

Reefer Containers Future Refrigerants

11th October 2023

Mark Bennett

Current Refrigerants

Standard reefers (cargo from -30°C to +30°C):

- R134A 96% of the fleet
- R404A 4% of the fleet
- CO₂ 0.2% of the fleet
- There are 1.8 million reefers (units) in operation today

Super Freezers:

- R23 etc – small fleet size

Extreme Operating Requirements

- Reefers are designed to operate in ambient temperatures from -30°C to $+50^{\circ}\text{C}$ – much more extreme than land transport
- Cargo temperatures vary from -30°C to $+30^{\circ}\text{C}$
- Ships holds are at 35°C to 45°C for long periods
- Up to 2,000 reefers can be carried on large ships powered by the ship's generators
- There are very few refrigerants that can meet these requirements – and meet all environmental regulations

F-Gas Refrigerant Regulations

European Union:

- F-gas phaseout – total by 2050, down to 4% of 2014 level by 2030/2035
- F-gas service restrictions likely from 2025 to 2030 using recycled gas only
- ‘F-gas’ apparently now includes R134A and R1234yf (awaiting clarification)

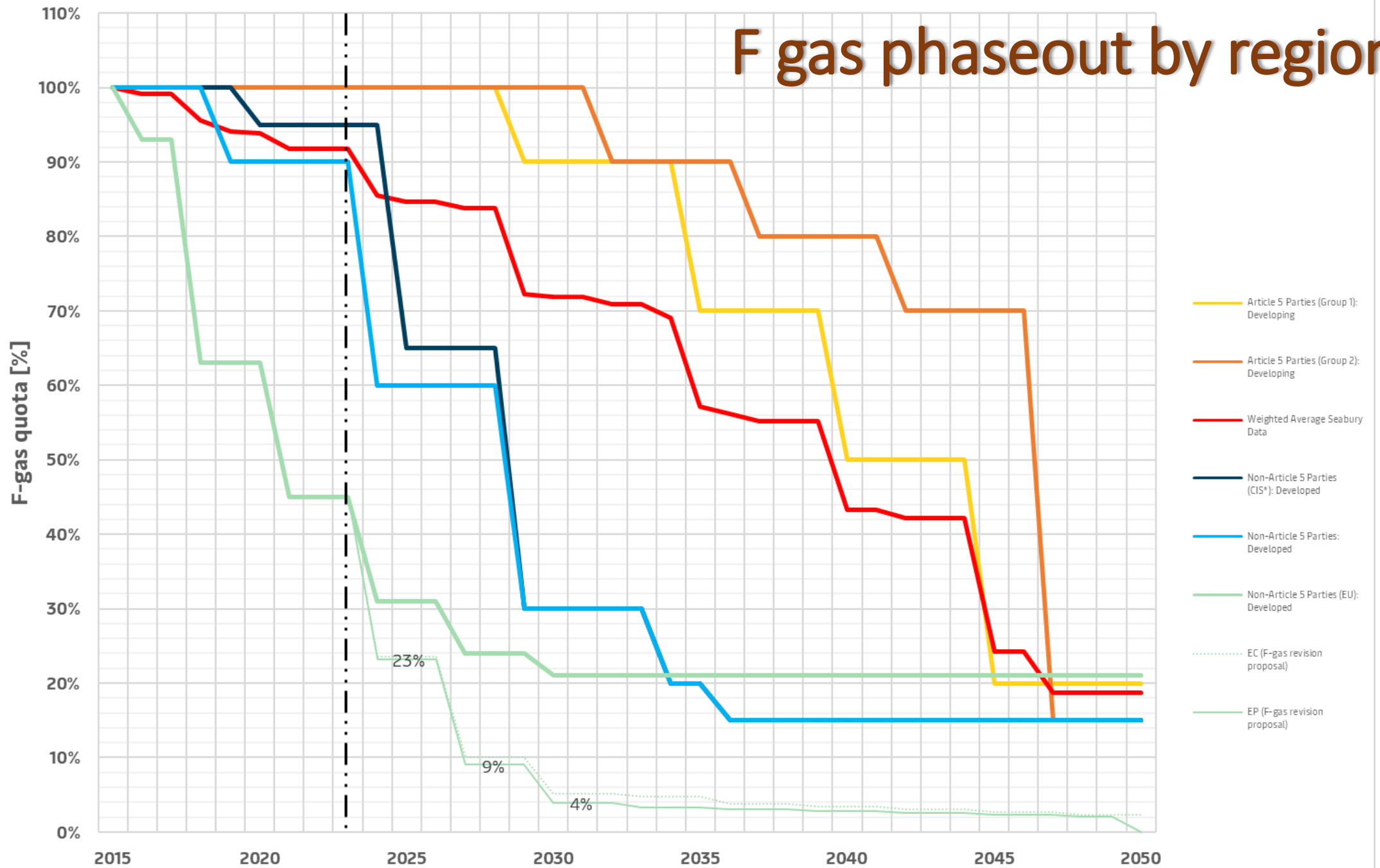
USA:

- F gas phasedown – no final date

IMO:

- Carbon tax on power consumption of reefers
- Reduce carbon intensity of ships 40% by 2030 compared to 2008

F gas phaseout by regions



PFAS – Potential Regulations

European Union:

- PFAS – proposed phaseout of most PFAS chemicals including R1234yf
- Proposals would ban Teflon (PTFE), HFO 1234yf and many others
- Critical materials for bearings, seals, and ultra-low GWP refrigerants
- No alternative products today to replace many PFAS
- Regulations unlikely to be finalised until end 2024/2025

USA:

- Does not see HFO 1234yf or its breakdown product TFA as a hazard
- Unlikely that Teflon will be banned (PTFE)

Impact of Regulations

European Union:

- Reefers are not directly covered as are only temporarily imported
- F gas service restrictions may prevent PTIs for European export cargo
- Price of R134A & R404A will rise

USA/other developed economies:

- No immediate service restrictions for reefers but phasedown of use

Other countries:

- Ongoing availability of R134A and R404A for service in most countries

Alternative Refrigerants for R134A

R513A:

- Can be used in c.40% of current reefers unmodified
- Machines built before 2018 may require modification to use it
- Not widely available at all - and expensive
- Will be subject to F gas phasedown in the EU as it contains R134A

R1234yf:

- Efficient refrigerant with ultra-low GWP and low carbon footprint
- Only usable in new machine designs – available in 1 to 2 years
- Widely used in automobile air-conditioning in many countries
- May be subject to F-gas(?) and PFAS phasedown in the EU

Other Alternative Refrigerants

R290 - Propane:

- Very efficient refrigerant with ultra-low GWP
- Highly flammable – a major concern on vessels and for servicing
- Widely available and cheap
- Up to 7 years to develop a machine before fire/explosion risks can be evaluated
- Being widely adopted in Europe for heat pumps – will the USA also do this?

R744 - CO₂:

- Machines using CO₂ already in service
- Significantly higher power consumption than best R134A machines
- Reduced quantity that can be carried on vessels due to power requirement
- Higher carbon footprint than best R134A machines
- Ultra-high system pressures - requires global service training

Power consumption, carbon footprint and lifespan

- 90% of carbon footprint of the most efficient R134A reefers is from power consumed, only 10% from gas leaks
- Every 1kWh of power consumed costs \$2.90 per day on board vessels
- Today's most efficient R134A machines can consume less than 1kWh
- Less power consumed means less IMO carbon tax and less carbon footprint
- 30% of the total carbon footprint of a reefer is in its production
- Reefers are increasingly being used up to 18 years
- Early retirement will create a much greater carbon footprint

Challenges

- Managing the existing 1.8 million unit reefer fleet if F-gas restrictions affect the ability to service and repair
- New R134A reefer purchases may face shorter lifespan
- R1234yf ultra-low GWP reefers available in 2 years may be targeted by future PFAS regulations
- CO₂ machinery increases power consumption, carbon footprint and reduces quantity on vessels
- Propane machines will require complex design to limit fire and explosion risks

Summary

- Best future refrigerant for carbon footprint is R1234yf
- Shipping industry should explain to national regulatory authorities the unique technical challenges for reefers
- Current owners must navigate changing regulations
- Future PFAS regulations: shipping industry submitted technical recommendations; likely completion by the EU in 2024.
- For buyers, uncertainty remains as to what to buy in the next 2 years to obtain a full operating life with good efficiency