Global Emissions of SF_6 and the Costs of Reducing Them: EPA's Global Emissions and Mitigation Reports

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Overview

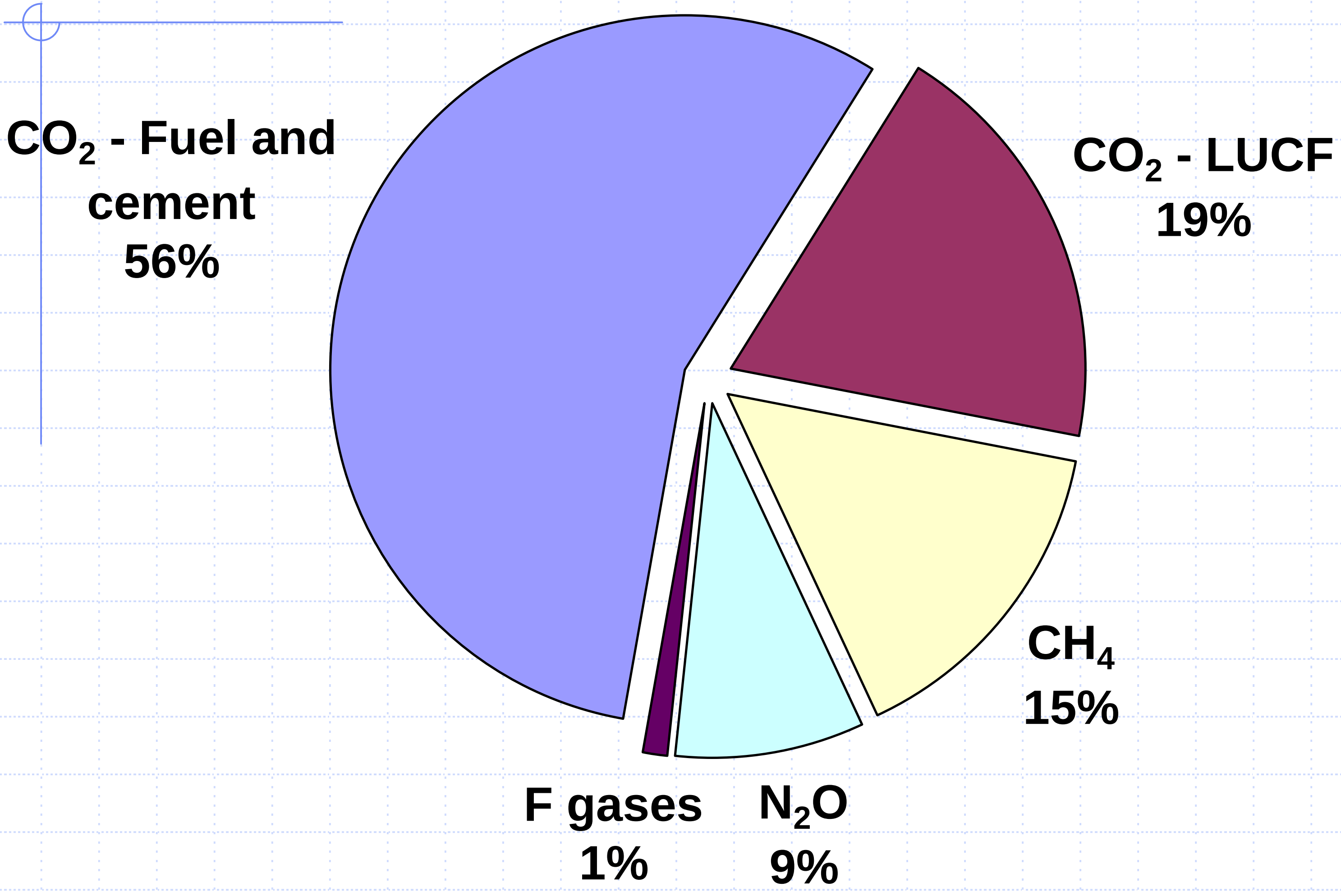
- Scope and purpose of the reports
- Role of fluorinated gases and SF_6
- Emissions
  - Assumptions
  - Results
- Reductions
  - Assumptions
  - Technologies
  - Results

Purpose of the Reports

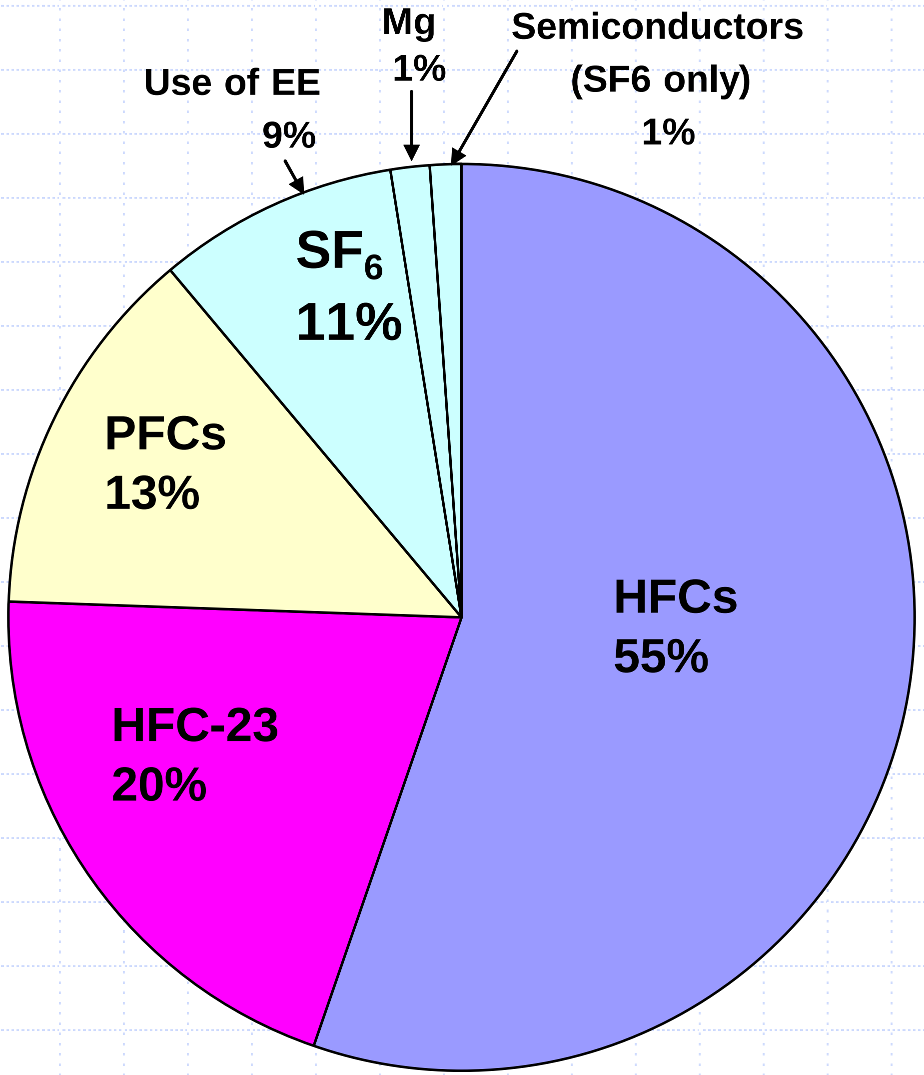
- Where are emissions and reduction opportunities for non-CO2 greenhouse gases?
  - Which industry sectors?
  - Which countries and regions?
- *Global Emissions Report:* Global and country-specific emissions
- *Global Mitigation Report:* Global and country-specific reduction opportunities and their costs
- Available at:

