Simulation of Barracks and Dormitory Type Buildings

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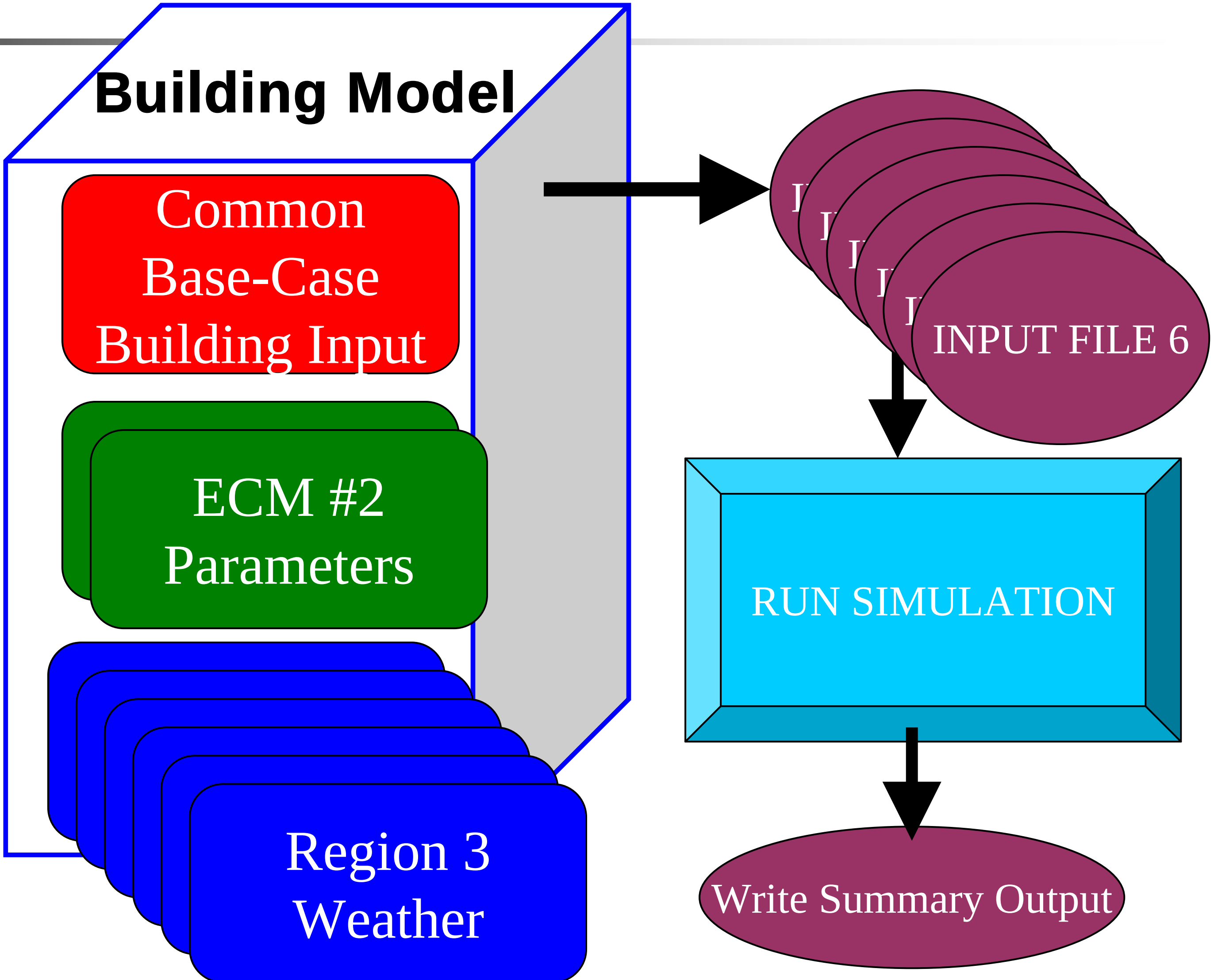
Background

- Overall Task:
  - Develop a database of energy saving technologies and measures for government building retrofits.
- Scope:
  - Three building types: industrial, office, barracks/dormitory
  - retrofit technologies: 20 industrial, 40 office & barracks/dormitory

Approach


Building Model
Common Base-Case Building Input
ECM #2 Parameters
Region 3 Weather
INPUT FILE 6
RUN SIMULATION
Write Summary Output

Status:

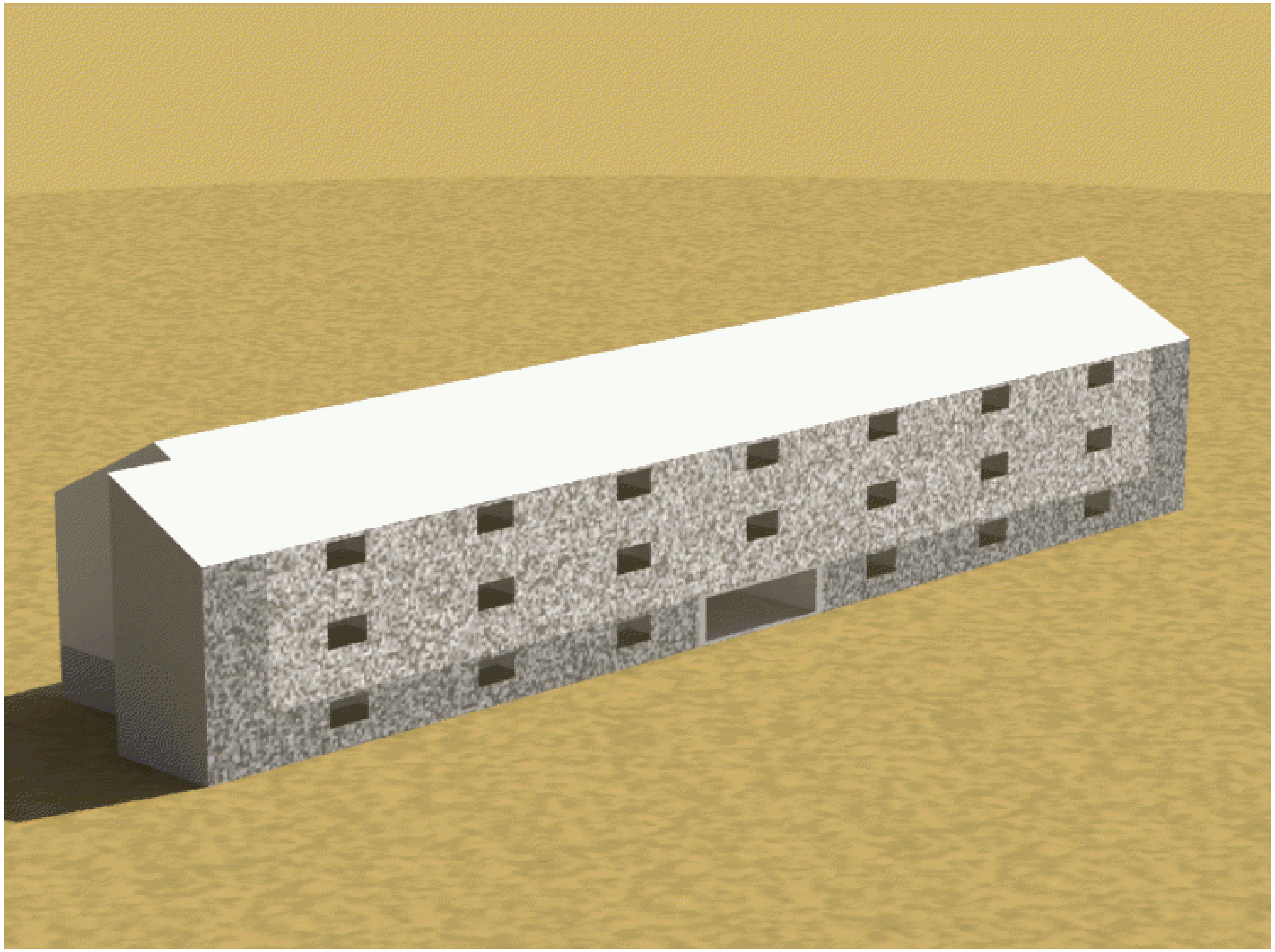
- Completed industrial building simulations using EnergyPlus and esp-r
- Developed barracks/dormitory simulation models in EnergyPlus
- Currently evaluating ‘energy conservation measures’ (ECMs) for barracks/dormitory in EnergyPlus

