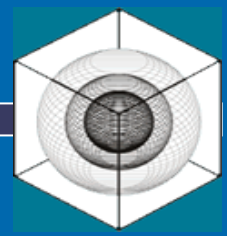
Infiltration Investigation of Investigation of a Radiantly Heated and Cooled Office



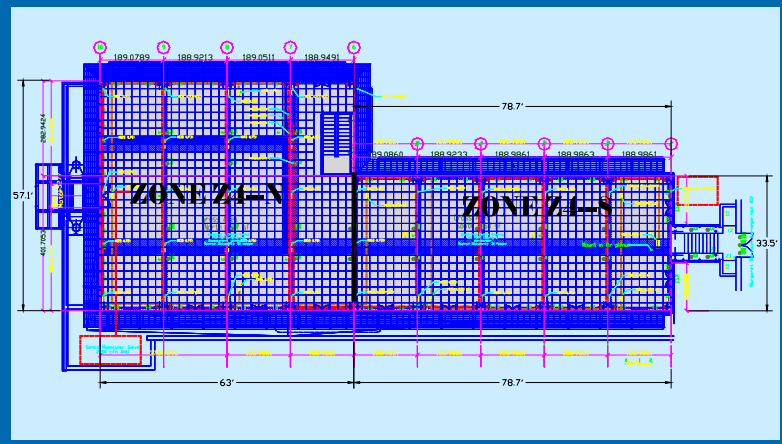
Xiangyang Gong
David E. Claridge
Energy Systems Laboratory
Texas A&M University

Introduction

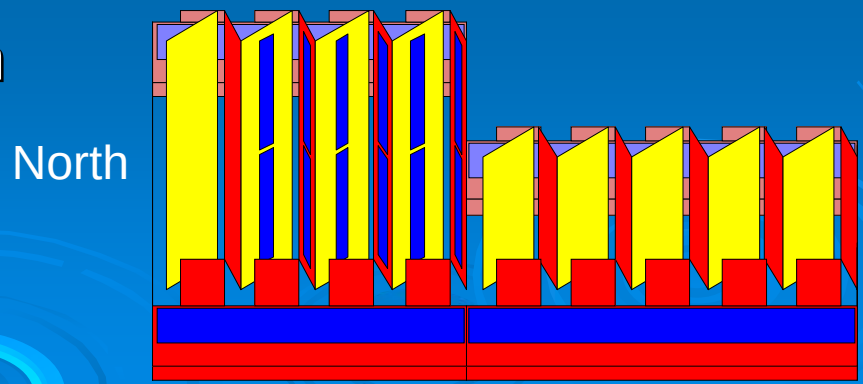
- Carnegie Mellon University Project
  - Intelligent Workplace (IW)
  - Advanced HVAC technology
  - Enhanced energy efficiency
- Project objectives
  - Install/test advanced energy supply system in IW
  - Apply sensible heating and cooling for energy distribution
- Role of TAMU

Case Study Office

- Floor PLAN
  - Area: 6,228 ft^2
- Characteristics
  - Steel structure
  - Adjustable shading
  - Sky lights
  - Radiant heating and cooling integrated with desiccant dehumidification



