

Integration of Airflow and Energy Simulation using CONTAM and TRNSYS

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Introduction

- Why?
- Program choices
- Methods
- Issues
- Preliminary results

Why?

- Influence on building energy usage of infiltration and ventilation rates
- Proof of concept – combining separate airflow and building energy modeling programs

Software Used – Airflow

- CONTAM
 - Multi-zone airflow and contaminant dispersal program
 - Construct a network of elements describing the flow paths
 - Zones represented by nodes modeled at a uniform temperature and pollutant concentration

Software Used – Building Energy

- TRNSYS
 - Transient system simulation program with modular structure
 - Simulation engine allows connecting system components, solving differential equations, and input/output control
 - Thermal building model includes heat transfer by conduction, convection and radiation, heat gains from occupants and equipment, and the storage of heat in the room air and building mass

TRNSYS - CONTAM Integration

- Ping-Pong vs Onion
- Full integration vs Separate models
- New TRNSYS type
- Solution uniqueness

Building Source

- PNL research reports
- 25 existing stock (as of 1979)
- 5 future construction (1980-1995)
- Includes load and setpoint schedules
- Size range: 1 to 45 floors, 6,200 to 2,480,000 ft² (576 to 230,399 m²)
- Located in cities throughout the US

Physical Models

- Simplified floor plans – geometric forms, such as “T” or “L”
- Occupied floor and plenums
- Standard building material properties
- Wall-to-Window ratio
- Wingwalls – included shading of building
- Zoning – every floor
- Elevators – single zone entire height of building

HVAC Parameters

- Schedules – lighting, receptacle, occupancy (weekdays, Saturdays, Sundays)
- Setpoints – Setpoint and set-up/set-back
- Fan operation schedule
- Economizers – “ideal” model
- Weather – TMY2

Airflow Paths

- Infiltration – any zone with exterior wall
- Inter-Zonal – between adjacent zones
- Parameters
 - Leakage values based on age and construction
 - Distributed at 3 heights for each floor and 2 for each plenum
 - Internal zones connected with two-way flow elements

Issues

- Number of Zones
 - How to limit by combining floors rather than eliminating floors from the models and using multipliers
 - Maintain overall geometry of buildings
- Airflow Paths
 - Are the inter-zonal paths important?

Number of Zones

- One building modeled with both single floors and combined floors
- Two floors combined into one floor in the model – except for top and bottom most floors
- 12 single floors vs 2 single and 5 combined floors
- Results show differences - so limit the use
- > 160 zones proved too computationally intensive
- 3 buildings contained more than 160 zones and had floors combined in the models

Inter-Zonal Airflow Paths

- One building modeled both with and without airflow between adjacent interior zones
- Results showed only small differences
- Little computational penalty – so leave the paths in the models

