

Overview of High-GWP Gases and Mitigation Options



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Outline

- Introduction
- Substitutes for Ozone Depleting Substances
 - Emission reduction options
 - Mitigation potentials and costs
- Industrial Sectors
 - Voluntary partnerships
 - Emission reduction options
 - Mitigation potentials and costs
- Conclusions

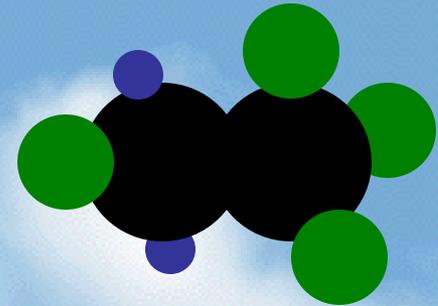
High-GWP Fluorinated Gases

- What Are They?: HFCs, PFCs, SF₆ (F-gases)
- Where Are They Produced / Used?
 - Substitutes for ozone-depleting substances
 - “Industrial” sectors
- Why Important?
 - Critical industries; environmentally important
 - High potential growth (early action = high payoffs)
 - Long atmospheric lifetimes
 - Relatively cheap to abate

High-GWP Fluorinated Gases

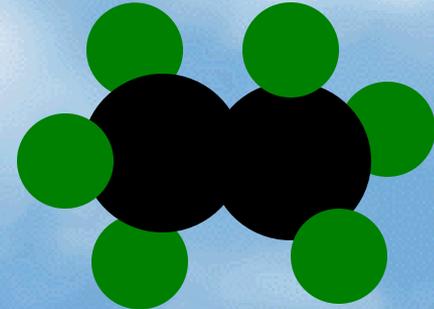
- Hydrofluorocarbons (HFCs)

HFC-134a =

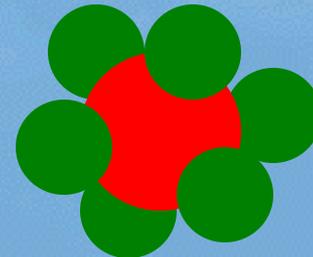


- Perfluorocarbons (PFCs)

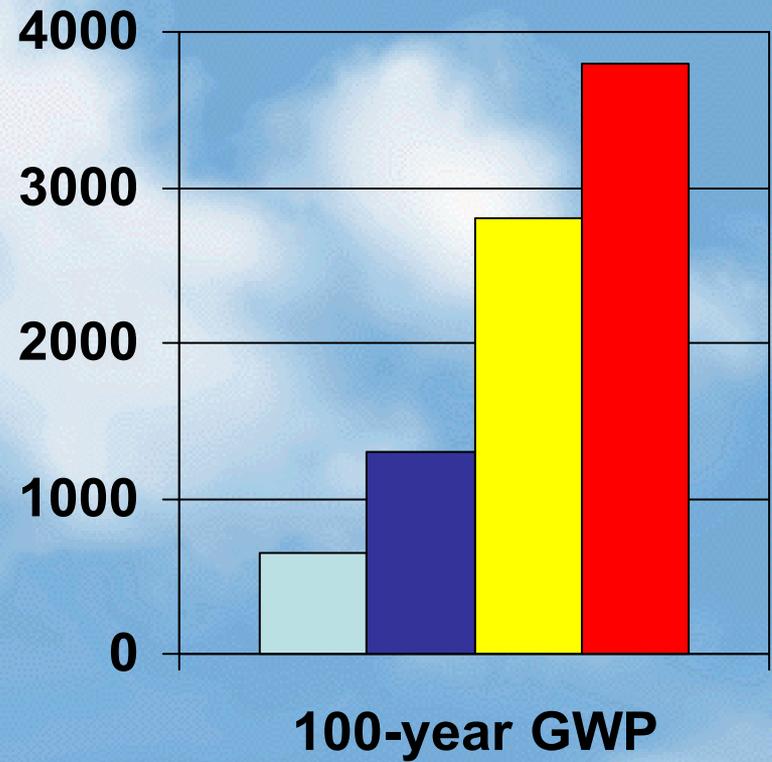
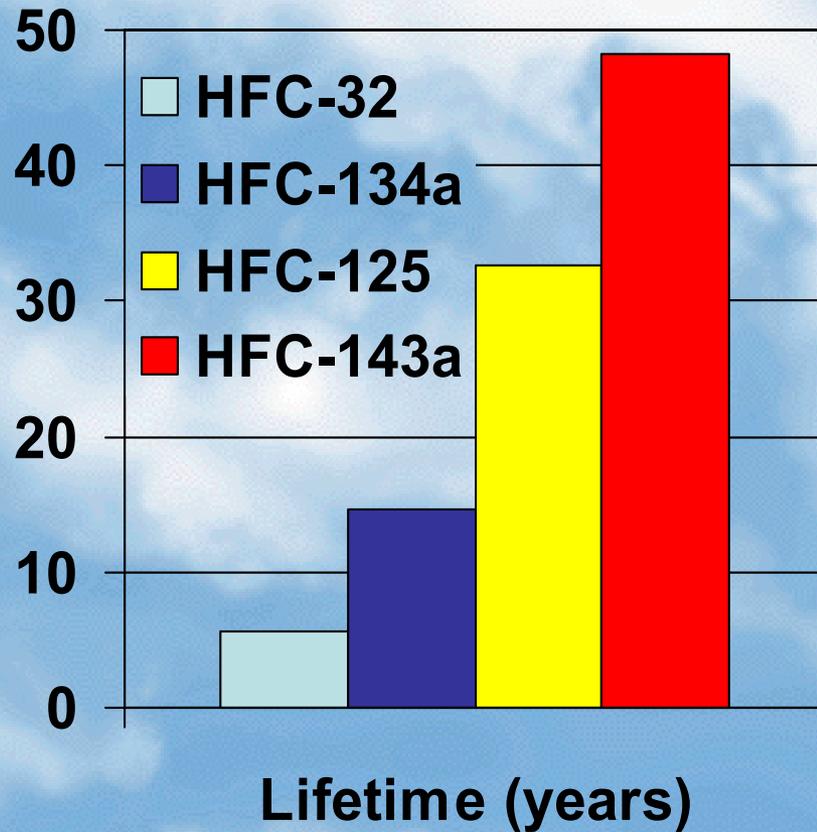
C_2F_6 = PFC-116 =



