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Haute Ecole d'Ingénierie et de Gestion
du Canton de Vaud

Patent PCT/CH2007/000189

CO_2 Hydrate Slurry Production & Distribution

Nestlé

AXIMA Refrigeration
suez

suisse énergie

KTI/CTI

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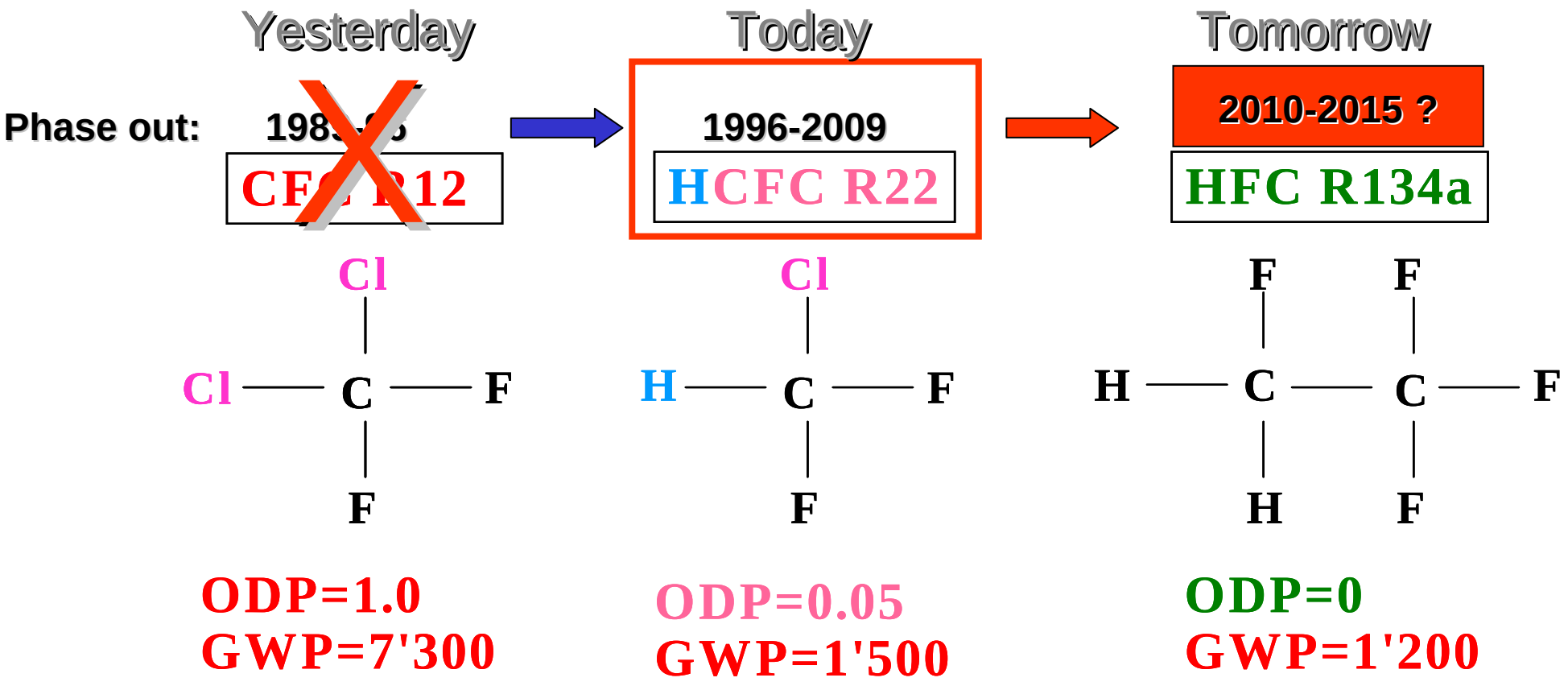
HCFC and HFC issues



ODP = **O**zone **D**epletion **P**otential GWP= **G**lobal **W**arming **P**otential

