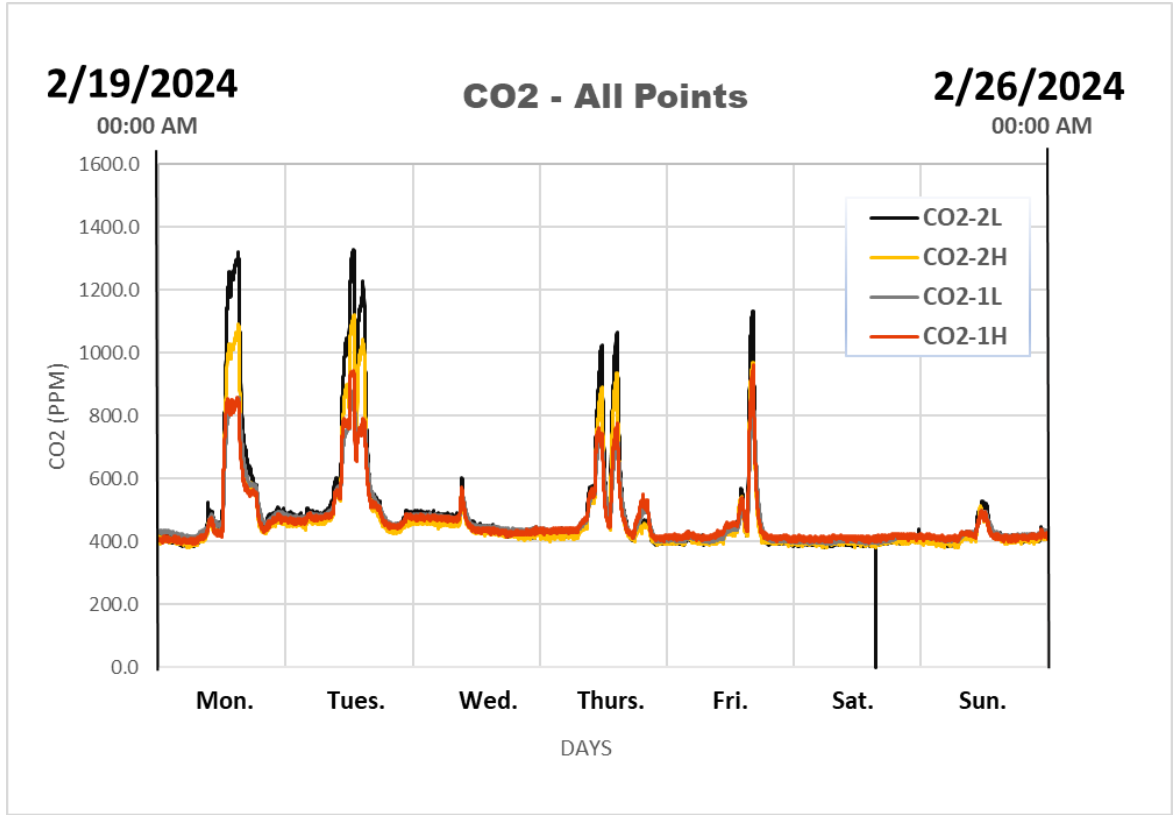
- ❑ **Heat Recovery Ventilation (HRV)**
- ❑ **Energy Recovery Ventilation (ERV)**
- ❑ **Demand Controlled Ventilation (DCV)**





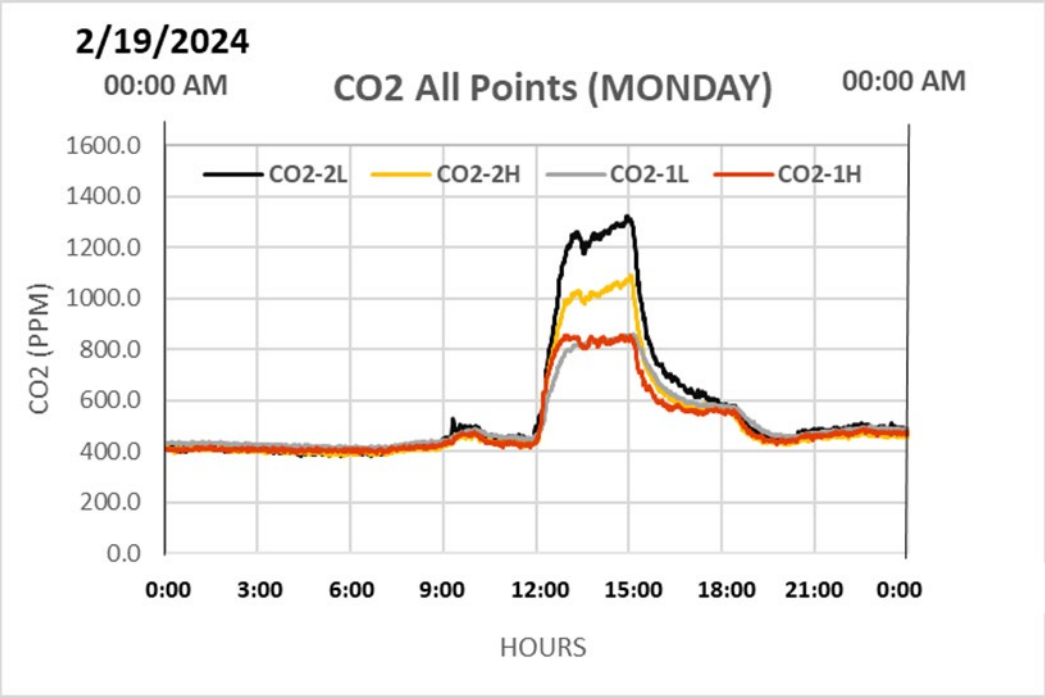
Dual Beam NDIR CO2 Sensors used for the experiment

