WHITEPAPER

TCO Deep Dive LCV
The True Cost of Refrigerated Transport

A cost compass revealing all visible and hidden cost drivers that decision-makers in refrigerated fleets need on their radar today.

Executive Summary

Most fleet calculations stop at acquisition, leasing, fuel, and driver costs. The refrigeration system shows up as a fixed line item – and stays that way. That's a mistake, and one that can be measured in hard numbers.

EPart of this cost is visible: workshop invoices, refrigerant, filter driers. The larger part is not: driver time for drop-off and pick-up, dispatch overhead, lost tours, replacement vehicles, documentation obligations. These indirect service costs are spread across different cost centers and never appear on a single maintenance invoice. Only once they are brought together does the true picture emerge.

Anyone who wants to calculate the true cost of temperature-controlled transport needs to bring five factors together: maintenance and service costs (direct and indirect), refrigerant costs, CO_2 pricing under ETS 2, payload and range losses, and the regulatory residual-value factor. Taken together, they paint a picture that puts the investment decision in a new light.

This whitepaper does not present figures from customer projects – the available data doesn't allow for that. Instead, it provides an illustrative calculation model based on publicly available market data, which fleet operators can populate with their own cost data.

2 x/year
Service standard for conventional cooling systems

€ 1.390+
Indirect service cost per vehicle/year

€ 14.200
Residual-value gap caused by refrigerant choice

The blind spot: The cooling system as an underestimated cost driver

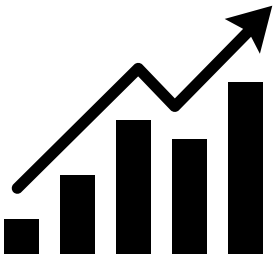
Registration statistics for refrigerated vehicles are still dominated by combustion engines. Even fleets that haven't electrified yet calculate meticulously: leasing rate, insurance, driver pay, diesel. What is rarely captured in full is the cooling system as a cost factor in its own right – independent of the drivetrain.

What's missing from most calculations isn't the obvious operating costs – energy, insurance, direct service spend. Those are well known. What's meant here are the indirect costs: driver time spent on workshop trips, dispatch overhead from vehicle downtime, replacement vehicles, lost tours. And beneath those lie the regulatory costs of the future: residual-value erosion from the F-Gas phase-out and a looming PFAS ban, rising refrigerant prices due to scarcity, additional CO_2 costs from ETS 2. Costs that are spread across different cost centers and therefore rarely become visible in total.

> The cooling system generates costs that never show up in any single budget line – which is why most TCO analyses underestimate them.

On top of that comes a shift that many calculations fail to anticipate. The cost landscape is changing:

- ETS 2 will make diesel operation sharply more expensive starting in 2027.
- The F-Gas Regulation is driving up refrigerant prices through artificial scarcity.
- Refrigerants containing PFAS also face a regulatory ban.
- Vehicles running synthetic refrigerants lose residual value for regulatory reasons – even when they're running technically flawlessly.



The five TCO drivers in detail

1. Maintenance and Service Costs

Maintenance for cooling systems isn't optional. The law requires an annual inspection by a certified refrigeration technician. Industry standard – and what most manufacturers recommend – goes further: twice a year, spring and autumn. At minimum every 800 to 1,000 operating hours.

What a service call costs

- Refrigeration technician labor: 2–4 hours per appointment
- Call-out and certification surcharge: varies by region
- Filter drier replacement: mandatory after the first 2 months of operation
- Refrigerant check and, if needed, top-up: depends on leak rate
- Vehicle downtime: average of 0.5–1 day per appointment

What downtime costs

- Lost tours: 2–5 deliveries per day, depending on operation
- Replacement vehicle or rescheduling: additional operational effort
- Driver pay with no output: downtime is an operating cost
- With 2 service appointments/year: 1–2 working days of vehicle tied-up time
- With 10 vehicles: up to 20 vehicle-days of downtime per year

Indirect service costs: What never appears on a service invoice

The direct service invoice – technician time, filter drier, refrigerant – is the visible part. The larger share of service costs is spread across different cost centers and never appears on any maintenance invoice. Only once these indirect costs are made visible can we talk about the true cost of refrigeration.

