Driving the Transition for Sustainable Change in Mobile Air Conditioning (MAC): Insights from EU & South Africa and the GIZ Greener Reefers project

MOP 37, Nairobi, 2025

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Supported by:

Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection

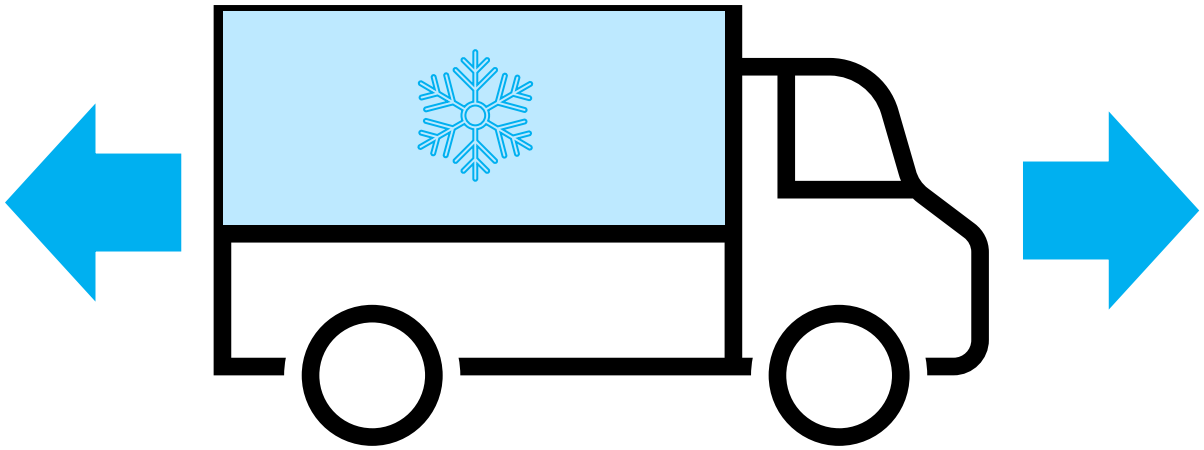
based on a decision of the German Bundestag

IKI INTERNATIONAL CLIMATE INITIATIVE

PROKLIMA NATURALLY COOL

Transport Cooling/ Mobile Refrigerantion:

Providing refrigerator and freezer capacity in a portable format



Mobile Air Conditioning (MAC):

Air conditioners in passenger cars, vans, buses and freight trucks

In both cases:

- Refrigerants: Currently using R134a with a GWP of 1560 (IPCC AR 6)
- Manufactures and OEMS using or exploring the use of HFO R1234yf which converts into „forever chemicals“ / TFA
- Technology with natural refrigerants exists: R290 and CO_2
- Challenges: High leakage rate due to vibration, highly mobile

Driving the Transition for Sustainable Change in Mobile Air Conditioning (MAC): Insights from EU & South Africa and the GIZ Greener Reefers project

MOP 37
Nairobi, Kenya
3-7 November 2025

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Reefer containers

1.8M reefer containers in worldwide operation
(+150K new every year)

Average life-time: 12 years

Sizes: 10ft, **20ft**, **40ft**, 45ft

ISO1496-2 setpoint range: -30C to +30C in ambient -30C to +50C.
Humidity 50%-98% RH.
Air composition O_2, CO_2, N_2

Fully electric
(connected to vessel, genset or grid)

Environment: Ocean, wares, handling -> Salty atmosphere, Shock, Vibration, electric spikes

Global Climate Commitments and Green Cooling

1. Global Climate Agreements

2. Maritime-Specific Actions

3. Regional Regulations

2015

The Paris Agreement:

- Commitment to limit global warming to 1.5°C.
- National Determined Contributions (NDCs) driving technology adoption.

2016

Kigali Amendment to the Montreal Protocol:

- Phasedown of HFCs (high-GWP refrigerants).
- Estimated to prevent 0.4°C of warming by 2100.

2023

International Maritime Organization (IMO)

- Target: 50% GHG reduction from shipping by 2050.
- Encouragement of alternative fuels and technologies like R290.

