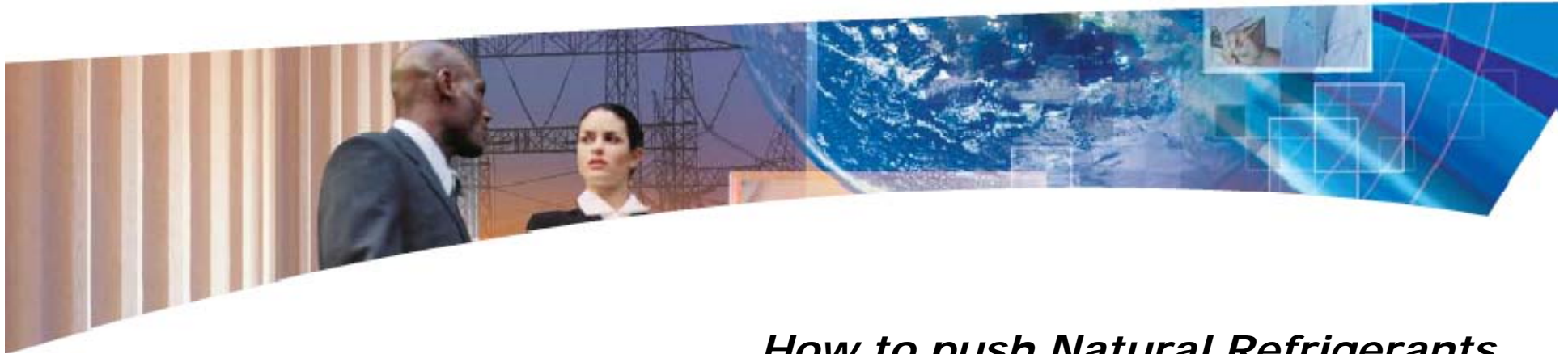


MAKING MODERN LIVING POSSIBLE

Danfoss



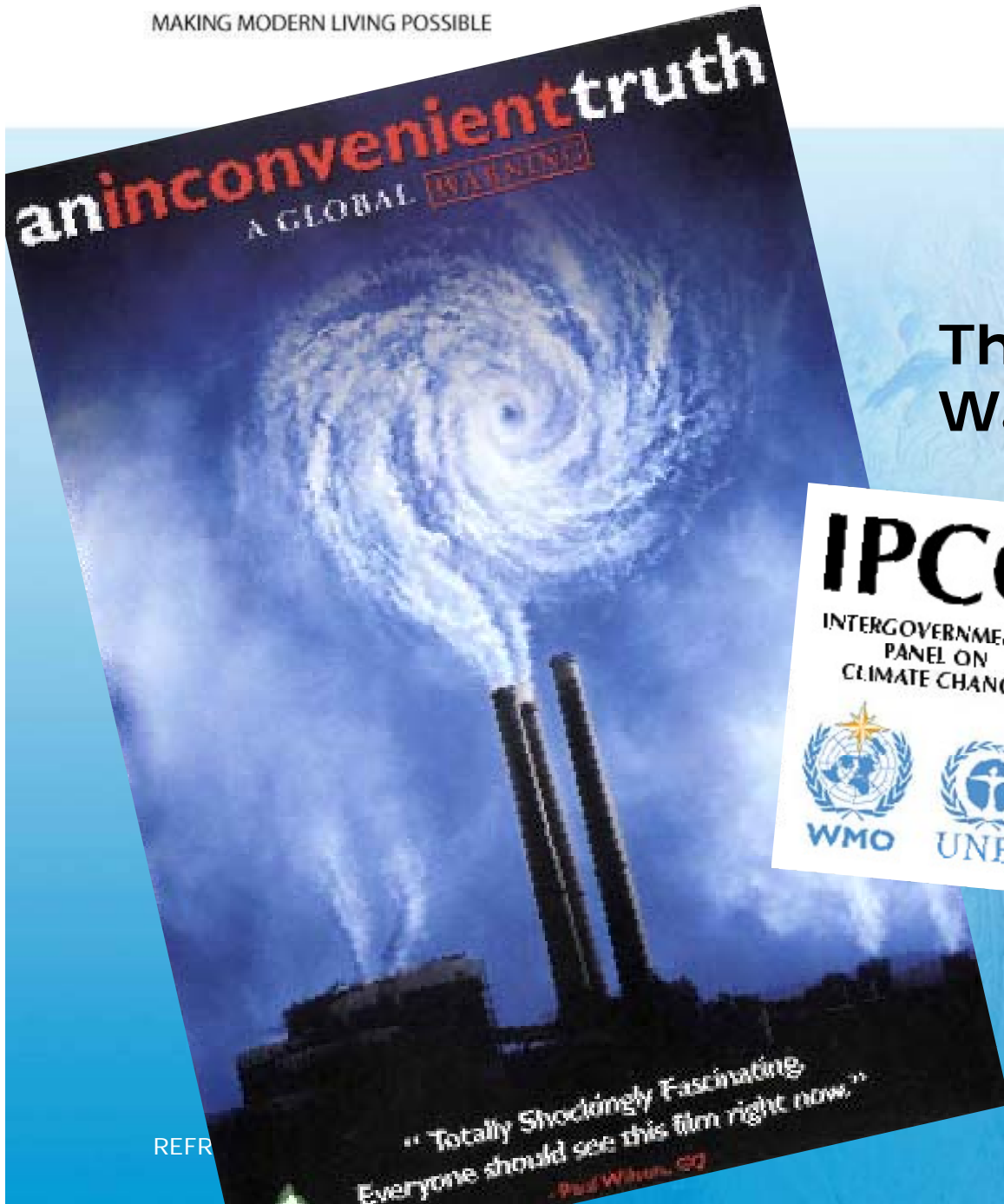
***How to push Natural Refrigerants
in the Natural Way...
(otherwise they should not make it)***

