COOLING TECHNOLOGY

The Future use of refrigerants under the impact of current regulations

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Refrigerant use under current legislation

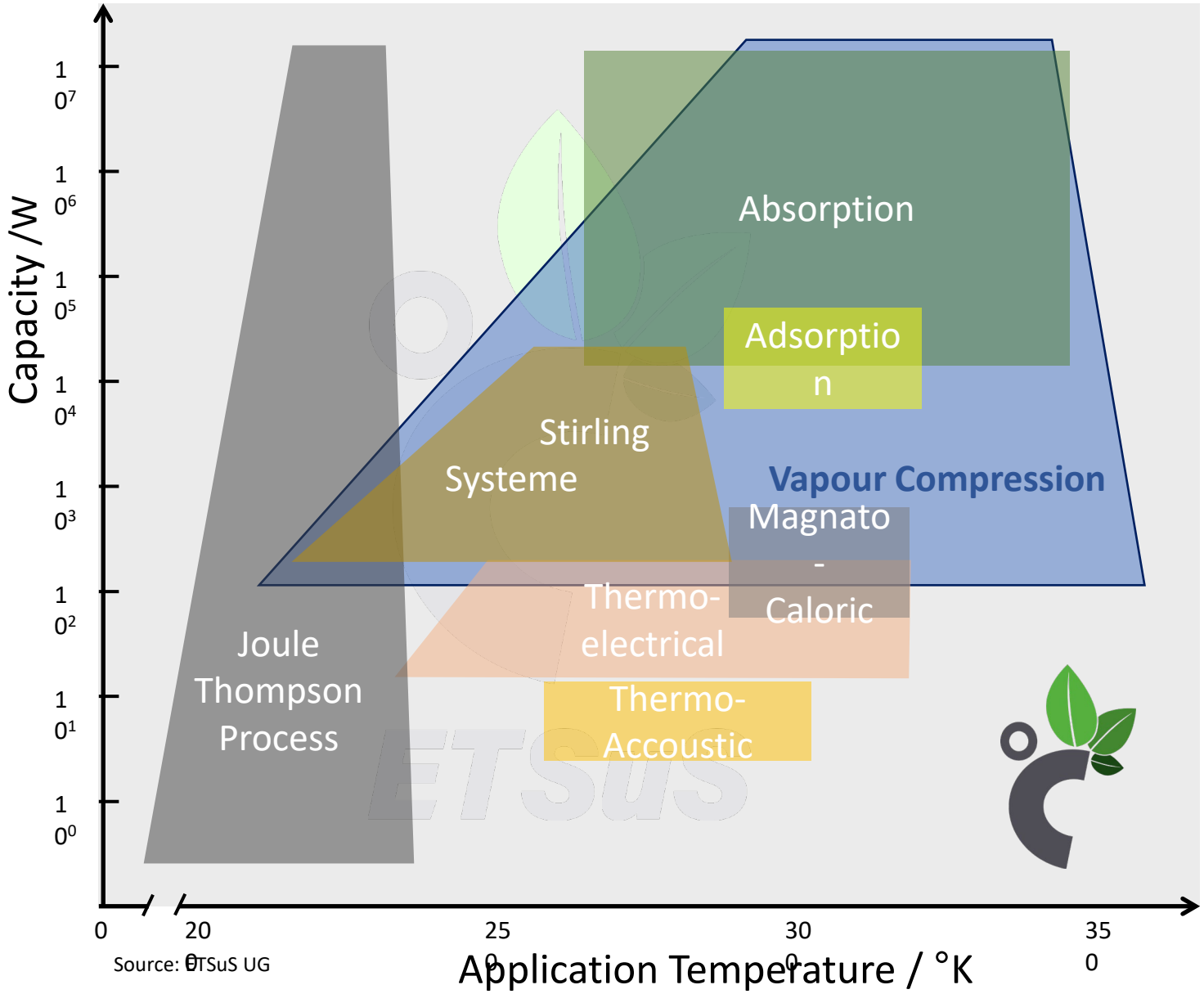
- Introduction
- Cooling technology – a short overview
- Refrigerants legal changes and technical challenges
- Motivation environmental challenge
- The technological challenge: F-Gas Regulation
- Refrigerants – once, now and future
- Summary and outlook