Indirect service costs – a complete picture

Vehicle-Related Downtime Costs

- Lost tours: 1–2 operational vehicle-days per year
- Undelivered shipments: 2–5 tours per downtime day
- Recourse risk & penalties for missed delivery windows
- (Reactivation effort: bringing the vehicle back into the route system)

Personnel and Logistics Costs

- Unproductive driver hours for drop-off and pick-up: 1–3 hours per appointment
- Dispatch overhead for vehicle downtime
- Coordination with the refrigeration service provider: scheduling, approvals
- Mandatory refrigerant log documentation

Replacement Mobility

- Replacement vehicle: €80–250/day, depending on availability
- Conversion costs for non-specialized replacement vehicles
- Cold-chain continuity for pharma or premium fresh goods

Long-Term Effects

- Increased vehicle wear from additional loading/unloading cycles
- Reputational risk from delayed deliveries
- Planning uncertainty from fluctuating service frequency

With two service appointments a year and 6 hours of downtime per appointment, personnel costs alone add up to around €800 per vehicle per year – before a single workshop invoice has even been issued. These costs don't show up under maintenance. They don't show up anywhere.

Service costs per vehicle per year: The full calculation

Assumptions: 250 operating days/year · Downtime cost €400/day · Refrigerant price R452A: €12/kg, 2 kg top-up/year · Refrigeration technician labor rate: €95/hour

Line item	Cost/year
DIRECT SERVICE COSTS	
Mandatory inspection (1x /year)	€ 380
Recommended service interval	€ 380
Filter drier replacement (year 1)	€ 120
Refrigerant top-up (estimate)	€ 240
INDIRECT SERVICE COSTS	
Operational fleet downtime (vehicle standstill & blocked driving time)	€ 780
Administrative overhead (route rescheduling & SLA compliance)	€ 200
Productivity loss (transfer trips & lost driver capacity)	€ 260
Replacement vehicle (estimate: 1 day at €150)	€ 150
Penalties / potential contractual fines (conservative)	variable
Total calculated service costs per refrigerated vehicle / year	**€ 2.510+**

For a fleet of 10 refrigerated vehicles, that adds up to an annual cost volume of roughly €25,000 – made up of direct maintenance costs and quantifiable indirect expenses. Lost tours and payload losses are not included in this figure. The actual amount is higher. That's the room for action that a complete TCO analysis reveals.

The ATP certificate: An overlooked mandatory deadline

Cross-border food transport requires a valid ATP certificate. It's a mandatory deadline in its own right – in addition to the general roadworthiness inspection and refrigeration maintenance. An expired ATP certificate immediately affects vehicle availability.

- Vehicle grounded for cross-border transport – regardless of technical condition
- Short-notice route rescheduling or replacement-vehicle procurement required
- Re-certification requires lead time – unplanned downtime results
- With multiple vehicles on different inspection schedules, coordination effort grows disproportionately

2. Refrigerant costs and regulatory price risk

Most calculations assume refrigerant costs are stable. That used to be true. It no longer is. The EU F-Gas Regulation reduces the HFC quota every year – less supply against the same demand drives prices up.

R452A – currently the most widely used 'transitional refrigerant' – has a GWP of 2,140 and, as a fluorinated compound, falls under the PFAS definition. Anyone converting to R454A or R513A – the industry's 'next generation' – is investing in systems that consist of 56–65% R1234yf: an HFO that breaks down into trifluoroacetic acid (TFA) and likewise falls under the PFAS definition. The conversion is expensive. The protection it offers is only temporary.

Propane R290 is subject to none of these dynamics. It's a naturally occurring gas with no production quota, no PFAS classification, and no regulatory phase-out risk. Its price is stable and can be reliably planned for over the long term.

Natural refrigerants stay predictable.

3. ETS 2: Additional CO_2 Costs from 2027

Europe's ETS 2 emissions trading system takes effect in 2027. Forecast: up to €200/tonne CO_2 by 2032, equivalent to roughly a 60-cent surcharge per liter of fuel. For diesel fleets, that's a predictable, growing additional burden. For electrified fleets, it's a structural cost advantage.