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VP R&D

Brussels, 27th Oct 2010



The Global Warming issue ...



... there is money in it ...



The two types of contributions...

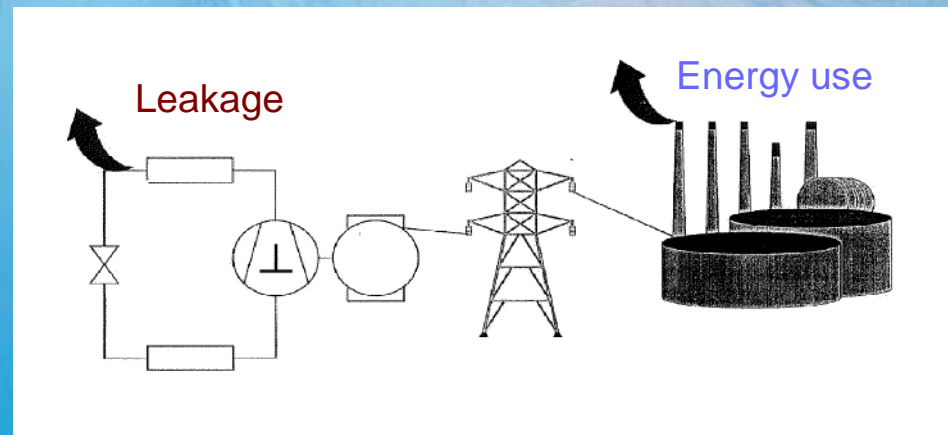
Energy use for system operation
"Indirect Emissions"

Refrigerant leakage/release
"Direct Emissions"

- ~~• Mobile Air Conditioning (HFC)~~

MAC DIRECTIVE
2006/40/EC

- Commercial Refrigeration (Supermarket DX HFC)
- Unitary Air Condition/Heat Pump (HFC)
- Commercial Air Condition (HFC)
- Light Commercial Appliance SME (HFC)
- Water Chiller (HFC)
- Domestic Refrigerator (HFC)
- Domestic Refrigerator (HC)





Refrigerants options

Table of Selected Radioactive Isotopes

GROUP	IA	IIA	IIIA	IVA	VIA	VIIA	VIIIA	IB	IIB	IIIB	IVB	VB	VIB	VIIIB	VIII
1	1.00794														
3	6.941	4	9.01218												
11	11.00877	12	24.305												
19	39.0983	20	40.08	21	44.9559	22	47.90	23	50.9415	24	51.996	25	54.9380	26	55.847
39	88.9059	40	91.22	41	92.9064	42	95.94	43	98.91	44	101.07	45	102.91	46	104.91
55	132.9054	56	137.33	57	138.9055	72	173.45	73	180.9479	74	186.207	75	188.207	76	190.23
87	223	88	226	89	227	104	209	105	209	106	209				