http://www.epa.gov/nonco2/econ-inv/international.html

Global GHG Emissions and Sinks, 2000



Total High-GWP Emissions = 503 MtCO2-eq



GER 2005 High-GWP Emissions by Gas

Caveats

- SF_6 emissions don't include
  - Manufacture of flat panel display
  - Manufacture of electrical equipment
  - Other SF_6 applications
- Other studies (e.g., RAND survey) indicate some of these sources are significant
- Assumes that SF_6 emissions make up the same fraction of semiconductor emissions in world as in U.S.

Example of "Other Application:" AWACS

IPCC Tier 1 Method:

AWACS Emissions = 740 kg x no. of planes

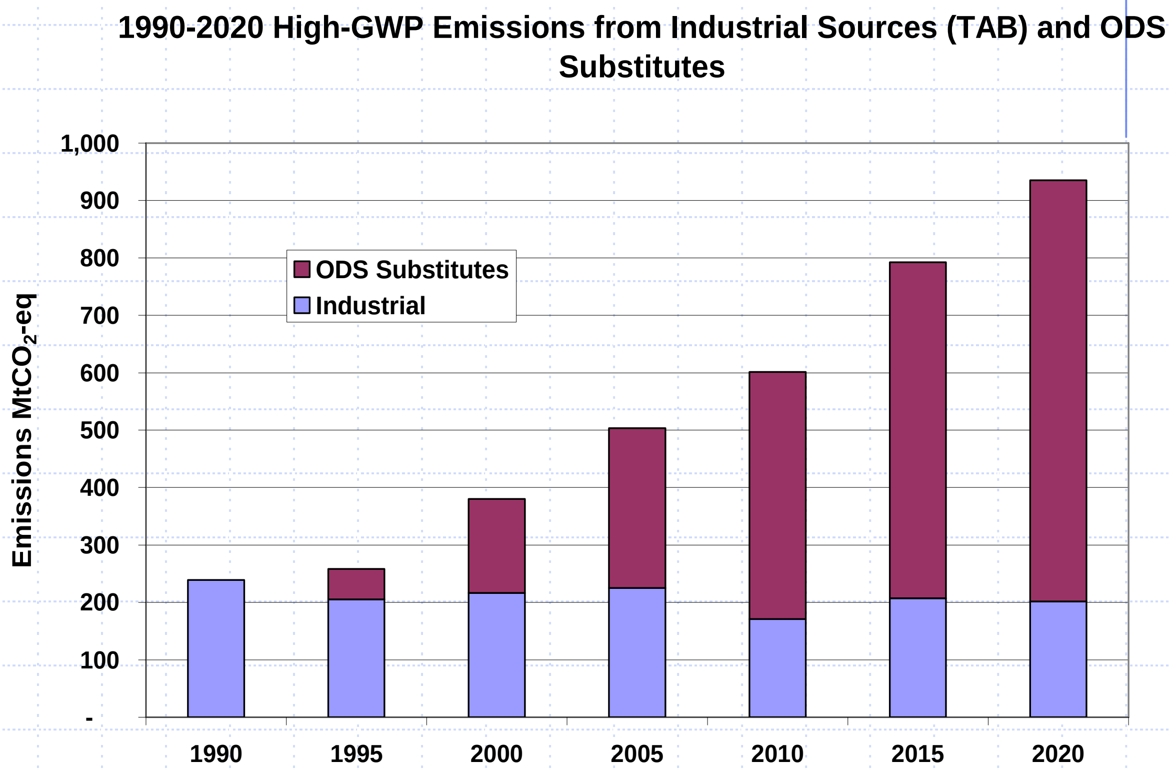
Global AWACS fleet = 70 planes (Boeing)

740 x 70 = 51,800 kg SF_6 = 1.24 $MtCO_2$-eq

= 2% of 2005 GER SF_6 emissions

Why are High-GWP Gases Important?

- High potential growth (early action = high payoffs)
- PFCs and SF_6 have long atmospheric lifetimes
- Relatively cheap to abate