Refrigerant use under current legislation

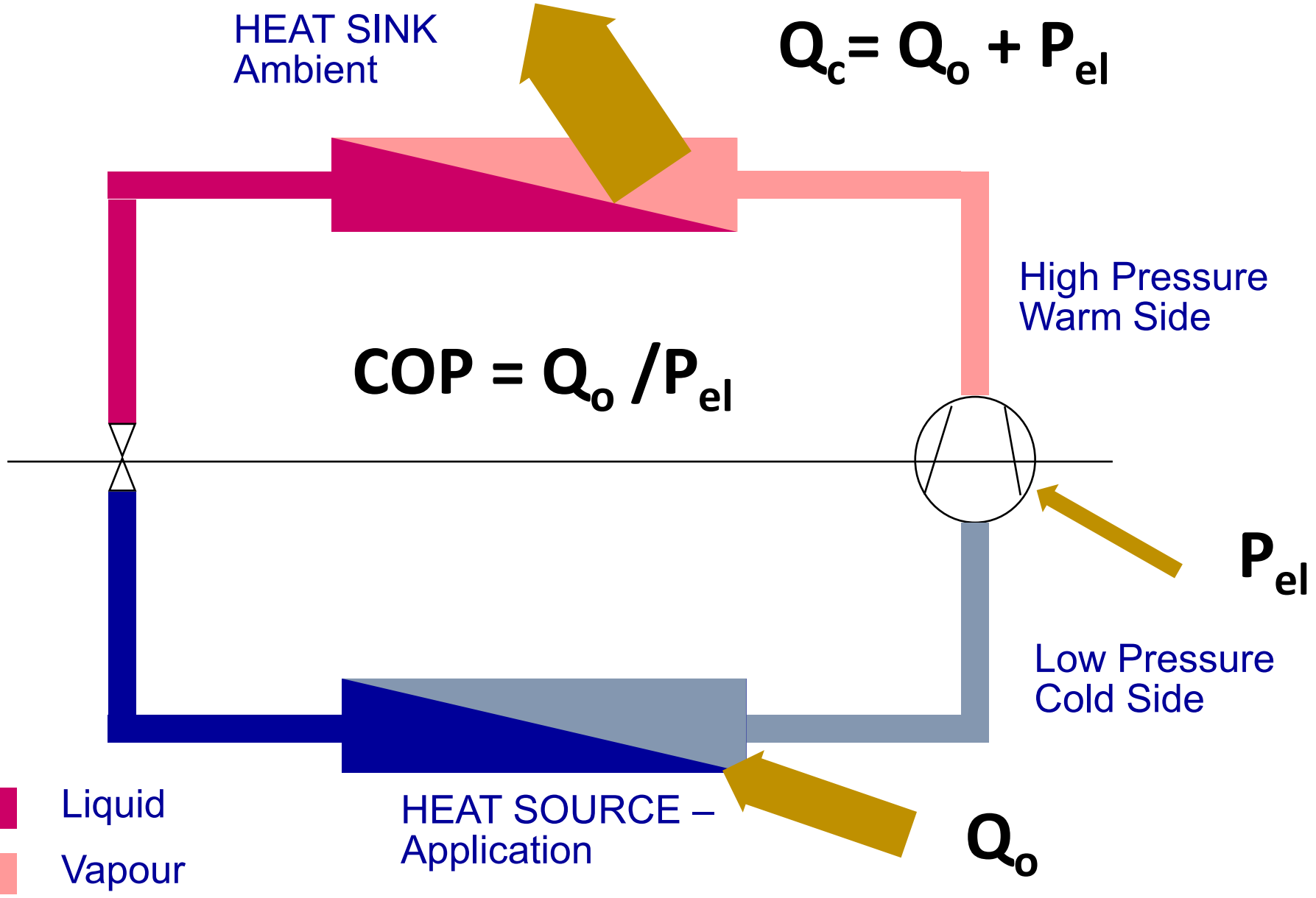
Cooling technology

- Why cooling technology?
- Technology options
- The vapour compression cycle

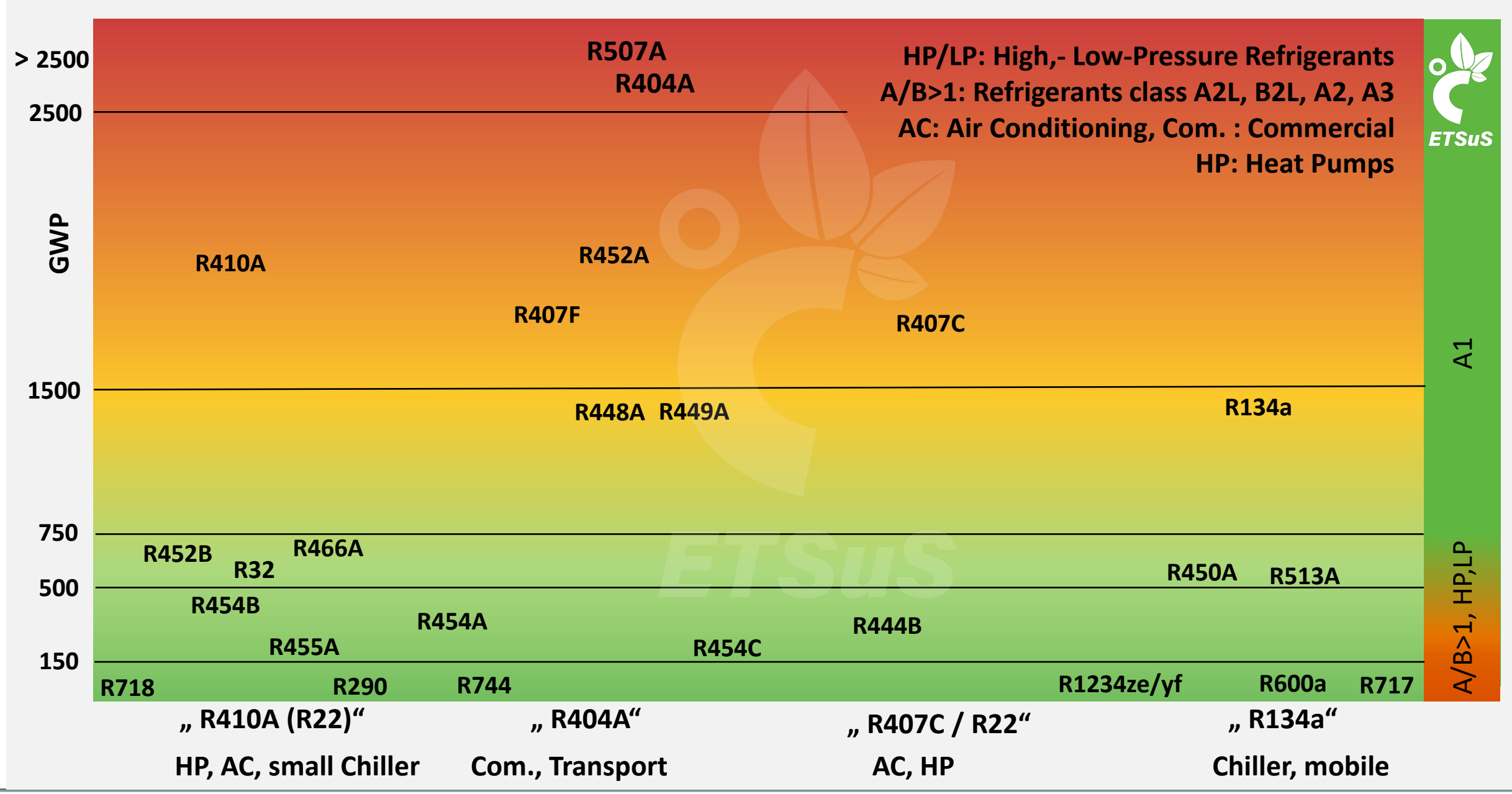
Cooling technology



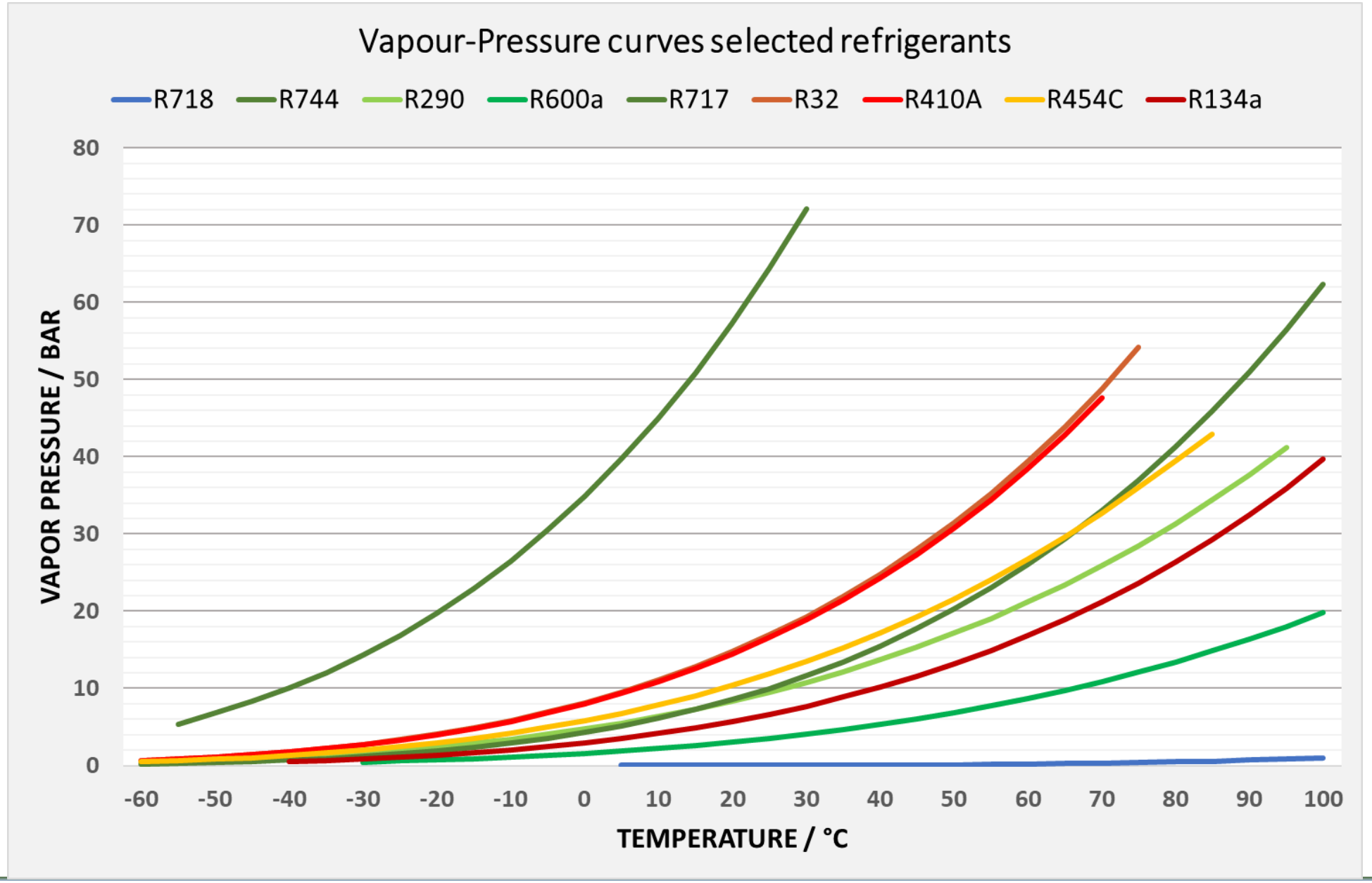
Vapour Compression Systems



Alternative Refrigerants



Thermodynamical Properties: pT



Refrigerant use under current legislation

Refrigerants legal changes and technical challenges

- Motivation environmental challenge - Metrics
- The technological challenge: F-Gas Regulation; Reach, Taxaonomy
- Refrigerants – once, now and future
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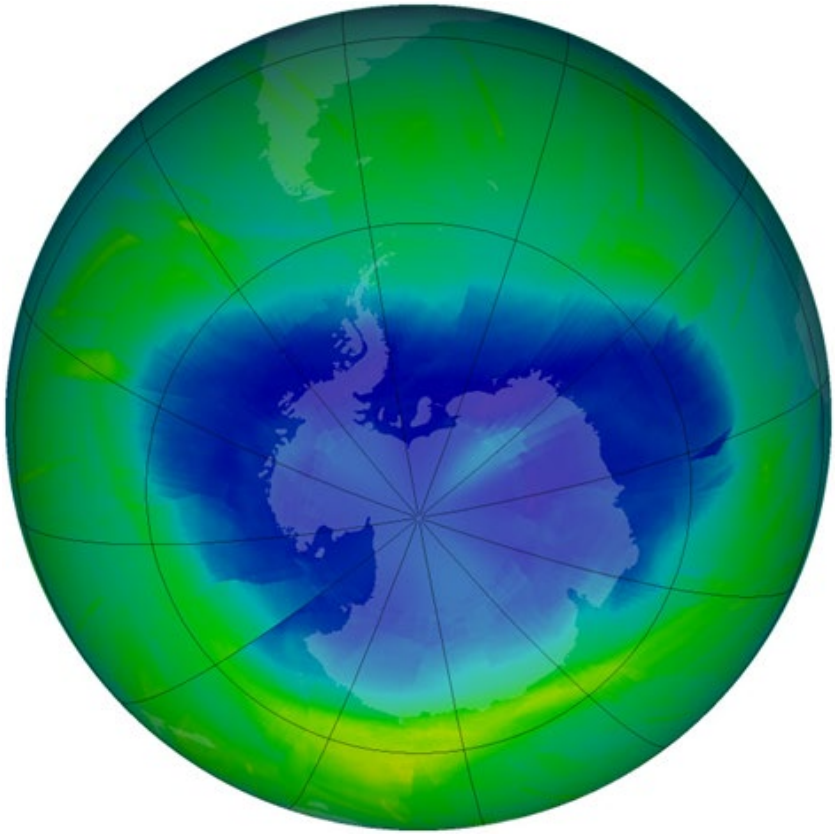
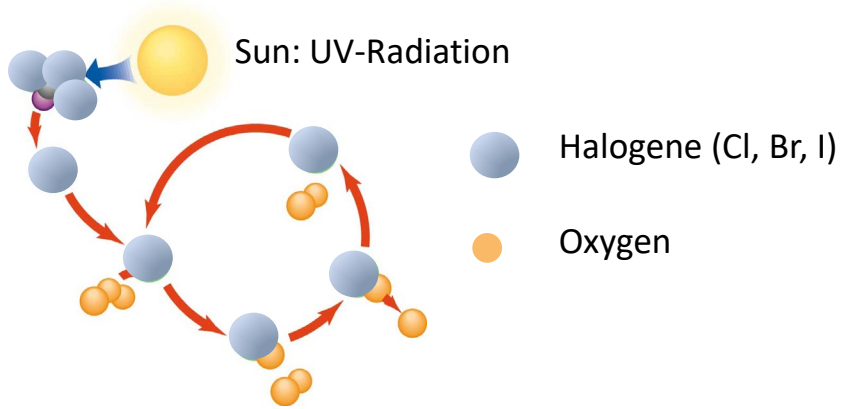
Motivation environmental challenge - Metrics

- ODP – Ozone Depletion Potential
- GWP – Global Warming Potential
- PFAS (Per- and polyfluorinated alkyl substances)
- TFA (Trifluoroacetic Acid)

