Impact of the natural ventilation in a bay of the IW on cooling and ventilation energy requirements for a typical summer in Pittsburgh

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IWESS Presentation

October 4th 2006

PURPOSE OF THE PROJECT

- Extend the previous studies : validation and improvement of the TRNSYS/COMIS model

- Define control strategies for the window opening

- Predict the system performance to meet the cooling and ventilation requirements

- Determine the most efficient control strategy to maximize energy saving, ensure thermal comfort and avoid condensation in IW

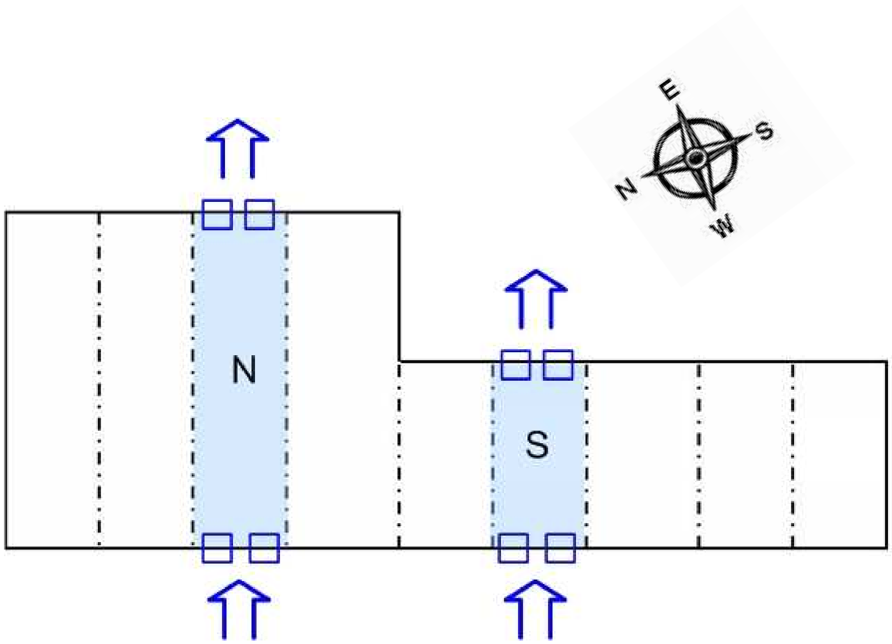
CONTENTS

1. PRESENTATION OF THE STUDY

Hybrid ventilation

Type of ventilation	**Hybrid**
Advantages	- less climatically dependent than natural ventilation - can optimize the use of the natural ventilation based on the cooling demand and the outside conditions - can design less robust natural ventilation systems
Disadvantages	- no first cost savings - occupants can be confused - energy savings may not be realized

1. PRESENTATION OF THE STUDY



Cross ventilation

Modeling assumptions

Zone :
- One bay (south or north) of IW (Pittsburgh, PA)
- 2 windows on each façade (E&W)
- Adiabatic walls (N&S)

Occupancy
- 6 persons max.
- Zone occupied from 7:00 AM to 8:00 PM (thermal comfort required during this period)

Window opening:
- Two positions : maximum opening / close
- 4 windows opened at the same time

Cooling system:
- Fan coils (T set point : 22°C with a nighttime setback)

Ventilation system:
- Semco unit (Tset point : Tin / RH set point : 50%)