only 8 elements are really suitable for refrigerant molecules

more flammable

more toxic

Transitional/Service Refrigerants

HCFC and HFC partly chlorinated

HFC Chlorine free

“Low GWP” R134a drop in

Natural halogen free

Refrigerants

Medium and Long Term Refrigerants

Single fluids

Blends

e.g. R22, R123, R124, R142b

R22-based: R402A, R403A, R408A

e.g. R134a, R125, R32, R143a, R152a

e.g. R404A, R507A, R407-series, R410A

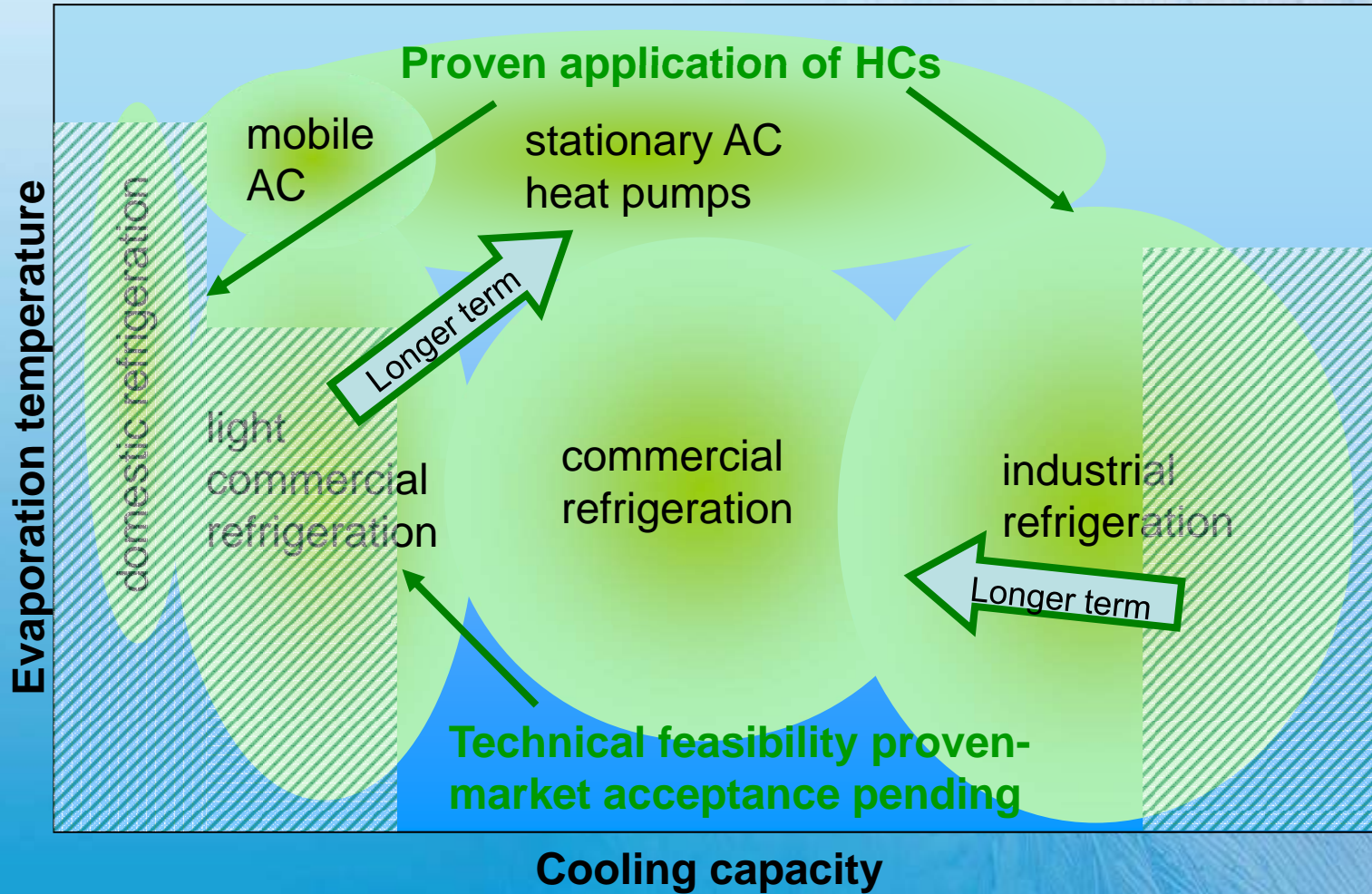
e.g. Blend H, Fluid DP-1, Auto AC-1, R1234yf