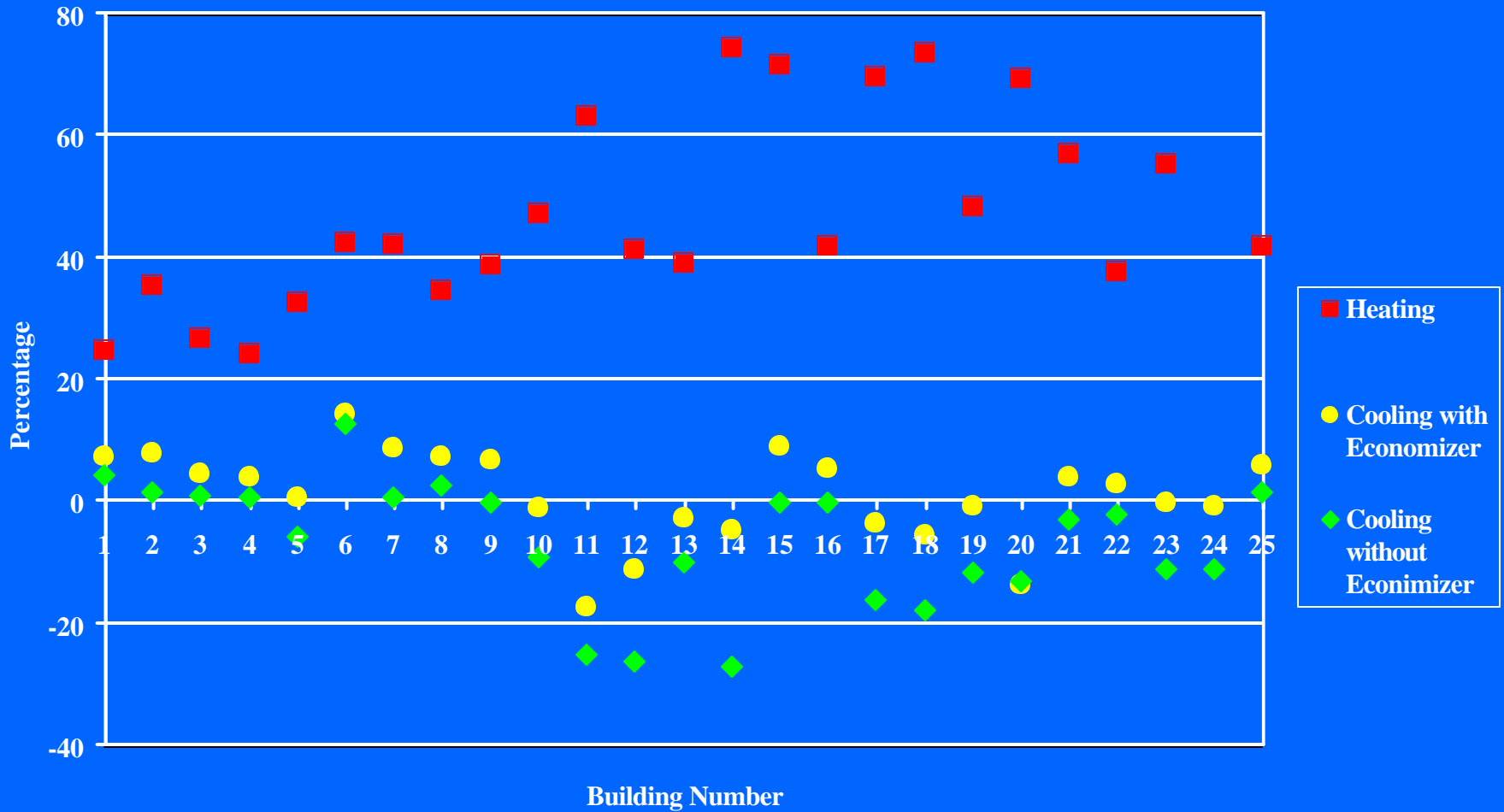
Simulations Run

- Building Pressurization Studies
 - Baseline – no infiltration, no inter-zonal airflow
 - Positive, neutral, negative building pressures
 - Ventilation outdoor air at 5 L/s/person (10 ft³/min/person)
- Ventilation Rate Studies
 - 0, 2.5, 5 & 10 L/s/person (0, 5, 10 & 20 ft³/min/person)
 - Neutral building pressure