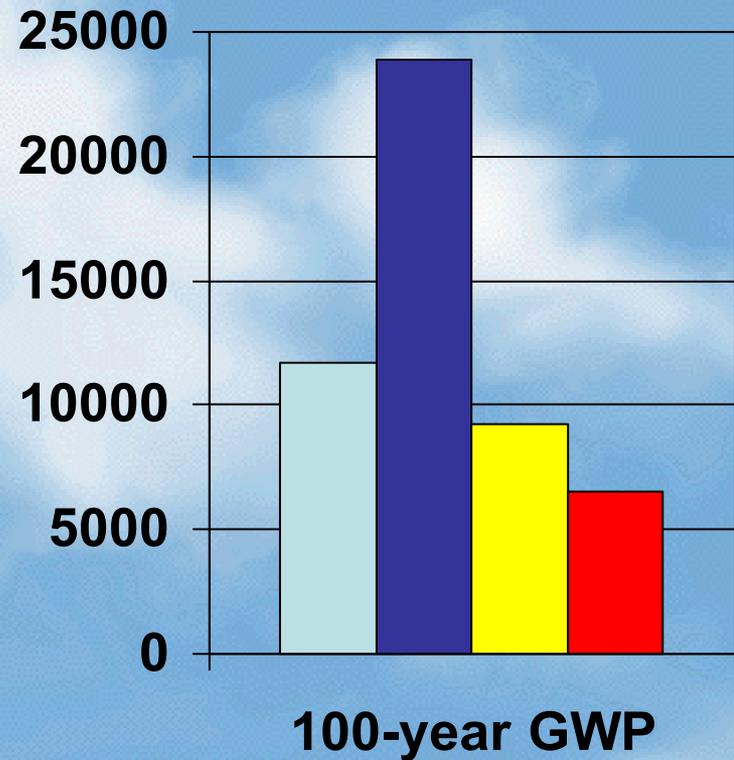
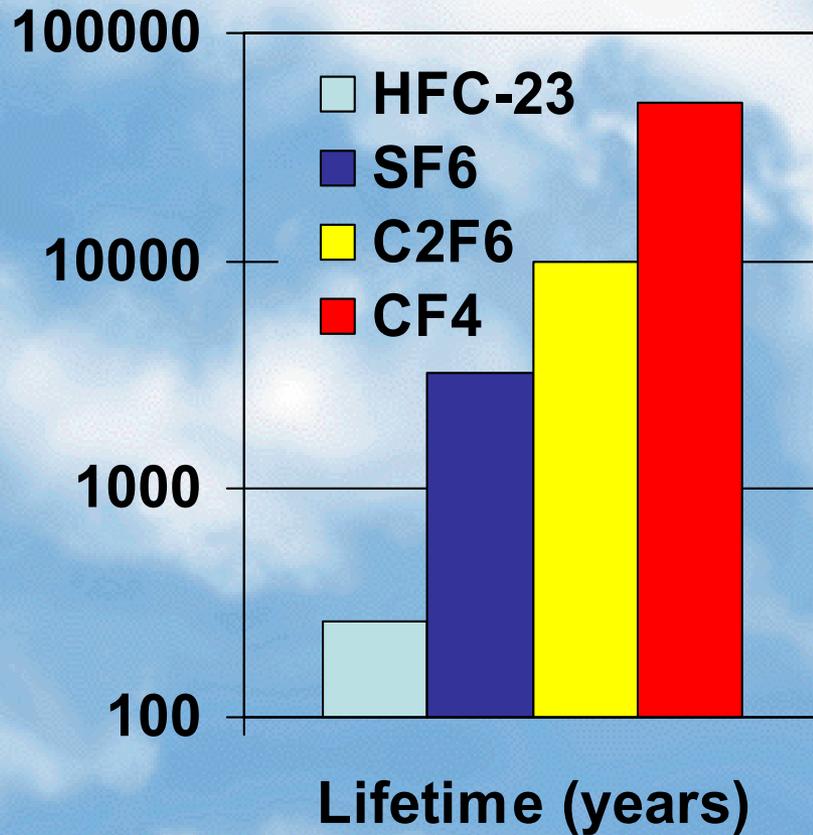
- Sulfur Hexafluoride (SF_6)



