Bring ideas to life
VIA University College

DES M1
Design of Energy Systems

Lecture 3

Refrigerants properties

Regulation / Natural refrigerants

Find data for refrigerants

	R134a	R404a	R717	R744
Type/name	HFC	HFC	Ammonia Natural	CO2 Natural
Critical point (^{0}C)	100,95	71	132.2	31
Normal temperature range (^{0}C)	´-28/90	-47/50	-40/120	-30/120
Specific latent heat (KJ/kg) for evaporation at -10 ^{0}C	204	180	1249	445
Pressure (Bar) at 40 ^{0}C and -10 ^{0}C	10/2	18/4.5	15.4/2.9	26/100
COP, 40/-10 ^{0}C (η=1)	4.03	3.2	4.29	3.31 (25C)
Safety issues	-	Explosion	Flammable(theoretic) and toxic	-
Environmental issues: GWP/ODP	1430/0	3922/0	~0/0	1/0

	R22	R134a	R404A	R600a	R717	R744
Type/name	HCFC Freon22	HFC	HFC	HC Isopro-pane	Natural Ammonia	Natural CO_2
Critical point (^{0}C)	96	101	72.1	135	132	31
Normal temperature range (^{0}C)	-20 to 90	-25 to 95	-5 to 60	-10 to 130	-35 to 130	-20 to 30 Transcritic al: 35
Specific latent heat (KJ/kg) for evaporation at -10 ^{0}C	212	205	176	364	1300	259
Pressure (Bar) at 40 ^{0}C and -10 ^{0}C	15/3.5	10/2.0	18/4.3	5.3/1.1	15/2-9	26/(90)
COP, 40/-10 ^{0}C (η=0,75)	3.08	3.02	3.5	3.09	3.22	
Safety issues				Flammable	Flammable toxic, corrosive	Toxic
Environmental issues: GWP/ODP	1810/ 0.055	1300/ 0	3260/ 0	3/ 0	0/ 0	1/ 0

The ideal refrigerant, 1

1. Best possible COP
2. Price and service costs, leakage??
3. Highest possible latent heat pr. kg circulated refrigerant
4. Suitable evap/condensing pressure and low discharge temperatur
5. Chemically stable
6. Not aggressive towards the materials used in the refrigeration system
7. Not react with oil
8. Critical pressure must be well beyond the calculated condensing pressure

The ideal refrigerant, 2

9. Not be flammable
10. Available at reasonable costs
11. Easy to spot leakages
12. Compressible at low energy consumption
13. Not freeze at the evaporating working temperatures
14. Not be harmful to people and environment
15. Low GWP and no ODP (Political issues)

Refrigerants
Required physical properties(1)

High latent heat for evaporization

- high ► high q_0 ► low q_{mR}

Specific volumetric capacity q_0/V

- high ► smaller compressor

Vapour pressurer

- higher than P_{atm} ► avoid leakage into system of air and moisture

Condensation pressure

- low ► reduce wall thickness in pipes (!! To a certain extent)
- below critical point (except for R744)

Refrigerants
Required physical propoties(2)

