Greener Reefers - introducing climate and environmentally friendly maritime cooling containers
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Sunday, 10th December 2023, 2:00 pm – 3:00 pm (GST/UTC+4) | Ozone to Cool Zone (Montreal Protocol Pavilion)

Opening (5’)
Philipp Denzinger, GIZ Proklima

Environmental impact and mitigation potential of greener reefers (10’)
Philipp Denzinger, GIZ Proklima

How to transition to sustainable reefers (10’)
Otto Schacht, Kühne Foundation

Energy efficient and climate friendly refrigeration systems (10’)
Kristina Norne Widell, SINTEF

Q & A (10’)
Everyone
Our Speakers
Moderator: Philipp Denzinger, GIZ Proklima

Philipp Denzinger  Otto Schacht  Kristina Norne Widell

GIZ Proklima  Kühne Foundation  SINTEF
Environmental impact and mitigation potential of greener reefers

Philipp Denzinger, GIZ Proklima
Background: Refrigerated Containers Reefers

- 2.49 million reefers in 2018 with a growth rate between 7.5% to 13% up to 2030.
- Market share of reefer containers vs reefer ships has increased steadily to 80% and it is expected to keep growing.

Sources:
Background: GHG emissions from container vessels

Total annual emissions: 236 million tonnes of CO$_2$eq. in 2018

Estimated indirect Reefer emissions (BAU) & mitigation potential (MIT)

Annual estimated indirect emissions in 2018: 41 million tonnes of CO\(_2\)eq.
Estimated BAU scenario (including small energy efficiency improvements)
Accumulated estimated mitigation potential: 908 million tonnes of CO\(_2\)eq. until 2050

Sources:
Direct emissions from Reefers

- Refrigerant emissions have been increasing in recent years
- Mainly due to an increase in number of reefer containers
- According to IMO (2020) in 2018 direct emissions of reefers are 4 million tonnes of CO₂eq. (AR4)
- Direct emissions according to AR6 GWP values, would be 4.86 million tonnes of CO₂eq.

Sources:
Estimated direct Reefer emissions (BAU) & mitigation potential (MIT)

Annual estimated direct emissions in 2018: 4.8 million tonnes of CO$_2$eq
Estimated BAU scenario: including low GWP HFCs and HFOs
Accumulated estimated mitigation potential: 32 million tonnes of CO$_2$eq until 2050 (moving gradually to natural refrigerants)

Sources:
# Background: Refrigerants available for potential use in Reefers

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>Type</th>
<th>Alternative for</th>
<th>GWP 20</th>
<th>GWP 100</th>
<th>PFAS</th>
<th>TFA</th>
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<tbody>
<tr>
<td>R23</td>
<td>HFC</td>
<td></td>
<td>12400</td>
<td>14600</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>R404A</td>
<td>HFC blend</td>
<td></td>
<td>7208</td>
<td>4728</td>
<td>Yes</td>
<td>Up to 20% R134a (4%), up to 10% R143a (52%)</td>
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<tr>
<td>R452A</td>
<td>HFC/HFO blend</td>
<td>R404A</td>
<td>4303</td>
<td>2292</td>
<td>Yes</td>
<td>Up to 100% R1234yf (30%)</td>
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<tr>
<td>R473A</td>
<td>HFC/HFO/CO₂ blend</td>
<td>R23</td>
<td>1915</td>
<td>1835</td>
<td>Yes (R125)</td>
<td>No</td>
</tr>
<tr>
<td>R134a</td>
<td>HFC</td>
<td></td>
<td>4140</td>
<td>1530</td>
<td>Yes</td>
<td>Up to 20% R134a (100%)</td>
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<tr>
<td>R32</td>
<td>HFC</td>
<td></td>
<td>2690</td>
<td>771</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>R513A</td>
<td>HFC/HFO blend</td>
<td>R134a</td>
<td>1823</td>
<td>673</td>
<td>Yes</td>
<td>Up to 20% R134a (44%), up to 100% R1234yf (56%)</td>
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<tr>
<td>R454A</td>
<td>HFC/HFO blend</td>
<td>R404A</td>
<td>1037</td>
<td>270</td>
<td>Yes</td>
<td>Up to 100% R1234yf (65%)</td>
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<tr>
<td>R1234yf</td>
<td>HFO</td>
<td>R134a / R513A</td>
<td>1.81</td>
<td>0.501</td>
<td>Yes</td>
<td>Up to R1234yf (100%)</td>
</tr>
<tr>
<td>R744</td>
<td>Natural (CO₂)</td>
<td></td>
<td>1</td>
<td>1</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>R290</td>
<td>Natural (Propane)</td>
<td></td>
<td>0.072</td>
<td>0.02</td>
<td>No</td>
<td>No</td>
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</tbody>
</table>