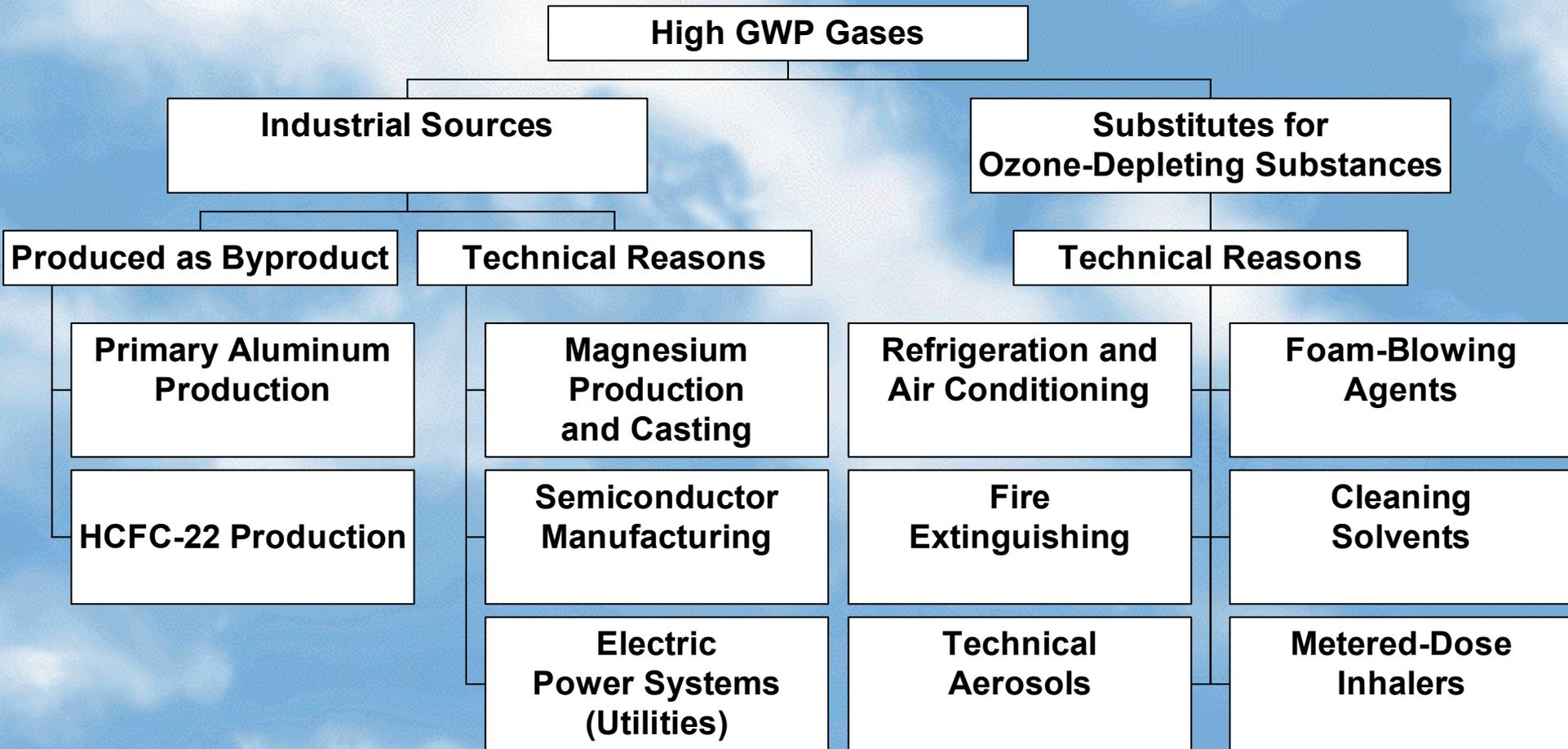
Examples of ODS Substitutes



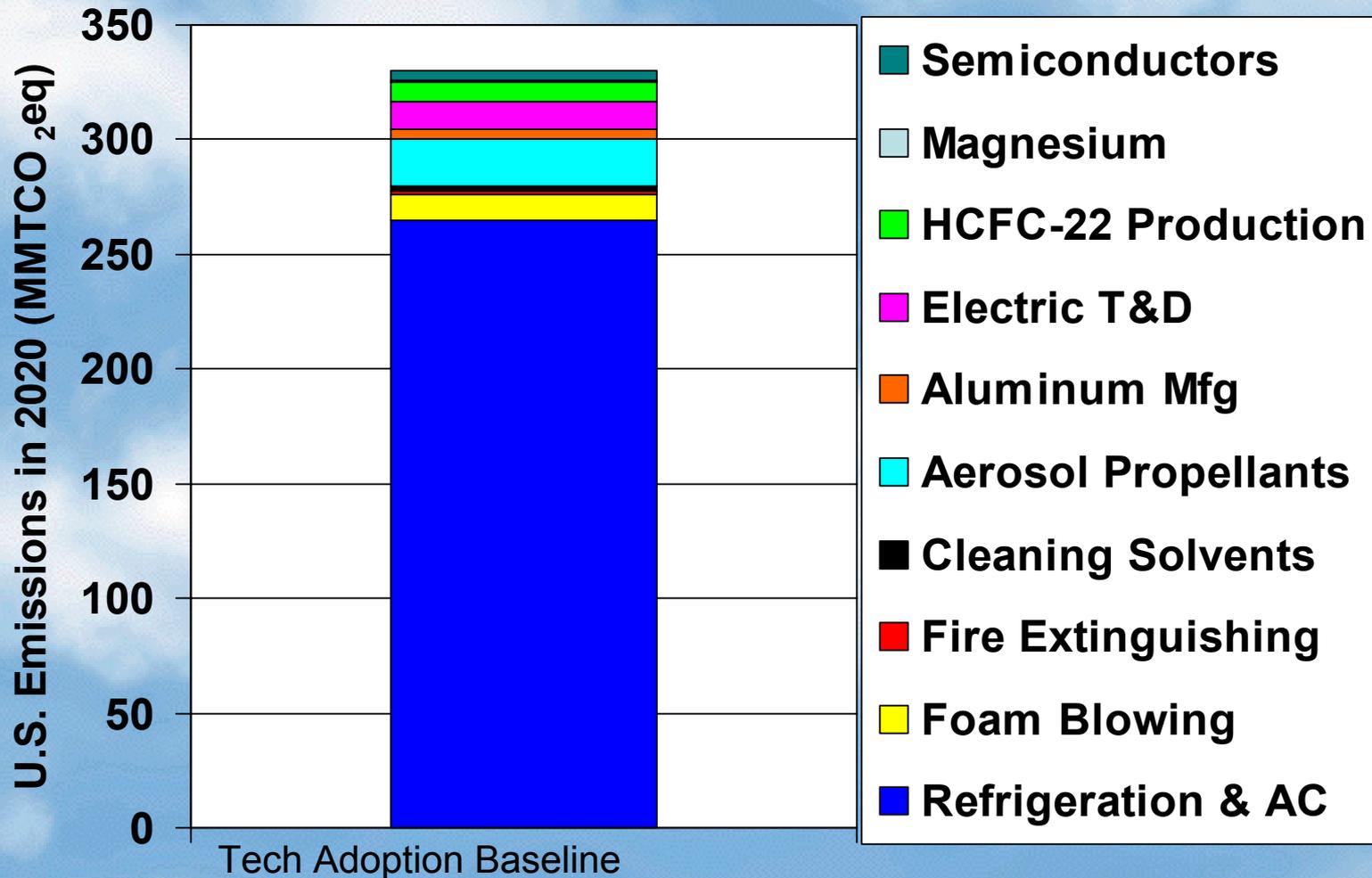
Examples of Industrial Gases



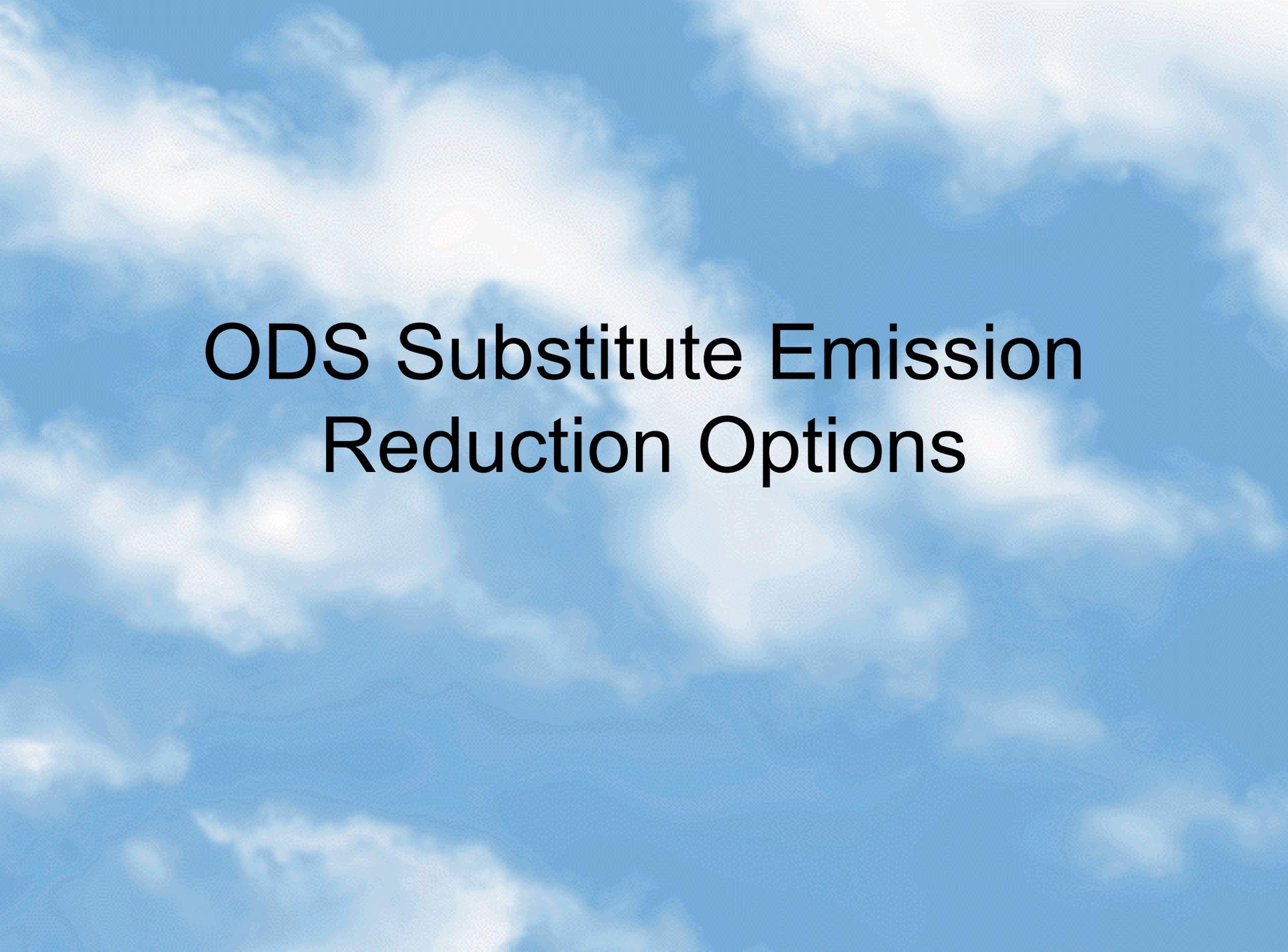
How Are High-GWP Gases Used?