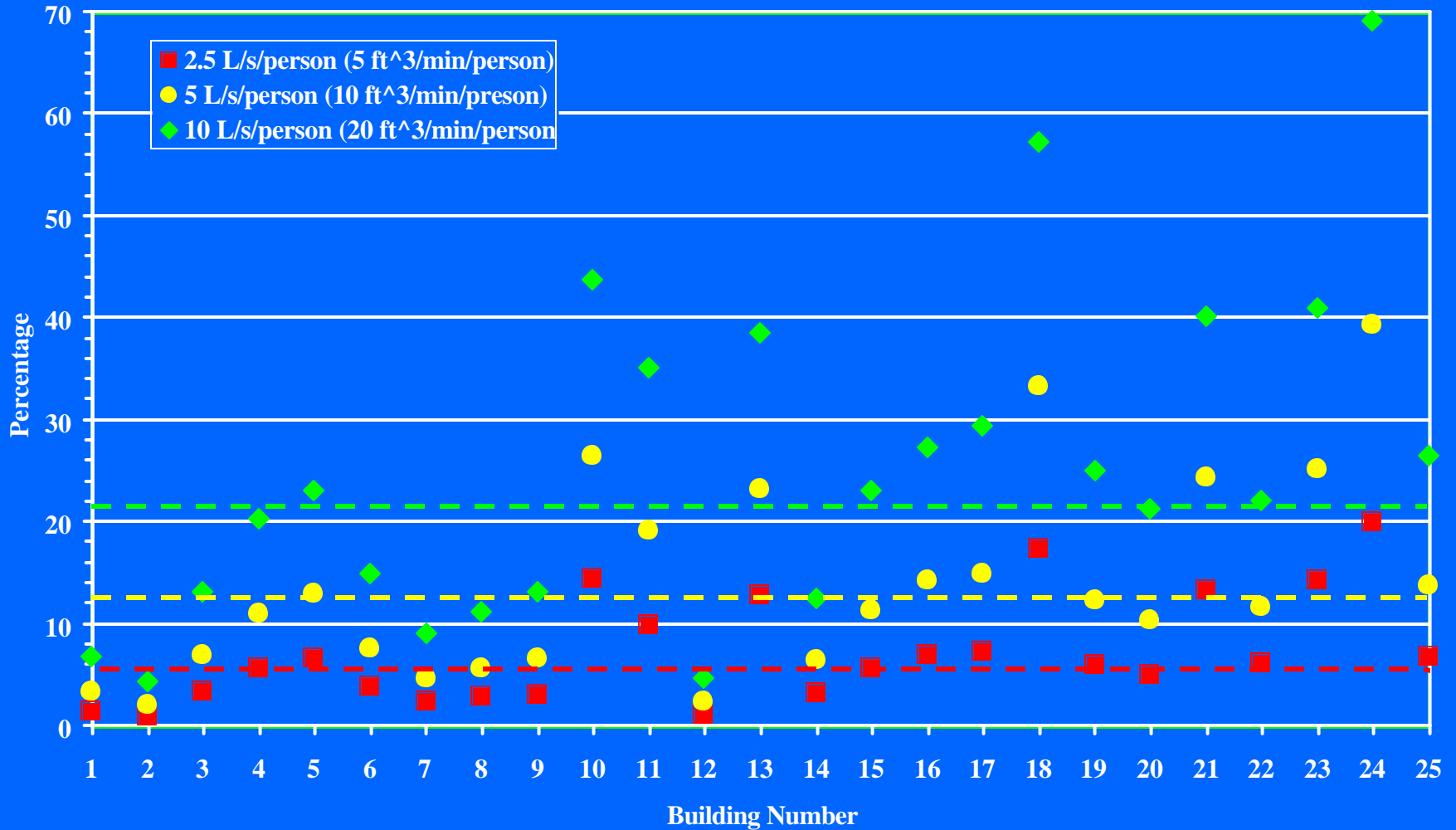
Preliminary Results

- Pressurization
 - Heating loads increased with increased infiltration
 - Cooling load changes depended on climate
- Ventilation
 - Heating loads increased with increased ventilation air
 - Cooling load changes depended on climate, but followed the same trends as the pressurization results