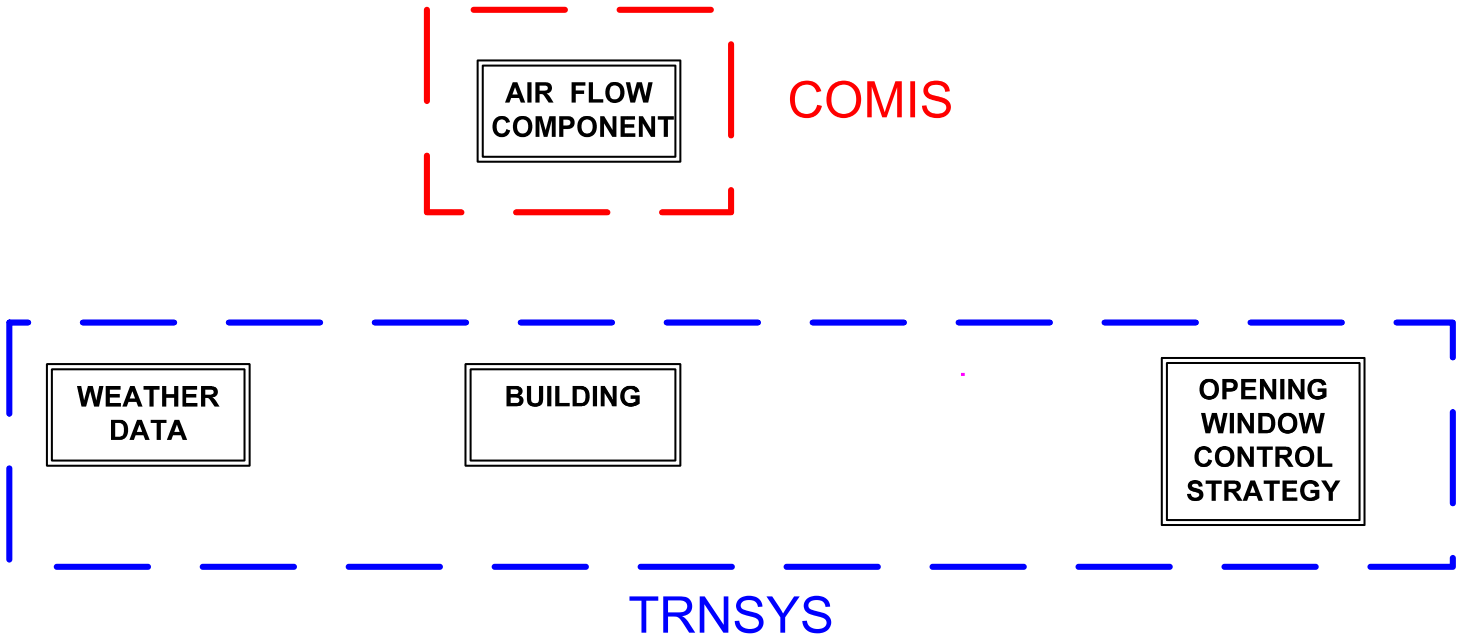
2. TRNSYS-COMIS model

- **TRNSYS (TRaNsient energy SYstem Simulation)**
Flexible tool designed to simulate the transient performance of thermal energy systems
(developed by SEL, CSTB, TESS, TRANSSOLAR)

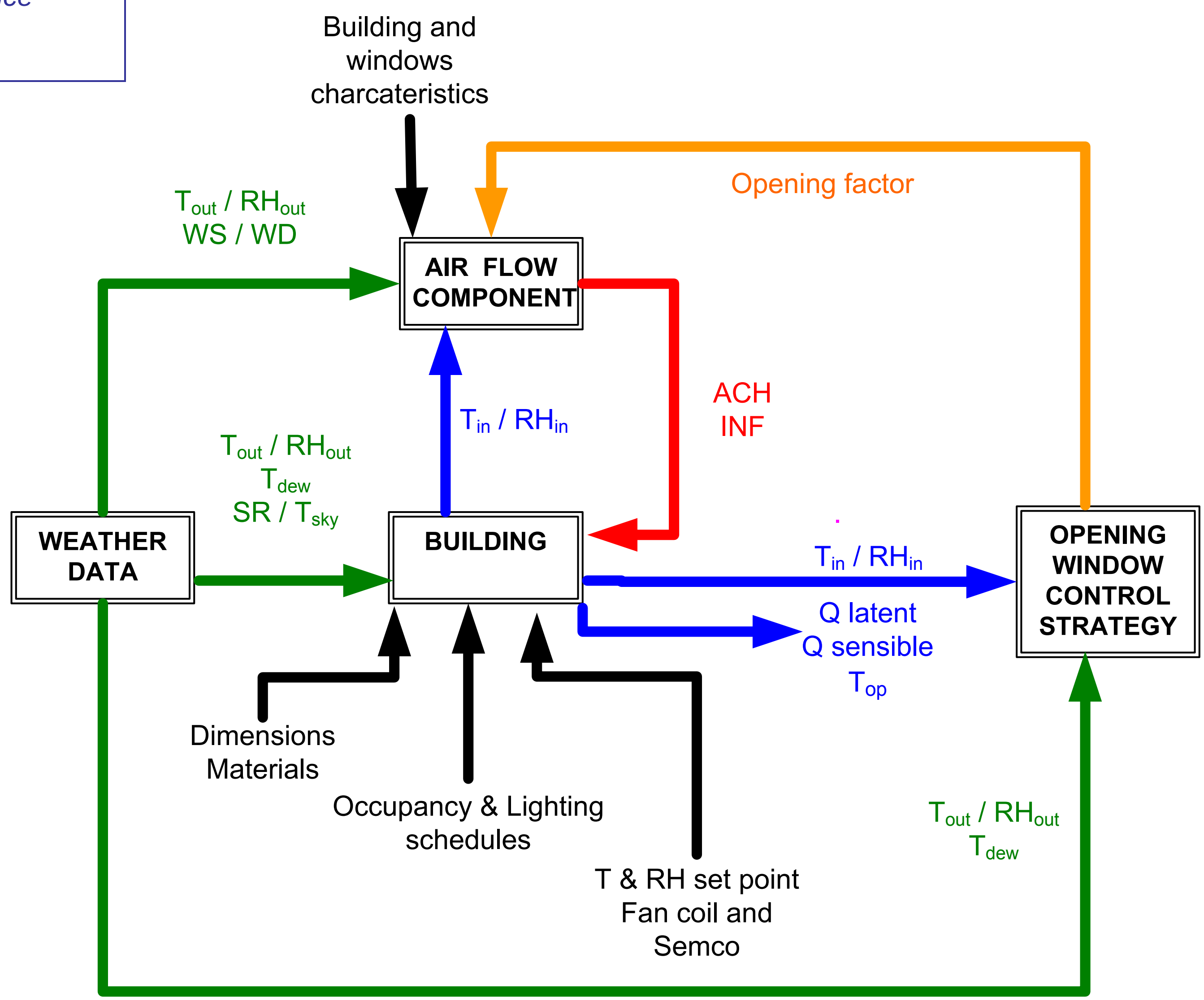
- **COMIS (Conjunction Of Multizone Infiltration Specialists)**
Multizone Air Flow and Contaminant Transport Model
(developed for IEA Annex 23, maintained by CSTB, EMPA, LBNL)

➢ **TRNSYS-COMIS model :**
dynamic thermal building model with an integrated ventilation model