2024

European Union F-Gas Regulation (2024):

- Quota system for HFCs.
- In discussion: EU REACH regarding ban on PFAS as “forever chemicals.”

United Nations Framework Convention on Climate Change

KIGALI in ActiON

IMO

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Overview of current and future refrigerants used in reefers

Refrigerant	Energy-efficiency and Coefficient of performance (COP[1])	Global warming potential (IPCC AR 6)[2]	Costs of refrigerants[3]	End-of-life	Side products/ PFAS[4]	Service and service ability[5]	Knowledge/ Application [6]	Flammability[7]	Toxicity of side products[8]	Summary
R134a	✓	1530 ✗	✗	✗	✗	✓	✓	✓	✓	✗
R1234yf	✓	0.5 ✓	✗	✗	✗✗	✓	✓	✗	✗	✗✗
R290	✓✓	0.02 ✓	✓	✓	✓	✓	✓	✗	✓	✓✓
R744 (CO_2)	✗	1 ✓	✓	✓	✓	✗	✗	✓ -	✓	✓

Future refrigeration technologies with natural refrigerants.Comparison of Energy Efficiency – Safety – Standards & Costs, 2013, Intermodal Europe Hamburg Messe by Holger König
IPCC Assessment report 6 Climate Change 2021: The Physical Science Basis
Significant price rise for higher GWP refrigerants - Cooling Post Cooling Post 25.02.2025
European Commission 19.10.2023, News Article by Directorate-General for Environment Health and environmental impacts prompt a call for strict ruling on ubiquitous 'forever chemicals'
Future refrigeration technologies with natural refrigerants.Comparison of Energy Efficiency – Safety – Standards & Costs, 2013, Intermodal Europe Hamburg Messe by Holger König
Ibd.
UN Environment and ASHRAE Factsheet 1 "Update on New Refrigerants Designations and Safety Classifications" November 2022 UNEP/ASHRAE Refrigerant Fact Sheet #1—Update on New Refrigerants Designations and Safety Classifications
Michael Feller, Karin Lux, Christian Hohenstein, Andreas Kornath. Structure and Properties of 2,3,3,3-Tetrafluoropropene (HFO-1234yf). Zeitschrift für Naturforschung B, 2014; 69b: 379 DOI: 10.5560/ZNB.2014-4017

Definition of *Greener Reefers*

Greener Reefers **are highly energy efficient refrigerated maritime containers that use natural refrigerants and blowing agents with ultra-low climate impact with less than 1 GWP value and do not contain F-gases and PFAS**.**

Reefer containers. © GIZ Proklima

**The definition of Greener Reefers as used herein has been formulated by the Deutsche Gesellschaft für Internationale Zusamenarbeit (GIZ) GmbH

Natural refrigerants are the future

Only two natural options exist that fulfil the sustainable criteria of Greener Reefers:
CO_2 (already exists)
R290 (requires demonstration)