Ozone Depletion

ODP



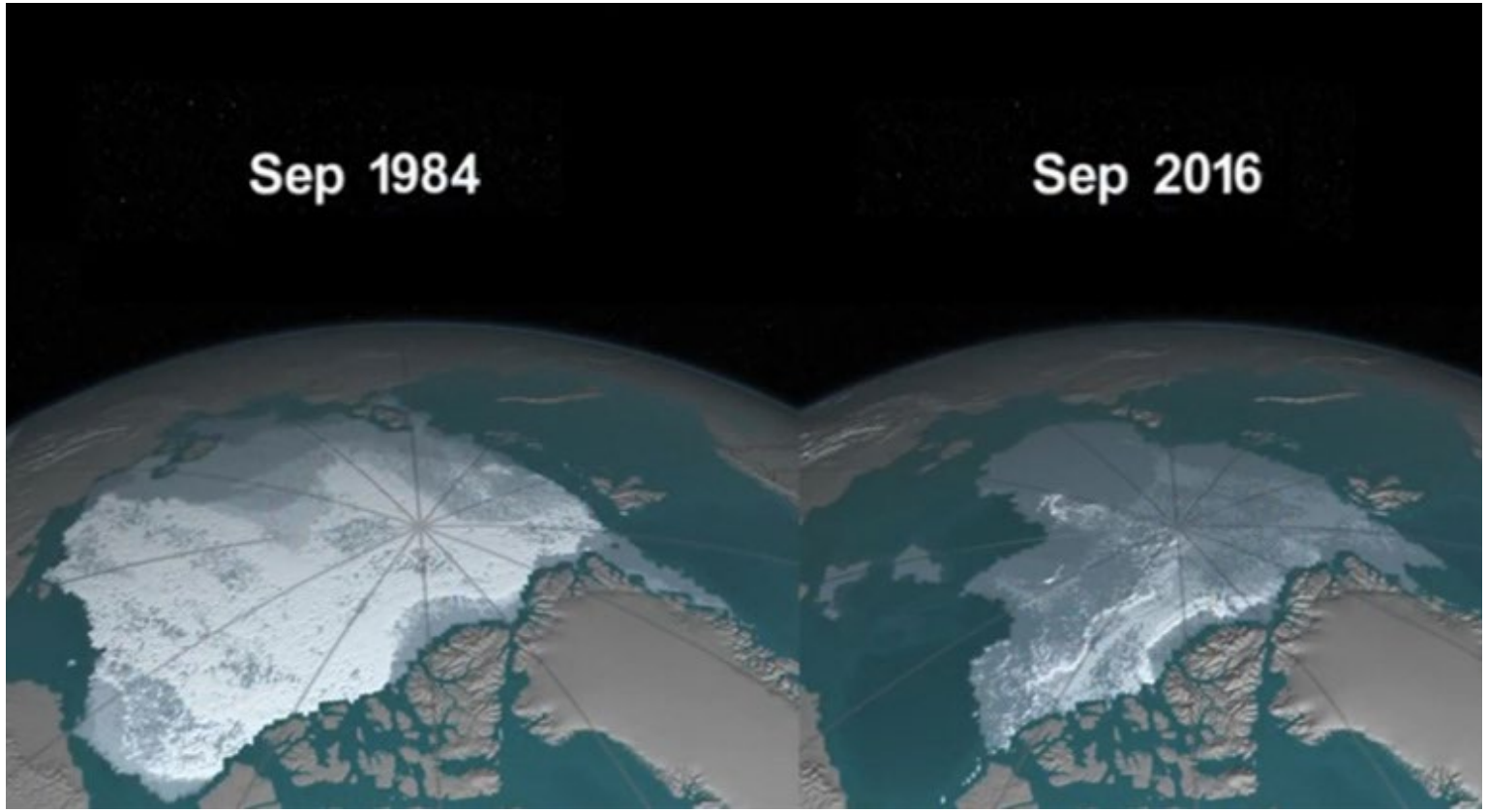


- Ozone Depletion Thesis:
  Molina & Rowland & Crutzen 1974
- CFCs as major contributor

Source: NASA Goddard Space Flight Center from Greenbelt, MD, USA - Snapshot of the Antarctic Ozone Hole 2010, Public Domain, https://commons.wikimedia.org/w/index.php?curid=69017095

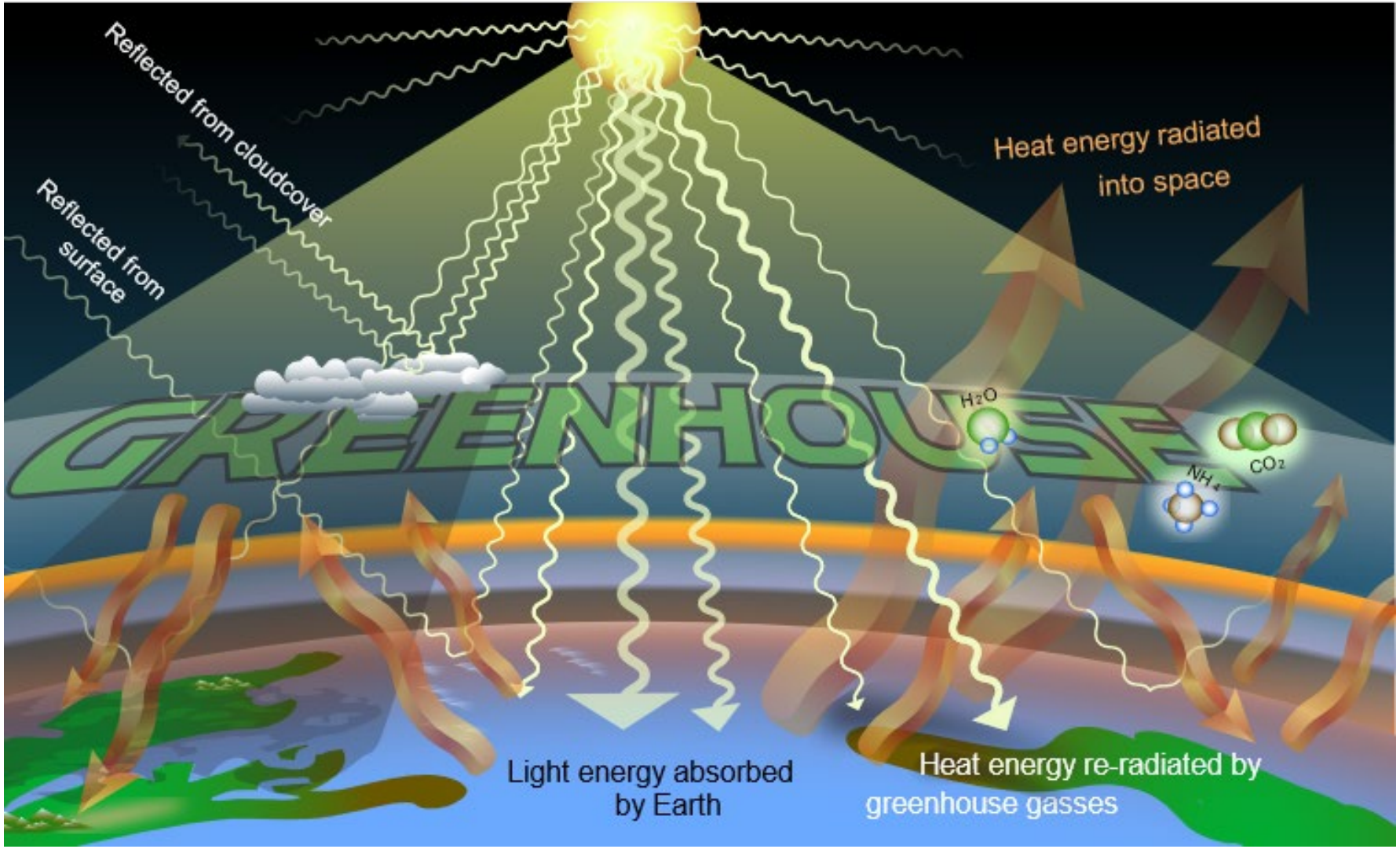
Global Warming

GWP



Quelle: © NASA Goddard Screenshot youtube.com

The Greenhouse Effect



Source: A loose necktie - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=78336181

Climate Conventions

Montreal Protocol (1987) 197 countries as parties (all UN members)

- Based on Vienna Convention (1985)
- Originally focussed on Protection of the Ozone layer
- Phase out/down of ODS (Ozone Depleting Substances)
- Broader approach on GHG (Greenhouse Gases)
- Kigali Amendment (2016):
  - Focussed on phase down of F-Gases (indirect via CO_2- emissions)
  - 15% target value of baseline

