Using thermo-chemicals for moisture control in the automotive industry

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Newcastle University

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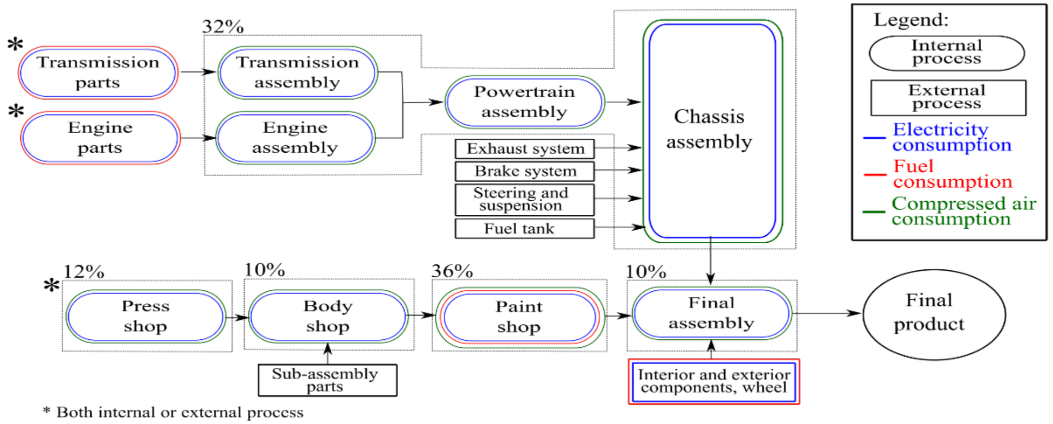
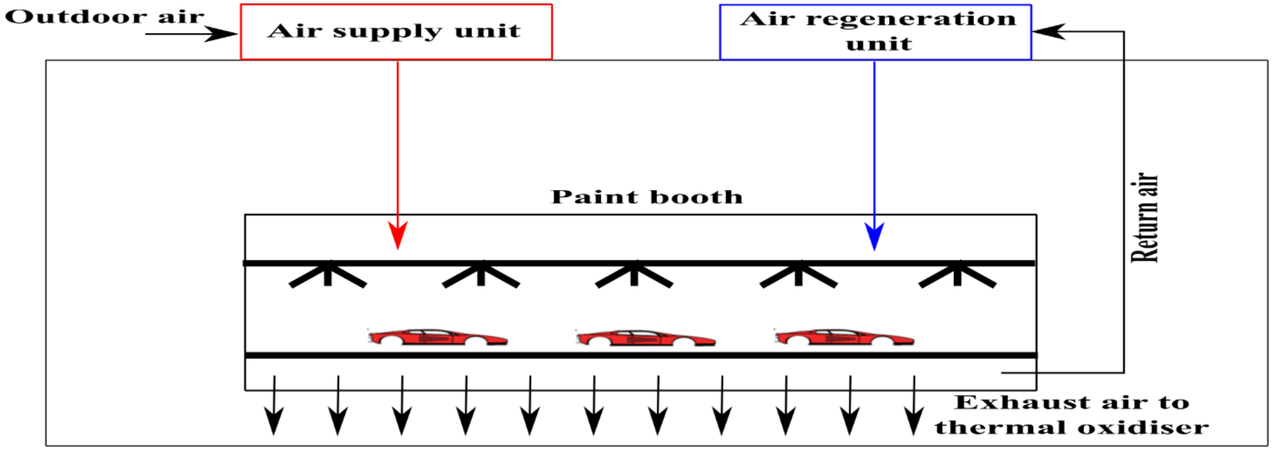
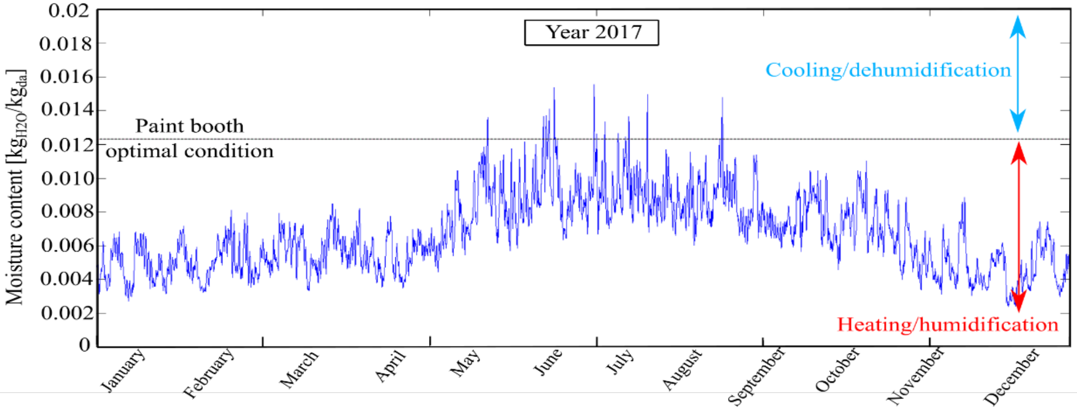
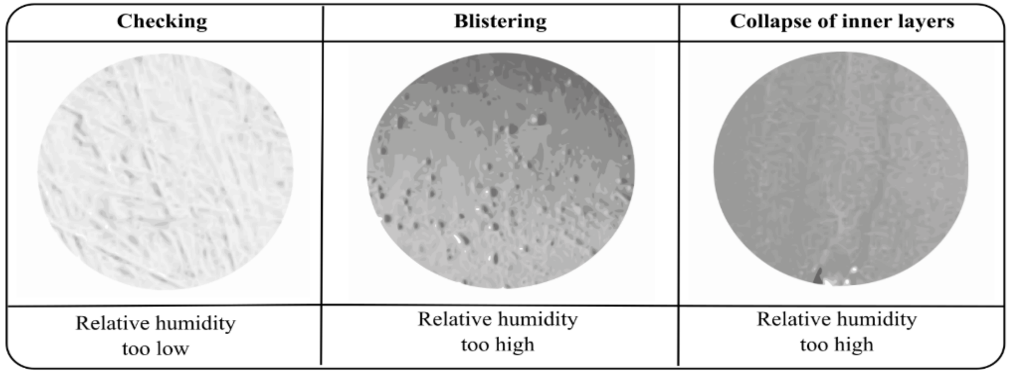
Background: Why TCFs can be important for the automotive industry?