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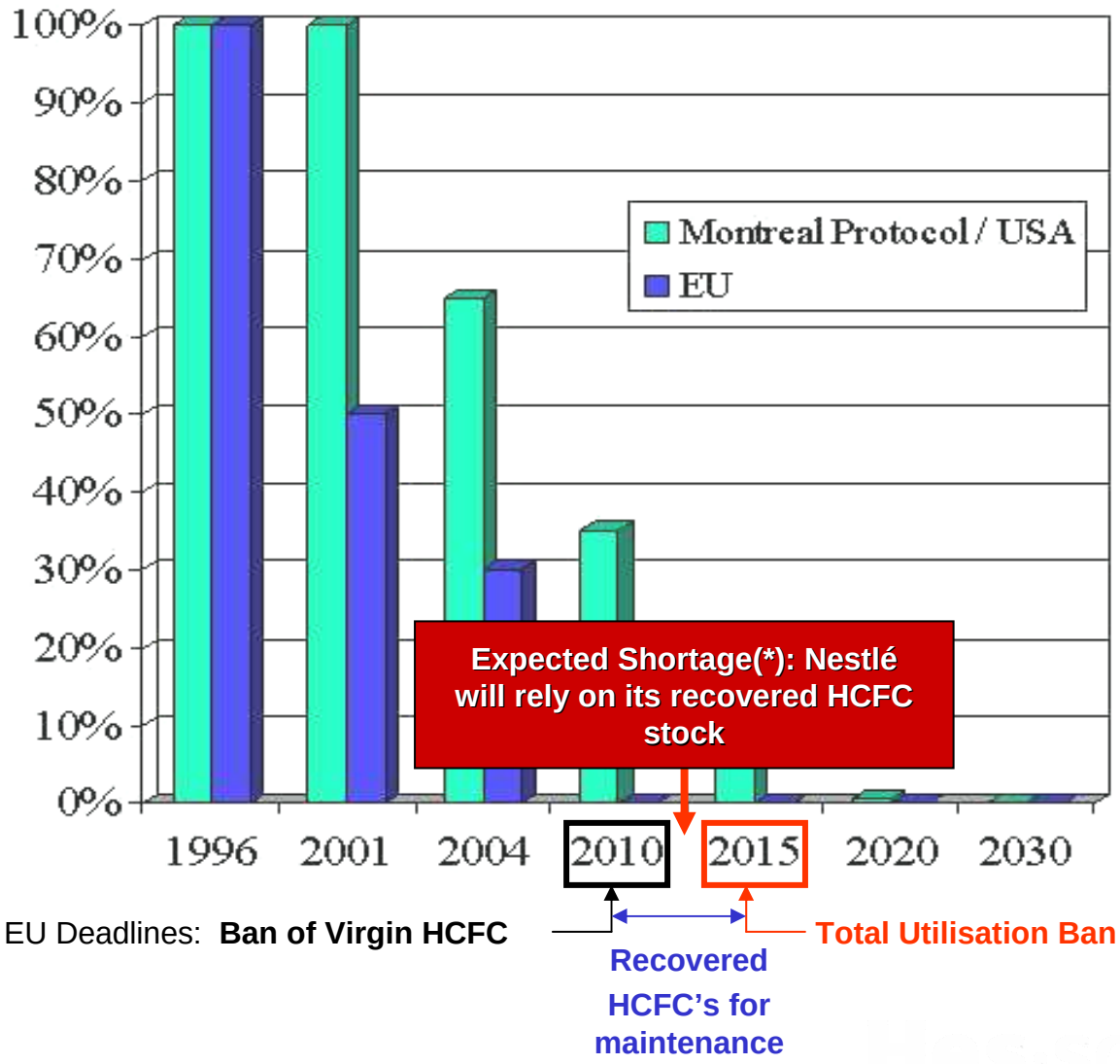
Ozone Depletion issue
Legal Obligation to phase out HCFC

