INTERIOR MOULD GROWTH RISK REDUCTION: APPLICATION OF NONLINEAR PROGRAMMING FOR ENVELOPE OPTIMIZATION

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PRESENTATION

- INTRODUCTION
- CASE STUDY
- SIMULATION
- OPTIMIZATION PROGRAMME
- RESULTS
- CONCLUSION

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INTRODUCTION

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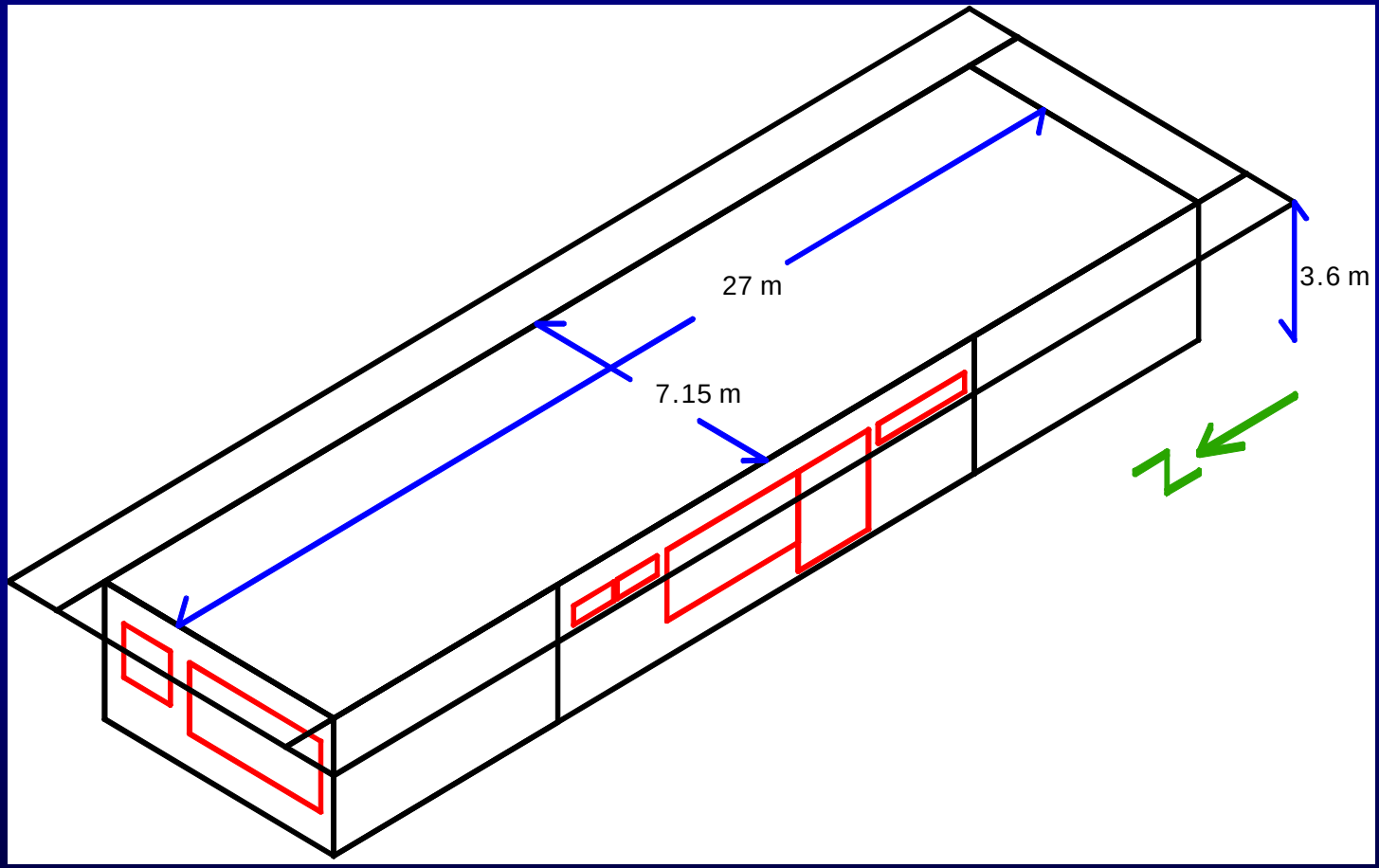
CASE STUDY

CASE STUDY



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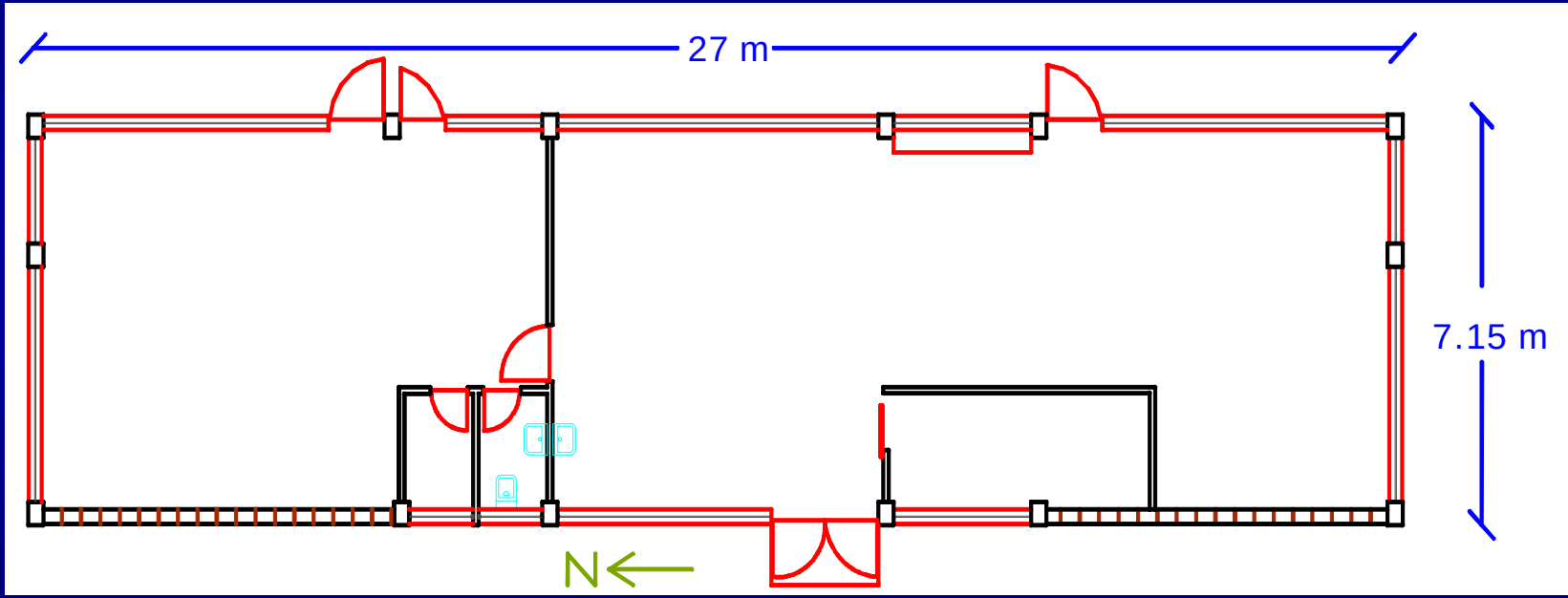
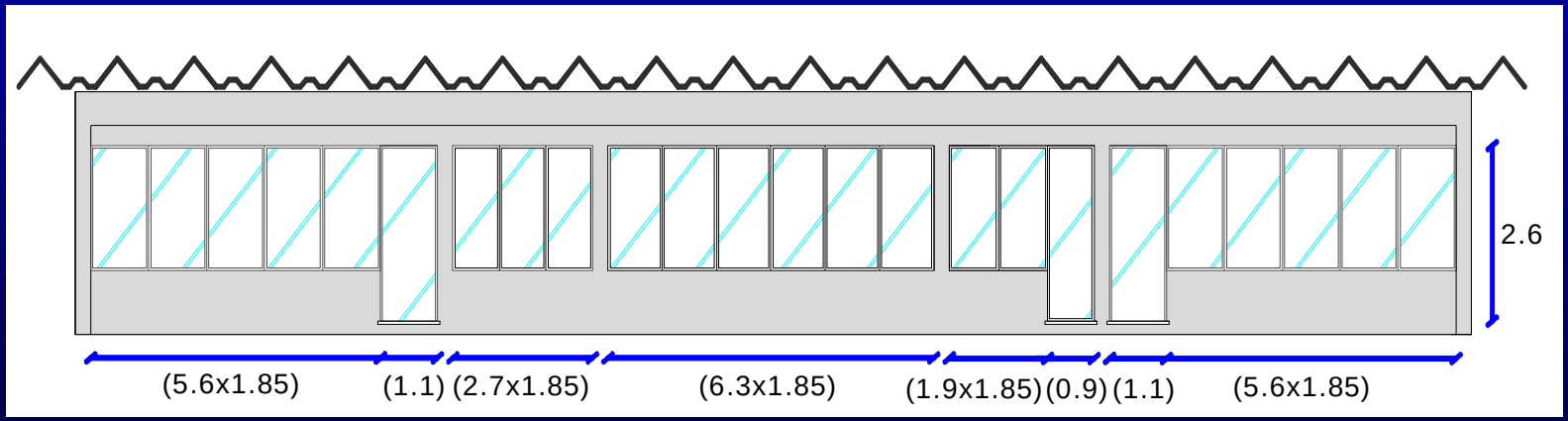