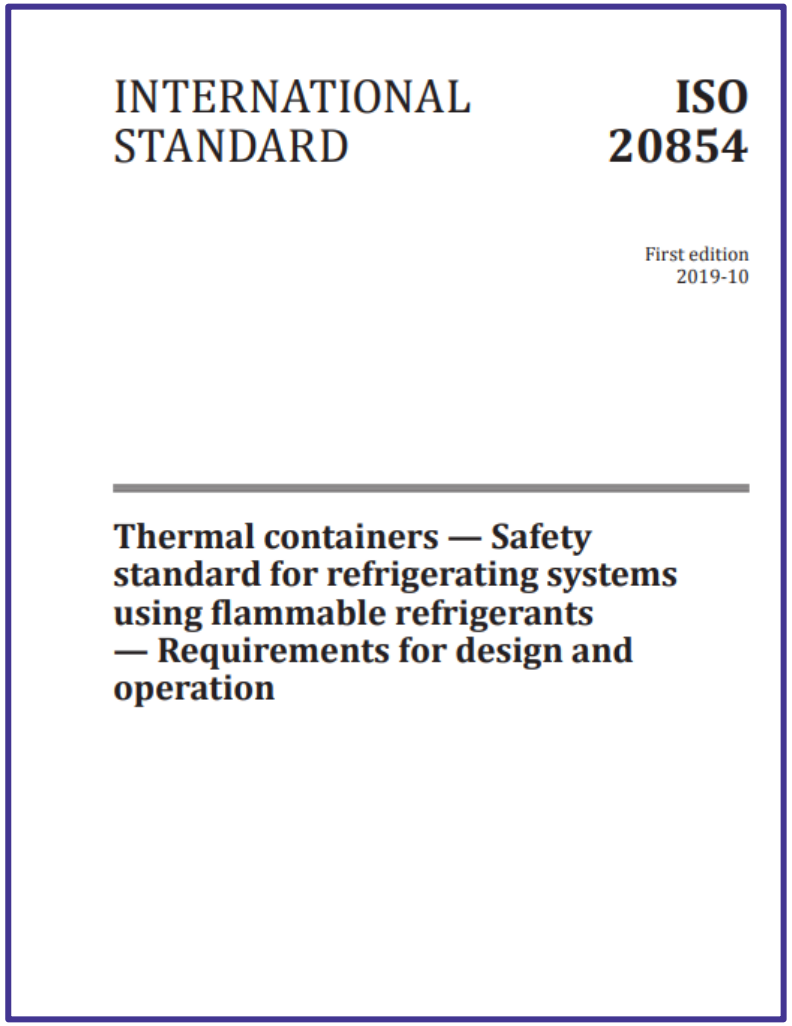
R290 shows **excellent thermodynamic properties** (high critical temperature, low freezing temperature, high thermal conductivity, and low viscosity)

R290 provides excellent **energy efficiency** at mid temperature applications (~0°C) and low temperature (~-20°C)

Risk of R290 when used in marine container environment is higher compared to use on land

R290 is flammable and therefore requires risk mitigation measures (higher costs) and **certified technicians**. However, an ISO 20854 (2019) safety standard already exists

Relevant regulations (IMO) also need to be aligned to use R290 on ships


INTERNATIONAL STANDARD

ISO 20854

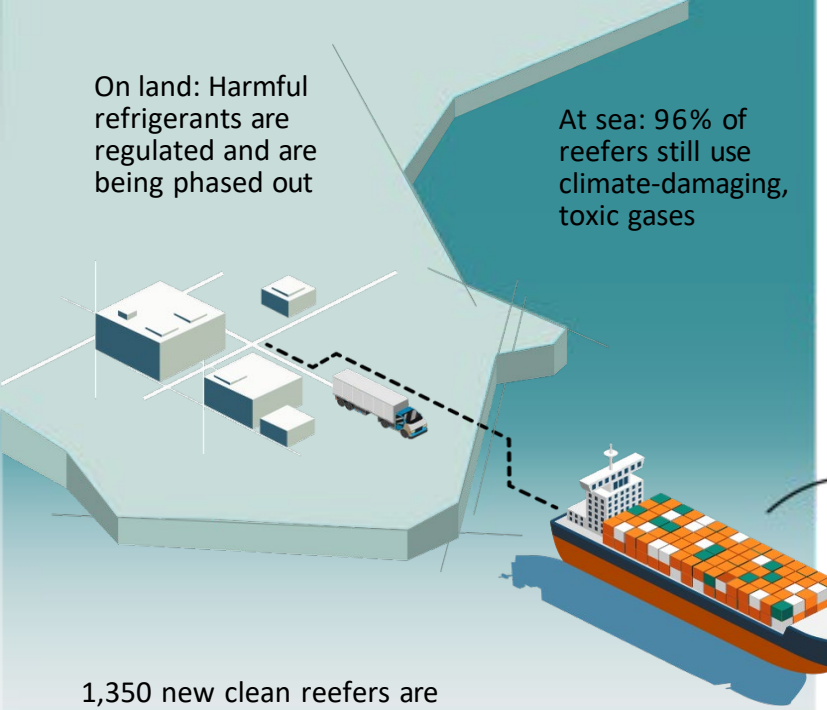
First edition
2019-10

Thermal containers — Safety standard for refrigerating systems using flammable refrigerants — Requirements for design and operation