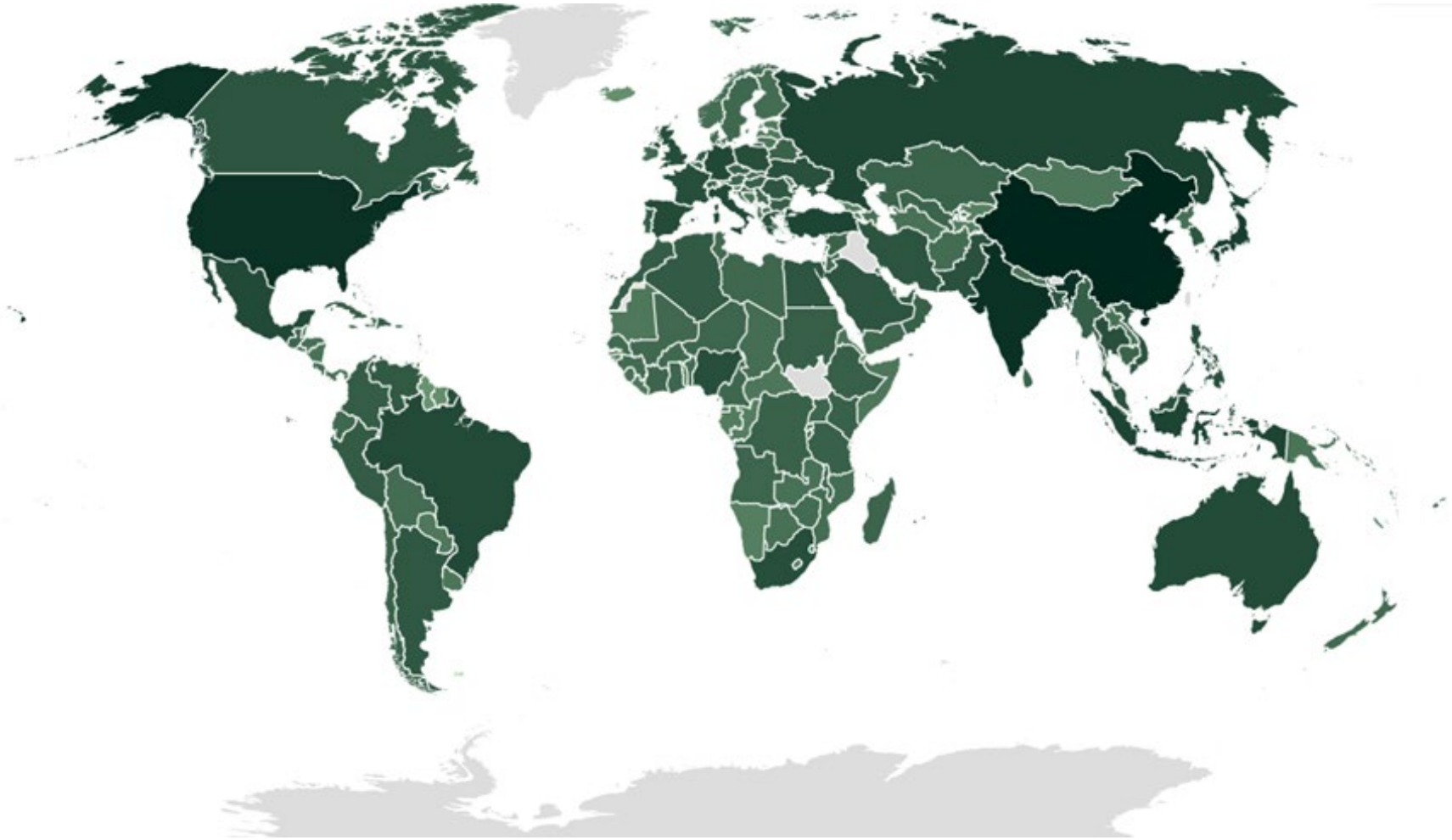
Kyoto Protocol (1997) 191 countries + EU ratified

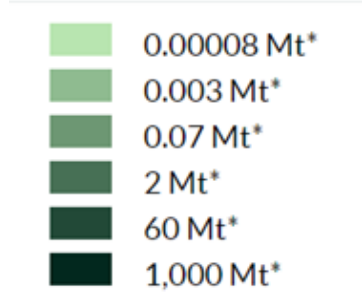
- Focussed on GHG emissions
- Paris Agreement (2015) to limit global warming to 1,5 °C, ratified by 185 nations

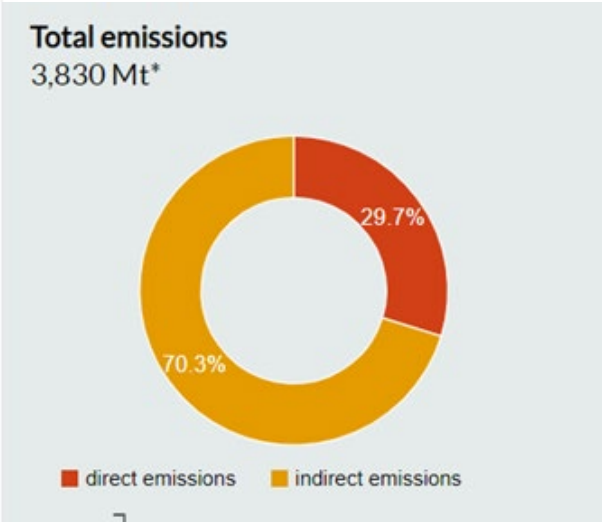
Global emissions cooling sector

- Cooling sector including AC , HP and cryogenics accounts for 7,8 % of global greenhouse gas emissions[1]
- Total emissions account to app. 4 Gt CO_{2e} in 2016
- Due to market development – mainly increase of AC sales – total emissions could increase dramatically
- Without counter measures energy demand could triple by 2050 compared to 2016
- With counter measures (mitigation measures) a reduction of 33 – 45 % is achievable in 2050

Global emissions cooling sector (2016)