CASE STUDY



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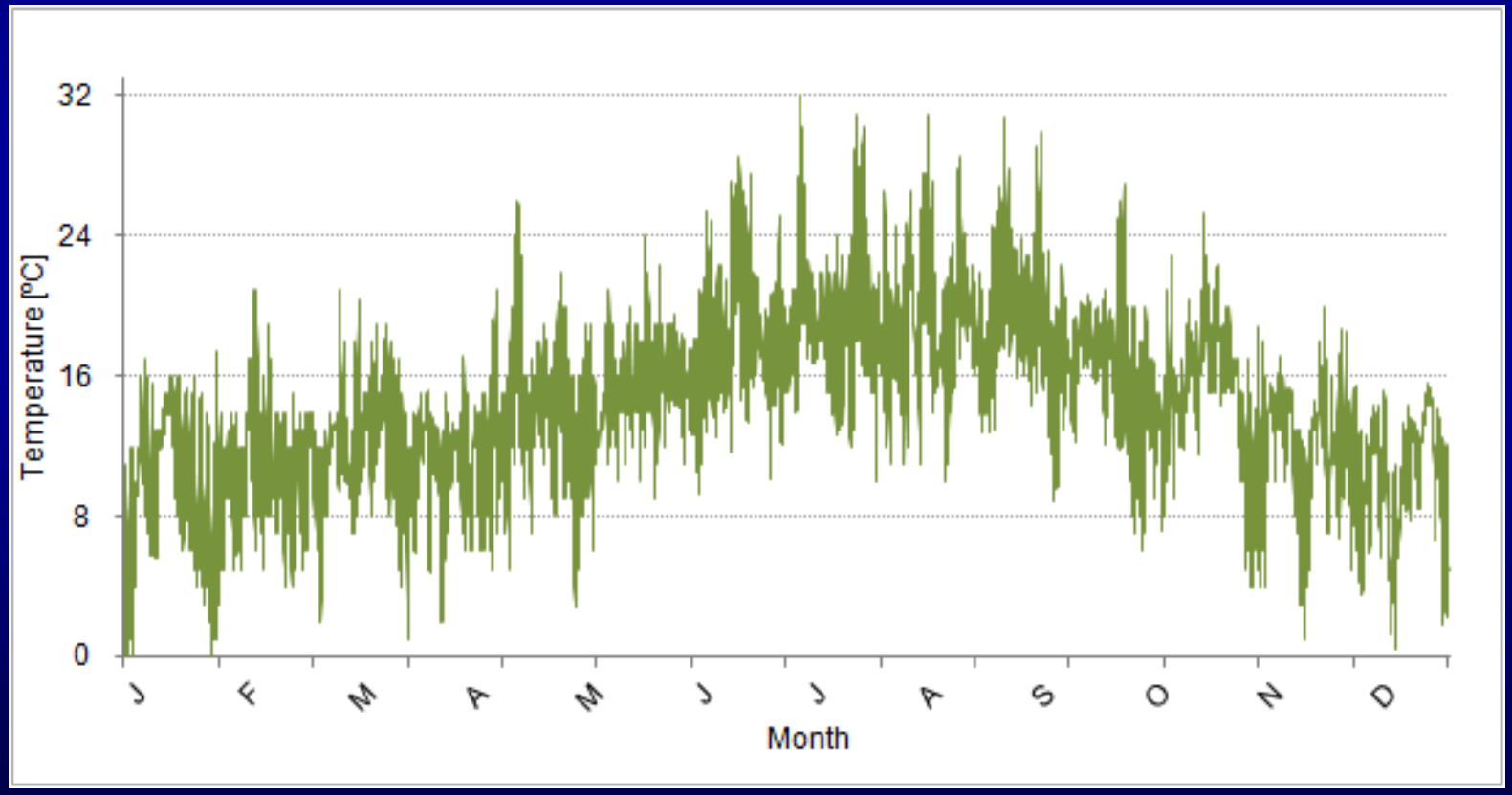
CASE STUDY