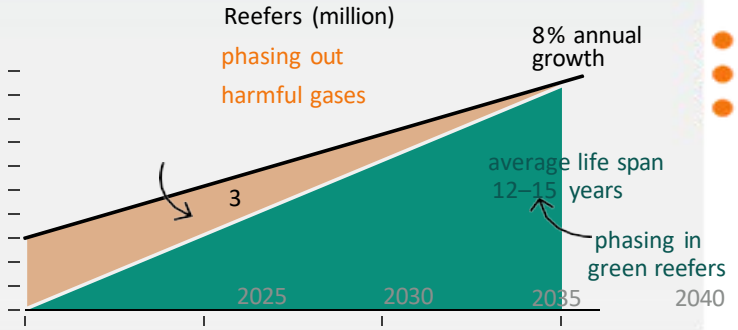
Time to end the use of harmful refrigerants in refrigerated maritime containers. All new reefers should use natural refrigerants - starting now.

On land: Harmful refrigerants are regulated and are being phased out

At sea: 96% of reefers still use climate-damaging, toxic gases



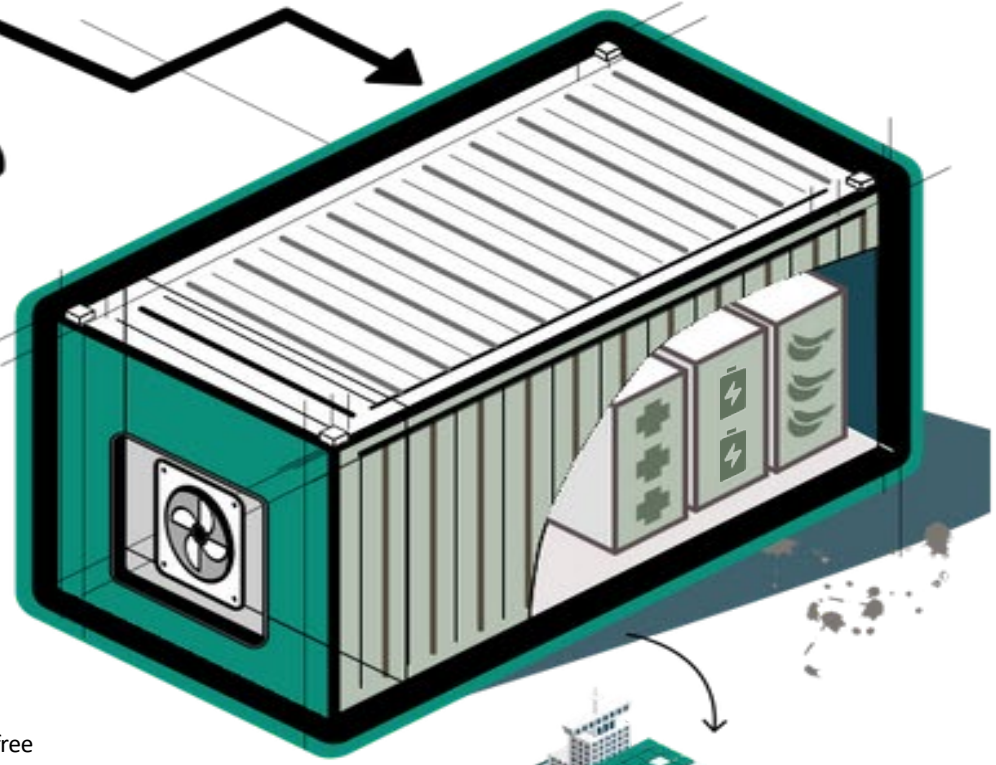
1,350 new clean reefers are needed per day to transition to a fully clean fleet by 2040