Pressure ratio

- low ►low energy consumption

Freezing point

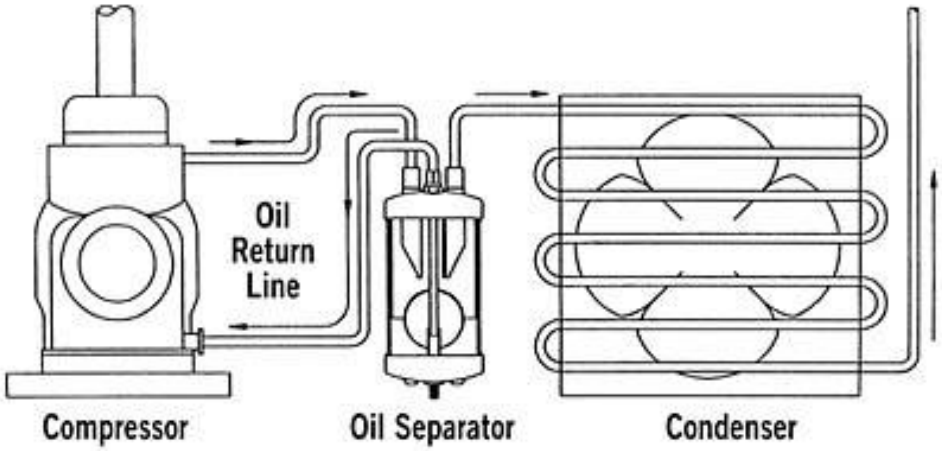
- Significantly lower than t_0

Dynamic viscosity

- low ►reduce pressure drop in liquid pipes

Refrigerants
Oil solubilty in refrigrant

- Oil absorb refrigerant and thus reduce the viscosity, which affects the lubrication of the compressors
- Can reduce heat transmission in heat exchangers
- Low solubility is preferred(Yes and no)



Refrigerants
Water solubilty in refrigrant

- Water in refrigerant can freeze or cause corrosion
- Water in refrigerant plant must be avoided at all costs, blocks up valves and potential filters and get stuck in evaporators

Refrigerants
Health & Safety

- Toxic
- Corrosion
- Panic reactions (smell, mainly R717)

- Safety precautions

Refrigerants
Flameable refrigerants

- HC refrigerants: Propane (R290), Isobutane (R600a), Propylene (R1270)
- Safety precautions
- Small quantity of refrigerant
- Chillers (in combination with seconday refrigerant)

R12, R11, “Freon”
Meets all technical demands, but have very negative impact on environment

GWP: 2400/4000
ODP: 1

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10 September 2014 Last updated at 23:49 GMT

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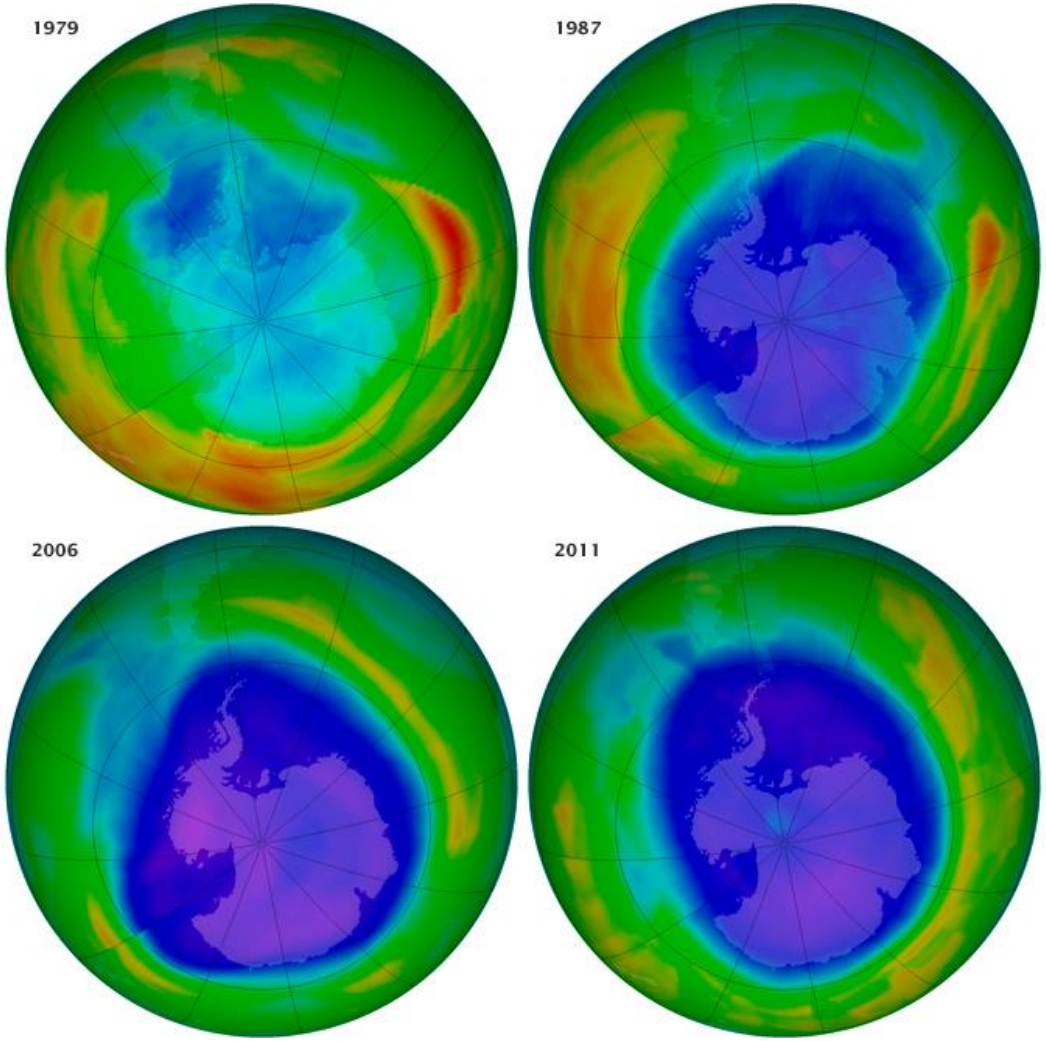
Ozone layer showing 'signs of recovery', UN says