building elements

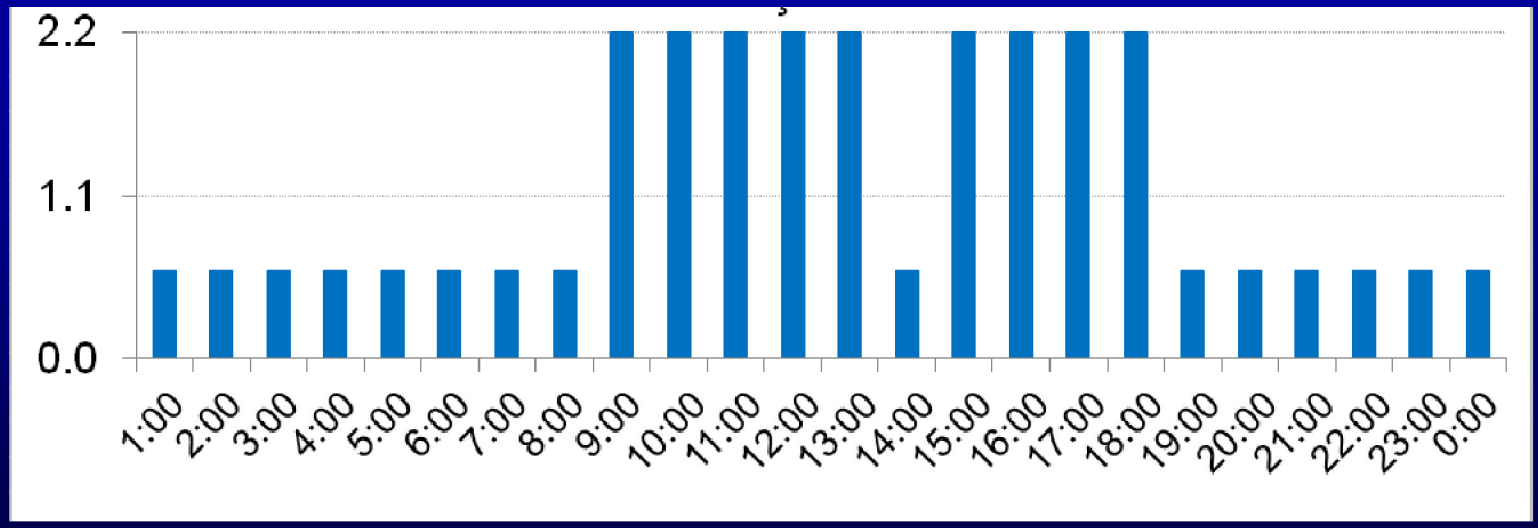
CASE STUDY

outdoor temperature



CASE STUDY

ventilation → 30 m^3/h.person



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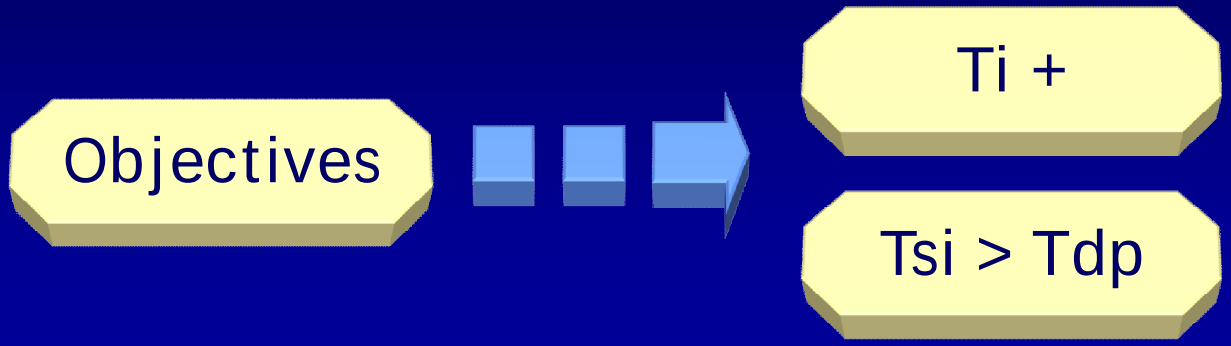

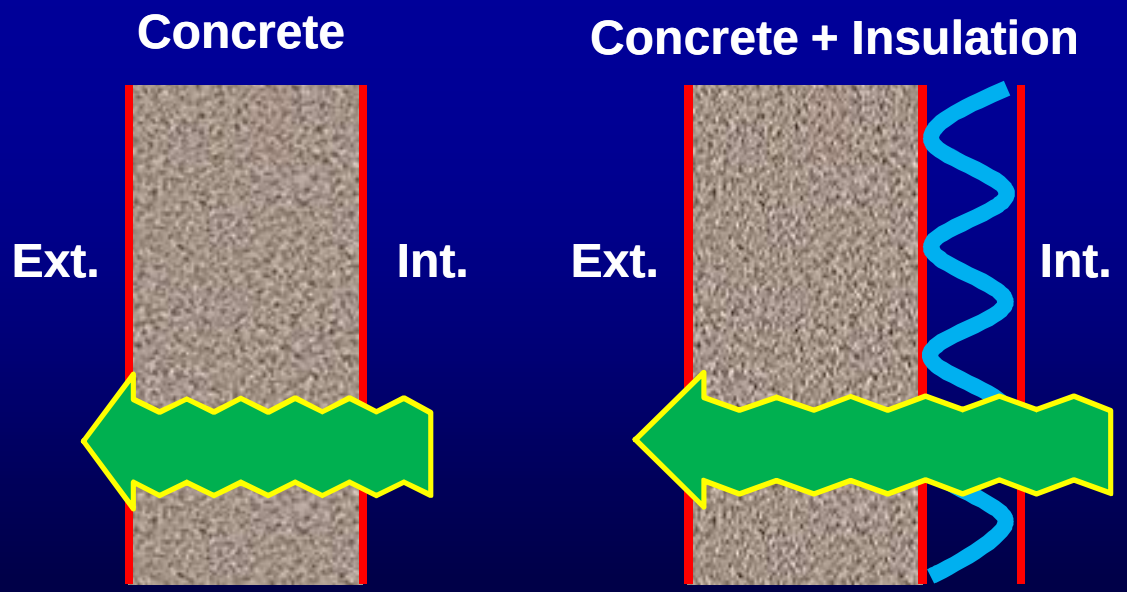

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SIMULATION

ENERGY PLUS

heat balance

$$T_z^t = \frac{\sum_{i=1}^{sl} Q_i + \sum_{i=1}^{N_{superfícies}} h_i A_i T_{si} + \sum_{i=1}^{N_{zonas}} \dot{m}_i C_p T_{zi} + \dot{m}_{inf} C_p T_\infty + \dot{m}_{sys} C_p T_{sup} - \left(\frac{C_z}{\delta t}\right)\left(-3T_z^{t-\delta t} + \frac{3}{2}T_z^{t-2\delta t} - \frac{1}{3}T_z^{t-3\delta t}\right)}{\left(\frac{11}{6}\right)\frac{C_z}{\delta t} + \sum_{i=1}^{N_{superfícies}} h_i A_i + \sum_{i=1}^{N_{zonas}} \dot{m}_i C_p + \dot{m}_{inf} C_p + \dot{m}_{sys} C_p}$$

heat transfer

$$\frac{\rho C_p \Delta x\left(T_{i,novo} - T_{i,antigo}\right)}{\Delta t} = \frac{\lambda\left(T_{i-1,novo} - T_{i,antigo}\right)}{\Delta x} + \frac{\lambda\left(T_{i+1,novo} - T_{i,novo}\right)}{\Delta x}$$