H-DisNet

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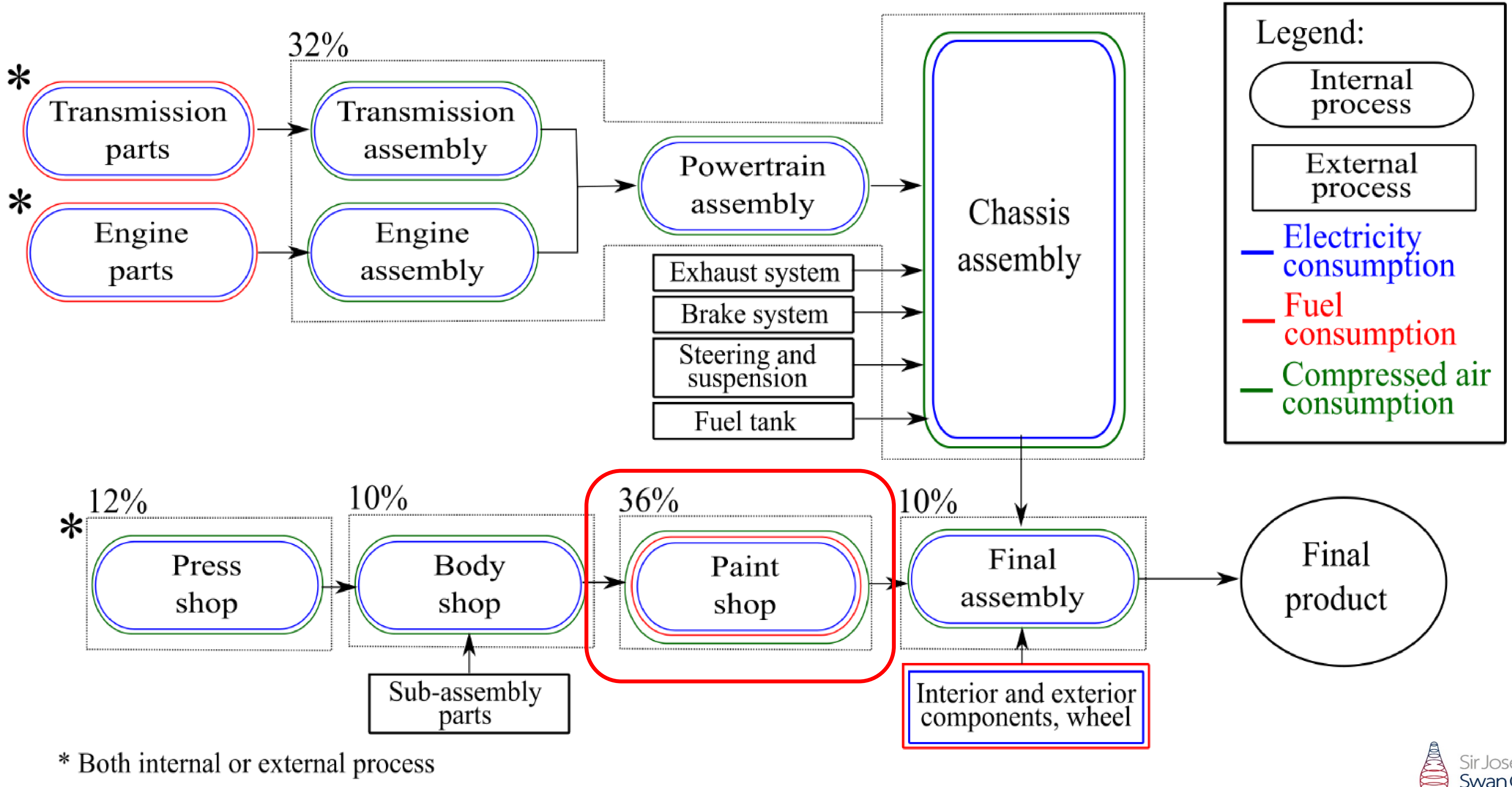
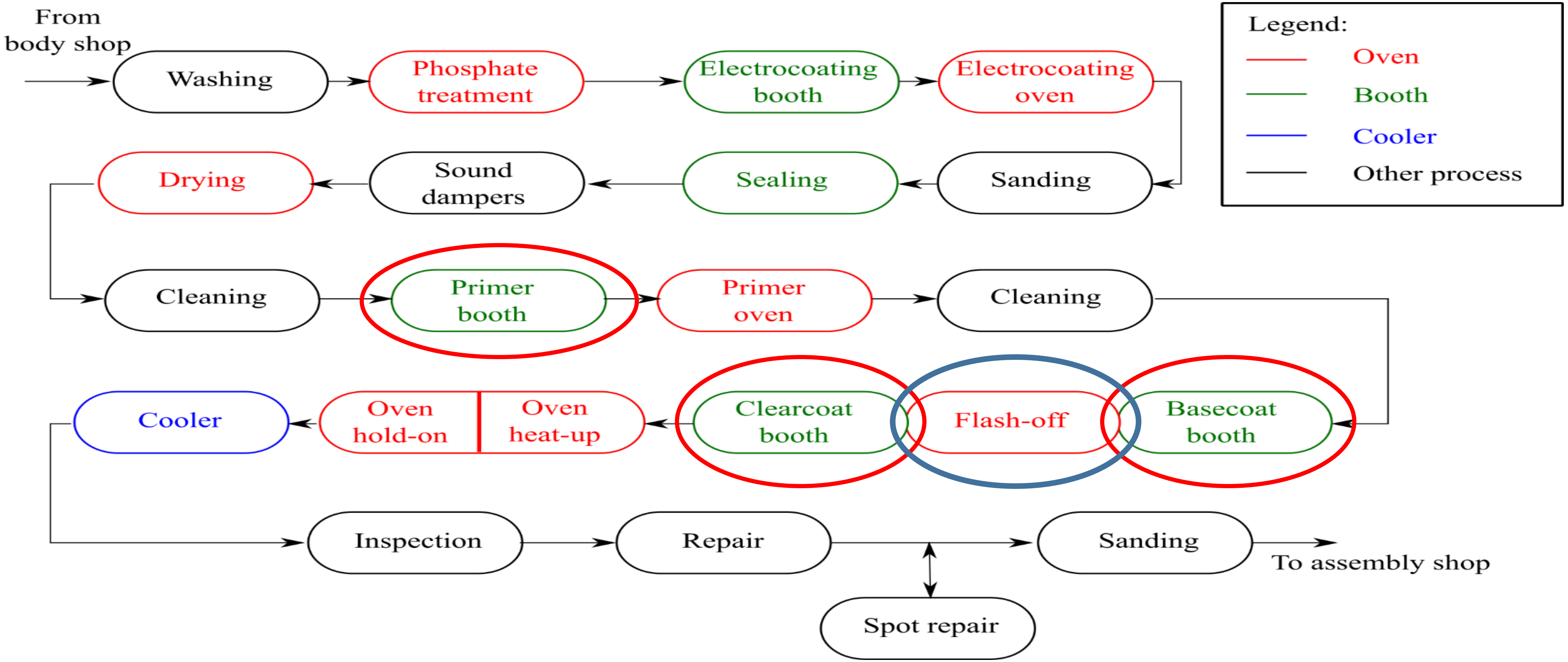
Vehicle manufacturing process