U.S. Baseline Emissions (2020)



Global Anthropogenic Emissions of Non-CO₂ Greenhouse Gases
Global Mitigation of Non-CO₂ Greenhouse Gases



ODS Substitute Emission Reduction Options

Ozone-Depleting Substances

- CFCs, HCFCs, Halons, Methyl Chloroform, Carbon Tetrachloride, etc.
- Deplete the Stratospheric Ozone Layer
- Are Greenhouse Gases (direct & indirect)
- Production Controlled Internationally by the *Montreal Protocol* and *US Clean Air Act*
- Various Alternatives, including High-GWP Fluorinated Gases (mainly HFCs)

ODS Substitute Options

- Refrigeration and Air Conditioning
 - Supermarket Design Options
 - Distributed System
 - Secondary Loops
 - Increased Recovery
 - Increased Leak Repair
 - Mobile Air Conditioner Options
 - CO₂
 - HFC-152a
 - Improved HFC-134a

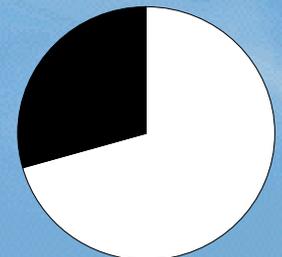
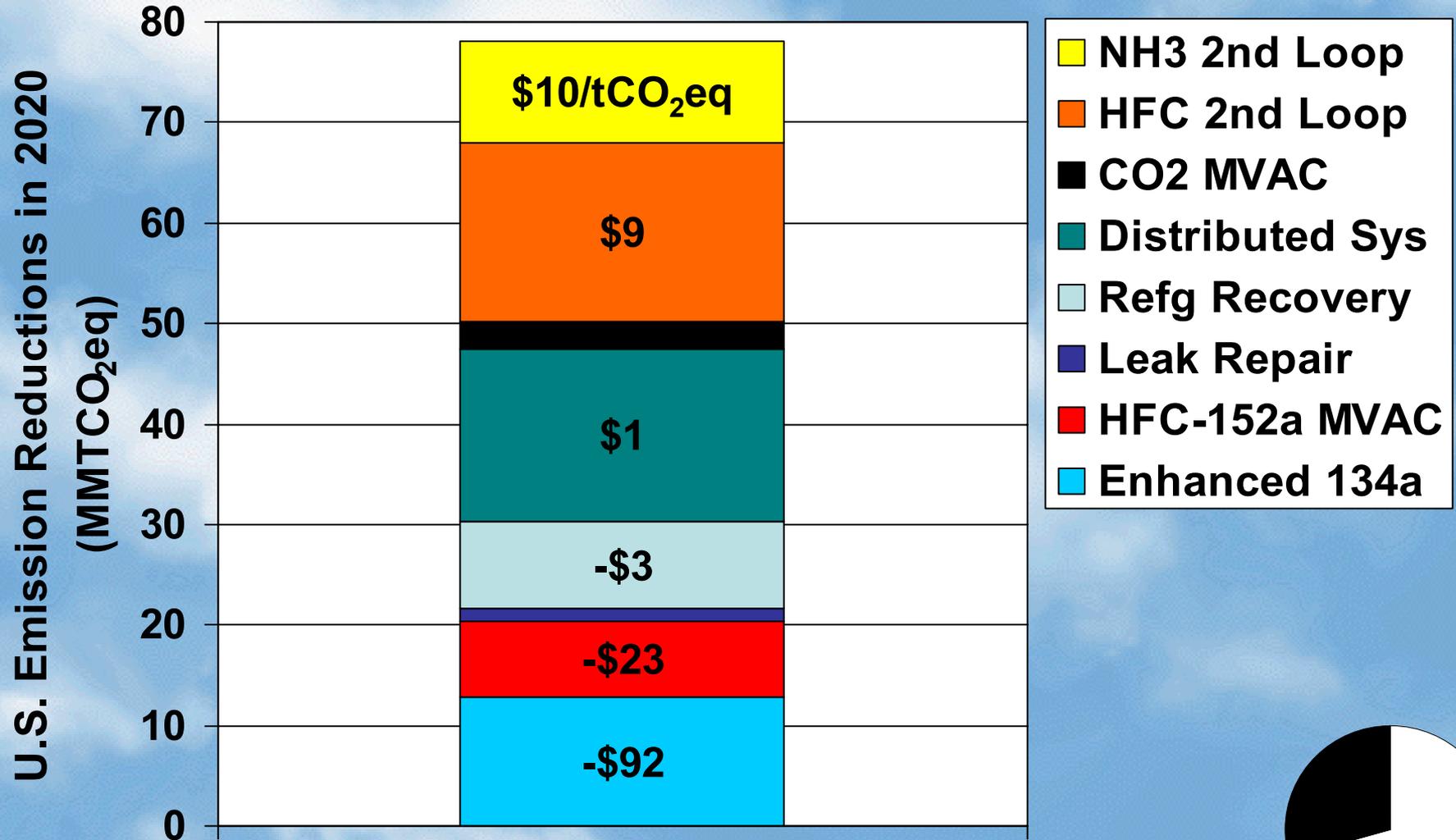


ODS Substitute Options

- Refrigeration and Air Conditioning
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 - Improved HFC-134a



Refrigeration and AC Options



(2000\$s)

ODS Substitute Options

- Foams

- Extruded Polystyrene Foam:

- Replace HFC-134a/CO₂ with CO₂/Alcohol

- Polyurethane Spray Foam:

- Replace HFC-245fa/CO₂ with CO₂ or HC

- Polyurethane Appliance Foam:

