
# Underperformance in Refrigeration: A technical challenge

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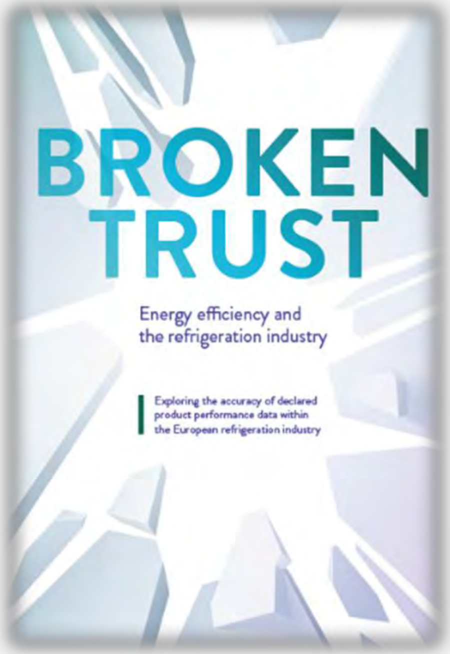
**Eurovent Certification**

*When performance falls short, operational efficiency and costs are compromised.*

# What does **underperformance** mean for you?




# Defining underperformance

Underperformance refers to deviations from **manufacturer-declared performance specifications**, such as energy efficiency and heat transfer capacity.

- Technical aspects include:
  - Lower-than-expected energy efficiency
  - Suboptimal heat transfer rates leading to insufficient cooling capacity
  - Accelerated degradation under operational stress

> *The performance you expect isn't always the performance you get.*

# Impact of underperformance on refrigeration system efficiency

Specifiers (e.g. consulting engineers, technical managers etc.) are responsible for selecting equipment based on technical data.

Underperforming systems lead to:

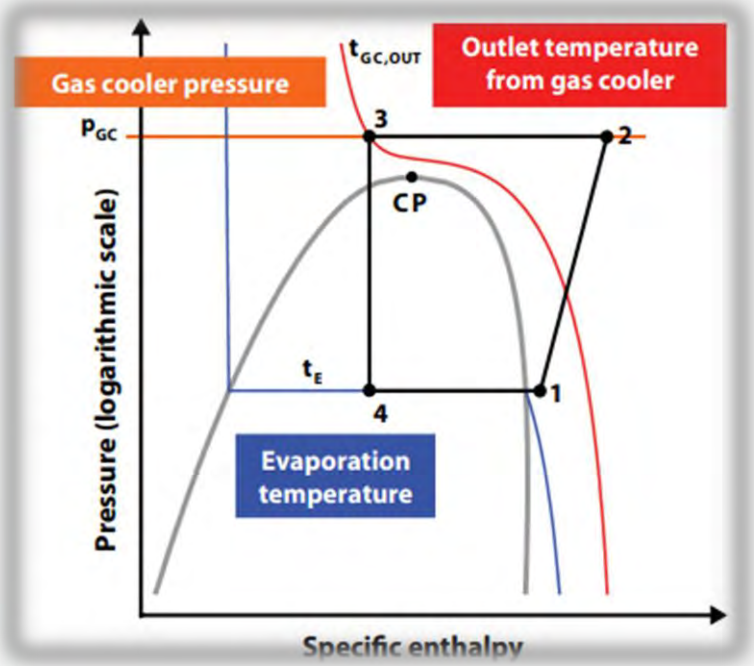
- Higher energy consumption beyond initial design specifications
- Maintenance overloads and reduced system lifespan
- Long-term operational inefficiencies that impact CAPEX and OPEX
- Decision-making based on **inaccurate or overstated performance claims** can result in costly retrofitting or system failure.

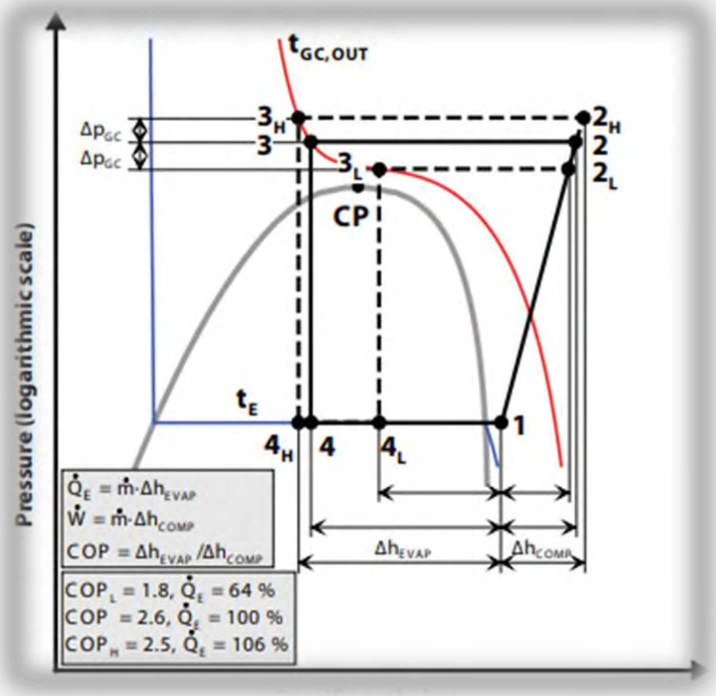
> ***Specifying based on inaccurate data jeopardises system efficiency and operational integrity***