East



North

South

West

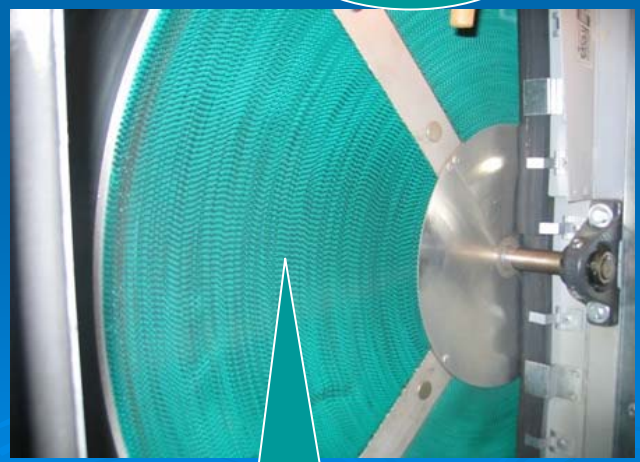
Advanced HVAC systems in office

Cool Wave

Mullion Radiator

Radiant Panel

Ventilator

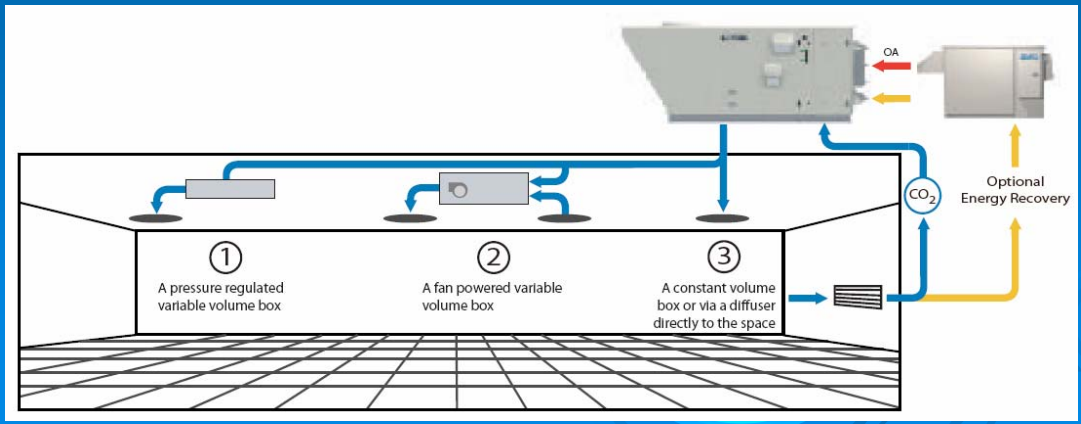


Desiccant Wheel

Controlled Shading

Objectives

- Conducted indoor humidity analysis of a radiantly cooled office (Gong and Claridge, ICEBO 2006)
- Investigate the infiltration
- Study the influence of infiltration on performance of the integrated system



Summary of indoor humidity and energy analysis

- High risk of condensation in a leaky building
- Radiant panels should be operated with surface temperature higher than 61°F (0.011lb/lb)
- Heat recovery is small at a low ventilation rate. In summer, the exhaust fan should be stopped to pressurize the building
- Infiltration of 0.1 ACH may be the maximum acceptable infiltration level
- High infiltration increases energy consumption

(Thermal load could be reduced by 31.5%, if infiltration can be reduced from 0.45 to 0.0 @ 650 CFM ventilation)

