Emissions Sources and Mitigation Strategies: Air Conditioning and Refrigeration Sector

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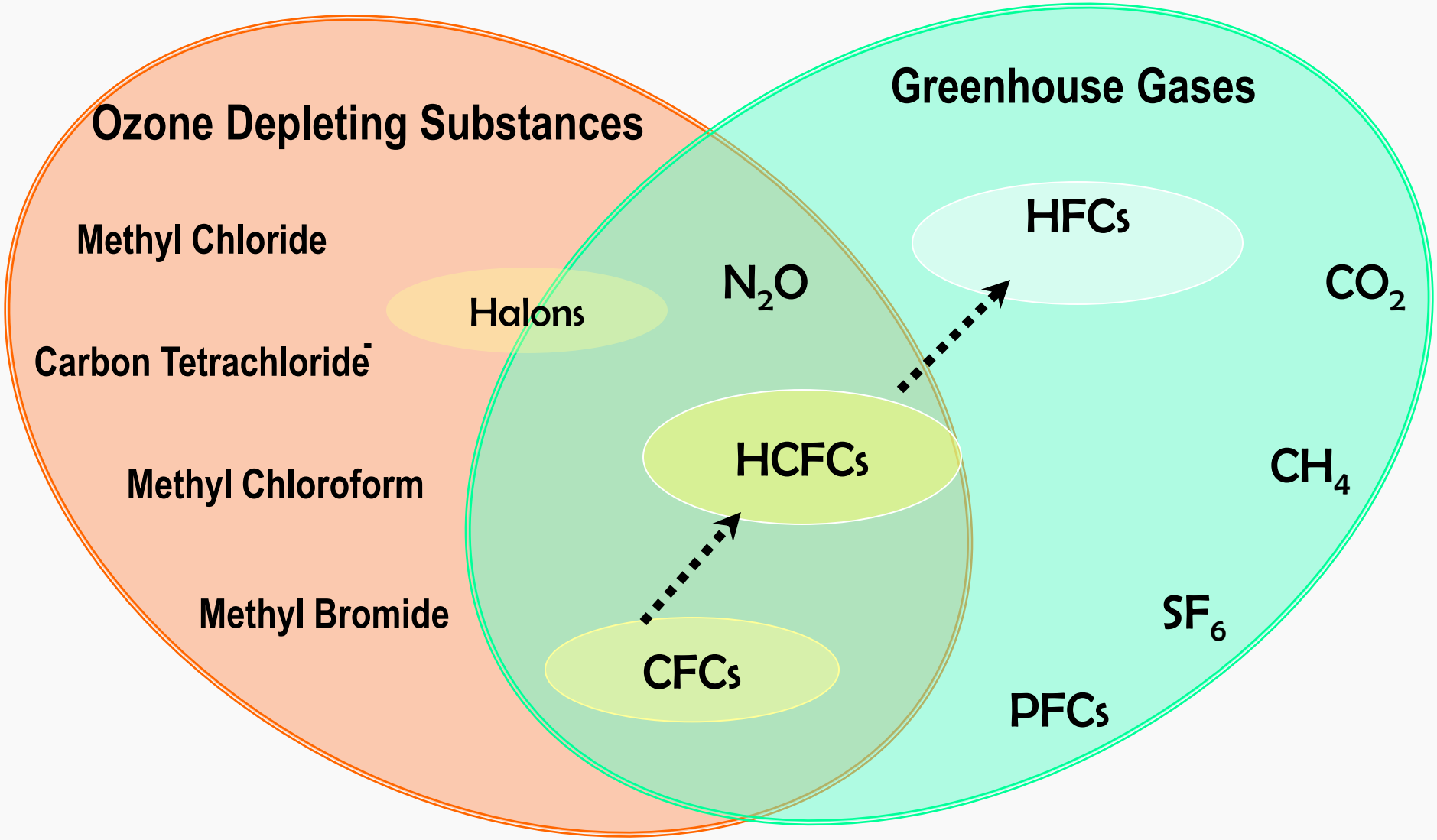
Scope of Presentation

- ODS Substitutes: Contributing to Climate
- Available Alternatives
- Sector-by-Sector Knowledge and Approaches
- Direct Climate Benefits and EE Co-Benefits
- Final Thoughts