# Case study: Data sheet analysis of non-certified CO2 Gas Coolers

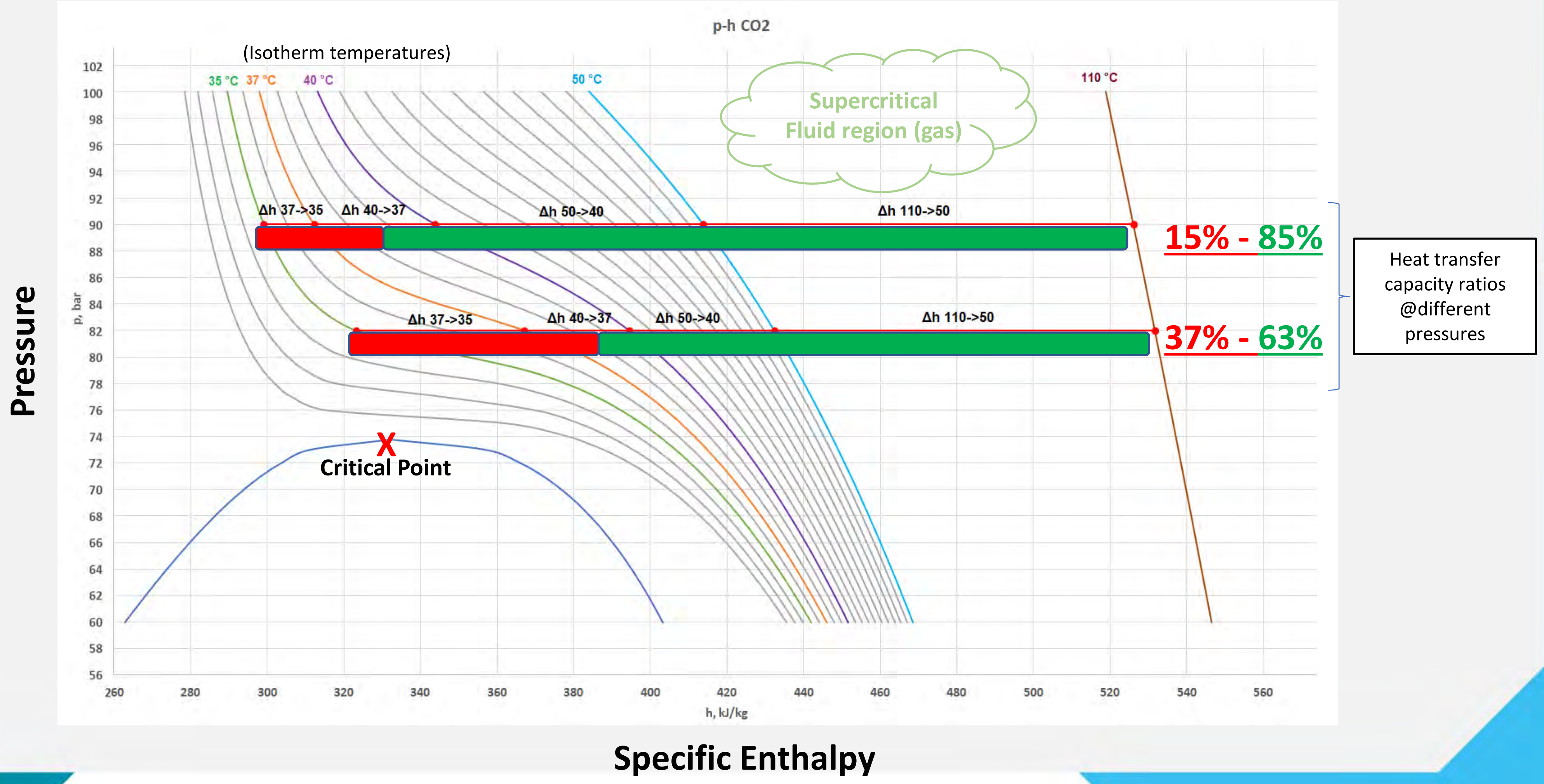
# What is a CO2 (R-744) Gas Cooler?