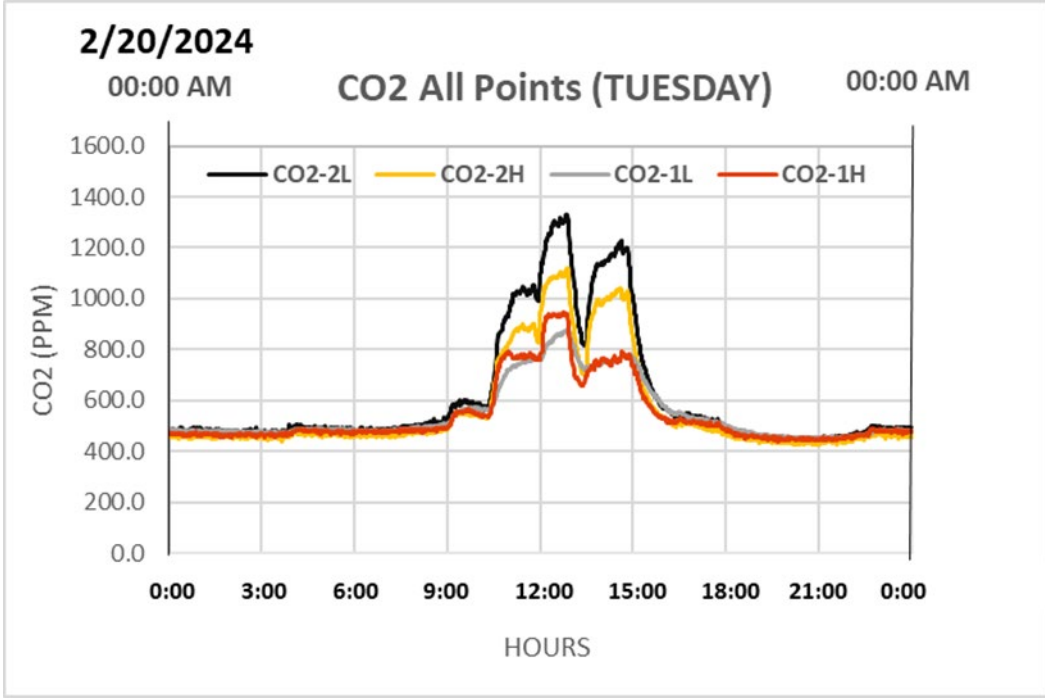
CO2 Concentration Levels Over a Week



CO2 Concentration Levels Over Weekdays

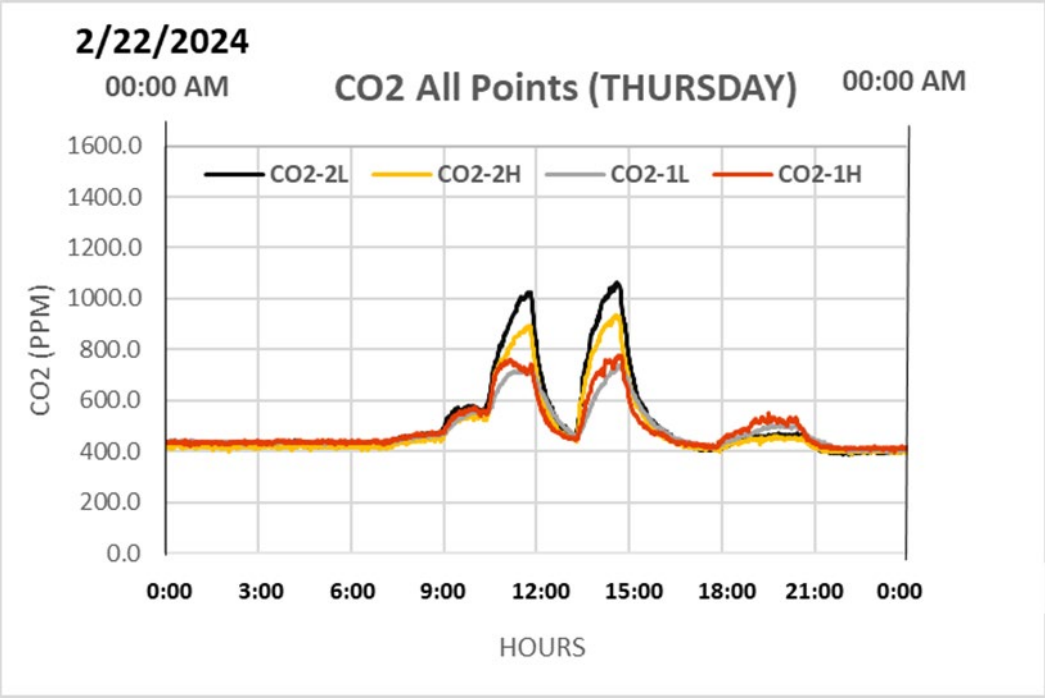
Examples for Monday / Tuesday

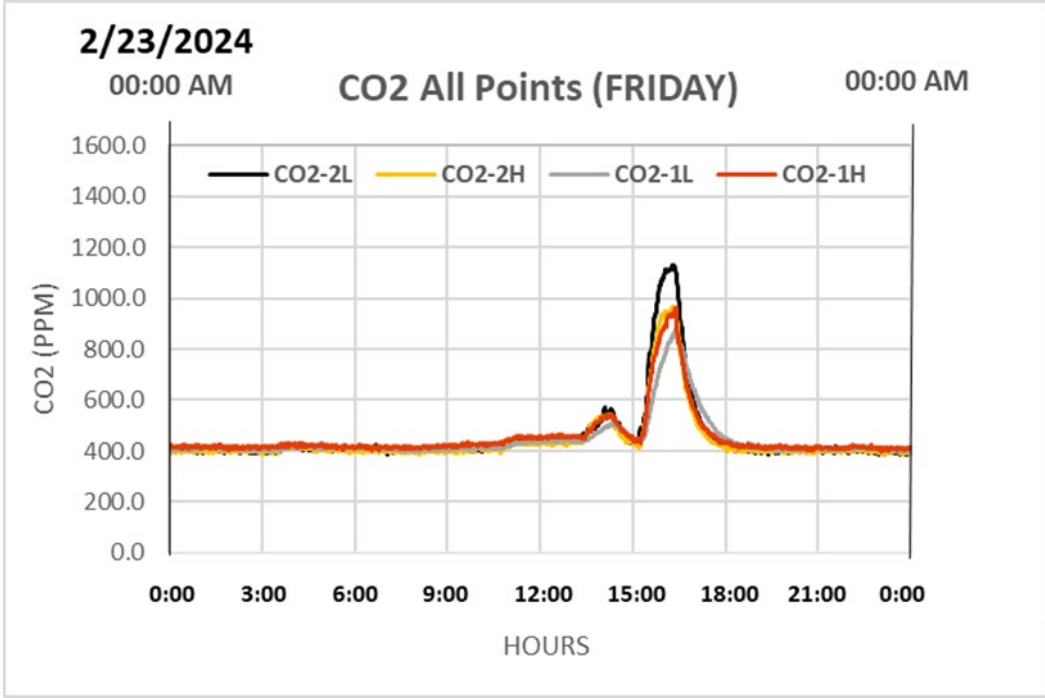




CO2 Concentration Levels Over Weekdays

Examples for Thursday / Friday





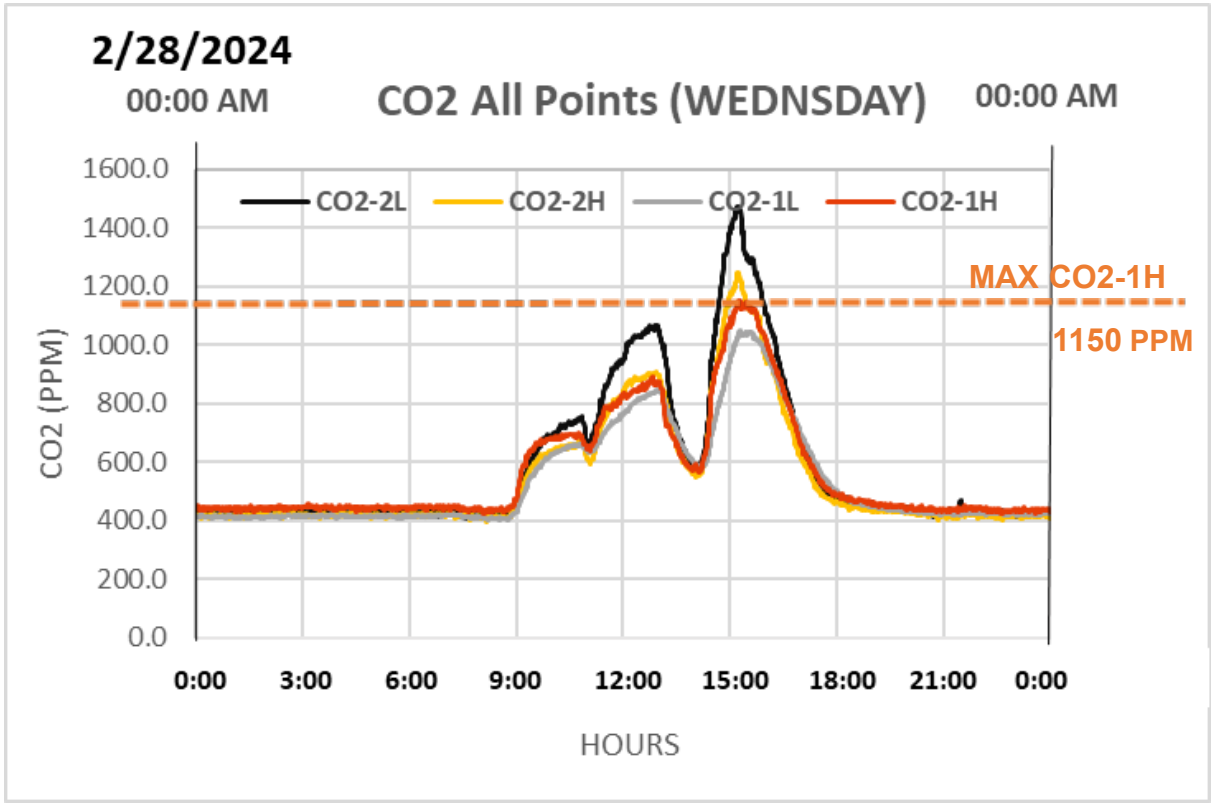
Average and Peak Load Measurements

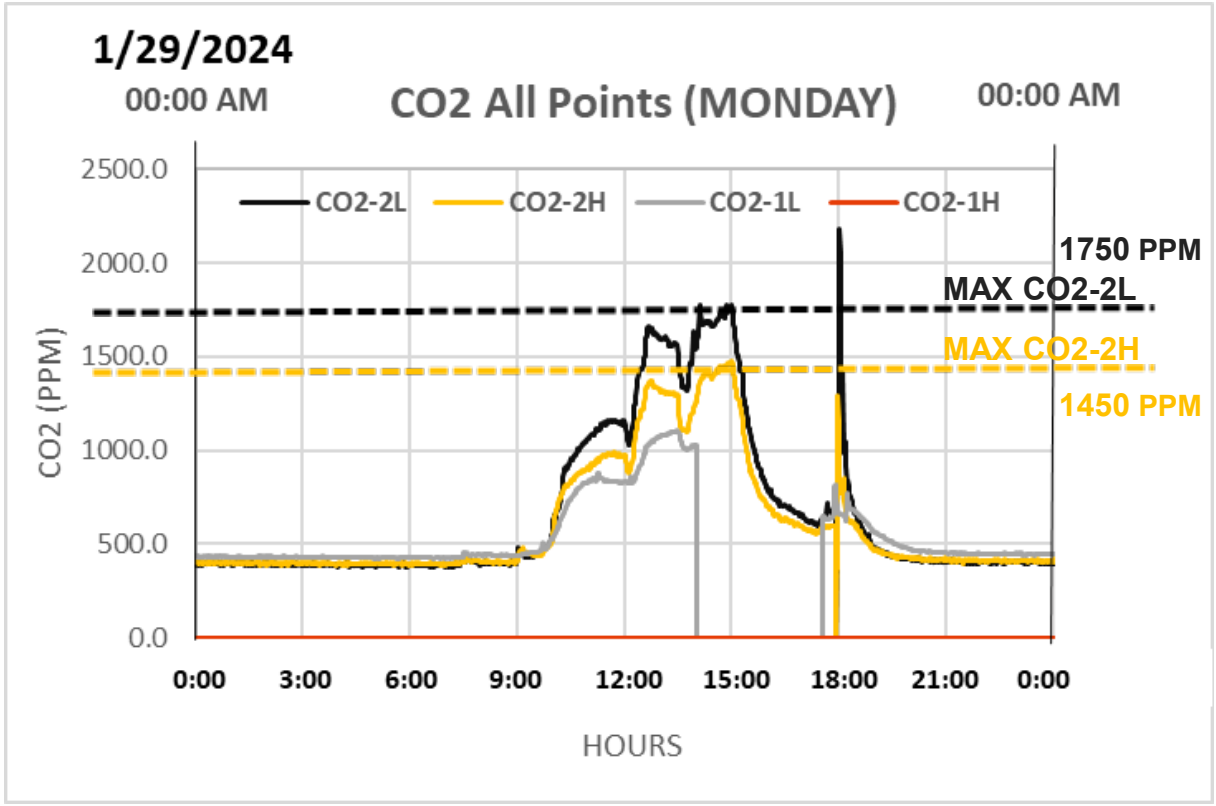
POINTS	1L	1H	2L	2H
MEAN (Occupied), PPM	507	525	568	542
MIN (Non-Occupied) CO2*, PPM	450	-	423	417
MAX ,PPM	1400	1150	1750	1450
Time of MAX values	**MON 10:14**	**WED 14:27**	**MON 13:18**	**MON 14:10**
% Percentage of Non-acceptable values (>1000)	%1	%1	**%9**	**%5**
% Percentage of Non-ideal values for cognitive performance (>750)	%7	%10	**%15**	**%14**

The average outdoor CO2 concentration is 430 (ppm).

