Building Simulation 2013 (Chambéry)

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Modelling the energy performance of night-time ventilation

Quasi-steady state calculation method

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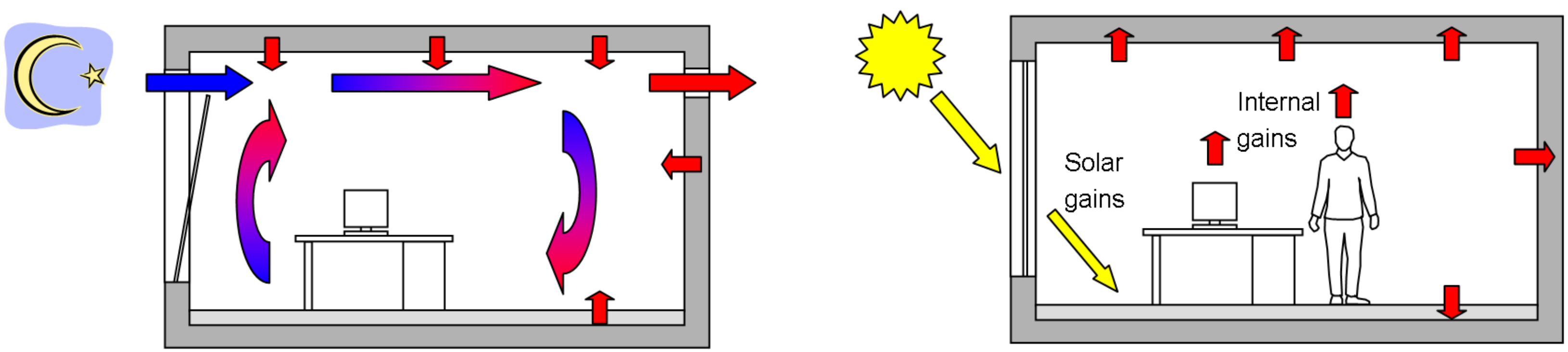
- What is the goal of night-time ventilation?
  - Achieve thermal comfort during the transition/summer season
  - Avoid the use of mechanical cooling system

- Principle
  - The building structure is cooled down overnight with relatively cold outdoor air
  - Heat sink available during the occupied period of the next day by making use of the exposed thermal mass



Problem:

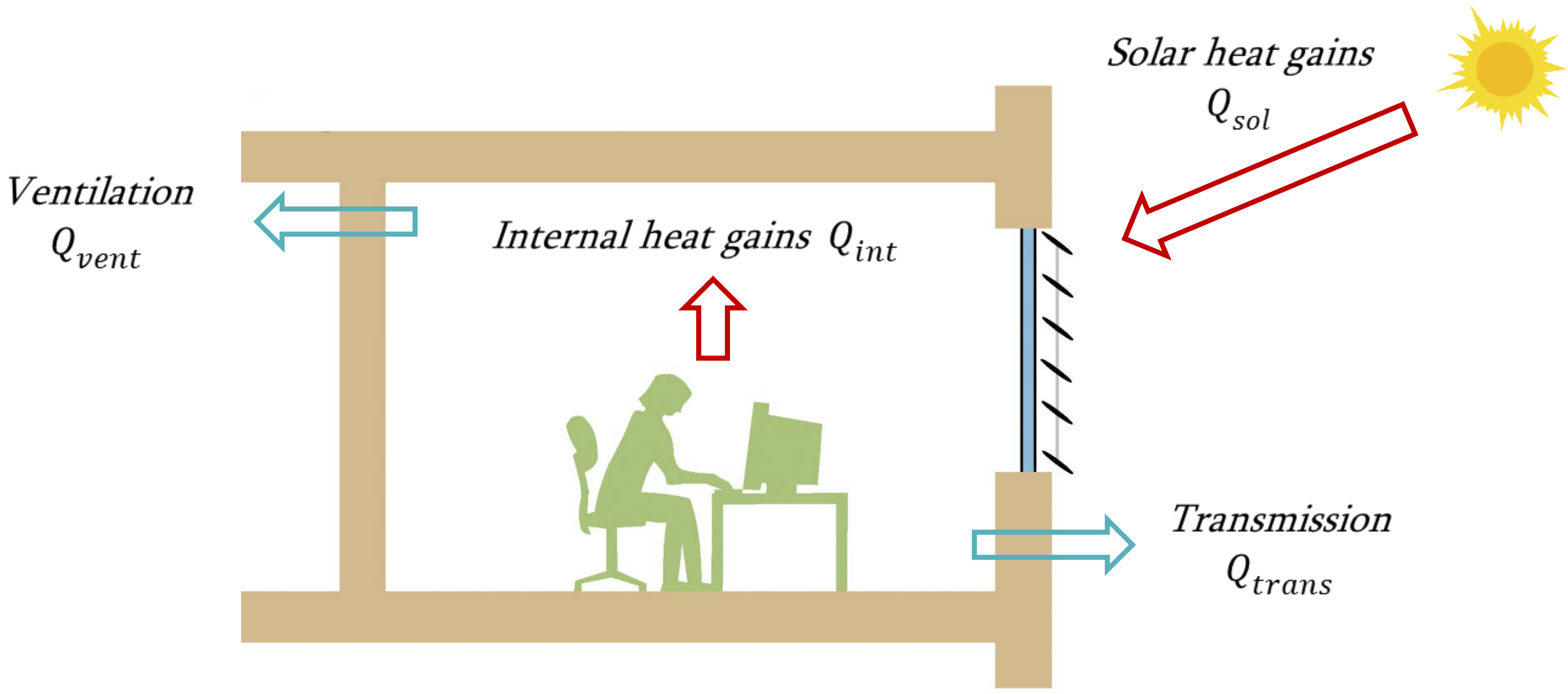
How to take into consideration the dynamic effects of night-time ventilation in the monthly calculation method?