Environmental impact
Ozone hole

1979



1987

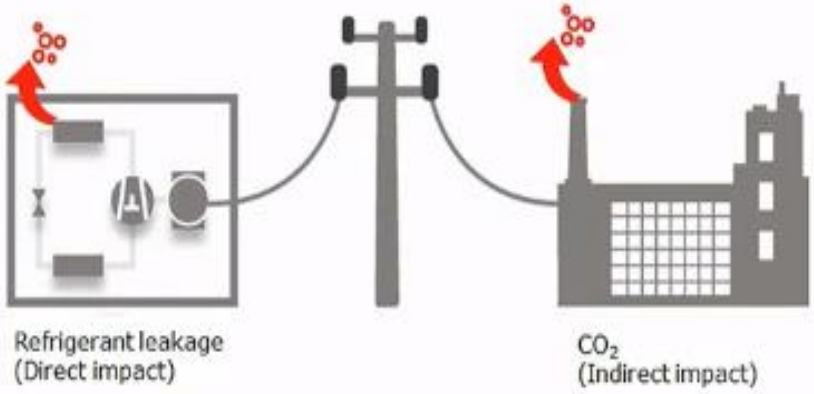
2006

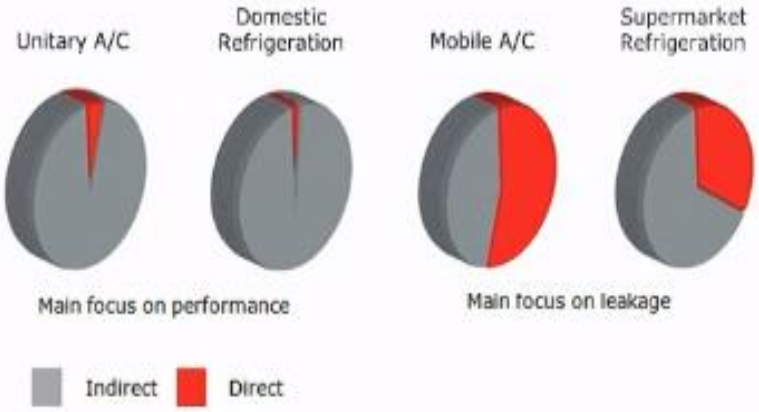
2011

Refrigerants and environment

TEWI = Direct Emission + Indirect Emission

- TEWI (Total Equivalent Warming Impact) is one of the most important ways to quantify emissions
- Minimising TEWI will reduce global warming
- Different types of applications have different composition of TEWI
- Supermarkets are one of the most critical direct emission sources