- Replace HFC-134a or HFC-245fa with HC
 - Recover/Destroy HFC at End of Life

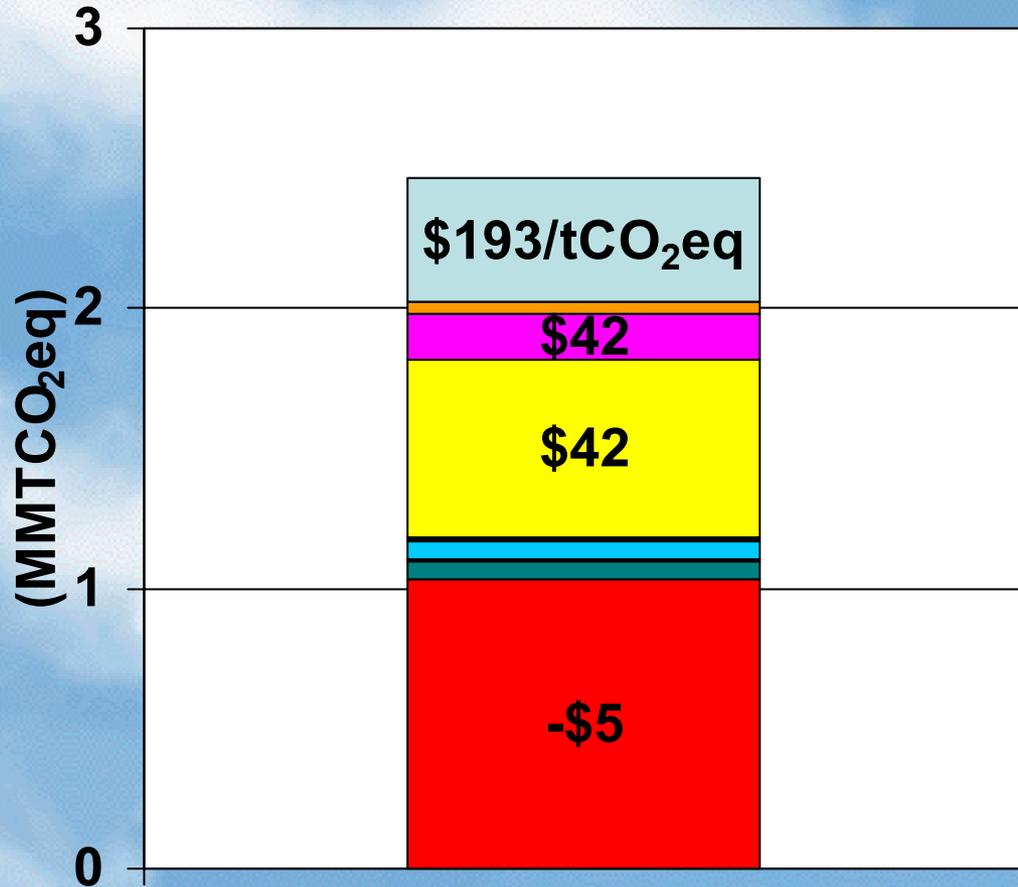
- Other Polyurethane Foam:

- Replace HFC with HC

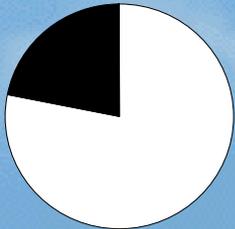


Foam Options

U.S. Emission Reductions in 2020



- Appliance: 245fa to HC
- Appliance: Manual EOL
- Appliance: 134a to HC
- Spray: 245fa/CO₂ to CO₂
- Appliance: Auto EOL
- PU Panels: 134a to HC
- PU Comp: 152a to HC
- PU Comp: 134a to HC
- Spray: 245fa/CO₂ to HC



(2000\$s)

ODS Substitute Options

- Fire Extinguishing
 - Water Mist Systems
 - Alternate Agent Instead of HFCs
 - Inert Gases
 - FK-5-1-12

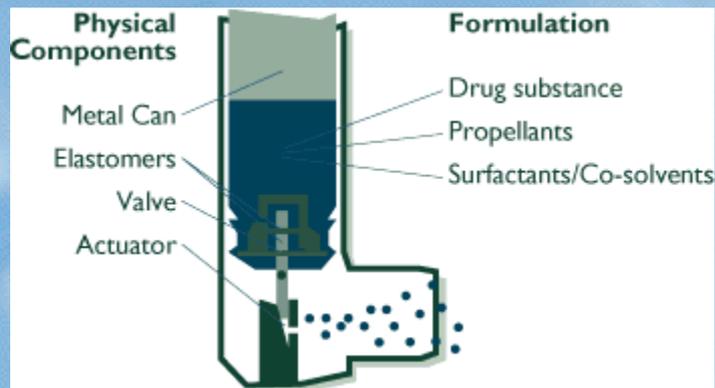


- Cleaning Solvents
 - Use Lower-GWP Solvents
 - Switch to Aqueous or Semi-Aqueous Cleaning
 - Retrofit Cleaning Equipment to Reduce Leaks