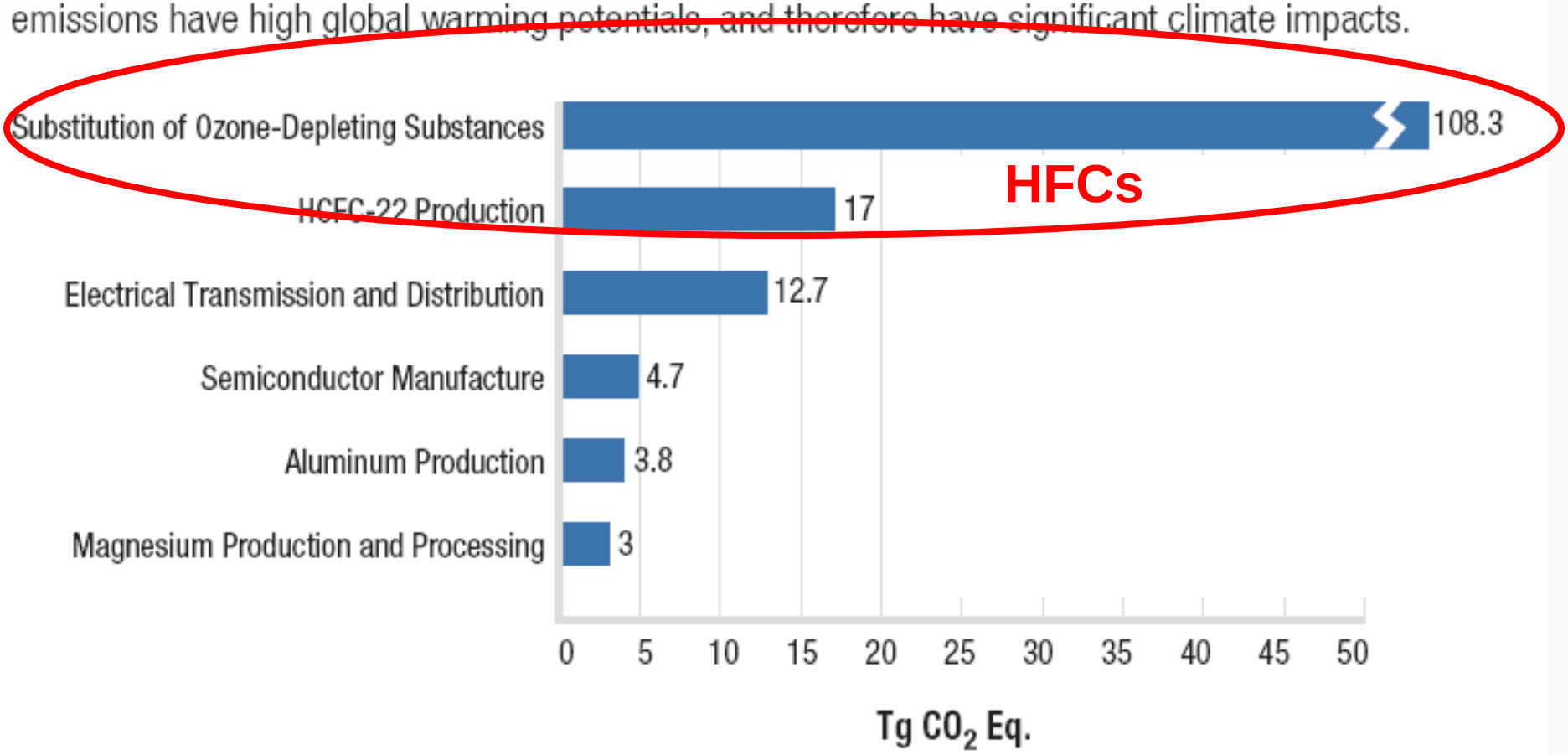
From ODS to HFCs



Significant Climate Emissions from ODS Substitutes

Figure 3-10 2007 U.S. Emissions of HFCs, PFCs, and SF_6 by Source

In 2007, HFCs, PFCs, and SF_6 accounted for 2.1 percent of U.S. greenhouse gas emissions on a GWP-weighted basis. Although the mass of these gases emitted is comparatively small, these emissions have high global warming potentials, and therefore have significant climate impacts.



