5. AUDIT

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Why is audit so urgent?

- Effective reduction of CO2 emission
- Renovation badly needed (much quicker and much more efficient)
- Impossible if not supported by realistic diagnosis
- With high priority to « quick wins »
- Be able to select, evaluate, decide…

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1. Starting from…

- 1.1. As built files, including manufacturer's data and commissioning results
- 1.2. Observations and recordings made by the building manager
- 1.3. Previous building story: initial design, achievements, problems, complains, actual maintenance…

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1.1. As built files

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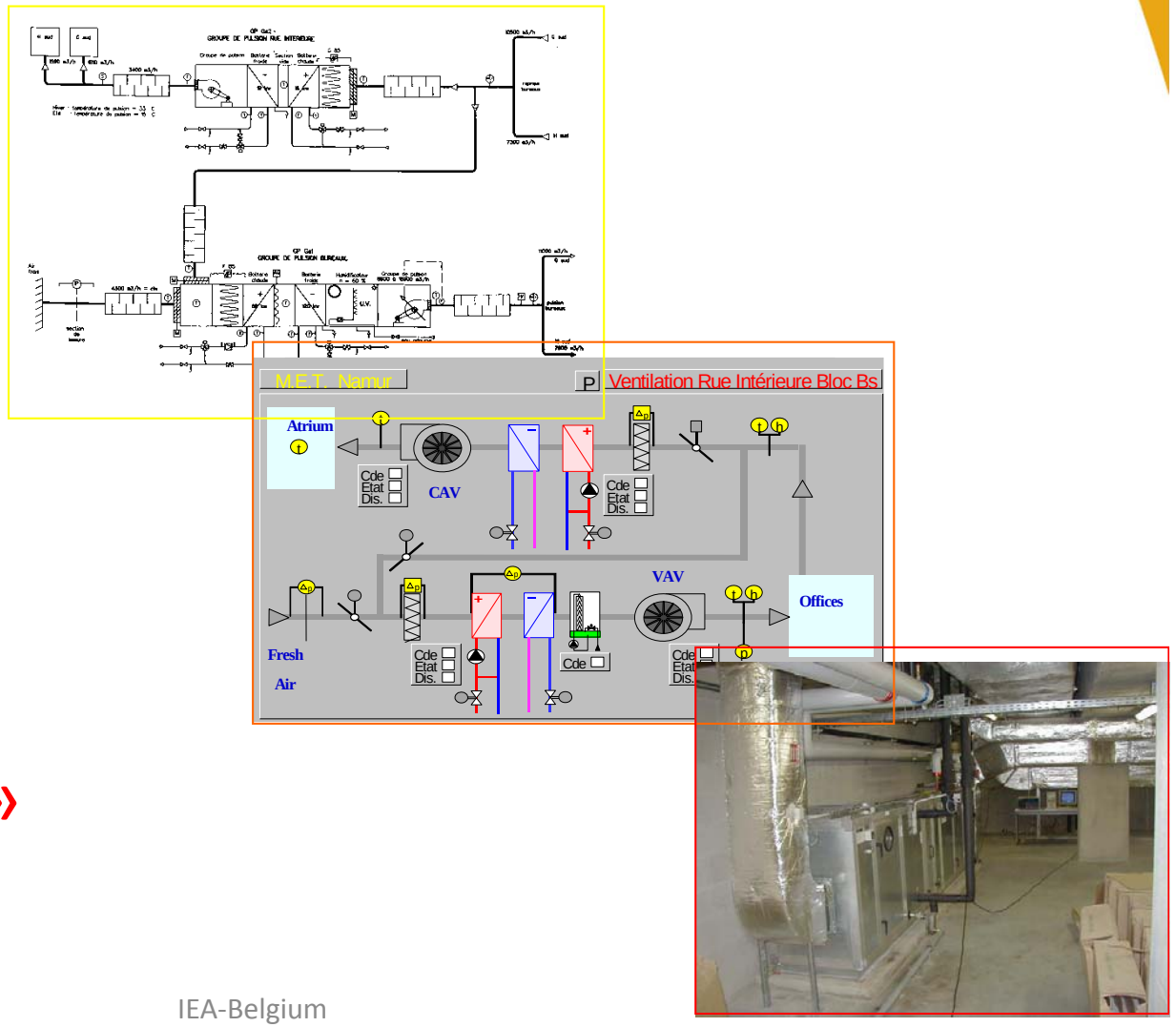
Documents produced at different stages of BLC

- « As designed »
- « As built »
- « As operating »



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1.2. Information already collected by the manager

- Records of water, gas and electricity consumptions

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1.3 Adding information…

- Not a funny game!
- On site measurements difficult and expensive
- Highest energy consumers: the *fans*
- *Chillers* coming in second position
- *Nominal* performances well identified
- *Average* performances more questionable
- Both (fans and chillers) are valuable measuring instruments

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First example:
Audit of an office building equipped with ventilated frontage and cooling ceiling system

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- Occupants complaining because of too hot environment
- A priori suspected: ventilated frontage, cooling ceiling and ventilation…

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The audit includes:

- Modelling
- Inspection
- Monitoring
- Tuning
- Prospective simulations

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FRONTAGE:
IDENTIFICATION OF

- SUPERFICIAL TEMPERATURES
- CORRESPONDING THERMAL LOAD

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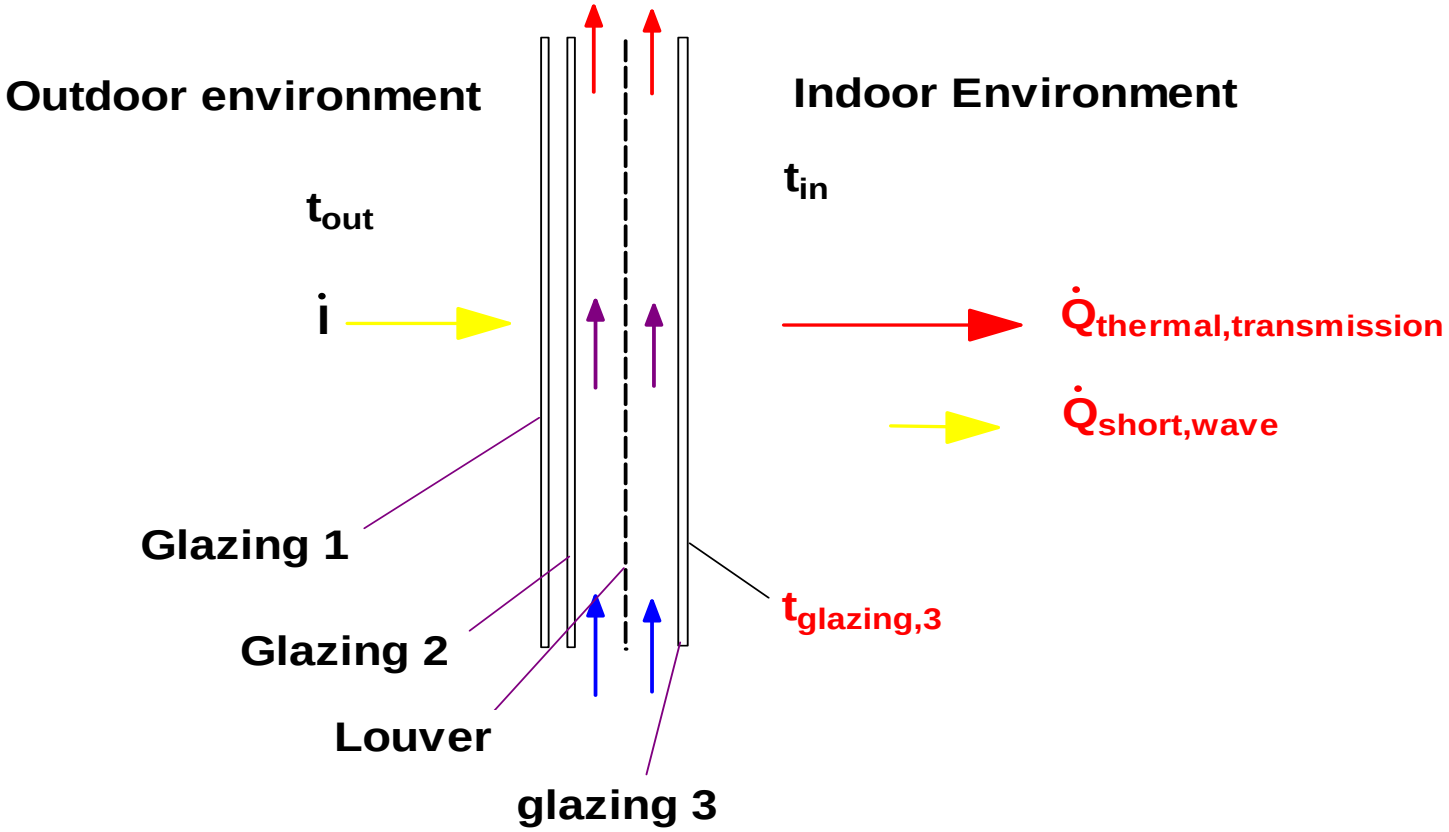