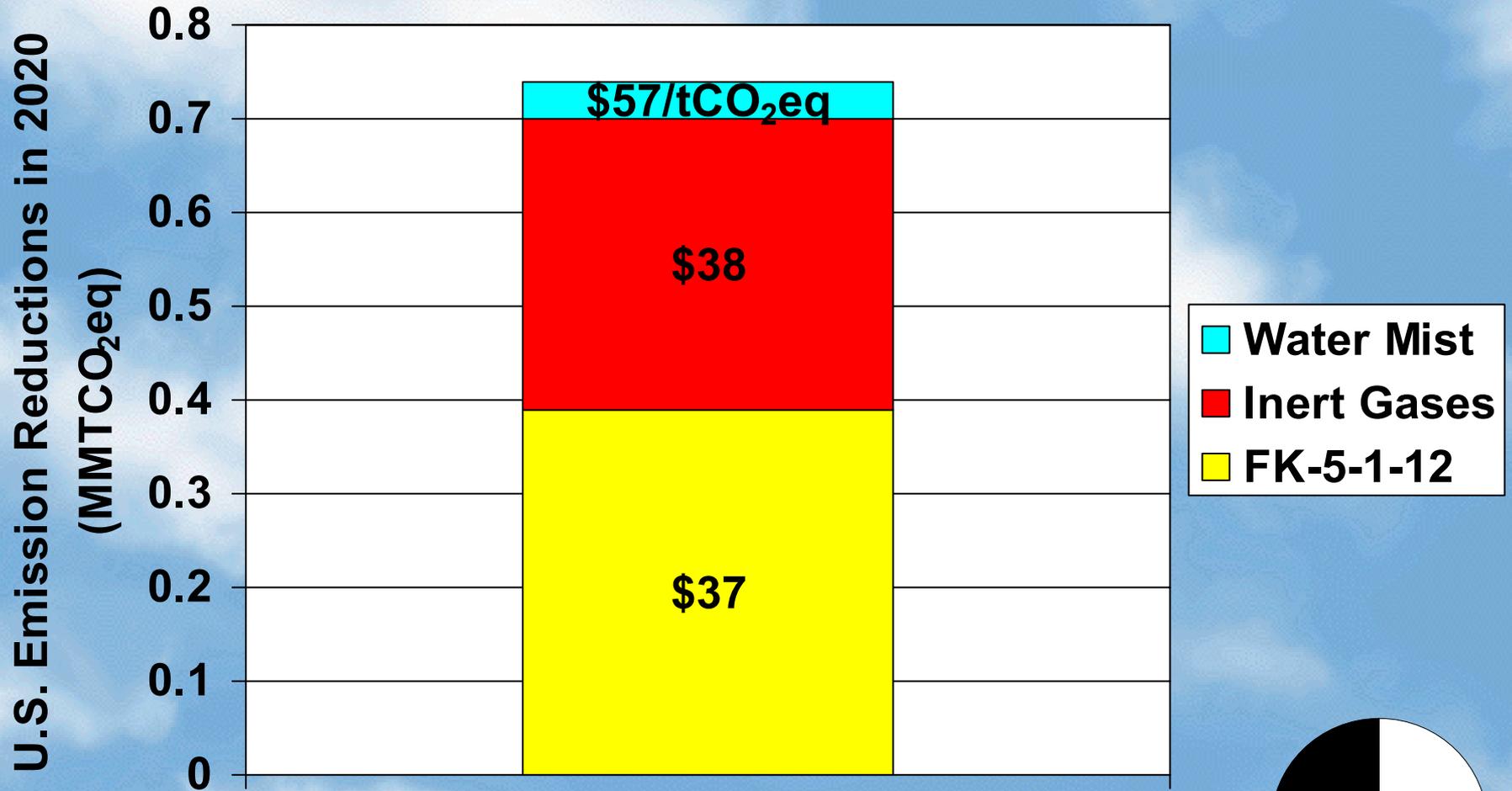


ODS Substitute Options

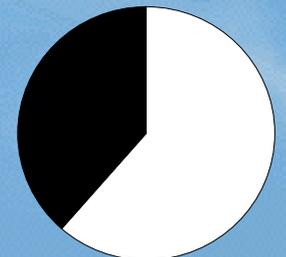
- Aerosols
 - Replace HFC-134a with HCs or HFC-152a
 - Replace HFCs with “Not-In-Kind” Alternatives (pumps, solid applicators, etc.)
 - Replace HFC Metered Dose Inhalers with Dry Powder Inhalers



Fire Suppression Options

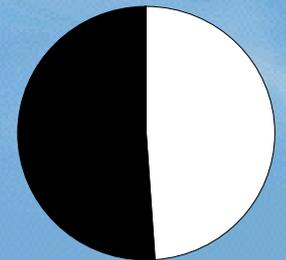
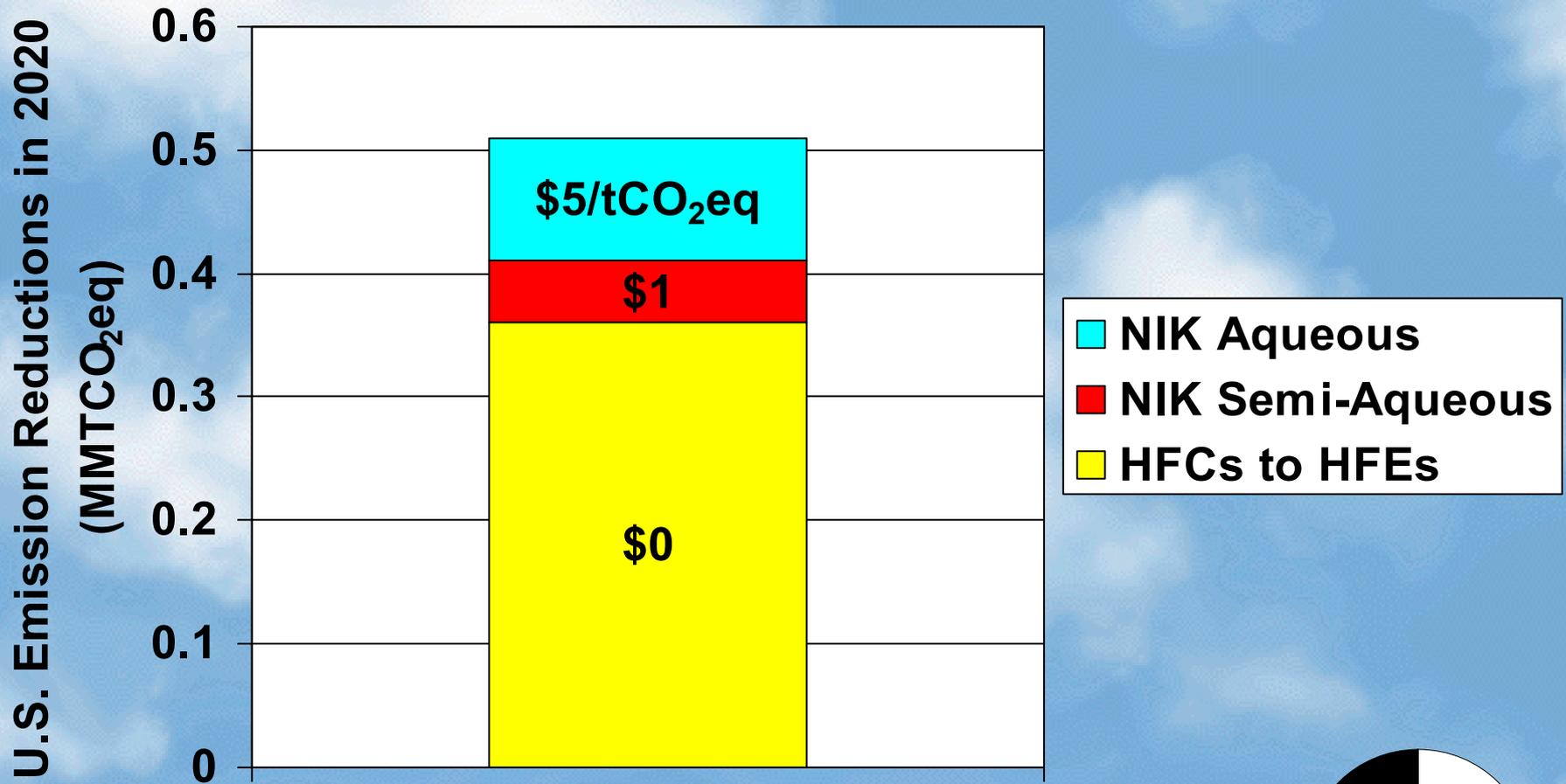


