WHITEPAPER

The End of the F-Gas Era.
How Transport Refrigeration Operators Master The Next Evolutionary Stage.

A Practical Guide for the Transition to Natural Refrigerants and Climate-Friendly Transport Refrigeration.

Executive Summary

Flourinated greenhouse gases face regulatory elimination. EU F-Gas Regulation 2024/573 and the expected REACH Regulation 2027 will systematically reduce market supply for fluorinated gases and largely phase them out by the mid-2030s.

For vehicle body builders and fleet operators, this is not a distant regulatory discussion. It is an immediate economic reality: rising refrigerant costs, growing compliance risks, and a service model based on a phasing-out technology.

The industry responds with evasion strategies: from HFCs like R452A to HFOs like R454a and R513a. But these drop-in solutions do not eliminate the fundamental problem – they merely postpone it. From climate impact to toxicity. From one regulation to the next.

This whitepaper analyses the regulatory drivers, examines the limits of current evasion strategies, and shows why switching to natural refrigerants – in particular propane (R290) – is not an ecological but a sound business decision.

2.000 x
more climate-damaging F-gases vs. CO_2

2027/28
REACH-Regulation
PFAS ban expected-Verbot

€ 200
CO_2-Price/tonne
ETS 2 by 2032 expected

GWP < 3
Propane R290
vs. GWP 2.140 R452A

Temperature-Controlled Transport in Transition

The European urban cold chain stands at a crossroads. On one side, demand for temperature-controlled transport is growing – driven by online retail of fresh food, stricter pharmaceutical supply chains, and the boom in urban delivery services. On the other, the technological foundations of this industry are coming under massive regulatory and economic pressure.

At the centre: refrigerants. For decades, fluorinated gases were the unquestioned standard. They work. They are available. And their use is deeply embedded in the industry's service models. But this self-evidence has an expiry date.

> Refrigerants are up to 2,000 times more harmful to the climate than CO_2. A leak in a single unit can exceed the annual climate impact of a mid-range car.

At the same time, electrification of the last mile is progressing faster than expected. More and more European municipalities are establishing Zero Emission Zones. More and more fleet operators are being forced to switch their vehicle fleets to electric drives – and are faced with the question of which cooling system suits an electric van. The answer from established manufacturers: the same fluorinated gases, just in a new housing.

Three Regulations That Change Everything

1. The EU F-Gas Regulation

The revised EU Regulation on fluorinated greenhouse gases (EU 2024/573) is the strictest instrument for limiting refrigerant emissions that Europe has ever adopted.

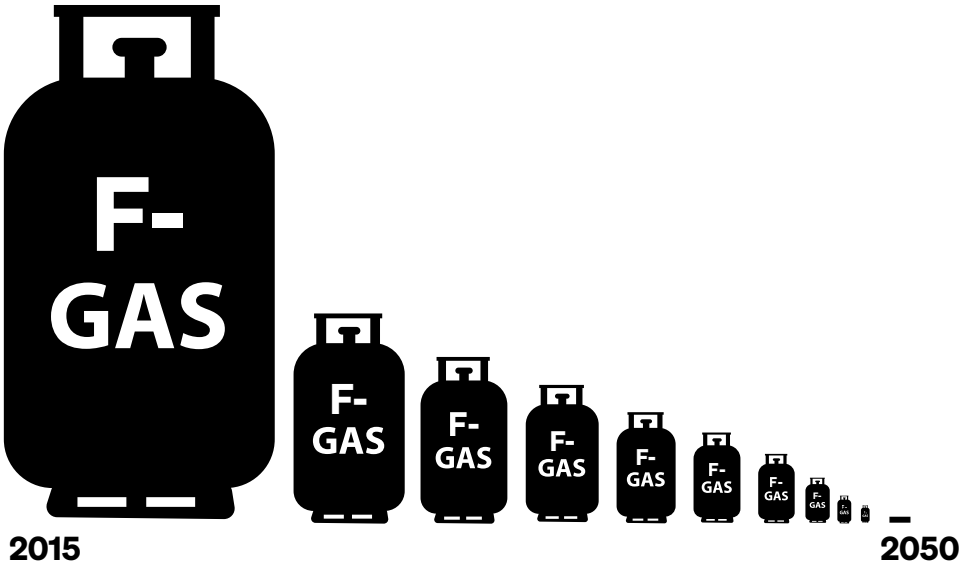
At its core: a phased phase-down and ultimately phase-out of the most common synthetic refrigerants.