Painting process



Objective for manufacturer: **Electricity** and **fuel consumption reduction** in the **paint shop** using available **waste heat sources**.

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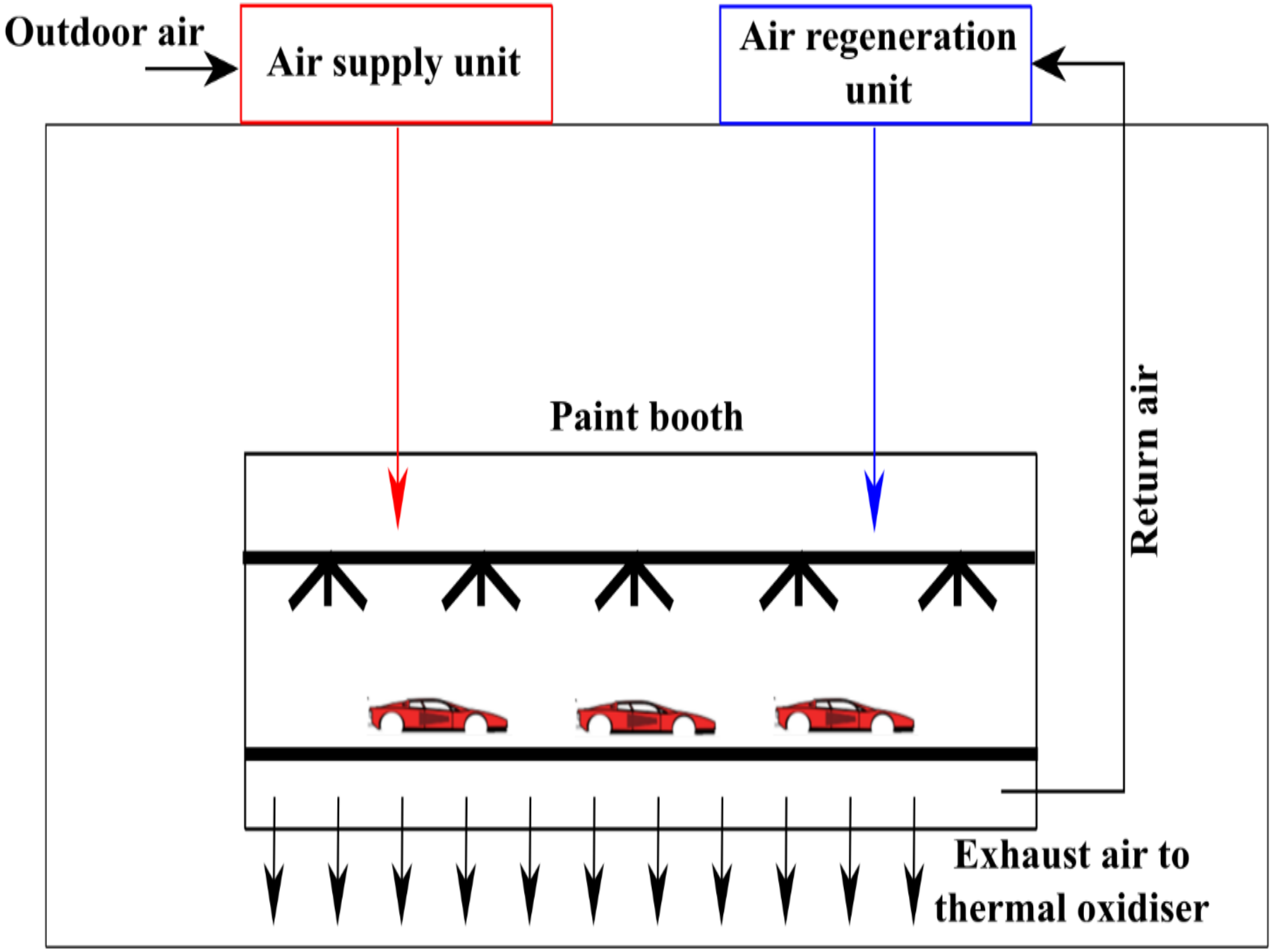
Current technological solution



- Air management systems used for **<u>temperature, humidity and dust control</u>** of the paint booth's supply air
- **<u>Air supply unit (ASU)</u>** treats 100% outdoor air. Process dependent on external condition
- **<u>Air regeneration unit (ARU)</u>** recirculates portion of air exhausted by paint booth (about 80-90%). Required cooling process is less dependent on external condition