- Water Mist
- Inert Gases
- FK-5-1-12



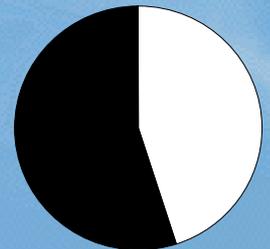
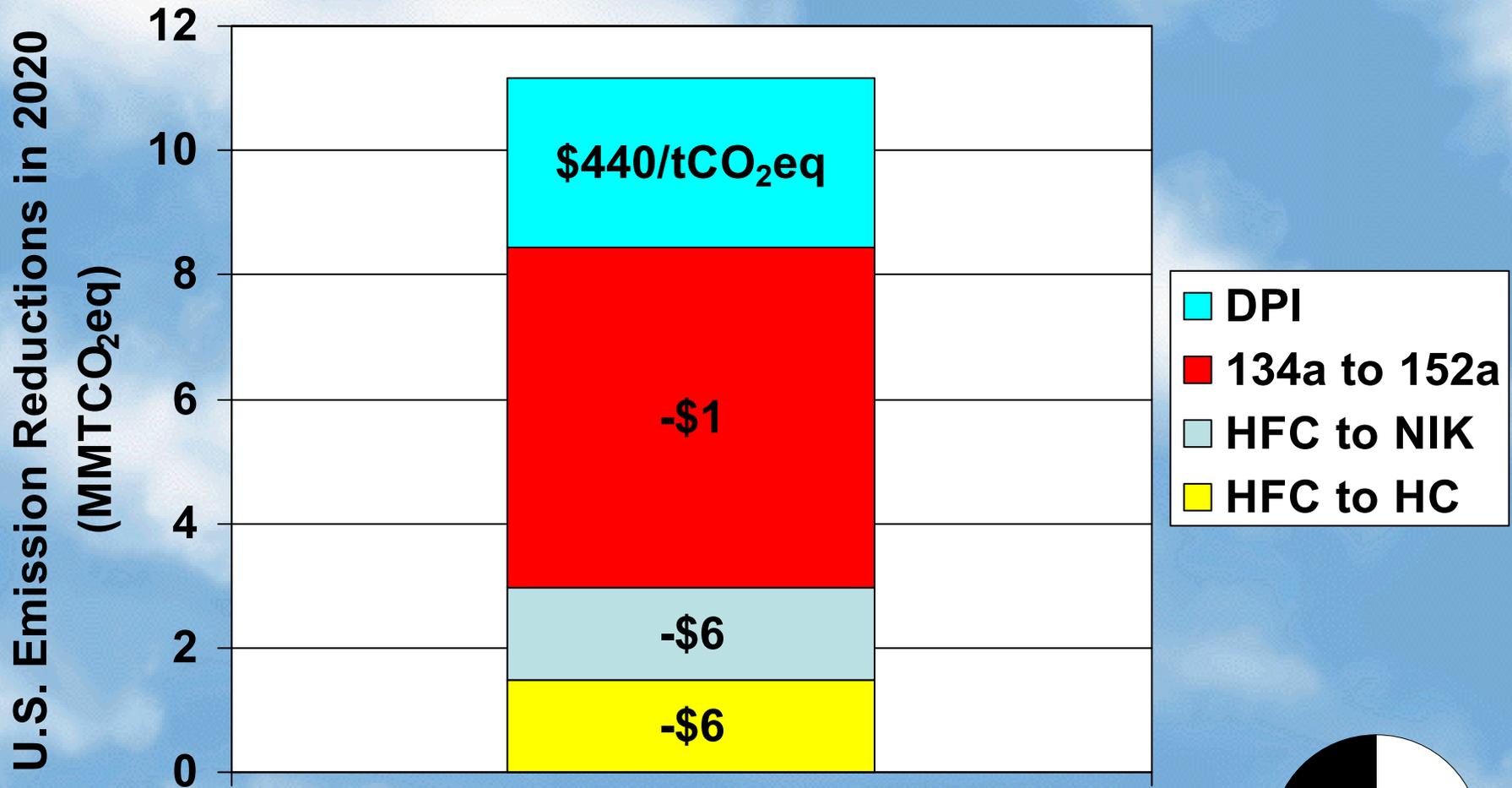
(2000\$s)

Cleaning Solvent Options



(2000\$s)

Aerosol Propellant Options



(2000\$s)



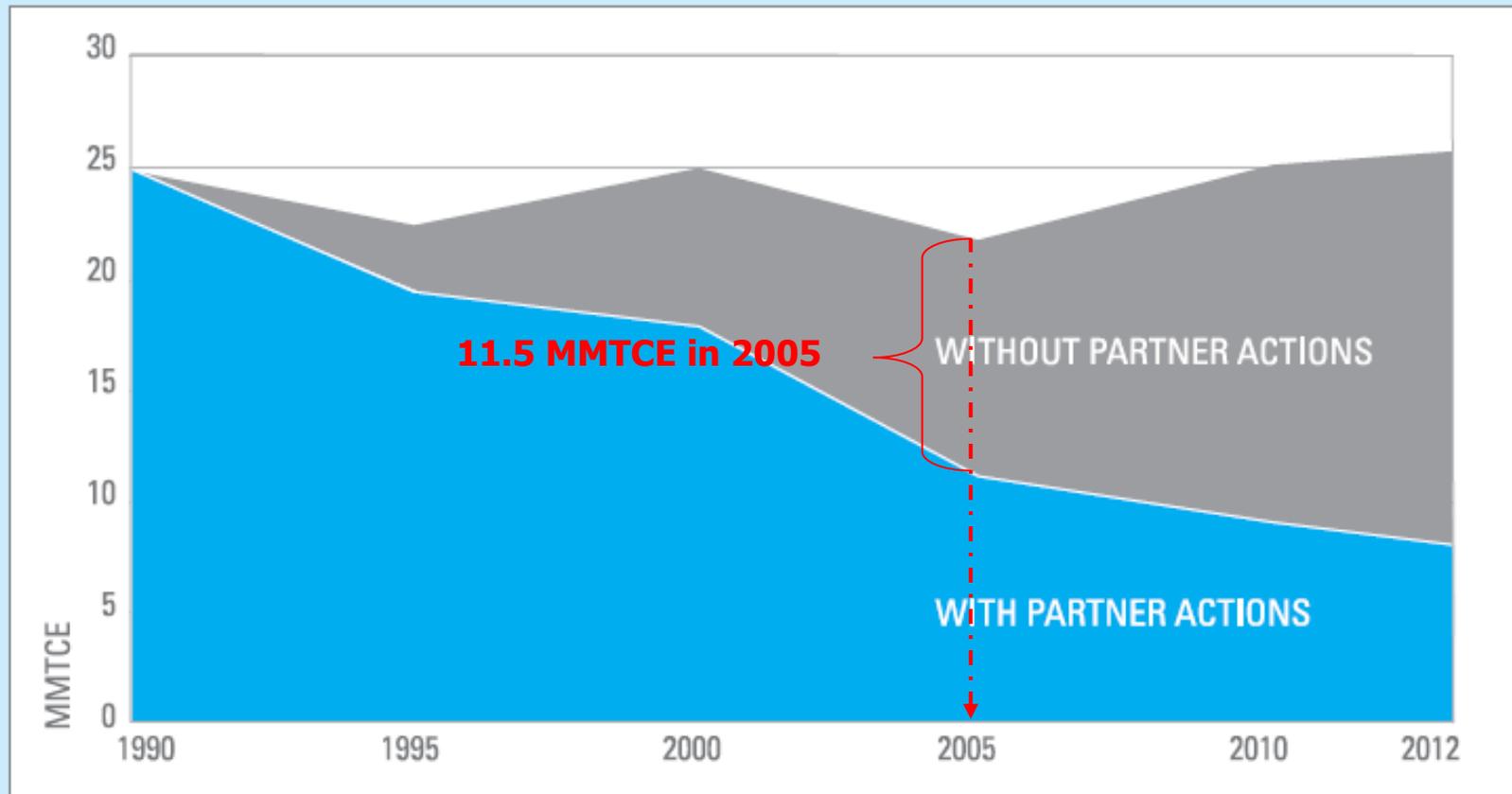
Industrial Sector Reduction Options

EPA Voluntary Partnerships

- **PFCs, HFC-23, SF₆, NF₃ from Semiconductors** - since 1996
 - *Program model for World Semiconductor Council; Goal - 10% below '95*
 - *Partners represent about 80% of U.S. emissions*
- **SF₆ from Electric Power Systems** - since 1999
 - *Partners represent 45% of U.S. generation*
- **HFC-23 from HCFC-22 Production** - since 1993
 - *100% participation; 60% intensity reduction '90-'05*
- **PFCs from Primary Aluminum** - since 1994
 - *77% PFC reduction 1990-2005; 53% carbon reduction by 2010*
- **SF₆ from Magnesium** - since 1999
 - *90% participation; Goal to eliminate SF₆ emissions by 2010*