The Energy Conservation Measures:

High performance windows
Operable windows
Solar wall for outdoor air preheating
Cool roofs
Roof insulation
Attic insulation
Insulated and sealed doors
Vestibules
Exterior light shelves
Exterior vertical fins
Roof Spray Cooling
Skylights or solar tubes
Detached window shading (trees)
Windbreaks
Setback thermostats
Night pre-cooling
CO2 sensors
Hybrid (mechanical/natural) ventilation
Hydronic heating with convectors
Radiant Floor heating
Hydronic radiant heating and cooling panels

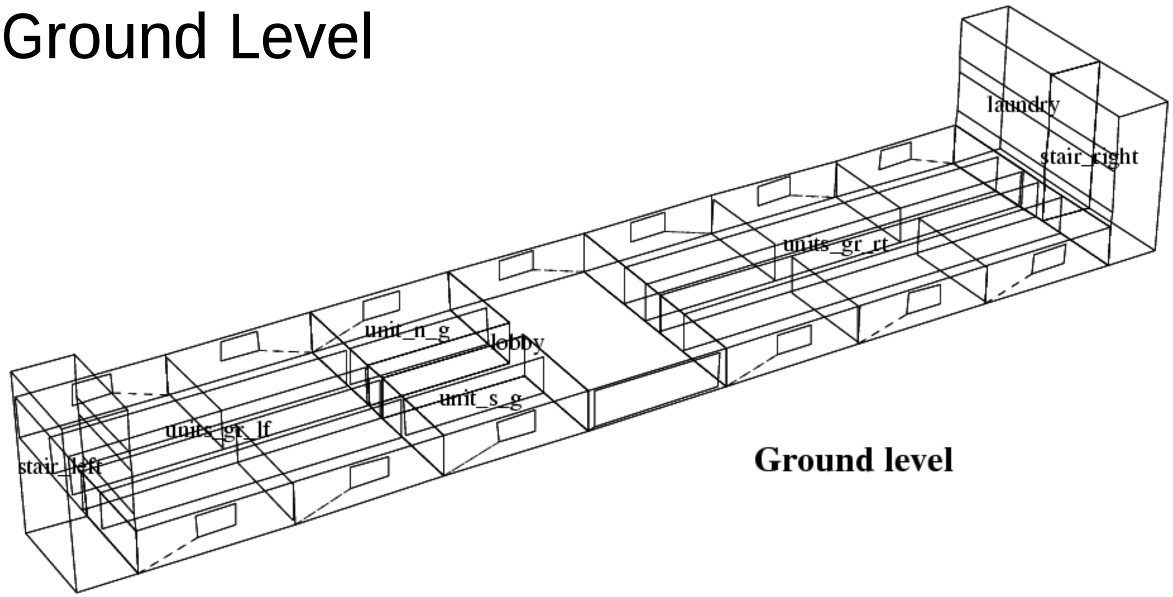
Attic ventilation
Separate A/C and ventilation system (DOAS)
Displacement ventilation
Replace window A/C with central air system
Replace window A/C with Dx split system
Heat pipe heat recovery
Enthalpy wheel heat recovery
Indirect evaporative coolers
Direct evaporative coolers
Replace motors with high efficiency motors
Thermal energy cold water storage
Thermal energy ice storage
Replace steam/hot water AHU heaters with indirect gas fired heaters
Insulate hot/cold water pipes
Insulate supply and return ducts
Reduce Duct leakage
Dimming control for daylight harvesting
Task lighting
Replace existing lights with T8 and instant start ballasts
Occupancy sensors