2. TRNSYS-COMIS model



2. TRNSYS-COMIS model



3. CONTROL STRATEGIES

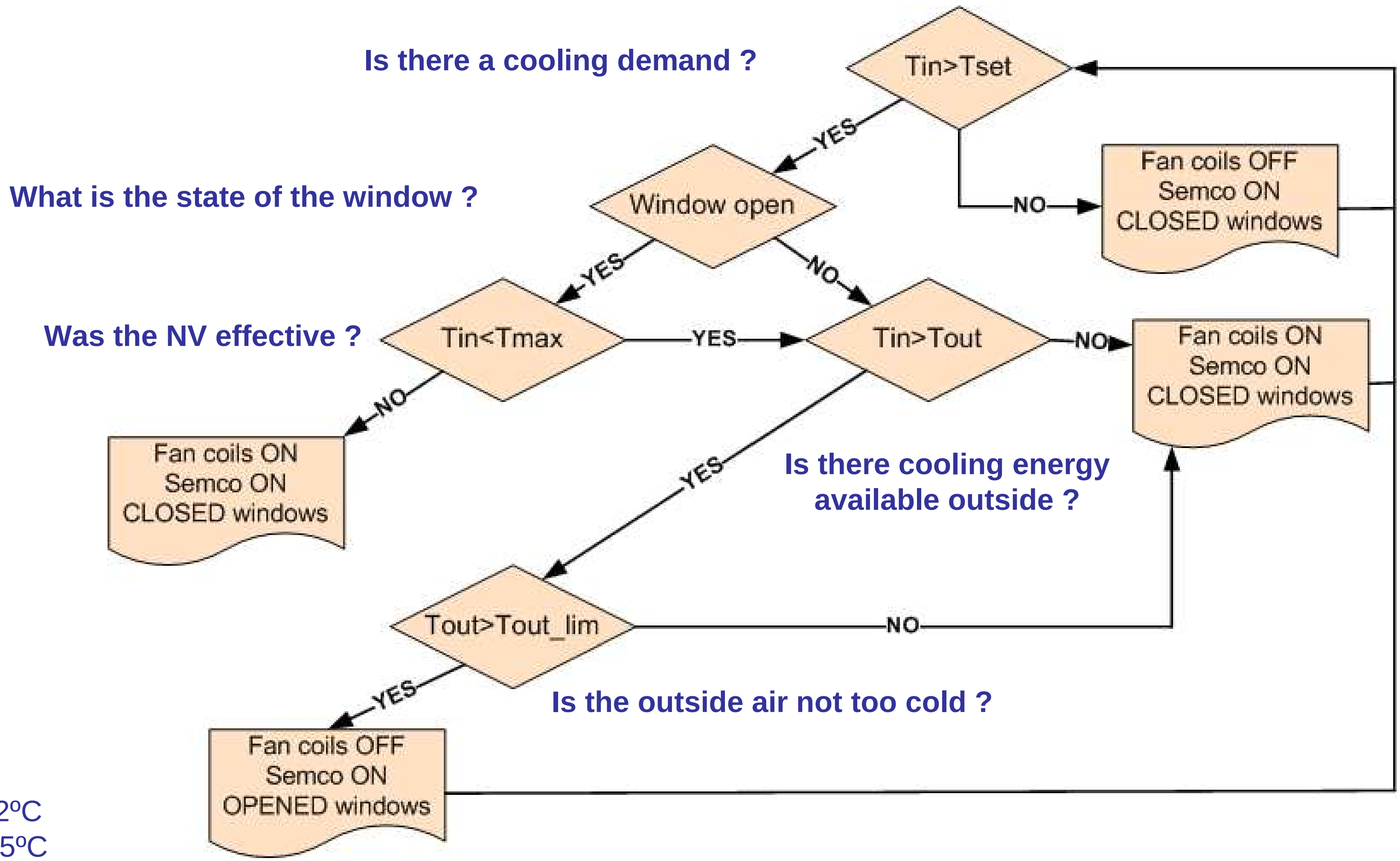
- Classical controls based on :
  - ✓ Temperature (Control A)
  - ✓ Temperature & Humidity (Control B)

  (Several on/off differential controllers with hysteresis)

- Different thresholds used for the controls

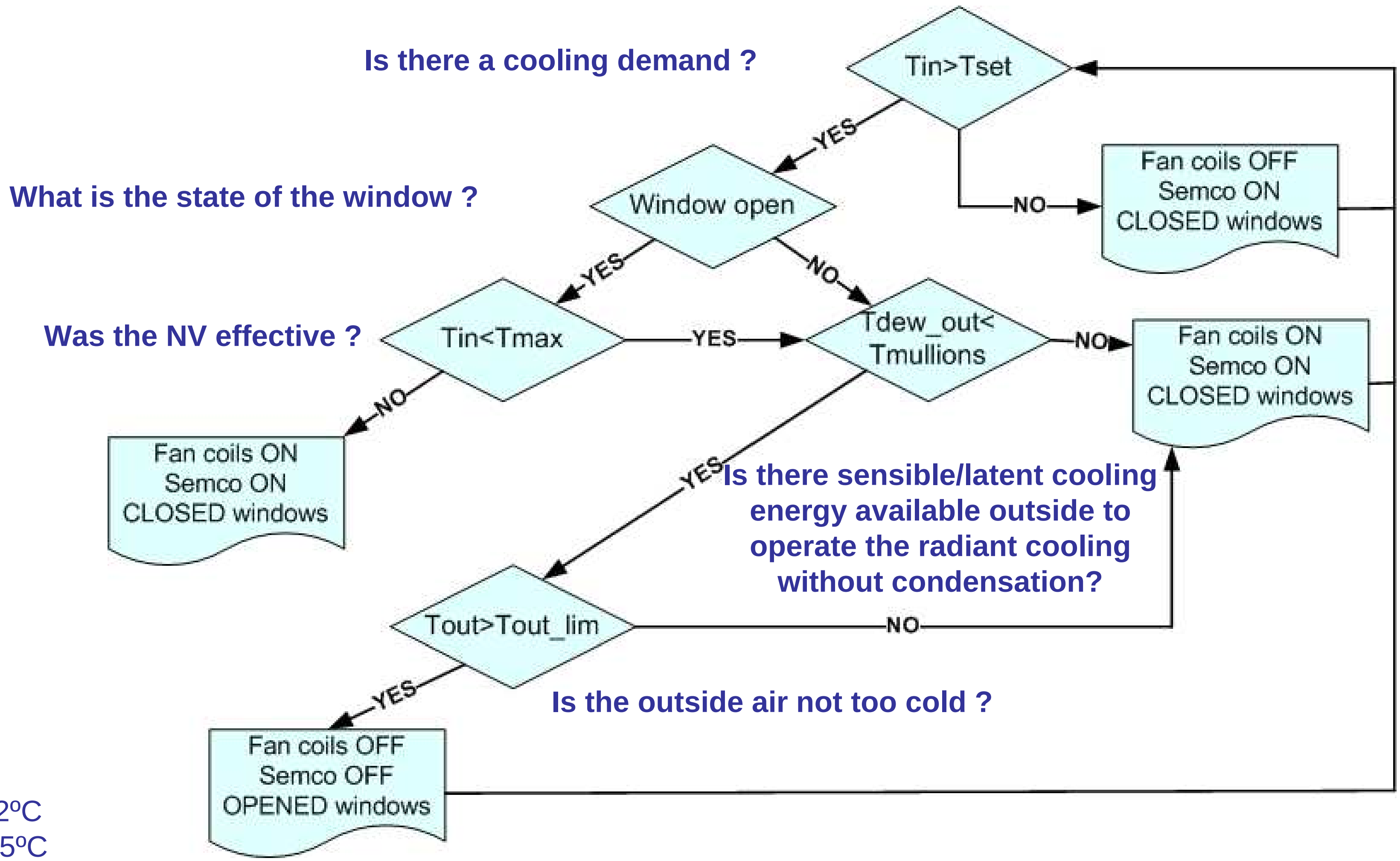
- Programmed in Fortran as a new TRNSYS component