Current reefers use harmful synthetic refrigerants

- Thousands of times worse for the climate
- Severe health risks from forever chemicals
- A hidden climate impact of maritime transport

By starting the transition now the entire fleet of reefers can be safe, PFAS-free and climate-friendly by 2040



New future-proof reefers with natural refrigerants

- Climate-friendly andPFAS-free
- Safe, affordable, trusted
- Already in widespread use on land

Sources: Accelerating the transition to climate and environmentally friendly reefers; Global Reefer Container Market Research Report: Forecast (2021-2026); www.reefertransport.nl

Greener Reefer Transition Alliance

CLIMATE CENTER by Kühne Foundation

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White paper for immediate steps for a sustainable future

- **Thanks to all contributions by the shipping and container industry to sharpen the content and providing insights to the maritime freight transport and logistics.**
  - Wageningen University
  - Thermo King
  - and more and more

- **Current reefer fleet operates with highly climate damaging refrigerant – 96% of reefers based on ATO Database**

- **Change needs to happen now – But how to transist to a sustainable future for one of the key freight transport modes?**

Mitigation Potential –Results

Scenario Analysis:

- Best-case scenario: Rapid adoption of R290 in 50% of new reefers.
- Worst Case: Non-compliance with regulations adds 171.8 Mt CO_2eq by 2050, equal to emissions from 40 coal plants annually.

Energy Efficiency Gains:

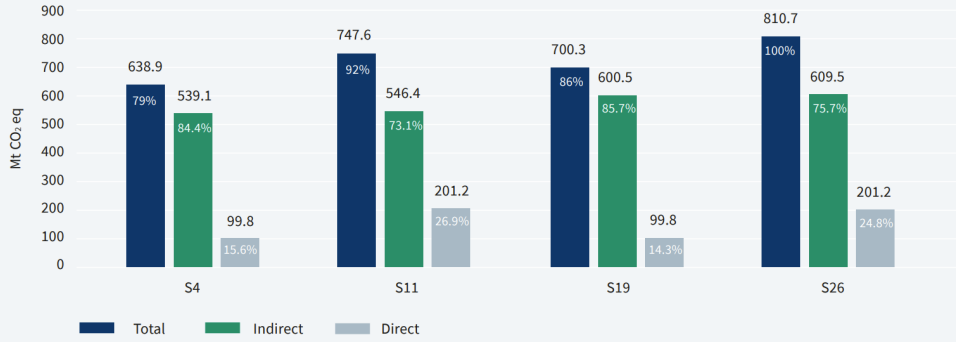
- Enhanced insulation, better temperature control, and maintenance can achieve 20% energy efficiency improvements.

Key Mitigation Pathways:

Switch to Natural Refrigerants:

- R290: Low GWP and better energy efficiency.
- R744: Non-flammable and recyclable.
- Align with Paris Agreement & IMO GHG reduction targets.
- Transitioning away from HFCs
- prevents TFA and other harmful byproducts.