We successfully lobbied against a tentative to bring dates forward



(*) based on a solid French report

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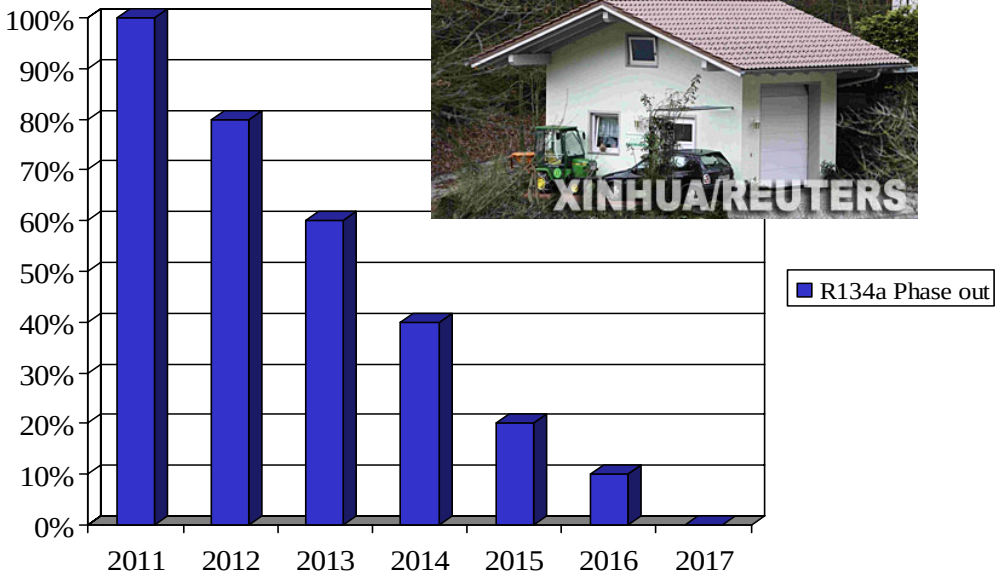
Global Warming issue (Kyoto Protocol)

1) **Denmark** and **Austria** have set HFCs ban from 2008. If successful, this will set a **precedent**.

2) *31 December 2008* - EU Commission to review F-gas regulation *(containment is expected to fail).*

3) HFC ban is voted for car air conditioning (<150 GWP)



Probability for HFC ban in the EU is high

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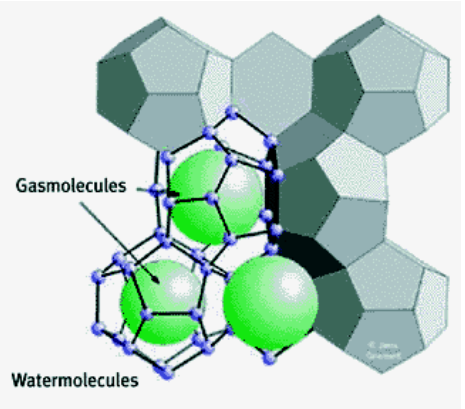
CO_2 Hydrates



- **$CO_2 + nH_2O \rightarrow CO_2$ Hydrates + ΔH**
- **The value of pure CO_2 hydrate dissociation enthalpy is an approximately 500 kJ/kg**
- **1.5 times higher than that of ice 333 kJ/kg.**

Characteristics of Refrigerants		ODP (Ozone)	GWP
CO_2	R744	0	1
HFC	R410A	0	1900
	R407	0	1600
HCFC	R22	0.055	1500