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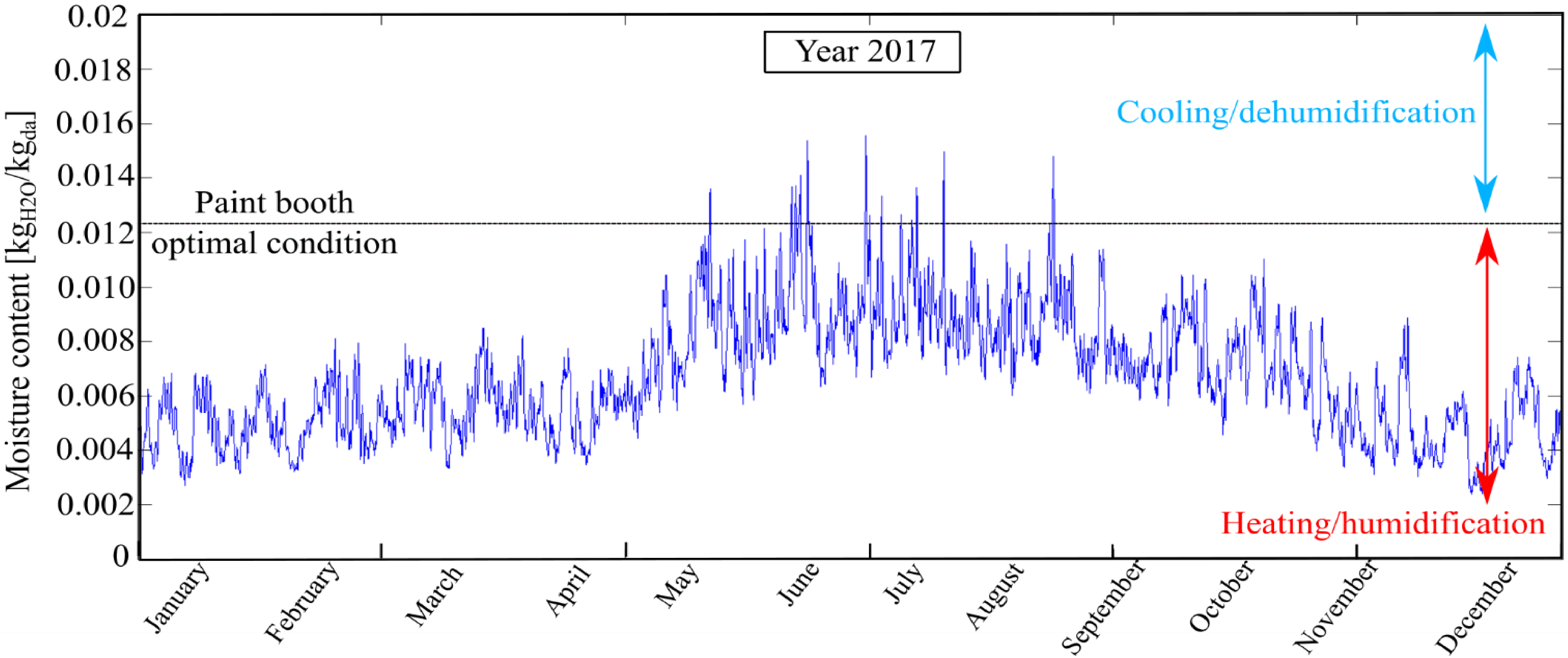
Automotive plant weather condition



- **Heating** and **humidification** required **most of the year**.
- **Few predictable days** require **dehumidification** and **cooling**.

