# SEMCO Ventilation System

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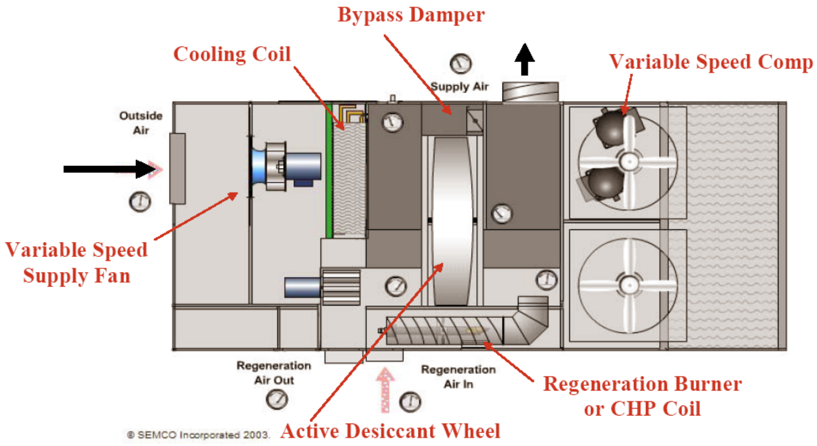
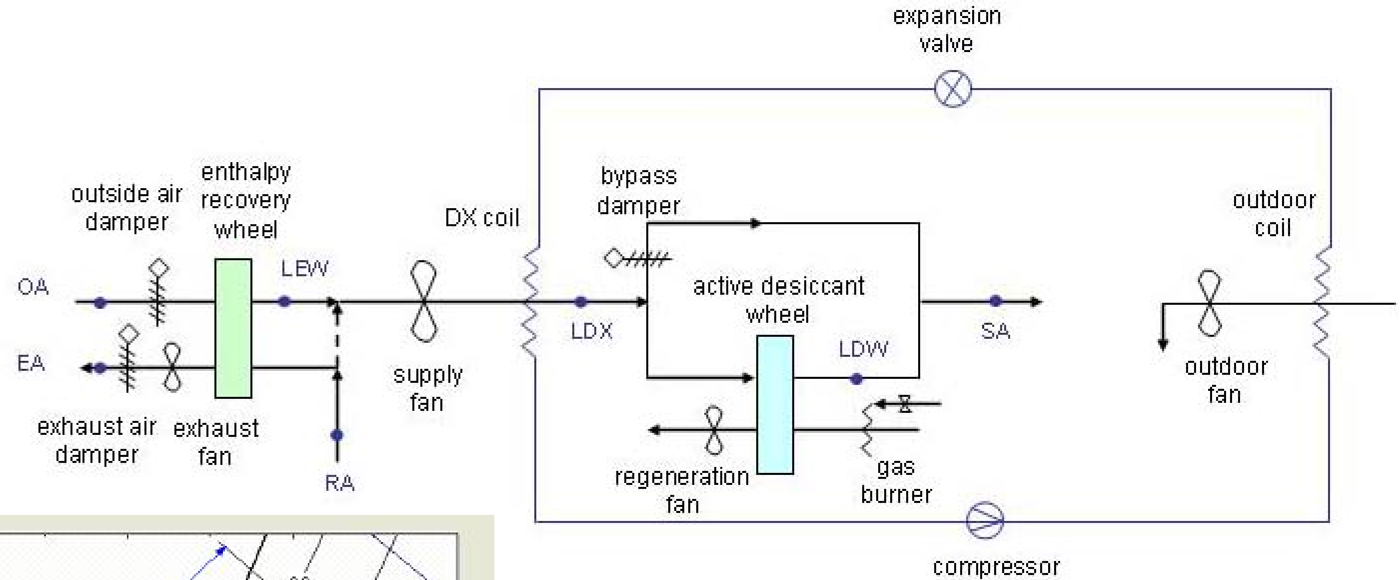
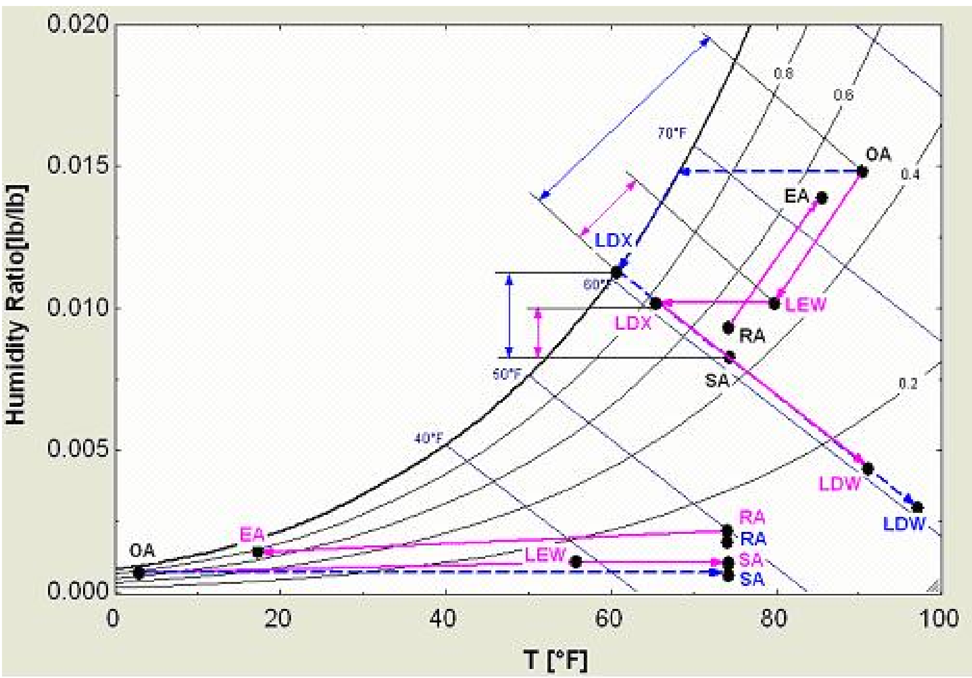
# SEMCO REV 2250 & FVR 2000