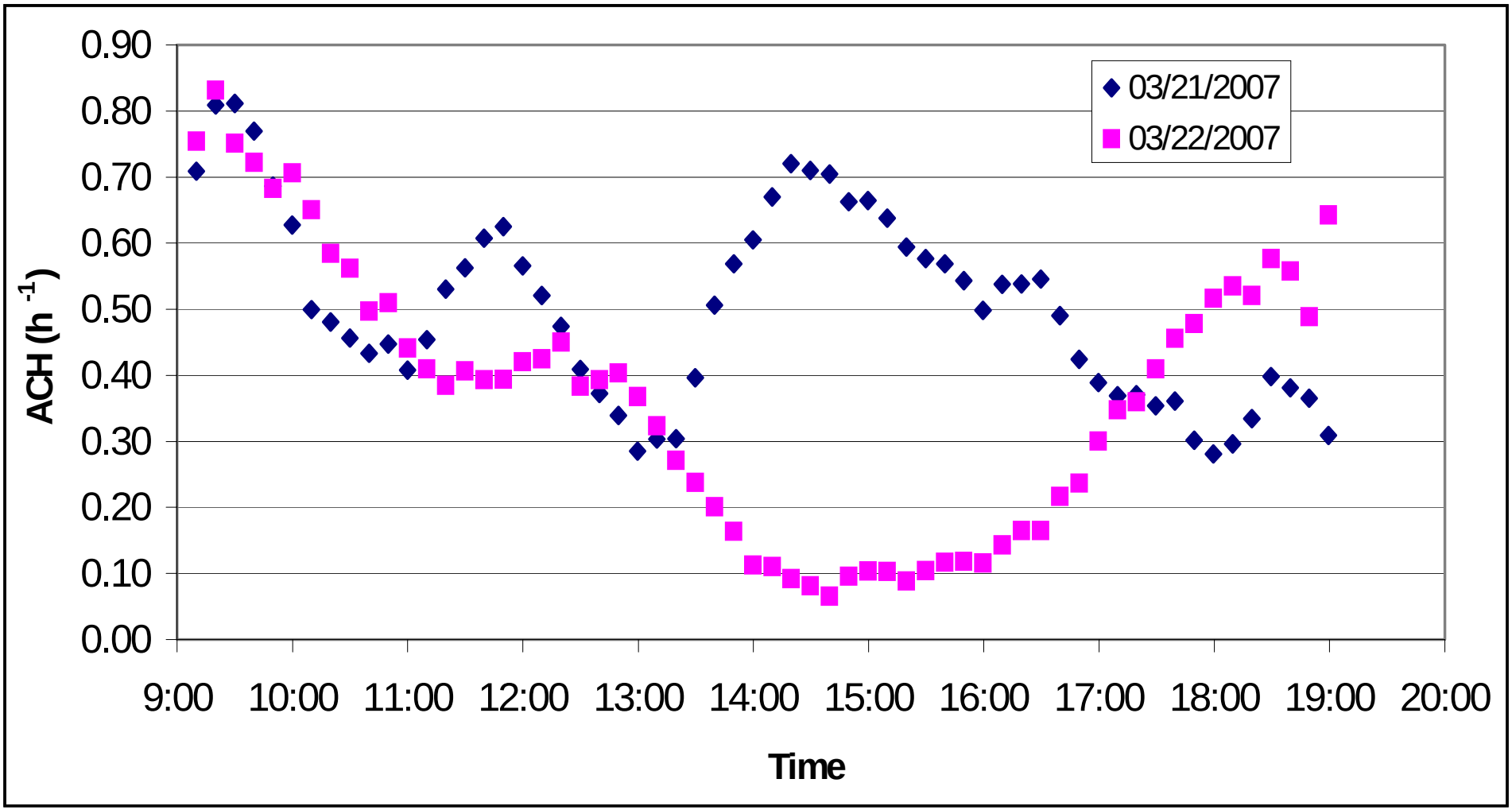
Infiltration Investigation of the Office Space

- Infiltration impact on
  - Indoor humidity
  - Water condensation on chilled pane
  - Heating and cooling load
  - HVAC equipment sizing
- Previous infiltration studies in the
  - Tracer gas measurements (Mahdavi et al. 2000, ACH 0.85-0.95)
  - Tracer gas measurements (Boonyakiat et al. 2000, ACH 0.78-1.31)
  - CO2 concentration method (Betz et al, 2006, 0.07-0.1)
  - Calibrated simulation (0.12 – 0.46 ACH monthly averages)