Sources of High-GWP Gases

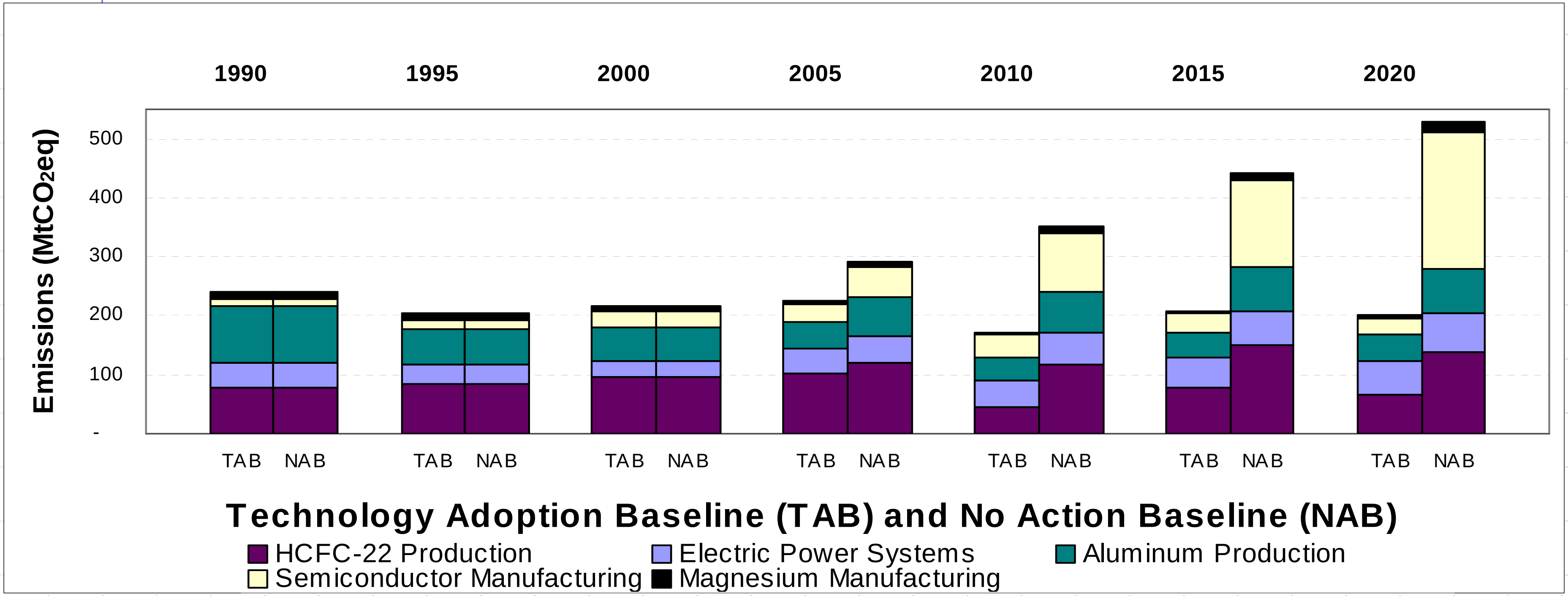
Industry	Gas	Reason Emitted
Substitutes for Ozone-Depleting Substances	HFCs	Various performance characteristics
Primary Aluminum	PFCs	Byproduct
HCFC-22 Production	HFC-23	Byproduct
Semiconductor Manufacture	HFC-23, PFCs, SF_6	Fluorine source for etching, cleaning
Magnesium prod. and processing	SF_6	Cover gas to prevent oxidation
Electric Transmission	SF_6	Insulating gas for electrical equip.

Estimating Emissions

- Current emissions: Used methods based on IPCC guidance
- Two scenarios for future emissions:
  - Technology Adoption: Assumes industries decrease emission rates to meet their global and regional emission reduction goals
  - No Action: Assumes current emission rates will continue unchanged

Industrial High-GWP Emissions by Sector: Technology-Adoption and No-Action Scenarios

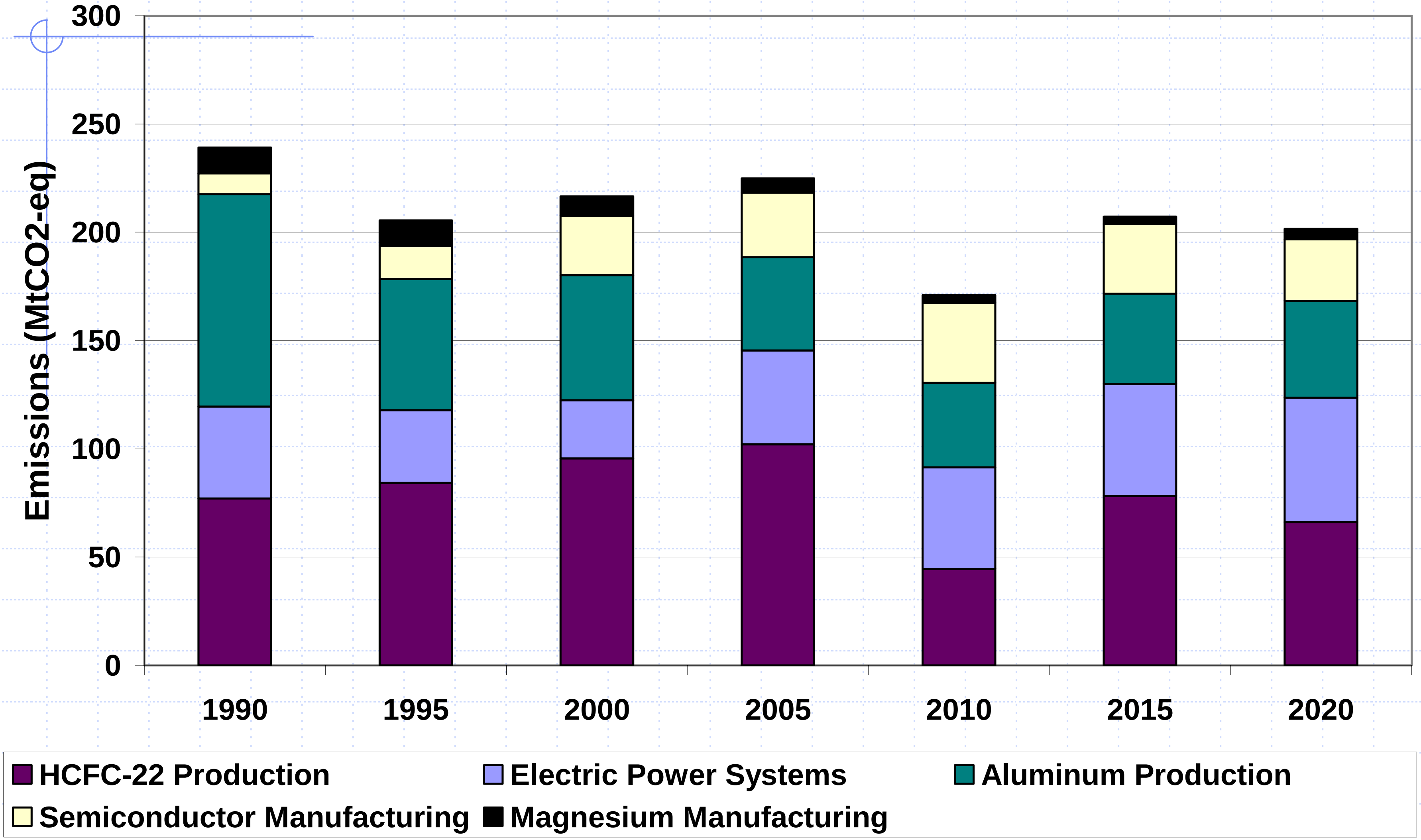
- Technology-Adoption
  - EPA believes future emissions are likely to be closer to this scenario
  - But additional actions are required to realize expected reductions
- No-Action
  - Provided as upper-bound
  - Shows industry commitments avert very large emissions