A CO2 Gas Cooler is an outdoor ventilated heat exchanger through which only the sensible heat within the R744 is rejected to ambient. An optimal Gas cooler operates in transcritical mode.  For the transcritical cycle process, the heat rejection is therefore called gas cooling and subsequently the heat exchanger used is called a **Gas Cooler**.




# CO2 gas cooler heat rejection – thermodynamics
# ‘Transcritical Process’



# The reality behind performance claims

## 48 heat exchangers' technical data was analysed

Table 1: Capacity range of sampled units.

| Capacity range | Sample Number of units |
|---|---|
| ≤50 kW | 11 |
| >50 kW and ≤100 kW | 9 |
| >100 kW and ≤150 kW | 10 |
| >150 kW and ≤200 kW | 9 |
| >200 kW and ≤250 kW | 6 |
| >250 kW | 3 |
| Overall | 48 |

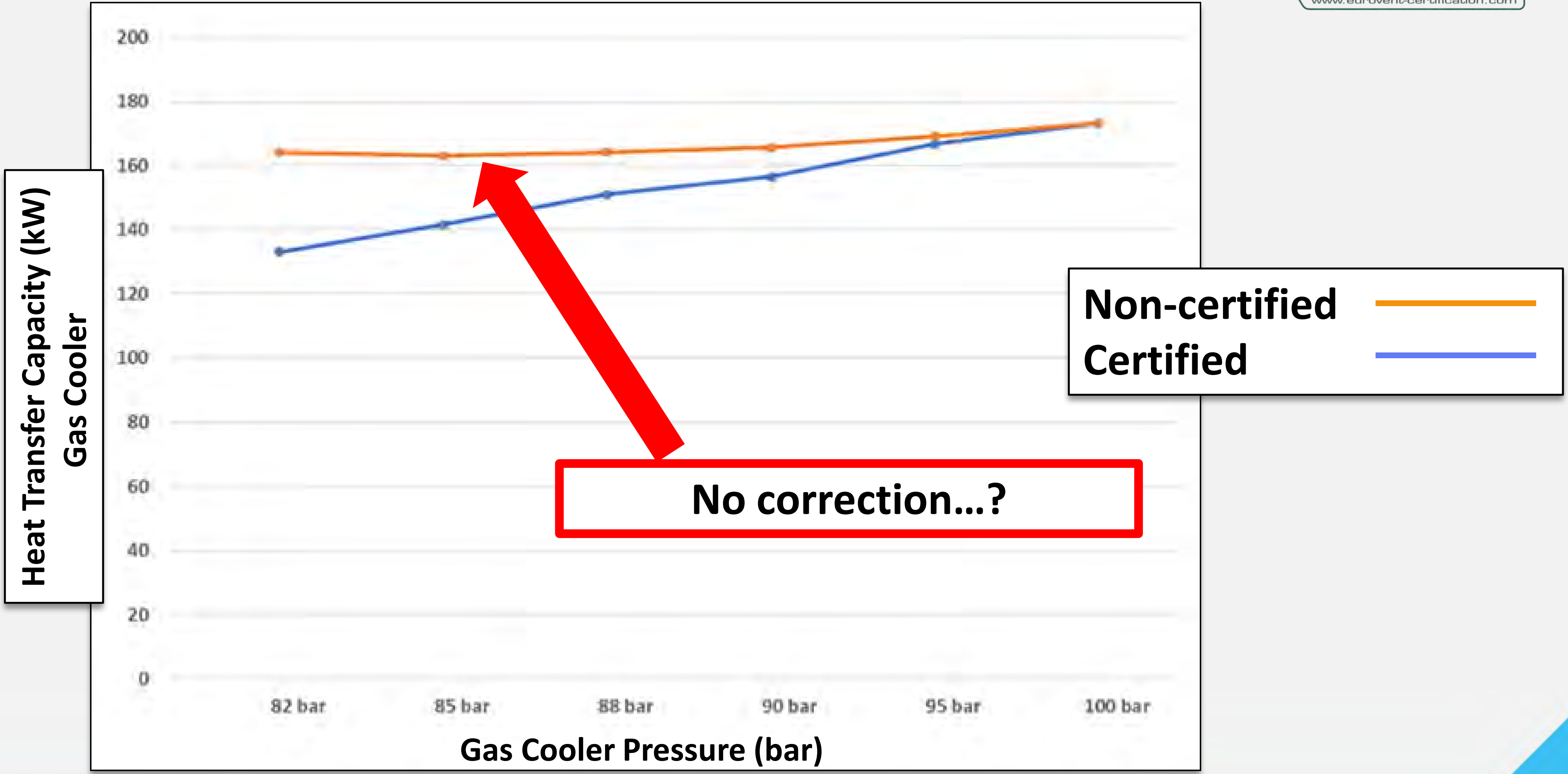
Table 2: Market Conditions A5, C5, C3 and C2 as defined in the Technical Certification Rules of the Eurovent Certified Performance programme for Heat Exchangers.