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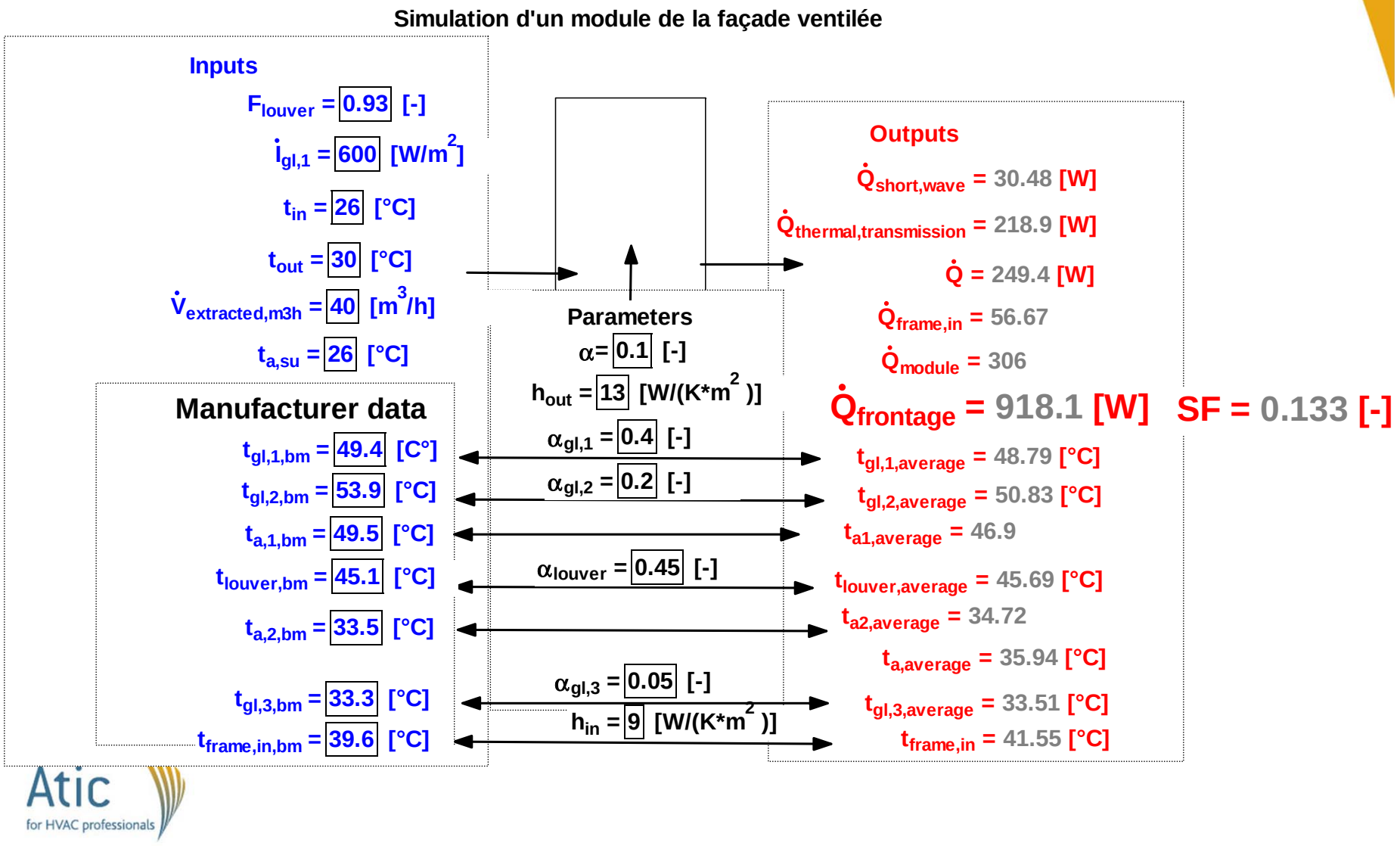
Model tuning on the basis of manufacturer data



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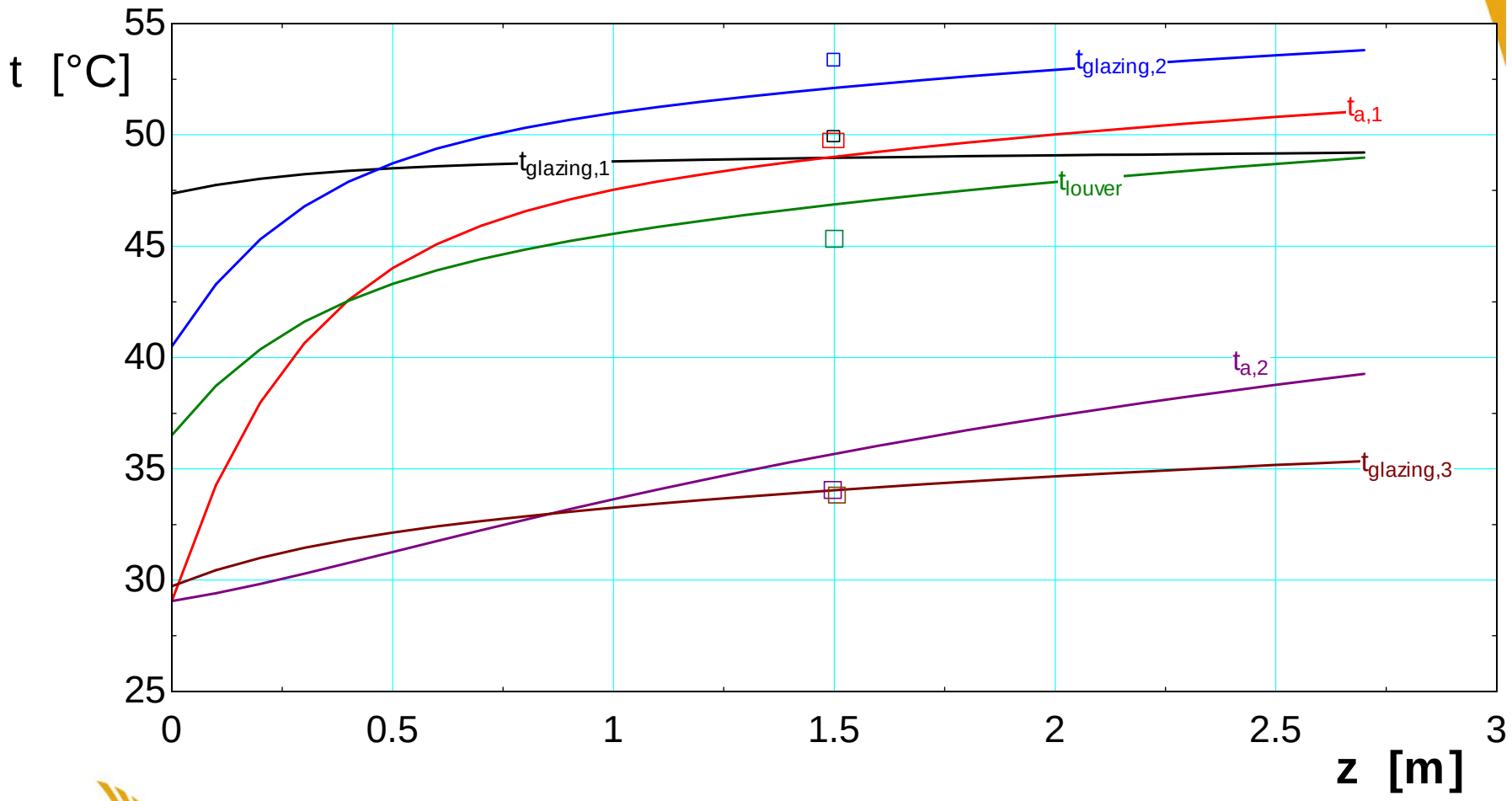

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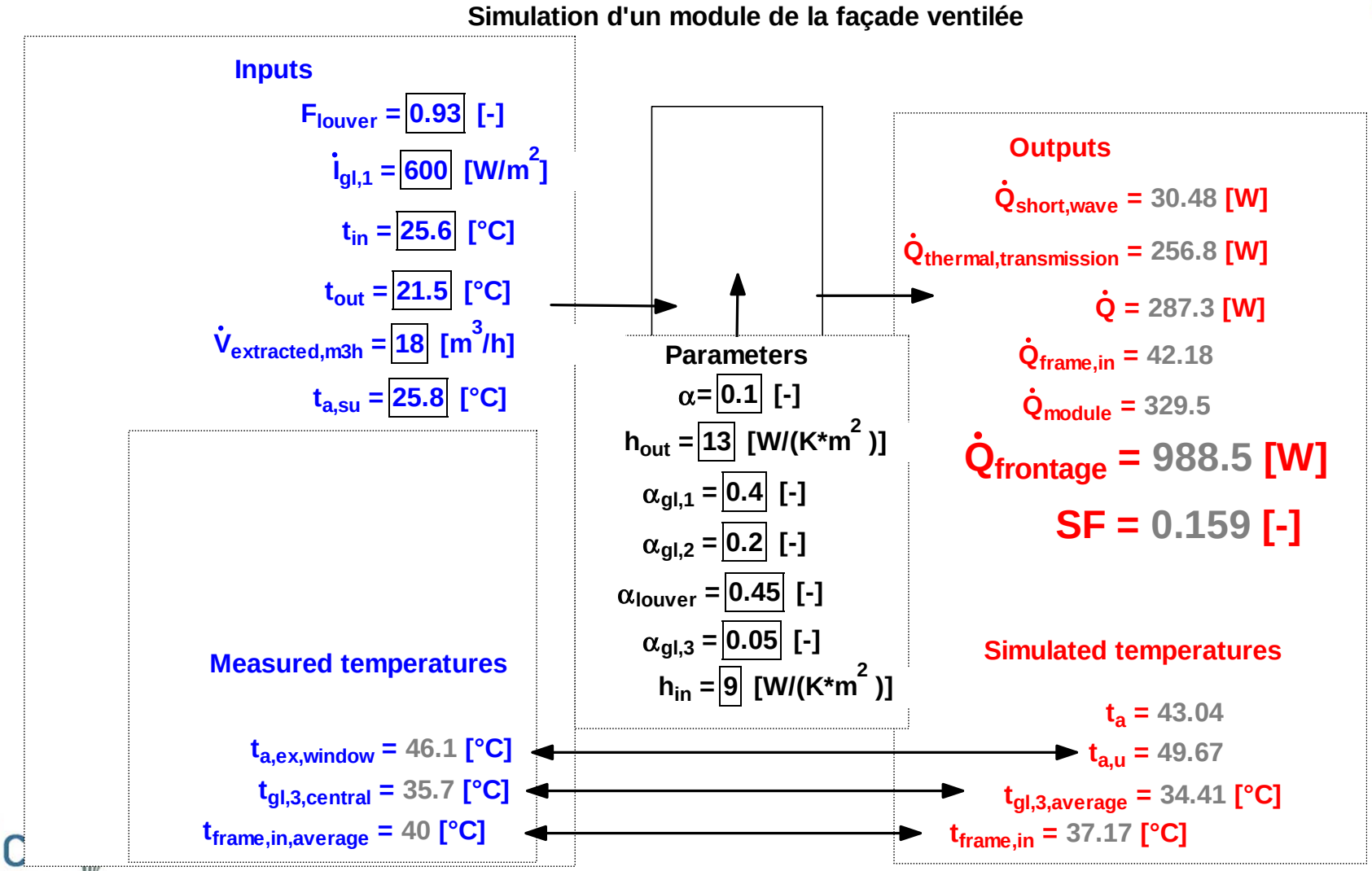
Experimental tuning