The Concerning CO2 Concentration Level:

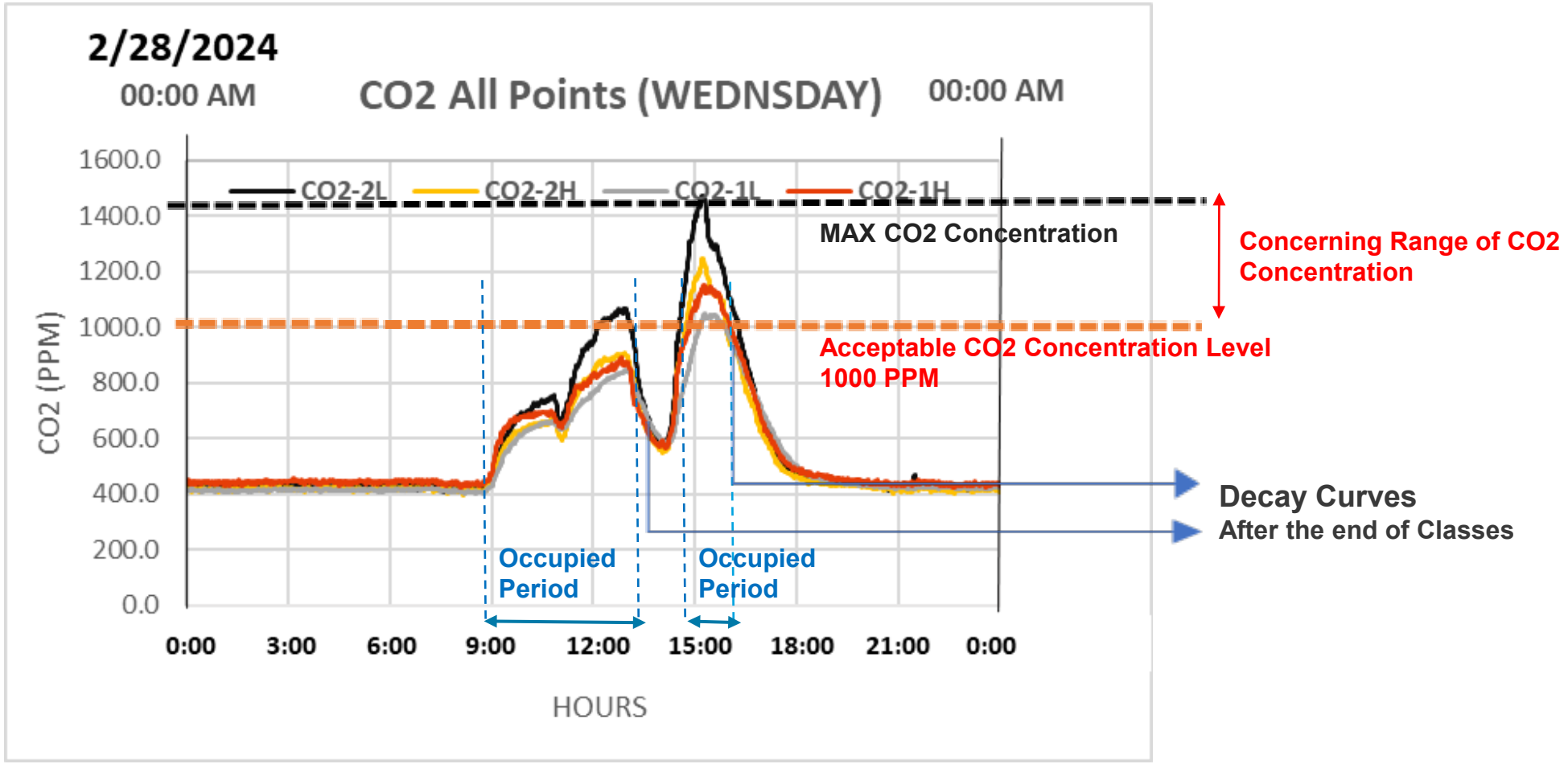
The maximum (critical days) for the points 1H, 2L, and 2H