€ 45 CO_2 price today Current ETS 1 level	**€ 200** **2032 forecast** ETS 2 expert estimate	**+60 ct** **per liter diesel** **at** € 200/t CO_2	**€ 275** 2045 Scenario Possible high-price pathway

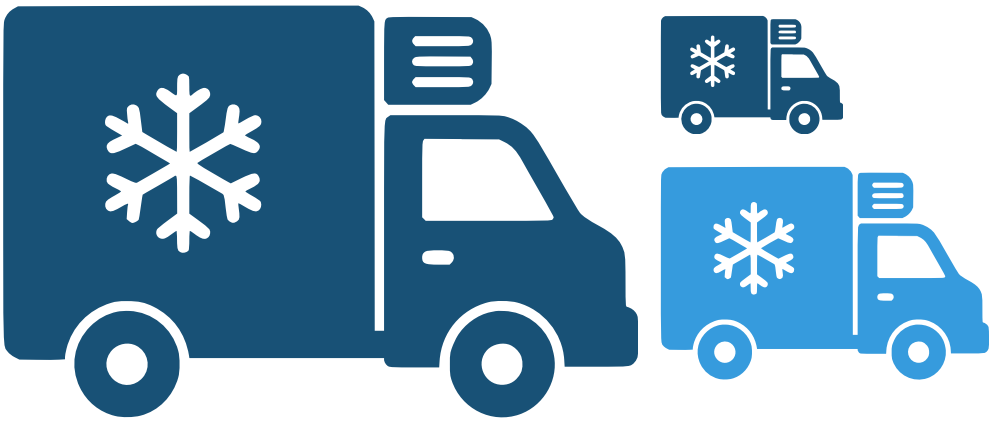
For fleets that are already electrified, ETS 2 is a structural advantage. For fleets still running on diesel, it's a calculable risk – one that grows larger with every year of delay.

4. Payload and range loss

- For an e-LCV with an 800 kg payload limit and a 100 kg cooling unit, 12.5% of available payload capacity is taken up by the unit alone. A modern R290 system weighs around 39 kg – for a typical fresh-goods delivery, that weight difference equates to 4–8 extra crates per tour.
- Cooling units are a significant energy consumer for e-LCVs. Modern R290 systems are optimized for e-LCV battery systems. In practice: up to 25% more range on the same route.

5. Regulatory residual-value factor

Vehicles running synthetic refrigerants – R452A, R454A, R513A – will suffer a regulatory-driven loss of value over the next 5–8 years. The F-Gas Regulation, REACH, and growing PFAS awareness are reshaping the resale market. The TCO model in Chapter 3 shows that refrigerant choice alone creates a residual-value gap of around €14,200 per vehicle.



After five years in operation, refrigerated vehicles with conventional cooling technology retain just 25% of their value. For e-vans, the value loss is even greater. A future-proof cooling system stabilizes residual value at 40%.

Comprehensive cost comparison: Looking beneath the surface

Three configurations put to the test

The trajectory of each individual cost driver shows that change is underway in refrigerated transport too. Under the new regulatory landscape, the calculated risk in refrigerated fleets shifts even further below the surface. The bar chart compares three fundamentally different refrigerated-vehicle configurations, making clear how the three cost layers shift depending on the choice of drivetrain and refrigerant. Model basis: light commercial vehicle, daily refrigerated operation, 5 years/150,000 km.