Source: www.green-cooling-initiative.org/

Fighting the consequence: Environmental Legislation

- Global Conventions
- Ratification

- EU Targets
- EU Legal Instruments

- National Laws
- „Standards“

Environmental Legislation: Example EU and Germany

Montreal, Kyoto –Prot. Amendments

Direct Emissions

Indirect Emissions

ODS

F-Gases

ErP „Eco-Design“

„Labelling“

„Buildings“

ChemG

ChemG, KrWG

EVPG

EnVKG

National Laws and Regulations

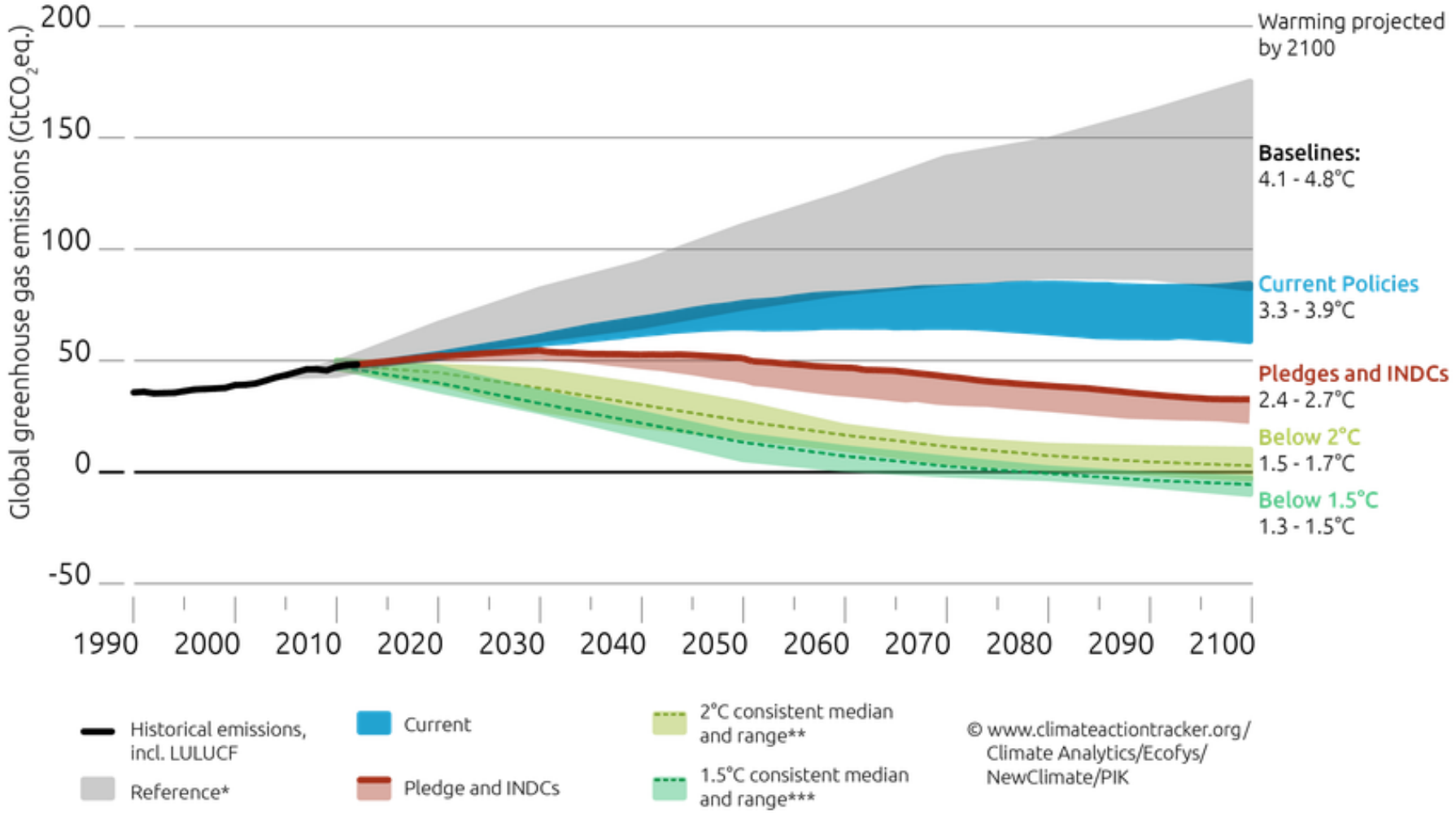
ChemOzonSchichtV

ChemKlimaschutzV

EVPGV

Standards

The need for global GHG mitigation



Refrigerant use under current legislation

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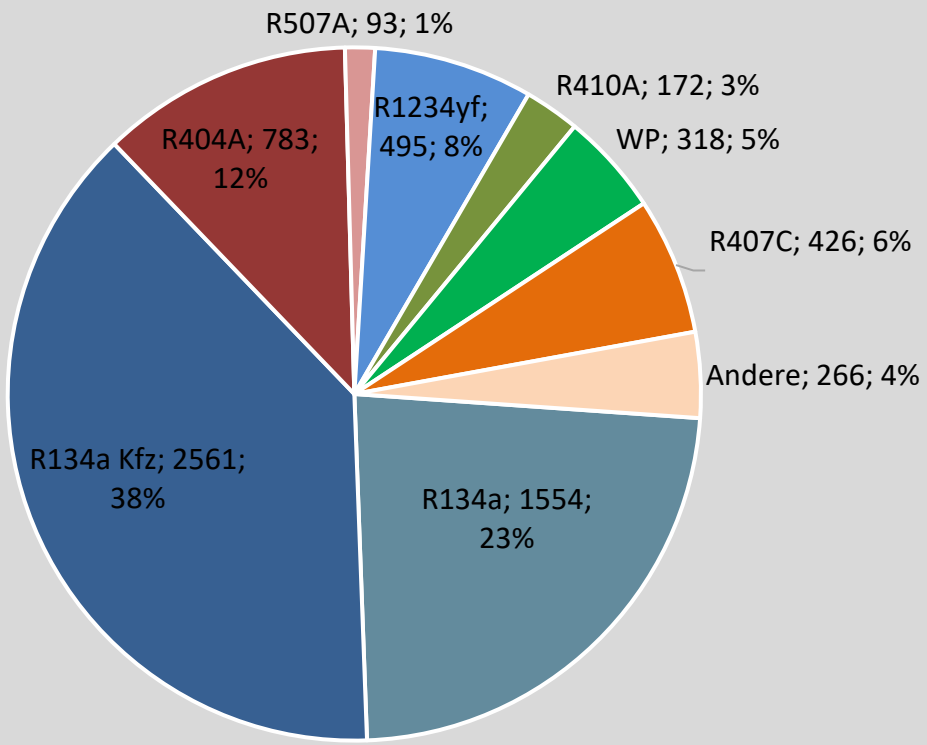
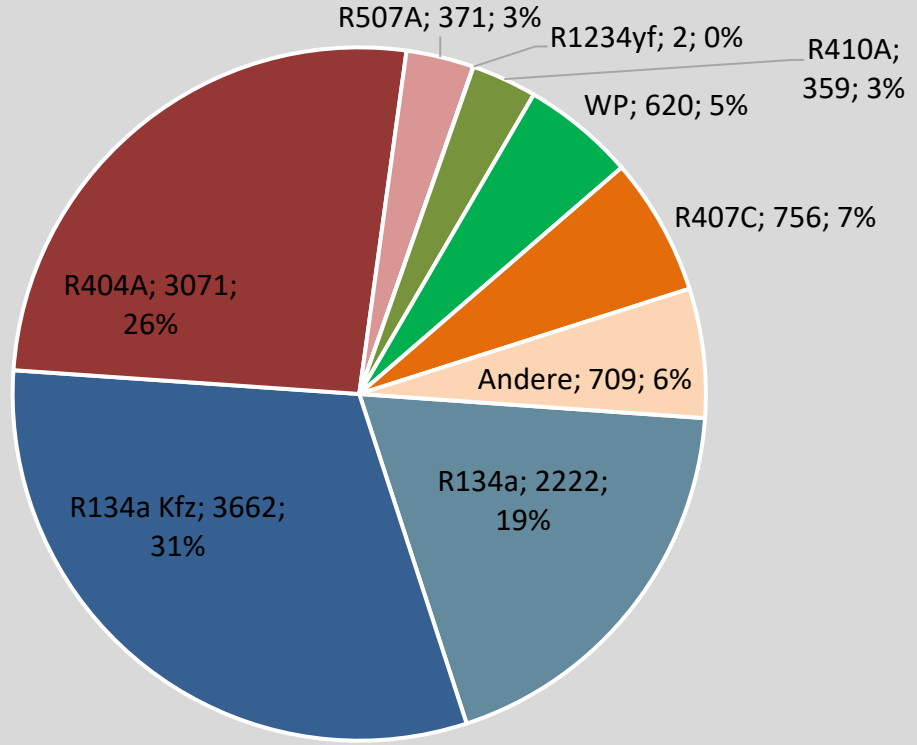
Refrigerant use DE 2016

Share per Ref. / to
Total ca. 6700 to

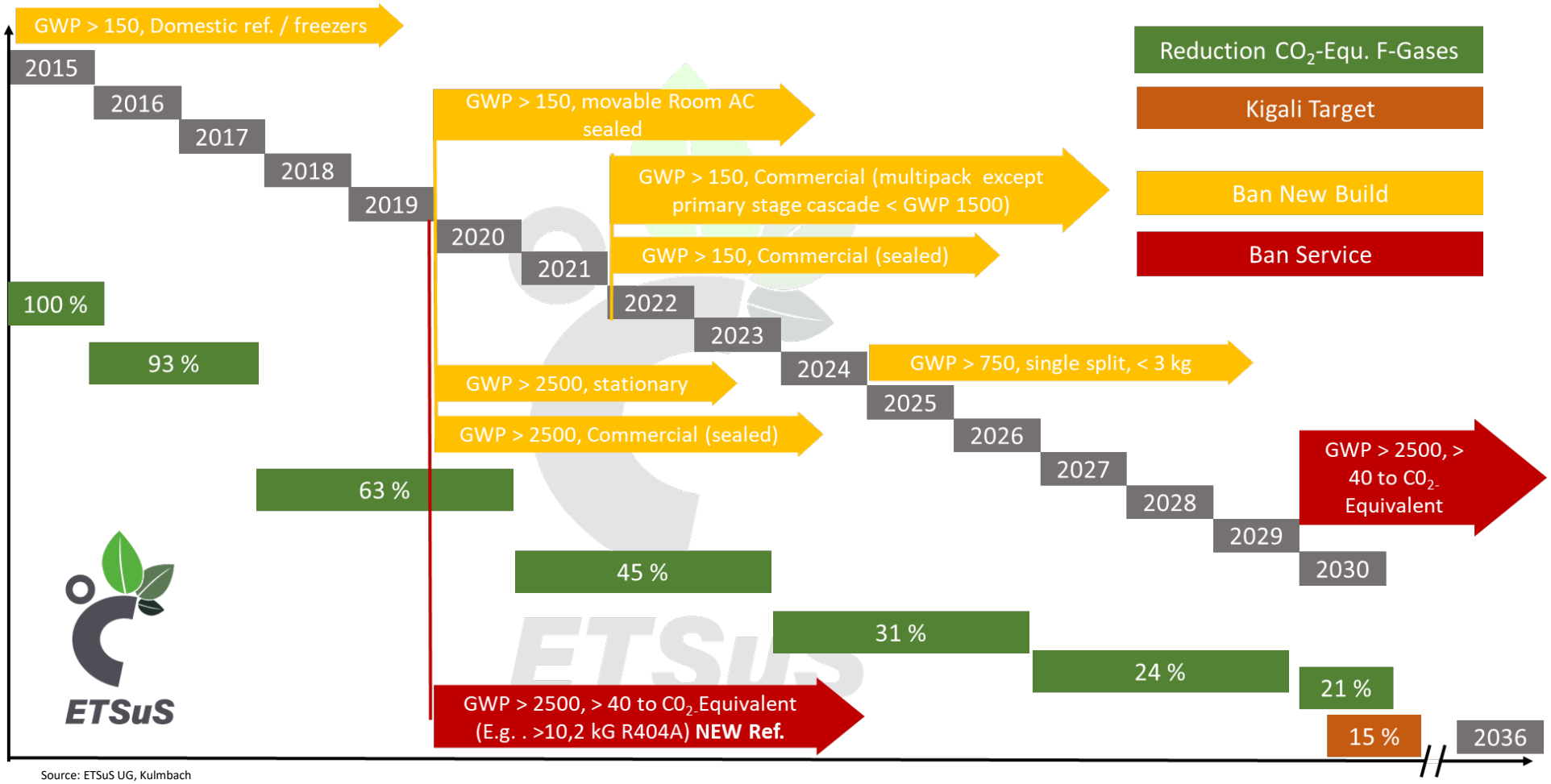


Share per Ref. / 1000 to CO_2-E.
Total ca. 12 Mio. to CO_2-E.



Average GWP 2016:
1776

F- Gas Regulation at a glance



Source: ETSuS UG, Kulmbach

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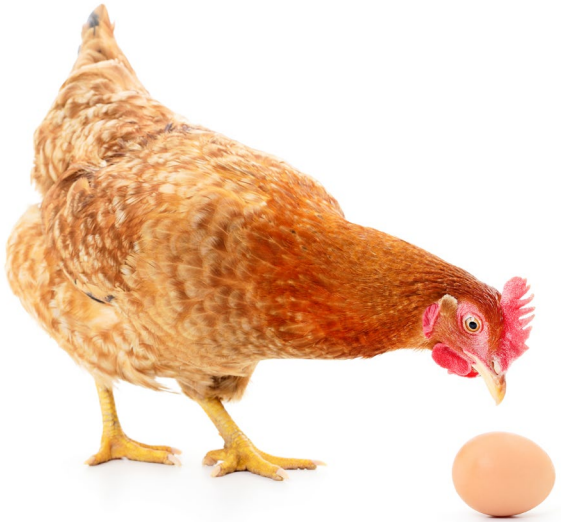
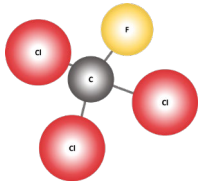
Technological und legal impact