Building Model

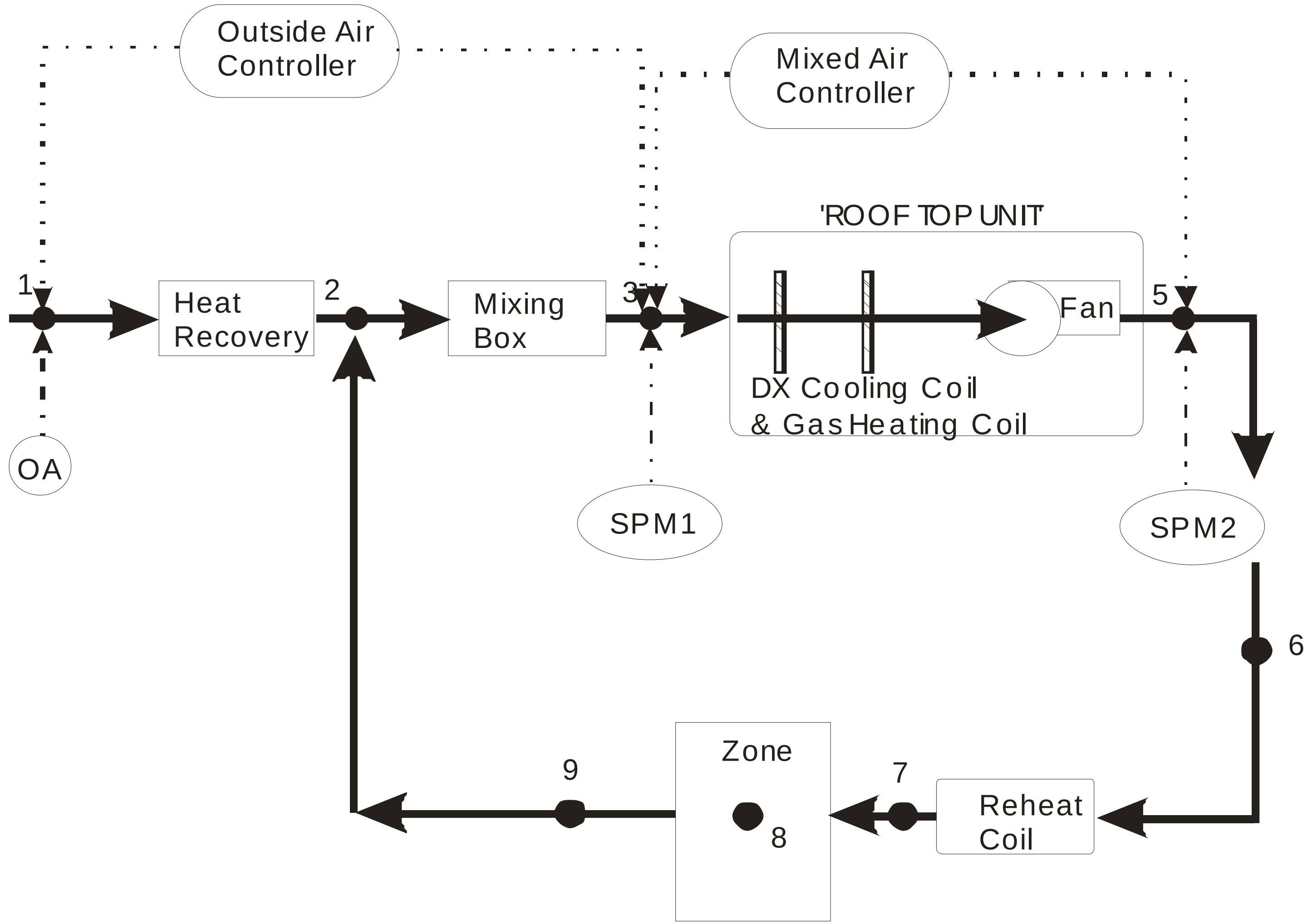


Building Model

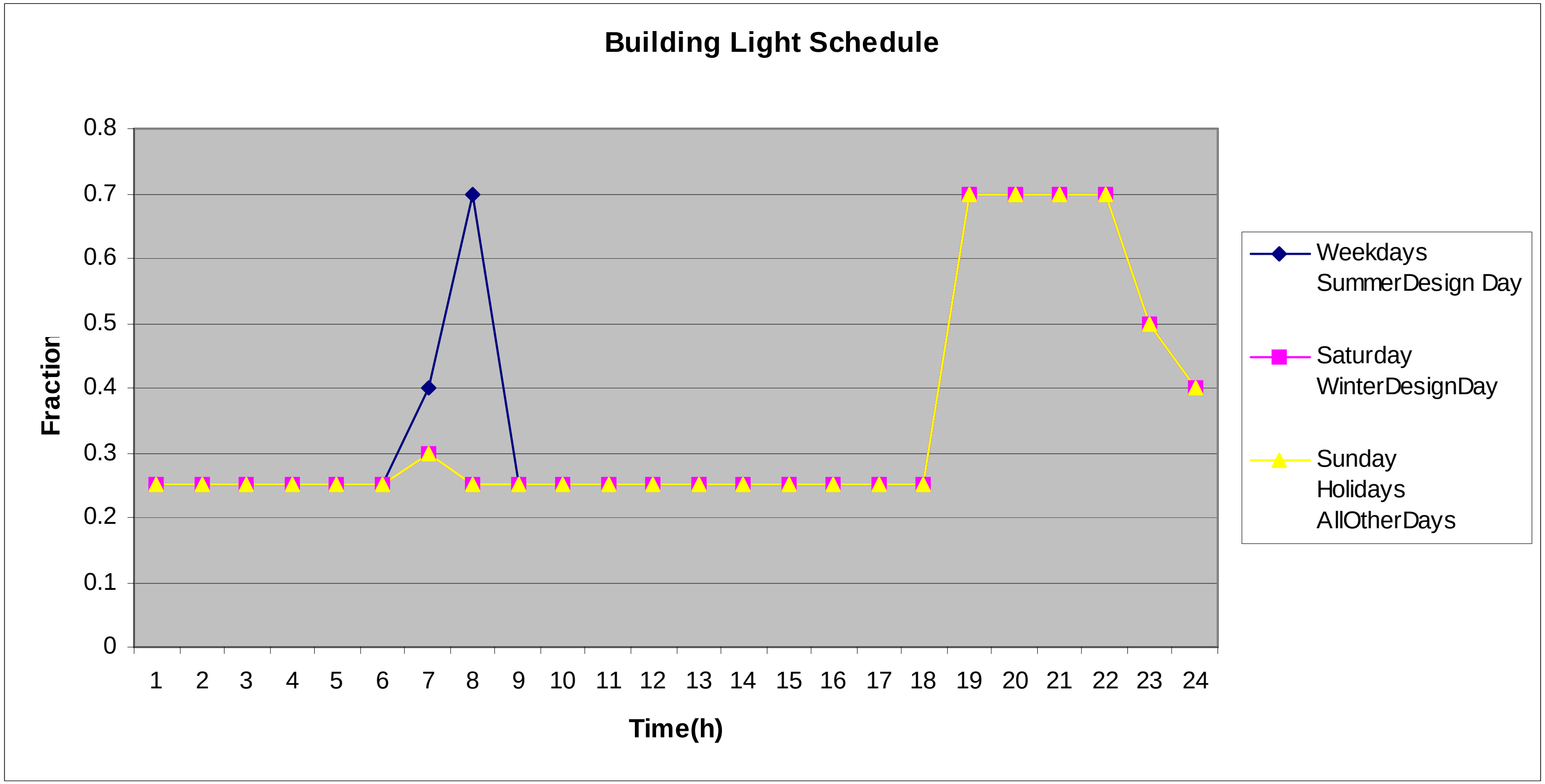
Zone Layout of Ground Level



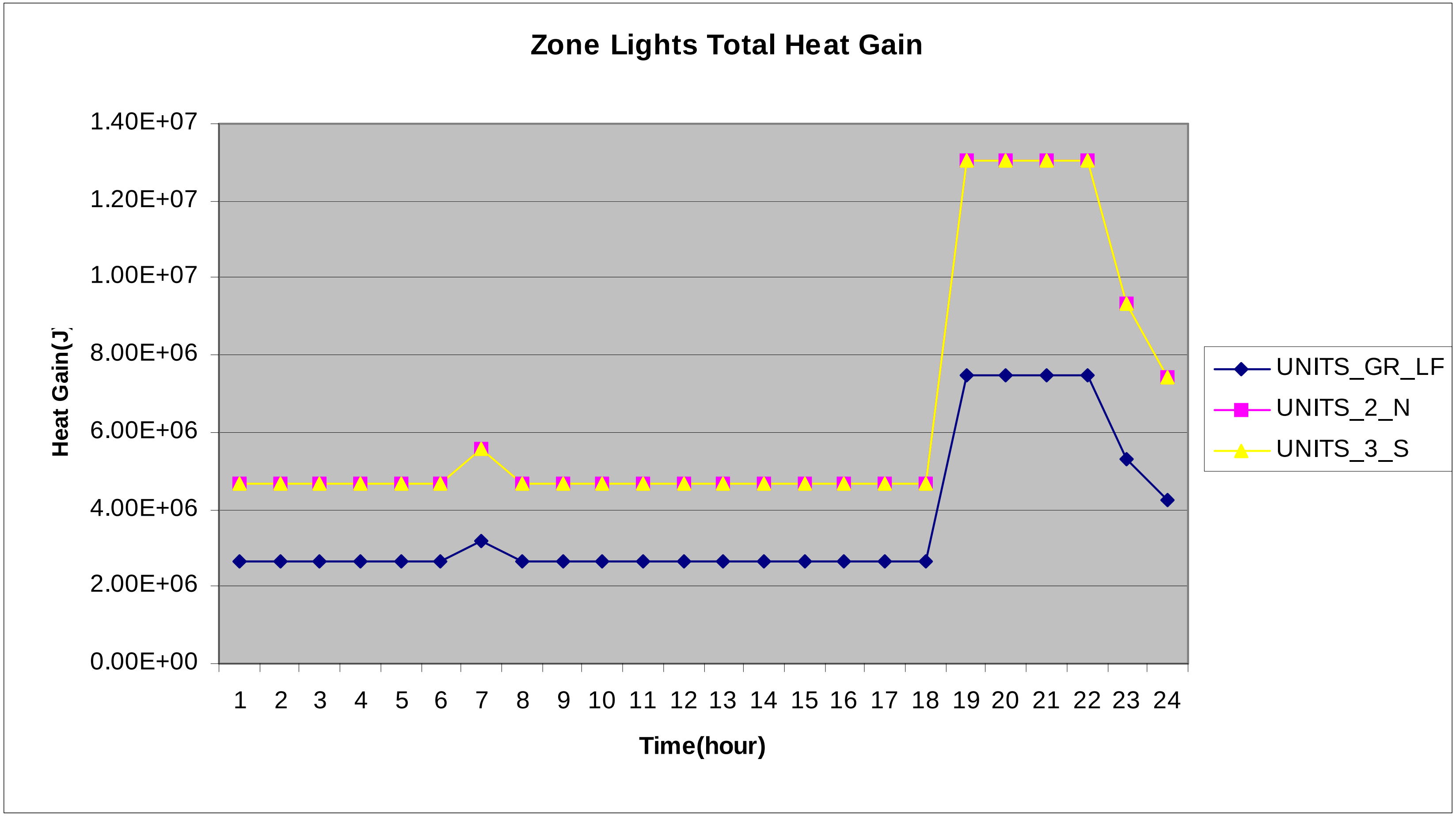
System Schematic



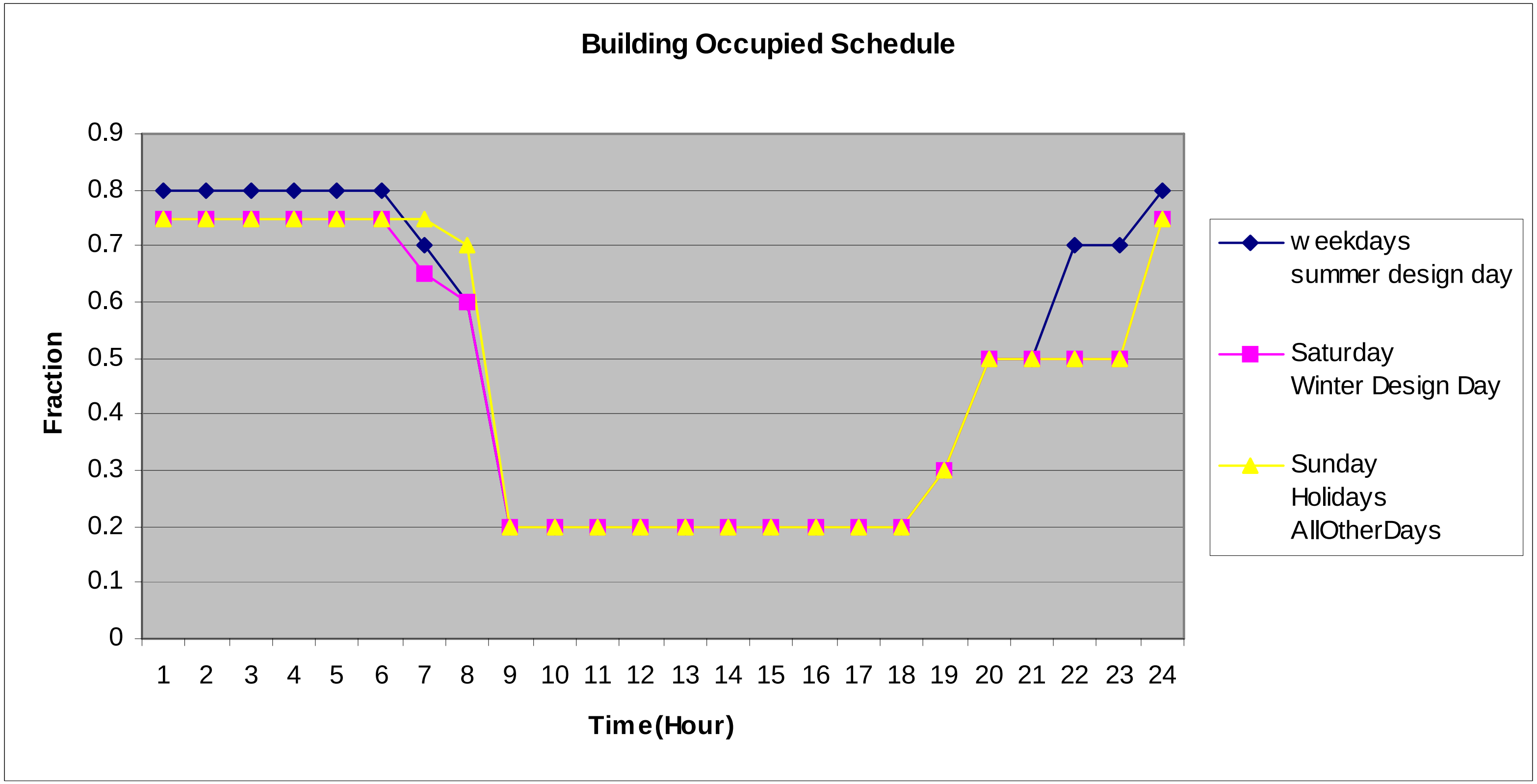
Schedules: Lights



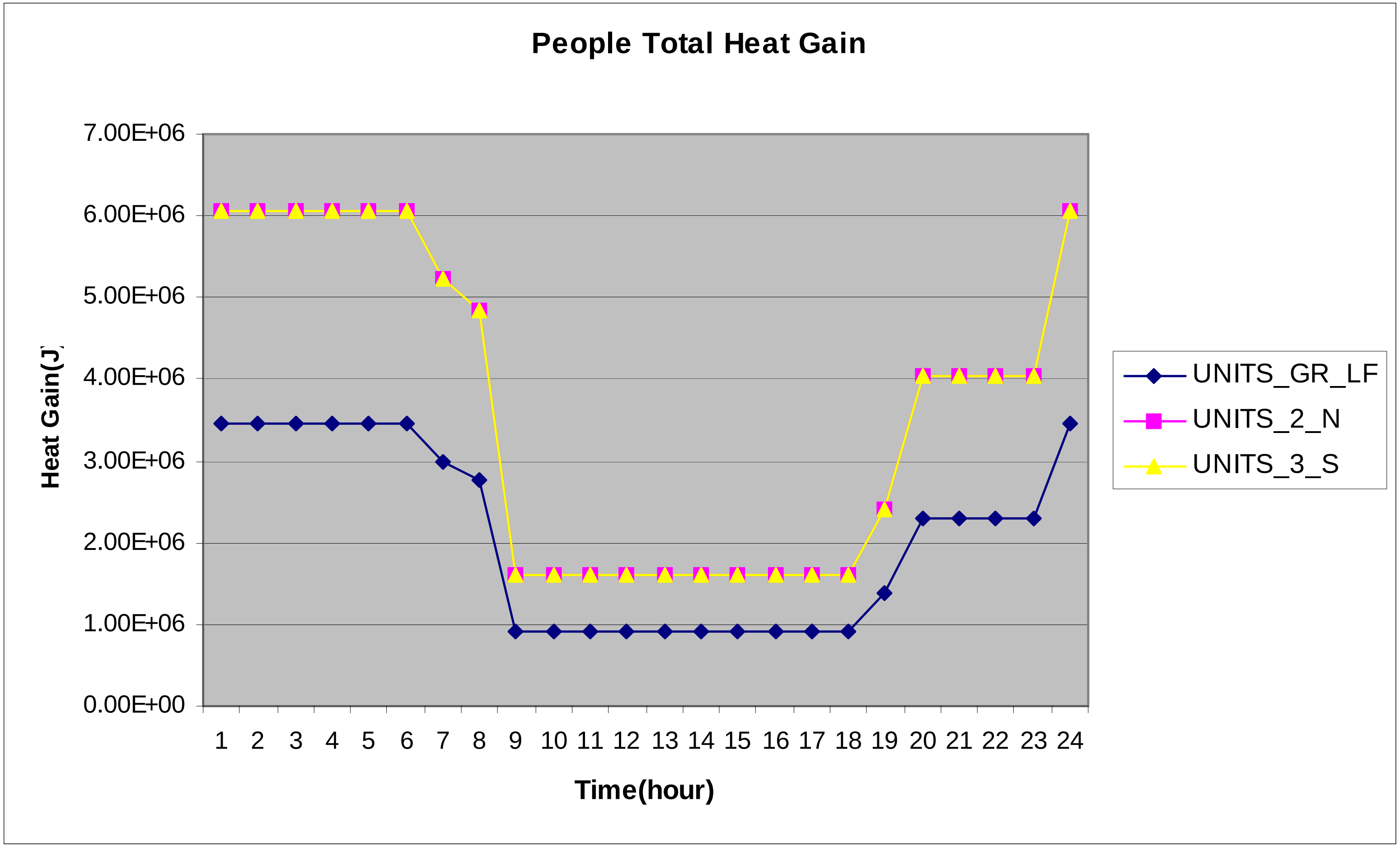
Lighting Heat Gains



Schedules: Occupancy



Occupancy Heat Gain



Analysis

- Basic Approach…
  - Simulate ‘Base-Case’—capture energy use
  - Modify ‘Base-Case’ to model ECM—capture energy use
  - Calculate difference between Base-Case and ECM energy

BUT…the systems tends to add complexity.