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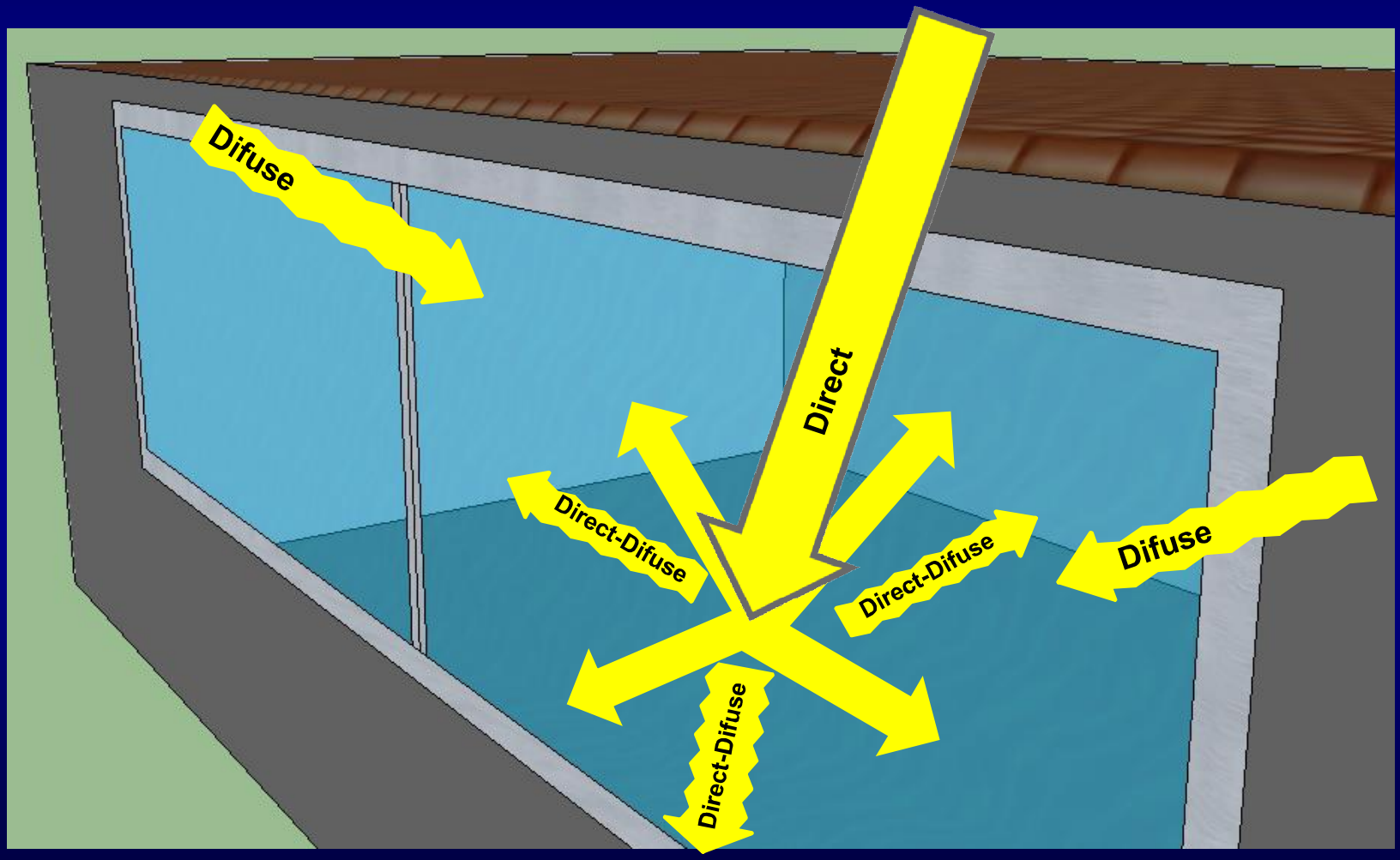
SIMULATION



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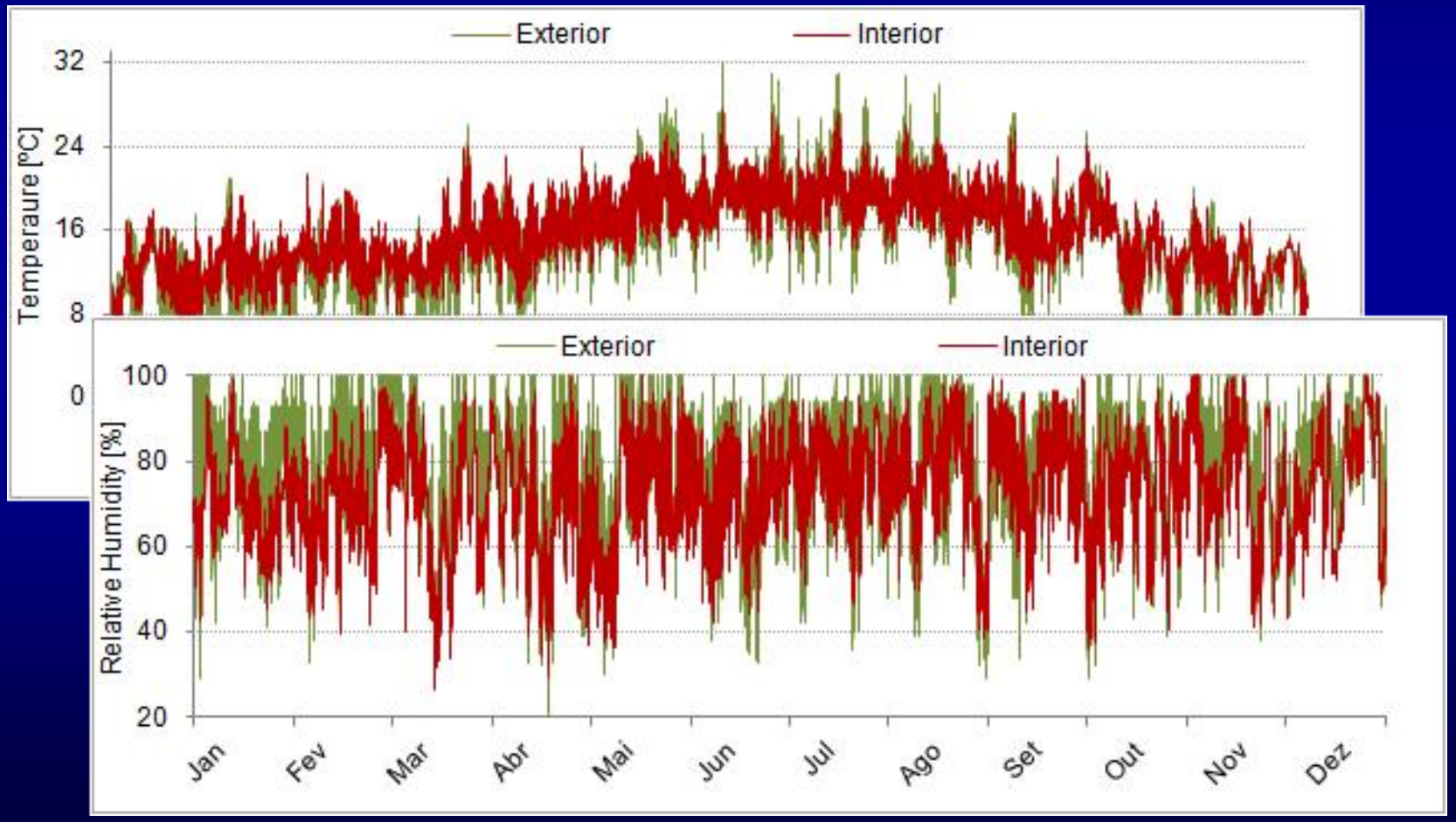
SIMULATION

Results



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SIMULATION

Results

Thickness (cm)		0	1	2	3	4	5	6	7	8	9
Tmin		0.4	1.6	2.3	2.9	3.3	3.7	4.0	4.2	4.4	4.6
Tmáx		30.7	33.1	34.6	35.5	36.3	36.8	37.3	37.6	37.9	38.1
Year	$T_{5\%}$	7.5	8.8	9.7	10.2	10.6	10.9	11.2	11.4	11.6	11.7
	$T_{méd}$	15.8	17.5	18.5	19.2	19.7	20.1	20.4	20.6	20.8	21.0
	$T_{95\%}$	23.6	26.0	27.4	28.3	29.0	29.5	29.9	30.3	30.6	30.8
Days with surface condensation on walls		33	12	4	2	1	1	1	1	1	0
Days with surface condensation on ceiling		126	22	4	4	1	1	1	1	1	0