- REV-2250 Revolution™ active desiccant-vapor compression hybrid rooftop unit
- FVR-2000 solid desiccant energy recovery module
- Nominal air flow 2250 cfm, maximum 3000 cfm
- Heating provided primarily by heat pump with gas assist
- Active solid desiccant for air dehumidification




# Flow Diagram of SEMCO at IW



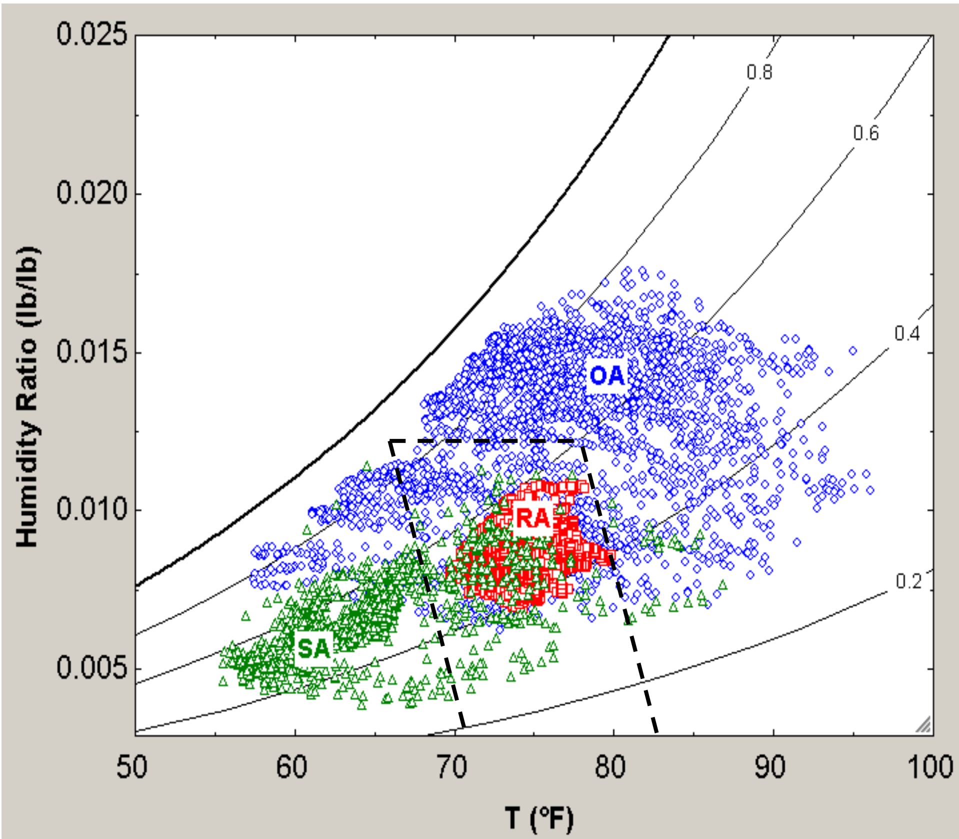




- Typical summer and winter operation
- With and without enthalpy recovery module
- Indicating heating and cooling load on heat pump coil and moisture removal by active desiccant wheel

# Work Accomplished

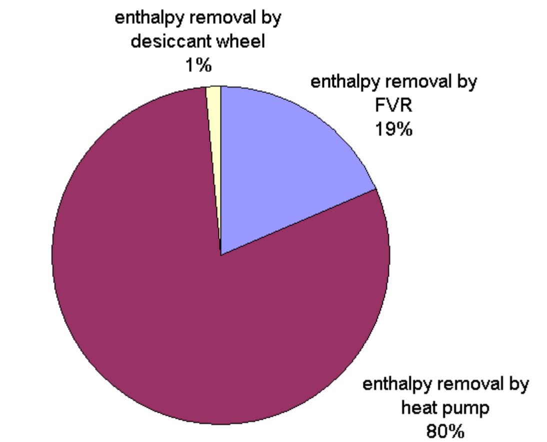
- System installed and commissioned
- System operation and control algorithms studied
- Overall system energy performance and operating cost investigated
- Approaches to reduce cost identified
- Winter and summer performance of enthalpy recovery wheel tested
- Winter and summer performance of active desiccant wheel tested
- Heat and mass transfer model to relate both wheels' performance to their design parameters and operating conditions constructed
- Problems with heat pump operation identified and investigated
  - Compressor cyclic operation due to reduced load, possible remedies: reduce low frequency limit, replace compressor
  - Defrost operation in heating mode, control logic changes: reversing valve, defrost triggers
  - Control logic visible, easy to modify