What the Regulation Covers

- Gradual reduction of total HFC quantities on the European market
- Sales bans for certain products with high-potency F-gases
- Tightening of leak inspection obligations
- Extension of certification requirements for technicians
- Complete phase-out of the most common refrigerants by 2050

What This Means for the Industry

- Rising prices for F-gas refrigerants due to artificial scarcity
- Growing compliance costs due to stricter inspection obligations
- Investments in technologies, training, and service networks that will be obsolete in 10-15 years
- Increasing dependence on externally certified refrigeration engineers
- Growing risk of supply shortages for refrigerants



The Wrong Solution – and Its Successors

The industry responds to regulatory pressure with a strategy as old as the problem itself: switching to the next-best synthetic refrigerant.

First it was the switch from R404A to R452A. Today many manufacturers promote HFOs such as R513a and R454a as the real solution. Both approaches follow the same logic — and fail at the same boundary.

R452A: The False Solution of the First Wave

R452A was introduced as a transitional solution – a refrigerant with a lower GWP than R404A that can continue to use existing systems with minimal modifications. Sounds pragmatic. But it is a deferral, not an exit.

R452A has a GWP of 2,140. It contains fluorinated components that fall under the PFAS definition.

> Those switching to R452A today are investing in a technology that will come under pressure again through the expected REACH Regulation 2027.

Red Flag Alert
HFO technologies with the risk of a PFAS classification could soon present themselves as stranded assets.

HFOs – The False Solution of the Second Wave

Hydrofluorolefins (HFOs) such as R513a or R454a are today positioned by many manufacturers as the real answer to the F-gas problem. Their GWP is drastically lower than conventional HFCs – R454a has a GWP of 238. At first glance, a convincing advance.

On second glance, the problem is revealed: HFOs are also fluorinated compounds. Some of them form trifluoroacetic acid (TFA) during chemical degradation.

R513a and R454a also bring a specific toxicity problem: both mixtures contain R1234yf – a component that breaks down in the atmosphere to trifluoroacetic acid (TFA). TFA is water-soluble, persistent, and accumulates in water bodies, soil organisms, and the food chain.

From a business perspective too, it is advisable not to ignore regulatory warning signs when making investments with PFAS exposure. TFA is classified as PFAS – and thus falls within the scope of the REACH Regulation expected for 2027.

> HFOs do not solve the F-gas problem.
> They trade climate impact for toxicity —
> and shift the problem from one regulation
> to the next.

The Pattern of Drop-in Strategies

The history of refrigerant development is the history of ever-new evasion manoeuvres:

R22 (HCFC) → banned due to ozone depletion
R404A (HFC) → phase-out due to GWP 3.922
R452A (HFC blend) → under pressure due to F-Gas Regulation and PFAS
R513a (HFO) → TFA problem, PFAS definition, REACH risk

Each generation is marketed as the solution. Each generation is in reality a deferral. The fundamental problem — synthetic fluorinated compounds in open systems — persists in every iteration.

Those relying on drop-in strategies are buying time. But not a future.

2. REACH and the PFAS ban

Parallel to the F-Gas Regulation, a second regulatory front is developing: the European chemicals framework REACH. The EU authorities have presented a universal restriction proposal for PFAS – a group of substances that includes both conventional HFCs such as R452A and HFOs such as R454a and R513a.

PFAS are synthetic compounds that are virtually non-degradable in the environment. They accumulate in organisms, drinking water, and soil – and with HFOs, active toxicity through TFA degradation products is added. A broad PFAS ban is expected for 2027, with transition periods until the mid-2030s.

What the PFAS Ban Means for Cooling Systems

- HFCs like R452A and HFOs like R454a and R513a fall under the PFAS definition as fluorinated compounds
- New units with these refrigerants could be banned from approval as early as 2027
- Drop-in strategies – switching from one fluorinated refrigerant to the next – no longer offer regulatory protection
- Operators of existing systems must expect rising procurement costs and a foreseeable maintenance ban
- The resale value of vehicles with fluorinated refrigerants will decline with each passing year

3. ETS 2: The Cost of Waiting Is Rising

From 2028, the European Emissions Trading System will be extended to road transport (ETS 2). Experts forecast a CO_2 price of up to €200 per tonne by 2032 – possibly €275/tonne by 2040.

+60 ct
per litre petrol
at CO_2-Price
€ 200/t (2032)

+80 ct
per litre diesel
est. additional
costs 2032

€ 275
per tonne CO_2
possible scenario
by 2040

For fleet operators still relying on diesel propulsion and synthetic refrigerants, the cost effects accumulate: higher fuel costs due to CO_2 pricing, rising refrigerant prices due to F-gas scarcity, growing compliance expenditure.

The economics tip over – earlier than many operations planners expect.

What This Means in Practice

For Vehicle Body Builders

The business model of many body builders rests on two pillars: the bodywork business and the recurring service of refrigeration units. The F-Gas Regulation, the PFAS risk, and the structural limits of drop-in strategies are eroding both pillars simultaneously.