Plan:

- Principle of the calculation method
  - Cooling need in EN ISO 13790
  - Methods tested for modelling night-time ventilation
- Development of the new calculation methods
  - Presentation of the simulation cases
  - Results
- Selection & Validation of the model *(not included in the paper)*

Principle of the calculation method

- How is calculated the cooling need in EN ISO 13790?

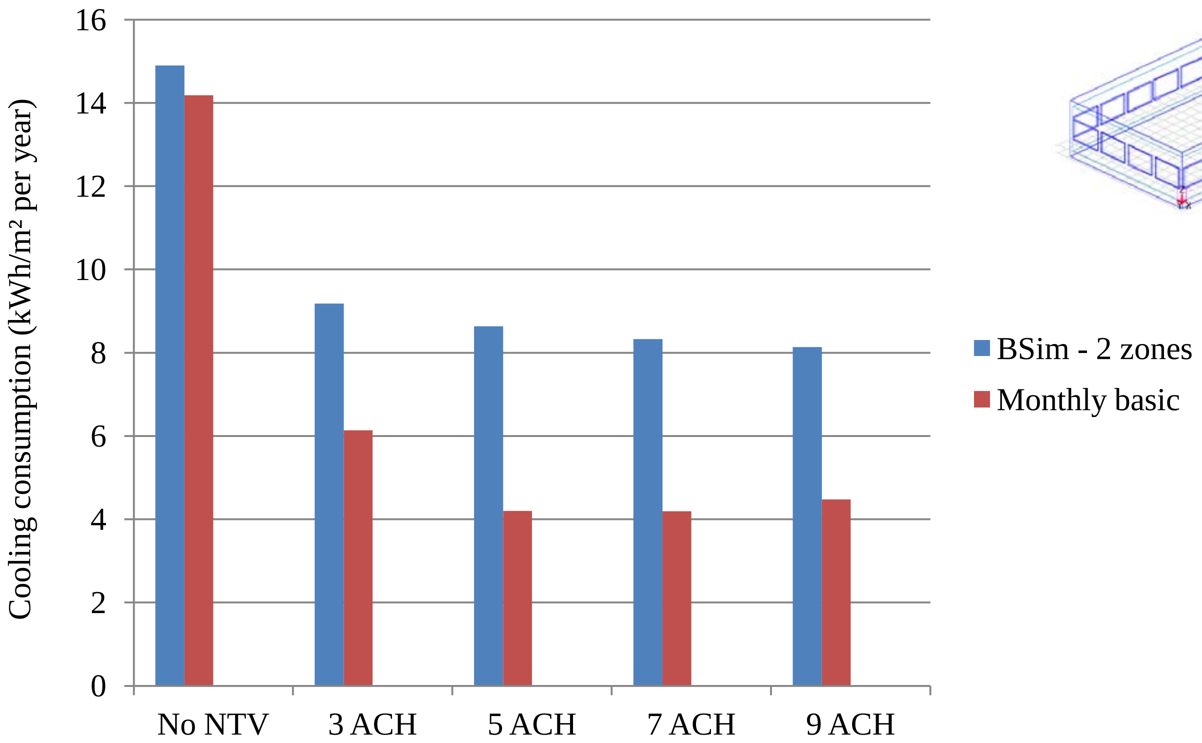


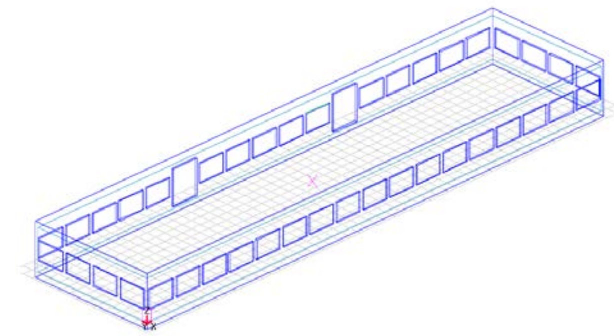
Monthly heat balance

$$Q_{C,nd} = (Q_{sol} + Q_{int}) - \eta \; (Q_{trans} + Q_{vent})$$

$\eta \in [0; 1]$

- Why do we need correction coefficients?





⇒ Overestimation of the capacity of NTV without correction coefficients

- limited heat storage capacity (function of the thermal mass)