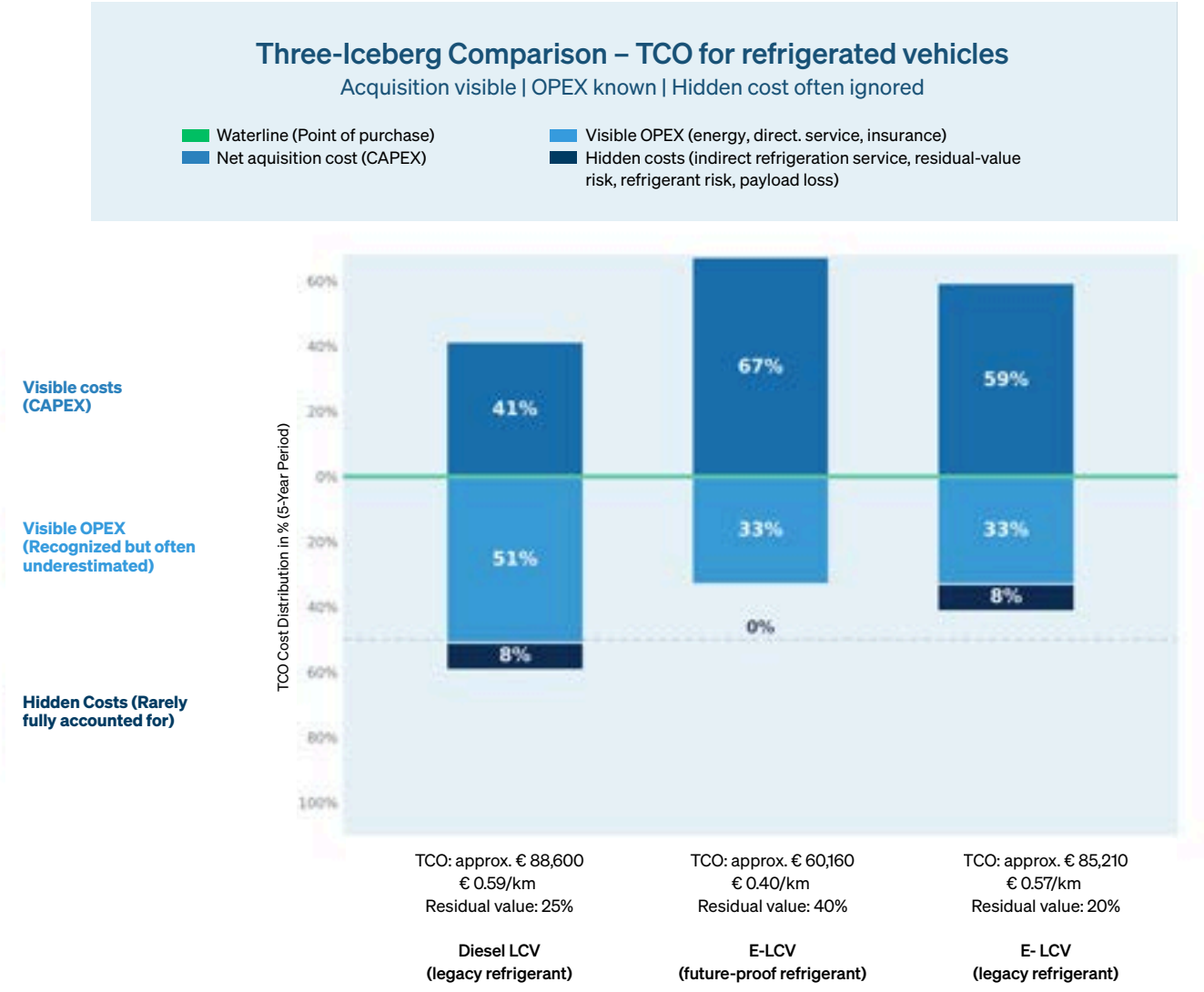


Fig. 1: TCO comparison for refrigerated vehicles on the Renault Master platform. Illustrative model with estimated values based on publicly available market data. Application: urban/regional distribution transport. The hidden-cost figures relate to refrigeration service only. Indirect costs from general vehicle maintenance are not included in this chart. pbx cooling 2026.

Direct TCO comparison: 5 years/150.000 km

Illustrative model based on publicly available market data (Renault Master Blue dCi 150 Diesel / Renault Master E-Tech Electric 87 kWh, urban/regional distribution traffic). All figures are estimates.

Cost item	Diesel-LCV + conventional cooling	E-LCV + natural refrigerant	E-LCV + conventional cooling
Acquisition (net)	ca. € 48.000	ca. € 67.000	ca. € 63.000
Residual value after 5 years	ca. € 12.000 25% F-Gas Deduction	ca. € 26.800 40%, future-proof	ca. € 12.600 20% F-Gas Deduction
Effective depreciation	€ 36.000	€ 40.200	€ 50.400
Energy / fuel	€ 30.000 Diesel, incl. ETS 2	€ 16.650 BEV-optimized refrigeration unit	€ 18.000 less efficient refrigeration unit
Vehicle maintenance	€ 2.600	€ 1.010	€ 1.010
Refrigeration service	€ 13.500	€ 0 maintenance-free	€ 13.500
Insurance & tax	€ 6.500	€ 4.800	€ 4.800
GHG quota credits & bonuses	€ 0	–€ 2.500	–€ 2.500
Total TCO	€ 88.600	€ 60.160	€ 85.210
Cost per kilometer	0,59 €/km	0,40 €/km	0,57 €/km

The key insight: the system that's cheapest to buy turns out to be the most expensive over its lifetime. The apparent savings on the cooling system for the E-LCV end up costing €25,050 more than the full-featured solution. And despite its higher purchase price, the future-proof E-LCV is the most economical system over the entire lifecycle.