Taking Action for Sound ODS Phaseout

- HFC Growth is direct result of ODS phaseout
- Montreal Protocol experience and success on HFC-sectors
  - **Refrigeration**
  - **Air Conditioning**
  - Foams
  - Aerosols
  - Solvents
  - Fire Suppression
- Montreal Protocol addressing HFCs as part of ODS transition

ODS Transition:
progress in every sector

- HCFC phaseout, managing legacy equipment, and climate change driving transition choices
- Technical options are universal, while local laws, regulations, standards, economics, competitiveness influence choices
- Energy efficiency spurring innovation in some sectors e.g., foams used in refrigeration appliances and building construction

Technology and Economic Assessment Panel's 2010 Report:
Key Messages on Managing Transition

Opportunity to Stem HFC Growth

- HFC emissions projected to be 9-19% of global CO_2 emissions by 2050 if left unchecked
- Majority of commercial HFCs have short atmospheric lifetimes

HFC	Atmospheric Lifetime	100-yr GWP
HFC-134a	14	1430
HFC-152a	1.4	124
HFC-32	4.9	675
HFC-125	29	6350
HFOs	Months	Under 10

- Important blends currently used: R-410A GWP ~2,088, R-407A GWP ~2,107, etc.

TEAP 2010 Report: Key Refrigerant Messages

- Over 60 new refrigerants introduced since 2006
  - Climate concerns & new options advancing innovations
- HFCs & non-fluorochemical options increasingly used
  - Emphasis on optimizing efficiency & lower-GWP refrigerants
- Lower GWP alternatives can replace HCFC-22:
  - lower GWP fluorochemical options: HFC-32, HFC-152a, HFC-161, HFC-1234yf, other unsaturated chemicals, blends
  - Non-fluorochemical options: HC-290, HC-600a, etc., ammonia, and carbon dioxide

Identifying Safer Alternatives

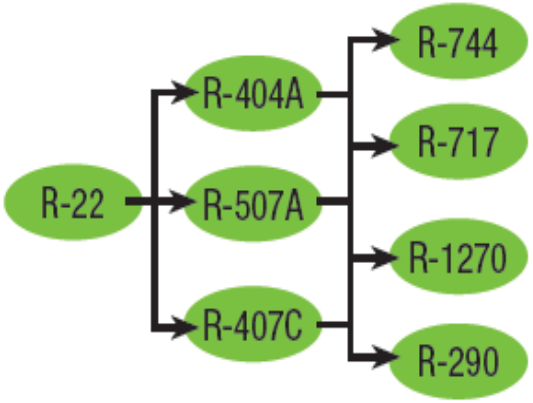
- U. S. EPA evaluates substitutes that reduce **overall** risk to human health & environment
- Significant New Alternatives Policy (SNAP) Program 400+ substitute alternatives with lower overall risks considering:
  - ODP & GWP, flammability, toxicity, local air quality, ecosystem effects, occupational health & safety
  - Next generation alternatives for ODS & HFCs
- Prohibition on intentional venting of HFCs and require servicing practices for motor vehicles