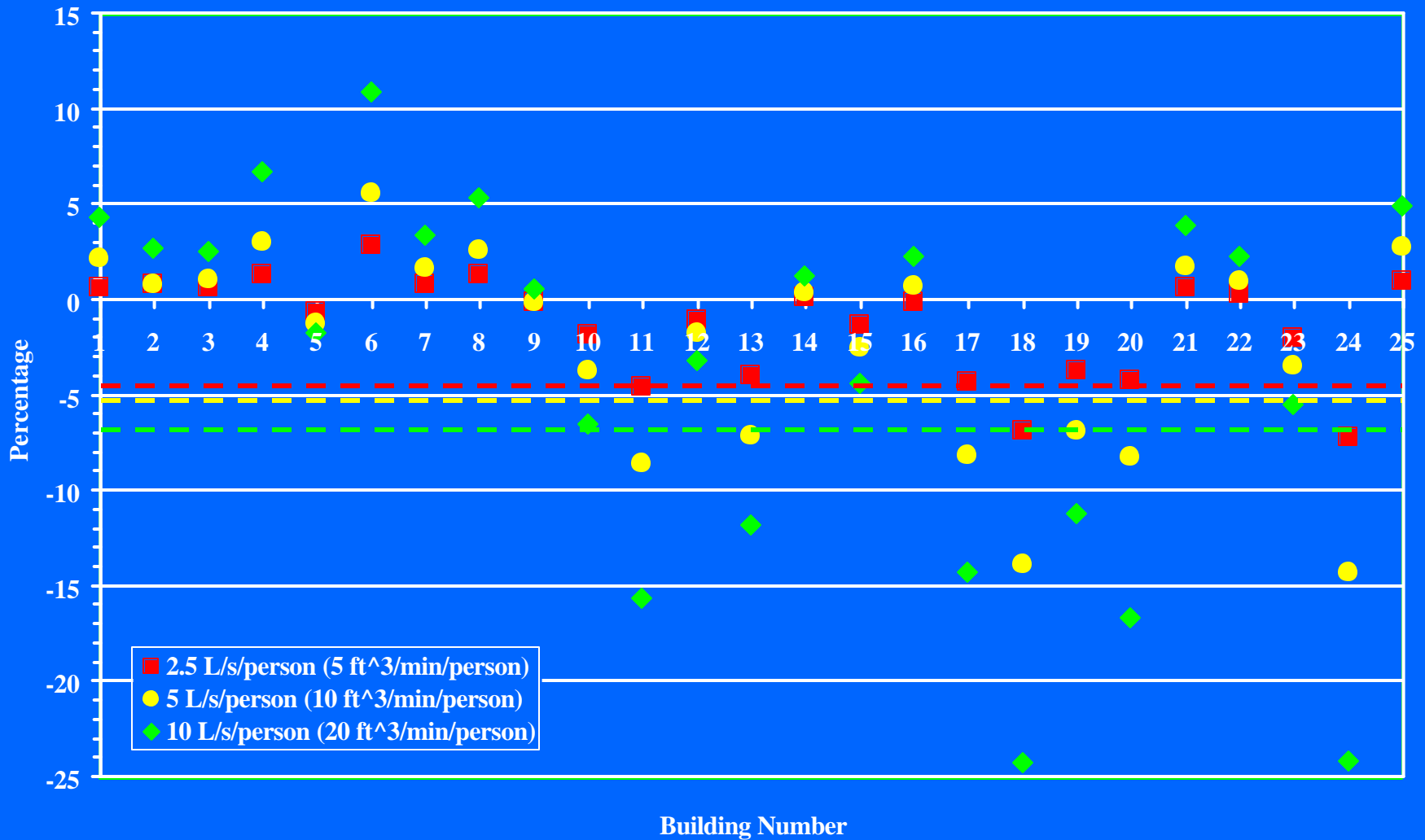
Percentage of Space Loads Due to Infiltration



