3. COMMISSIONING AND MANAGEMENT

SIMULATION-ASSISTED COMMISSIONING OF A CHILLING PLANT

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- Calculation verified several time
- Special measurements in “parallel” with official commissioning.
- Building fully occupied with cooling plant not yet working correctly…
- And one of the hottest summers of the century!
- Progressive extension of cooling system…

- Stimulated interest for more commissioning

to track all cooling bottlenecks and overheating risks

- Illustration of what could become a "continuous" commissioning process

Problems which were, or could have been, resolved, thanks to model-assisted commissioning

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Lack of cooling capacity

- Electrical current threshold originally set at a too low level
- Chillers nominal capacity not met
- Had been easy to detect by comparative simulation!

Refrigerant leakage

- Reduction of cooling capacity
- Easy to detect by comparative simulation!

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Sticky check valves

- Warm water circuit polluted by cooling towers
- "parasitic" mixings due to fluid re-circulation
- Easy to detect by inspecting distributions of all fluids temperature

Fouling of the cooling towers

- Tapped by a mix of dust and calcium carbonate
- Up to 70 % of reduction of heat transfer coefficients!
- Could have been detected on time if…

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Fouling of the condensers

- Same fouling as the cooling towers
- Heat transfer coefficients have to be tracked continuously
- Detection by simulation a little more delicate
- But very significant differences observed before and after maintenance

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- No excuse for not detecting on time most of performance degradations
- Simple simulation models available
- Easy to tune, on basis of manufacturer data and of "as built" files
- Pre-tuning would help a lot in initial Cx
- Continuous re-tuning would help for preventive maintenance

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- BEMS *and* Model assisted continuous commissioning should become very soon a cost-effective business!

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Example of corrective action:

- Adaptation of fans rotation speeds to actual pressure drops

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Using a fan as air flow meter

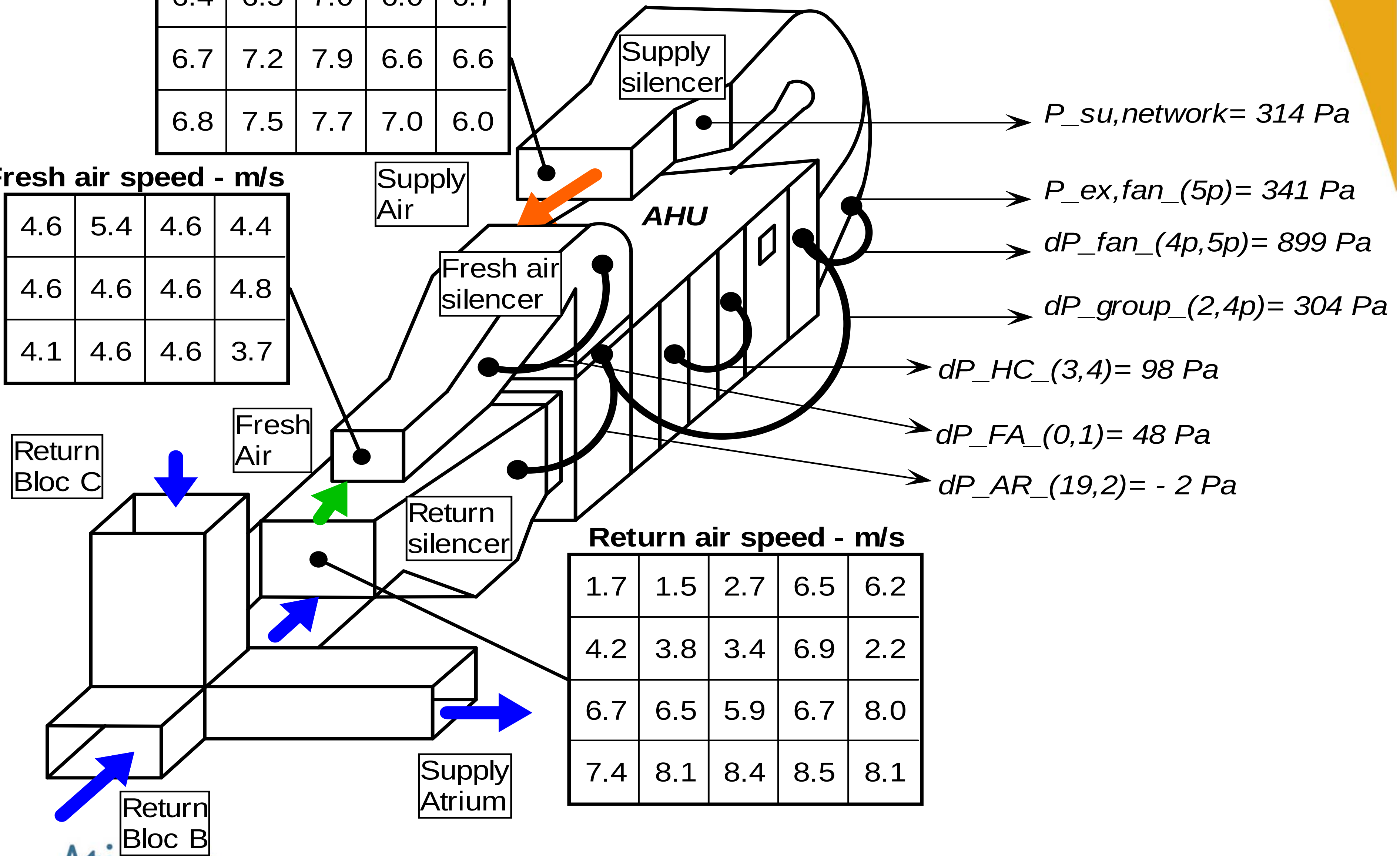
- **The principle**
- Measurements of airflow rates are difficult…