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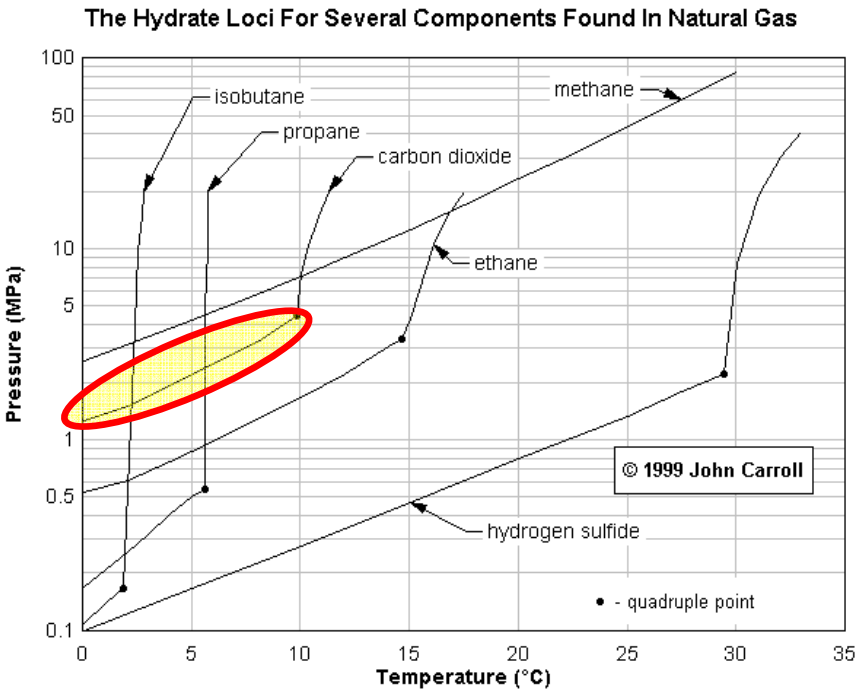
CO_2 Hydrates and Slurry

Advantages of Hydrate Slurry :

- Refrigerant : compound of CO_2
- Source of CO_2: recovered from industrial processes
- Multiphase fluid
- High enthalpy density
- Adaptive Melting Temperature
- Low viscosity
- High efficiency (> 30%)



Density [kg/m³]	Enthalpy [KJ/kg]	Temperature range [°C]	Pressure range [bar]
~ 1050	500	2 – 7	20 – 35