Global and Regional Reduction Goals

Industry	Global Industry Assoc., Region, or Country	Percent of World Production/ Emissions in 2003	Goal
Semiconductor manufacturing	World Semiconductor Council	85%	Reduce fluorinated emissions to 90% of 1995 level by 2010
Magnesium production and processing	International Magnesium Association	70% (about 90% of sector's SF_6 emissions)	Phase out SF_6 use by 2011
Aluminum production	International Aluminum Institute	70% (but goal applies to entire industry)	Reduce PFCs/ton Al by 80% relative to 1990 levels by 2010
Electrical Equipment (Use)	EU-25+3, Japan, U.S.	40% of use emissions	Country-specific reductions from 2003 totaling 2.5 MtCO2-eq, (15%).
HCFC-22	China, India, Korea, Mexico	65% of emissions	CDM projects totaling 55 MtCO2-eq, (63% of 2010)

1990-2020 High-GWP Industrial Emissions by Sector



Current SF_6 Emissions from Use of Electrical Equipment

- Manufacturing not included!
- Bottom-up country and regional studies used for U.S., Japan, EU-25+3 (Ecofys)
- For rest of the world,

Emissions = RAND sales to utilities

+ nameplate capacity of retiring equip. (40-year life)

+ 16% add-on for Russia and China (not in RAND)

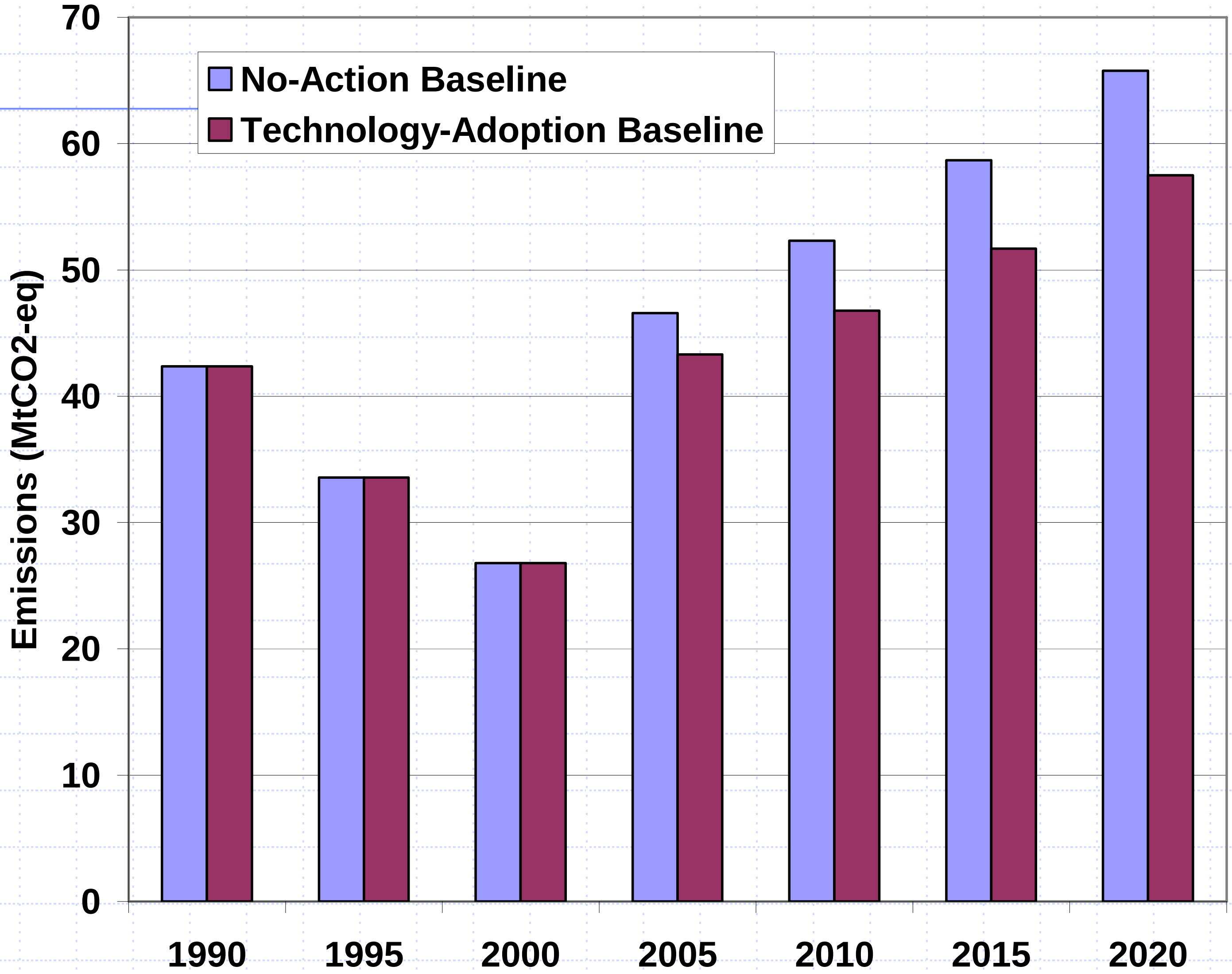
- U.S., Japanese, EU-25+3 emissions

These emissions are allocated to countries according to their net electricity consumption.