Supply air speed - m/s

6.4	6.5	7.0	6.0	6.7
6.7	7.2	7.9	6.6	6.6
6.8	7.5	7.7	7.0	6.0

Fresh air speed - m/s

4.6	5.4	4.6	4.4
4.6	4.6	4.6	4.8
4.1	4.6	4.6	3.7



Return air speed - m/s

1.7	1.5	2.7	6.5	6.2
4.2	3.8	3.4	6.9	2.2
6.7	6.5	5.9	6.7	8.0
7.4	8.1	8.4	8.5	8.1

supply air flow rate = 18014 m³/h
fresh air flow rate = 2462 m³/h

- Much better solution: using the fan as flow meter

Flow rate calculation:

$$\dot{V} = \phi \cdot A \cdot U$$

with

$$A = \pi \cdot \frac{D^2}{4}$$

(reference area)

$$\dot{M} = \frac{\dot{V}}{v}$$

(specific air flow rate)

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Pressure factor calculation:

$$\psi = \frac{\Delta p_{total}}{P_{dynam,periph}}$$

with

$$P_{dynam,periph} = \frac{U^2}{2 \cdot v}$$

(peripheral dynamic pressure)

Power calculation:

$$\dot{W} = \frac{\dot{W}_s}{\varepsilon_s}$$

with

$$\dot{W}_s = \dot{V} \cdot \Delta p_{total}$$

(isentropic power)

and

$$\varepsilon_s = \phi \cdot \frac{\Psi}{\lambda}$$

Pressures:

$$p_{ex} = p_{tot,ex} - p_{dynam,ex}$$

with

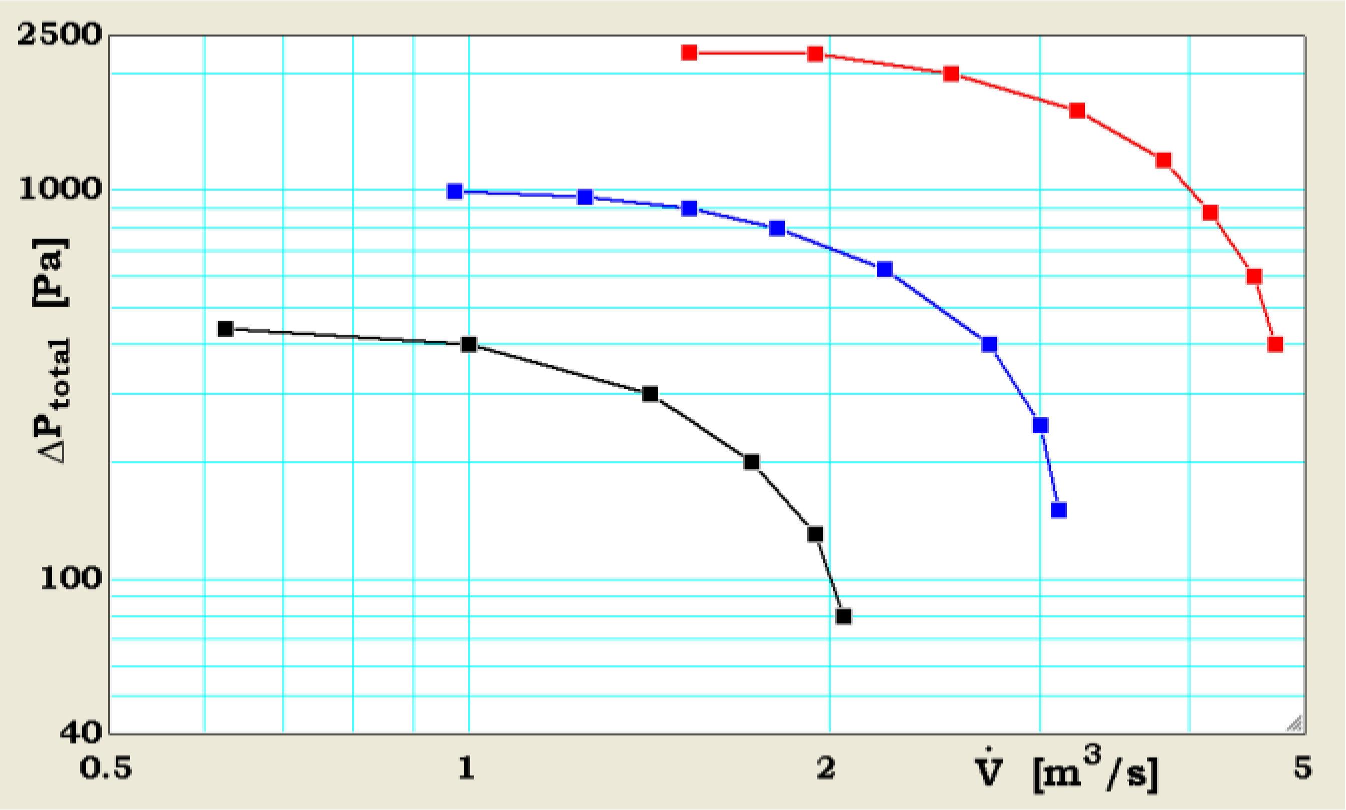
$$p_{tot,ex} = p_{su} + \Delta p_{total}$$

and

$$p_{dynam,ex} = \frac{C_{ex}^{\ 2}}{2 \cdot v}$$

(exhaust dynamic pressure)