Control based on Temperature (Control A)



T_{set} = 22ºC
T_{max} = 25ºC

Control based on Temperature and Humidity (Control B)



T_{set} = 22ºC
T_{max} = 25ºC

Summary

Control strategy	Schedule	Building loads		Ventilation loads	
		sensible	**latent**	**sensible**	**latent**
Base case	[O] No natural ventilation	Fan coils	Semco unit	Semco unit	
Control A (T)	[N] nighttime natural ventilation [D&N] daytime and nighttime natural ventilation	Fan coils / opening windows	Semco unit	Semco unit	
Control B (T&RH)	[N] nighttime natural ventilation [D&N] daytime and nighttime natural ventilation	Fan coils / opening windows	Semco unit / opening windows	Semco unit	

Control A = Influence of the minimum outside air temperature (Tout_limit) on the system performance and thermal comfort

Control B = Influence of the water temperature in the mullions (Tmullions) on the system performance and thermal comfort

4. SYSTEM PERFORMANCE

Bay in South

	Energy savings (%)			**Thermal comfort (% of time in the comfort zone)**		**Hours of opening windows**
Case	**Sensible**	**Latent**	**Total**	**Occupied**	**Unoccupied**	
Base case	*4,541 kWh*	*2,137 kWh*	*6,679kWh*	*0.88*	*0.74*	*0*
Control Temperature						
[N], Tout> 17C	15.0	*-184*	*-48.7*	0.83	0.38	525
[N], Tout> 15C	21.0	*-205*	*-51.5*	0.77	0.40	705
[N&D], Tout>17/19C	18.0	*-219*	*-57.8*	0.77	0.36	620
[N&D], Tout>15/19C	23.3	*-240*	*-60.9*	0.72	0.29	787
Control Temperature and Humidity						
[N&D], Tout>17/19C, DP<12C	14.2	*-4.8*	8.9	0.88	0.54	468
[N&D], Tout>17/19C, DP<14C	20.9	*-1.0*	**13.9**	**0.84**	0.49	733
[N&D], Tout>17/19C, DP<15C	26.1	*3.3*	18.8	0.78	0.45	950
[N&D], Tout>17/19C, DP<16C	33.8	*11.0*	26.5	0.73	0.38	1255
[N&D], Tout>17/19C, DP<18C	45.8	*32.6*	41.6	0.59	0.29	1811

4. SYSTEM PERFORMANCE

The IW and the climate **are not ideal** for the natural ventilation:
-light thermal mass
-location of the windows
-not enhanced use of the stack effect
-High humidity in the outside air

Nevertheless, **decrease the total energy demand** : **14% of energy savings** (to maintain the thermal comfort during 84% of the occupied period) both in North and South bays : around 1,000 kWh per bay per summer

The use of the hybrid ventilation does not impact much the **cooling peak** (around 3.1kW – South bay / 3.4kW North bay).

The natural ventilation provides **required ventilation**.

5. FURTHER RESEARCH

Precision of the previous results can be improved thanks to:
✓ Measurement of the pressure coefficient Cp (to characterize the air tightness of the IW façade)
✓ CFD modeling (to study the air flow pattern in the IW)

Exercising the model in its current form:
✓Increasing the thermal mass of the building
✓Decreasing the time step between two control decisions (from 1 hr to 45 min or 30 min)
✓Defining additional opening position of the windows