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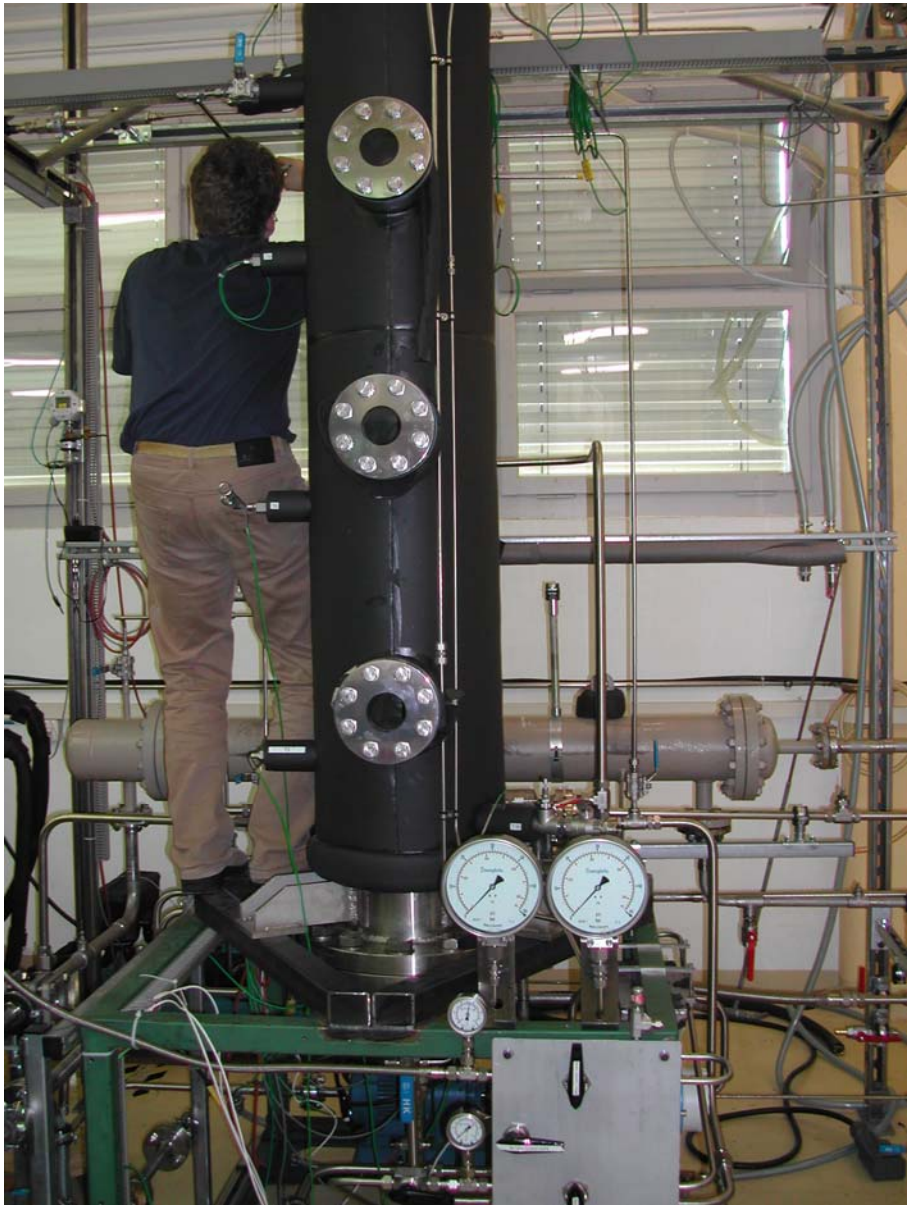
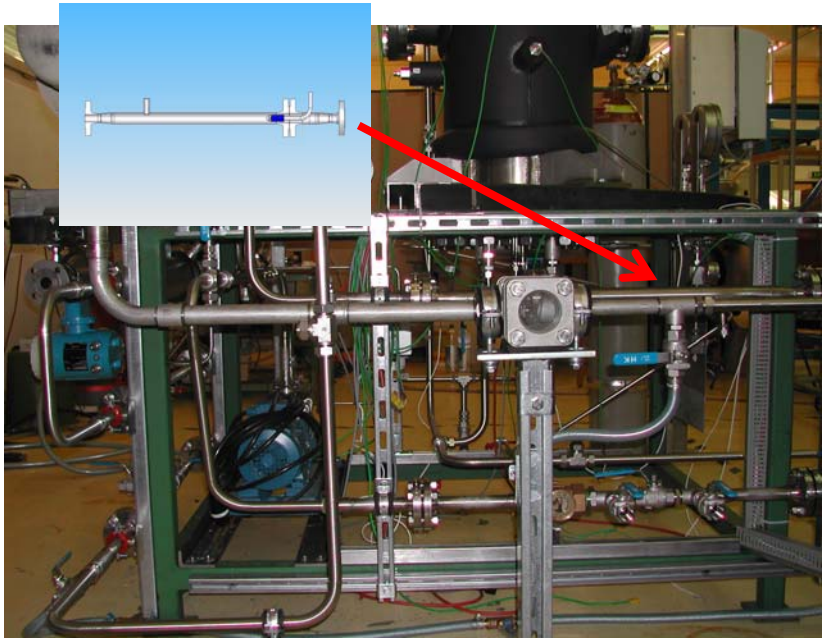
CO_2 Hydrates Slurry Production





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CO_2 Hydrate Slurry Consumption Loop

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Clean Cooling Solutions SA

Clean Cooling Solutions

Future Nature

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Market Estimation

Estimates of World Demand for Air Conditioners

	x 1000 unités			
(1) All air conditioners	2003	2004	2005	2006
World total	54,379	58,147	60,422	62,97
Japan	7,307	7,679	7,5	7,5
Asia (excl. Japan)	23,65	26,43	28,312	30,34
Middle East	2,218	2,366	2,515	2,604
Europe	4,359	6,000	5,087	5,382
North America	13,075	12,876	12,881	12,889
Central & South America	2,243	2,331	2,418	2,473
Africa	814	850	885	915
Oceania	712	815	825	868

source :JRAIA

34 billions US$