- limited temperature variation in the building (from 20°C to 26°C)

- Methods tested for modelling night-time ventilation

$$Q_{C,nd} = (Q_{sol} + Q_{int}) - \eta \; (Q_{trans} + Q_{vent})$$

$$Q_{vent} = \rho_{air}\, C_{air} \left(f_{vent,t}\, q_{vent} + C_{NTV}\, f_{NTV,t}\, q_{NTV}\right) \left(\theta_{int,SP} - \theta_{ext}\right) t$$

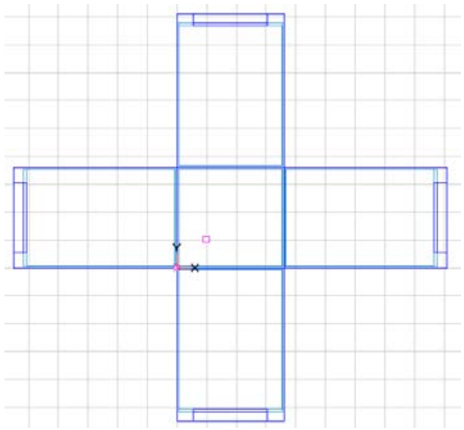
Method 1
(proposed in EN ISO 13790)

$$\eta = \frac{1 - \left(C_\gamma\, \gamma_C\right)^{-a_C}}{1 - \left(C_\gamma\, \gamma_C\right)^{-(a_C+1)}}$$

Method 2

DEVELOPMENT OF THE CALCULATION METHOD

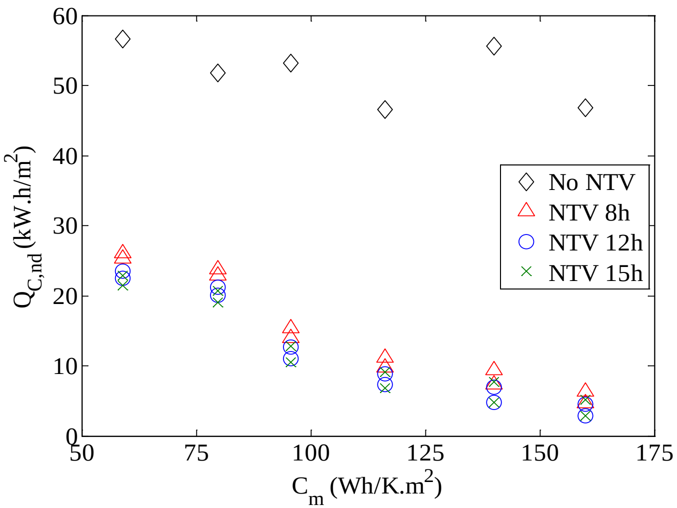
- Development of the models
  - Danish climate
  - single office room (5×3.50×2.55 m)
  - 55 % of the façade glazed, no solar shading