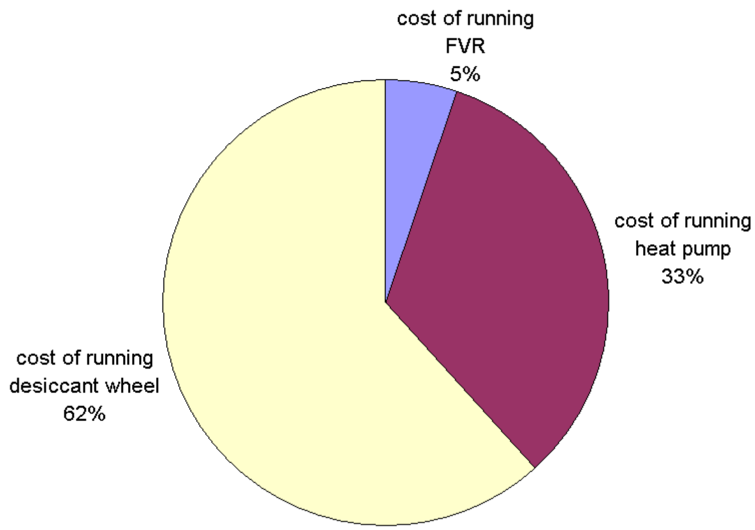
# Effectiveness of Overall System

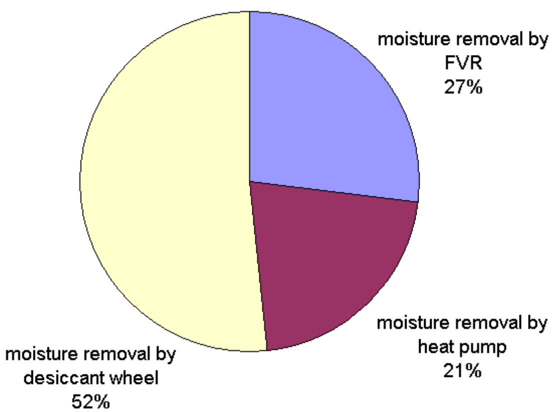


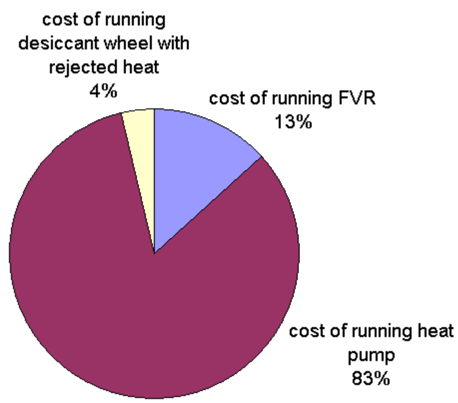

- Plotted for July 2006
- Space conditions controlled within ASHRAE comfort zone for a wide range of outdoor conditions
- Difference in SA and RA temperature: heat gain through building façade, heat generated by people and office appliance and infiltration, minus the heat removed by other cooling devices
- Difference in SA and RA humidity: moisture generated by people, coffee maker and infiltration

# Energy Performance of Overall System



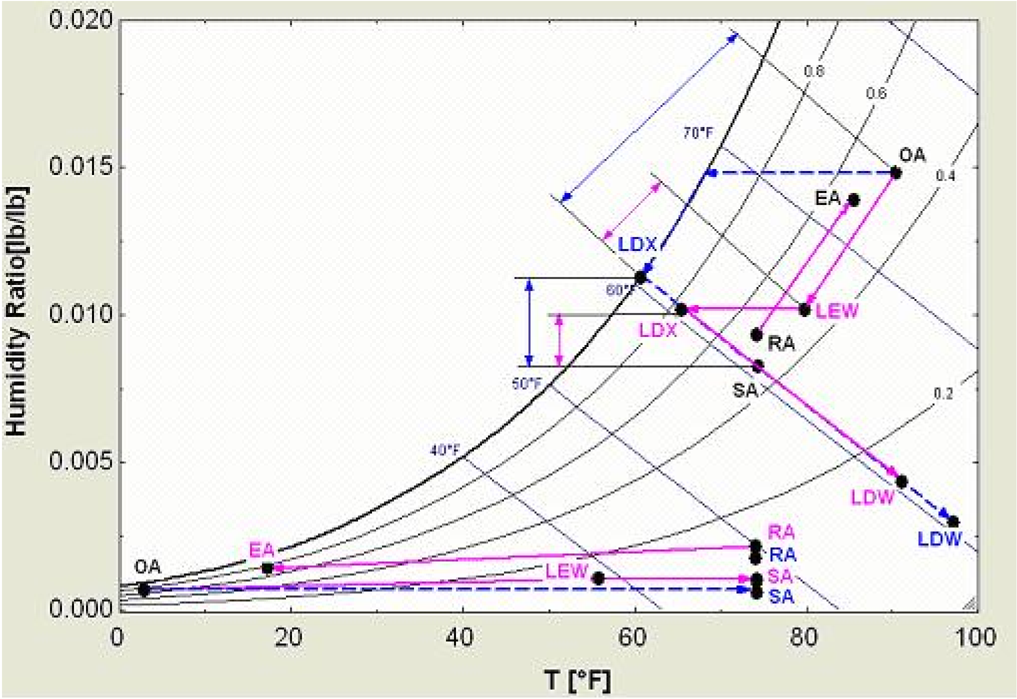




- Active desiccant wheel effective in removing moisture
- Expensive to operate active desiccant wheel, alternative energy source will help
- Enthalpy recovery cost effective

# Economics of Enthalpy Recovery




- Enthalpy recovery capacity 1200 cfm
- DOAS operation
- Pittsburgh
- Capital cost incremental -$3839 if use DX coil + boiler, -$2359 if use heat pump + boiler
- Annual operating energy cost saving $2480 for DX coil + boiler, $1627 for heat pump + boiler

# Desiccant Wheel Modeling

Design Parameters:

- Wheel dimension
  - Wheel depth
  - Wheel diameter
  - Wheel split
- Channel dimension
  - Channel shape
  - Channel size
- Material selection
  - Desiccant material
  - Substrate
  - Thickness