Proporties for carbon chain based refrigerants

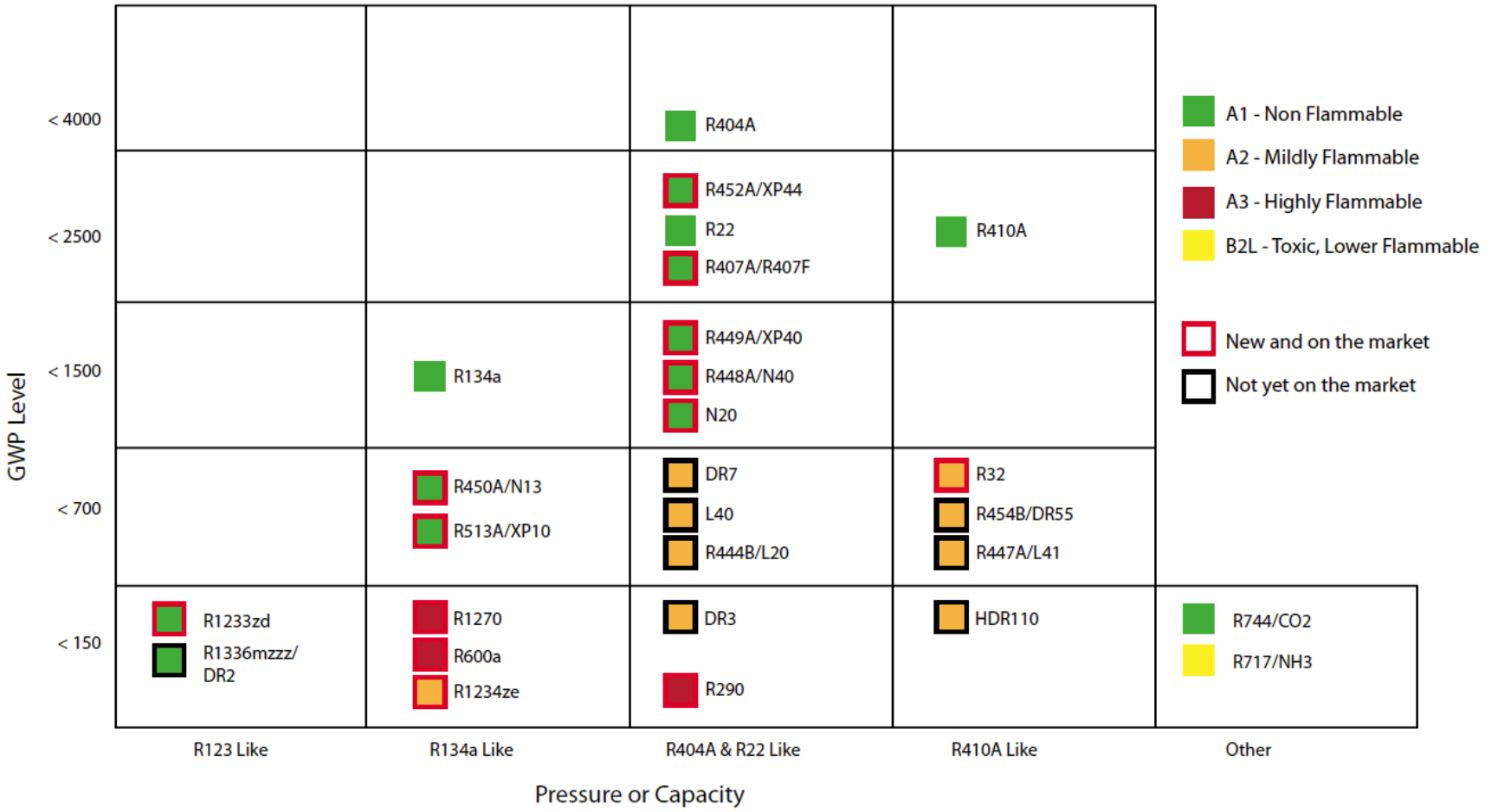
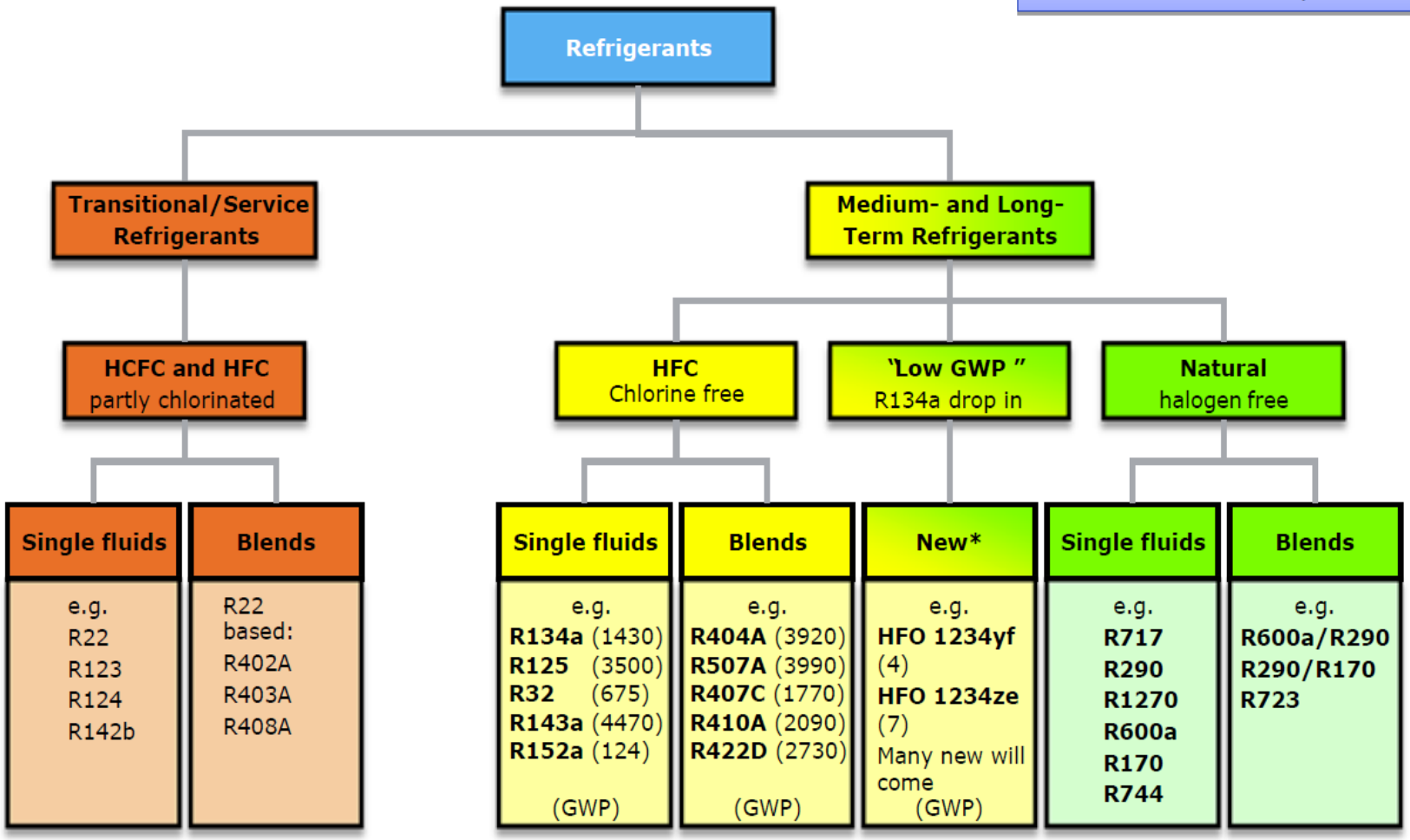