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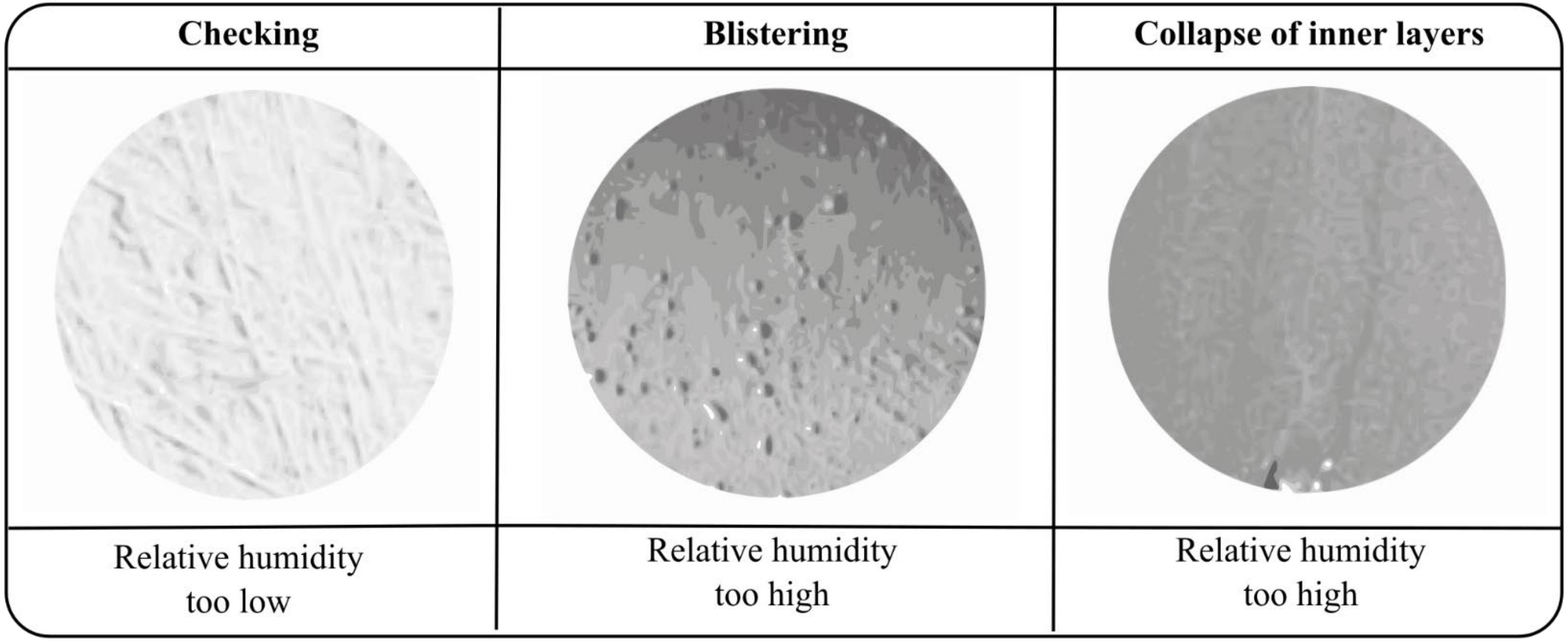
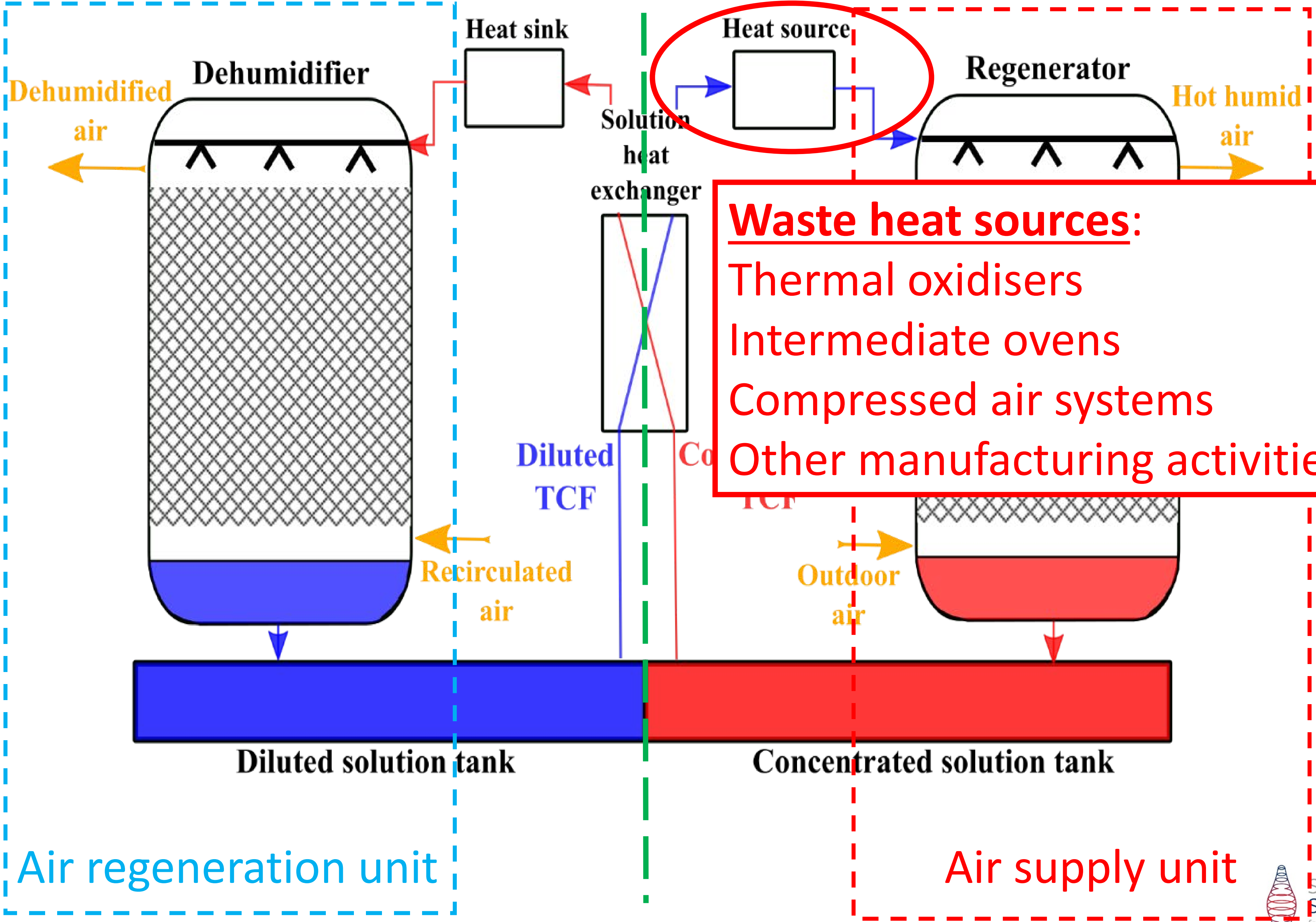
Effect of humidity on paint layer formation



An **inappropriate control** results in **paint defects**, which in turns require **re-working of the vehicle**, process that is **time-** and **cost-consuming**.

[1] CAREL. Air humidity in paint booths - Sustainable solutions for correct application of paints. Technical report, 2017



Waste heat sources:

Thermal oxidisers

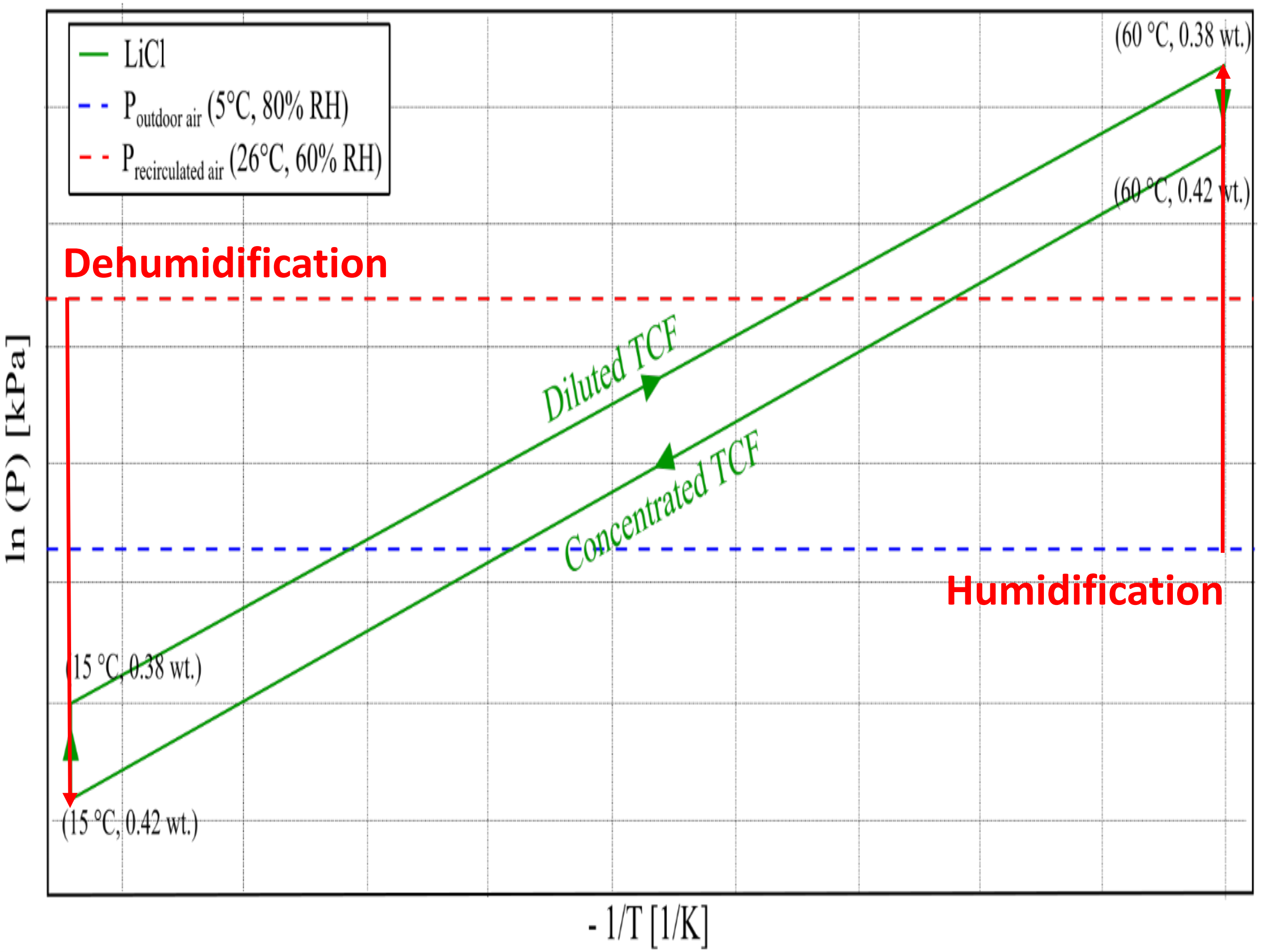
Intermediate ovens

Compressed air systems

Other manufacturing activities

H-DisNet technological solution

van't Hoff diagram



- **Moisture absorption** and **desorption** process driven by **difference in vapour pressure between air and desiccant solution**.
- **Significant savings** in terms of **electricity and fuel consumption**.

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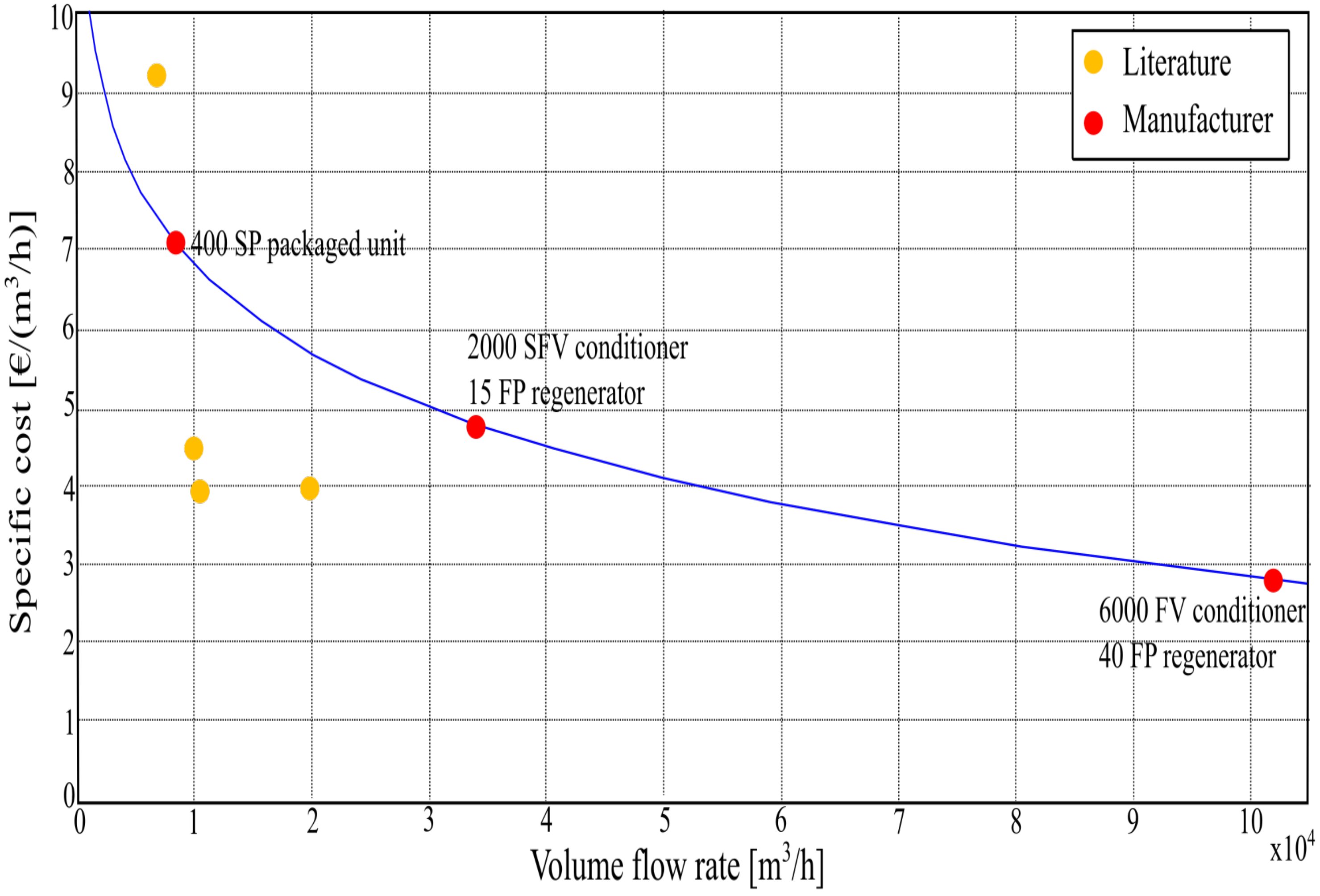
Thermo-chemical system capital cost analysis



Method:

- Specific cost function was regressed.
- **Characterisation strategy** based on the **flow rate**.