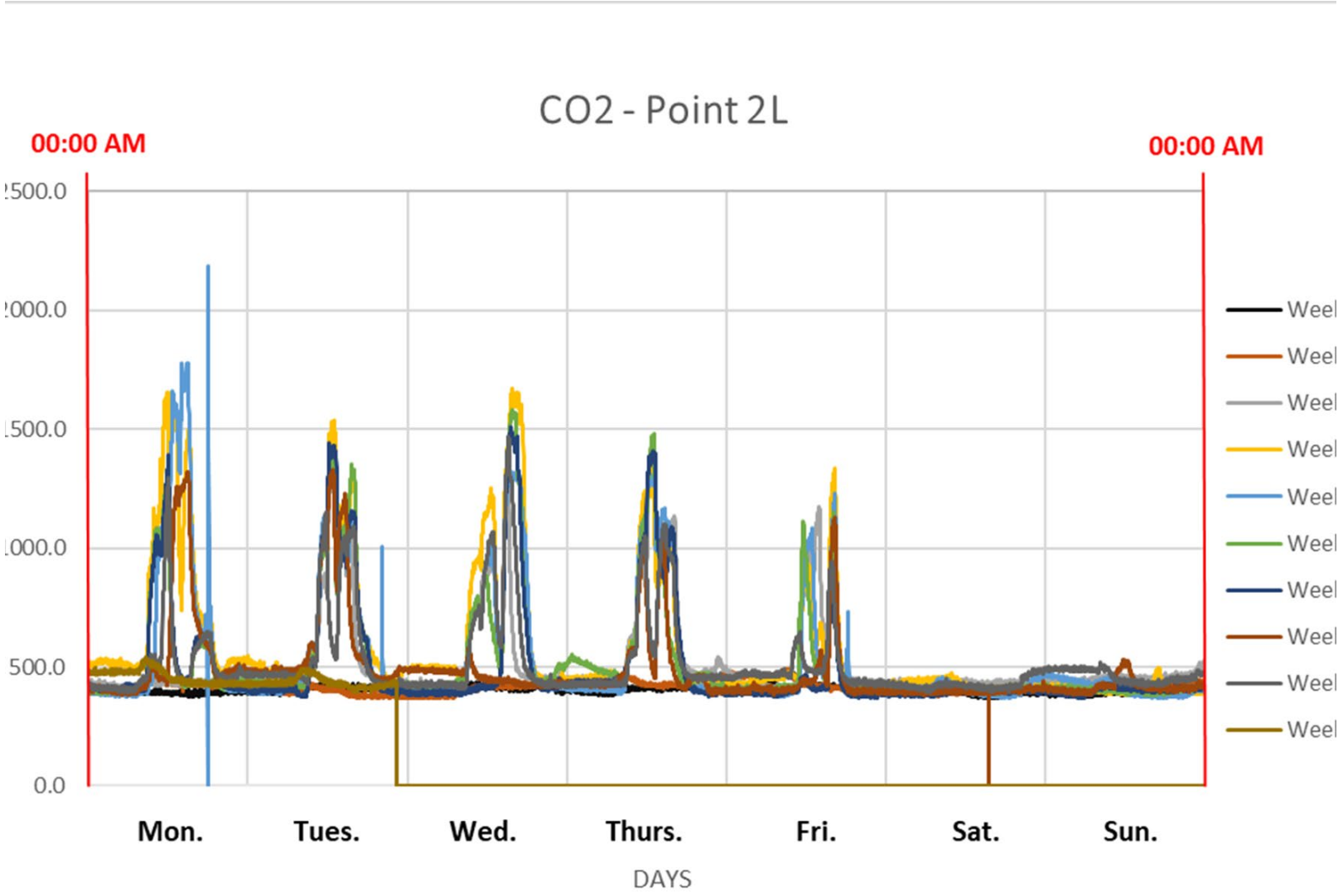
Concerning CO2 Concentration Levels

The maximum (critical days) for the points 1H, 2L, and 2H



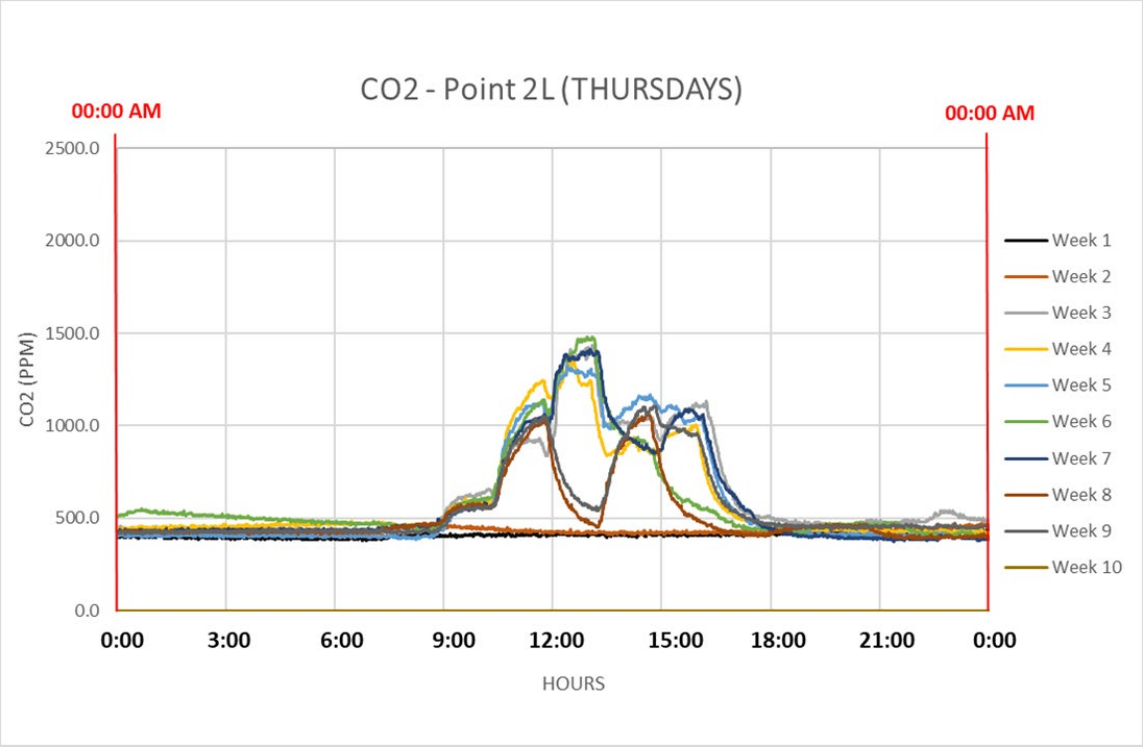
Weeks Overlays at the Critical Point (2L)

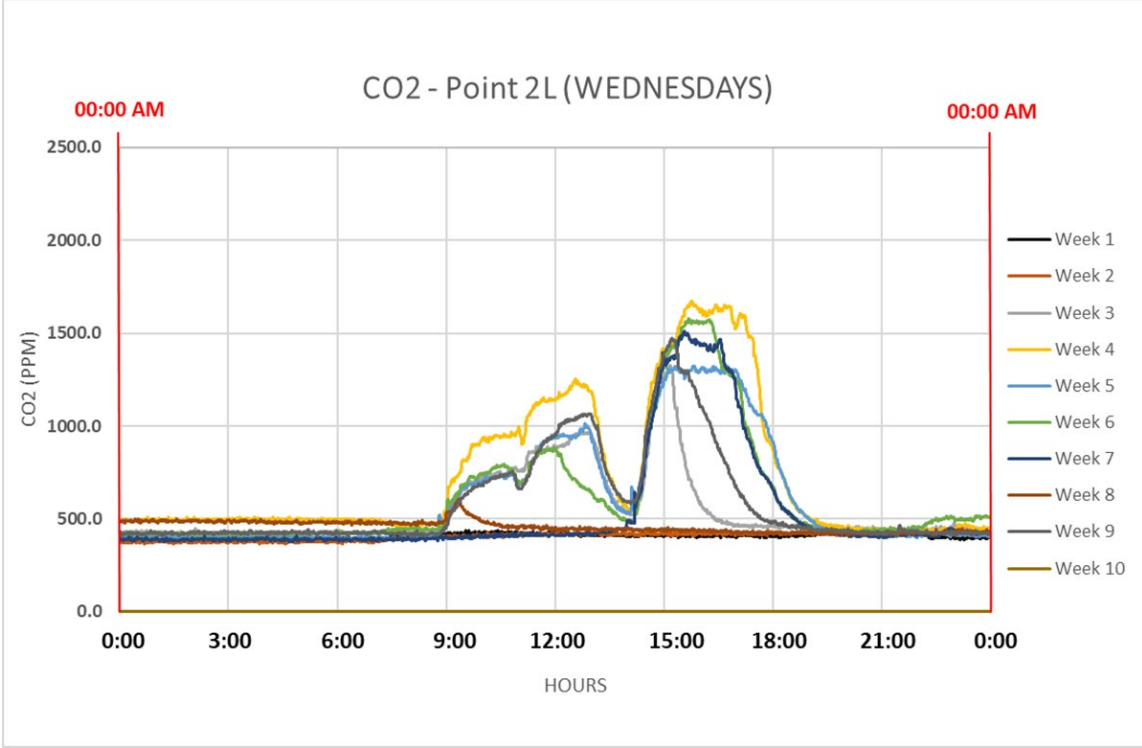
Highest CO2 Concentration Levels



Workdays Overlays at the Critical Point (2L)

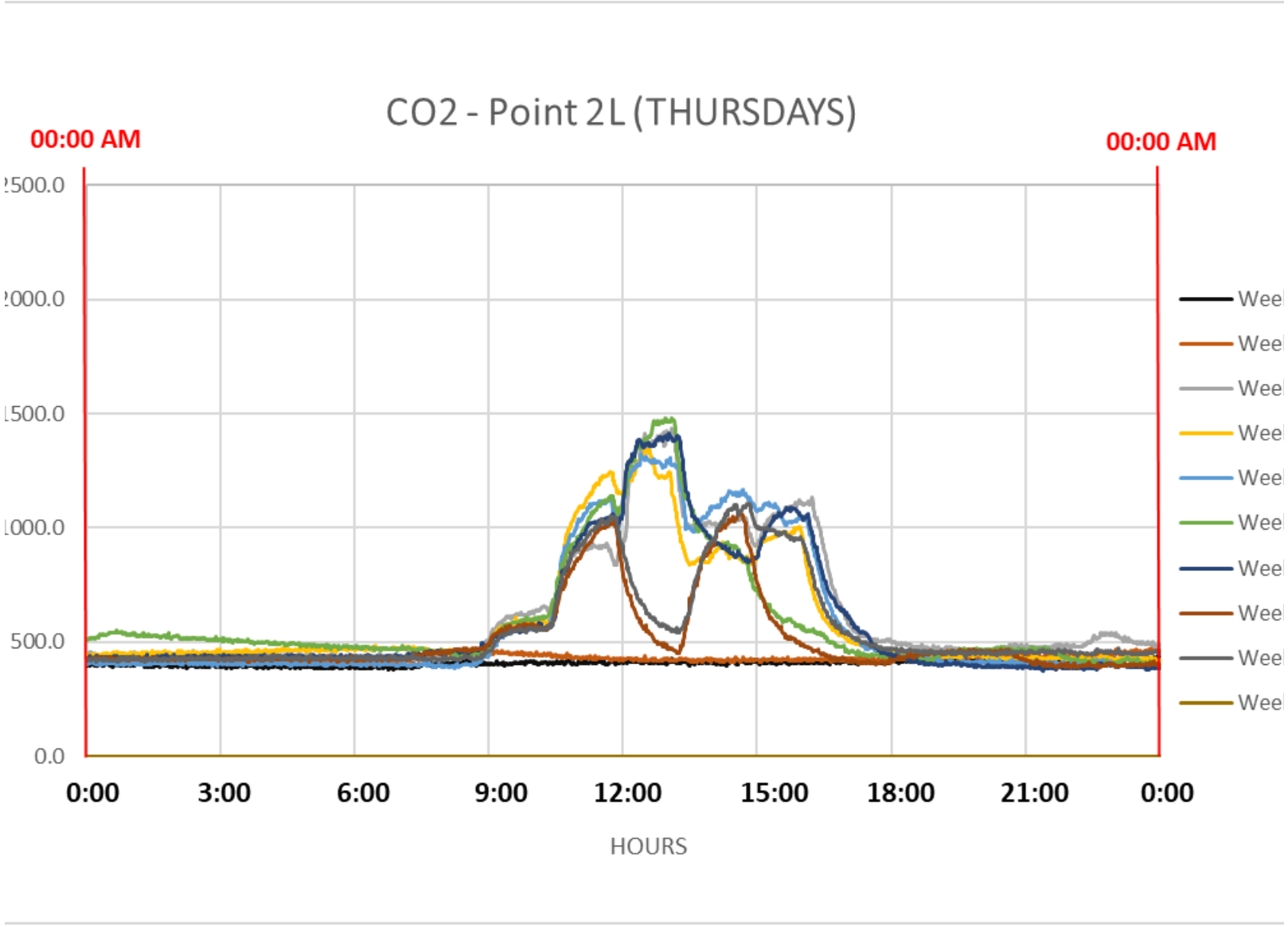
Similar pattern on each workday





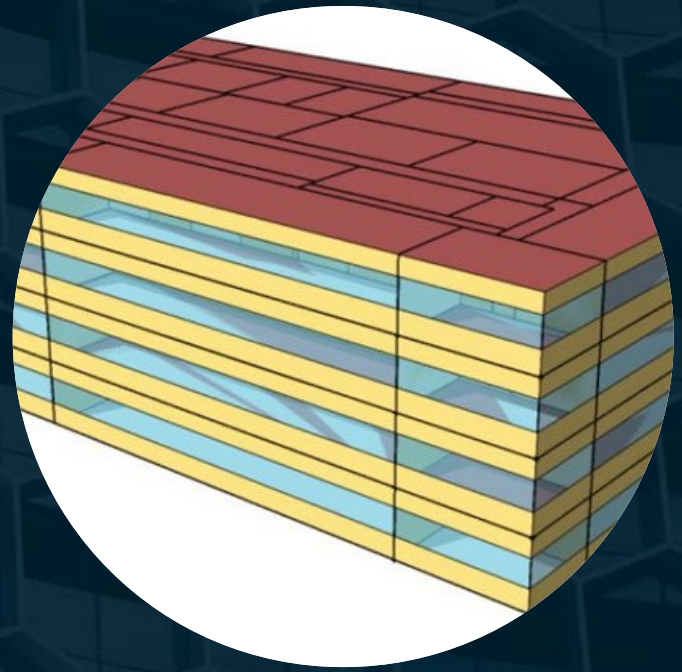
Overlay of CO2 concentrations on same weekday