Operating Variables:

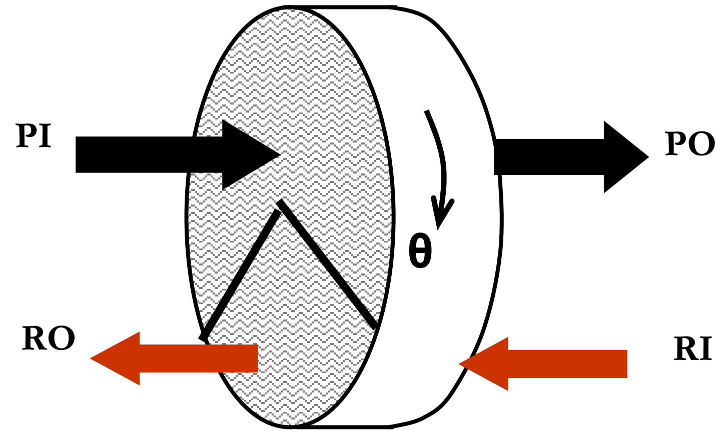
- Rotary speed
- Regeneration/exhaust air flow
- Regeneration temperature

Modeling Results:

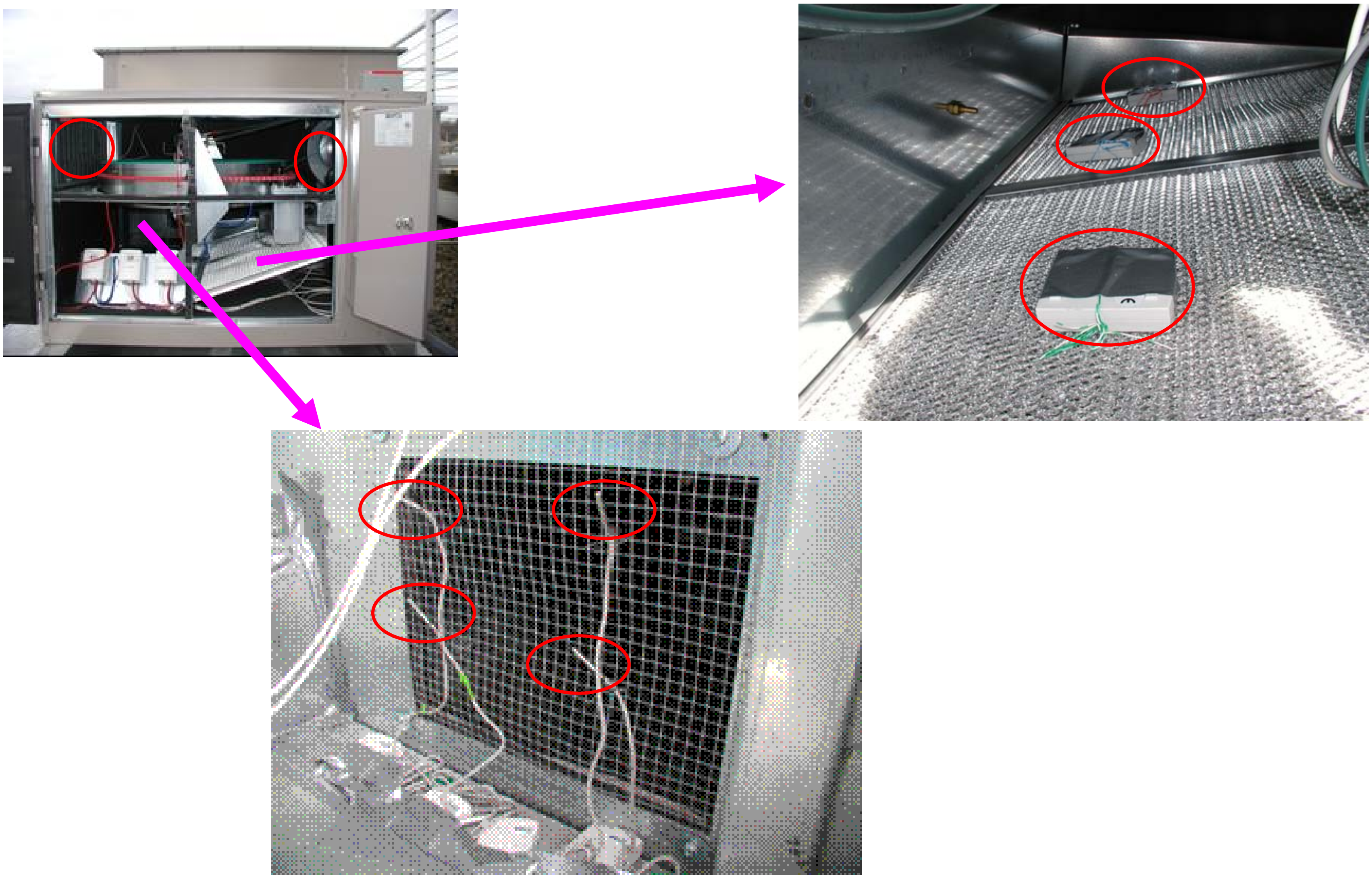
- Temperature and humidity of PO and RO
- Temperature and loading of desiccant material