Based on the regressed function, the **cost** of the system at **different flow rates** can be determined.

The regressed cost for a **100,000 m^3/h** system would be **€ 283,580**.

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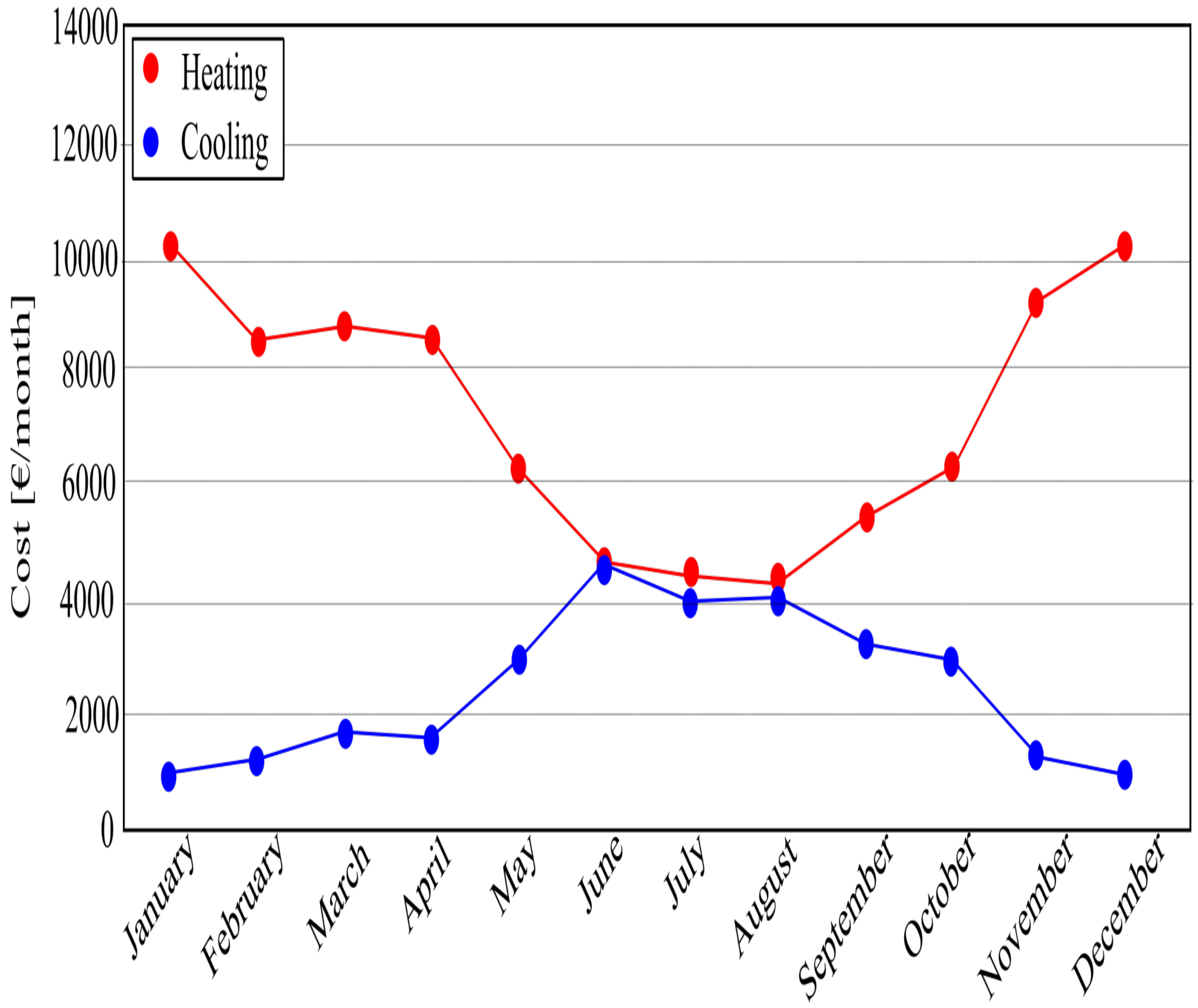
Preliminary economic analysis