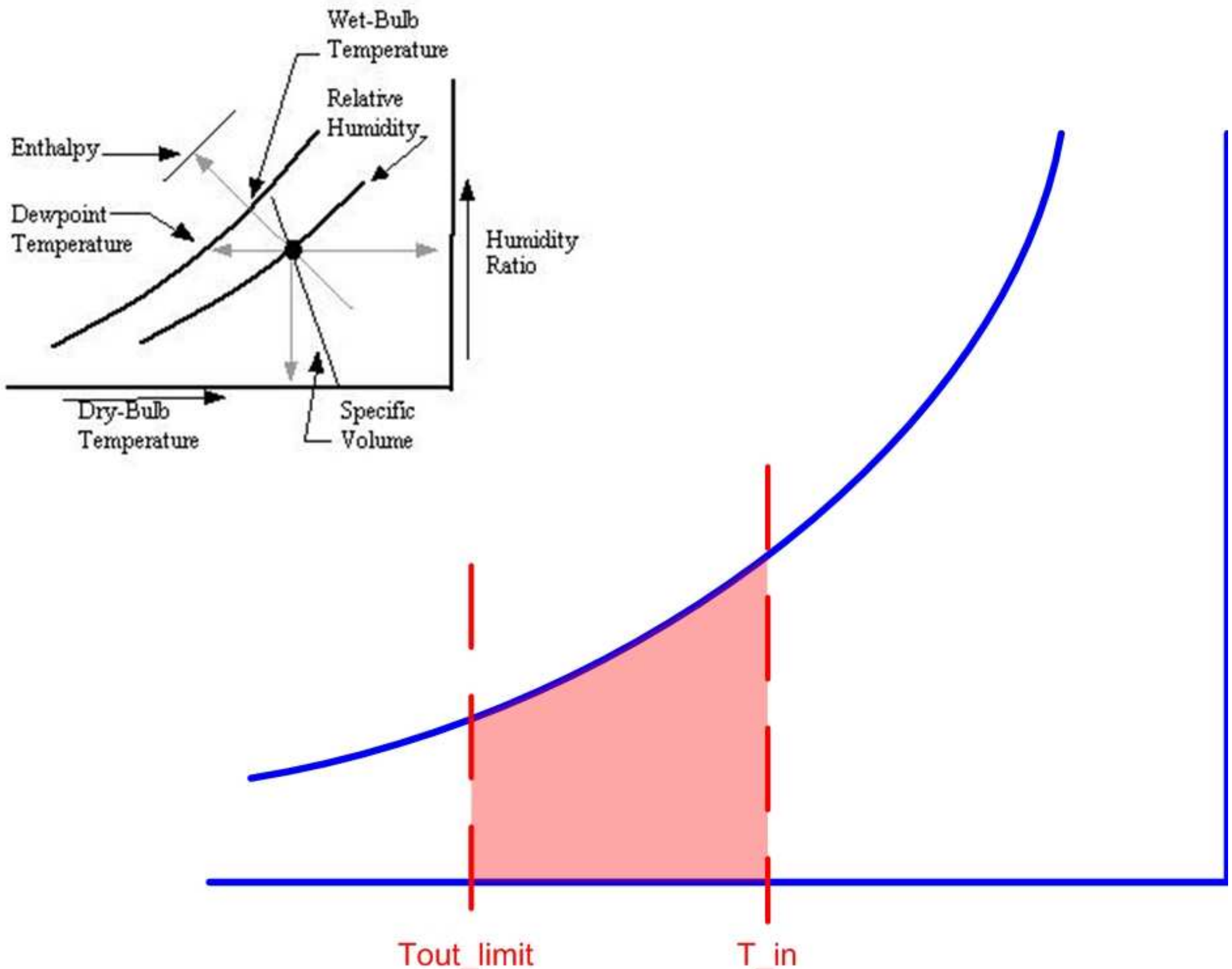
Additional extensions of the model:
✓ Improving the control strategy to open the windows (optimum or predictive control)
✓ Using fan assisted natural ventilation
✓ Implementing the solar shading control with the ventilation control

Additional research:
✓ Economical effect on energy consumption based on the electricity consumption of the fan coils and the Semco.
✓ Develop a modular model that can be used for the ITEST project (SOMFY)

1 - Presentation of the study
2 - TRNSYS/COMIS model
3 - Control strategies
4 - System performance
5 - Further research

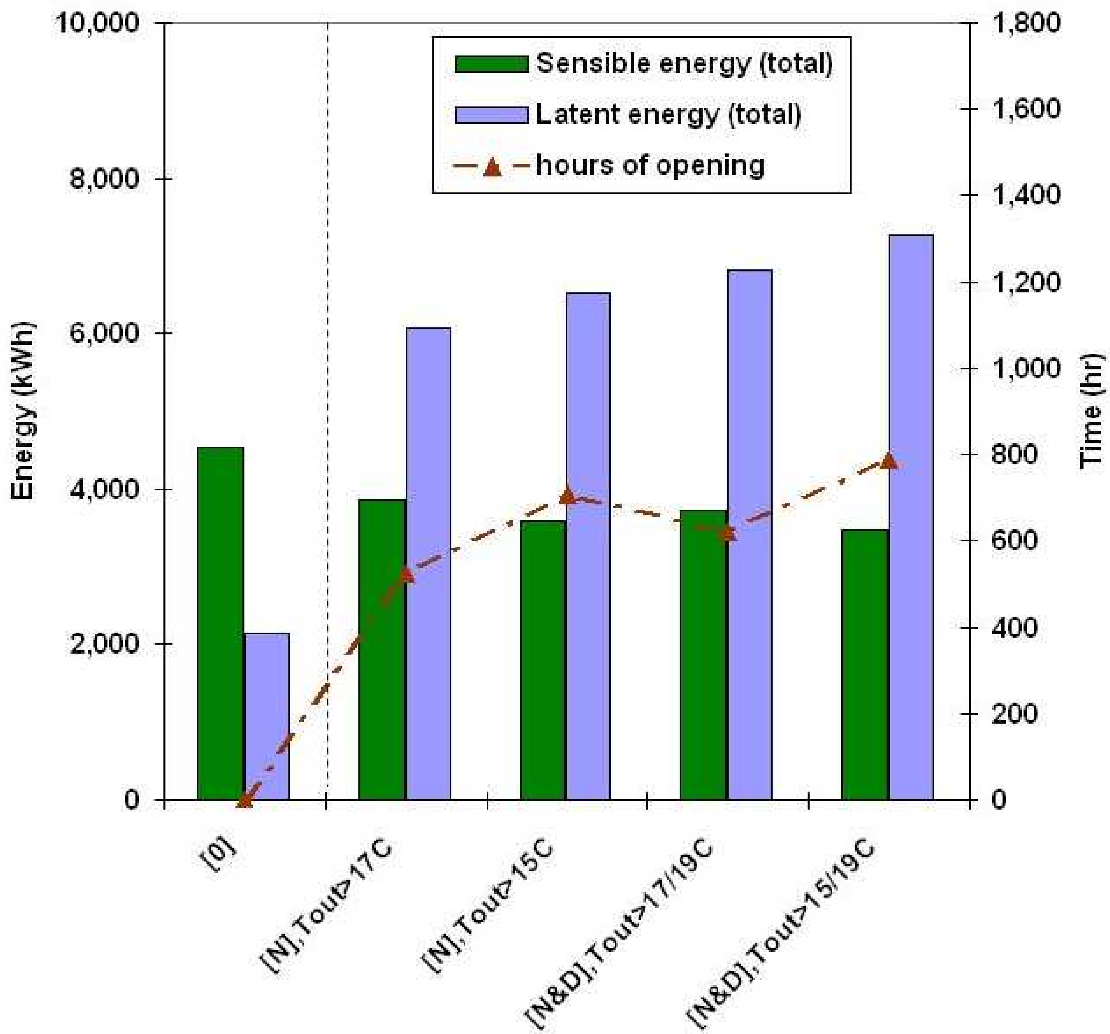
QUESTIONS ?