Model Application:

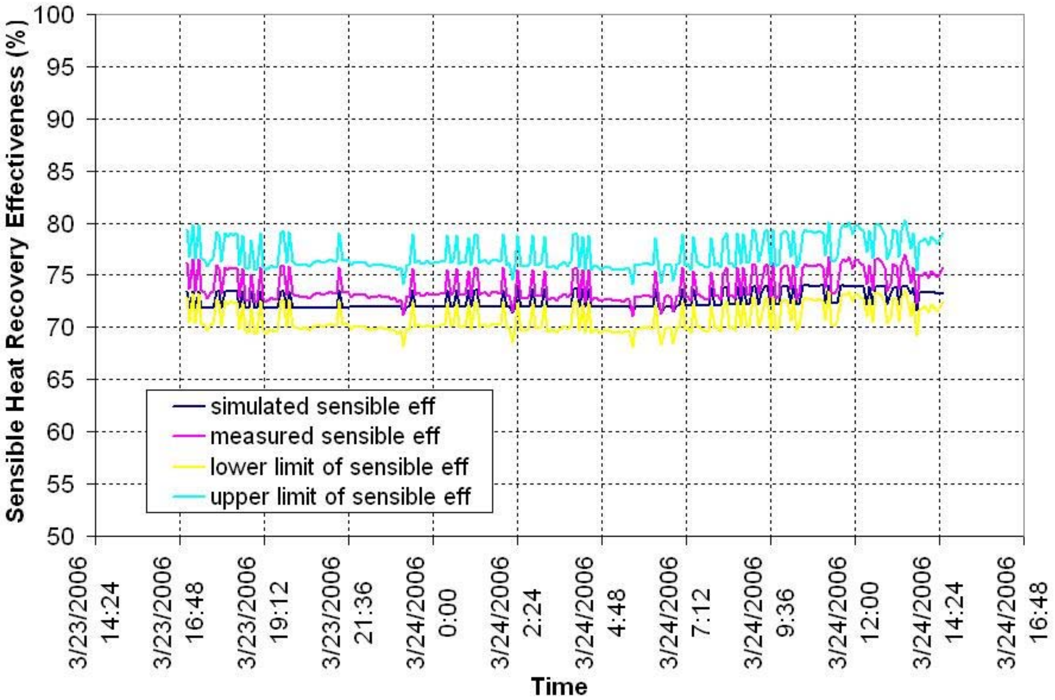
- Performance prediction
- Equipment design
- Equipment control