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Simulation d'un module de la façade ventilée

Inputs

F_{louver} = 0.93 [-]

$\dot{i}_{gl,1}$ = 800 [W/m^2]

t_{in} = 26 [°C]

t_{out} = 30 [°C]

$\dot{V}_{extracted,m3h}$ = 40 [m^3/h]

$t_{a,su}$ = 26 [°C]

Parameters

α = 0.1 [-]

h_{out} = 13 [W/(K*m^2)]

$\alpha_{gl,1}$ = 0.4 [-]

$\alpha_{gl,2}$ = 0.2 [-]

α_{louver} = 0.45 [-]

$\alpha_{gl,3}$ = 0.05 [-]

h_{in} = 9 [W/(K*m^2)]

Outputs

$\dot{Q}_{short,wave}$ = 40.64 [W]

$\dot{Q}_{thermal,transmission}$ = 288.9 [W]

$\dot{Q}$ = 329.5 [W]

$\dot{Q}_{frame,in}$ = 73.17

$\dot{Q}_{module}$ = 402.7

$\dot{Q}_{frontage}$ = 1208 [W]

SF = 0.133 [-]

Simulated temperatures

t_a = 45.06

$t_{a,u}$ = 49.83

$t_{gl,3,average}$ = 35.91 [°C]

$t_{frame,in}$ = 46.07 [°C]

THERMAL COMFORT

- 1) In reference conditions
- 2) Considering the actual active surface of the cooling ceiling
- 3) Experimental verification and tuning

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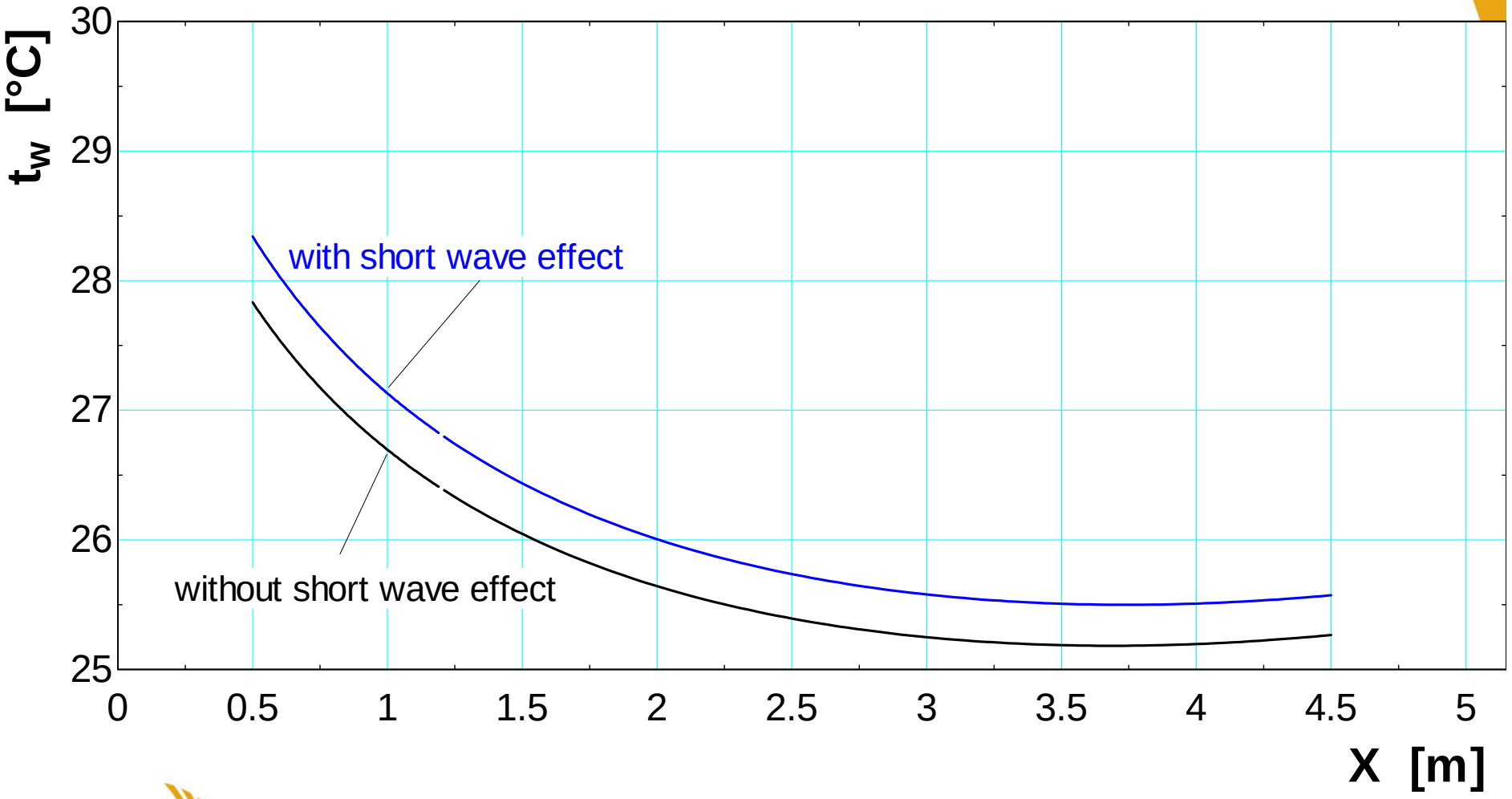

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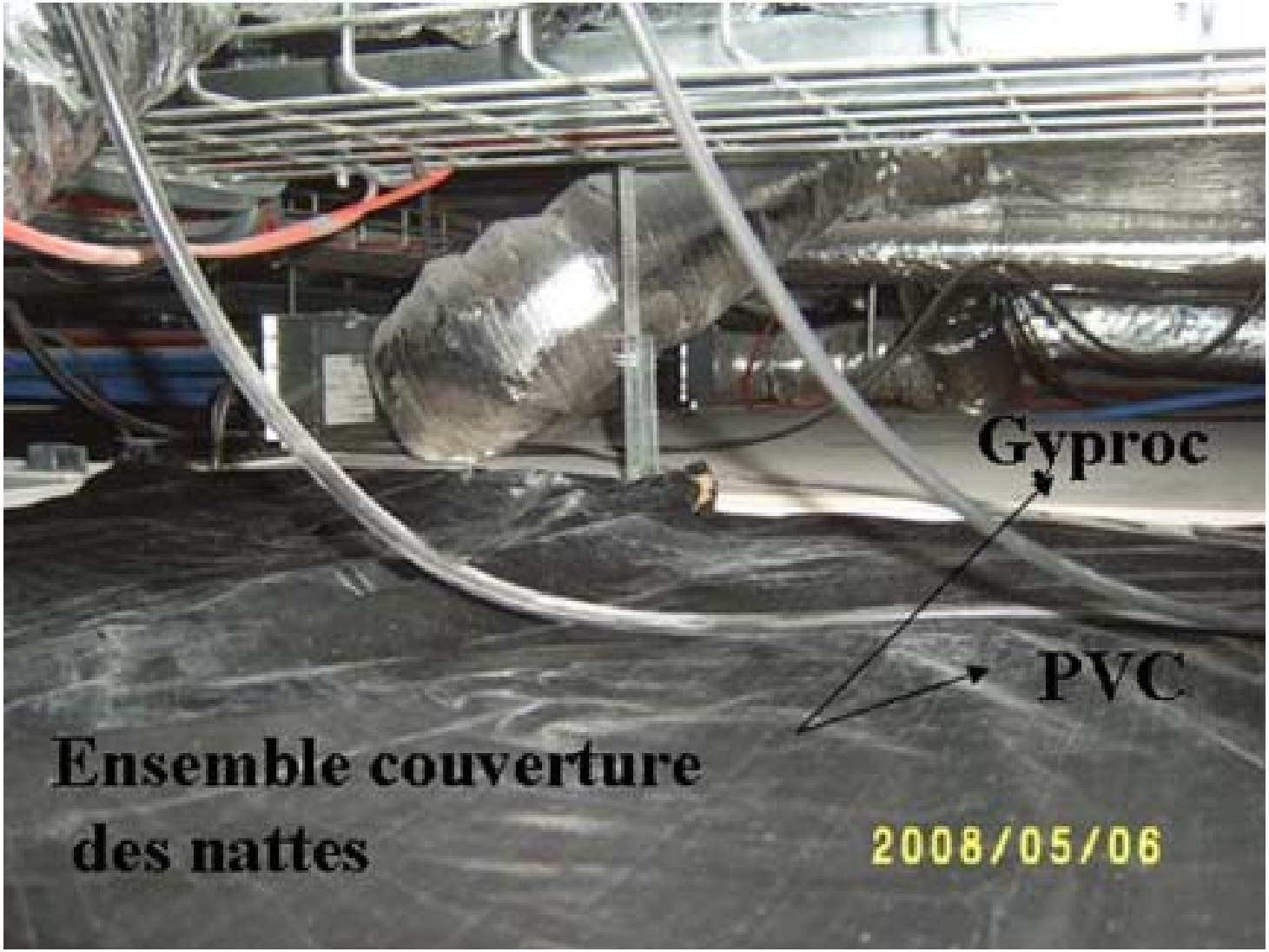
Considering the actual active surface of the cooling ceiling !