Available Options: Commercial Refrigeration

Stand-Alone Equipment

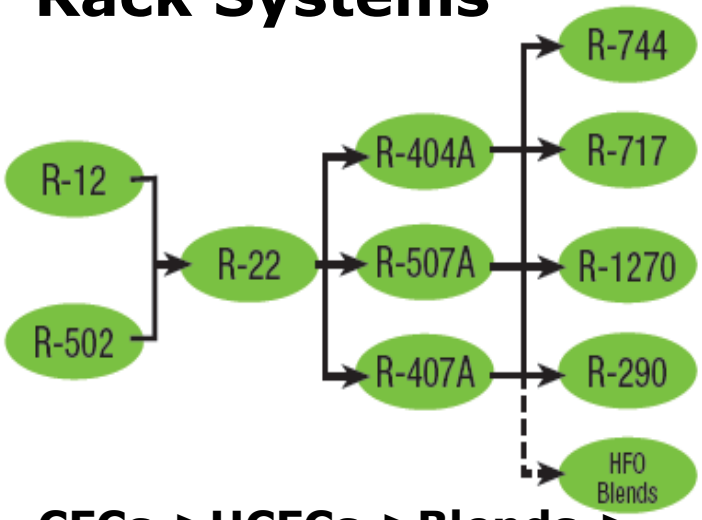
CFCs/HCFCs->HFCs-> HCs/CO_2

Condensing Unit Systems



HCFCs->HFCs-> CO_2, ammonia, HCs

Multiplex Rack Systems



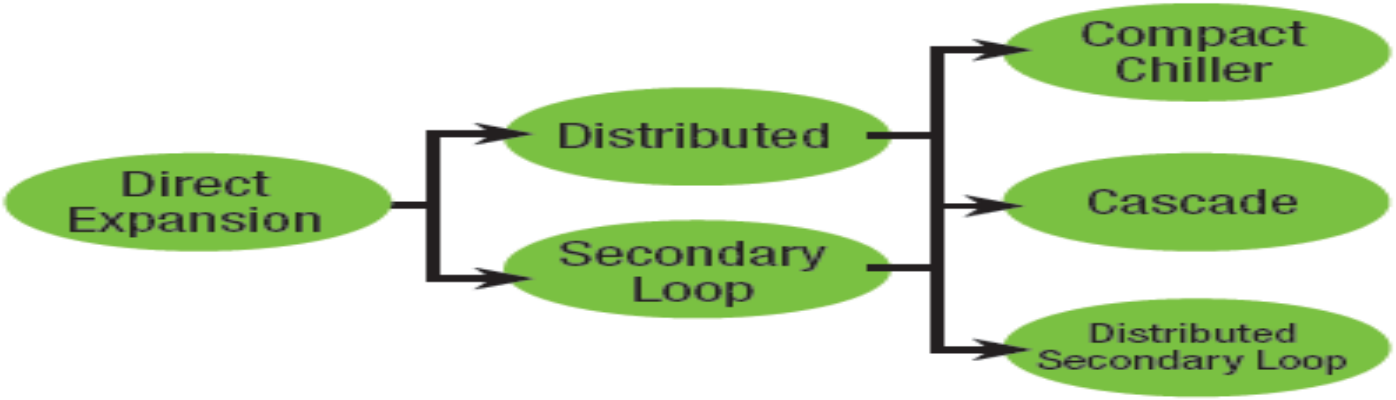
CFCs->HCFCs->Blends-> CO_2, ammonia, HCs, HFOs

Advanced Designs
Another Path to Reductions

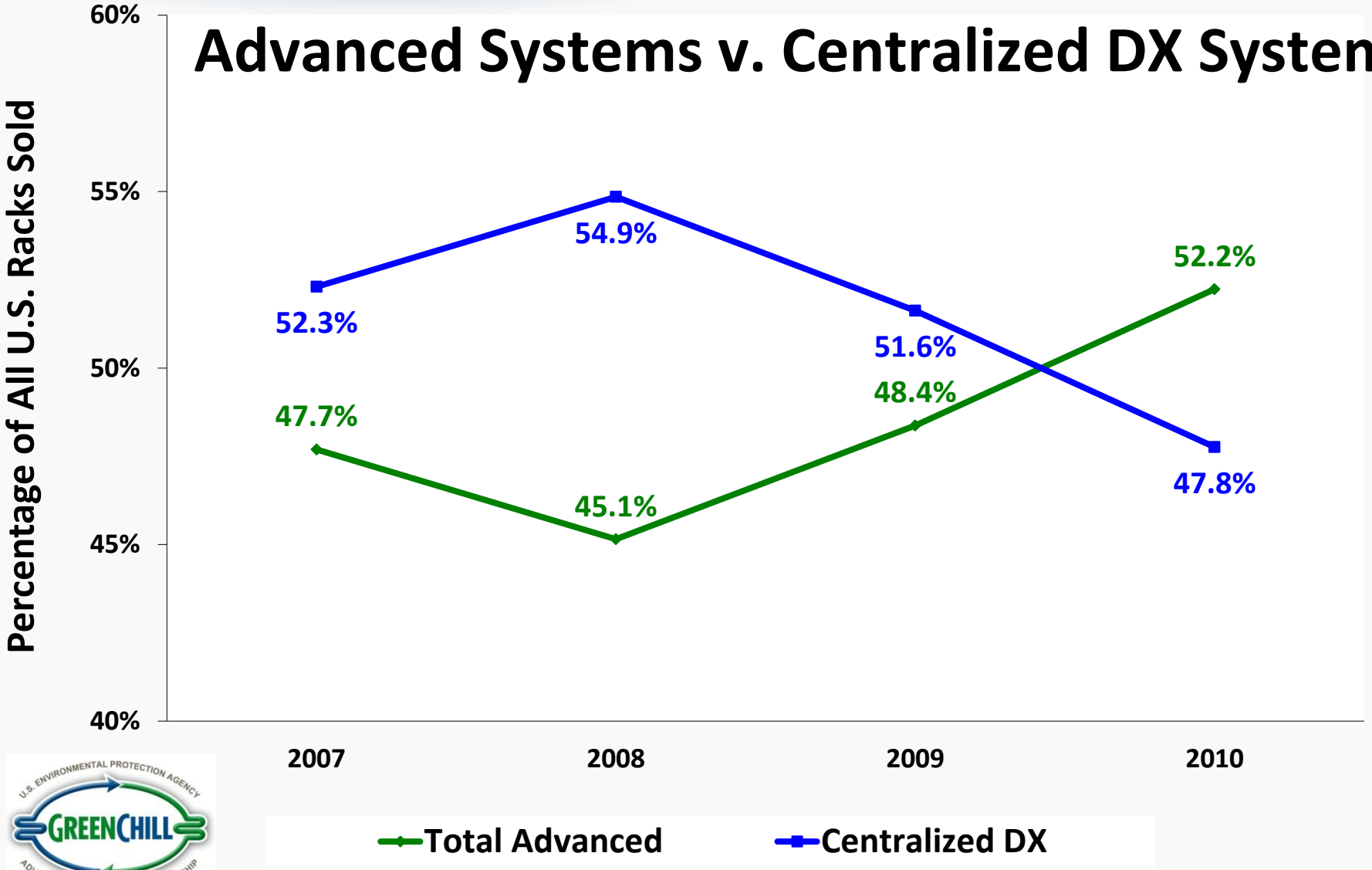
Advanced Refrigeration Designs:

- Distributed systems lower refrigerant charge 30–50%
- Indirect systems lower refrigerant charge 50–80%
- Europe: indirect systems are norm
- US: distributed systems and indirect systems gaining significant market share

Supermarkets can reduce HFC emissions by changing system designs



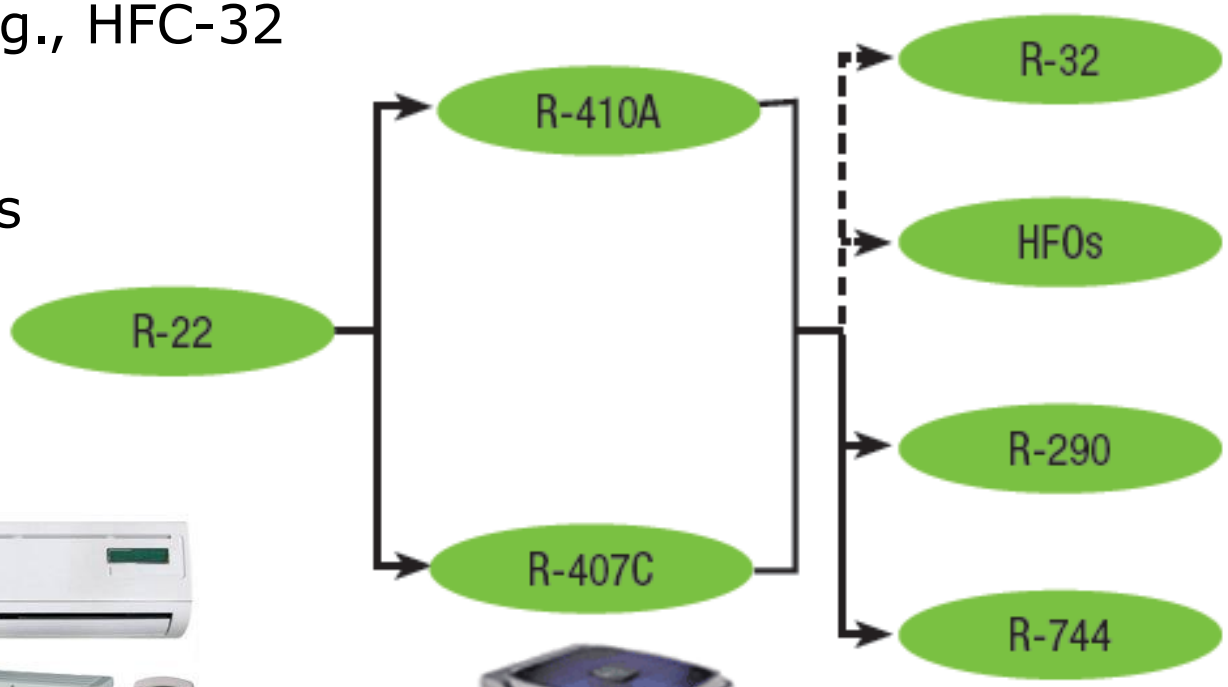
New Commercial Refrigeration Systems



Available & Near Term Options: Unitary A/C

Alternatives to R-407C & R-410A:

- lower GWP HFCs, e.g., HFC-32
- HCs and CO2
- future: HFOs, blends



Motor Vehicle Transition

Yesterday: high-GWP/ODP CFCs

Today: high-GWP HFCs

Tomorrow: low GWP alternatives

HFO-1234yf
CO2

HFC-134a

CFC-12

Information on Alternatives

TRANSITIONING TO LOW-GWP ALTERNATIVES IN BUILDING/CONSTRUCTION FOAMS

Background

TRANSITIONING TO LOW-GWP ALTERNATIVES IN MVACs

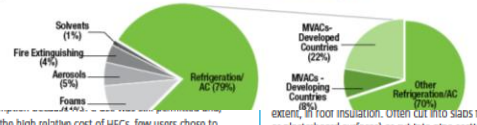
Background

Motor Vehicle Air Conditioners (MVACs) cool passenger cars, light duty trucks, buses, and rail vehicles. They have been produced in the United States since the 1960s and in Japan since the 1970s. MVACs were not widely used in Europe or developing countries until the 1990s. The charge size is 0.5-1.2 kg and the average lifetime is 12-16 years.

This fact sheet provides current information on low Global Warming Potential (GWP) alternatives in newly manufactured MVACs relevant to the *Montreal Protocol on Substances that Deplete the Ozone Layer.*[1]

MVACs in passenger cars, light duty trucks, buses, and rail vehicles account for an estimated 24% of

2010 HFC Consumption
(Estimates Presented in $MMTCO_2eq.$)



given the high relative cost of HFCs, few users chose to adopt HFCs. However, as the first HCFC phaseout obligations for developing countries approach in 2013, users are considering alternatives. Several low-GWP alternatives have become available over the last few years, offering developing

Applications of XPS and PU Foams in the Building/

and to a limited extent, in floor insulation. Often cut into slabs for composite panels (with metal or plasterboard surfaces) or cut into pipe sections for use in smaller insulated buildings. Typically the first building/construction foam type to be manufactured in emerging markets, due to low investment cost and range of end-use applications.

Pipe-in-Pipe—used primarily in pipe insulation, particularly for district central heating systems in cities

TRANSITIONING TO LOW-GWP ALTERNATIVES IN COMMERCIAL REFRIGERATION

Background

This fact sheet provides current information on low Global Warming Potential (GWP) alternatives in newly manufactured commercial refrigeration equipment relevant to the *Montreal Protocol on Substances that Deplete the Ozone Layer.*[1] Commercial refrigeration includes refrigerated equipment found in supermarkets, convenience stores, restaurants, and other food service establishments. In 2006, there were an estimated 530,000 supermarkets worldwide, containing roughly 546,000 metric tons of refrigerant. Due to their large charge sizes, the multiplex rack systems typically used in these supermarkets account for the greatest percentage (60%) of refrigerant installed in the commercial refrigeration sector. HCFCs account for the majority of refrigerant (55%). Figure 1 and Figure 2 graphically present the distribution of the global commercial refrigeration stock by system and refrigerant type in 2006. Equipment in this sector typically last approximately 15-20 years. Equipment can be broadly categorized as either self-contained or remote refrigeration systems, as explained further below:

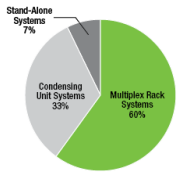


Figure 1: Distribution of Global Commercial Refrigerant Stock by System Type (2006)

TRANSITIONING TO LOW-GWP ALTERNATIVES IN DOMESTIC REFRIGERATION

Background

This fact sheet provides current information on low global warming potential (GWP) alternatives in newly manufactured domestic refrigeration equipment relevant to the *Montreal Protocol on Substances that Deplete the Ozone Layer.*[1]

In 2009, an estimated 1.5-1.8 billion domestic refrigerators and freezers were in operation worldwide. Approximately 100 million new units are