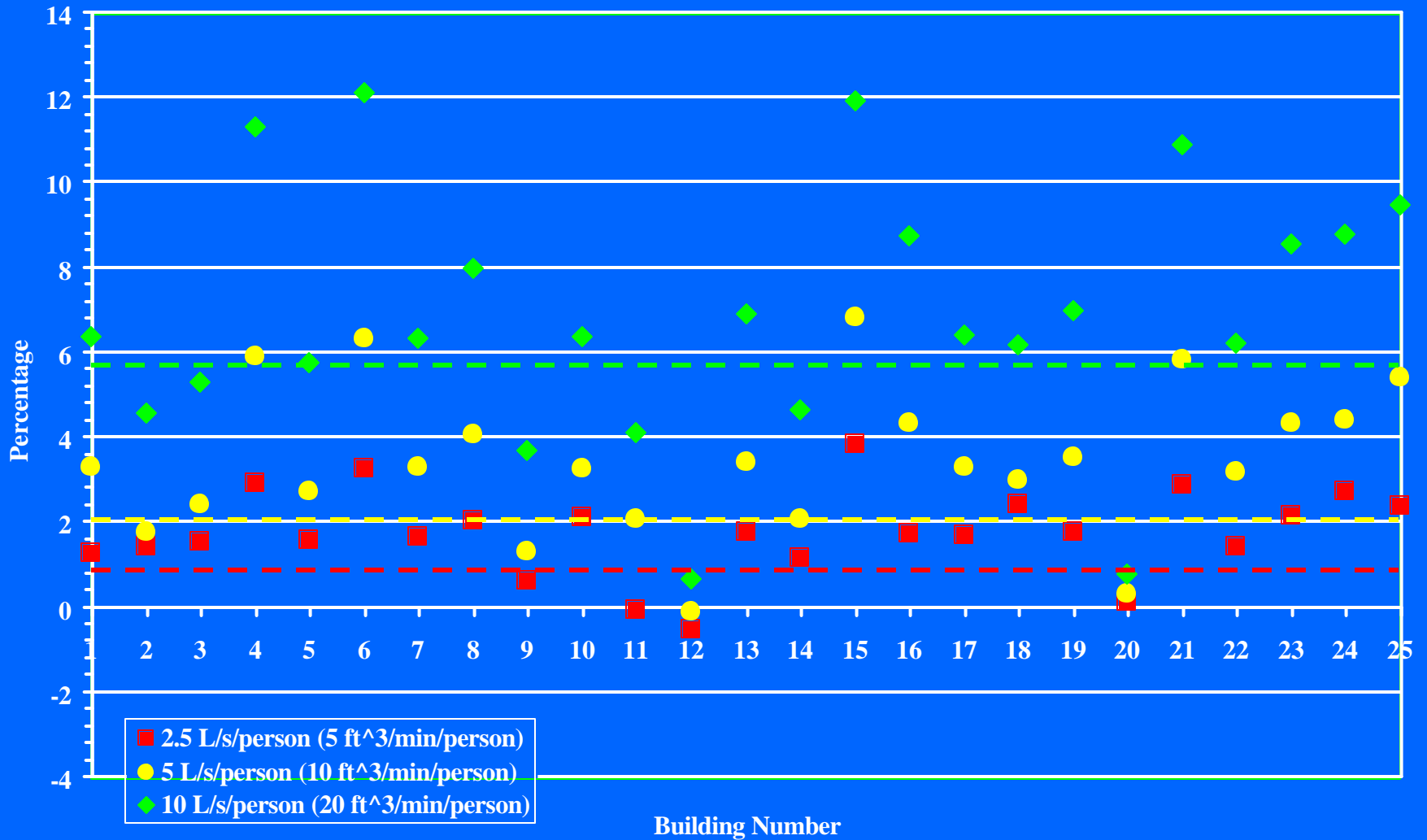
Percentage of Heating Load Due to Ventilation



Percentage of Cooling Load Due to Ventilation



Percentage of Cooling - Economizer Load Due to Ventilation



Summary

- Intent to test methodologies and look at order of magnitude results and trends
- Showed possibilities in modeling energy and airflow using TRNSYS and CONTAM combination
- Further analysis of results is needed and may show areas for future work