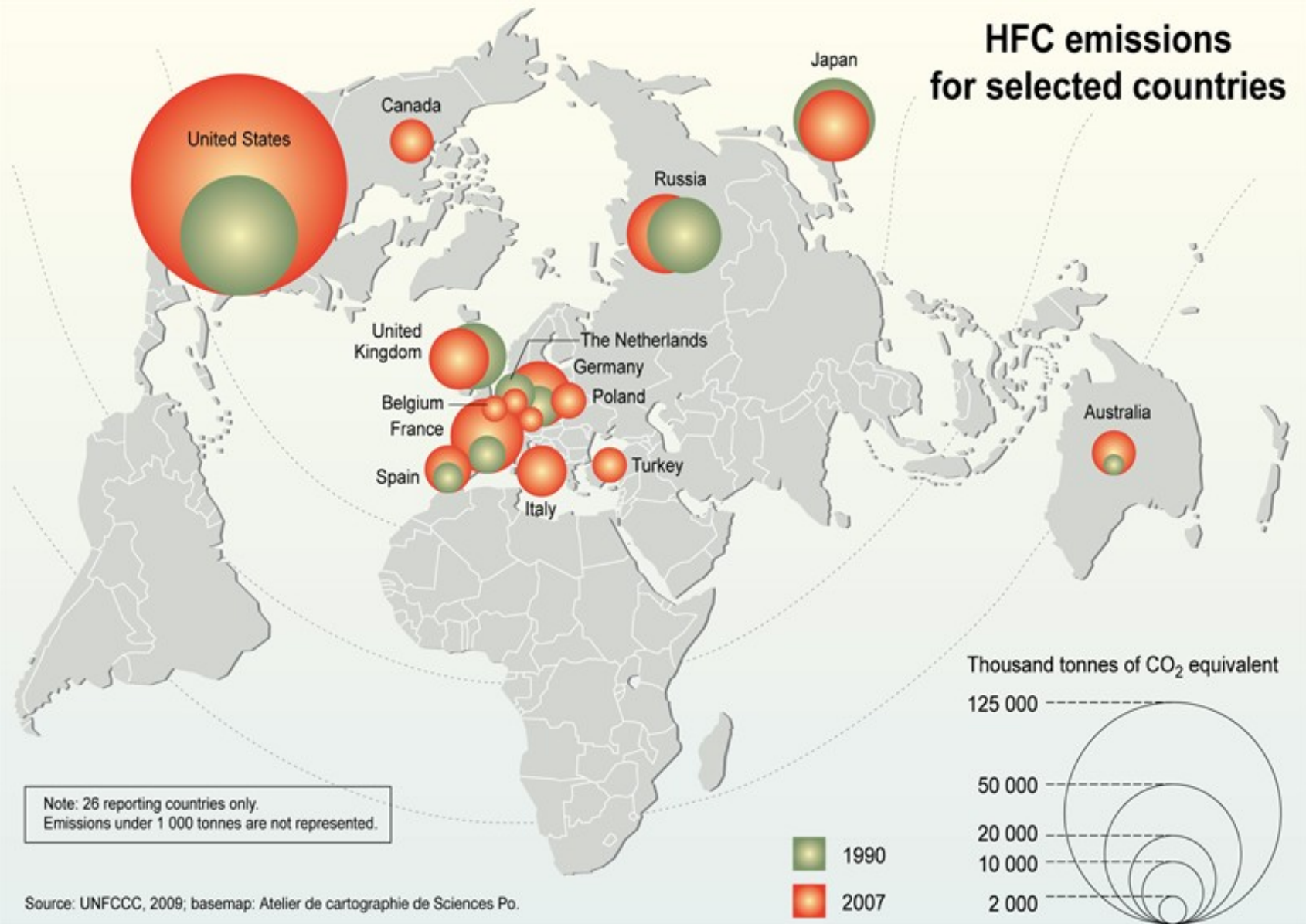


# Natural Alternatives in the Refrigeration & Air Conditioning Sectors



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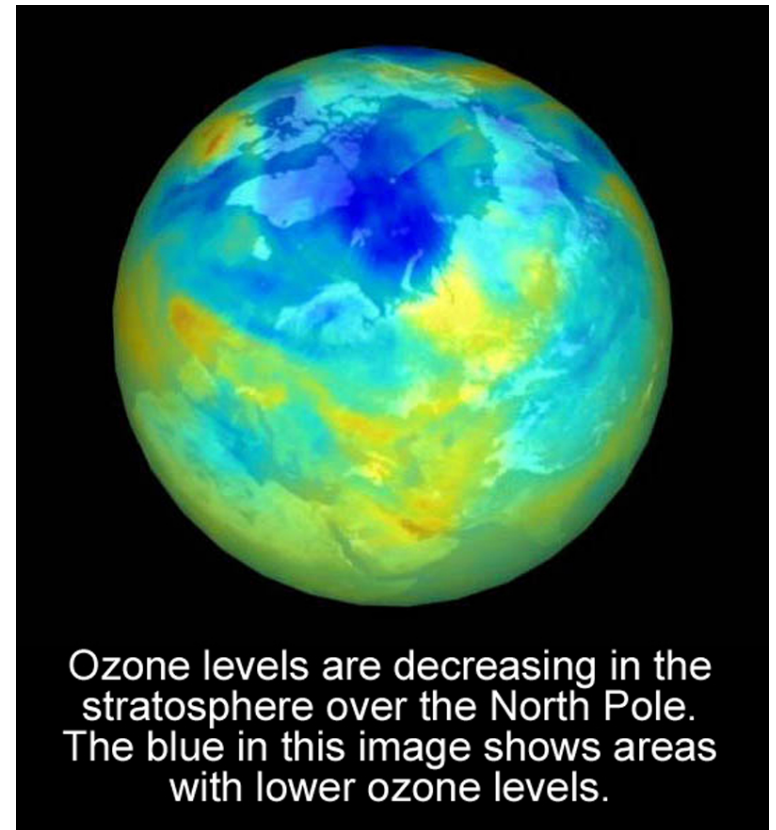
## HFC emissions for selected countries