Figure 7: Carbon Chain Based Refrigerants (HCs, HFCs, HCFCs)

Refrigerants Options

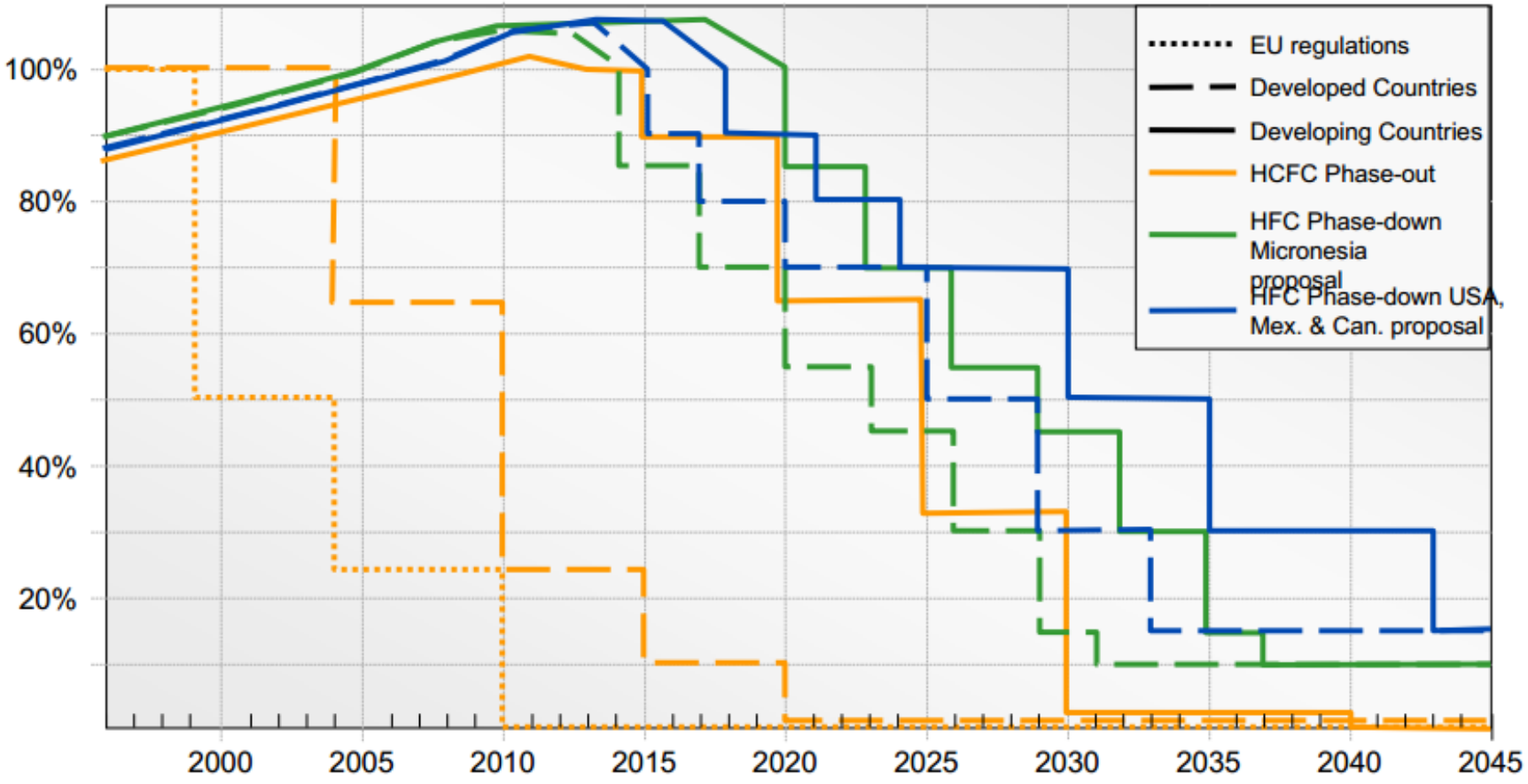
Many of the new refrigerants are flammable or mildly flammable!