| Condition in transcritical mode | Gas Cooler inlet pressure | Gas Cooler inlet temperature | Air inlet temperature | Gas Cooler outlet temperature | DT (temperature approach) |
|---|---|---|---|---|---|
| A5 (SC20) | 90 bar | 110°C | 30°C | 35°C | 5K |
| C5 | 80 bar | 100°C | 27°C | 32°C | 5K |
| C3 | 80 bar | 100°C | 29°C | 32°C | 3K |
| C2 | 80 bar | 100°C | 30°C | 32°C | 2K |

Correction factors to determine the expected capacity under any market C-condition are the following:

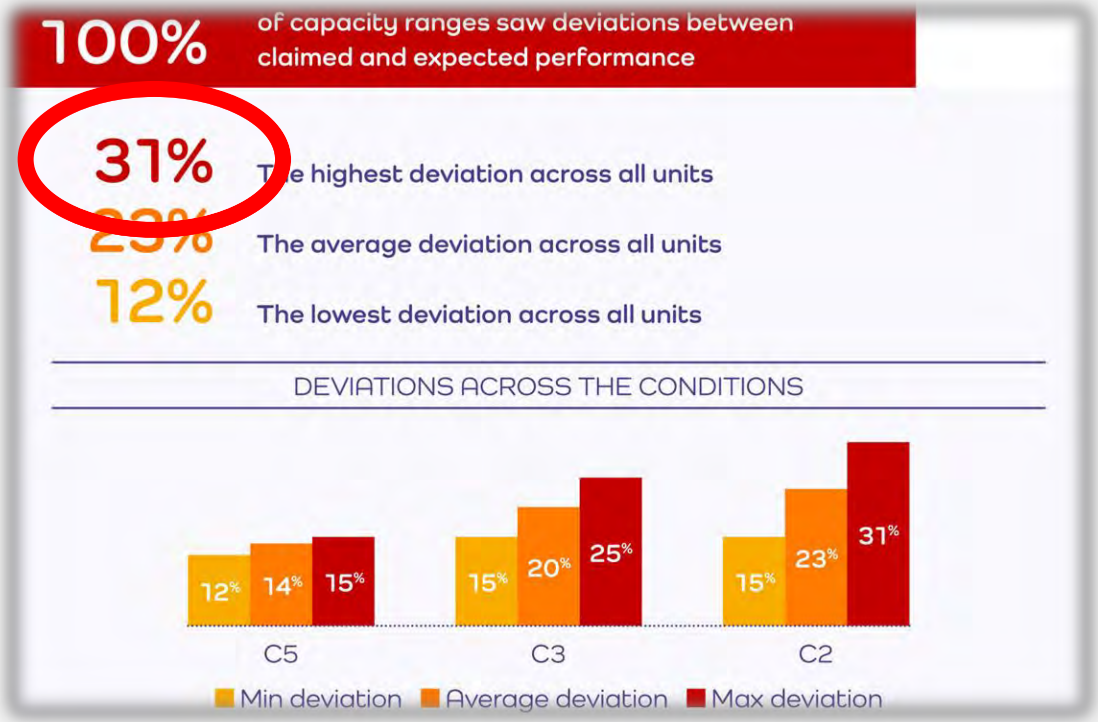
| Condition in transcritical mode | Correction factor |
|---|---|
| A5 (SC20) | 1.00 |
| C5 | 0.80 |
| C3 | 0.62 |
| C2 | 0.52 |

# The reality behind performance claims



# The reality behind performance claims

**Every unit**, regardless of size, exhibited a discrepancy between claimed and expected performance.




**CO2 Gas Cooler**

> ***100% of non-certified units showed deviations between claimed and expected performance***

# …to put it into perspective…

- Electrical consumption is the largest source of carbon emitted from a std. supermarket store.
- Refrigeration accounts for approx. 40% of the total electrical usage
- Lighting accounts for another 25%

Actual proportions would vary from store to store, depending on store design.