Polynomial laws established with manufacturer data



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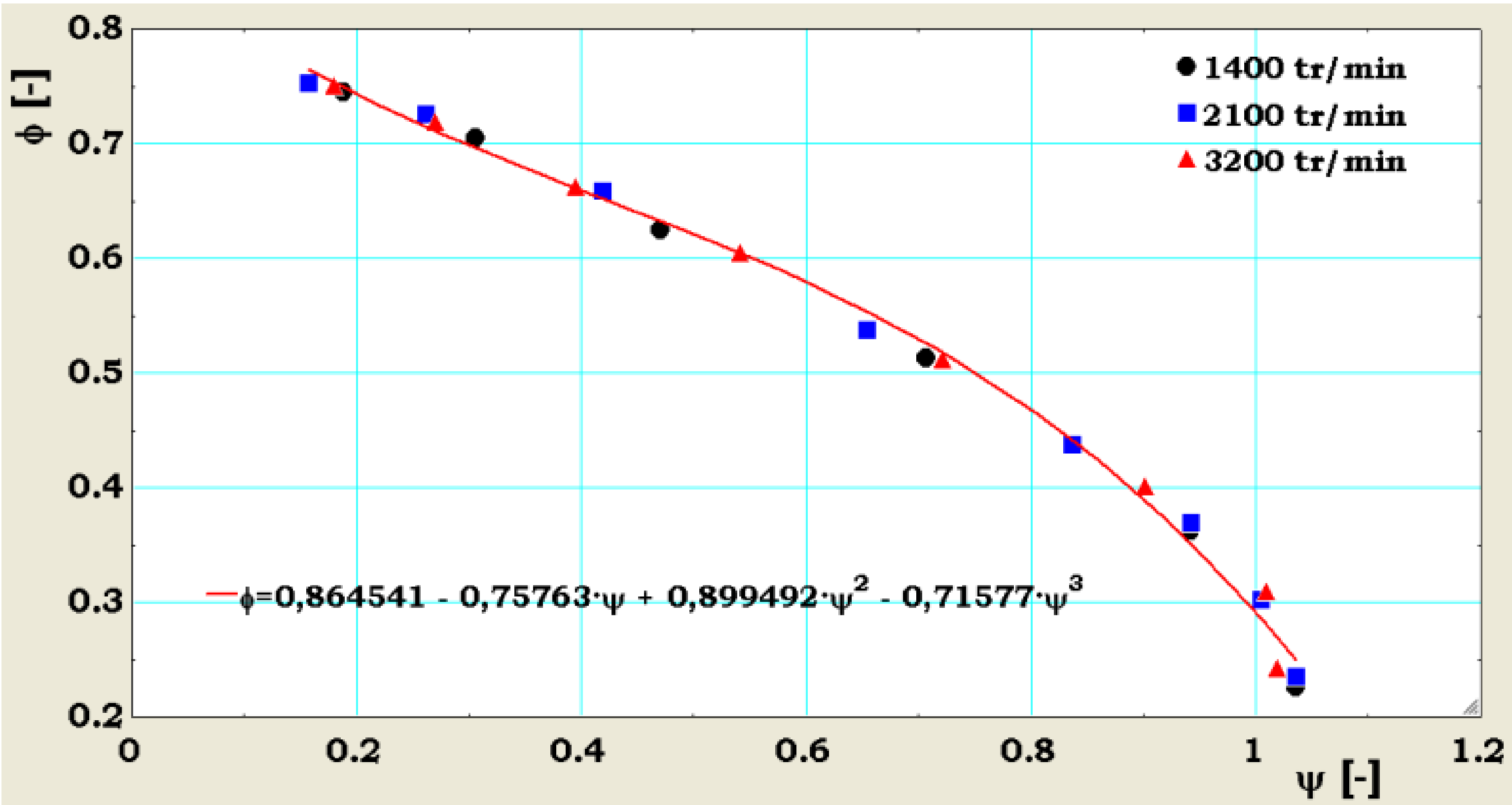
Corresponding phi-psi regression curve



Second example: using refrigeration compressor as enthalpy flow meter

The principle

Cooling power *should* correspond to enthalpy flow rate of secondary fluid, but…

- Flow rate and supply-exhaust temperature difference not easy to measure…
- Measurements not easier on refrigerant side…

Interesting alternative:

- Cooling power determined from electrical consumption, associated to evaporation and condenser pressures (usually indicated on the control panel)