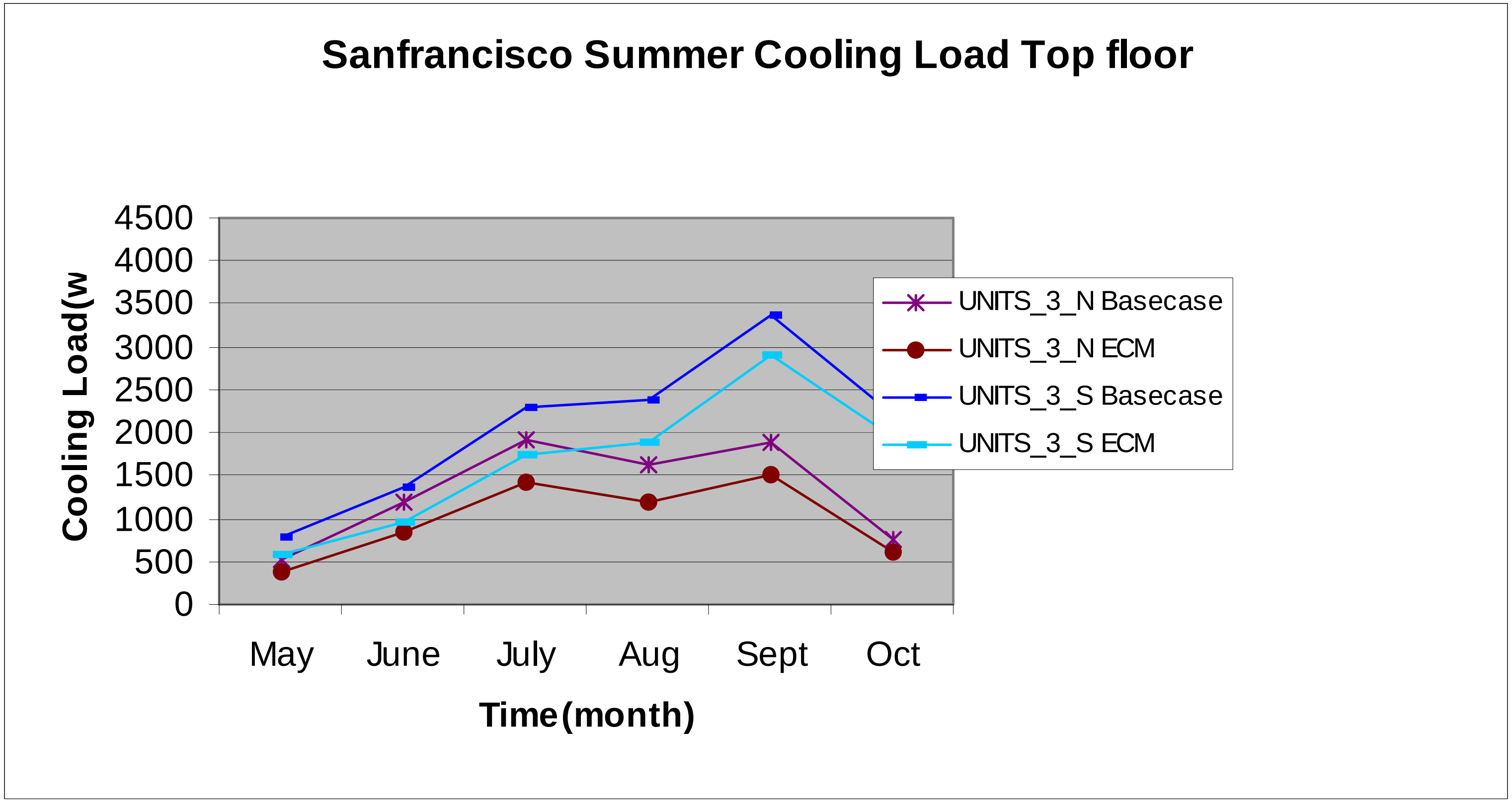
Additional analysis usually required.

Example: Attic Ventilation

- Three potential energy saving mechanisms:
  - Heat transfer through attic floor
  - Heat transfer from ducts located in attic
  - Change in COP for Condensing Units operating in attic space.

Example Attic Ventilation

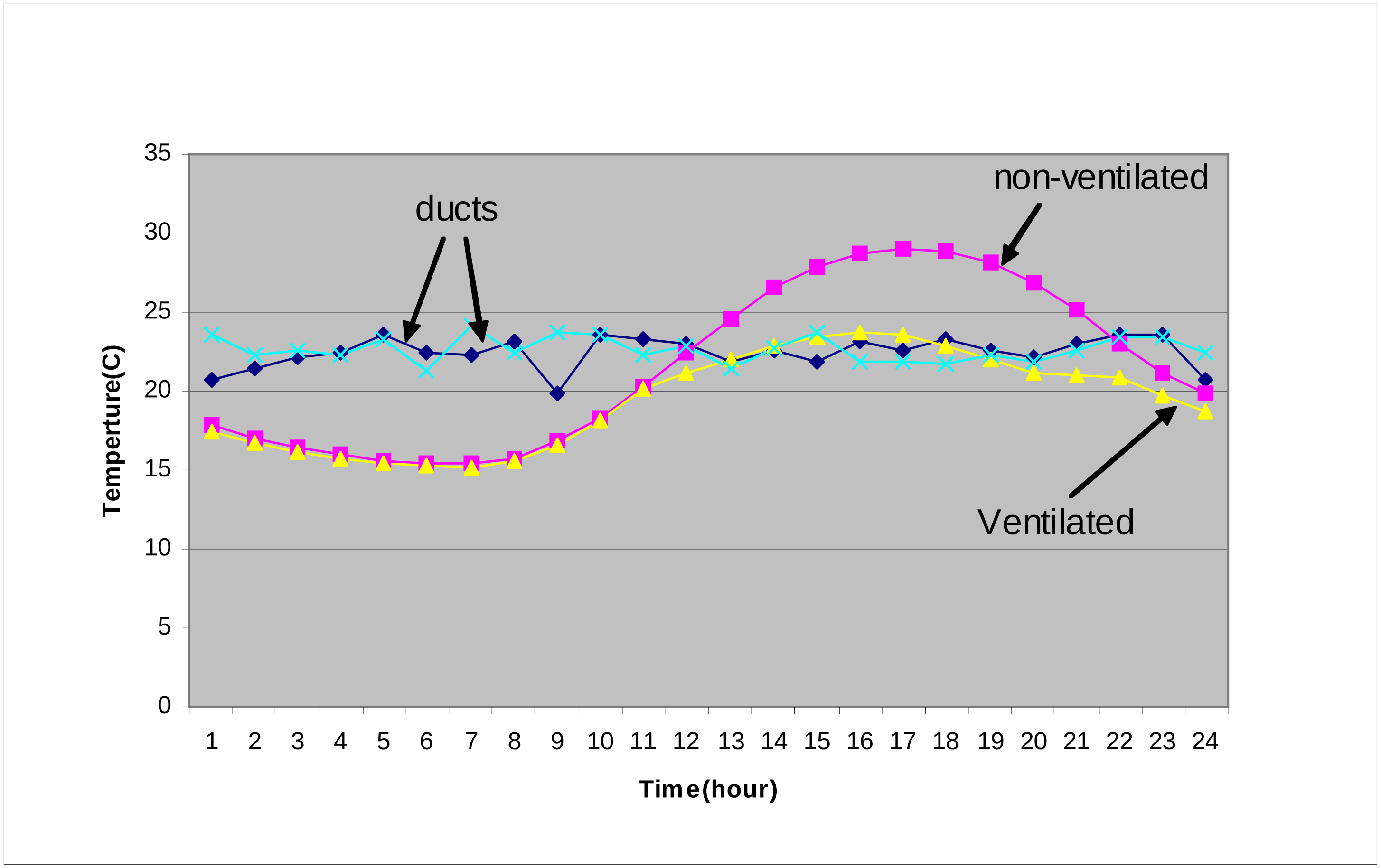
- Simulation captures heat transfer through the floor directly…