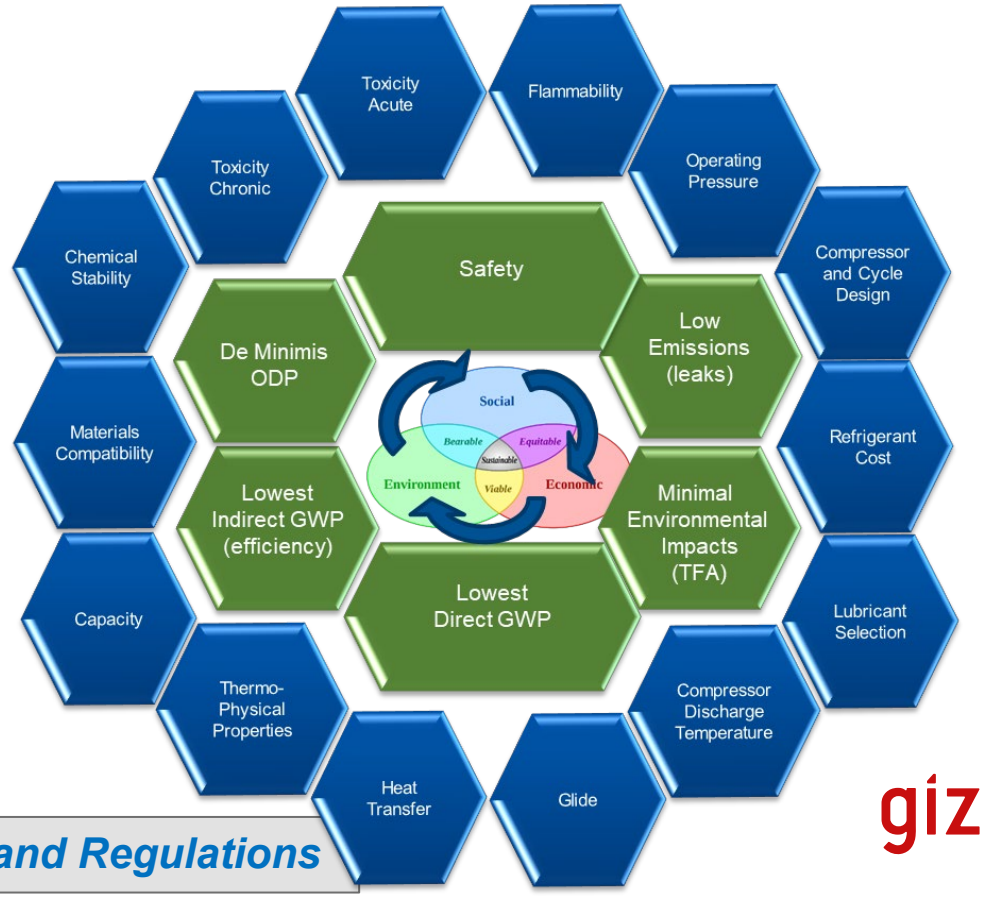
Figure 12. Behaviour of Direct and Indirect Emissions of selected scenarios, average off all years



Project Definition and Background

Partnership Thermo King – GIZ
Project Propane Reefer (POC)

- Sustainability for Refrigerated Intermodal Reefer Containers
- Direct Emissions: GWP, charge, leak rate and non-reclaimed end of life (8%)
- Indirect Emission → from energy consumption (90%)
- Equipment manufacturing (CO_2 in materials and processing) (2%)
- Food loss. (A lot)
- As an industry we must provide sustainable solutions from “cradle-to-grave” for benefit of World population



TEWI, LCCP, TCO, Safety and Regulations

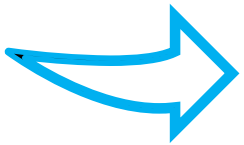
Driving Sustainability: Benefits and Path Forward

Benefits & Why It Matters:

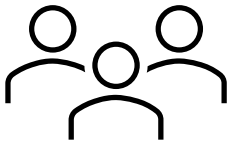
- Accelerates compliance with climate goals, including IMO 2023.
- Reduces emissions directly and indirectly
- Positions the reefer industry as a leader in sustainability, ensuring competitiveness.
- Meets growing demand for eco-friendly logistics solutions.

The Path Forward:

- **Natural Refrigerants:** R290 and R744 offer energy-efficient, eco-friendly solutions. Overcoming technical challenges is key.
- Energy Efficiency: Improvements like better insulation and optimized systems can reduce emissions by up to 20%.
- Global Climate Goals: Compliance with the Paris Agreement and IMO targets ensures long-term industry viability.



Conclusion:
Reefer containers are crucial for global trade but contribute significantly to emissions. Immediate action is needed to adopt sustainable cooling technologies to meet climate targets.



Collaborative Effort:
Industry-wide cooperation, including public-private partnerships, is essential for scaling solutions.

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Time to learn about the use of harmful refrigerants in refrigerated maritime containers and join the Greener Reefer transition Alliance to make natural refrigerants a reality.

Read our new Whitepaper

and

join the conversation on **LinkedIn**

Reach out to us:

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