Japan; units in Europe and

R-600a, have since

market and are

TRANSITIONING TO LOW-GWP ALTERNATIVES IN UNITARY AIR CONDITIONING

Background

This fact sheet provides current information on low Global Warming Potential (GWP) alternatives for new equipment in unitary air conditioning (AC) relevant to the *Montreal Protocol on Substances that Deplete the Ozone Layer.*[1]

The unitary AC sector comprises systems that cool enclosed spaces ranging from single rooms to large exhibition halls. These systems have a typical lifetime of 15 years and generally fall into four categories:

Small Self-Contained Air Conditioners

- Window-mounted, portable, and through-the-wall
- Capacities of 1-10.5 kW
- Average charge size of 0.7 kg

Non-Ducted or Duct-Free Split Residential and Commercial Air Conditioners

- Compressor/heat exchanger units installed outside the space to be cooled/heated
- Capacities of 2-20 kW for a mini split (single evaporator), 4.5-135 kW for a multisplit system
- Charge sizes of 0.5-90 kg

Ducted Split Residential Air Conditioners

- Duct supplies cooled/heated air to each room or zone
  - Used primarily in developed countries, especially in North America
- Capacities of 5-17.5 kW
- Charge sizes of 1-6 kg

Ducted, Commercial, Split and Packaged Air Conditioners

- Mounted on roofs or on the ground adjacent to buildings
- Capacities typically range from 5-420 kW

2010 HFC Consumption
(Estimates Presented in $MMTCO_2eq.$)

Global HFC Consumption Total: 1,087 $MMTCO_2eq.$
Global HFC Consumption Unitary AC: 91 $MMTCO_2eq.$
Global Fluid AC Sector Total: 858 $MMTCO_2eq.$
Global HFC Consumption Unitary AC: 91 $MMTCO_2eq.$

China's Experience

China manufactures half of the world's 50 million mini-split AC systems annually. It's the largest manufacturer of AC equipment in the developing world. A significant portion of production is for the export market—China supplies nearly 85% of the window, wall, and mini-split AC imports to the United States. While R-22 continues to dominate unitary AC domestically, the country manufactures both R-22 and R-410A units. The R-410A units are in high demand as exports to developed countries. China has commercialized room ACs with R-290 and is researching unitary AC products with R-32.

This equipment accounts for an estimated 87 million metric tons of carbon dioxide equivalent ($MMTCO_2eq.$) or 8% of global HFC consumption in 2010. In the refrigeration/AC sector, unitary AC accounts for 11% of consumption. This percentage is expected to increase as the transition from HCFCs to HFCs matures. An estimated 38% of HFC consumption in the unitary AC sector (35 $MMTCO_2eq.$) is in developing countries.

HFC Alternatives and Market Trends

Today, most unitary AC systems use HCFC-22. Since 2000, developed countries have been transitioning to R-410A and to some extent, R-407C. Most developing countries continue to rely on R-22. Currently, R-22 represents approximately 85% (1.2 million tons) of refrigerant stocks in existing unitary AC systems worldwide. Of the units sold today, R-22 accounts for approximately 60%, while R-410A and R-407C account for most of the remainder; propane (R-290) accounts for less than 1%.

Carbon Dioxide (R-744)

- Research to improve efficiency is underway
- Custom-built applications and demonstration units are available
- Increased use is expected in cool to moderately warm climates