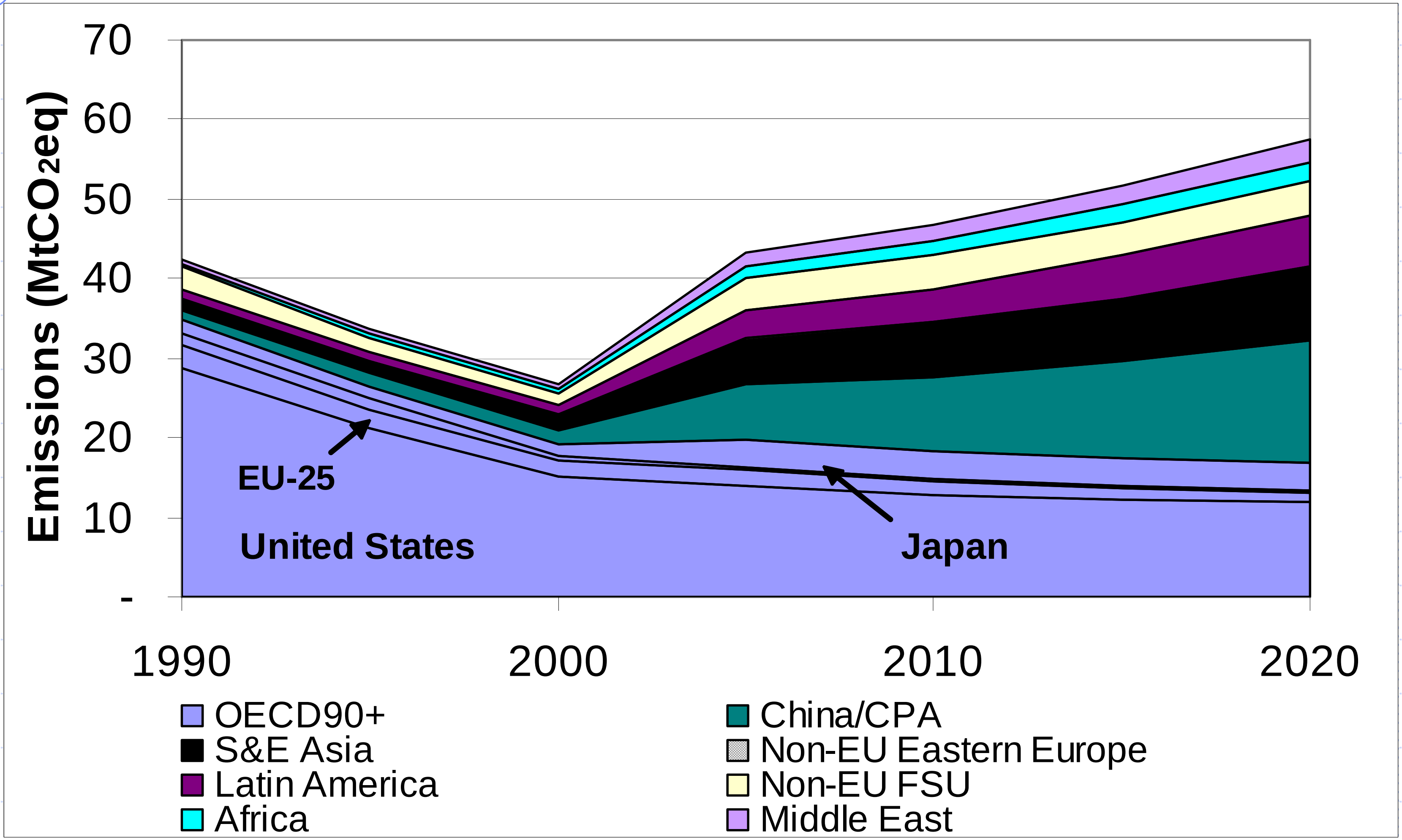
Future SF_6 Emissions from Use of Electrical Equipment

- For Technology-Adoption scenario, U.S., Japan, EU-25+3 are assumed to meet their emission reduction goals
- Other developed countries maintain constant emissions (system growth offset by decreasing charge sizes and leak rates)
- Developing countries' emissions grow with net electricity consumption (charge sizes already small)

TAB and NAB Scenarios for Use of Electrical Equipment



Emissions from Use of Electrical Equipment by Region (TAB)