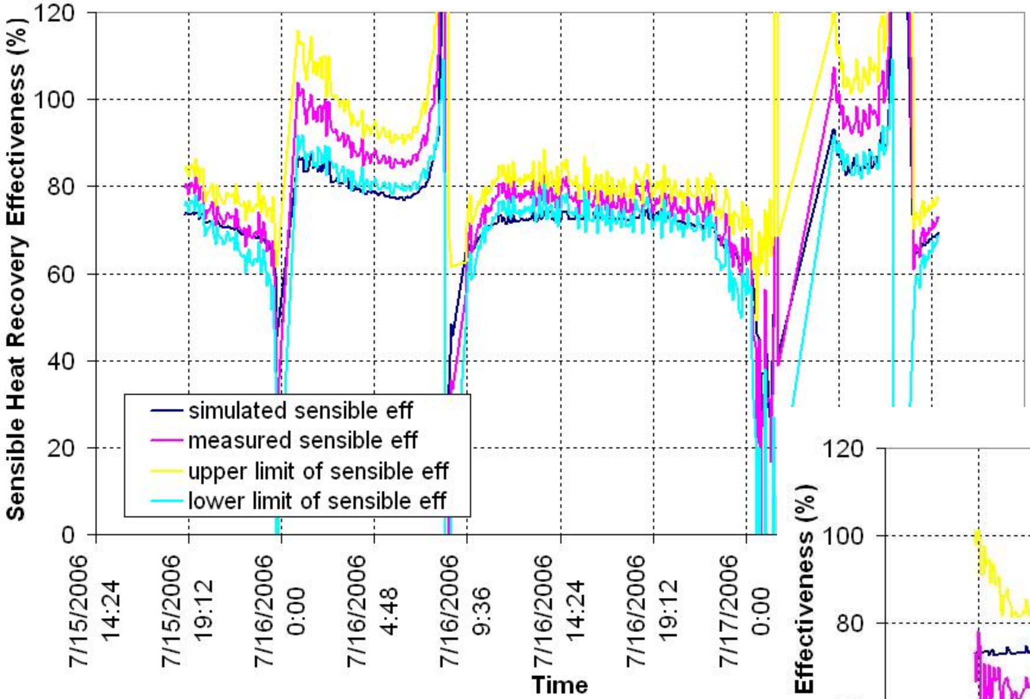
# Enthalpy Wheel Experiment Setup

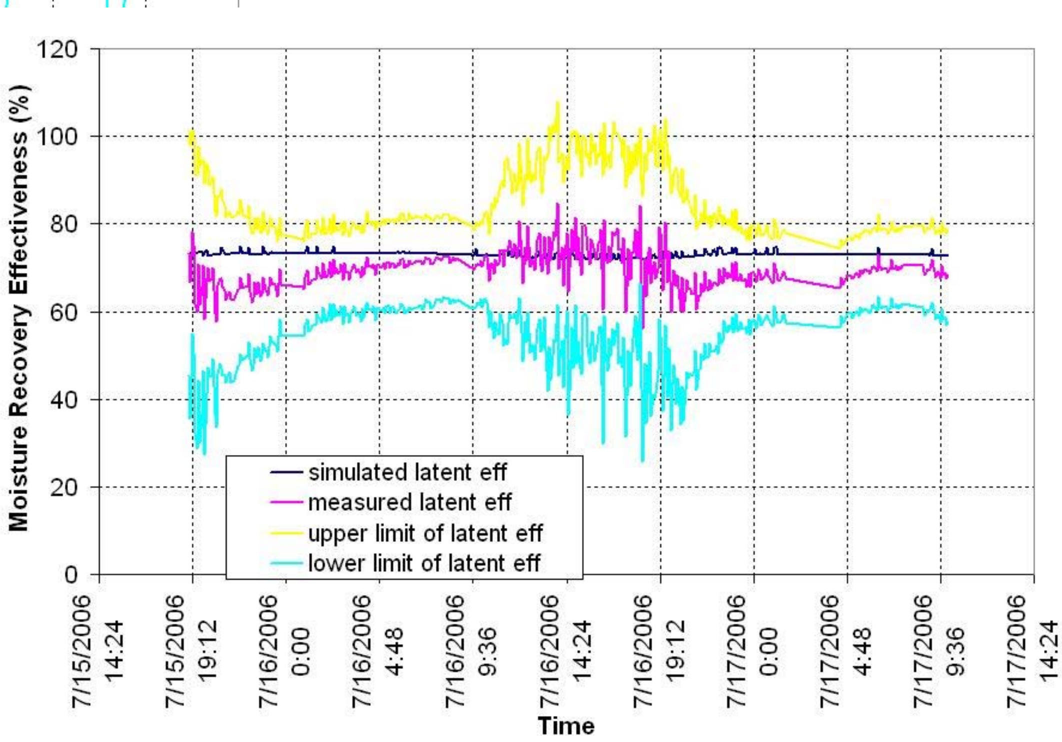


# Validation for Enthalpy Wheel: Winter



# Validation for Enthalpy Wheel: Summer



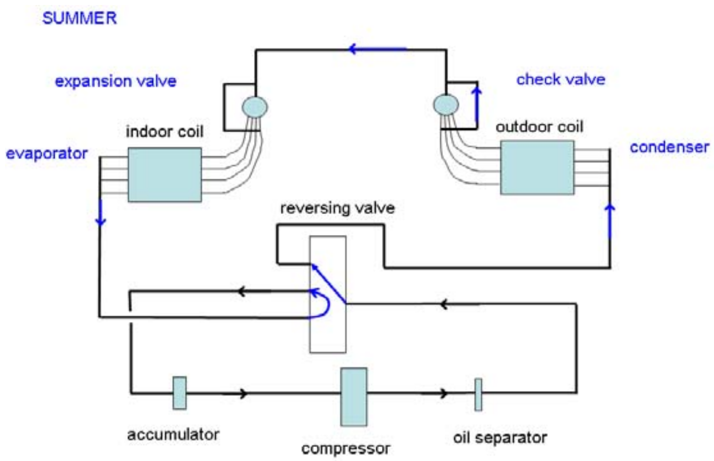
# Performance of Heat Pump System

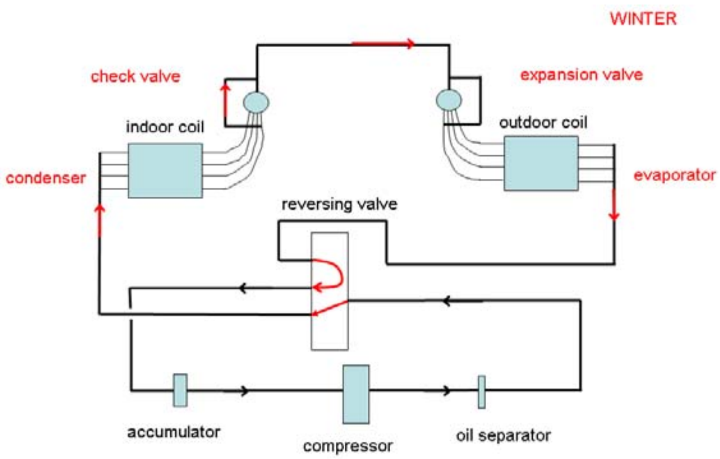
- Summer performance

  COP = cooling output/power input to compressor and condenser fan

  Average COP for July: 4.4
- Winter performance

  Difficulties encountered during defrost operation, changed control logic for reversing valve operation and defrost trigger



# Economics of Overall System

During Year 2006,

- Total energy consumption of the system: 34,345 kWh electricity, 331,143 $ft^3$ natural gas
- Energy cost: $6.6/day for electricity, $9.5/day for natural gas
- Possibilities to reduce cost:
  - Tailor system to application
  - Proper sizing of the components
  - Alternative energy source
  - More sophisticated control strategies

# Preliminary Conclusions

- In winter, delivers air at user specified temperature by means of heat pump and gas heating through the desiccant wheel
- In summer, keeps the space dewpoint low enough to allow for more effective operation of radiant panels, water mullions and fan coils
- In both winter and summer, enthalpy recovery effectiveness over 70%, save energy and cost on ventilating IW
- Enthalpy recovery is a cost effective design option for most climatic conditions
- Combined heat and mass transfer analysis confirms enthalpy recovery performance corresponding to its design and operating parameters
- Expensive to operate the system, ways to reduce cost identified

# Further Investigation

- Design and installation of heat exchanger coil to utilize rejected heat from engine generator: implications on system integration, energy performance and cost
- Replacement of DX coil with chilled/hot water coil: implications on system integration, energy performance and cost
- Other modifications of the machine to suit the needs of IW: DOAS, downsized compressor, less noisy condenser fans
- Operation strategies of the ventilation system: four major components, when to operate what based on occupancy, indoor and outdoor temperature and humidity
- Analysis of alternative ways to do DOAS: capital and operating cost, resulting indoor condition
- Design and operation of active desiccant dehumidification unit for ventilation with space sensible cooling/heating devices