- F-Gase
- ChemG
- (CE)
- …



Fluids

- ErP
- PED
- CE
- …

Components

Application

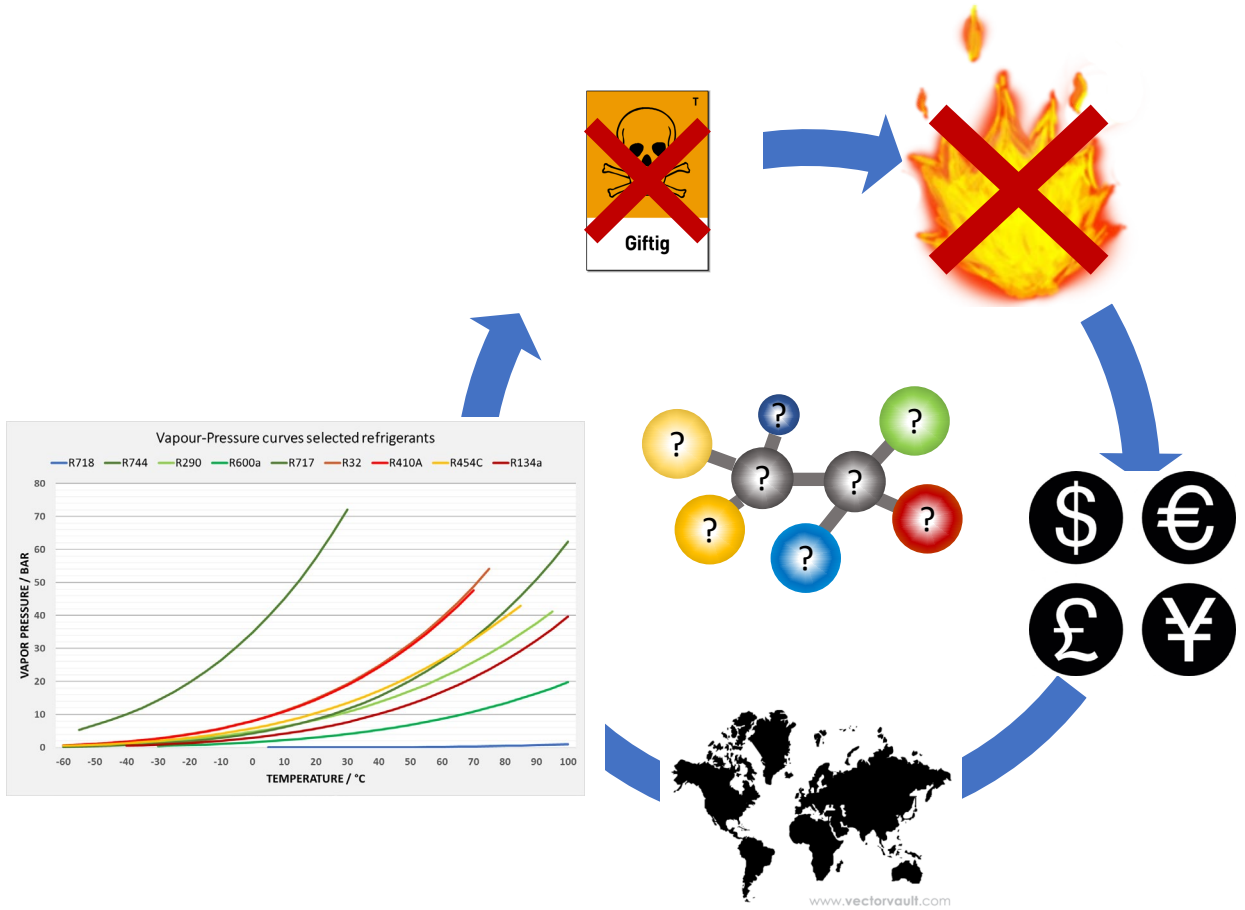
Products

- ArbSchG
- BetrSichV
- (F-Gase)
- …

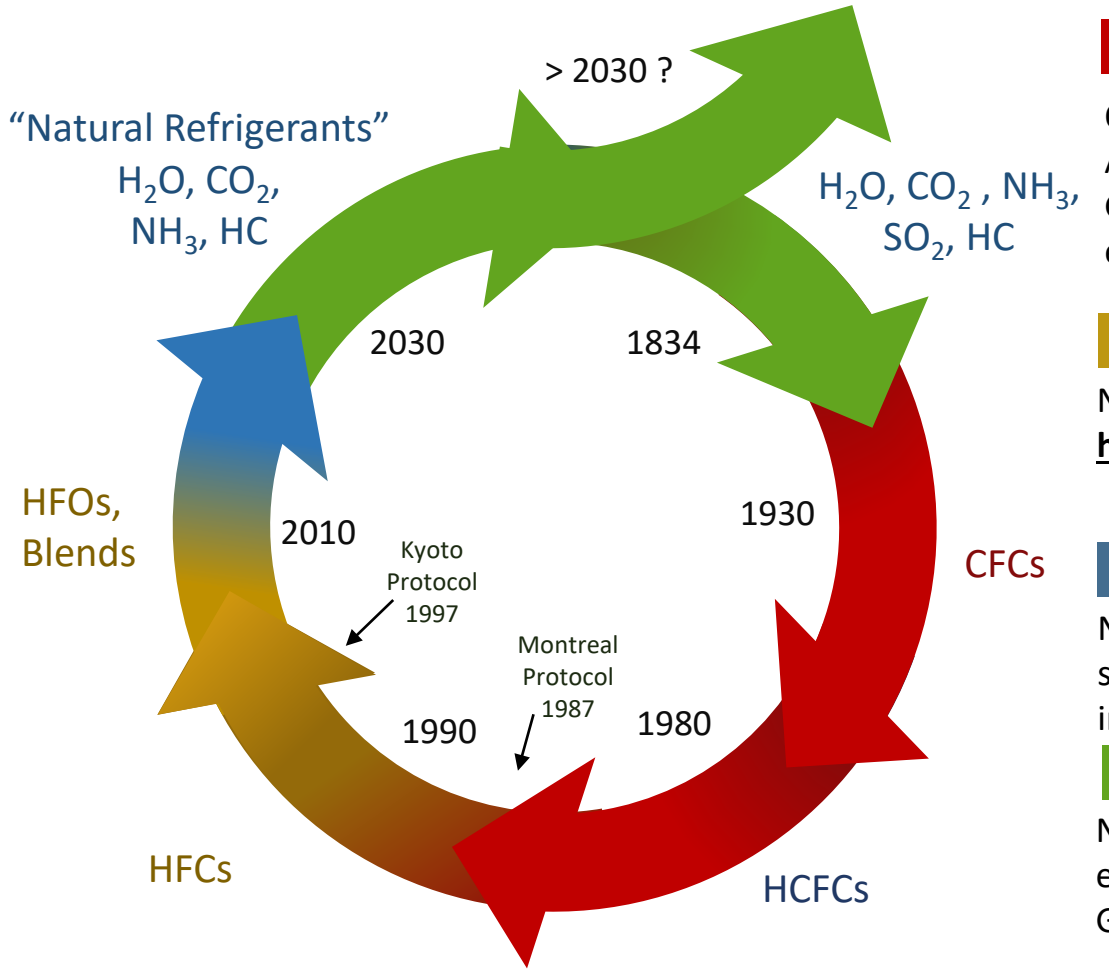
ErP

- PED, MD, LVD
- (ATEX)
- CE
- …

Refrigerants: The ideal choice



Refrigerants – Historical Devlopment



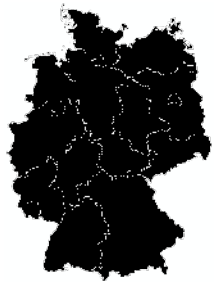
Ozone Depleting Substances (ODS): Artificially substances and significant high Global Warming Potential (GWP) **highest** environmental impact

No Ozone Depletion Potential (ODP), but **high** GWP

No ODP, lower (GWP) artificial substances with **lower** environmental impact

Naturally occurring substances with **lowest** environmental impact, (no ODP and lowest GWP)

Regulatives Umfeld

Product – „CE“	„Humans“	Application	
„Manufacturer „Free Trade..“ GPSD, PED, MD, LVD… Harmonised Standards …EN 378, EN 60335	„Employer“ „OHS“ WSD, WPSD;WES, ATEX-B….	„User“ „Safe Operation“ ErP, F-Gase, EPBD, CPD, CLP, ADR,	
ProdSG, 1., 9., 14. ProdSV ChemG., GefStoffV BImschG,V…	ArbSchG, 15. SozVersG BetrSichV ArbStättV. …	BImSchG, -V EnEV MBO, MVV TB, BRL, MARL	
	TRBS, TRGS ASR DGUV-R	LBO, VStättV, FeuV,...	

A little refrigerant cooking cooking session in the witches kitchen

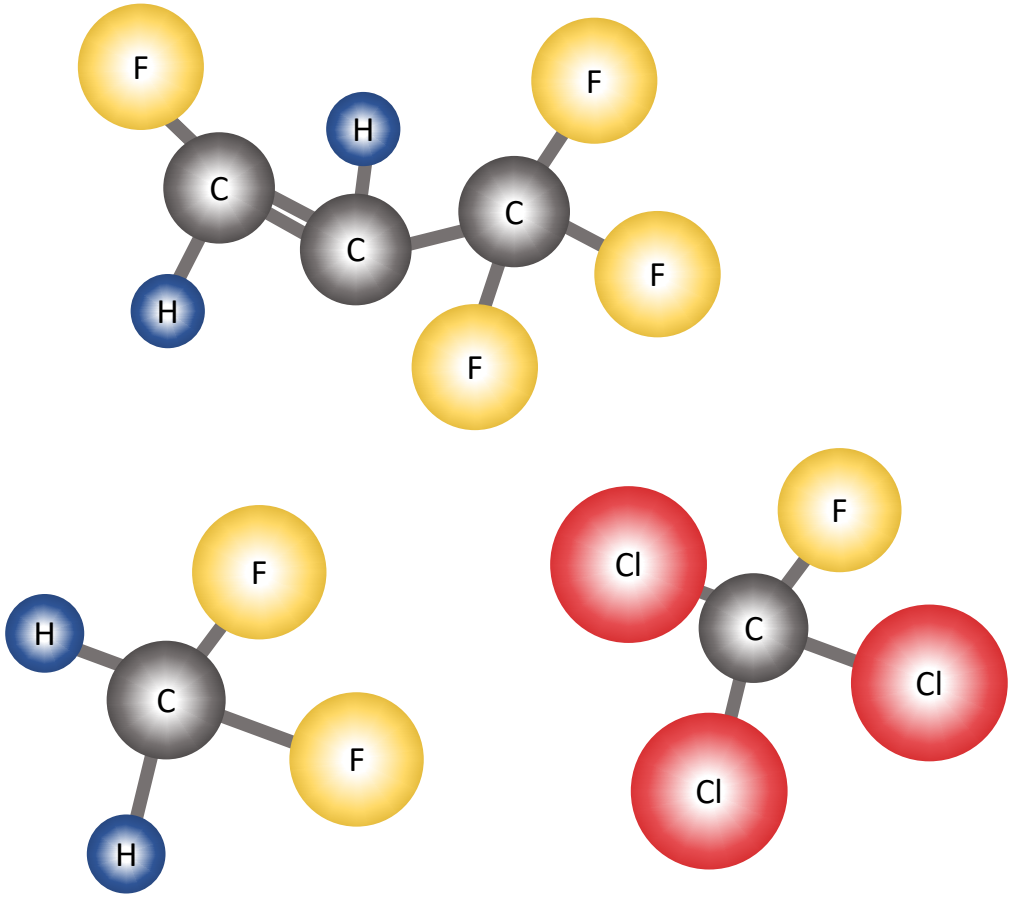
The Safety vs. “Environmental” classification dilemma