Used for development of load schedules for building systems simulations



Building Performance Simulations

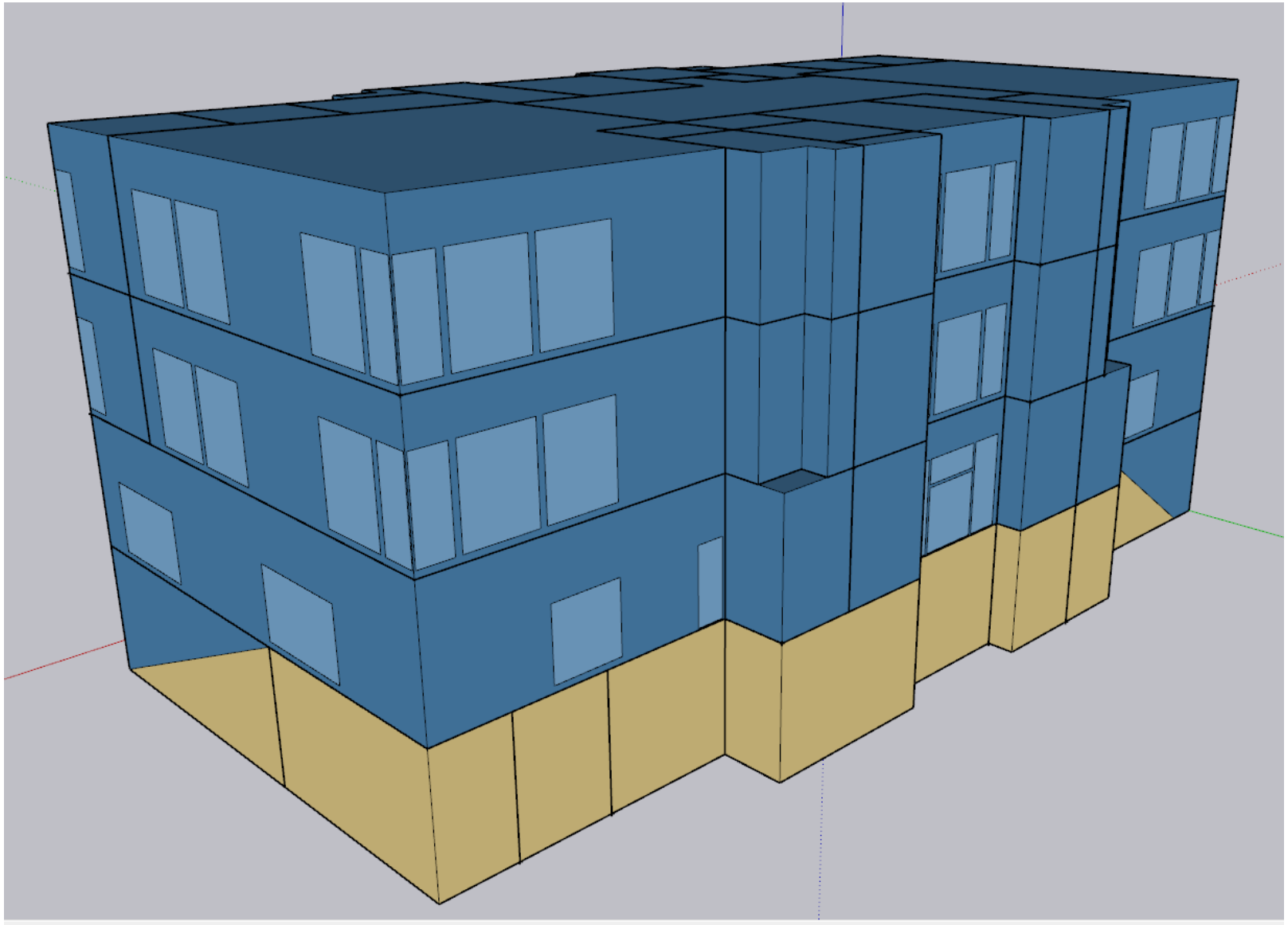
OpenStudio & EnergyPlus Modeling



Fully-detailed
Energy+ Model

4-pipe FCUs

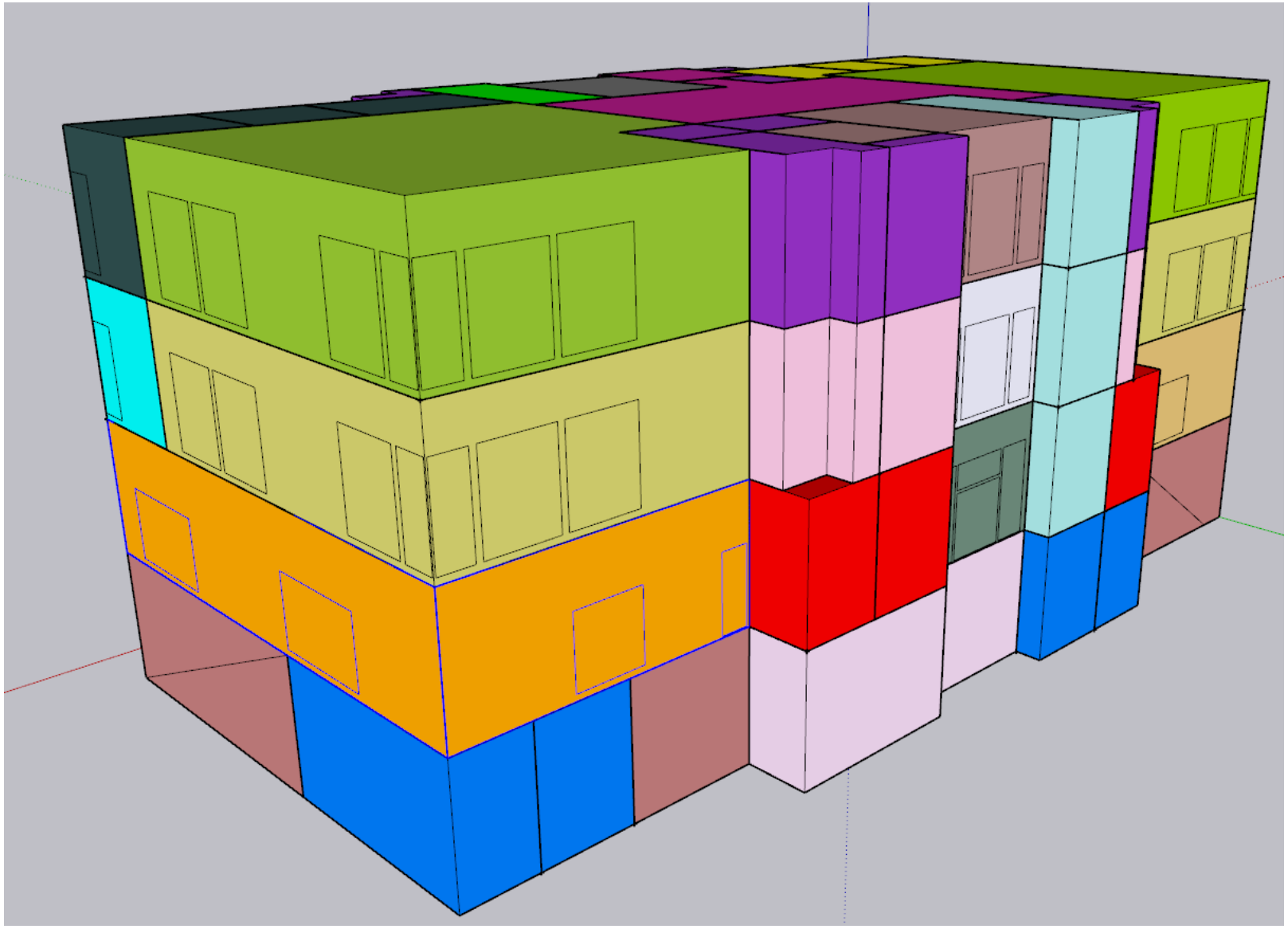
+ DOAS (CV)