**Per- and polyfluoroalkyl substances (PFAS)** are a large class of synthetic chemicals that increasingly detected as environmental pollutants and linked to negative effects on human health. **Trifluoroacetic acid (TFA)** is an ultra short chain type of PFAS, commonly found in the breakdown of f-gases.

Sources:
- Certain HFCs and HFOs Are in PFAS Group that Five EU Countries Intend to Restrict - R744
Background: Political Context for Reefers Today

**Kigali Amendment**
- The Kigali Amendment under the Montreal Protocol phases down HFCs (e.g., R-134a, R-404A, R-32) on a global scale up to 2047.

**UNFCCC process**
- Paris Agreement: Global temperature to limit the increase to 1.5 °C
- Establishment of the National Determined Contributions
- COP 28: Cooling Pledge

**IMO Strategy 2023**
- Reduction of the total annual GHG emissions from international shipping by 20%-30% by 2030
- By 70%-80% by 2040 compared to 2008.
- Net zero by or around 2050

**EU F Gas Regulation and REACH**
- Limiting the total amount of F-gases (HFCs) that can be sold
- Banning the use of F-gases for reefers from 2029 onwards (tbc)
- Proposal for restriction on PFAS under REACH

Sources:
- The Kigali Amendment (2016): The amendment to the Montreal Protocol agreed by the Twenty-Eighth Meeting of the Parties
- 2023 IMO Strategy on Reduction of GHG Emissions from Ships
- The Paris Agreement | UNFCCC
- EU legislation to control F-gases (europa.eu)
**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 11 GWP** value and do not contain f-gases and are **PFAS-free**.

Reefer containers. © GIZ Proklima
Natural refrigerants are the future

• Only two natural options exist that fulfil the sustainable criteria of Greener Reefers:
  - CO2 (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)

• Risks of R290 when used in marine container environment is higher from when used 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

Sources:
Greener Reefers Project

Comissioned by

Implemented by

Project Duration
April 2023 until April 2026

Project Budget
EUR 2.900.000

Source Microsoft Picture
Greener Reefers Project

**Stakeholders:**
- Maritime organisations addressing climate change
- Shipping industry: container manufactures, shipping lines, port terminals
- Research institutions
- Training institutions
- Representatives of IMO, Montreal Protocol, UNFCCC

**Partner countries:**
- South Africa (Department of Forestry, Fisheries and the Environment)
Outputs of the Greener Reefers Project

- Reefer market and technologies
- Capacity development regarding reefers
- Preparation of enabling environment for climate friendly reefers incl. Eco label
- Dissemination of mitigation strategies
Do you want to be part or support the Greener Reefers Project? If so please contact us!
Philipp Denzinger

Proklima International
Project Manager

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www.green-cooling-initiative.org
How to transition to sustainable reefers

Otto Schacht, Kühne Foundation
How to catalyze the transition to sustainable reefers?

- **Wholistic perspective**
  - Refrigerants
  - Box design
  - Temperature protocols
  - Load factors

- **Cost** – but “costs” need to be put into broader perspective (cost per unit cargo, cost to consumer, relative to other climate costs)

- **Communication**
  - Do cargo owners know about high GWP of current refrigerants?
  - Do they know about the “forever chemicals”?
  - Be transparent

Source MSC
How to catalyze the transition to sustainable reefers?