29 Dec

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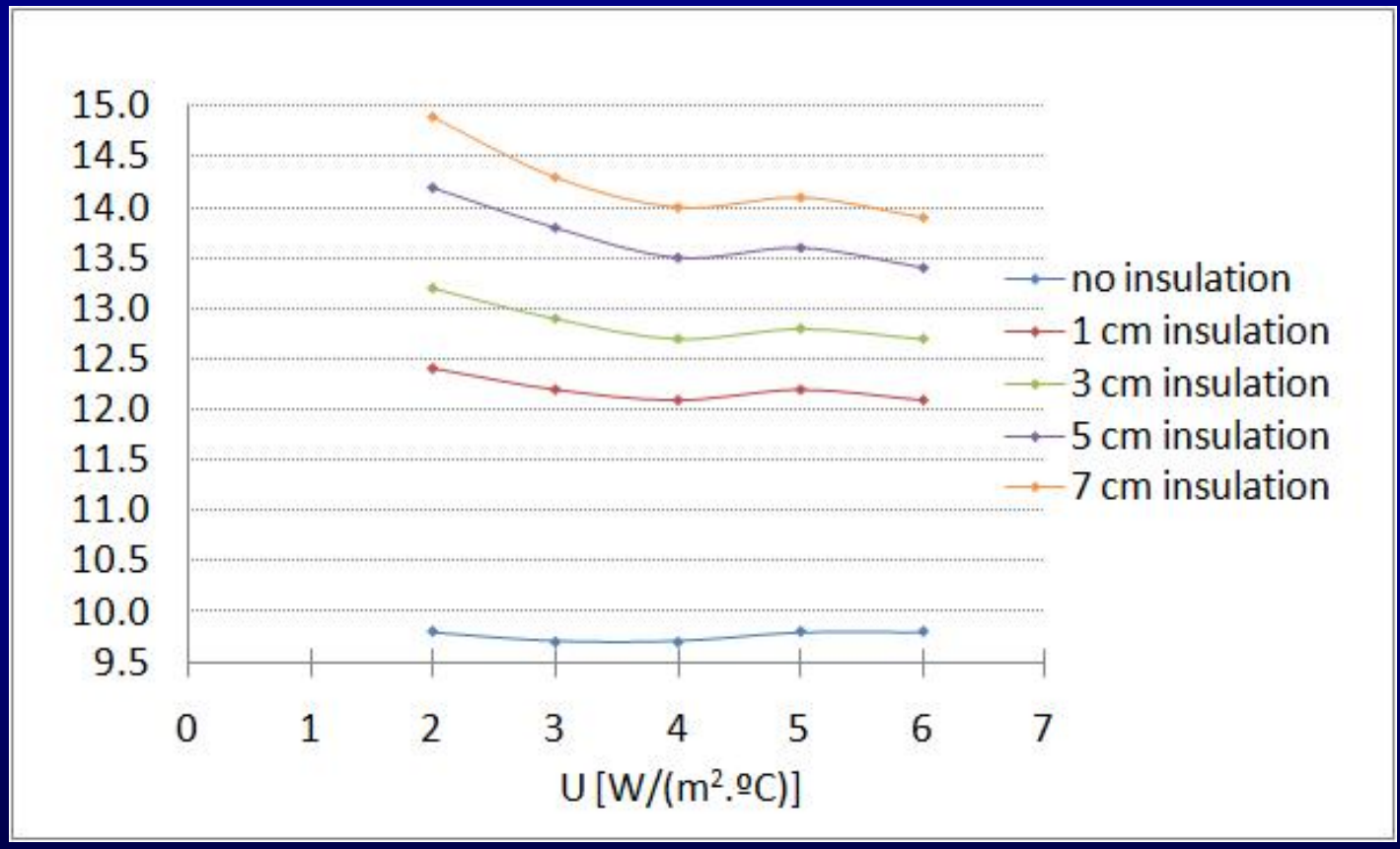
SIMULATION

- Average air temperature in January



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OPTIMIZATION PROGRAMME

Minimize

$$\sum_{i=1}^{Np} A_i \left(x_i^{ins} C^{ins}\right) + \sum_{j=N_p+1}^{Ns} A_j C_U^{win}$$

Restrictions

$$T_z^t = \frac{\sum_{i=1}^{sl} Q_i^t + \sum_{k=1}^{Ns} h_k A_k T_{sk}^t + m_{\inf} C_p T_\infty^t - \left(\frac{C_z}{\delta t}\right)\left(-3T_z^{t-\delta t} + \frac{3}{2}T_z^{t-2\delta t} - \frac{1}{3}T_z^{t-3\delta t}\right)}{\left(\frac{11}{6}\right)\frac{C_z}{\delta t} + \sum_{k=1}^{Ns} h_k A_k + m_{\inf} C_p}$$

$$\rho^{con} C_p^{\ con} \left(x_i^{con}\right)^2 x_i^{ins} \left(T_{coni}^t - T_{coni}^{t-\delta t}\right) = \left[\lambda^{con} x_i^{ins} \left(T_\infty^t - T_{coni}^t\right) + \lambda^{ins} x_i^{con} \left(T_{si}^t - T_{coni}^t\right)\right]\delta t$$

$$\rho^{ins} C_p^{\ ins} \left(x_i^{ins}\right)^2 \left(T_{si}^t - T_{si}^{t-\delta t}\right) = \left[\lambda^{ins} \left(T_{coni}^t - T_{si}^t\right) + h_i x_i^{íns} \left(T_z^t - T_{si}^t\right) + x_i^{íns} \frac{RD^t}{\sum_{i=1}^{Np} A_i}\right]\delta t$$

$$\rho^{glas} C_p^{\ glas} \left(x_j^{glas}\right)^2 \left(T_{sj}^t - T_{sj}^{t-\delta t}\right) = \left[\frac{x_j^{glass}}{\frac{1}{U} - 0.17}\left(T_\infty^t - T_{sj}^t\right) + h_j \left(T_z^t - T_{sj}^t\right)\right]\delta t$$

$$T_{si}^t \geq T_{dp}^t$$

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OPTIMIZATION

Minimize $z = c^T x + d^T y$

subject to:

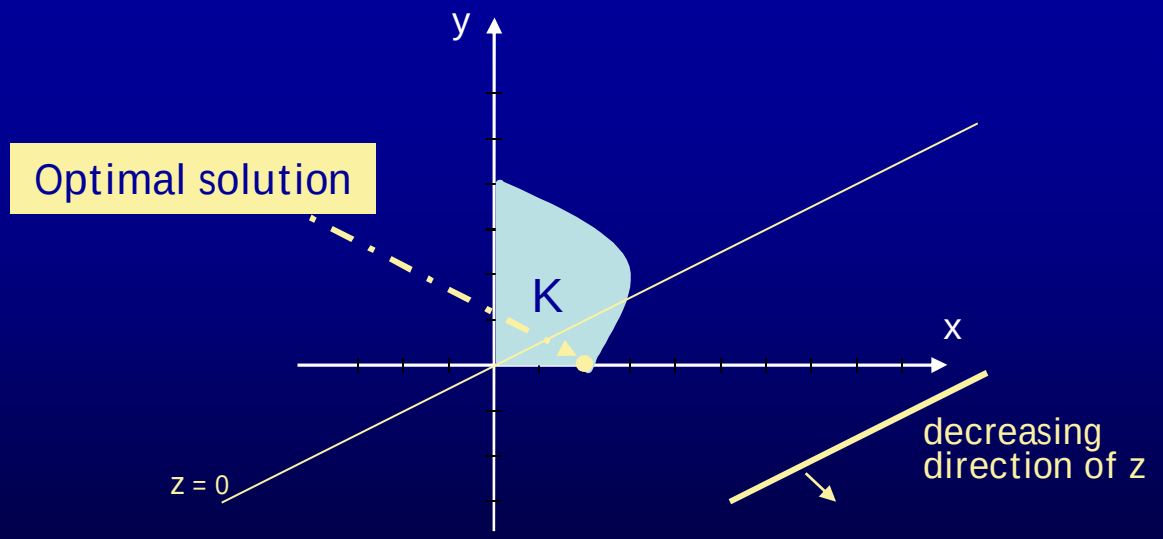
$f(x) + A_1 y \leq b_1$

$A_2 x + A_3 y \leq b_2$

$l_1 \leq x \leq u_1, \; l_2 \leq y \leq u_2$

f.o. linear

K – nonlinear feasible region



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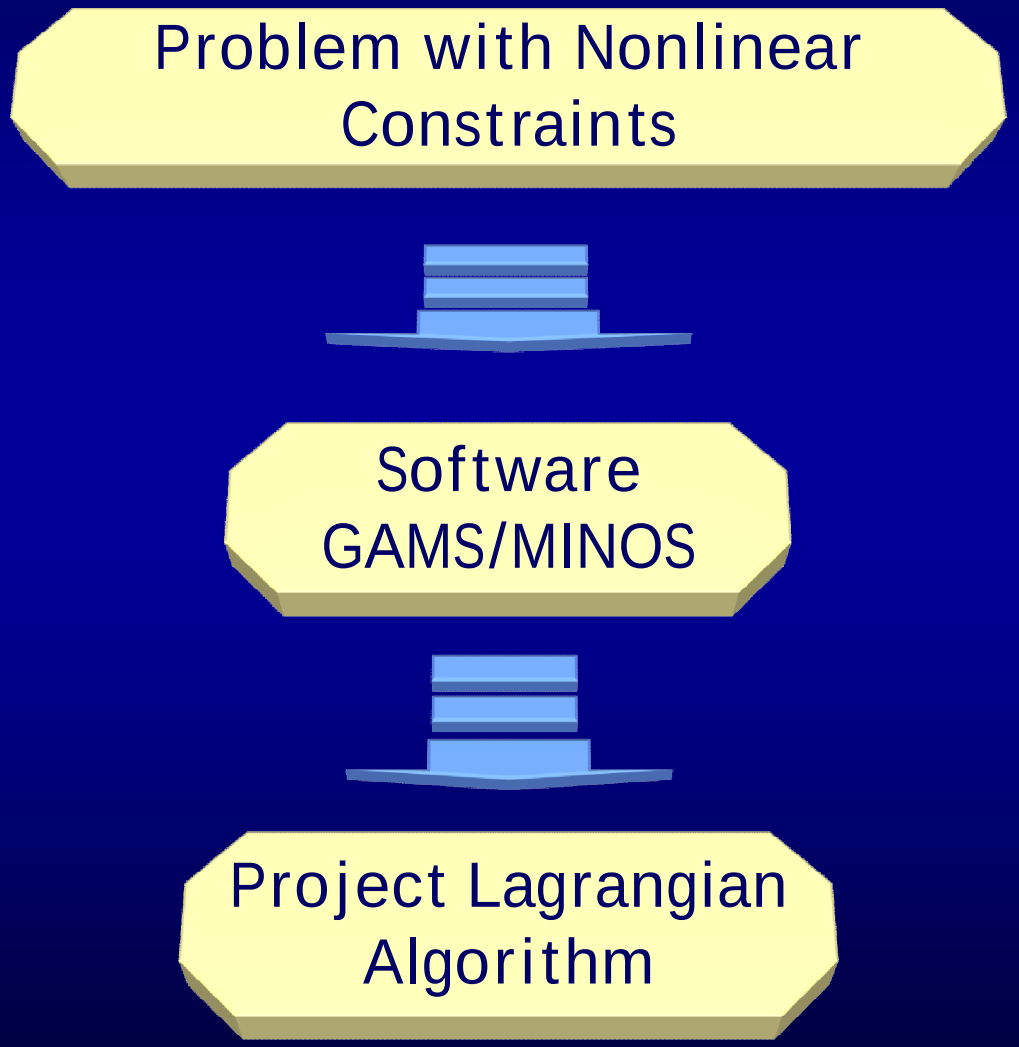
OPTIMIZATION – CASE STUDY



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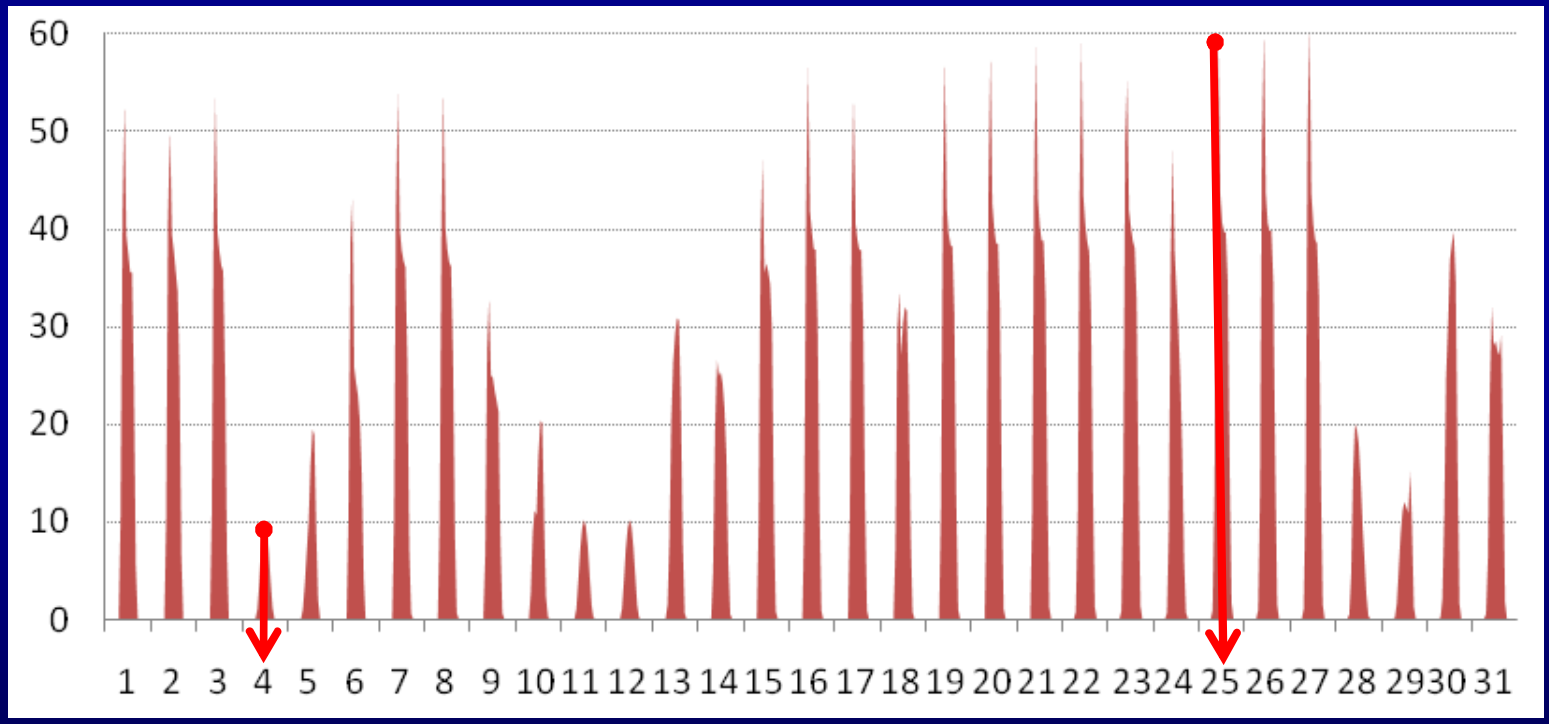
OPTIMIZATION – CASE STUDY