(CIBSE case study June 2014)

Note: Tesco's & Sainsbury's amongst others have switched to 100% renewable electricity. **However, what about the consumption of net zero Energy?**

# …Improving Energy Efficiency!

- LED lighting across the store & distribution centre lighting
- Intelligent Controls
- **Energy efficient products (do we know the 'Performance', are they doing what they declare!)**
- Using in store data to highlight energy waste, benchmarking & using AI predictive algorithms

**What about making sure the data being used at design is trusted data!**

# Comparison of energy consumption between a certified and a non-certified product

# Impact of overestimated performance of CO2 gas coolers on plant efficiency

Impact of an overestimation of $CO_2$ gas cooler on the efficiency of a refrigeration plant, i.e. on the annual power consumption (and related cost) of the system.

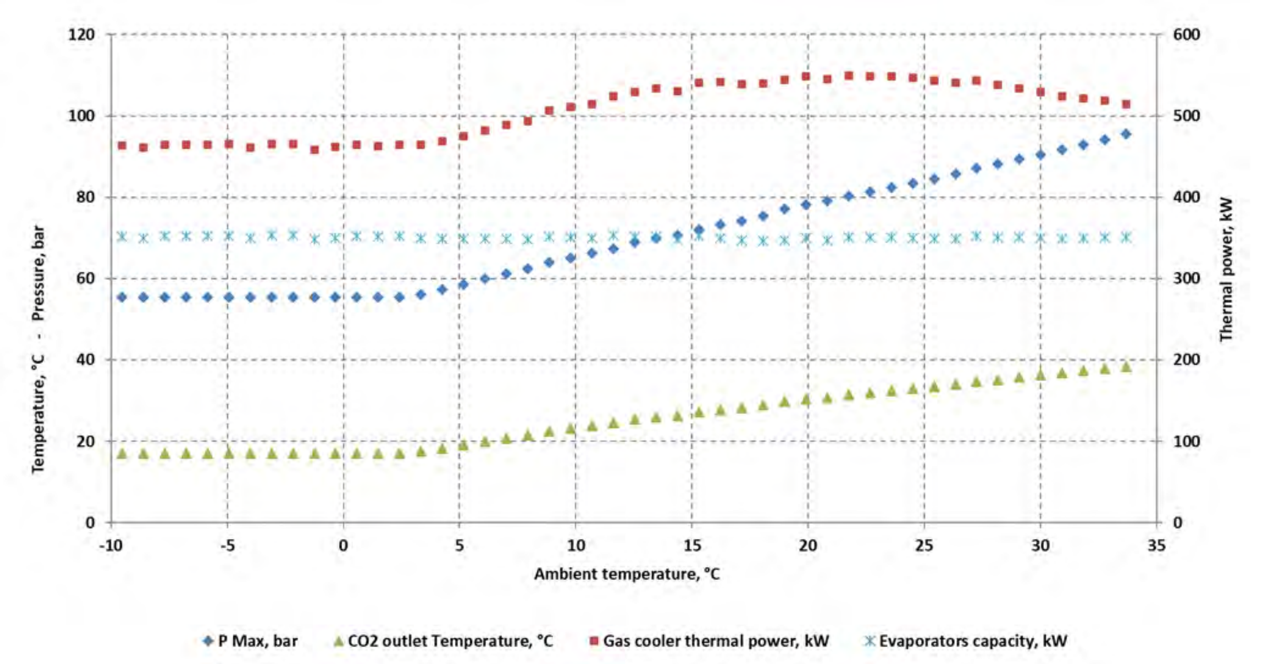
Simulations to estimate the efficiency of the thermodynamic cycle, combining some thermodynamics empirical rules to the rated thermal capacity of the $CO_2$ gas cooler.

- Two temperature levels:
  - Medium temperature (MT): $T_{evap,MT}$ = -8 °C; $Q_{evap,MT}$ = 250 kW
  - Low temperature (LT): $T_{evap,LT}$ = -30 °C; $Q_{evap,LT}$ = 100 kW
- Design ambient temperature: 30°C
- Maximum operating pressure: 99 bar
- Design gas cooler capacity (SC20) = 490 kW
- Electricity specific cost: 0,25 £/kWh*

* Reference: Money Supermarket Business Electricity

# Impact of overestimated performance of CO2 gas coolers on plant efficiency

If we perform the simulation considering that design capacity is in line with the real performance of the $CO_2$ gas cooler (case 1), we obtain the following results:

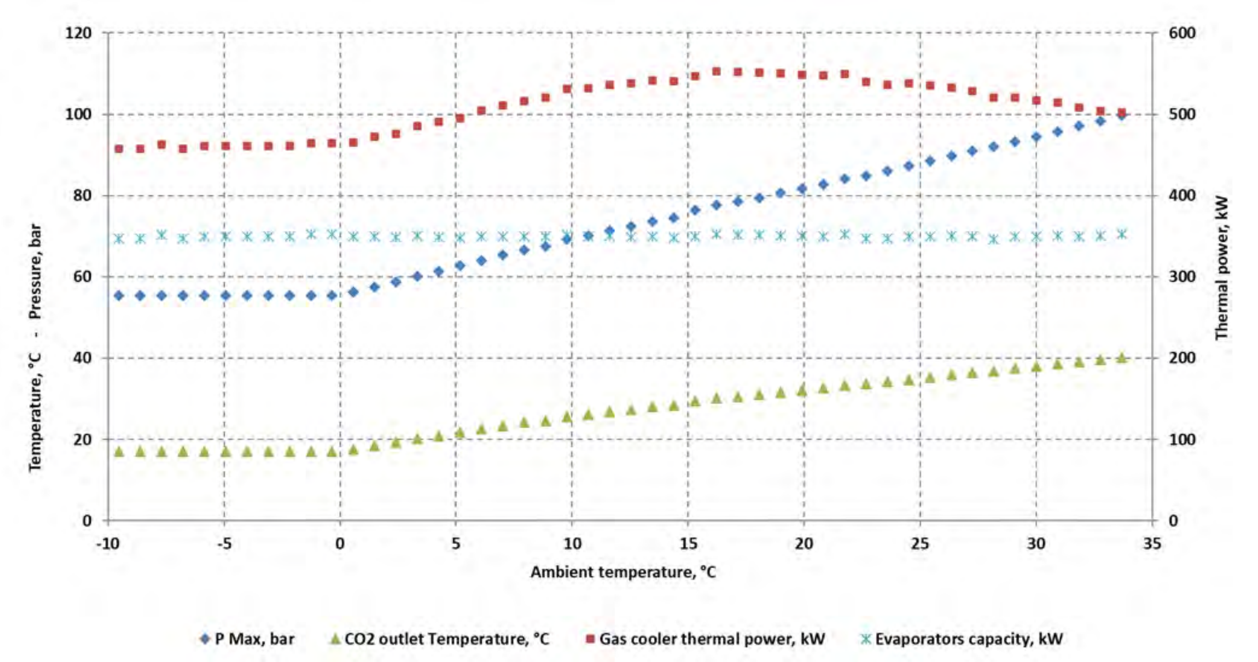



Economic simulation (case 1) considering Energy cost of 0.25 £/kWh

| | |
|---|---|
| Plant electricity consumption, MWh/year | 1.456 |
| Gas cooler fans electricity cost, £/year | 8,133 |
| Compressor electricity cost, £/year | 355,867 |
| Total cost, £/year | 364,000 |

## Impact of overestimated performance of $CO_2$ gas coolers on plant efficiency

What will be the results if the real capacity of the gas cooler is lower than the declared value? To answer this question, let's now consider a second example (case 2) in which the manufacturer has applied, for instance, a **23%** oversizing coefficient: this would result in a real thermal capacity lower than the declared one.




Economic simulation (case 2) considering Energy cost of 0.25 £/kWh

| | |
|---|---|
| Plant electricity consumption, MWh/year | 1.518 |
| Gas cooler fans electricity cost, £/year | 8,633 |
| Compressor electricity cost, £/year | 370,867 |
| Total cost, £/year | 379,500 |

## Impact of overestimated performance of $CO_2$ gas coolers on plant efficiency

The compressor has to compensate the lack of capacity of the gas cooler to maintain capacity. The maximum pressure of the system at design condition is over 99 bar, **more than 4 bar higher than the design maximum pressure**.

This difference may appear insignificant, but the impact on the annual power consumption is absolutely non-negligible:

| | | |
|---|---|---|
| Plant electricity consumption, MWh/year | +4,2% | 62 |
| Gas cooler fans electricity cost, £/year | +6,1% | 500 |
| Compressor electricity cost, £/year | +4,2% | 15.000 |
| Total cost, £/year | +4,3% | 15,500 |

The annual increase of cost considering a gas cooler capacity 25% lower than expected performance is therefore about **£15,500**, resulting in **£155,000** in a 10-years lifetime.