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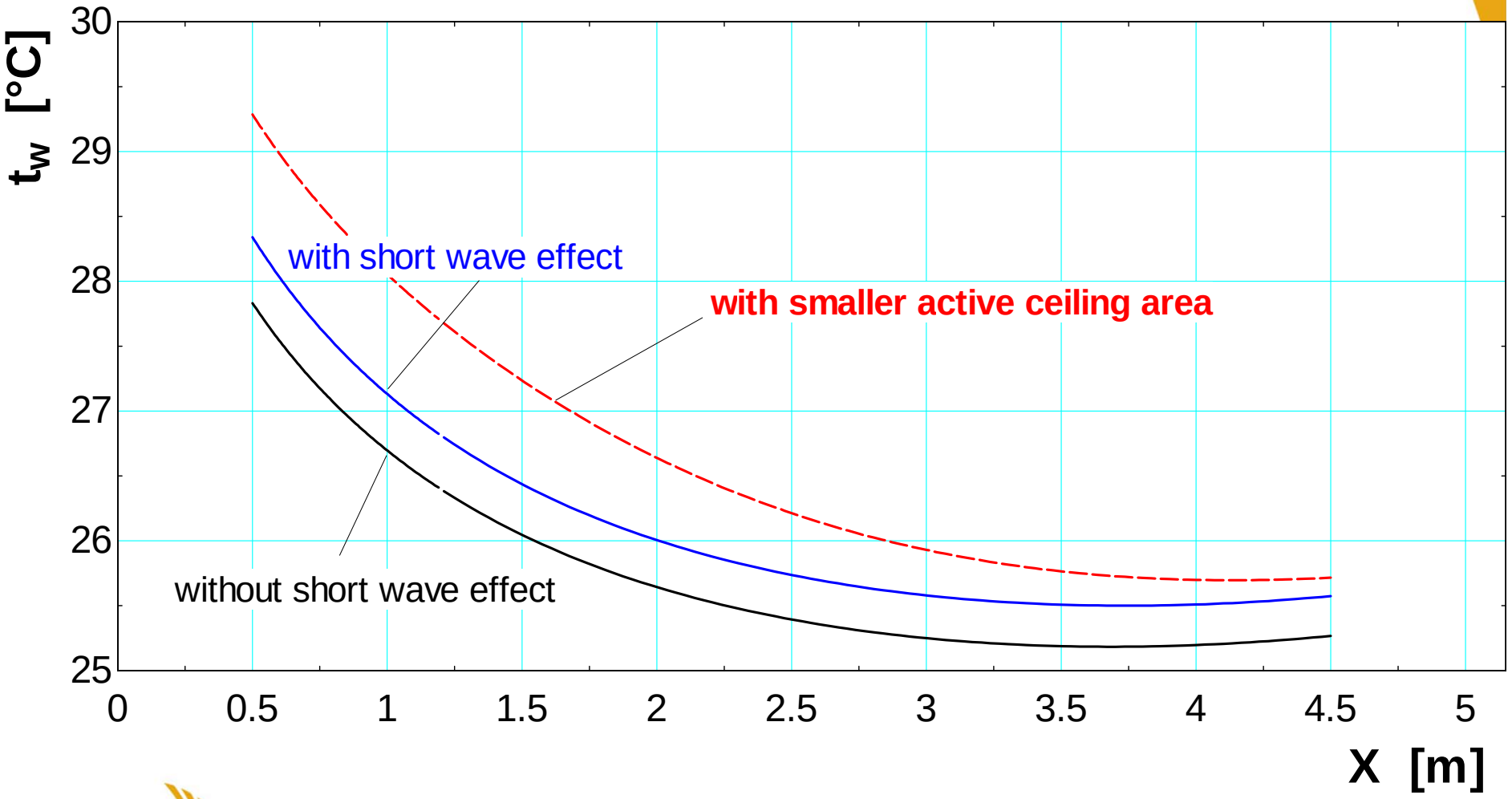
Perte de couverture
de la natte
2008/05/06



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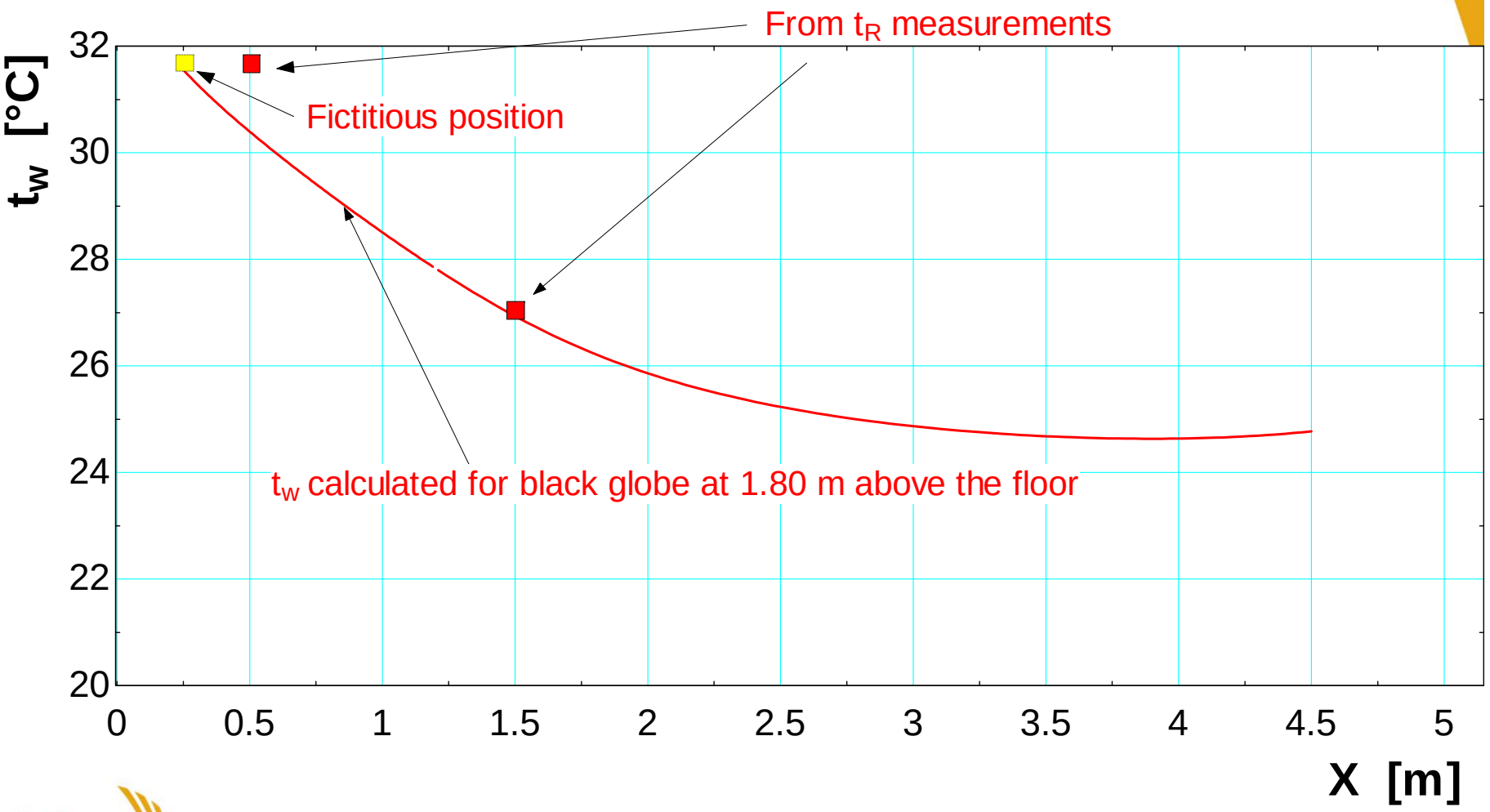
Experimental verification and tuning



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SIMULATION OF THE WHOLE SYSTEM

- Cooling ceiling model: tuned on the basis of on site measurements
- Simulation of the whole (room and HVAC) system: associating calculation of mean radiant temperatures to simulations of frontage, ceiling and room
- Frontage: simplified (correlation) model generated from reference model…

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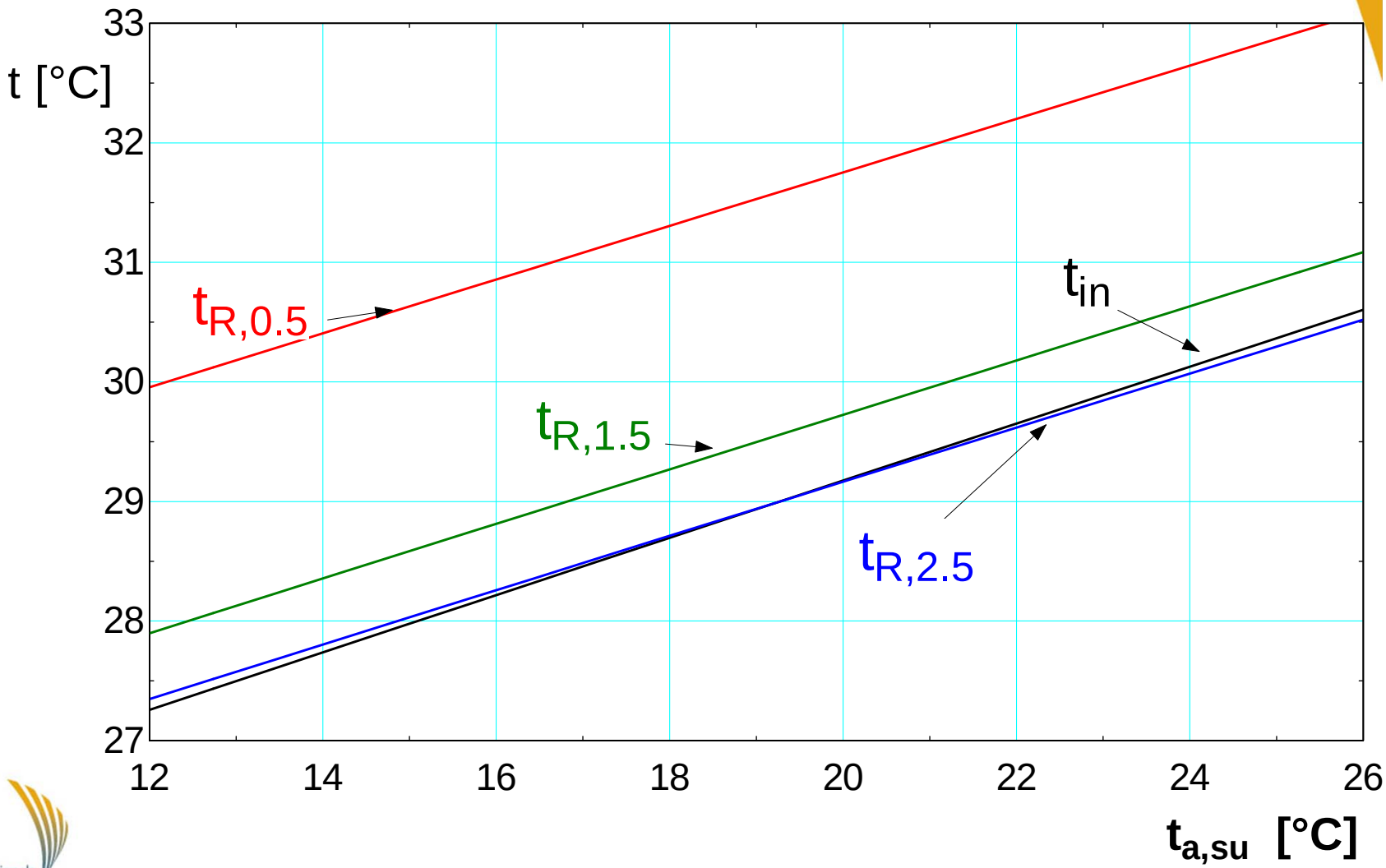
Effect of air supply temperature



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Second example:
Energy audit of a large office building

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- Retrofit opportunities to be proposed in sequence (owner fully free to choose)
- Audit supported by reference simulation with a “big” and well known software
- Analysis of all records already available, extensive visits and complementary measurements to calibrate the reference simulation model

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- Detailed simulation performed on one selected year
- Validation with all records actually available
- “Radiography” of actual energy use with identification of most significant factors
- Exploration of retrofit opportunities with the help of an engineering equation solver
- Most promising retrofits included in “reference” simulation model for integrated evaluations.