Industrial Emission Reduction Options

FIGURE 19. PARTNER ACTIONS ARE PROJECTED TO MAINTAIN EMISSIONS OF HIGH GWP GASES BELOW 1990 LEVELS THROUGH 2012



Company Commitments

- Report annual emissions
 - Consistent with IPCC guidelines
- Identify reduction opportunities
 - Process optimization
 - Substitute chemistries
 - Capture/Recycle
 - Abatement
- Set emission reduction goal
- Share pre-competitive information



EPA Responsibilities

- Help assess options
- Establish emission estimation methods & reporting tools
- Recognize, reward partner achievements
- Facilitate information sharing - technical clearinghouse
- Recruit domestic partners and promote similar voluntary commitments internationally

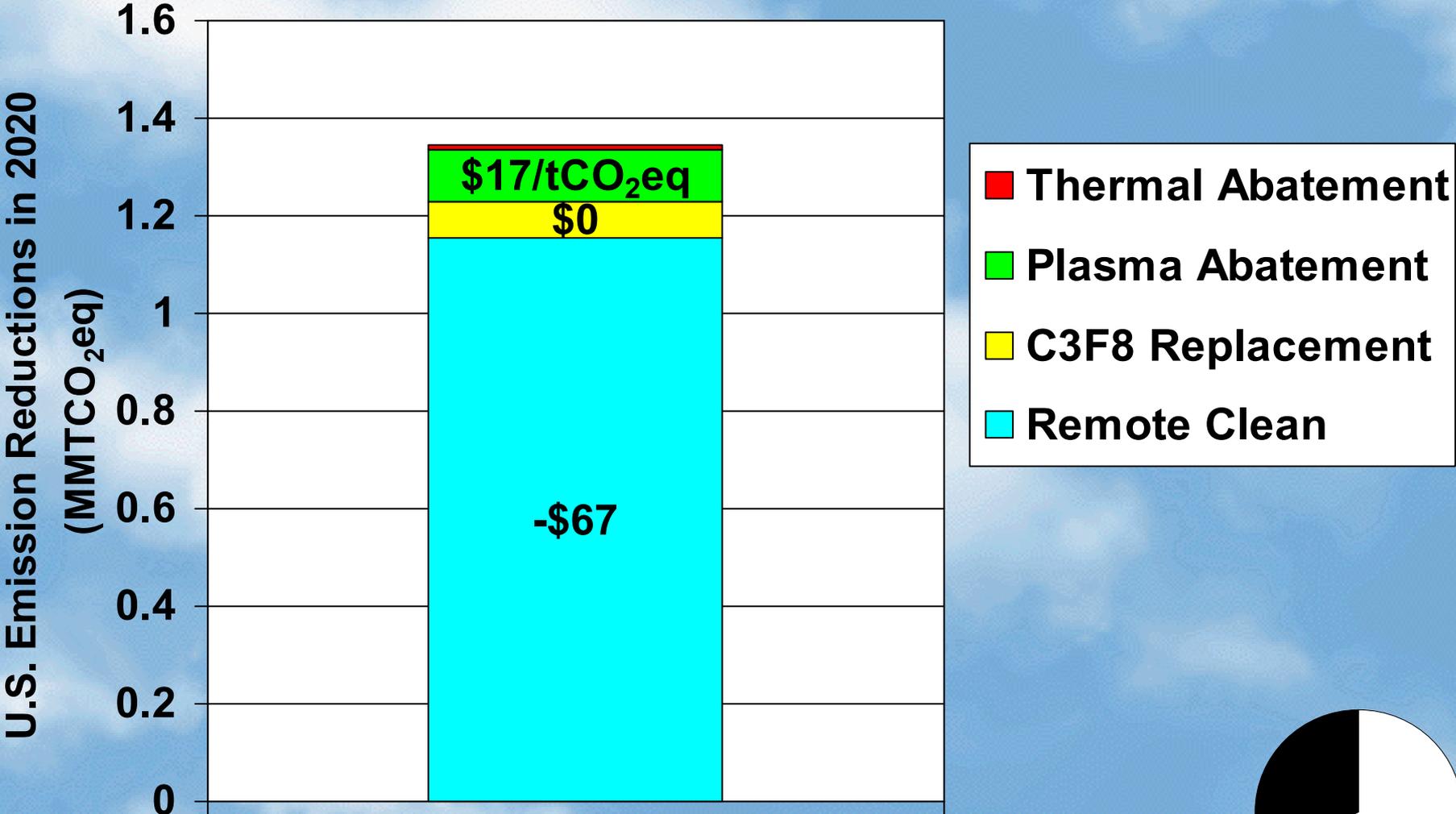
Industrial Abatement Options

- Magnesium Production and Casting
 - Alternative melt protection technologies
 - SO₂
 - Fluorinated cover gases
- Manufacturing of the Chemical HCFC-22
 - Process optimization
 - Thermal oxidation
- Primary Aluminum
 - Technology upgrades
 - Management and operations

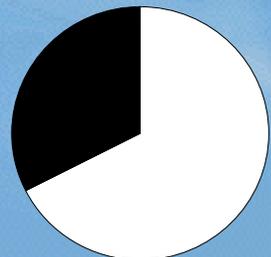
Semiconductor Emission Control Approaches

- Pollution Prevention Strategy
 - Process optimization
 - Alternative CVD cleaning chemistries
 - C_3F_8
 - Remote and *in situ* NF_3
 - Capture/Recovery
 - Membrane
 - Destruction
 - Thermal
 - Catalytic
 - Plasma

Semiconductor Mfg. Options



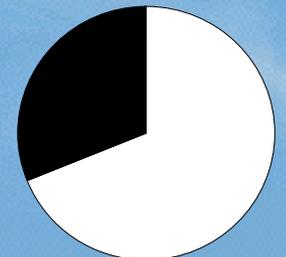
(2000\$s) Tech Adoption Baseline



Industrial Abatement Options

- Electric Power (Transmission & Distribution)
 - Leak Detection & In-service Repair
 - Equipment Refurbishment
 - Employee Training for Improved Gas Tracking, Handling & Recycling

Electric Utilities - Equipment Options



Conclusions

- Low cost reduction potentials in most sectors
 - Need to account for various industry structures
 - Recognize early action via sector-wide commitments to reduce emissions
 - High quality data essential
 - measurement drives management
- Many require capital turnover, will take time
 - Don't limit technology development
- Keep a broad perspective
 - Consider CFCs, HCFCs as well as HFCs
 - Consider energy efficiency as well as chemical

Thank You!

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www.epa.gov/nonco2/

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