**Of course, the higher the gap between declared and real gas cooler capacity, the higher the impact on the plant power consumption!**

# Result

- **Certified**: 1,456 MWh/year **Non-certified**: 1,518 MWh/year

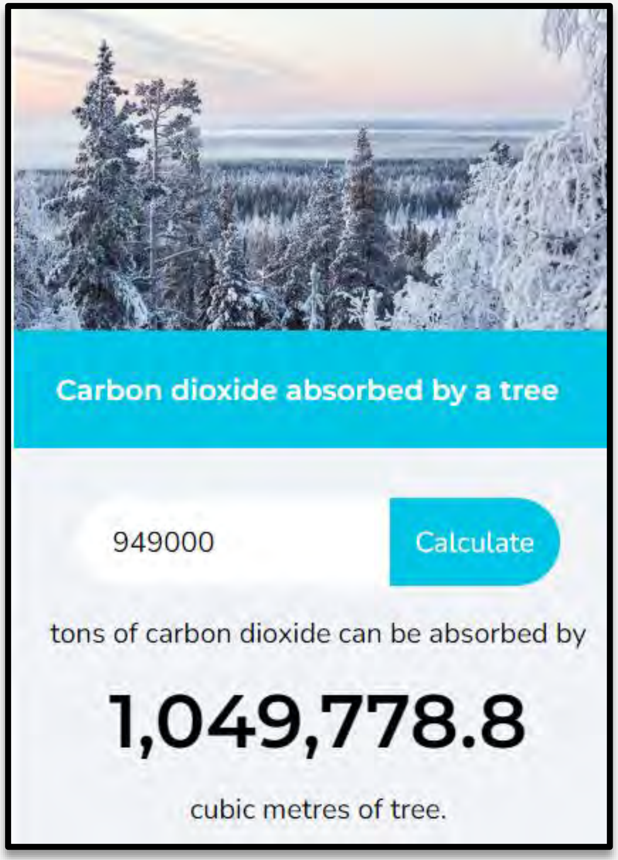
- **Difference @ 0.25 £/kWh**: **15,500 £/year**
- Over a 10-year operating span – **£155,000**
- Even when considering only capital costs, the payback periods range between 2.5 and 4 years.
- Additionally – $CO_2$ footprint reduction of **24.8 t/year** for certified products per medium sized supermarket, **for $CO_2$ gas cooling ONLY!**
- Looking at refrigerated display cabinets (RDCs), initial estimations suggest **twice this amount** of potential reductions: **49.6t/year**