Example: Attic Ventilation

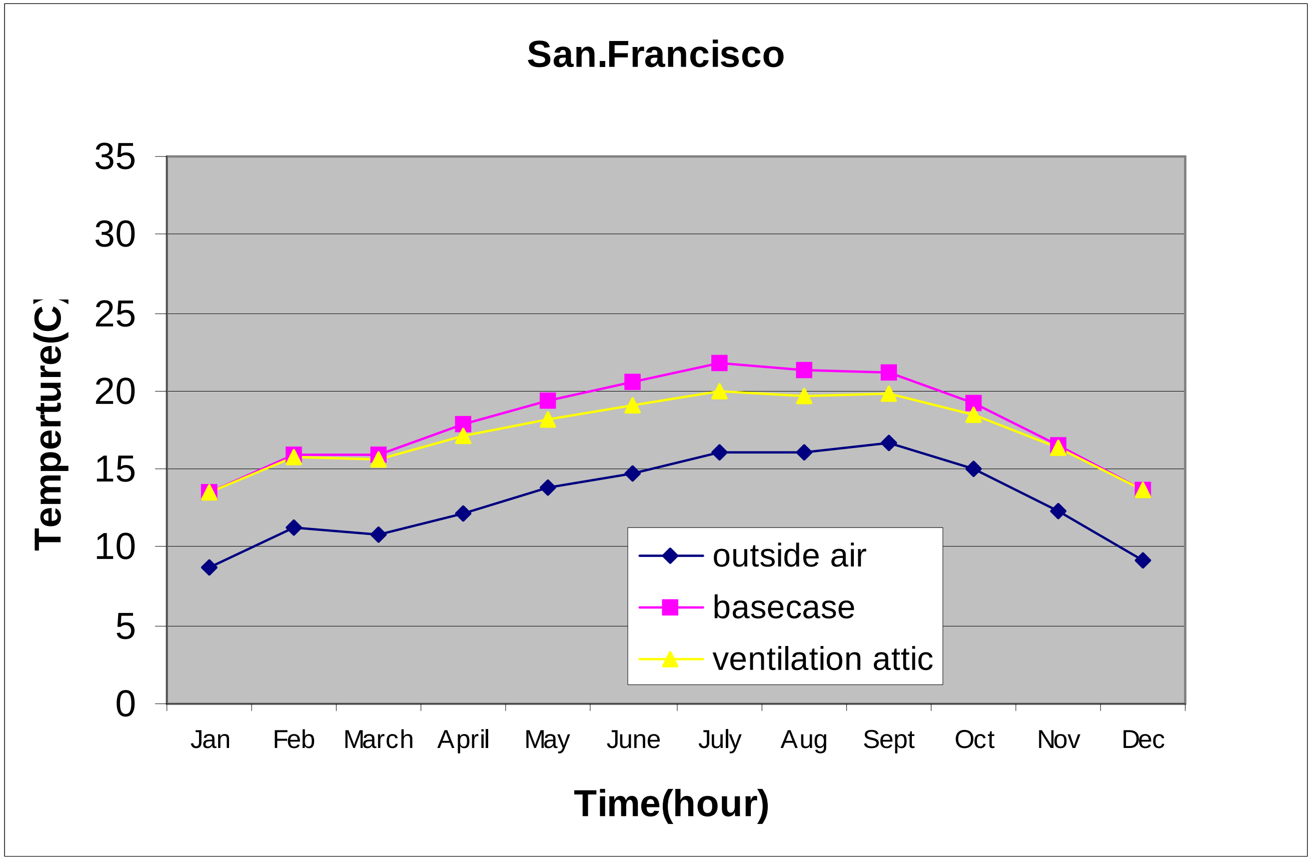
- But no direct output to account for:
  - heat transfer from ducts located in the attic.
  - change in COP for Condensing units operating in attic space.
- However, temperature data is available