Toxicity / Flammability	Lower Chronic Toxicity	Higher Chronic Toxicity
No Flame Propagation	A1	B1
Lower Flammability	A2L	B2L
Flammable	A2	B2
Higher Flammibility	A3	B3

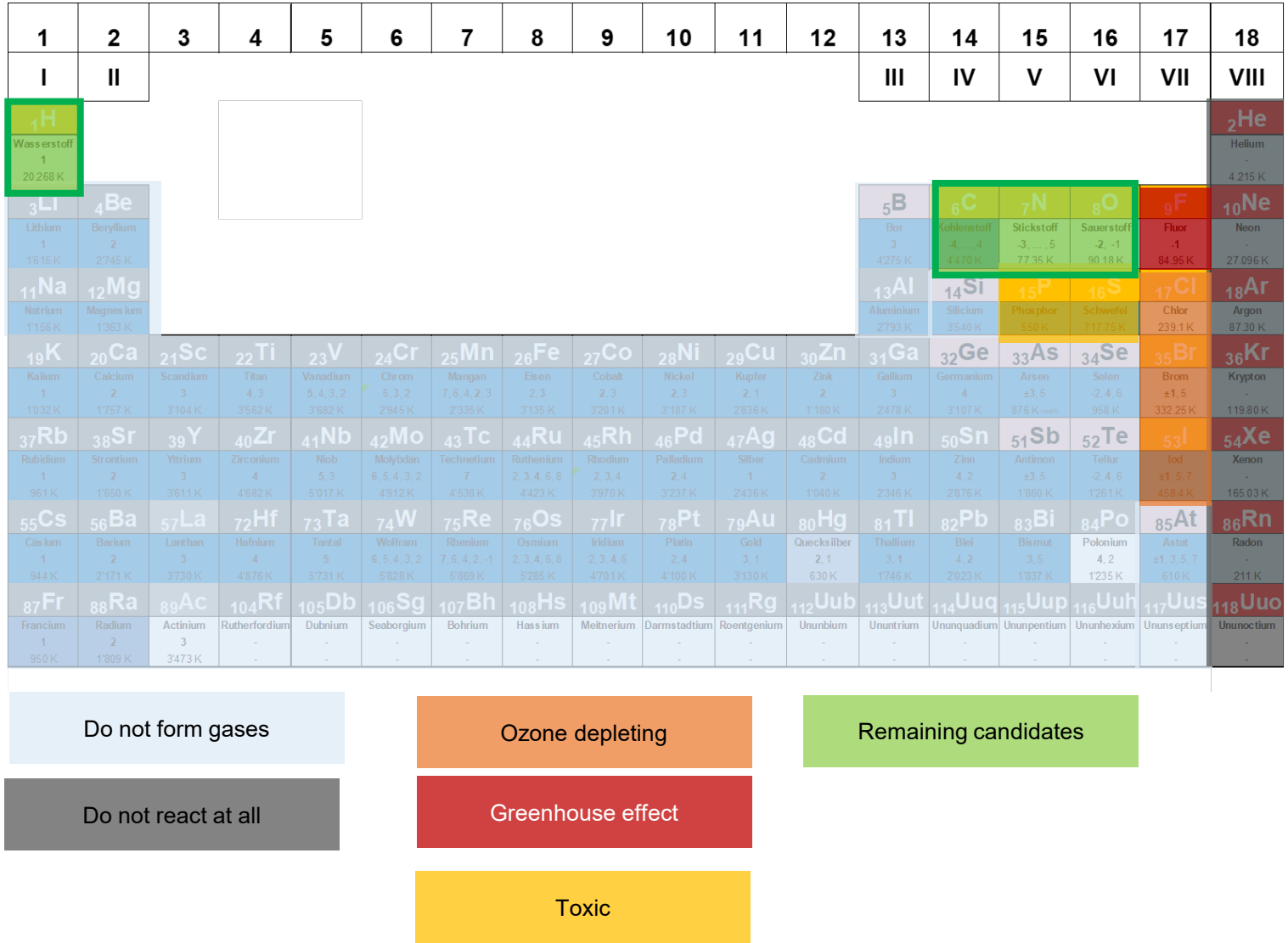
	GWP
Highest GWP	A1
High GWP	A2, A2L
Lower GWP	A2L
Lowest / GDP	A3, B2L, R744

Refrigerants

- CFCs, HCFCs, HFCs
  - R11, R22, R134a, R32, R125
- Mixtures
  - Azeotropic
    - R502, R507
  - Non/Azeotropic
    - R410A, R407C
- HFOs
  - HFO1234yf, HFO1234ze,
- Natural Refrigerants”
  - R744, R717, …
- HCs
  - R290, R170, R600a,

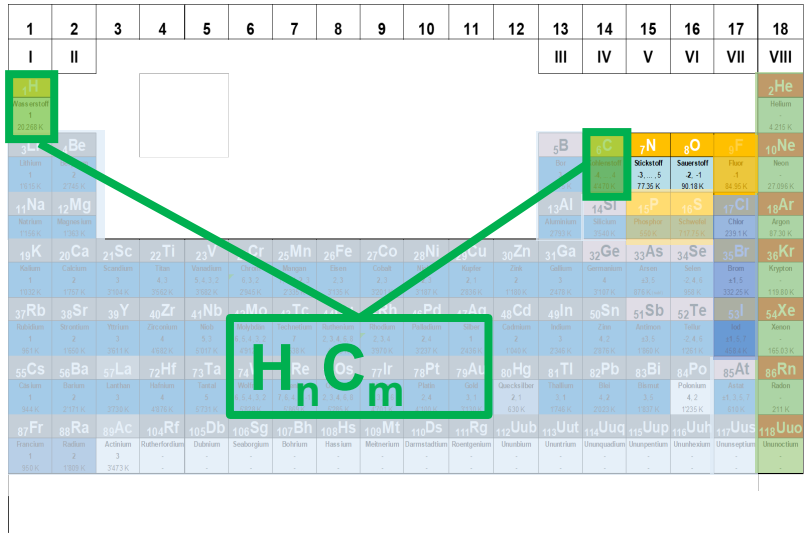


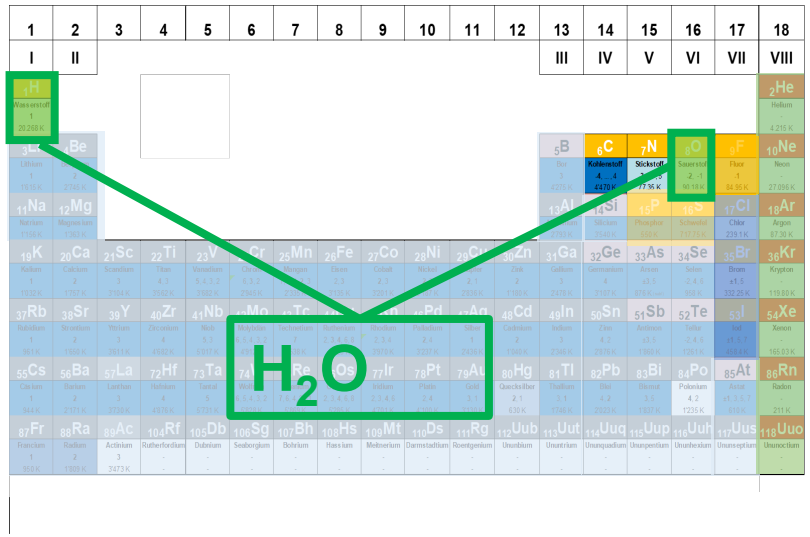
Refrigerant cooking session – the ingredients – What's left?