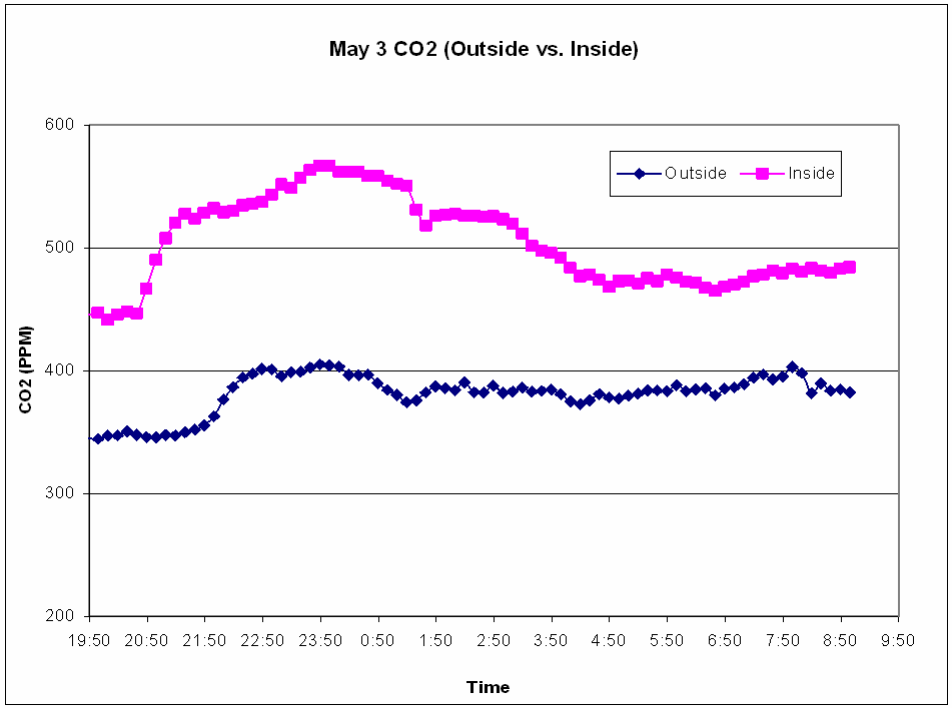
Infiltration Investigation of the Office Space

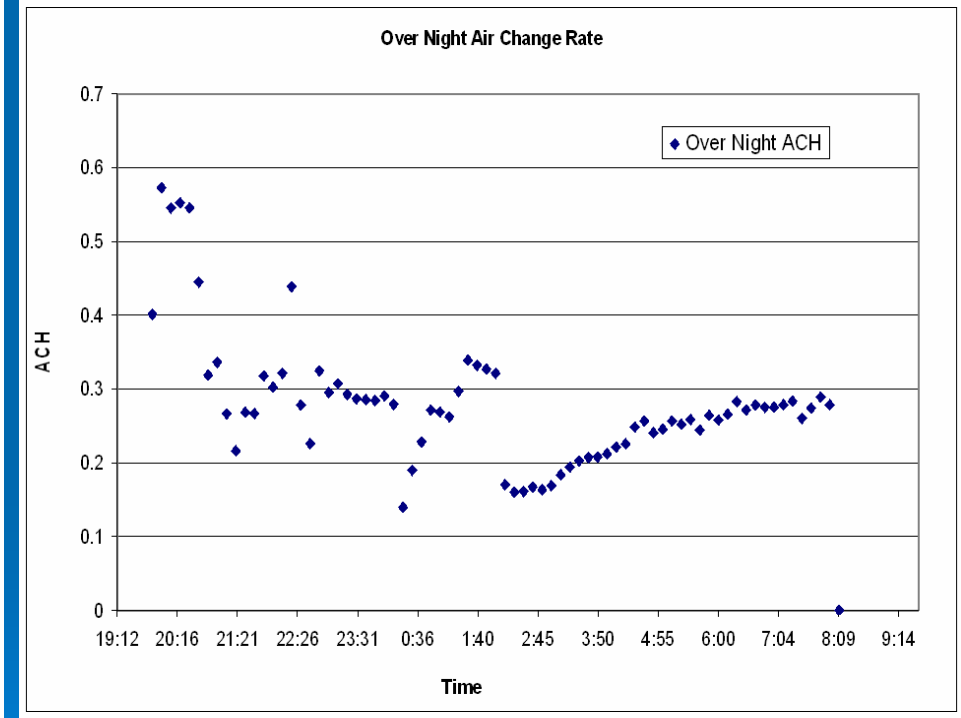
- Current investigation
  - Reanalyzed CO2 measurement data
  - Blower door measurements
  - Analyzed logged humidity data in the current ventilation sys.