Top view

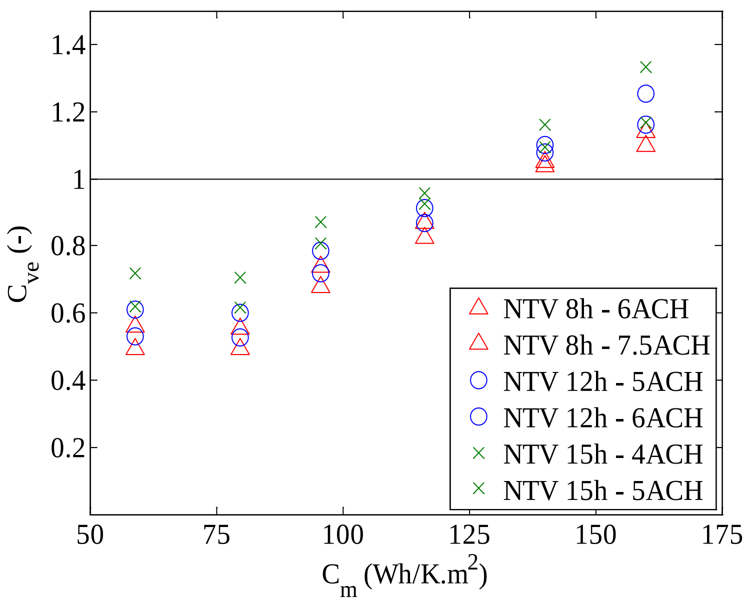
- 288 simulations
  - 6 levels of thermal mass (60 – 140 Wh/K.m²)
  - air change rates for NTV (4 – 7.5 ACH)
  - maximum time of operation (from 8h to 15h)
  - 4 orientations
  - 2 levels of internal heat loads

- Results: Effect of night-time ventilation (South facing room)

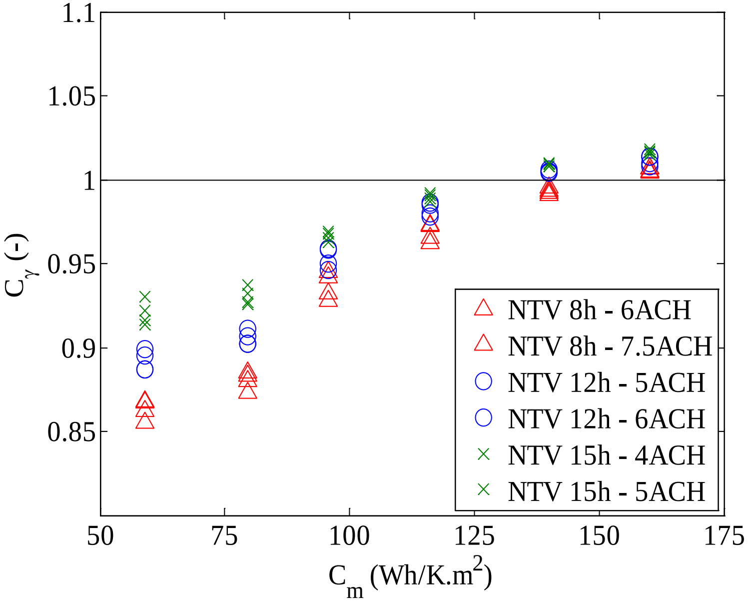


- Parameters influencing C_{ve} and C_{γ}
  - Major influence of the thermal mass
  - Minor influence of the maximum time of operation