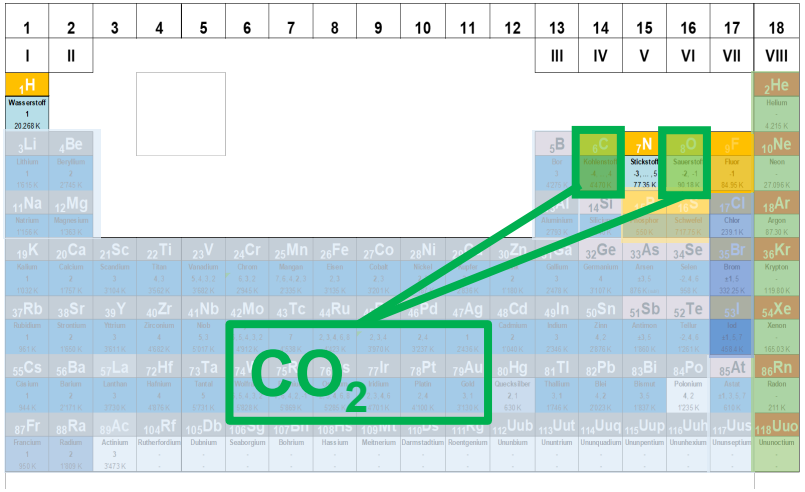


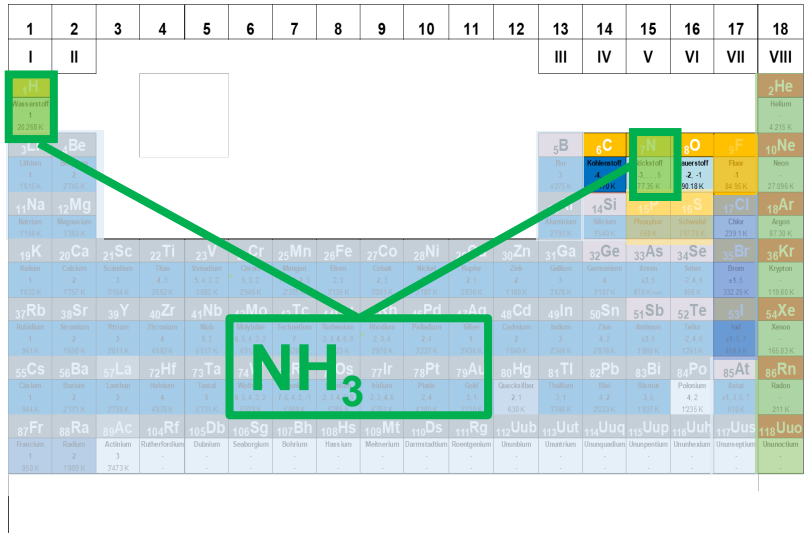
Source: ETSuS UG

Refrigerant cooking session – the ingredients



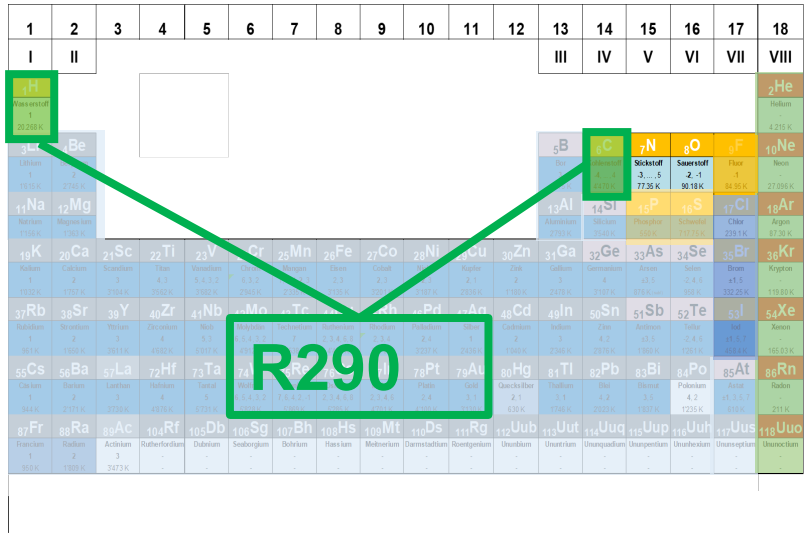


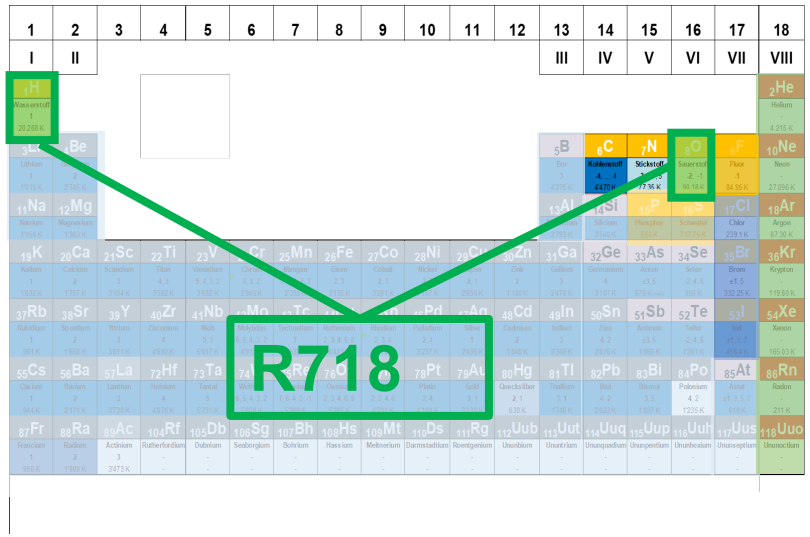


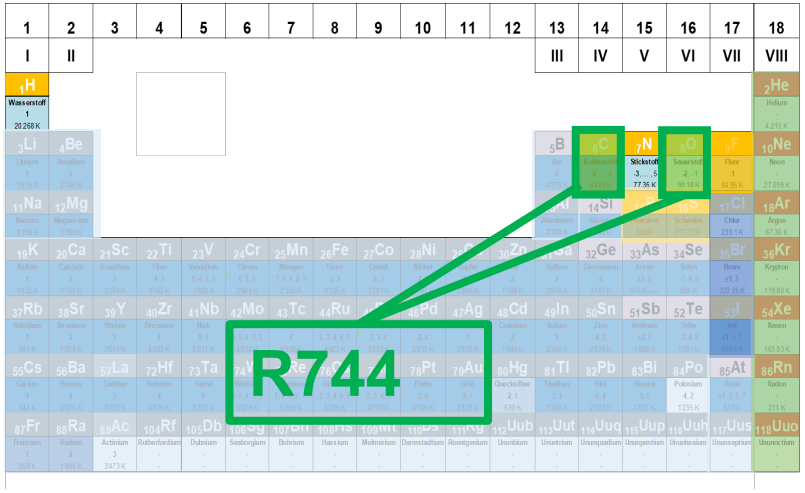


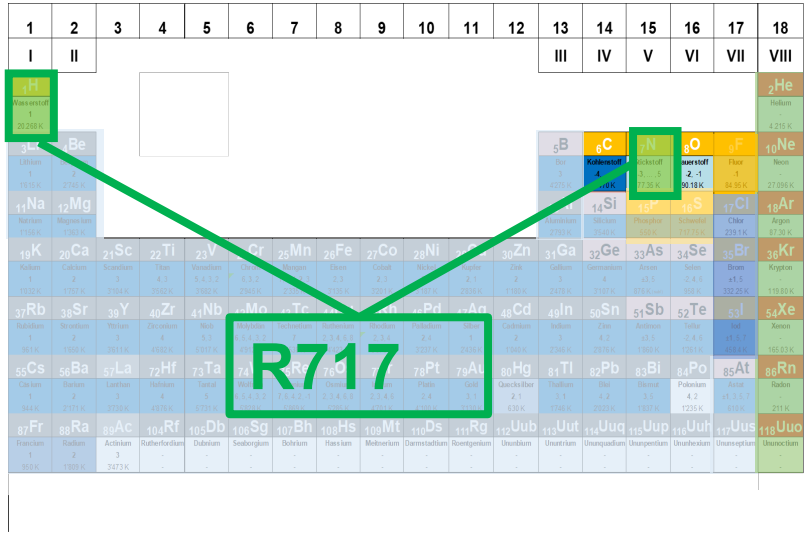
Source: ETSuS UG

Refrigerant cooking session – the ultimate soution









Source: ETSuS UG

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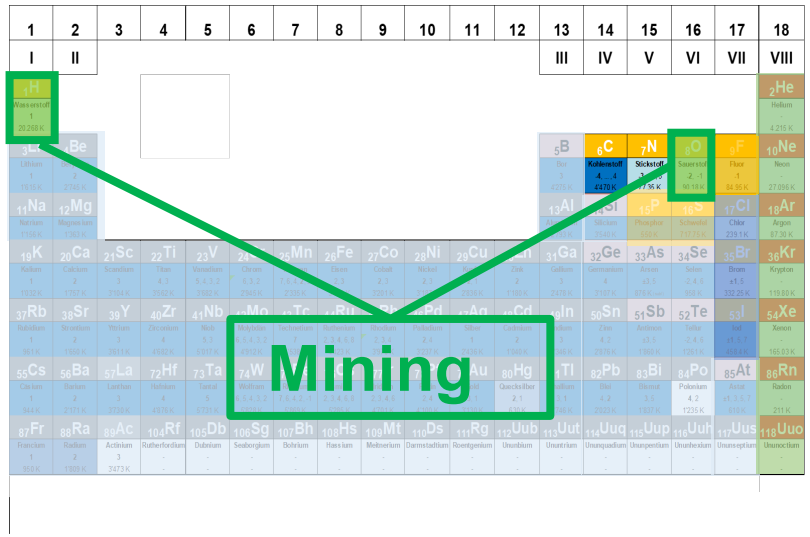

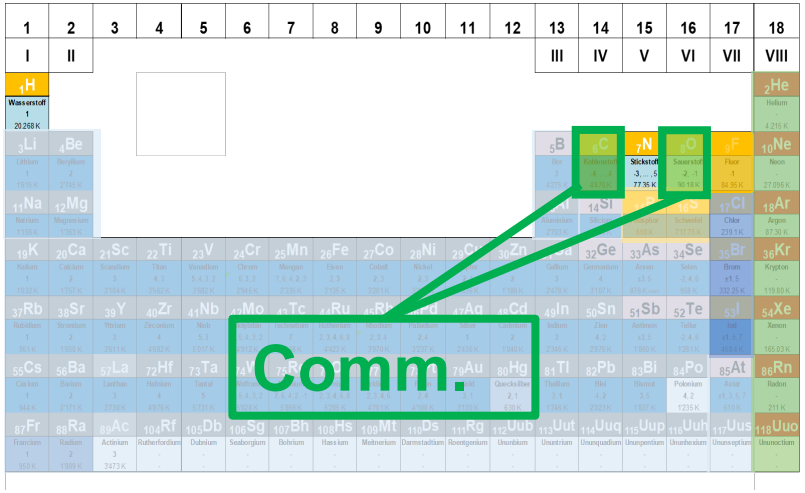

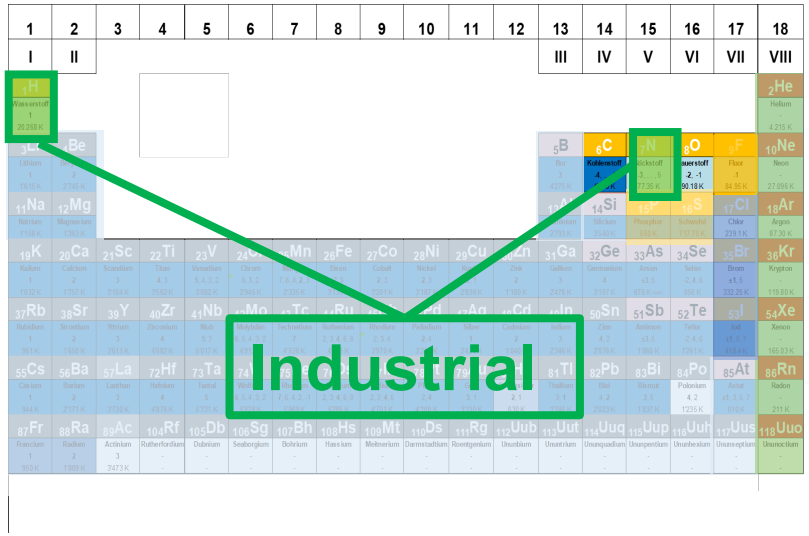

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Thank you for your kind attention.

Contact

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