- JANUARY SELECTED DAYS



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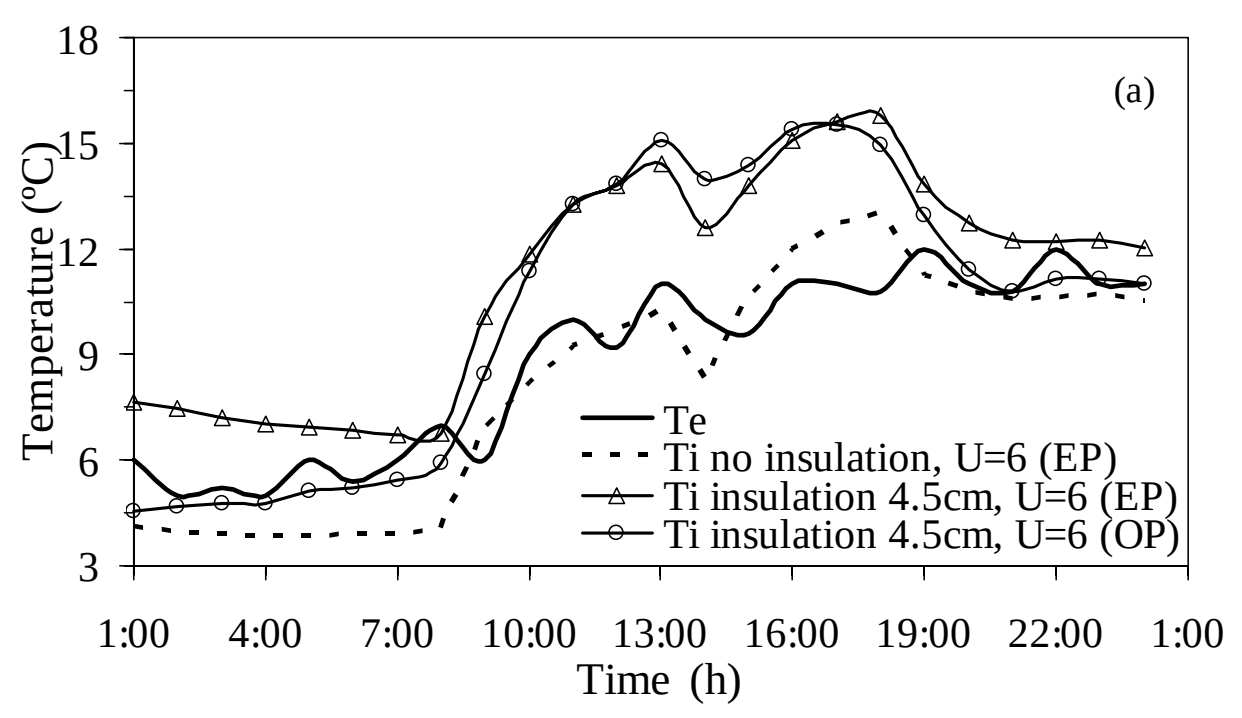
RESULTS

Indoor Temperature – January 4



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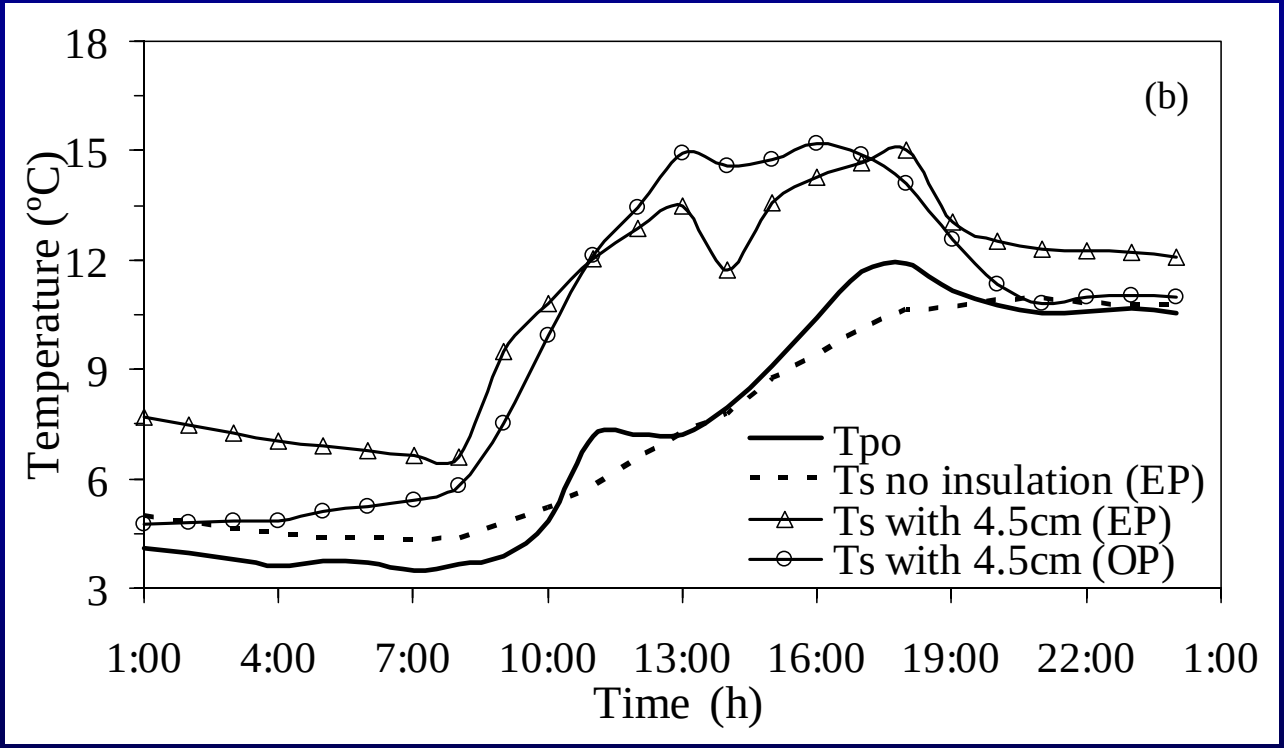
RESULTS