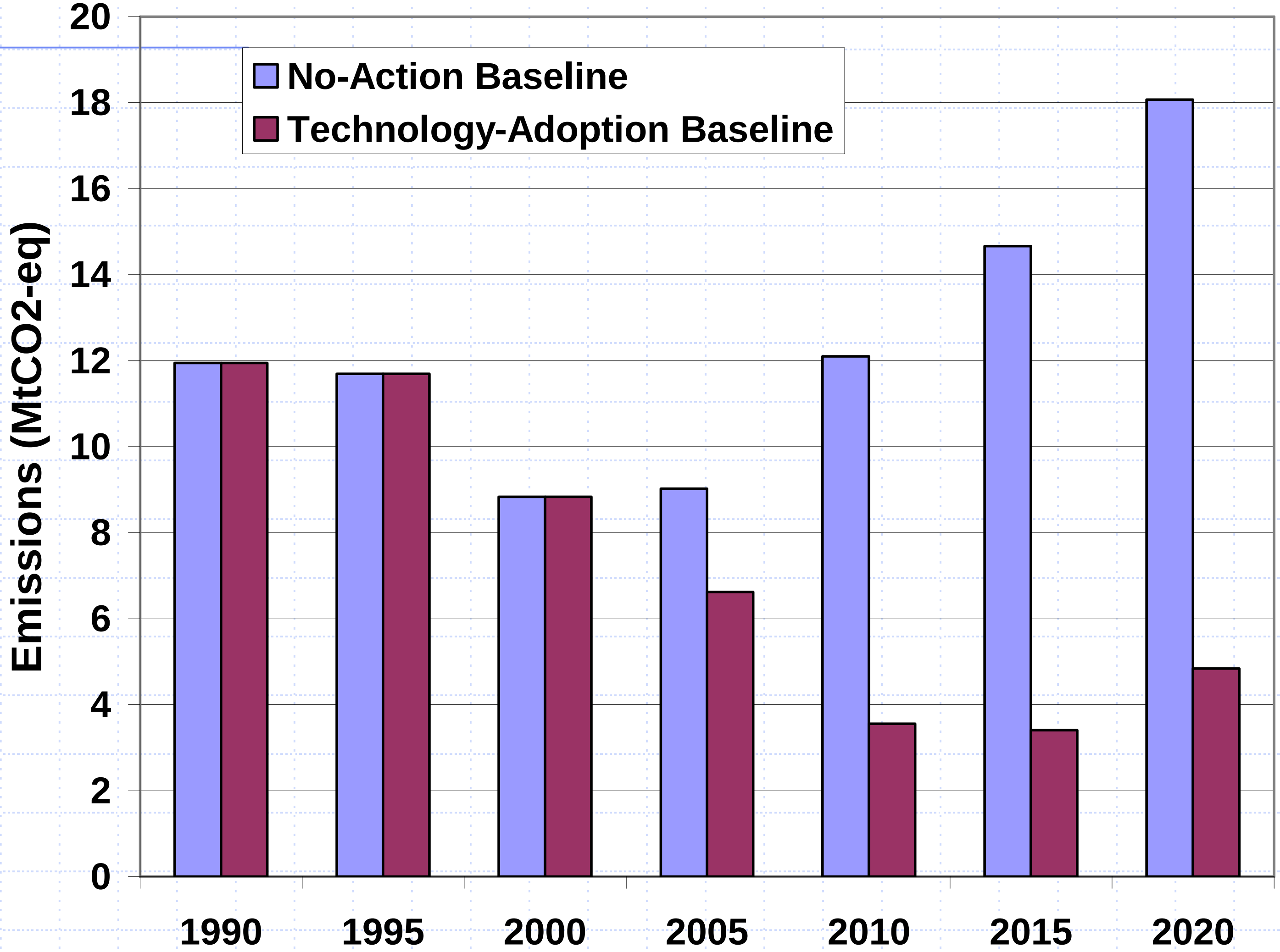
Current SF_6 Emissions from Mg

- Production/processing estimates
  - Primary and secondary production: USGS
  - Die Casting: Regional studies or auto production
- Emission and usage factors
  - Where SF_6 is used, 0.75 - 1 kg SF_6/ton Mg
  - In China, 10% primary and 100% die casters use SF_6

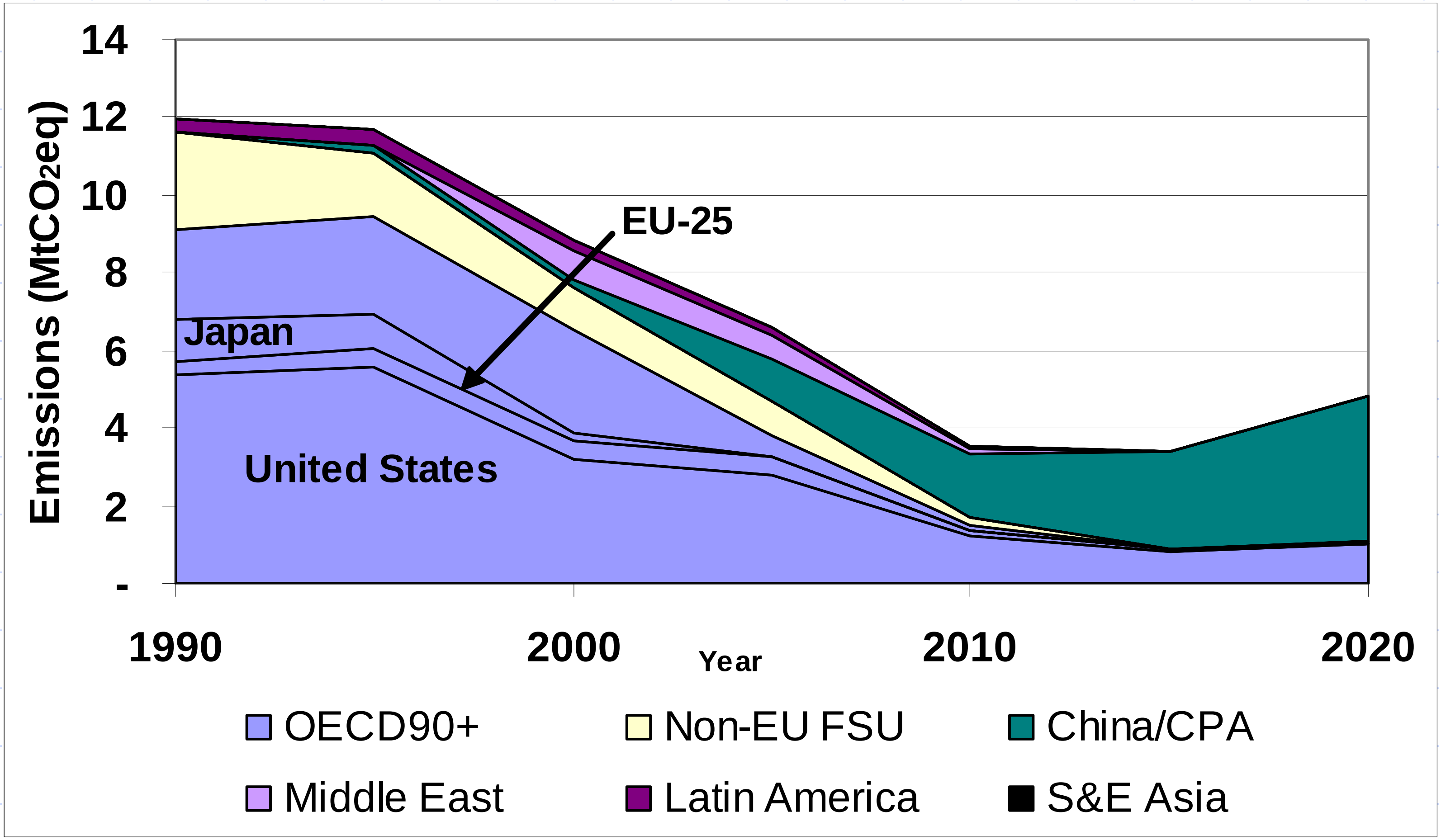
Future SF_6 Emissions from Mg

- Production/processing growth
  - Primary: 1% – 6%, depending on region
  - Casting: 2% - 10%, depending on region
  - Growth assumed to slow after 2010
- Emission factor changes
  - For Technology-Adoption scenario, almost all producers/processors outside of China are assumed to phase out use of SF_6 by 2011 under IMA goal.

NAB and TAB Scenarios for Magnesium Production and Processing



Emissions from Production and Processing of Magnesium by Region (TAB)



Reduction Options, Potentials, and Costs

- Again, two scenarios
  - Technology Adoption: Assumes industries decrease emission rates to meet their global and regional emission reduction goals.
    - Both emissions and reduction potentials lower.
    - Some options (e.g., SF_6 recycling in Europe) fully implemented in baseline and thus aren't in MAC.
  - No Action: Assumes current emission rates will continue unchanged. Emissions and reduction potentials higher.

Reduction Options for Use of Electrical Equipment* (TAB)

Technology	Baseline market penetration	Share of unabated emissions to which applied	Fraction of share reduced
SF_6 Recycling	80% (rises to 93% in U.S.)	67%	95%
Leak Detection and Repair	80% (rises to 93% in U.S.)	30%	50%
Equipment Refurbishment	80% (rises to 93% in U.S.)	3%	95%

*All countries but EU-25+3 and Japan. For EU-25+3 and Japan, options, reduction potentials, and costs drawn from 2005 Ecofys study for Capiel.