12 different
Space Types

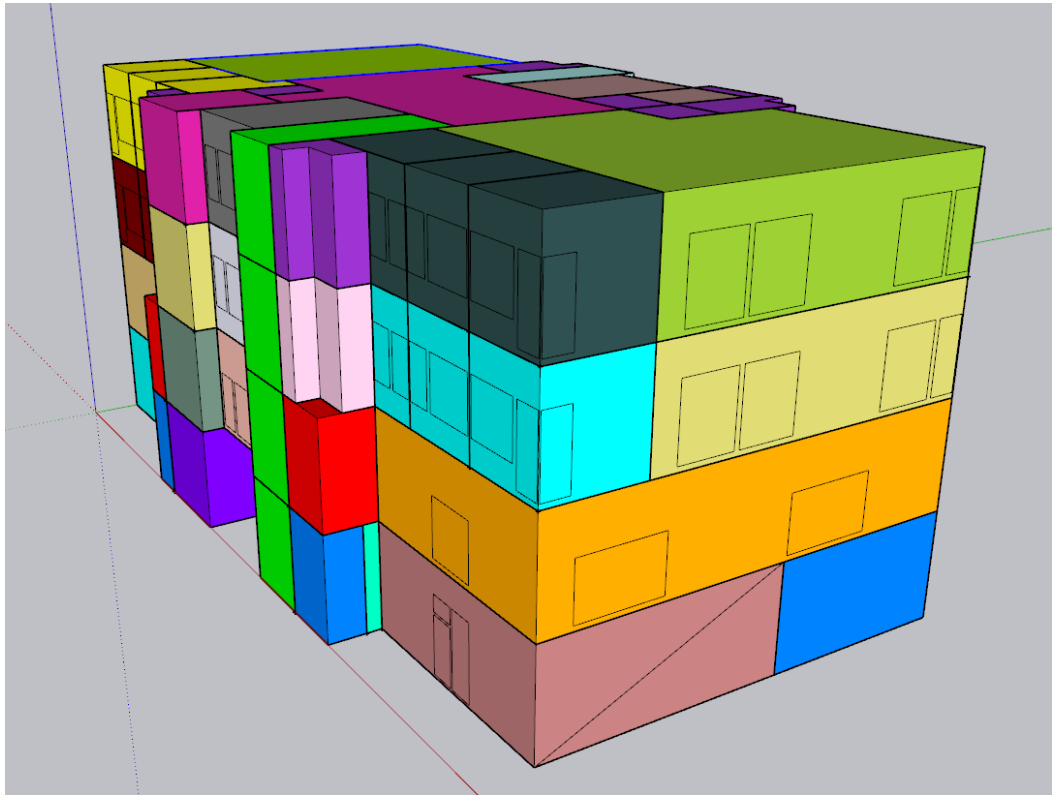
30+ Thermal Zones

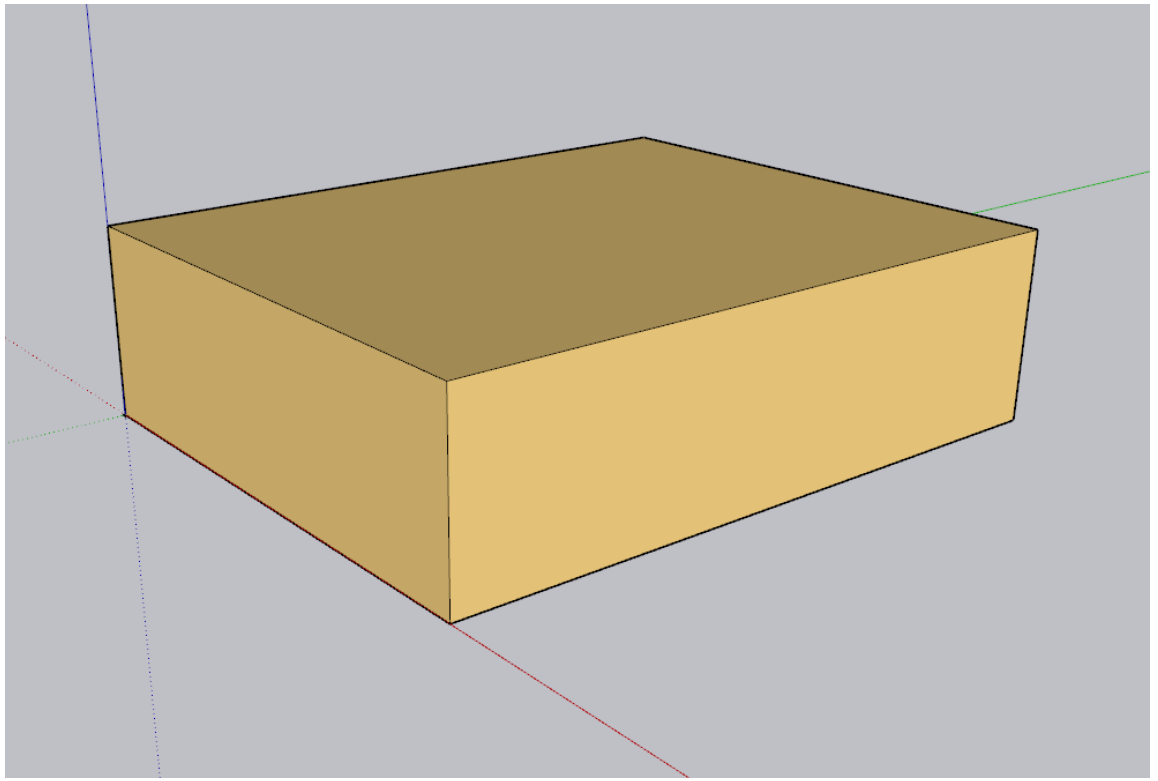
40+ FCUs / CUH / UH



Calibration and Analysis on Reduced Model

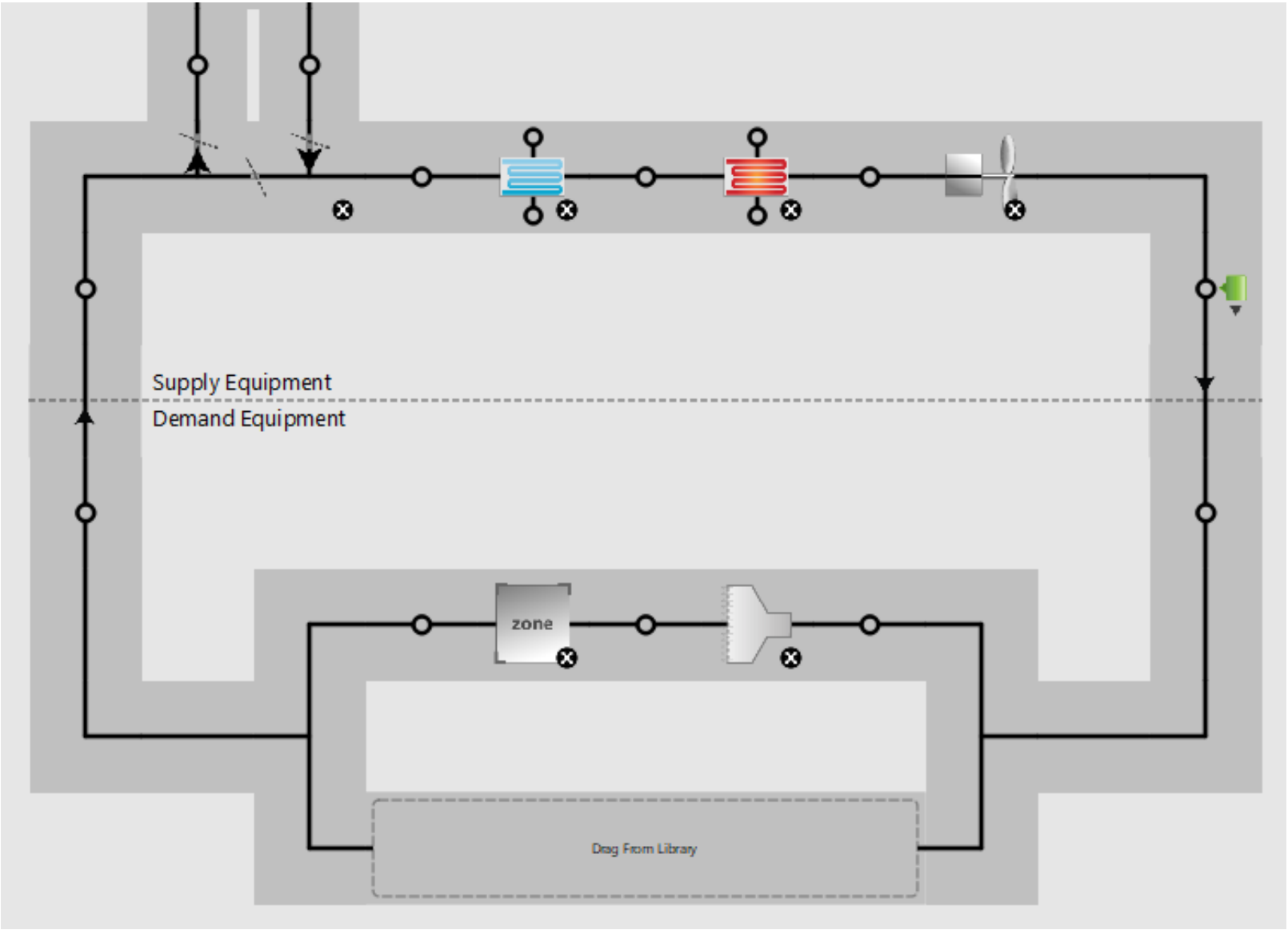
CO2 Analysis can be easily extracted



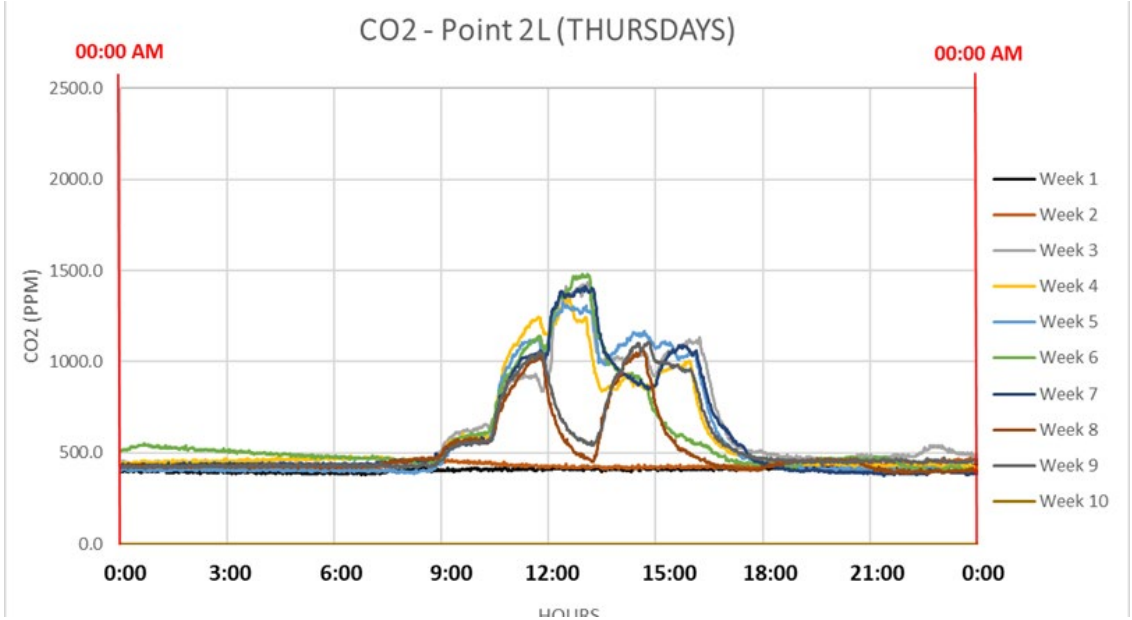