- Method 1



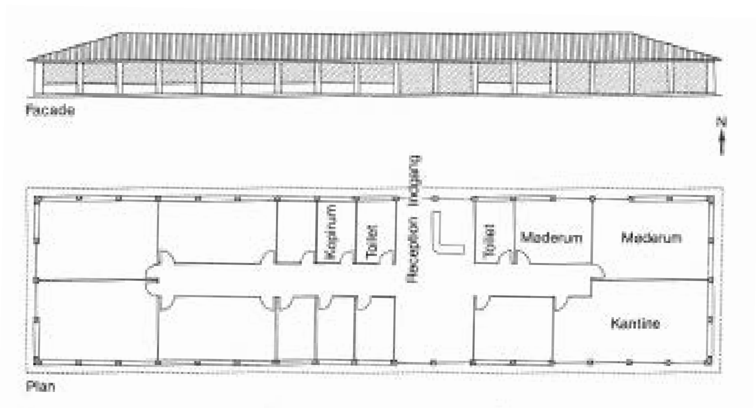
- Method 2

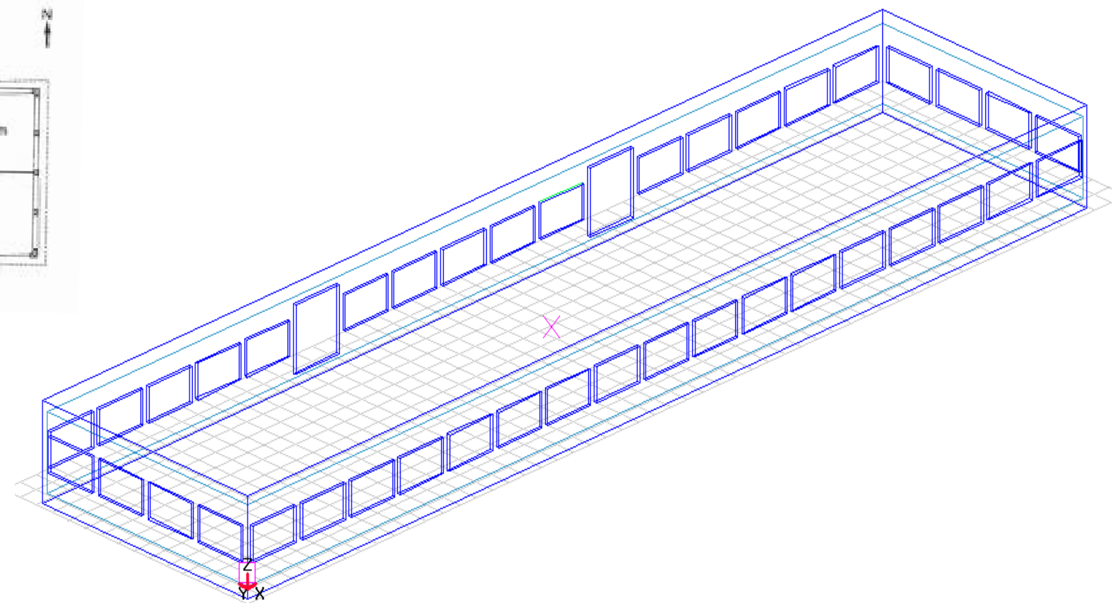


SELECTION & VALIDATION OF THE MODEL

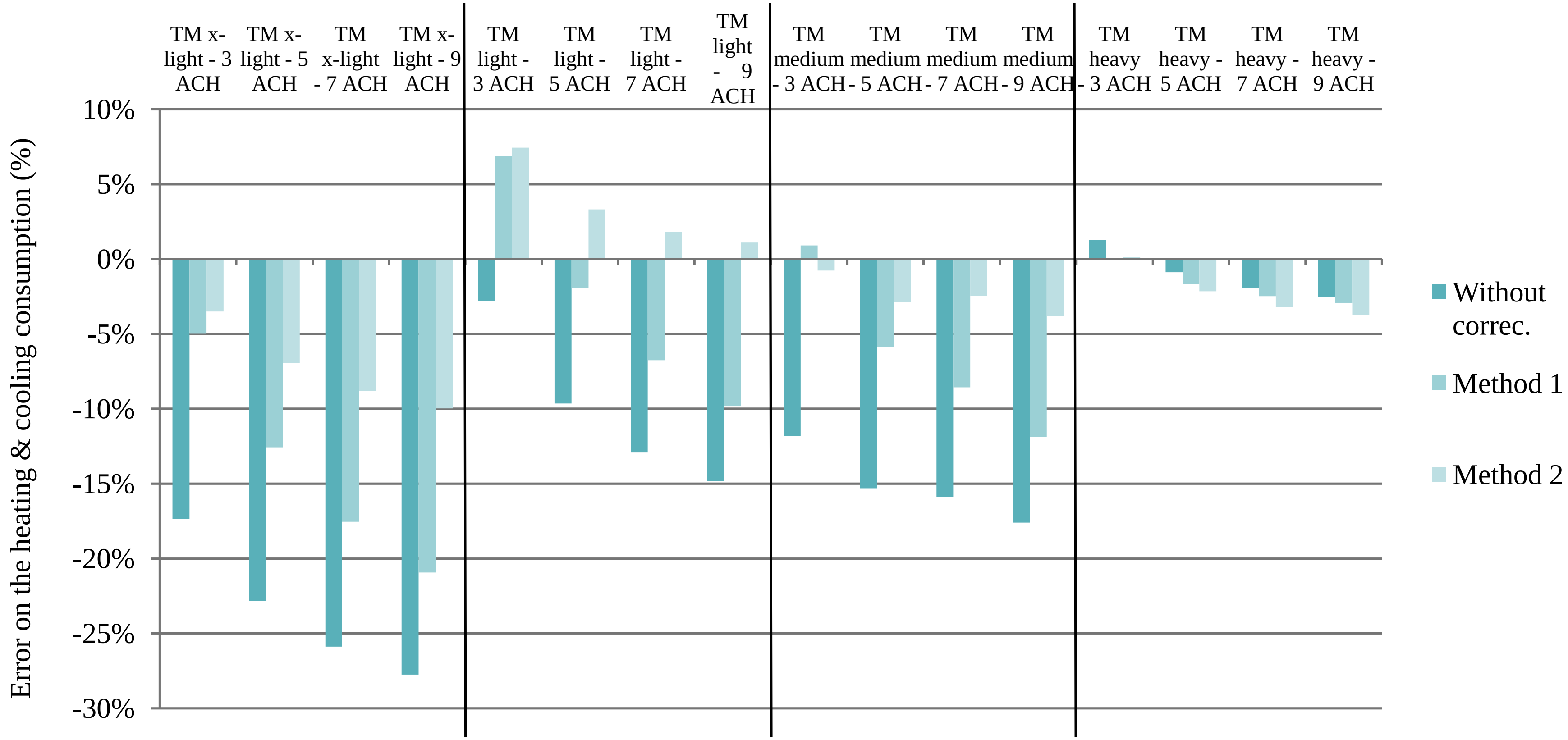
- Model used for validation (Danish BR)
    - Different shape
    - Different window-to-floor-area ratio
    - 2 thermal zones

Test with 4 different levels of thermal mass and different air change rates.





- Validation results



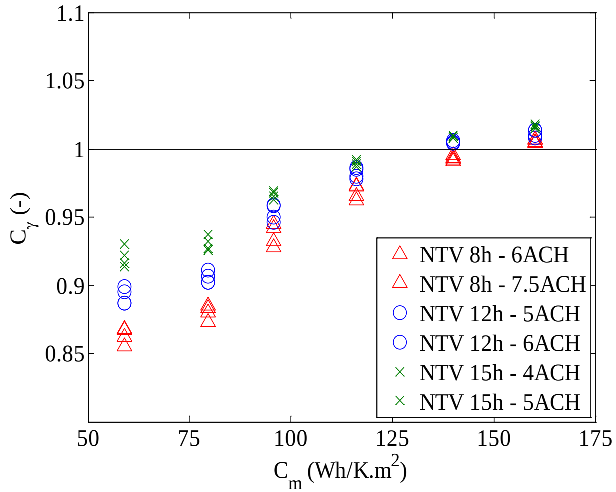
Accuracy of Method 2 ⇒ ± 5%

CONCLUSION

- 2 calculation methods have been developed (C_{ve} and C_γ) from 288 simulations
- Only one method has been selected (after the validation case): C_γ
  - Accuracy of ± 5 % (on the total energy consumption)
  - Accurate even in mono-zone modelling (robustness)
  - BUT not tested with other climates

$$\eta_{C,ls} = \frac{1 - \left(C_\gamma\, \gamma_C\right)^{-a_C}}{1 - \left(C_\gamma\, \gamma_C\right)^{-(a_C+1)}}$$

$$C_\gamma = min\begin{pmatrix} 0.7666 + 0.0013\, C_m + 0.0044\, max\, hrs_{NTV} \\ 1 \end{pmatrix}$$



Thank you for your attention!

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