Surface condensation – January 4



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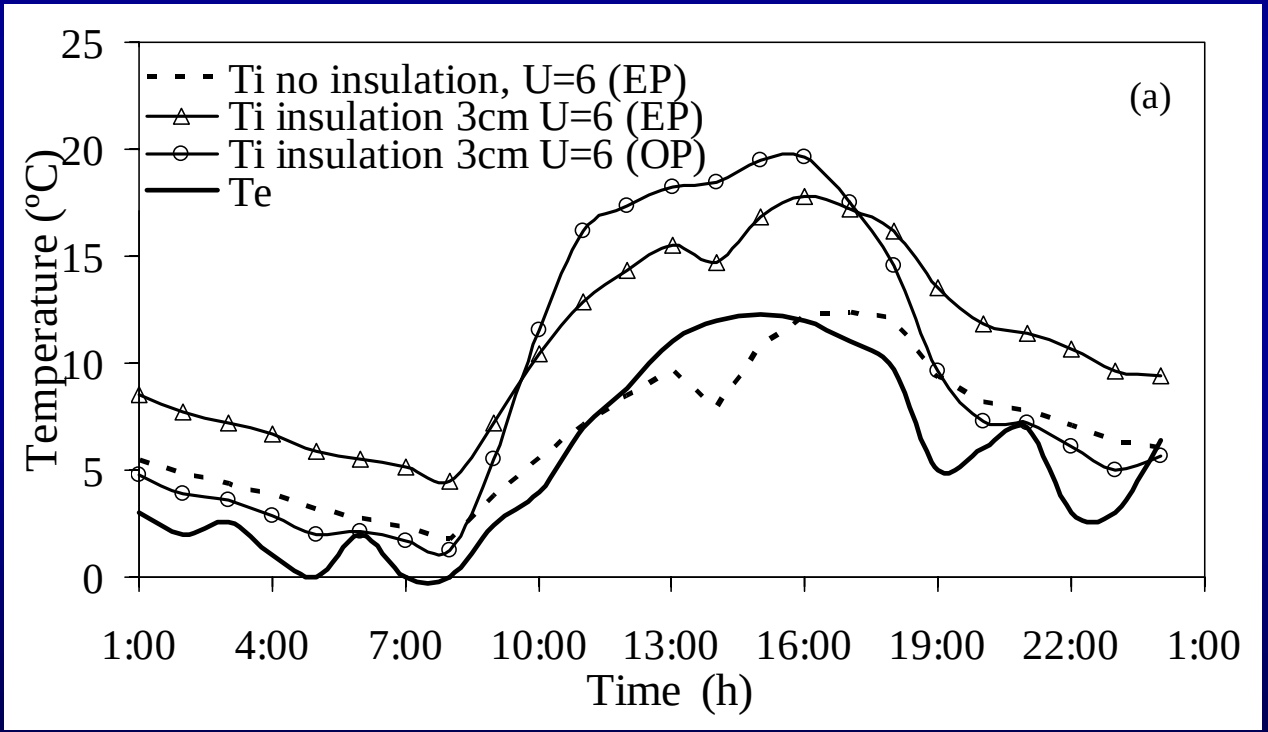
RESULTS

Simulation – January 25



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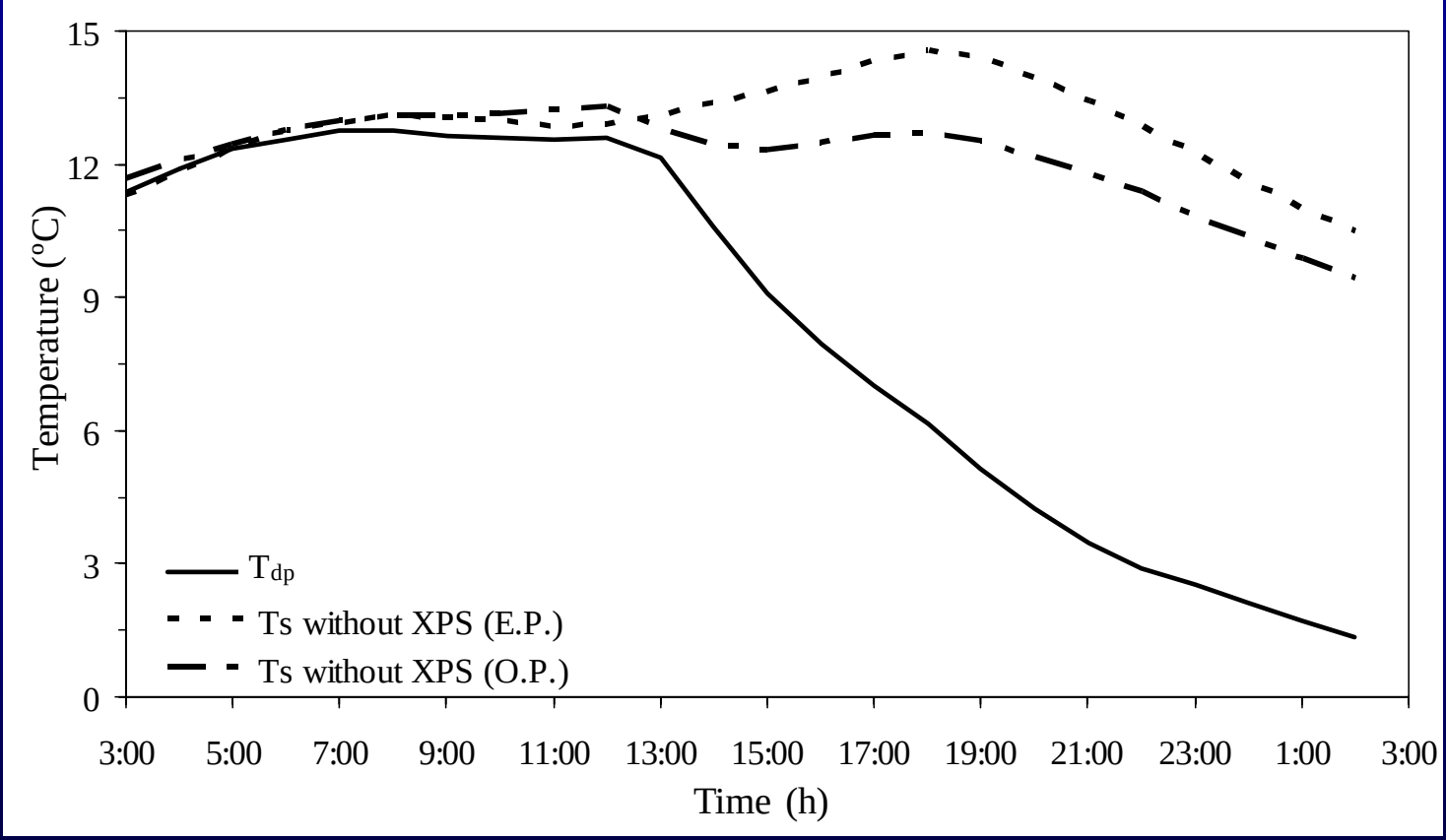
RESULTS

Simulation – December 29



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CONCLUSIONS

Simulation

- **Detailed inputs**
- **Detailed results**
- **Optimization derived from full analysis repetition**

Optimization programme

- **Simulation merged in optimization process**
- **Simplified model with simpler inputs**
- **Easy to use with acceptable results**

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