Control based on Temperature (Control A)



Bay in South

Control A (Temperature)



Fan coils OFF when windows are open
Semco always ON

Opening the windows leads to:

✓ a decrease of the total sensible energy demand by taking advantage of the cooling energy available outside

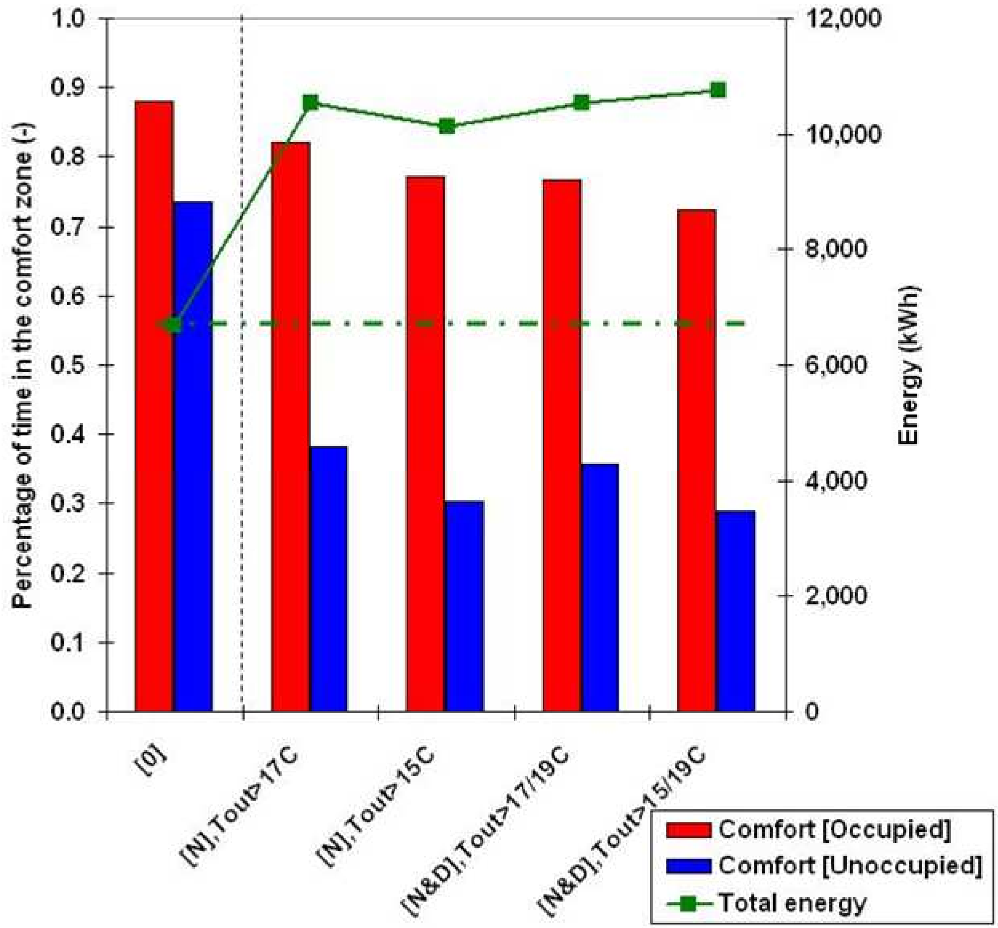
✓ an increase of the latent energy demand by only taking the temperature into account for the opening strategy

Nighttime natural ventilation is more efficient than both nighttime and day time natural ventilation

Bay in South

Control A (Temperature)