Dedicated Outdoor Air System (DOAS) with preconditioned constant-volume (CV) fresh air supply

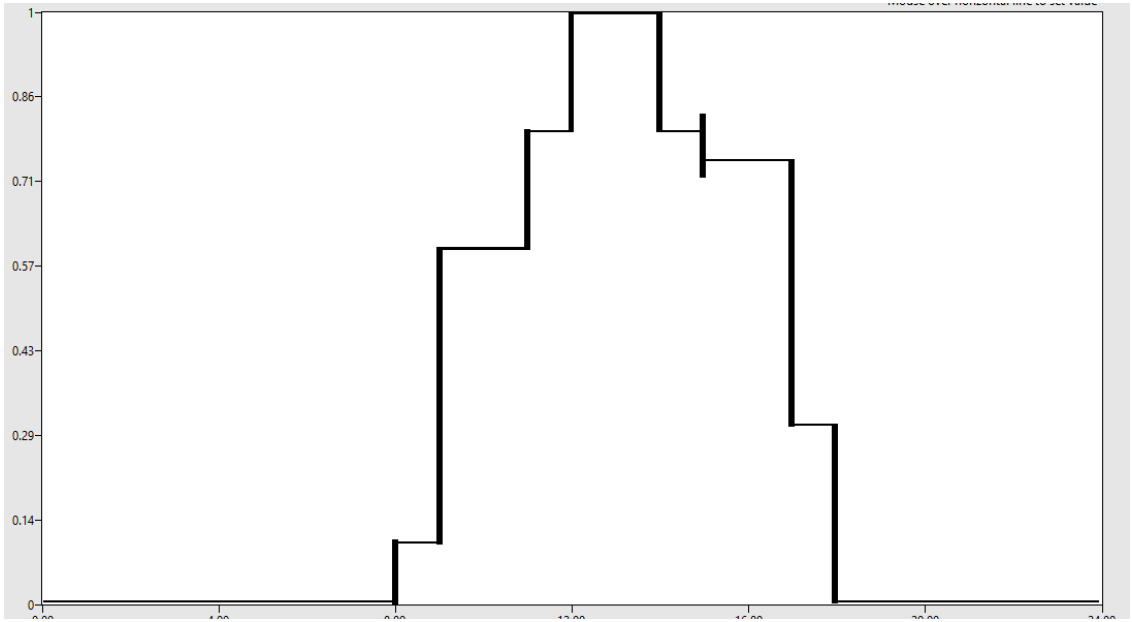
Single-zone problem with occupancy-driven fresh air demand



Transposing CO2 measurements into Occupancy Schedules



CO2 “Load Profile” measured in-situ over 10 weeks



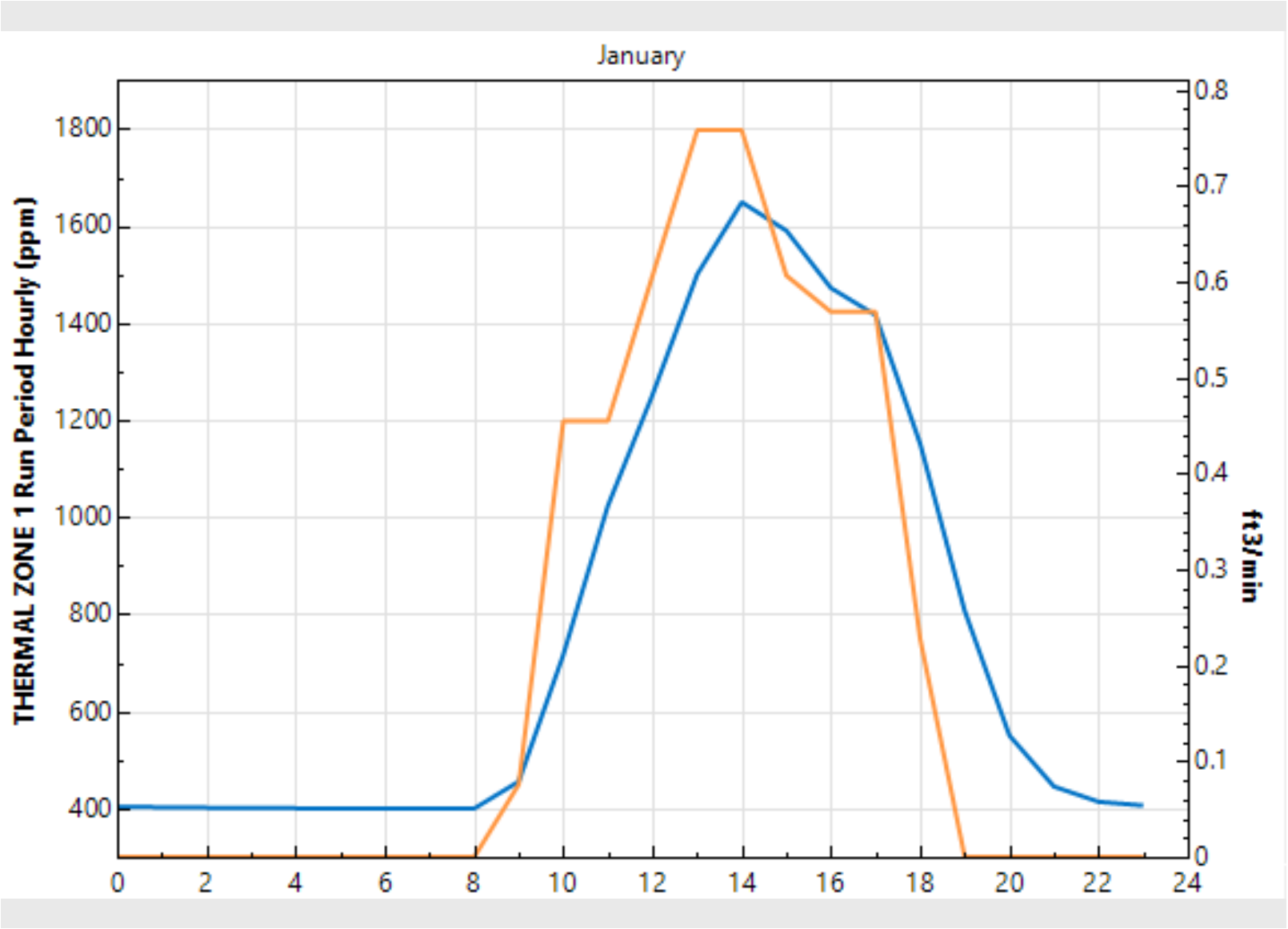
Prescriptive Occupancy Schedule as “CO2-Load”