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In the case considered the following facts are observed:

- Enormous losses in the distribution of sanitary hot water
- Disappointing efficiencies of fans
- Significant energy waste because of valves leakages
- Too much rigid control laws and schedules…

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A few other facts…

- Fuel and electricity “signatures” can be used to detect important wastes ;
- BEMS deserve to be carefully checked;
- Actual air renewal deserves to be checked by CO2 measurements;
- Combined CO2 and H2O mass balances allow detecting non-efficient control of air humidity;
- Fans rotation speeds are easy to check and to tune;
- “Condensing” boiler are very often not condensing at!

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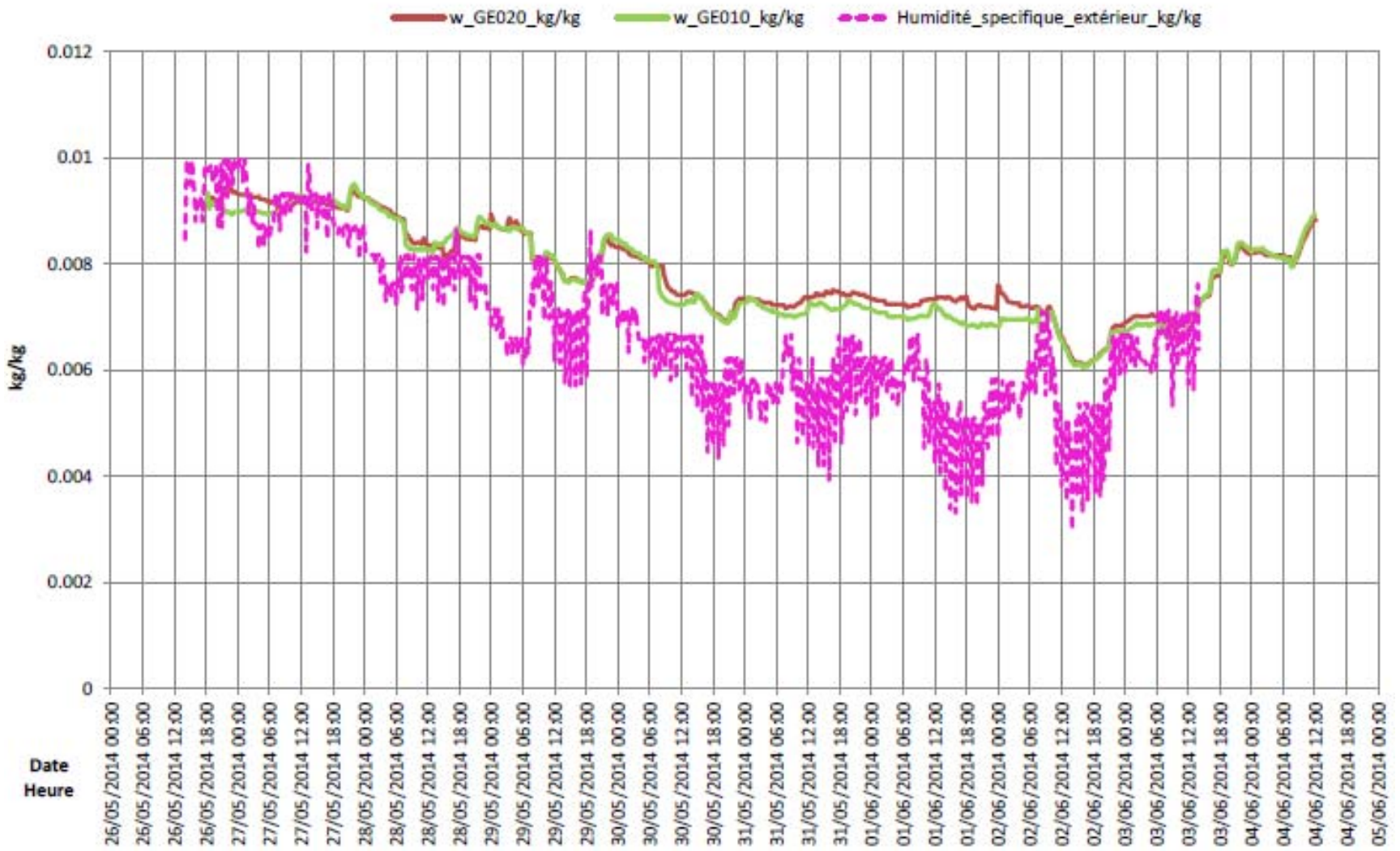
Unappropriate humidification



2 jour	3 $\dot{V}_{air,m3\h}$ [m3/h]	4 $X_{CO2,out}$ [-]	5 $X_{CO2,in}$ [-]	6 ω_{out} [-]	7 ω_{in} [-]	8 n_{occ} [-]	9 Surventilation [-]	10 $\dot{Q}_{latent}$ [W]
27	28525	0.0004	0.000523	0.00901	0.0092	163.8	4.878	-2061
28	28525	0.0004	0.000524	0.00787	0.00841	165.1	4.839	6205
29	28525	0.0004	0.000466	0.00722	0.00791	87.89	9.091	12872
30	28525	0.0004	0.000478	0.00601	0.0072	103.9	7.692	24116
2	28525	0.0004	0.000521	0.00505	0.00643	161.1	4.959	26333
3	28525	0.0004	0.000535	0.00666	0.00731	179.8	4.444	8232

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Unappropriated rotation speeds of fans

2 or 3 variables used to identify actual flow rate:

- Actual rotation speed
- “Head” (or total pressure increase)
- Electrical consumption

To be combined with help of similarity laws and manufacturer’s curves

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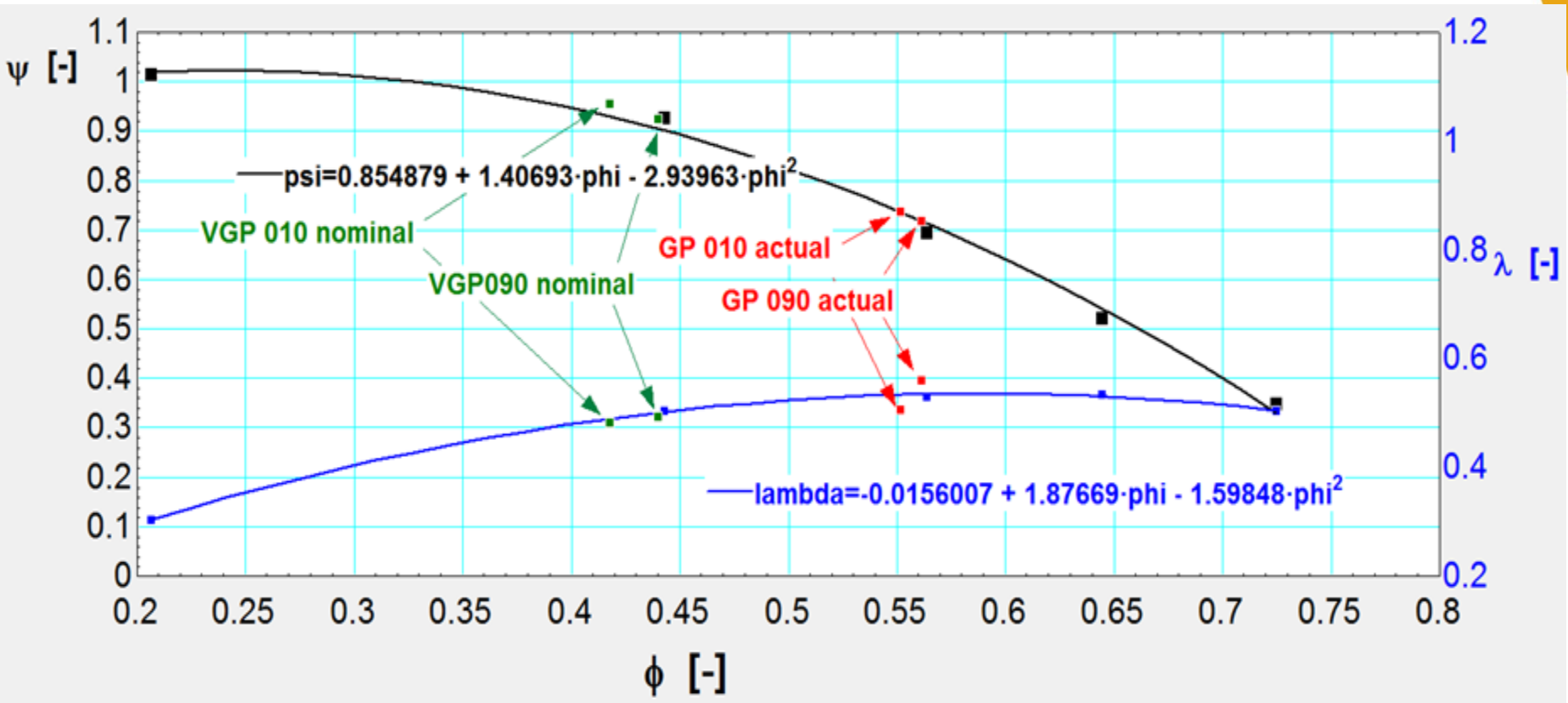