Fan coils OFF when windows are open
Semco ON



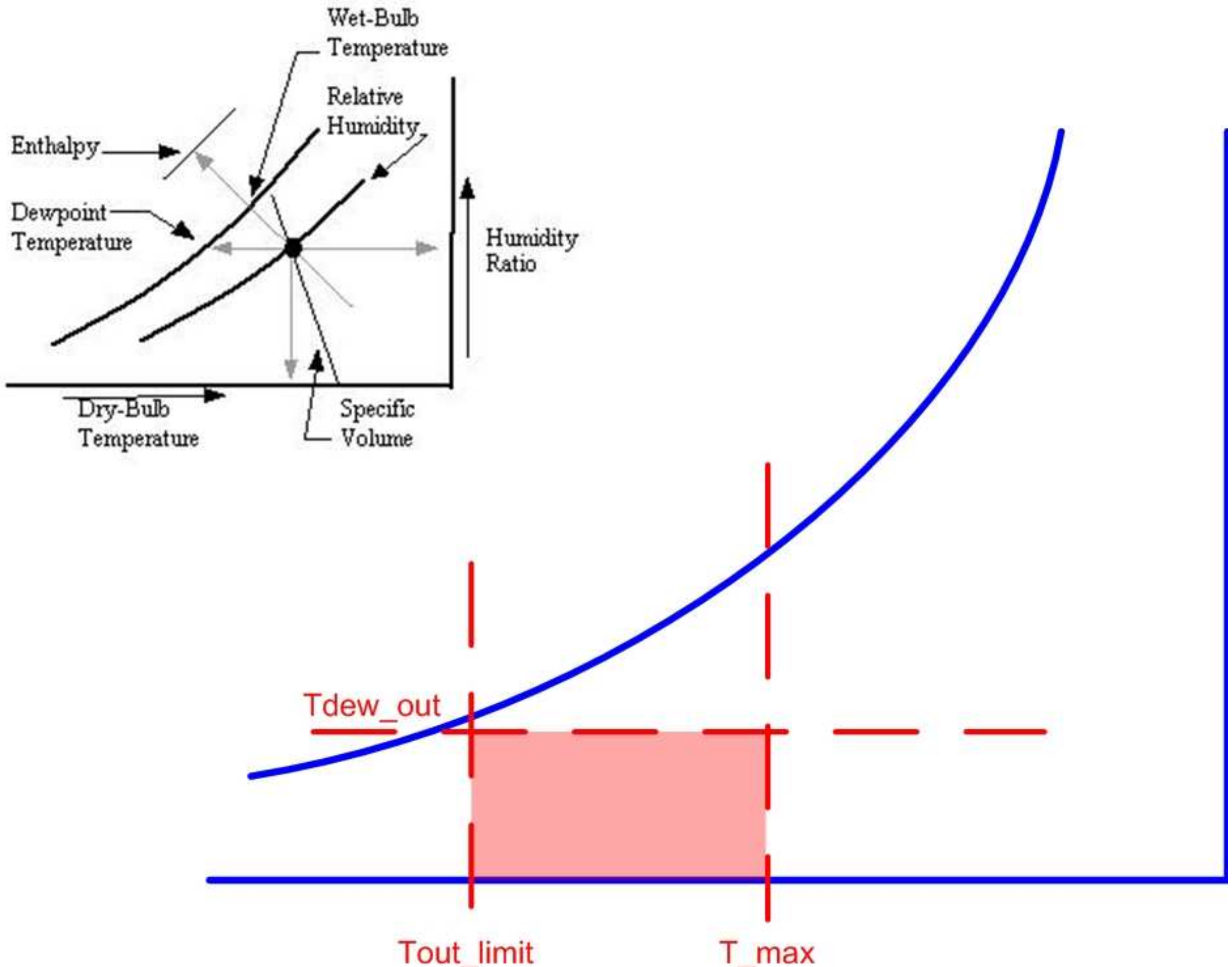
Opening the windows leads to:

✓an increase of the total energy demand by only taking the temperature into account for the opening strategy

✓a decrease of the thermal comfort in the bay

Thermal comfort zone : 22ºC<Top<26ºC / 25%<RH<65%

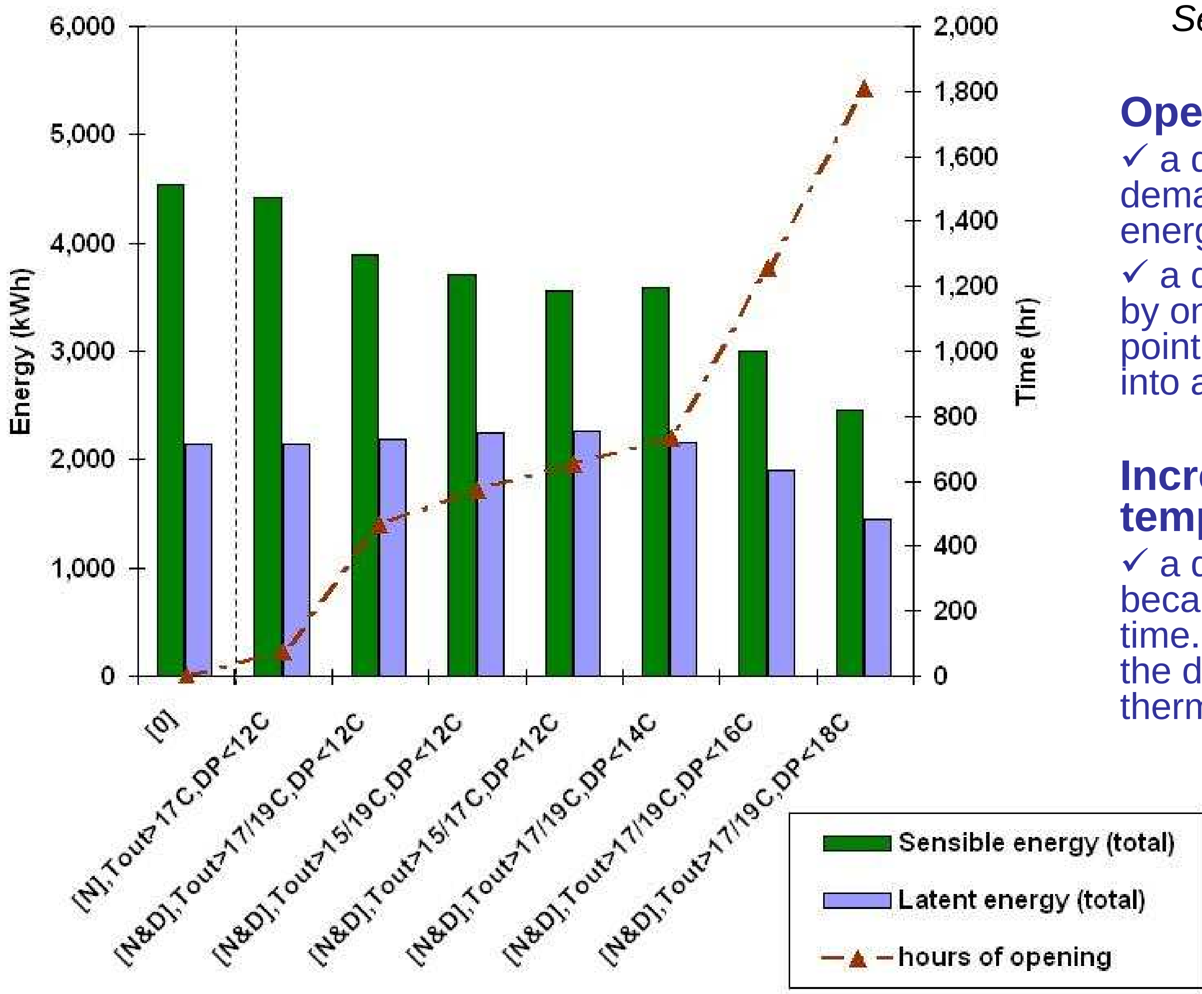
Control based on Temperature and Humidity (Control B)