Air Exchange Rates Based on CO2 Concentrations



Air exchange rate based on CO_2 concentrations





Indoor and Outdoor CO2 Concentrations on the Night of May 3, 2006

Overnight ACH Based CO2 Measurement on May 3, 2006

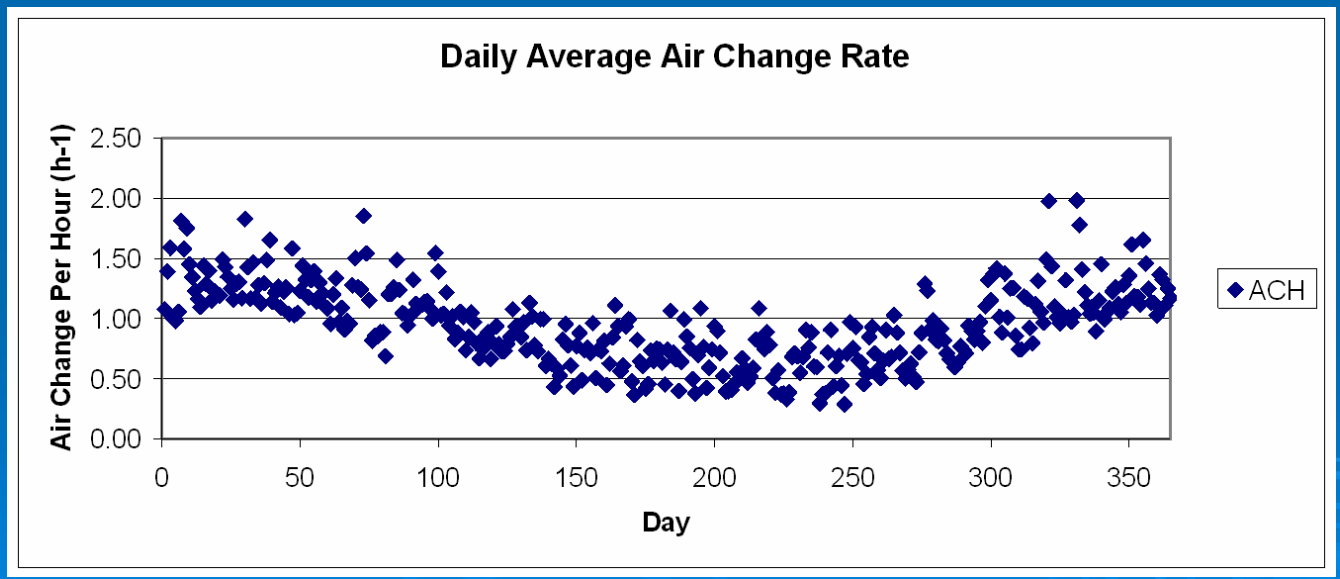
Infiltration Rate Errors

- CO2 error (ppm) 10 20
- ACH error 21% 41%

Air exchange rate based on blower door measurements

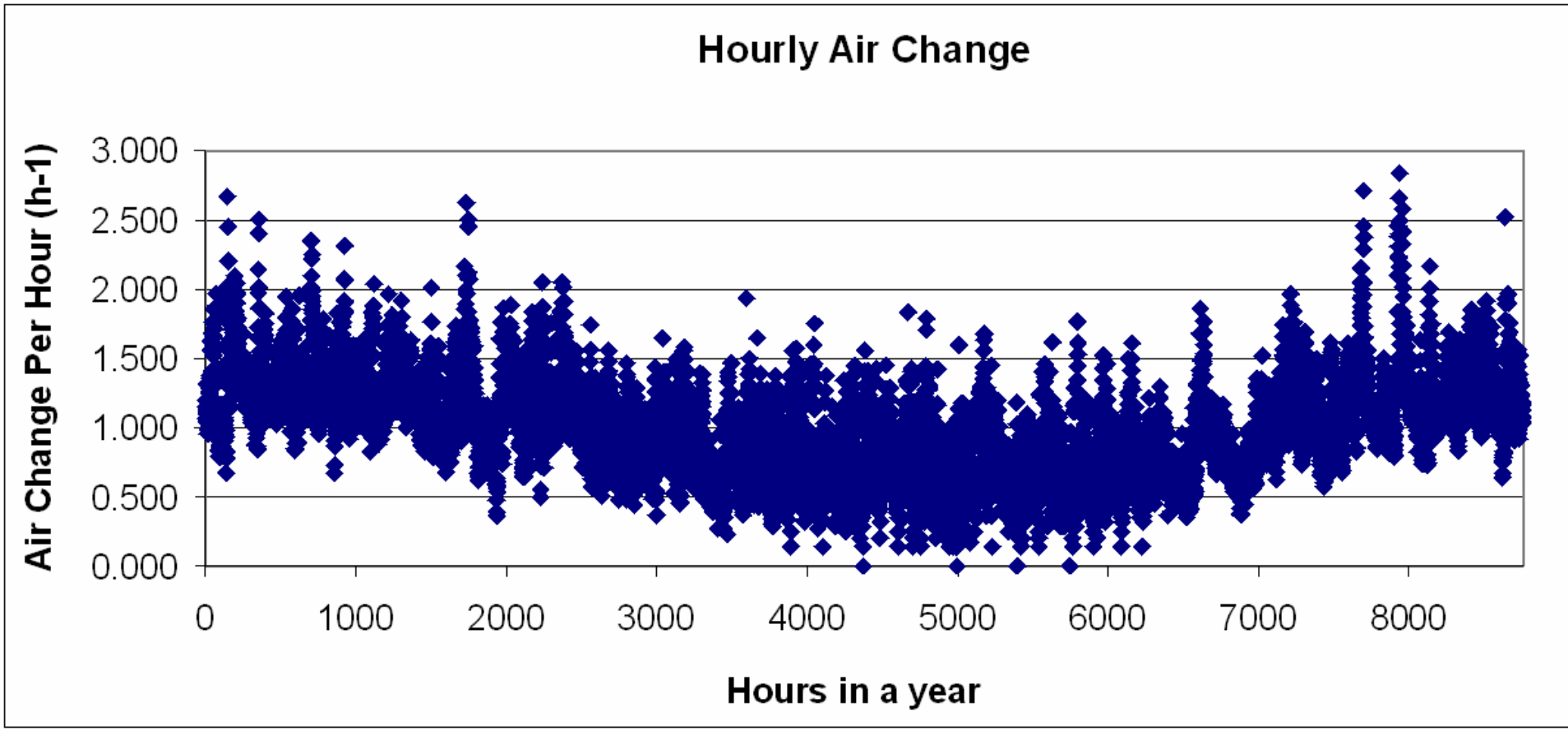
- Blower door measurement results (Oct 6th, 2006)