The Inconvenient Truth

- Installing R452A or HFOs offers customers a technology with a foreseeable expiry date
- Drop-in strategies provide no strategic protection – they delay the inevitable investment decision
- The installation effort for conventional systems remains constantly high
- Constant adaption to technology updates requires recurring investments in training and equipment
- The service business with fluorinated refrigerants is being thinned out by regulation

The Opportunity

- Early transition to natural refrigerants creates regional market leadership
- Maintenance-free systems reduce complexity and liability risks
- Demand for E-LCV refrigeration is growing annually

Für Fleet Operators

The operating costs of a refrigerated transport vehicle consist of far more than fuel and leasing. The regulatory changes – compounded by the limits of HFO evasion strategies – make a complete TCO recalculation unavoidable.

The inconvient Truth

- Refrigerant costs continue to climb due to market scarcity driven by regulatory phase-downs
- HFOs with R1234yf content offer no regulatory security – expected PFAS ban applies here too
- Semi-annual maintenance (every 1,500 operating hours) ties up vehicles and creates downtime
- Technology change (every 2–4 years) leads to unstable operations in the fleet
- ETS 2 significantly increases diesel operating costs from 2028
- Vehicles with fluorinated refrigerants lose residual value

The Opportunity

- Maintenance-free systems with natural refrigerant eliminate cost risks
- Future-proof investment: Natural Refrigerants without restrictions beyond 2050

The Answer That Already Works

Hydrocarbons, in particularly propane is not a new refrigerant. What is new: an Austrian refrigeration technology start-up has succeeded in making the thermodynamic advantages of R290 usable for temperature-controlled transport. Excellent volumetric efficiency and outstanding cooling performance with minimal global warming potential provide the optimal basis for a new generation of transport refrigeration units that breaks away from traditional system dependencies and creates long-term security on the refrigerant question.

> Propane R290 clears the way for the next evolutionary stage of temperature-controlled transport – cost-friendly, climate-friendly, and future-proof.

At pbx cooling, this future has already begun. The transport refrigeration system ecos M24 – the result of intensive research since 2019 — resolves the classic conflict of objectives between climate friendliness and economic viability. By using the natural refrigerant R290 with minimal effort, the technology offers maximum operational benefit. From a logistics perspective, the plug-and-play installation, the absolute maintenance-free operation of the refrigeration circuit, and 50+ data points whose continuous data streams enable the construction of AI-optimised dispatching define the current state of the art in the urban cold chain.

Technical Advantages

- GWP < 3 – effectively climate-neutral
- No PFAS – no TFA degradation problem
- Hermetically sealed system: no loss of refrigerant possible
- F-gas-free, PFAS-free – future-proof beyond 2050
- Natural refrigerant: no scarcity, no price increases

Economic benefits

- Maintenance-free: no service stop every 1,500 operating hours required
- Installation time < 4 hours instead of 30 technician hours
- No certified refrigeration engineer required
- At least +15% payload due to 39 kg system weight
- Exact temperature control strategy

GWP Comparison: From False Solution to Real Alternative

R404A (old standard)	**GWP 3.922**	
R452A (transitional HFC)	**GWP 2.140**	
R513a HFO – "new generation"	**GWP 629**	
⚠ Low GWP ≠ no PFAS problem. R1234yf component degrades to TFA — persistent, toxic, bioaccumulating.		
R290 (Propane – NatRefs)	**GWP < 3**	

WP = Global Warming Potential, reference value CO_2 = 1. TFA = Trifluoroacetic acid.
Sources: EU F-Gas Regulation, IPCC AR6, ECHA PFAS Restriction Proposal.

Bottom line: Stay ahead of the chill. Act today – not in 2032

The Regulatory Signals Are Clear. F-Gas Regulation, PFAS restrictions and CO_2 pricing through ETS 2 together create pressure that permanently changes the economics of synthetic refrigerants — whether HFCs or HFOs. Drop-in strategies are not a way out. They are a deferral at a higher price.

The Technology for the Transition Exists. It is proven, economical, and immediately available. Propane R290 is neither F-gas nor HFO nor PFAS. It is a natural refrigerant that already meets all regulatory requirements beyond 2050 — and simultaneously cools better, weighs less, and requires no maintenance.

> The transition is inevitable. The timing is not. Companies that move early don't just cut costs - they gain expertise, supply chain depth, and market position that latecomers cannot buy.

Want to learn more about the future of thermal transport?

Simply scan the code and arrange a no-obligation consultation.

We show you what opportunities the transition to natural refrigerants opens up for your company – technically, economically, and regulatorically – and how you can put these potentials into practice.

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