# Available Alternatives

## US Slowly Catching Up With EU

- \* **CO<sub>2</sub>**
  - \* GWP of 1
  - \* Used as a refrigerant, a foam blowing agent and a fire extinguishing gas
- \* **Ammonia**
  - \* GWP of 0
  - \* Has been used as a refrigerant for 125 years
- \* **Water**
- \* **Hydrocarbons**
  - \* GWP of less than 20
  - \* Can be used as refrigerants (limited), foam blowing agents, and aerosol propellants
- \* **Not-in-Kind**



**Commercialized alternatives are currently available across the refrigeration, foam, and air conditioning sectors**

Sector	Examples of Alternatives	Use of Alternatives in Sector		
		Industrialized Countries	Developing Countries	Global Total
Industrial refrigeration systems (a)	Ammonia, CO2, HC	92%	40%	65%
Industrial air conditioning systems (a)	Ammonia, CO2, HC	40%	15%	~ 25%
Domestic refrigerators (vapor compression cycle) (b)	HC	51%	22%	36%
Foam in domestic refrigerators (c)	HC	66%	68%	67%
Foam in other appliances (c)	HC	38%	< 1%	28%
Polyurethane foam boards and panels (c)	HC	82%	21%	76%
Fire protection systems (d)	Water, foams, dry chemicals, inert gases	-	-	75%
Asthma medication (e)	Dry powder inhalers	-	-	~ 33%
Solvents (f)	Aqueous, no-clean, alcohols, others	> 90%	> 80%	> 80%

Sources: FTOC 2010; RTOC 2010; TEAP 2009ab; TEAP 2010a  
The percentages in this table refer to: (a) refrigerants used in new installations annually; (b) annual production of new equipment; (c) annual consumption of blowing agents; (d) usage or market; (e) annual medical doses; (f) market penetration in solvent applications.

# Commercial Refrigeration

- \* **Self Contained Units:** Propane, isobutene, hydrocarbon blends and CO<sub>2</sub>
- \* **Condensing Units:** CO<sub>2</sub> (EU and Japan)
- \* **Rack Systems:** CO<sub>2</sub>, glycol, trans-critical CO<sub>2</sub> and cascade systems with CO<sub>2</sub> and ammonia
- \* **Central plants:** ammonia and ammonia/CO<sub>2</sub>, water distributed system using HCs or CO<sub>2</sub>
- \* **Packaged systems:** ammonia and CO<sub>2</sub> work but increase costs at present, can be replaced by rack or central plant systems
- \* **Refrigerated Transport Systems:** CO<sub>2</sub> and hydrocarbons (EU)

# Self Contained Units Case Study: Ben & Jerry's Hydrocarbon Freezers

- \* In 2011, 70% of their freezers worldwide used Hydrocarbons instead of HFCs
- \* These units are 10% more energy efficient
- \* Unilever and Ben Jerry's announced plans in 2012 to only purchase hydrocarbon freezers for the US market



# Rack System Case Studies: Cascade Systems

- \* Supervalu's CO<sub>2</sub> and Ammonia Cascade System: Carpinteria, Ca Albertson
  - \* an ammonia primary system
  - \* a CO<sub>2</sub> medium temperature cascade to a DX system on the low temperature side
  - \* Only 250lbs of ammonia are needed, which is located in an outdoor enclosure
- \* Ammonia/CO<sub>2</sub> Cascade Refrigeration System at a Defense Commissary Agency Project
  - \* 8-25% energy savings
  - \* The ammonia is separated into 10lb modules, to make them safe for highly populated areas



# Rack System Case Studies: CO<sub>2</sub> Transcritical Systems

## \* Overwaitea

- \* Uses a Hill PHOENIX Advansor transcritical CO<sub>2</sub> booster refrigeration system
- \* CO<sub>2</sub> is cheaper than HFC: \$2/lb compared to \$20/lb

## \* Carrefour

- \* Installed first CO<sub>2</sub> transcritical unit in Istanbul, Turkey
- \* The new refrigeration installation will reduce the stores energy bills by 7%