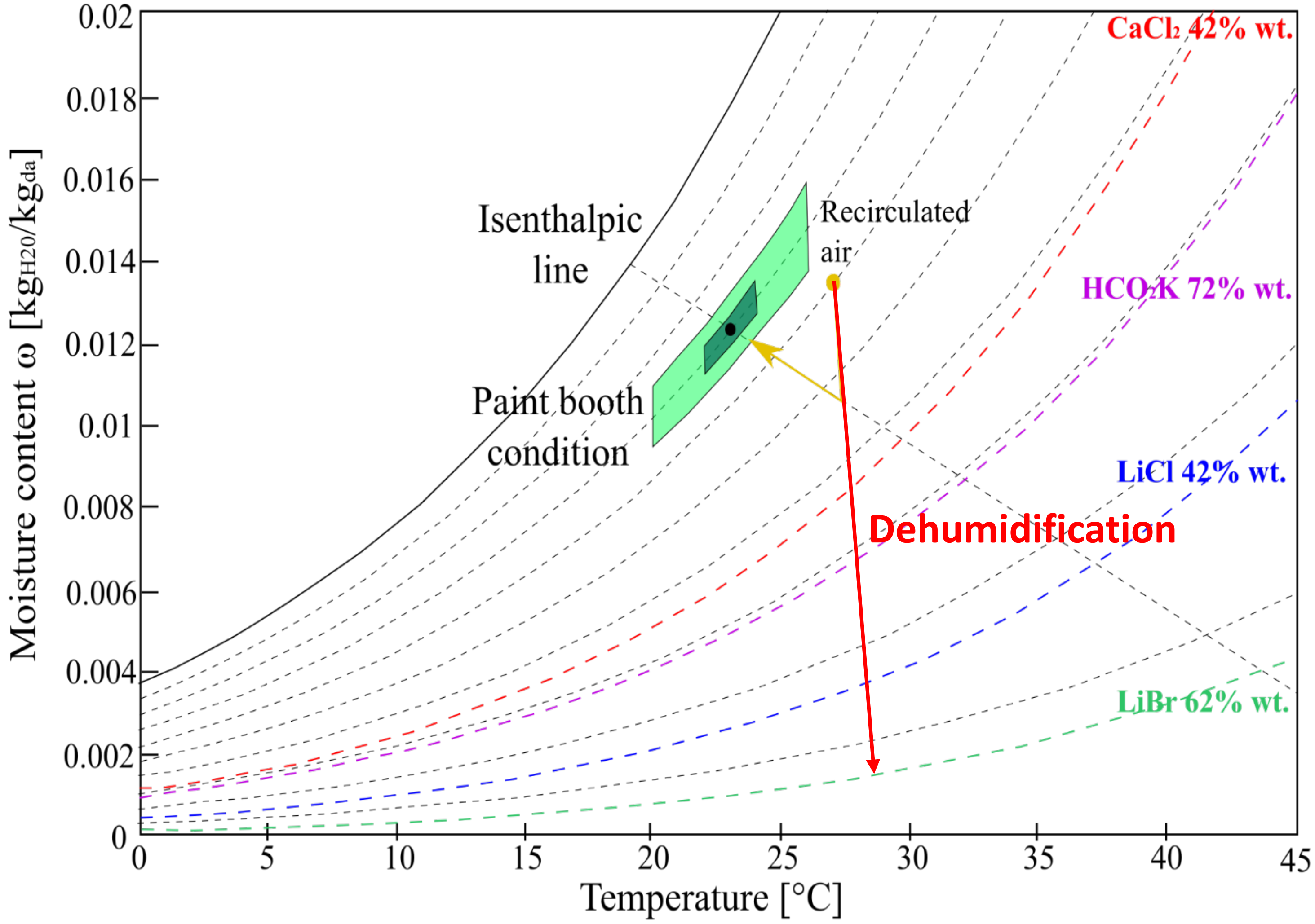


Natural gas cost € 0.02 kWh^{-1}
Electricity cost € 0.1 kWh^{-1}

Parameter	Value
ASU/ARU volume flow rate	100,000 m^3/h
Paint booth temperature	23 °C
Paint booth RH	70 %
Working hours	5962.5 h/y
Heating ASU savings	€ 87,113.6 y^{-1}
Humidification ASU savings	€ 21,778.4 y^{-1}
Cooling ARU savings	€ 29,133.6 y^{-1}
TCF system capital cost	€ 283,580
O&M TCF system cost	€ 19,850 y^{-1}
Payback period	Lower than 3 years

Additional **economic factor** considering **avoided vehicle reworking**

Choice of TCF for the process



Dehumidification effectiveness

$$\varepsilon_{deh} = \frac{\omega_{air,in} - \omega_{air,out}}{\omega_{air,in} - \omega_{TCF,eq}(T_{TCF}, x_{TCF})}$$

ω_{air} = air moisture content, $\omega_{sol,eq}$ = equilibrium moisture content of the TCF, it represents the minimum value of moisture content achievable with TCF

ε_{deh} for well-designed system is usually 0.7

Salt	Cost per metric ton of salt (€)
LiCl-anhydrous	7,260
LiBr-anhydrous	2,860
HCO_2K-anhydrous	323
$CaCl_2$-dihydrate	143

Cheaper TCFs with **lower regeneration temperature** and **moisture desorption ability** ($CaCl_2$) or **less corrosive** (HCO_2K) can be used

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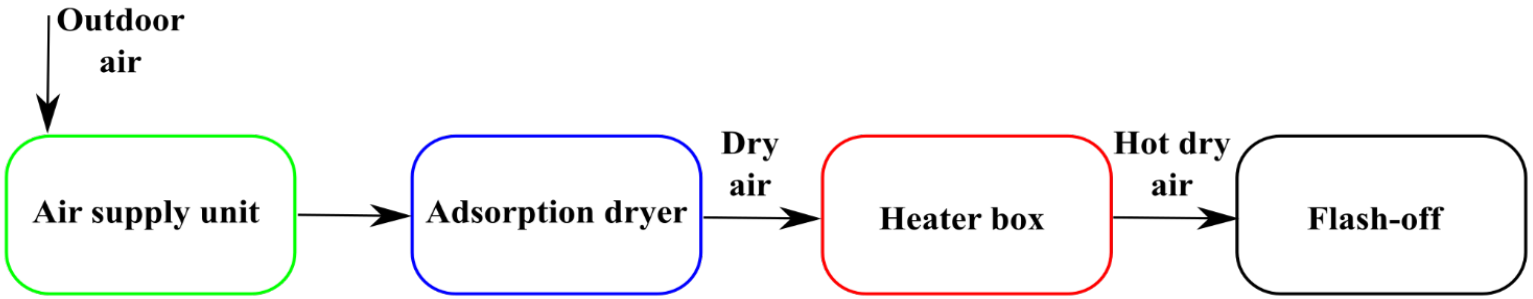
Additional advantages

- **Concentrated TCF** can be used as a **replacement** of **electric adsorption dryers** used for **flash-off process**



Additional **€ 40,000** of **electricity savings** achievable

- **Dust ability removal** of TCFs.

- Effect of humidity on **powder paint.**

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Conclusions:

1) Energy-efficient temperature and humidity control in a paint shop can result in significant economic savings and increased paint quality.

2) In cold climates, simultaneous need for heating/humidification and dehumidification/cooling. H-DisNet could perform both tasks. More significant electricity and fuel savings are achievable.

3) A capital cost function for the TCF system valid for different flow rates was determined; payback period is lower than 3 years.

4) LiBr, LiCl, $CaCl_2$, and HCO_2K applicable in the process but $CaCl_2$ and HCO_2K are cheaper and suitable for lower-temperature application.

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Thanks for your attention