San Francisco, Summer Design Day



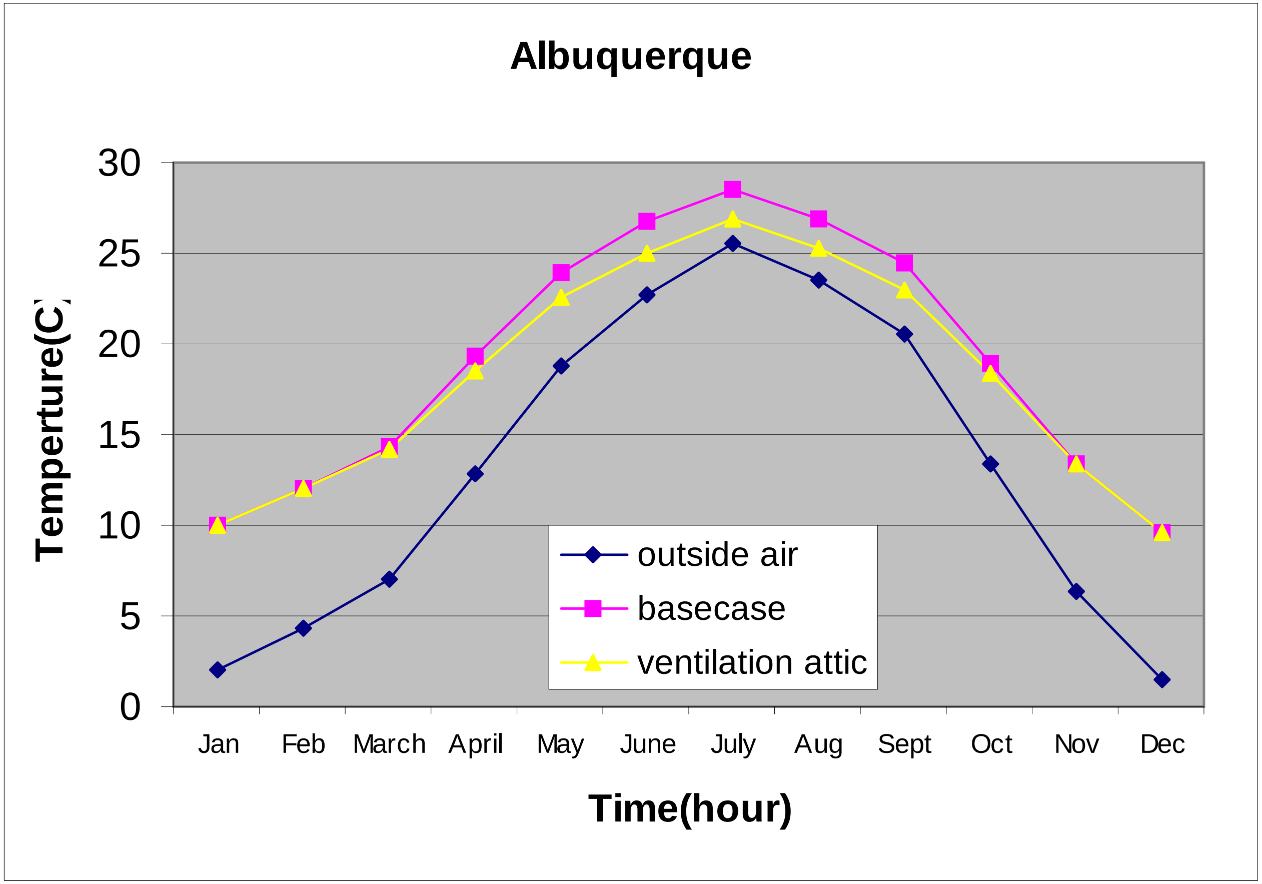
Example: Attic Ventilation

- Seasonal effects in temperate climate



Example: Attic Ventilation

- Seasonal effects in hot dry climate

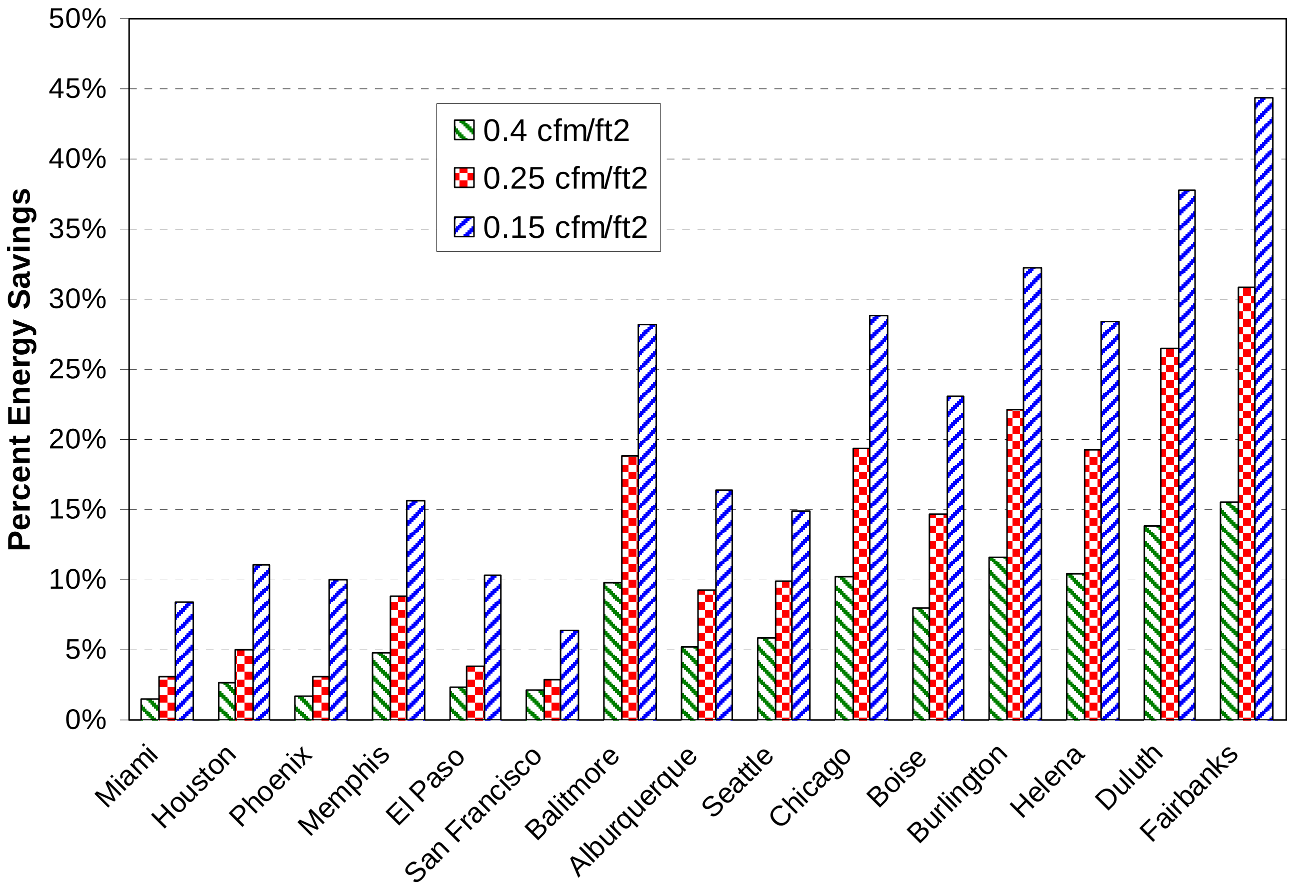


Spreadsheet Calculations

- Select ‘ON’ hours based on temperature
- Calculate duct heat gains/losses for ‘ON’ hours only in the spreadsheet.
- Automate the process…