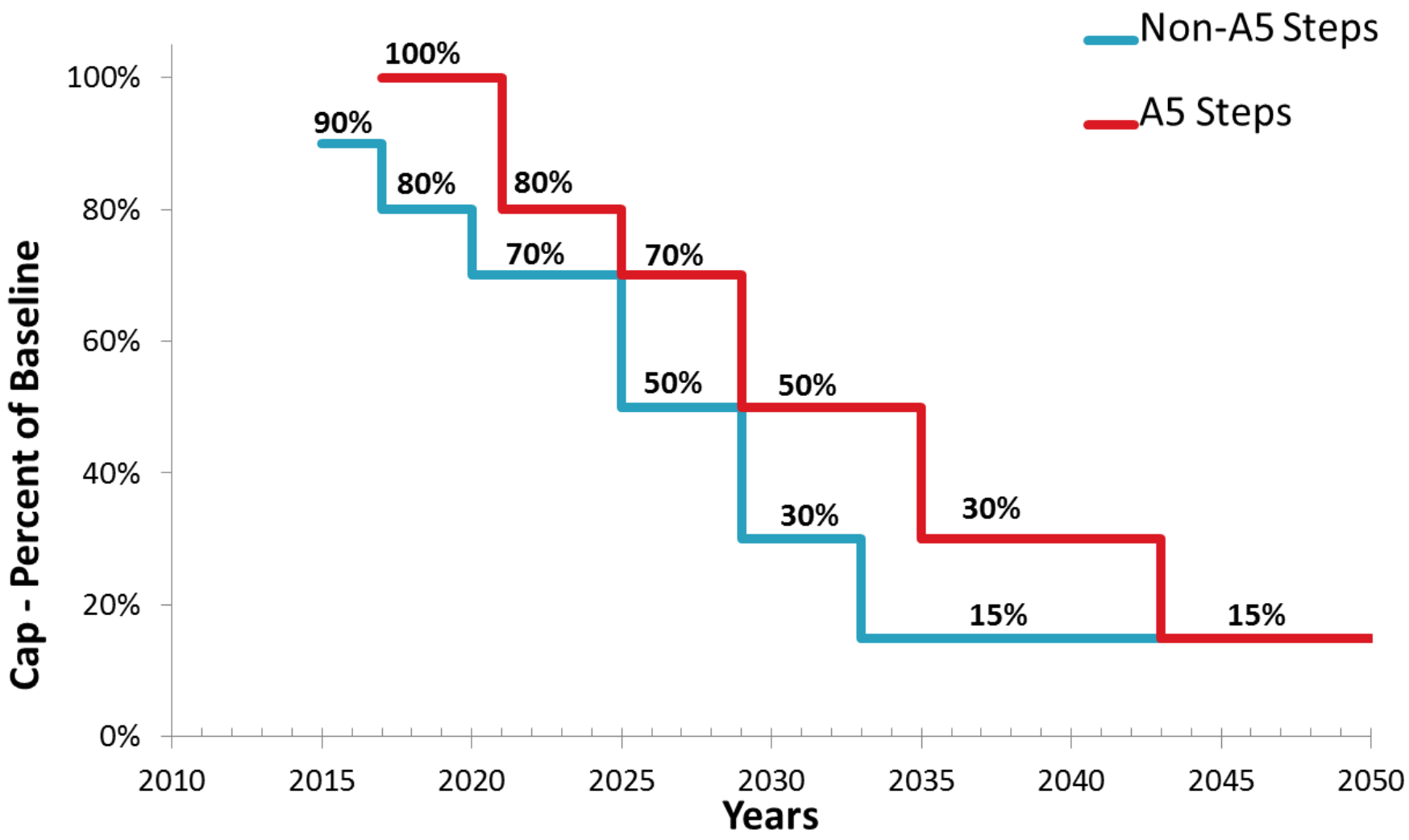
Refrigerant	GWP	ODP*
R-410A	2,088	0
R-22	1,810	0.055
R-407C	1,774	0
HFO blends	<1,000*	0
R-32	675	0
R-1234ze	6	0
R-1234yf	4	0
R-290	3.3	0
R-744	1	0

*ODP=ozone depletion potential.
•Value shown is based on HFO blend that mirrors the composition of R-407C, substituting R-1234yf with R-134a.

North American Proposal

- Control HFC Production & Consumption
- Phase*down*, not Phase*out* of HFCs
- Control By-Product Emissions of HFC-23
- Leaves Unchanged UNFCCC Obligations
- Cumulative reductions over **98 gigatons** through 2050
  - Even contributions from developing/developed countries
  - Additional benefits:
    - Improved energy efficiency by upgrading equipment designs, using better materials
    - Reduction in overall electricity needs

Proposed Phasedown Schedule



Final Thoughts

- Suite of known alternatives, technologies, and better handling can significantly reduce HFC consumption in near & long term
- Considering ODS and HFCs together allows for focus on sectors, rather than chemicals
  - U.S. SNAP program sector focused
- Montreal Protocol has unparalleled technical sector expertise
  - National expertise may rest within ODS programs
- Significant near-term direct and indirect climate benefits

For Additional Information

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- Website: www.epa.gov/ozone/strathome.html

- Amendment Proposals and EPA Benefits Analysis: http://ozone.unep.org/highlights.shtml