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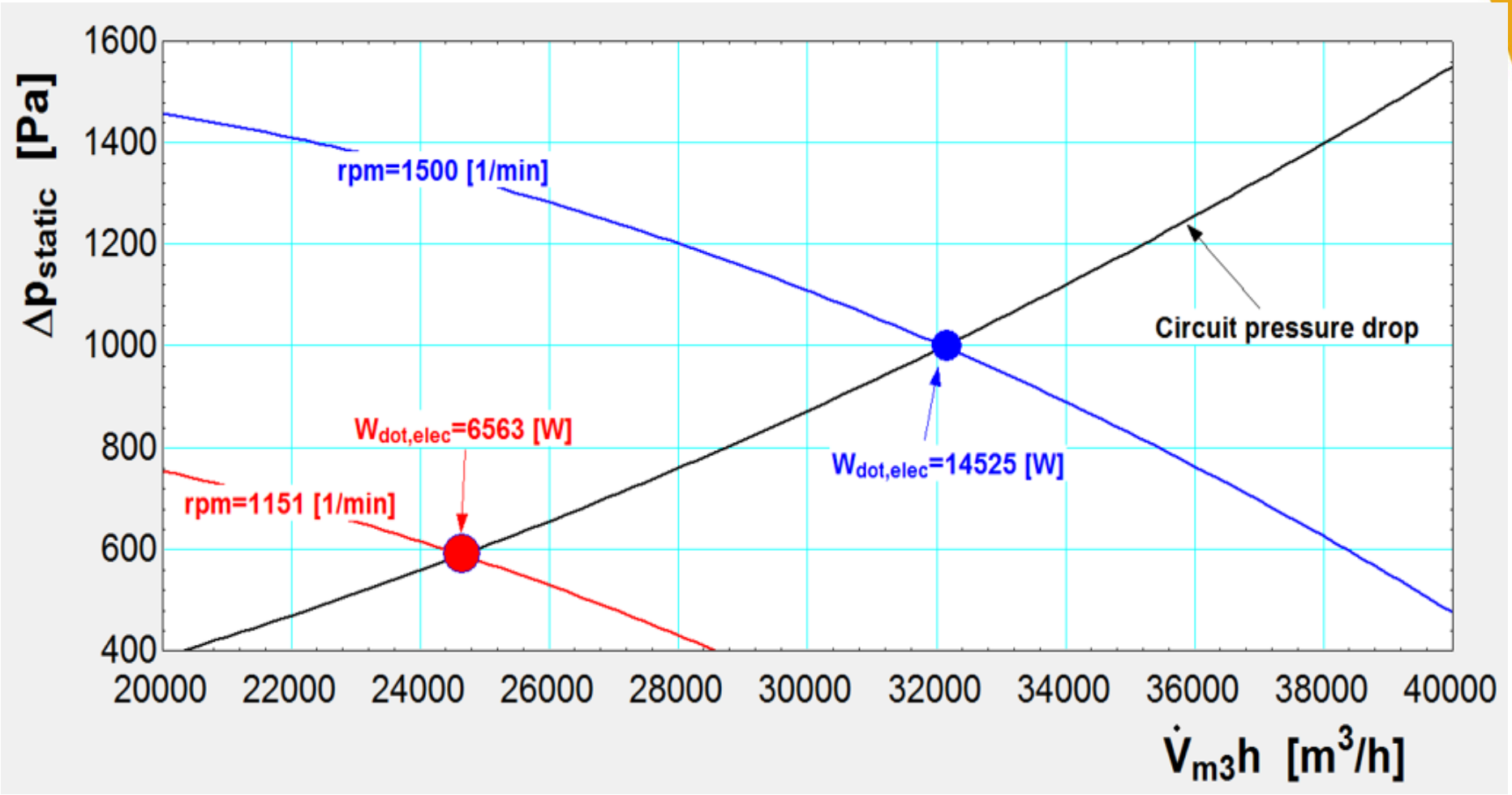

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- Two (very cheap) possibilities:
- 1) Frequency tuning (if inverter);
- 2) Change the pulleys ratio
- Two important benefits:
- 1) Reduction of heating and/or cooling energy consumptions;
- 2) Spectacular reduction of electrical power!

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Poor use of “condensing” boilers

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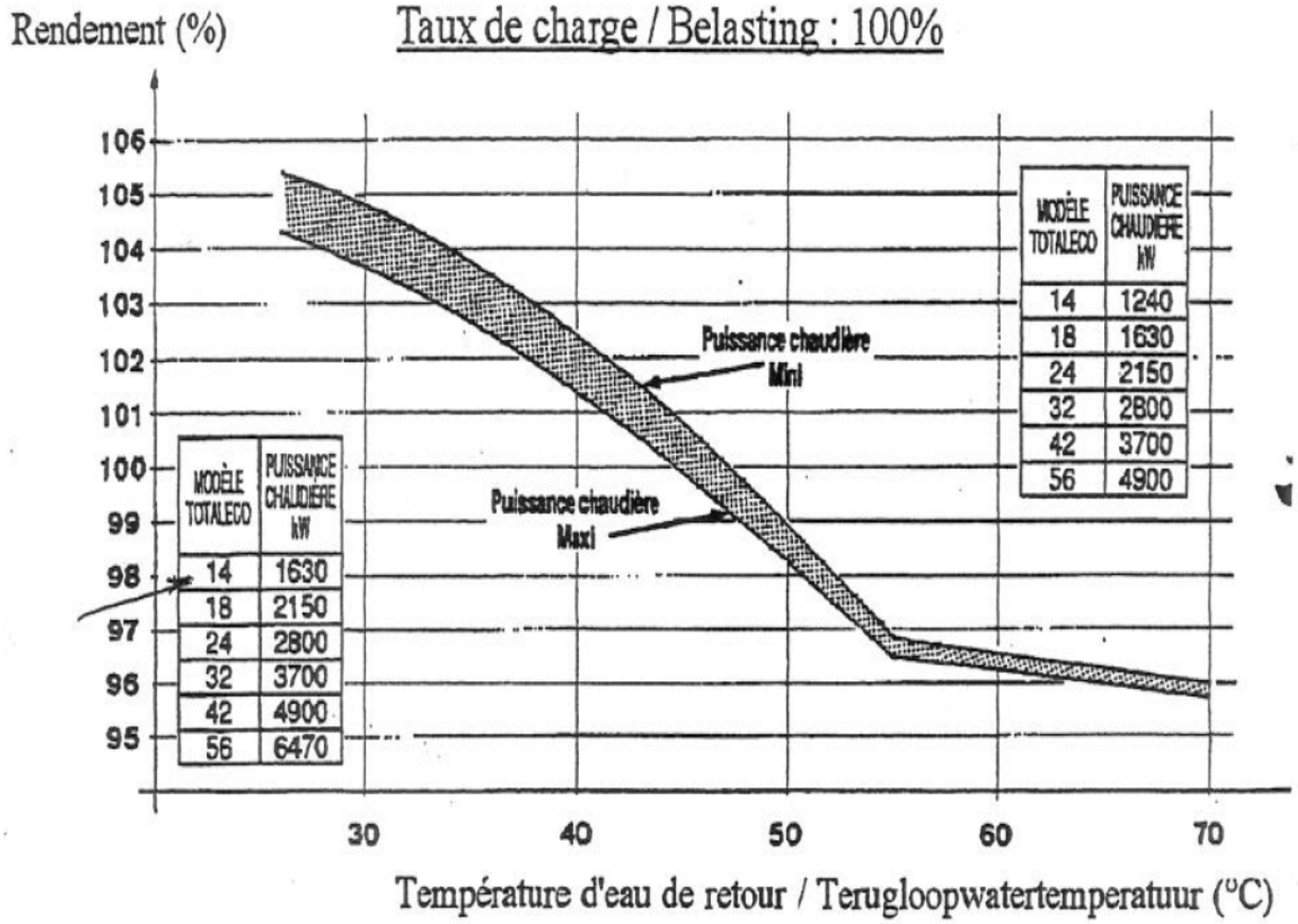

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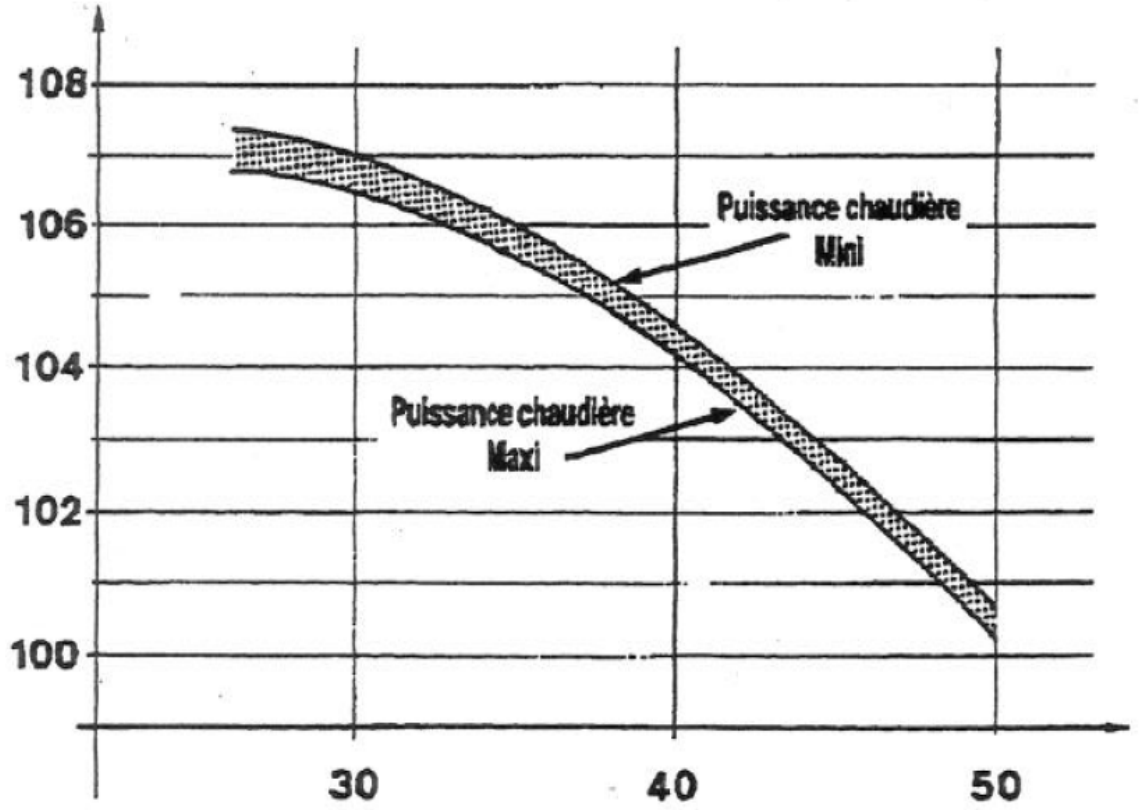
Rendement (%)