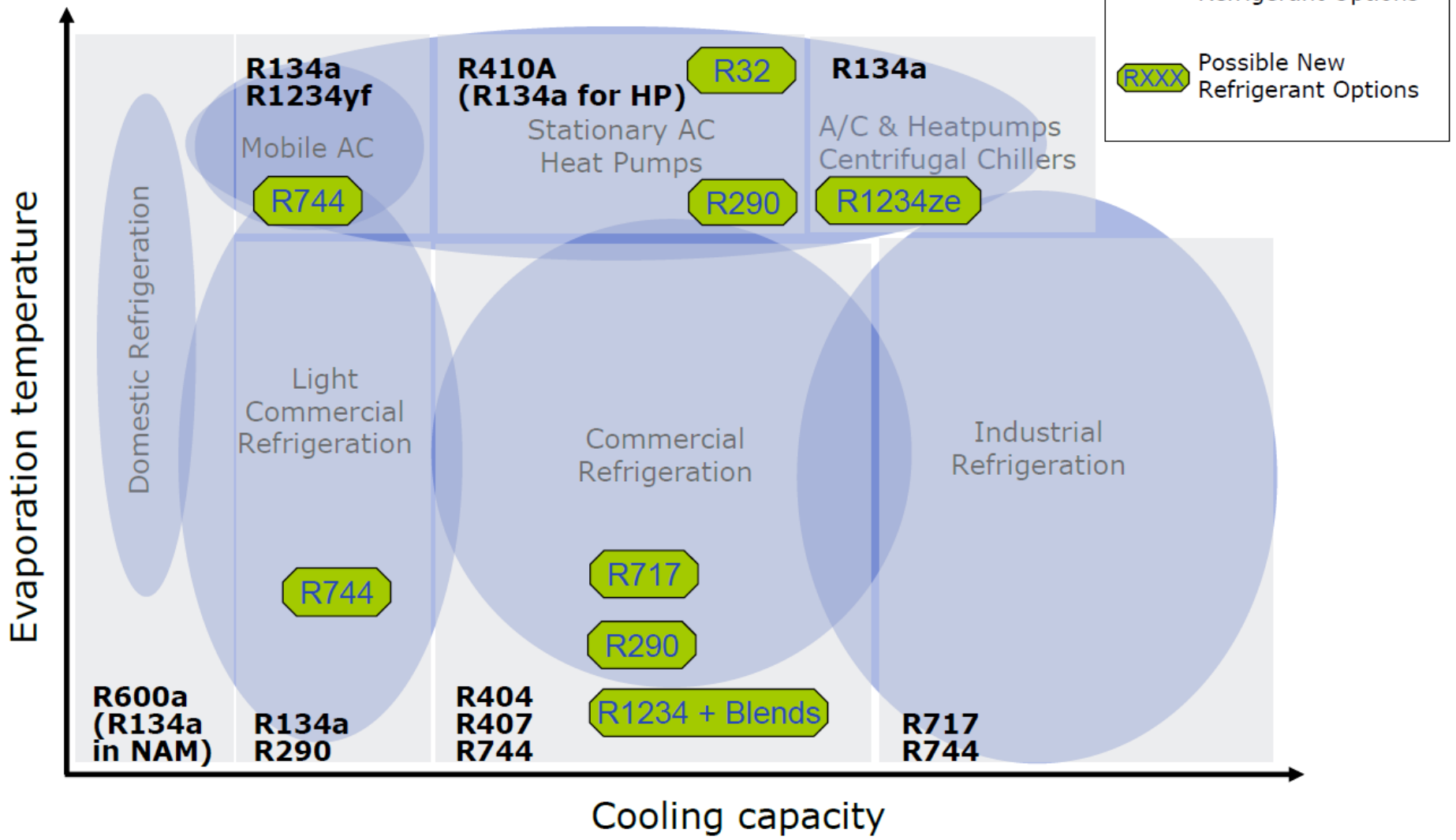
The choice of the refrigerant has an impact on the (energetic) systems performance and reliability (GWP in brackets)

Regulatory – Phase-down/out Schedules and Proposals

Conclusion: HFCs are under pressure (The question is when?)



Applications & Main Refrigerants



Natural refrigerants

Ammonia, R717

CO_2, R744

HC, eg. Propane, Isobuthane

Natural refrigerants

Annex 1. Refrigeration properties

Refrigerant	R22	R134a	R404A	R410A	R717 (NH_3)	R744 (CO_2)	R290 (propane)
Efficiency						 */  **	
Safety							
Environment (ODP, GWP)							
Pressure & temperature							
Chemical properties							
Economic aspects	 /  ***	 /  ***	/ ***	/ ***			
Availability	/						
Typical applications	All	light commercial, commercial, A/C	commercial	commercial, heat pumps, A/C	commercial & industrial refrig-eration	light commercial, commercial, in-dustrial, transport, HP	domestic, light commercial, commercial, heat pumps

** Some refrigeration applications*

*** Heat pumps, secondary media, and some refrigeration applications*

**** Higher taxes (Nordic countries)*

If you want to learn more:
Refrigerants from a Danfoss Perspective

https://www.youtube.com/watch?v=B7AvCE9FAX4
https://www.youtube.com/watch?v=I2otsot38FM
https://www.youtube.com/watch?v=T8fsESff4Gk
https://www.youtube.com/watch?v=T8fsESff4Gk
https://www.youtube.com/watch?v=ko9gfcCaluk