Reduction Options for Mg Production/Processing (TAB)

Technology	Baseline market penetration	Share of unabated emissions to which applied	Fraction of share reduced
SO_2	Rises to 50% by 2011 outside China	50%	100%
Fluorinated gases	Rises to 50% by 2011 outside China	50%	97%

Inputs into Cost Analysis Example: SF_6 Recycling (EE)

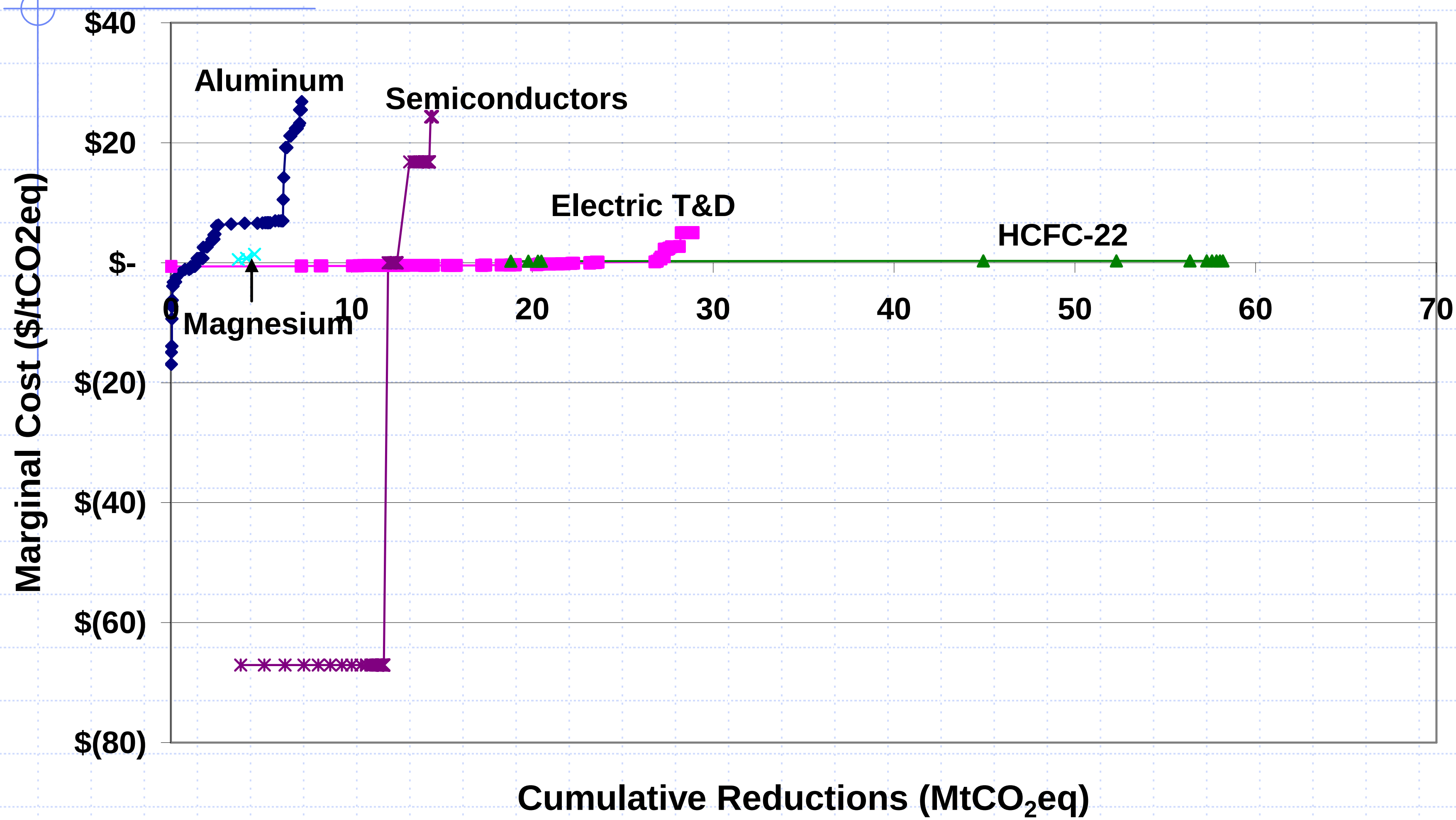
Effectiveness

- Applicability: 67%
- Baseline market penetration: 80%
- Maximum market penetration: 100%
- Reduction efficiency: 95%
- Total reduction off baseline: 50%
- U.S. reduction: 6.6 $MtCO_2eq$

Cost (U.S.)

- Capital costs: $5.6 M ($25,000 per unit)
- Operating costs: $277,000 (labor)
- Gas savings: $4.3 M
- Project lifetime: 10 yrs
- Cost/tCO_2-eq: ($0.10)