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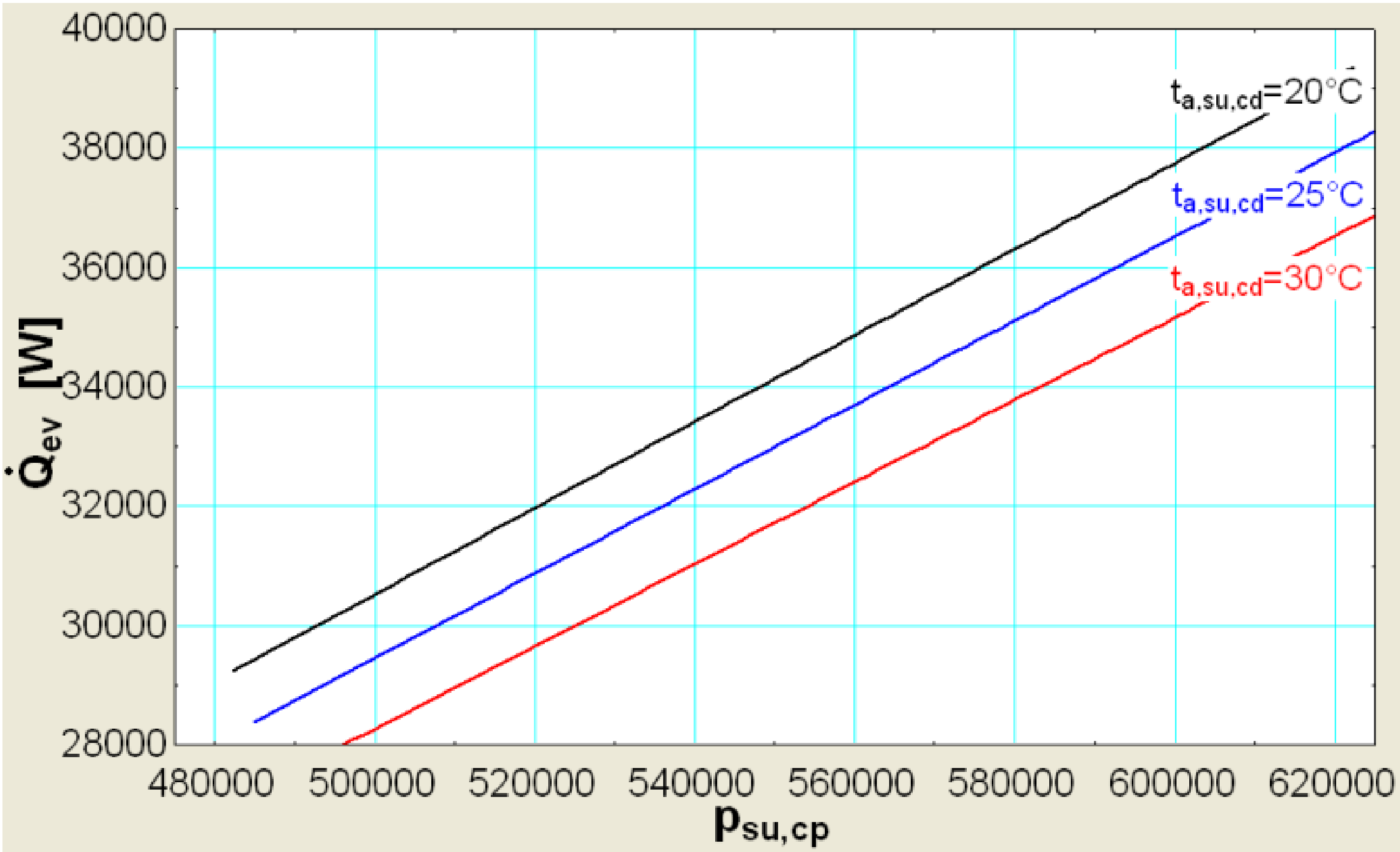
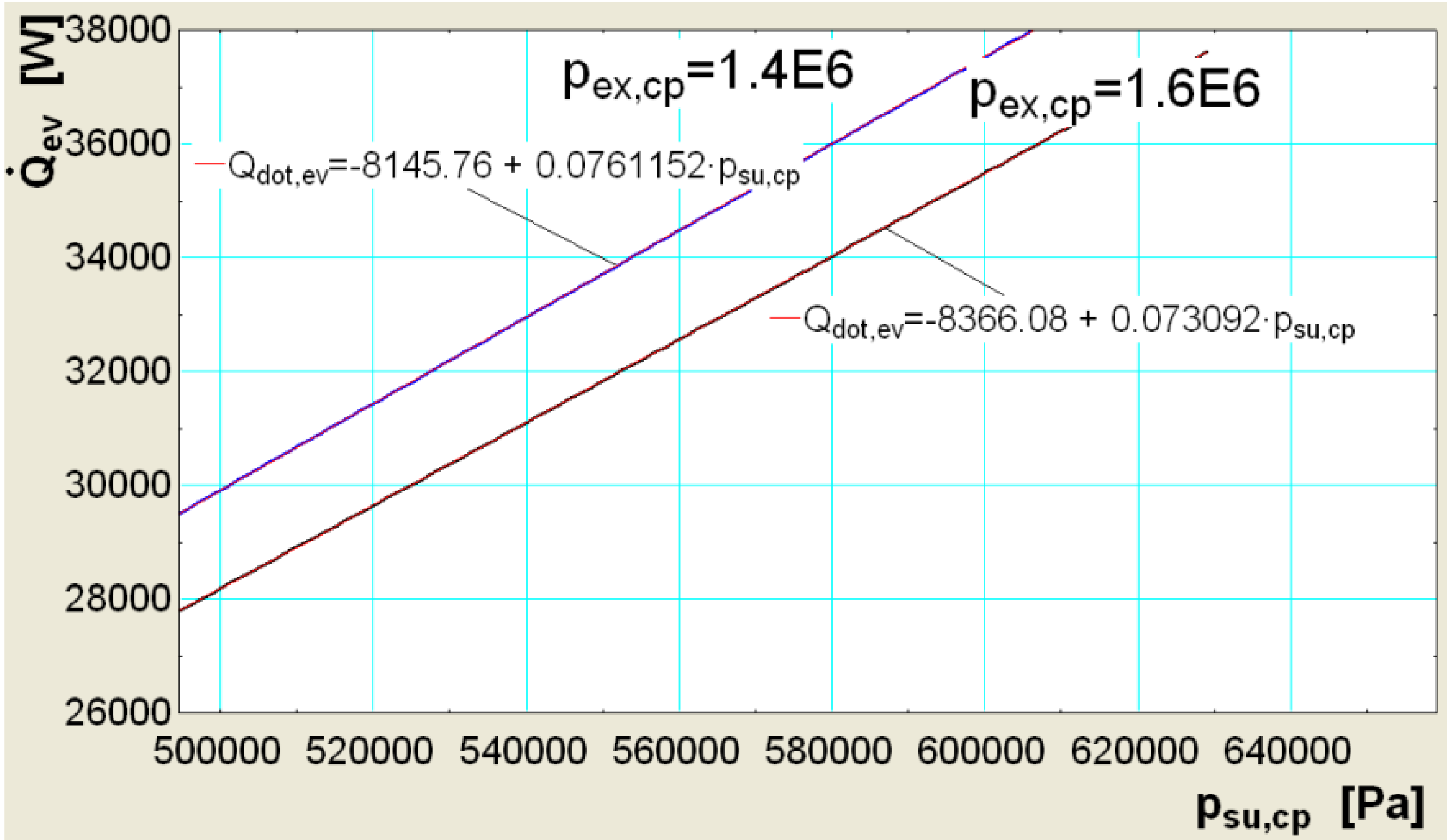
Cooling power defined as function of refrigerant pressure at compressor supply



Shift function of condensing pressure



So…

- If correctly identified and modelled, HVAC components become valuable sensors
- Not only fans and chillers, but also boilers, pumps, heat exchangers, valves, dampers, coils and terminal units
- This would make a bit easier HVAC energy audit.

Our dream: a real-time view on all consumptions!