• Broad Alliance
  • Manufacturers, logistics service providers, shipping lines
  • + Cargo owners, consumers
  • + Certification bodies
  • + Training agencies

• Take care of the secondary effects
  • Recycling of containers (techniques, business models etc.)
  • End of life management of refrigerants
Looking ahead to the low carbon society of 2050

- **Reefer demand in a changing climate?**
  - More extreme temperatures
  - Longer seasons

- **Mode shift from high carbon aviation?**

- **Different trade flows**
  - More trade in low carbon products
  - Different routes

….the low carbon society of 2050 will be very different from that of today – **get ready** - its only 26 years away
Otto Schacht

Advisor
Kühne Foundation

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www.kuehne-stiftung.org/areas/climate/area
Energy efficient and climate friendly refrigeration systems
Kristina N. Widell

Senior Researcher, SINTEF Ocean

Energy efficient and climate friendly refrigeration systems
UN climate priority: Highly efficient clean cooling technologies

Urgent and should be accelerated!

Cooling – responsible for 7% of global GHG emissions

1/3 of food produced is lost

1/3 of total GHG emissions related to food systems

1/3 of total GHG emissions related to food systems
Food cold chain
60% of all food

- Keep product quality high
- Efficient use of resources
- Low emissions

Refrigeration systems necessary

Processing → Transport → Storage → Transport → Retail

Short distance - last mile

Domestic
3 degree report

• Freezing of food
• Extend storage life
• Maintain nutritional quality and prevent deterioration
• Optimise utilisation (scheduled consumption and reduce food waste)

Refrigeration reefer containers:
  50% cooling
  50% freezing

1/3 of food produced is lost

Processing and packaging

Three Degrees Of Change
FROZEN FOOD IN A RESILIENT AND SUSTAINABLE FOOD SYSTEM
Summary report & initial findings
November 2023

International Institute of Refrigeration
Centre for Sustainable Cooling
3 degree report

- Changing from -18°C to -15°C for frozen storage
- Reducing energy demand
  - 2-3% per 1 °C
  - Industry case: up to 10%
- Reducing carbon emissions
  - Equivalent to carbon emitted by nearly 4 million cars/yr.
- Reefers: propulsion system (fossil fuel)
How should we do this?

- Keep product quality high
- Efficient use of resources
- Low emissions

Refrigerants  Safety  Energy efficiency

Energy demand
Refrigerants: when do we have a problem?

• Refrigerants leaking
  • Production
  • Filling, servicing
  • Components malfunctioning
  • End-of-life-treatment

• ODP: Ozone depletion potential (R22)
• GWP: Global warming potential (R134a)
• PFAS: Environmental and health risks («HFOs»)

Solution: Natural Refrigerants

No unexpected surprises (€ £ $…)

ODP: Ozone depletion potential (R22)
GWP: Global warming potential (R134a)
PFAS: Environmental and health risks («HFOs»)
Reefers

- Information supplied by the COA Reefer Forum Work Group
- Overview of current and proposed regulations that restrict the use of refrigerant F-Gases and the consequential issues
- R134a is used in 96% of the existing reefer container fleet
- No immediately available alternative refrigerant that meets all the required operational criteria

GWP=1430
Reefers

• Regulation of F-gas refrigerants – overview
  • EU regulation, IMO resolution, REACH etc

• Reefer container global fleet & operating criteria
  • Global shipments of perishable refrigerated cargo were 307 million tonnes in 2022
  • The operating life of a marine reefer container is 18 years.
  • Operate in ambient temperatures varying from -30 °C to +50 °C

• Refrigerant options
  • R1234yf
  • R744 / CO₂
  • R290 / Propane
How should we do this?

- Keep product quality high
- Efficient use of resources
- Low emissions

Refrigerants  Safety  Energy efficiency
Safety: important messages

- Following standards, guidelines and codes of good practice has reduced the number of accidents
- Some accidents happen when technicians are not properly trained and informed
How should we do this?

- Keep product quality high
- Efficient use of resources
- Low emissions

Refrigerants  Safety  Energy efficiency
Energy efficiency: why so important?

- Energy savings
  - Reduction in energy demand: spend less to get the same result

- Lower environmental impact
  - Reduction in greenhouse gases and other pollutants

- Energy security
  - Less dependency on imported energy

- Reduced energy costs
  - Increased economy competitiveness and job creation
Summary

- Food is essential: Food cold chain
- Refrigerants: Natural working fluids
- Safety: Good practice, training and education
- Energy:
  - Reduce energy demand
  - Prevent food loss and waste

Ref: Widell, Hafner, Minetto, Pachai, Evans: “Training on clean cooling and heating solutions”
Thank you for listening!

Montreal Protocol
Advancing Climate Action
COP28 UAE 30 Nov–12 Dec