Taux de charge / Belasting : 50%



Température d'eau de retour / Terugloopwatertemperatuur (°C)

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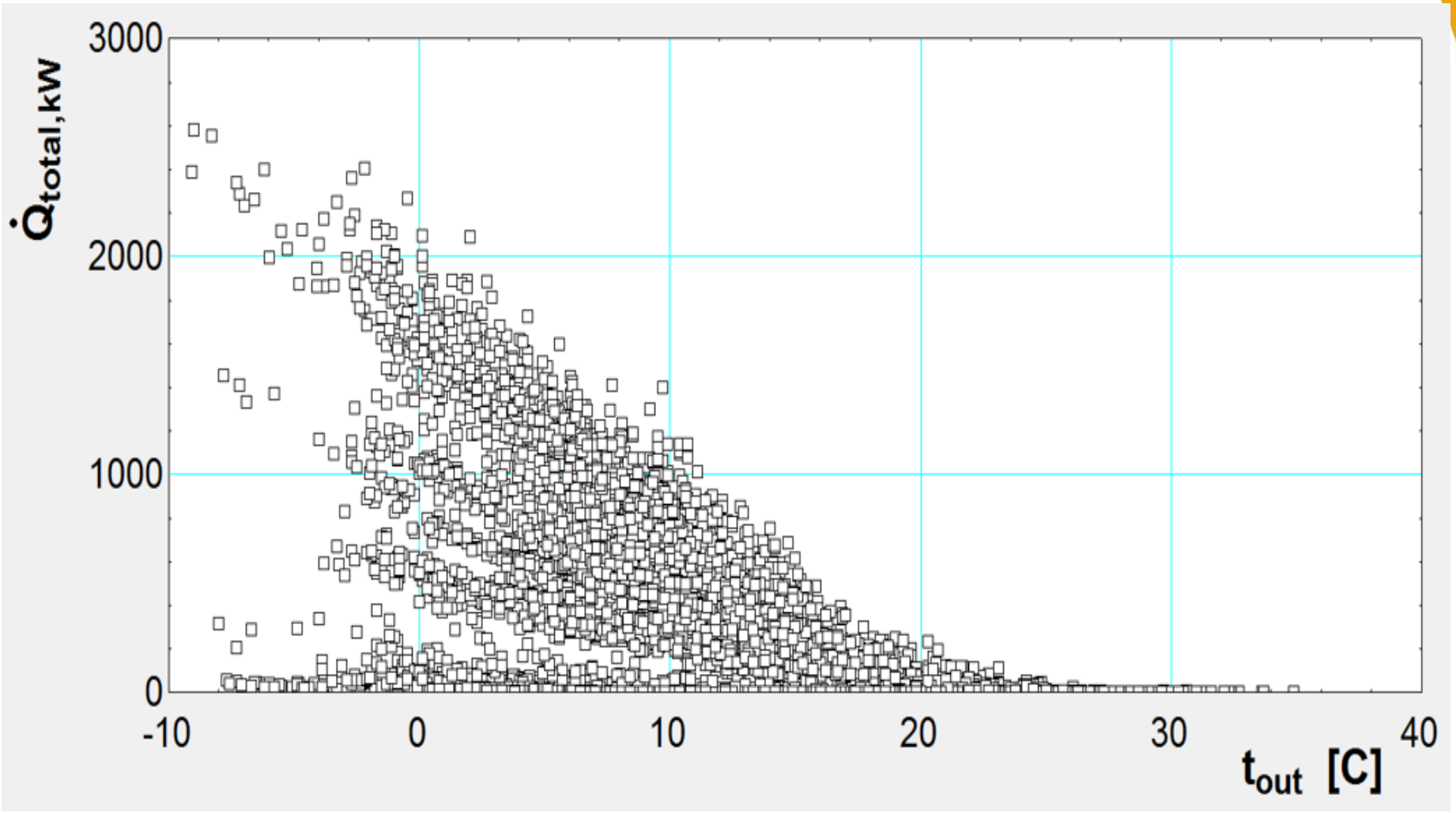

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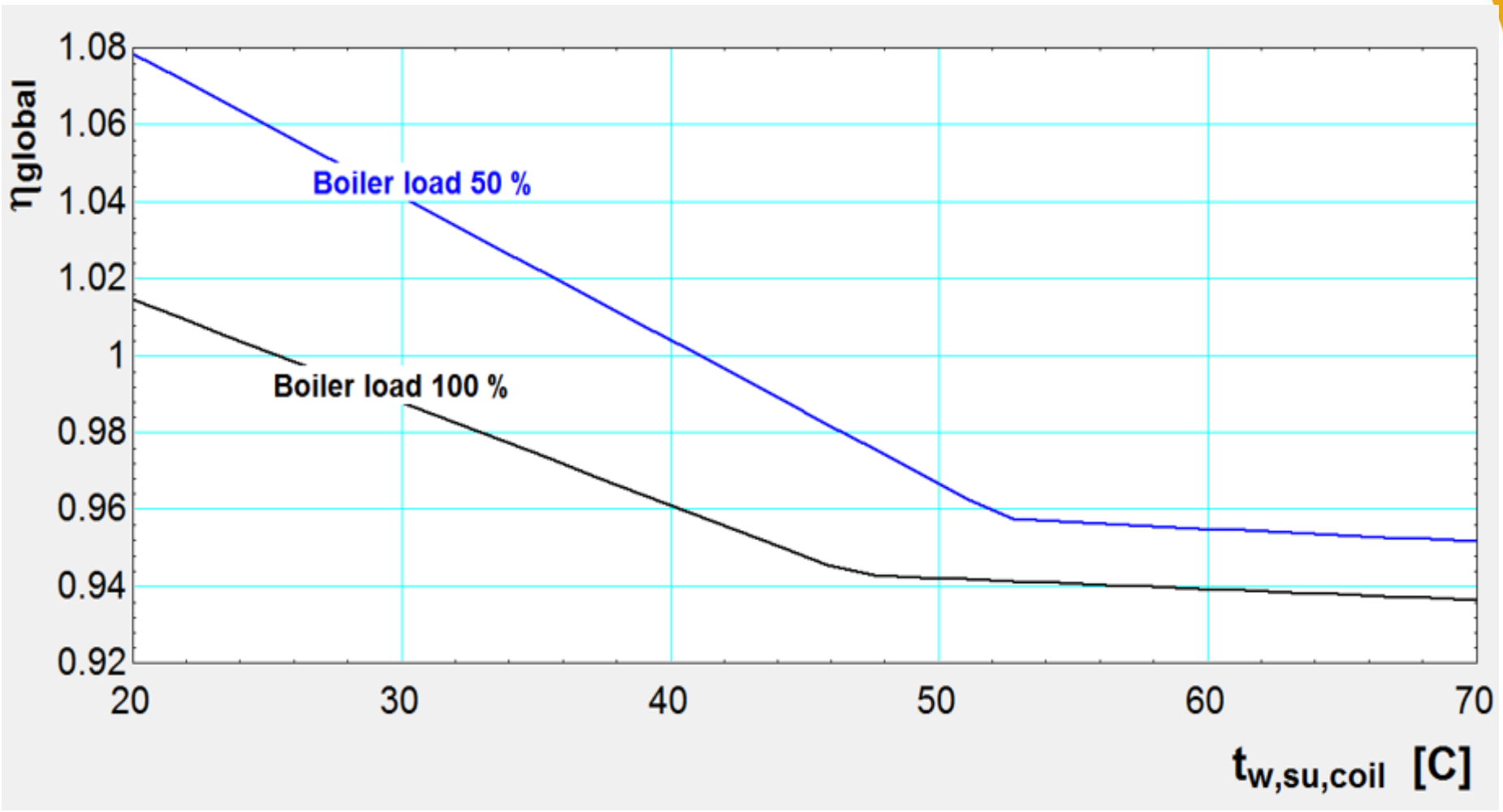