Diesel + Synthetic Refrigerant

Cheap today, expensive tomorrow.

Cheap to buy. But the diesel-driven compressor permanently increases fuel consumption. Refrigerant keeps getting more expensive. And by the end of the holding period: a residual-value collapse as the refrigerant is phased out.

E-LCV + Synthetic Refrigerant

The worst-case scenario.

Anyone who cuts corners on the cooling system of an electric vehicle combines the E-LCV's high purchase price with the full risk profile of old cooling technology. The apparent purchase-price advantage of about €4,000 ultimately turns into a TCO disadvantage of €24,050 compared with the future-proof solution.

E-LCV + Natural Refrigerant

Foresight pays off.

A higher purchase price. But almost no maintenance burden. Highly efficient use of the battery. No refrigerant risk – neither in price nor in regulation. A stable residual value. The economically superior system over the entire lifecycle.

Investment protection: Regulatory tailwind as a TCO factor

TCO isn't a static calculation. It changes along with the regulatory environment – and that environment is moving in a direction that systematically favors fleet operators using natural refrigerants.

F-Gas Regulation + REACH as a Residual-Value Factor

The TCO model shows it concretely: the residual-value gap between a future-proof E-LCV (40%) and an E-LCV with a legacy refrigerant (20%) is about €14,200 – based on refrigerant choice alone. This gap results from regulatory decisions that are already set in stone today.

ETS 2 as a Structural Advantage for E-LCVs

Starting in 2027, ETS 2 will make diesel fleets more expensive every year. E-LCV fleets are unaffected. The model already calculates with a conservative ETS 2 rate – the actual gap will be larger.

Five facts that must not be overlooked when purchasing refrigerated LCVs and cooling systems

1. Maintenance-free operation saves €2,500+ per vehicle per year – including direct service costs and indirect expenses such as driver time, dispatch, replacement vehicles, and lost tours
2. Refrigerant costs: R290 is stable for the long term; R452A and HFOs such as R454A/R513A are being phased out under regulation as PFAS compounds
3. ETS 2 from 2027: E-LCV fleets running R290 are structurally advantaged
4. Cooling systems optimized for modern LCVs measurably improve operational efficiency (+15% payload and +25% range)
5. Residual-value protection: according to the TCO model, refrigerant choice alone creates a residual-value gap of around €14,200 per vehicle

The future of transport refrigeration has already begun

Everything up to this point has been a model calculation – sound in logic, but still theory. A practical path to an F-gas-free world is opened up by a technology powered by the natural refrigerant propane R290. The research team behind it set out to develop a transport refrigeration system that meets the specific requirements of modern (electric) refrigerated vehicles – delivering a revolutionary approach to the urban cold chain after five decades of technological standstill. Today, PBX GmbH's former start-up is on track to establish itself across Europe as 'Next Generation LCV Refrigeration.' The first fully maintenance-free cooling system has already proven itself in real-world operation and is successfully in use in Austria, Germany, France, the Netherlands, Romania, Switzerland, Sweden, and the United Kingdom.

Mind the cost below the surface.

Fleet operators who expand their TCO calculation to include the five cost factors described here will find that the cooling system is not a fixed line item. It's a variable with substantial leverage – in the service invoice, in residual value, in regulation, and in operational efficiency.

> The question isn't whether switching to a future-proof technology pays off. The question is how much it will cost companies that are still hesitating.

Want to put your refrigerated-fleet calculation to the test? Let's work through the numbers together.

Simply scan the code to schedule a no-obligation consultation.

pbx clean cooling

We'll show you the opportunities that switching to natural refrigerants opens up for your business – technically, economically, and from a regulatory standpoint – and how you can turn that potential into practice.

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