Pressure (Pa)	10.2	11.2	8.6	9.0	8.8
CFM	5950	5925	5952	5935	5963



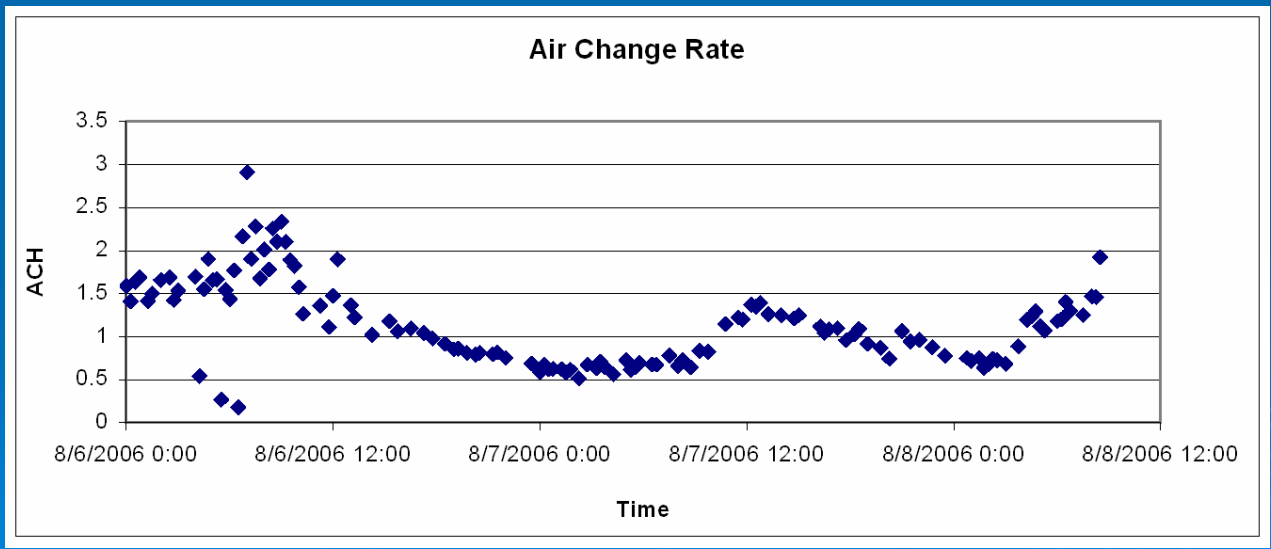
IW Average Daily Infiltration Based on Interpretation of Blower Door Measurement Data

Hourly Infiltration Based on Blower Door Measurements



Air exchange rate based on logged humidity data

- Operating data of the desiccant ventilation unit are logged including:
  - Supply air, Return air, and Outside air temperature, humidity;
  - Supply air CFM



Average Daily Infiltration Based on Interpretation of Logged Humidity Data

Summary of infiltration investigation

- Infiltration analysis results

Approaches	Tracer Gas	CO2 Concentration	Blower Door	Logged Humidity
Infiltration (ACH)	0.86-0.95	0.0-1.2	0.4-2.0	0.5-2.0

- Calibrated DOE 2 simulation suggests smaller infiltration value (0.12 – 0.42 ACH monthly averages)

Summary of infiltration investigation

- Infiltration analysis results

Approaches	Tracer Gas	CO2 Concentration	Blower Door	Logged Humidity
Infiltration (ACH)	0.86-0.95	0.0-1.2	0.4-2.0	0.5-2.0

- Calibrated DOE 2 simulation suggests smaller infiltration value (0.12 – 0.42 ACH monthly averages)
- Site visit and measurement finds significant amount of leaking air coming from third floor
- Outside air leakage ranges from 0.1-0.5 ACH; the third floor air ranges from 0.46-1.03 ACH

Summary of integrated system study

- Compared with single duct VAV air system at current infiltration level
  - Integrated active desiccant system consumes:
    +28.5% thermal energy; -2.8% electricity; +5.6% primary energy
  - Integrated passive desiccant system consumes:
    -21.0% thermal energy; -2.3% electricity; -11.4% primary energy
- Energy consumption at optimal condition (0 infiltration; 650 CFM ventilation)
  - Integrated active desiccant system consumes:

    -15.7% primary energy (Compared with SDVAV)
  - Integrated passive desiccant system consumes:

    -24.8% primary energy (Compared with SDVAV)
- Benefit

  Enhanced comfort level; less noise; independent humidity control

Commissioning Conclusions

- Complex advanced systems require careful commissioning
- Air leakage in this case resulted in an integrated desiccant/radiant cooling system with poorer energy performance than a conventional system