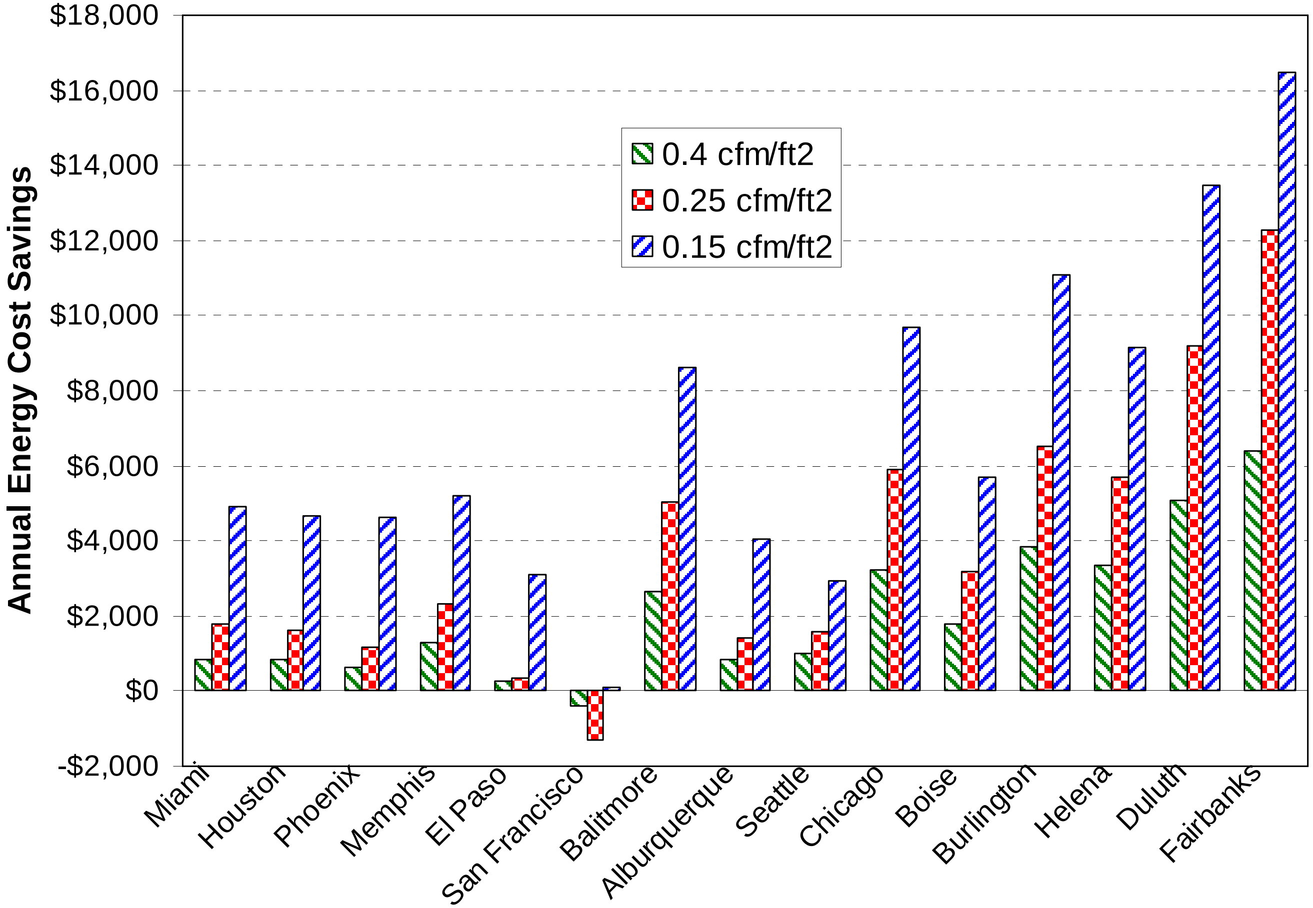
Some Results: Air Tightness

Energy Savings…



Some Results: Air Tightness

Cost Savings…

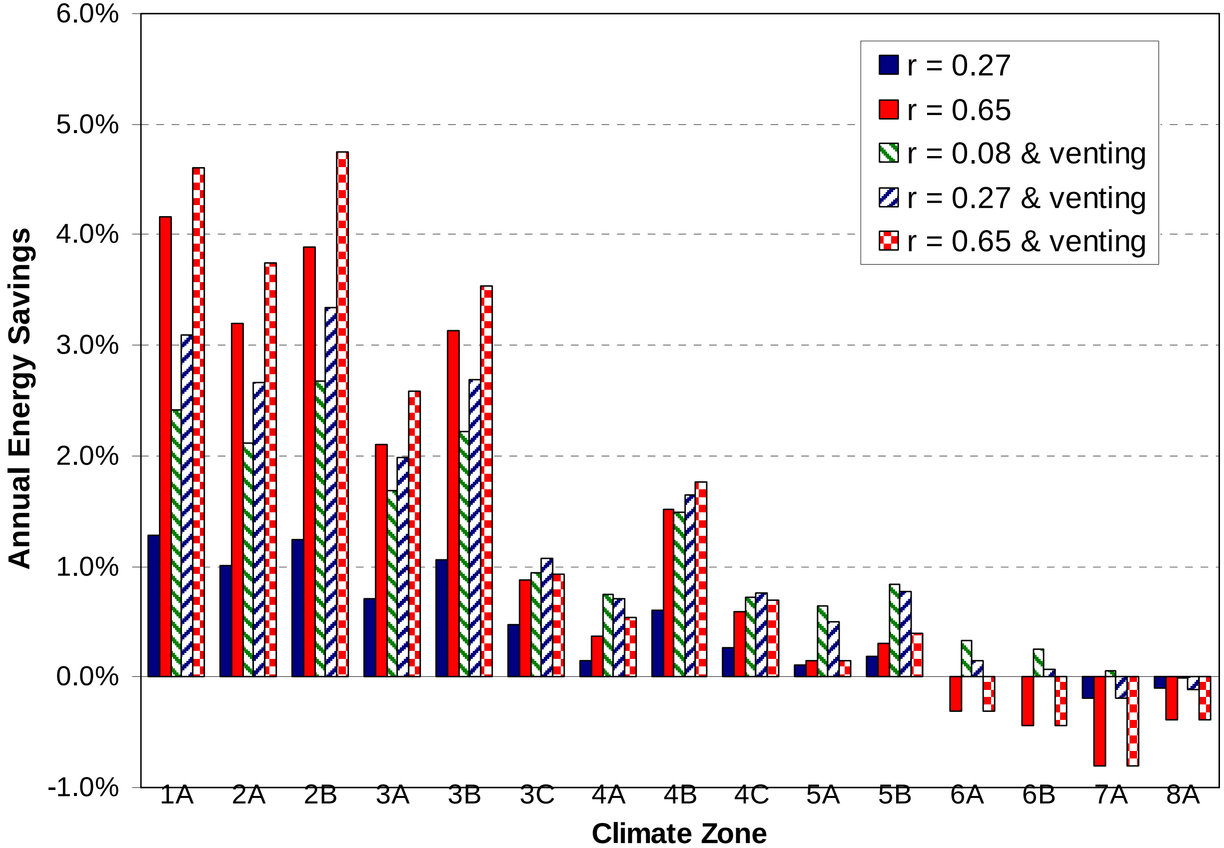


Analysis

- Highest savings for heating dominated climates (highest temp. differences.
- Net energy savings in all climates.
- San Francisco’s cooling loads increased and heating loads decreased.
  - heating loads more than offset cooling loads
  - but cost of gas did not offset the cost of electricity

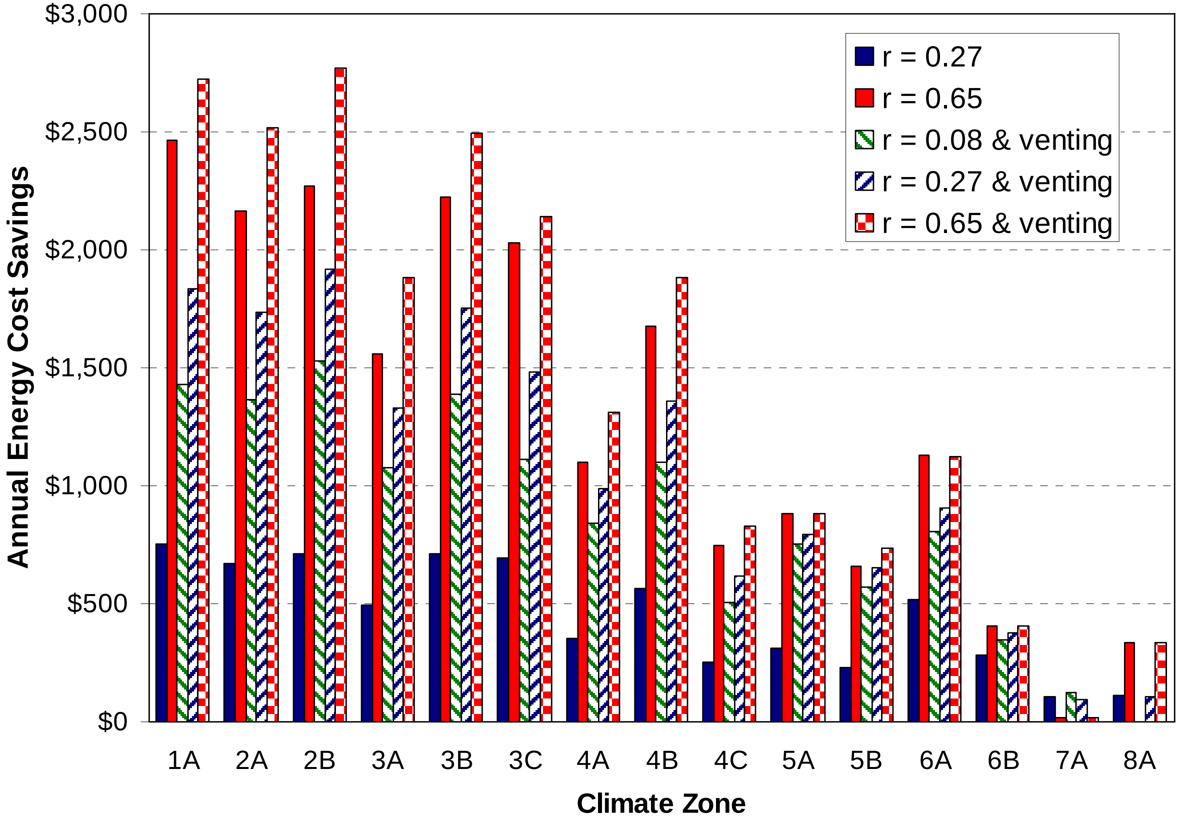
Some Results: Cool Roofs

Energy Savings…



Some Results: Cool Roofs

Energy Costs...



Analysis

- Cool roofs decrease cooling loads and increase heating loads.
- Yield energy savings in cooling dominated climates.
- Yield cost savings in all climates due to the differential between gas and electricity costs.

Conclusions

- The simulation-based approach captures the interactions of many complex thermal processes.
  - limited by availability of simulation models
  - limited by availability of simulation output
- Currently ‘Post-processing’ of simulation data is usually required in order to assess all thermal effects:
  - usually yield reasonable estimates.
  - complicates parametric studies
- The exercise often promotes development of new simulation models.