[1)] $CO_2$ Mix 400g/kWh in Northern Europe

**TOTAL Potential Food Retail $CO_2$ footprint reduction in G.Britian**

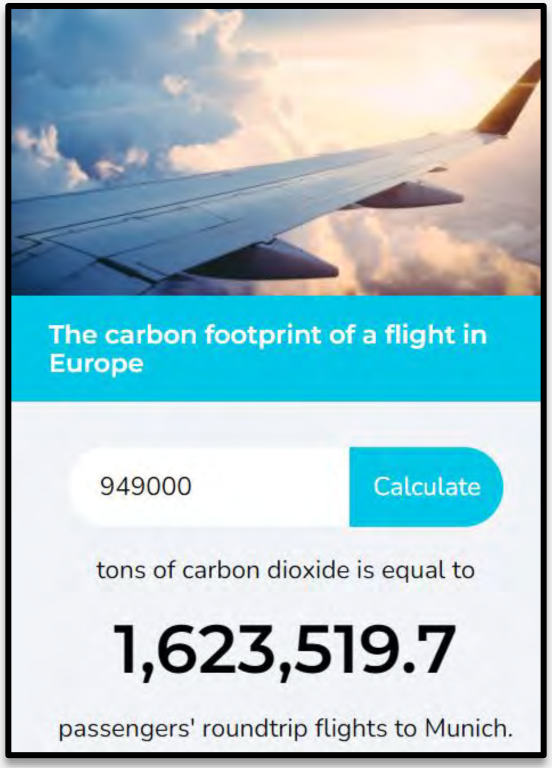
**949K Tons $CO_2$**

# …to put it into perspective…




**Total area of Wembley stadium is 4 Million cubic metres, therefore, imagine a 1/4 of this stadium filled with trees**

# …to put it into perspective…



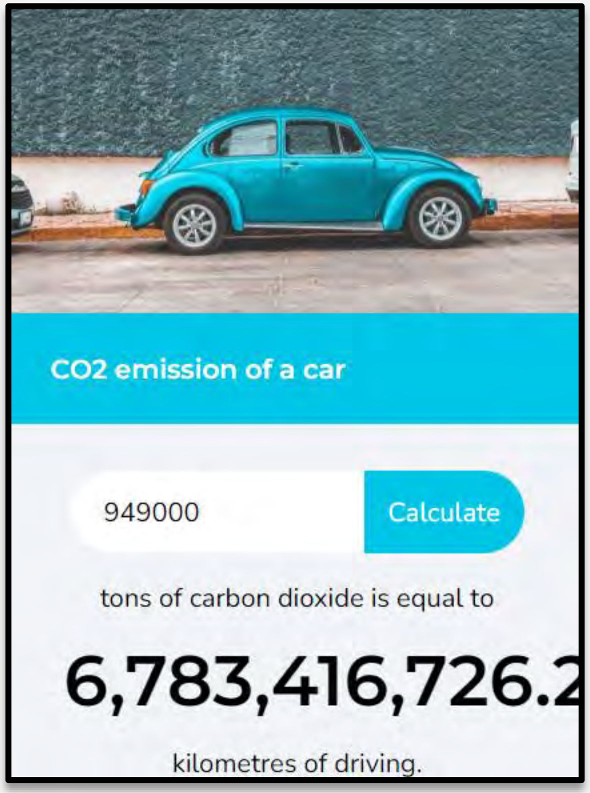

Example: use an aircraft A320 or 737-800 series, which approx. has 170 – 180 seats = **average 175 seats**

Therefore, 1,623,519/175 = **9,277** flights

Estimated 3 flights per day = 9,277/3 = **3,092 days**

Therefore = 3,092 / 365 = **8.47 years**

# …to put it into perspective…




Example converted to miles: **4,215,079,739**

Average car drive per year = **10,400 miles**

No. of car drivers = **405,296 per year**

UK licensed cars in Great Britian: 40 million

**Therefore, this covers approx. 1% of total cars!**

# Mitigating Underperformance Through consistent Certification

## The Value of Independent Product Certification

| | In-house laboratory testing | Independent laboratory testing | Product certification |
|---|---|---|---|
| Independent from manufacturer | ✗ | ✓ | ✓ |
| Manufacturer has no control of the testing process | ✗ | ✓ | ✓ |
| Standardised testing procedure | ✗ | ✓ | ✓ |
| Laboratories must be assessed according to ISO 17025 standard | ✗ | ✗ | ✓ |
| Manufacturer has no direct contact with laboratory | ✗ | ✗ | ✓ |
| Manufacturer does not select products to be tested | ✗ | ✗ | ✓ |
| Independent factory audits to ensure production line quality | ✗ | ✗ | ✓ |
| Includes software checks / software certification | ✗ | ✗ | ✓ |
| The technical credibility and continuity of all submitted data independently checked | ✗ | ✗ | ✓ |
| Ongoing independent surveillance process | ✗ | ✗ | ✓ |

- Certification ensures that heat exchangers meet industry standards for energy efficiency, heat transfer, and operational integrity.
- Independent testing conducted through the certification process, verifies performance under real operating conditions, protecting specifiers from technical and operational risks.
- Eurovent Certified equipment is more likely to maintain technical performance over its operational life cycle.

# Secure Performance and Reliability with Eurovent Certification

## RECOMMENDATIONS

**1** The refrigeration industry must acknowledge the issue of overstated performance, and work together to reduce the risks.

**2** Manufacturers should embrace independent laboratory testing and voluntary third-party certification to build trust.

**3** Industry players must understand the importance of independently verified data, and be able to identify products with reliable product information.

**4** To reduce risk further, key decision-makers can include certifications such as Eurovent Certified Performance as a qualifier in all refrigeration projects. This will ensure:

- Products perform as advertised
- Energy efficiency and carbon footprint targets are met.

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# Thank you

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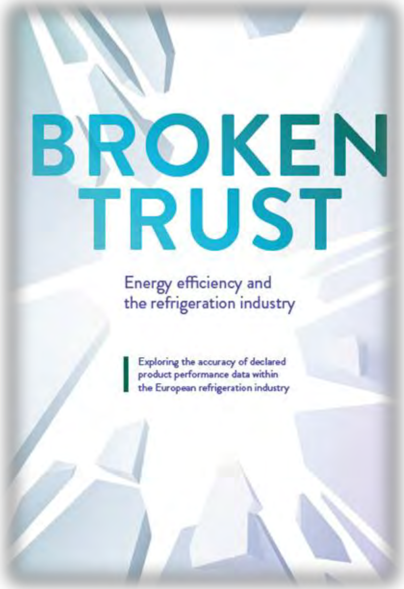
Download the White Paper

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