e.g. R717, R290, R1270, R600a, R170, R744

e.g. R600a/R290, R290/R170, R723



The HC refrigeration application map



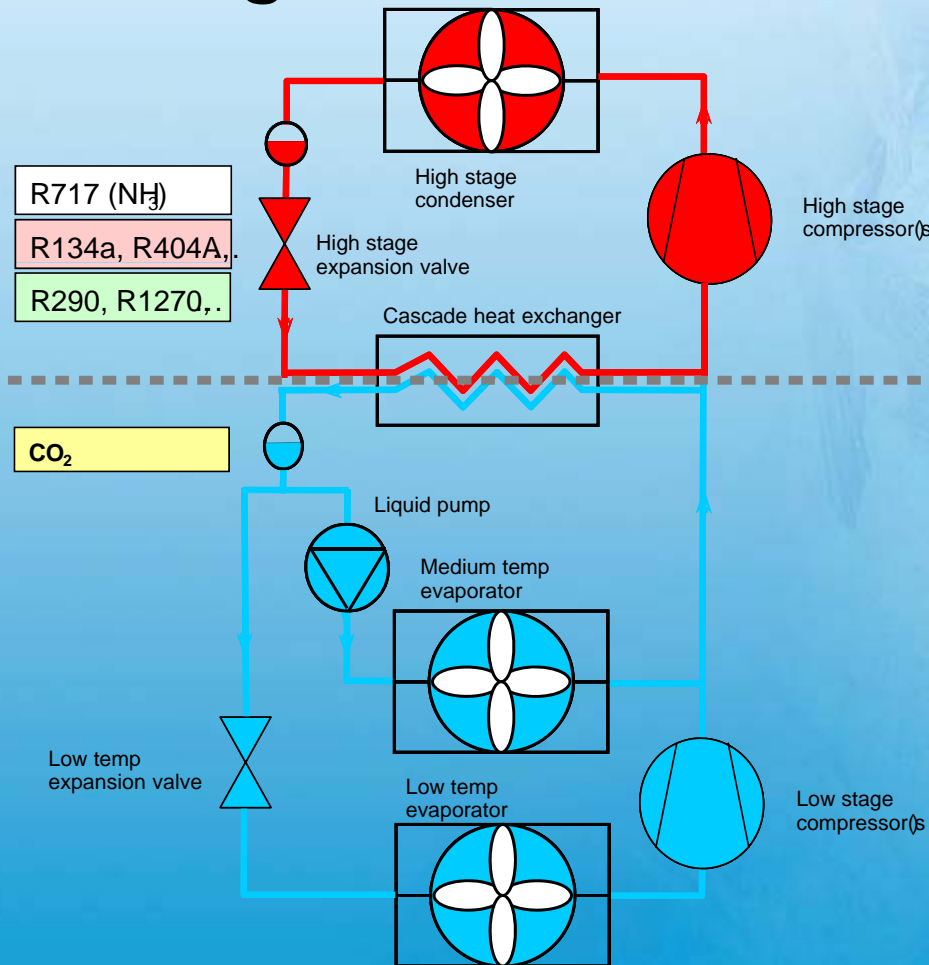


CO₂ Status Bottle Cooling & Automotive

- Depending on the component selection, the system layout and the actual cooling requirement CO₂ systems can be better, equal or worse than HFCs ones.
- But with increasing ambient temperature the COP of CO₂ systems generally drop faster..
- Aiming for one global refrigerant/solution



CO₂ Status Supermarket/Industrial Refrigeration



- Direct GHG emission from the cooling distribution system calls for an alternative solution
- Cooling generation with CO₂ has energetic drawbacks in rather warm climates, but otherwise...
- Cascade systems build on state of the art technology and are globally applicable

Ammonia (already well established...)



1. Ammonia is a excellent in various ways ...

1. Environmental benign
2. High efficiency in a relative big temperature range
3. Huge experience base

2. But due to Ammonia's toxicity some requirements have to be full filled:

1. Safety requirements to be implemented for large systems
2. Limitation of ammonia charge in several locations

How to push natural refrigerants further?



Liability:

1. Eliminate liability barriers in a responsible way

Technology:

1. Apply minimal refrigerant charge technologies
2. Set highest system efficiency standard based on technologies using natural refrigerants
3. Enhance safe (and efficient) operation by adding intelligence/electronics to systems

⇒ More refrigeration capacity out of less refrigerant mass in more energy efficient and safe systems...