Fresh Air Supply
of 500cfm

for 2000 sf

with up to
100 students

Peaks
at
1600 ppm

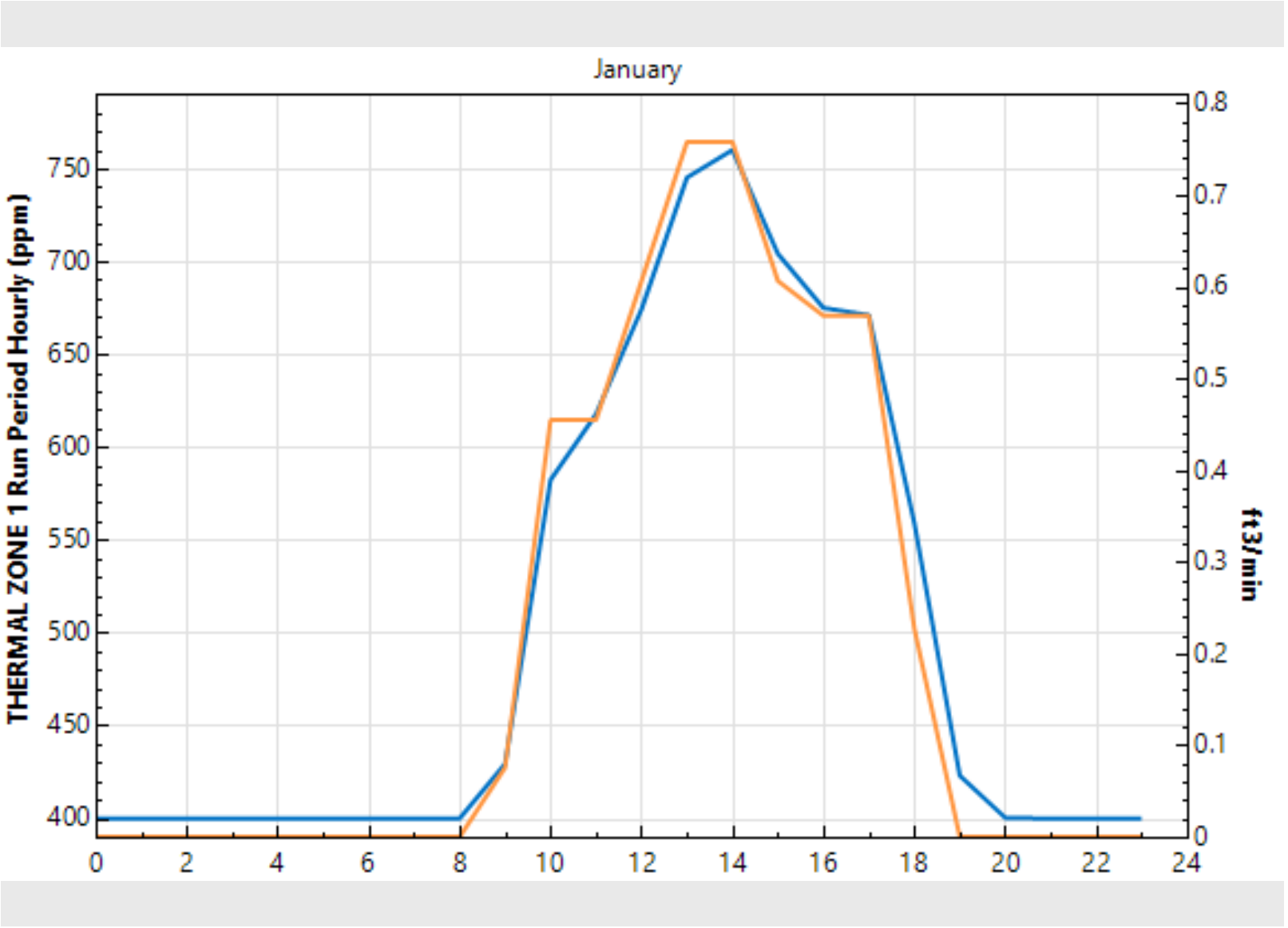


Fresh Air Supply
auto sized **2000**cfm

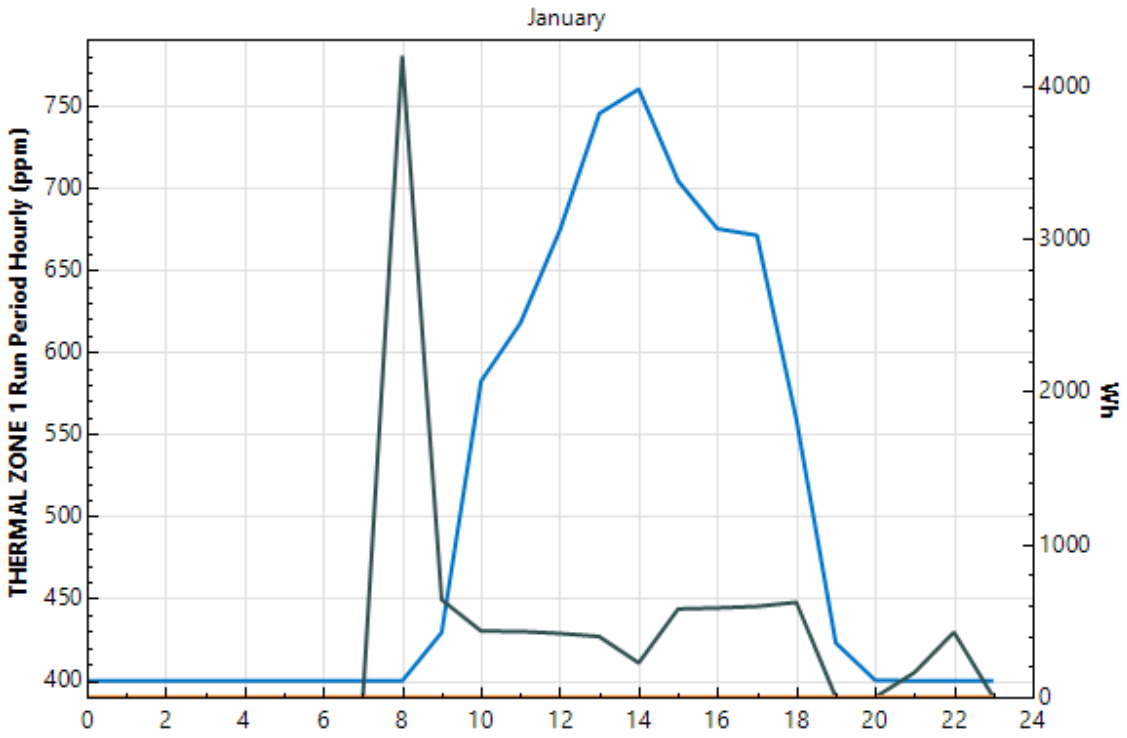
for 2000 sf

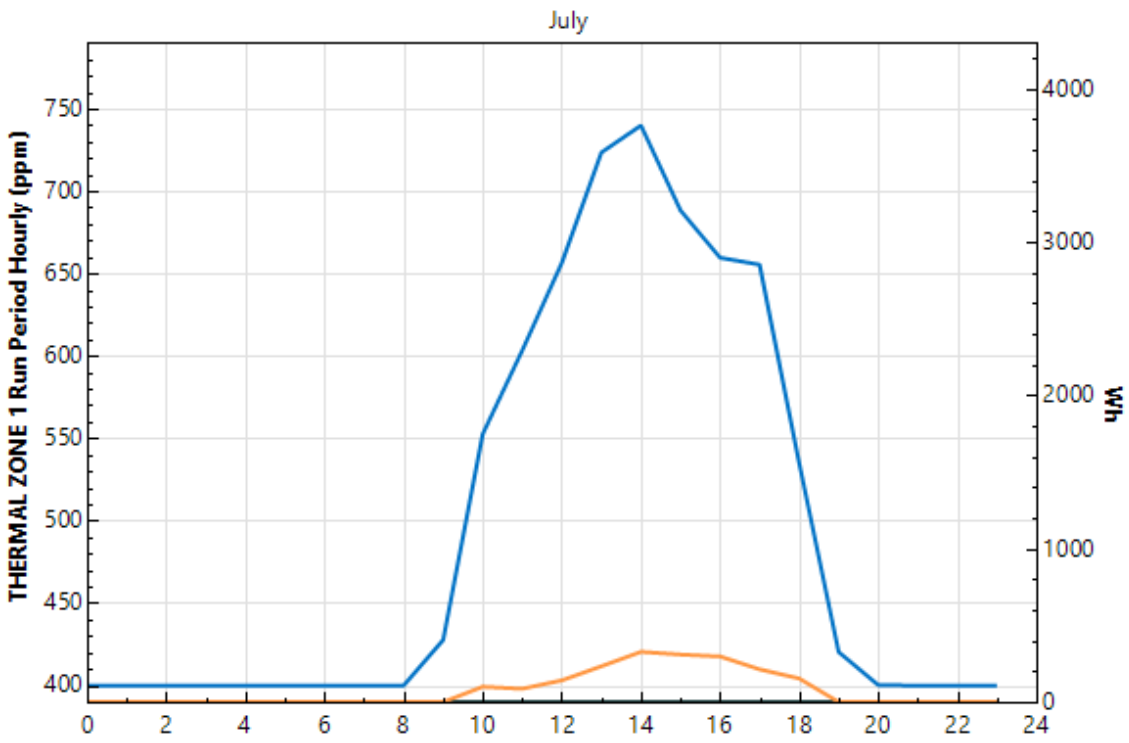
with up to
100 students

Maintains
under
750 ppm



Ventilation Heating/Cooling Load Increase





Demand Criteria Towards Specific Space Needs in Net-Zero High-Performance Buildings

Healthy Environments

Cost to Society

Cognitive Performance

Productivity Cost

Energy Performance

Energy Cost

Cost Benefit Analysis Framework

Thank You