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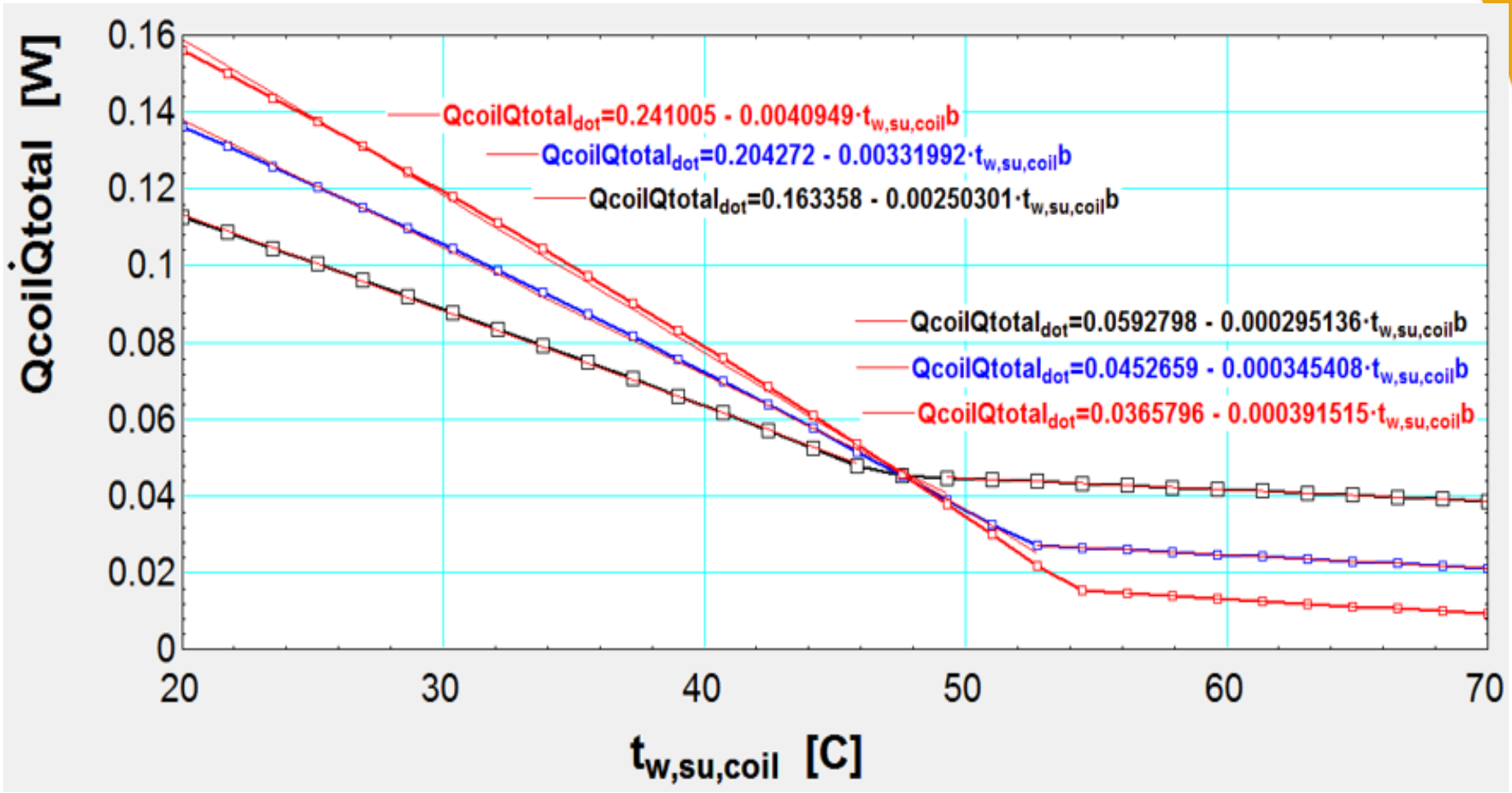

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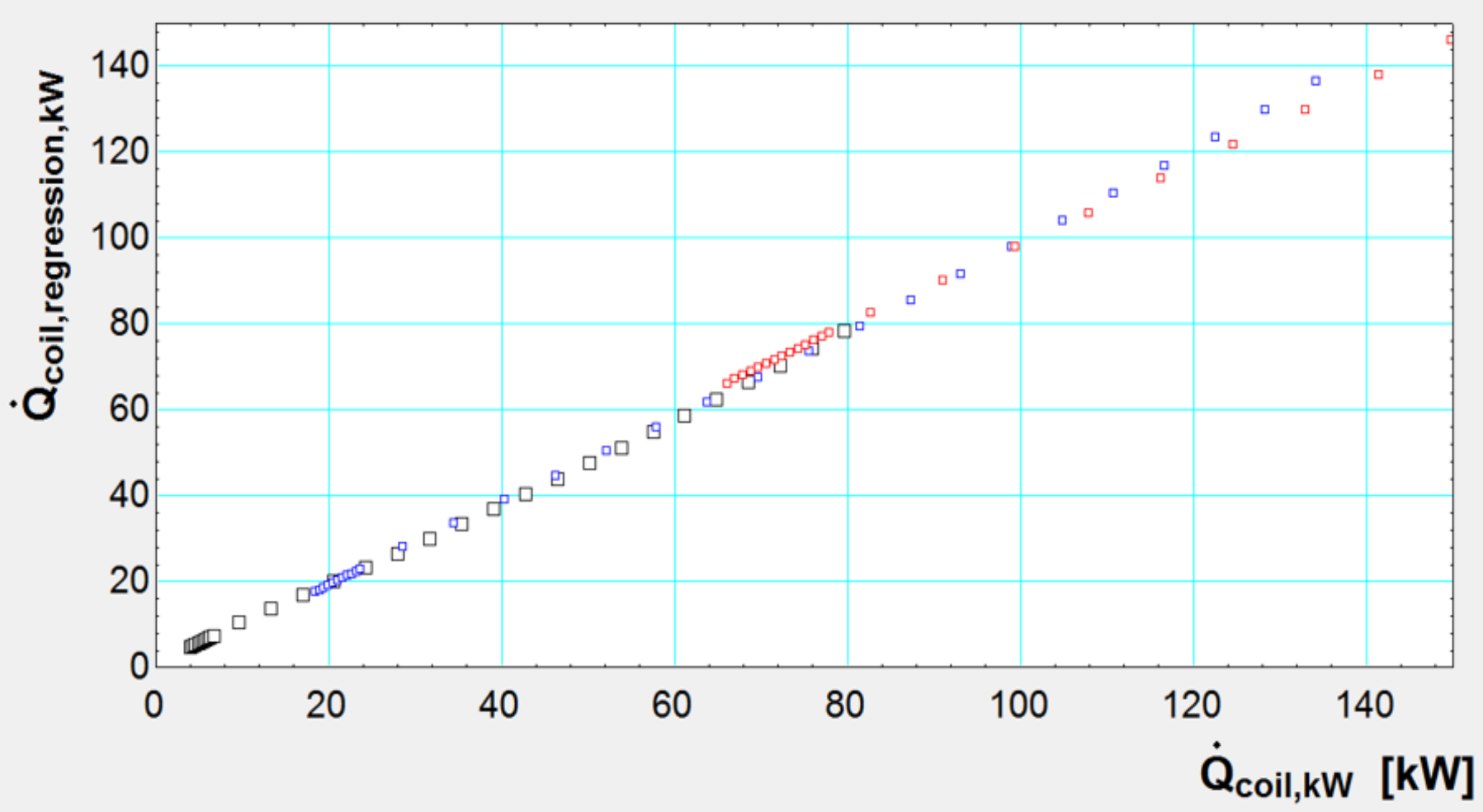

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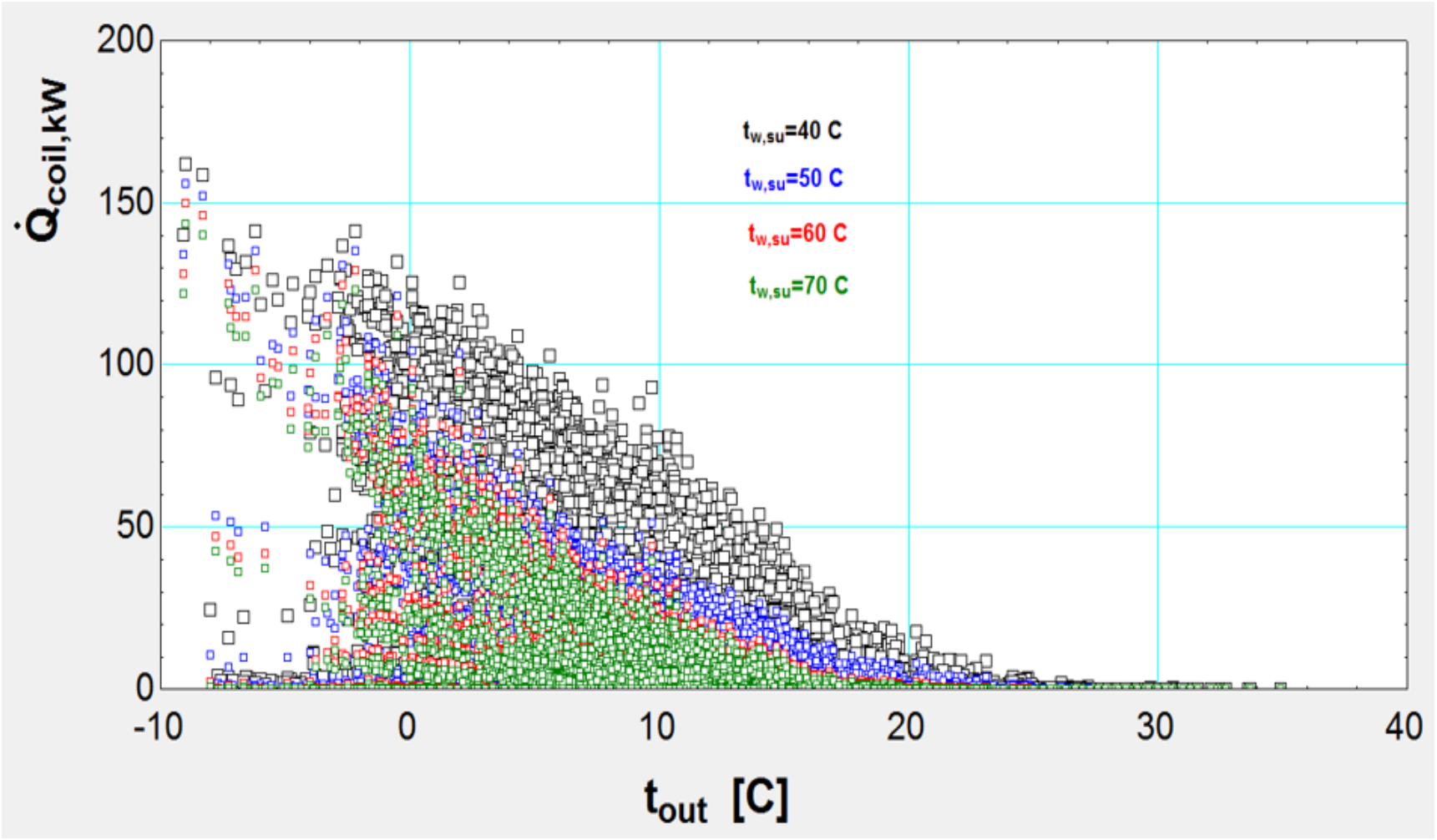

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Simulation indicates what could be recovered if…

- Correcting defect in piping topology
- *varying water flow rate* (to get the lowest return temperature)…

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Among the conclusions:

- BMS deserves careful commissioning;
- CO2 measurements help in identifying excess of air renewal;
- Combined CO2 and H2O balances help in identifying wastes associated to humidity control;
- Fans are reliable flow meters;
- Ensure “condensing” boilers are actually condensing!

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