Bay in South

Control B (Temperature and Humidity)

Fan coils OFF when windows are open
Semco OFF when windows are open



Opening the windows leads to:

✓ a decrease of the total sensible energy demand by taking advantage of the cooling energy available outside

✓ a decrease of the latent energy demand by only admitting air with a specific dew point (taking the temperature and humidity into account)

Increasing the dew point temperature leads to:

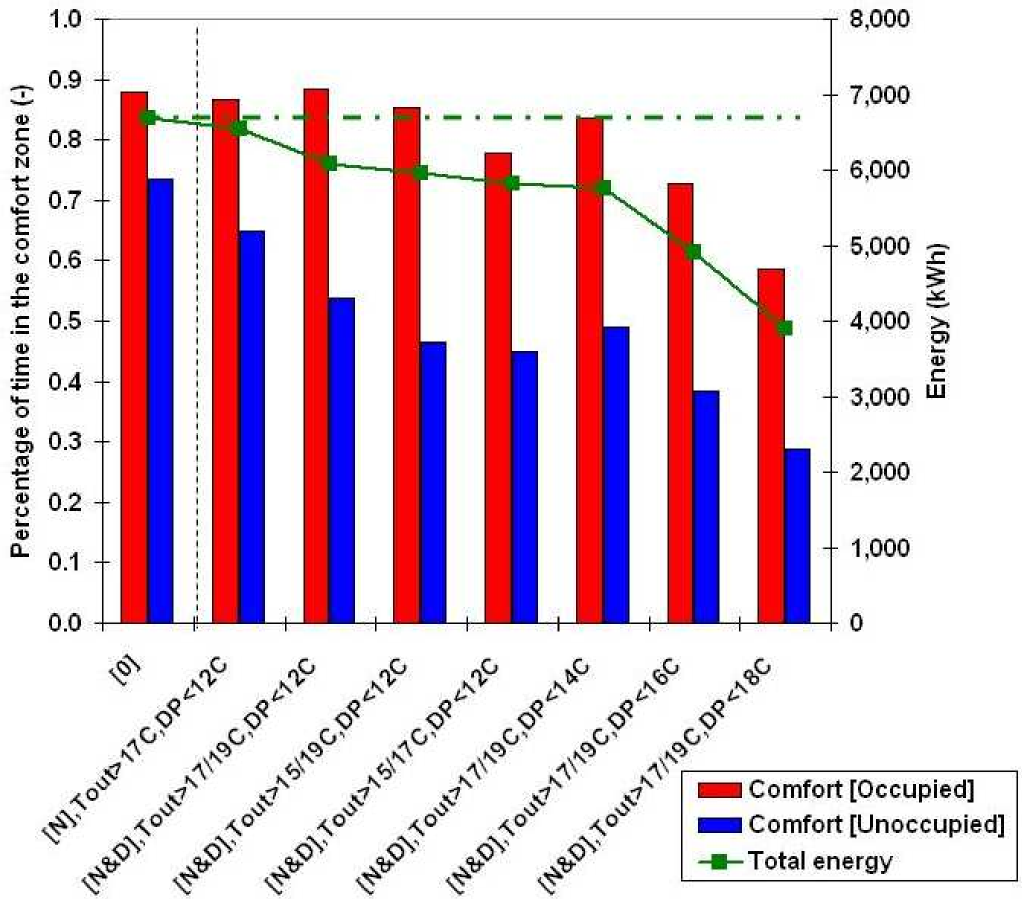
✓ a decrease of the latent energy demand because the SEMCO is operating less time. But the inadequacy of the choice of the dew point can be assessed by the thermal comfort study

Nighttime natural ventilation is less efficient than both nighttime and day time natural ventilation

Bay in South

Control B (Temperature and Humidity)

Fan coils OFF when windows are open
Semco OFF when windows are open



Opening the windows leads to:

✓a decrease of the total energy delivered by the ventilation and cooling systems (by limiting the time of operation)

✓a decrease of the thermal comfort in the bay when the limit of dew point temperature is too high

Thermal comfort zone : 22ºC<Top<26ºC / 25%<RH<65%