# Case Study: Waitrose Installs Water & Propane Refrigeration system

- \* The installations comprise of integral cabinets and close coupled cold room systems
- \* The total on site HC charge is less than 100 kg, 100 kg in the chillers outside & >1kg charge inside the building
- \* According to Waitrose, the propane based fridges:
  - \* Cut its carbon footprint by 15%
  - \* Cut energy costs by 20%
  - \* Cut servicing and maintenance costs by at least 50%



# Industrial Refrigeration Case Study: Unilever Factory, the Netherlands



- \* Uses ammonia condenser heat pumps
  - \* Utilizes heat recovery and water heating by means of an additional heat pump
- \* Replacing the 3.2 MW HCFC-22 refrigeration system resulted in **40% reduction of energy consumption**
- \* The total annual cost savings are more than £1.4 million, resulting in a **payback time of 2.7 years**

# Industrial Refrigeration Case Study: Wal-mart Canada

- \* 400,000 sq ft distribution center in Alberta, Canada that serves 104 Wal-Mart stores
- \* Using ammonia has resulted in a 33% energy efficiency increase
- \* Will avoid \$2 million in energy costs over five years



# Alternatives are Already Scaled Up

- \* **AEON:** “The company will introduce CO<sub>2</sub> refrigeration systems into 10% of all new stores in fiscal 2012, 15% in fiscal 2013 and 25% in fiscal 2014. From fiscal 2015 the company will install these greener machines in all new stores.”
- \* **Sainsbury:** delivered 100 CO<sub>2</sub> stores by March 2012 and is on target to double its CO<sub>2</sub> store to 250 by 2014
- \* **Sobey's:** 34 transcritical CO<sub>2</sub> system installations, with 22 more approved for 2013.
- \* **Tesco:** Converted 46 stores to CO<sub>2</sub> in one year
- \* **Waitrose:** Has 67 HFC-free stores

# Domestic Refrigeration

- \* *Between 80 & 90% of all domestic refrigerators and freezers in the EU already use hydrocarbon technologies.*



GE Monogram HFC  
free refrigerator

- \* *It is predicted that at least 75 percent of global new refrigerator production will use hydrocarbon refrigerants in 10 years. TEAP Report, 2010*
- \* There are over 600 million hydrocarbon, or GreenFreeze, refrigerators in the world today
- \* Isobutane is the standard refrigerant for European refrigerators
- \* Hydrocarbon refrigerators are at least 10% more energy efficient

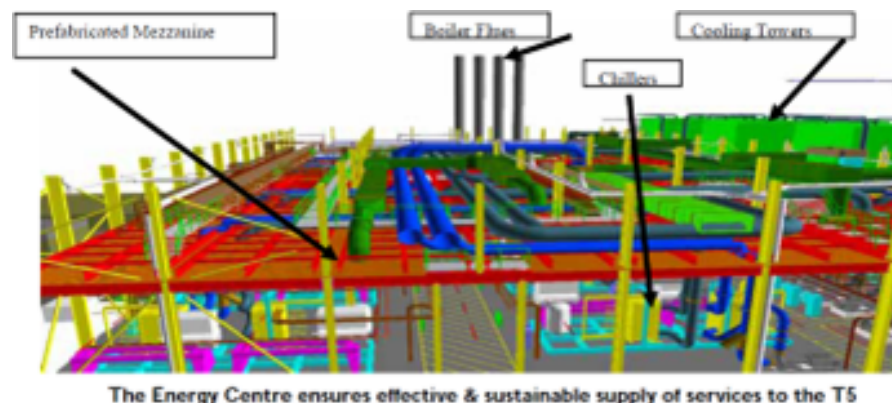
# Air Conditioning Sector

- \* Ammonia and hydrocarbon chillers are already on the market, with increased energy efficiency of about 10% in small hydrocarbon chillers to 20% for small ammonia chillers
- \* CO<sub>2</sub> is expected to have the same energy efficiency in moderate and 10% lower energy efficiency in warm climates
- \* For large centrifugal chillers, water as refrigerant is an environmentally benign solution, with 5-10% better energy efficiency
- \* International space station



# Commercial Air-conditioning Case Study: Heathrow Airport Terminal 5

- \* Four systems:
  - \* cooling capacity of 6.6 MW each
  - \* Ammonia charge of 1,300 kg each
- \* The facility incorporates a chilled water storage system to minimize the installed chiller capacity through a ‘peak lopping’ strategy
- \* It also utilizes “free cooling” by capturing and storing night-time and low ambient temperature cooling opportunities.



The Energy Centre ensures effective & sustainable supply of services to the T5

# Domestic Air conditioning Case Study: Benson A/C Systems

- \* Australian company manufacturing propane air conditioning units, both wall split and ducted split models
- \* The capacity of the wall split units range from 2.4kW to 12.5kW, with the charge size ranging from 0.2kg to around 1kg
- \* The ducted split model capacity ranges from 3.5kW to 100kW
- \* **All units have 15-20% better energy efficiency than HFC units**





# Questions?



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