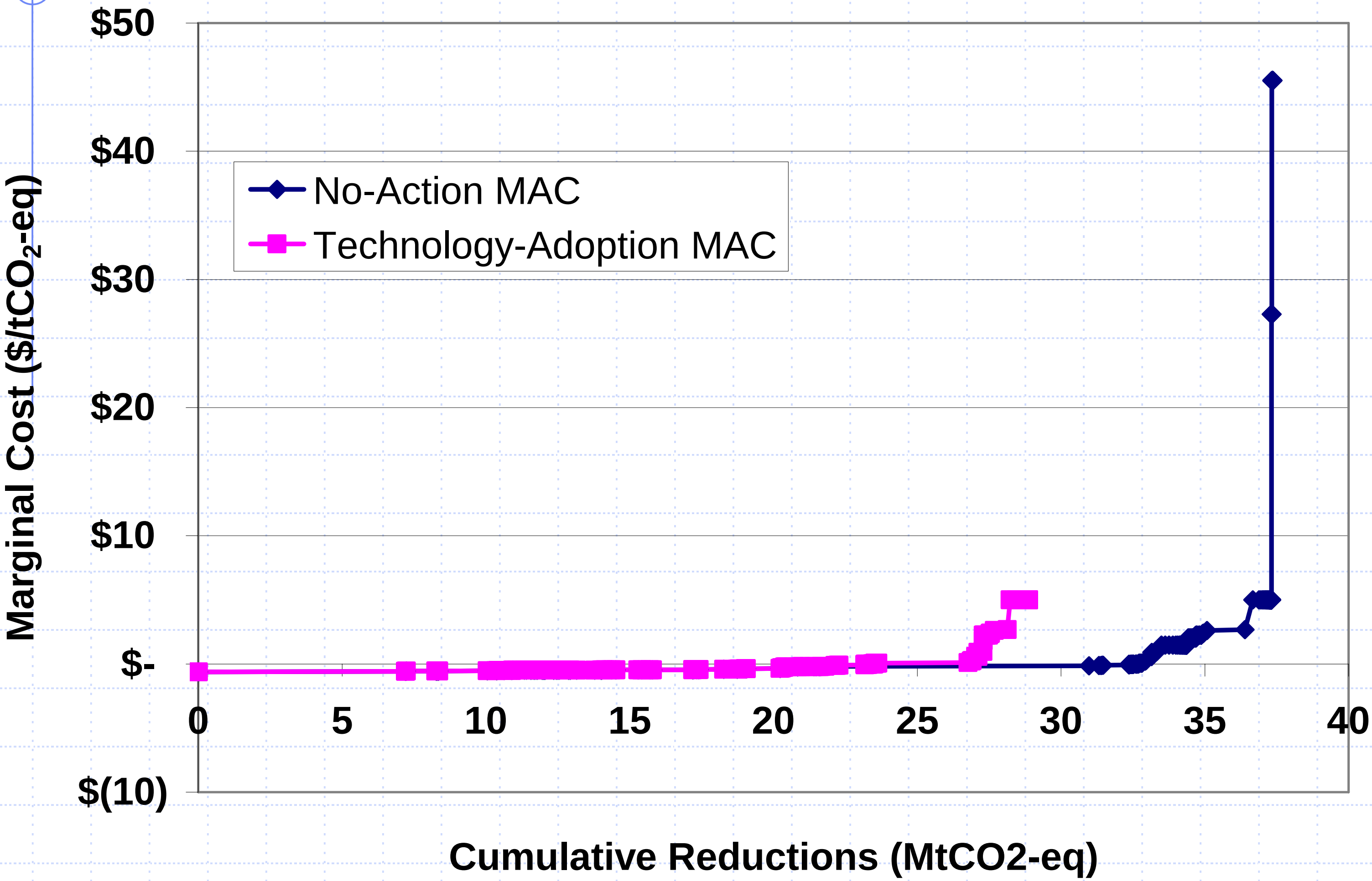
2020 Sector-by-Sector Technology Adoption MACs for High-GWP Industrial Sources



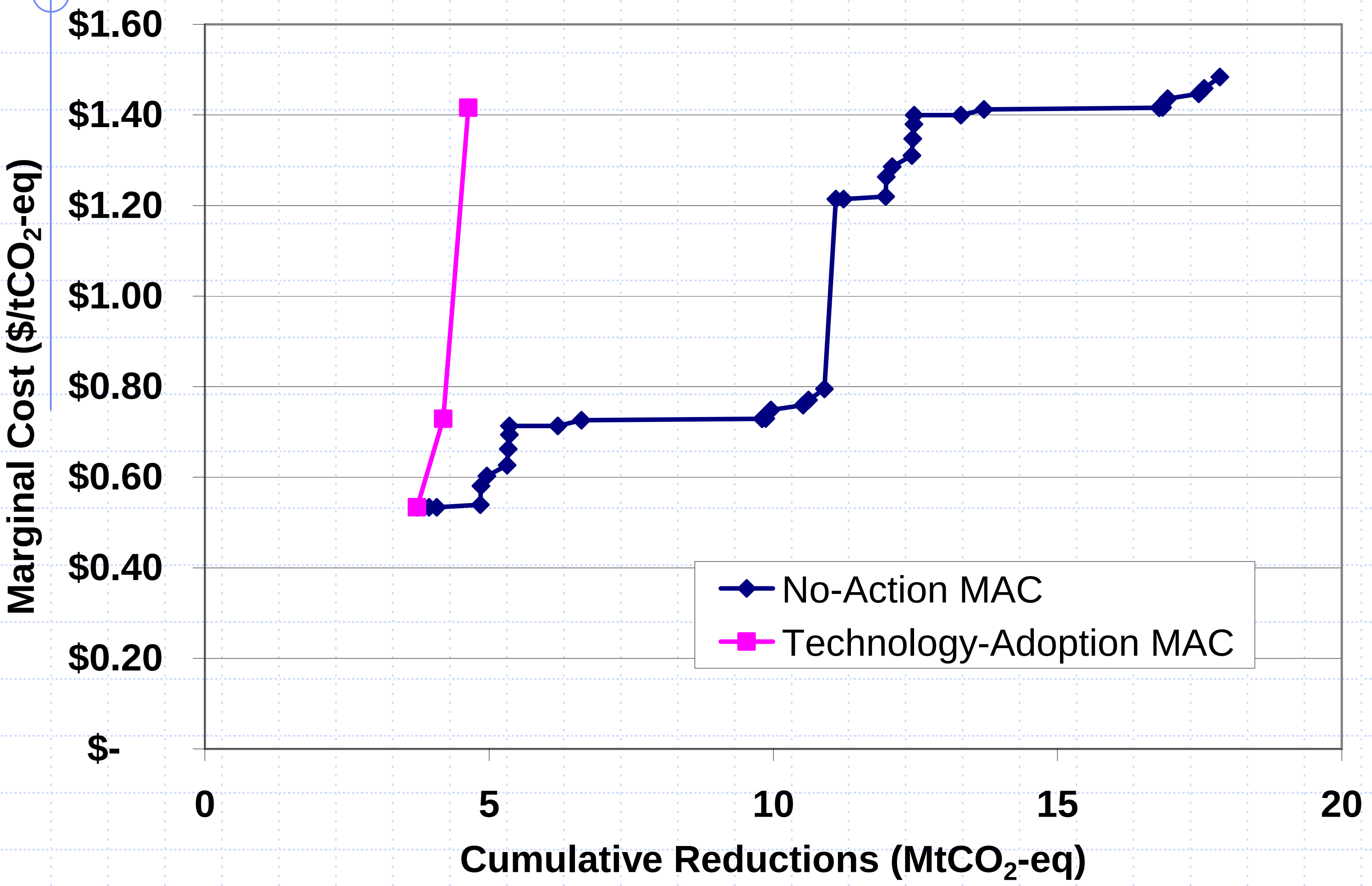
Options with Largest SF_6 Reductions (2020)

Industry Sector	Option	Reduction (MtCO2-eq)	Cost ($/tCO2-eq)
Use of Electrical Equipment	SF_6 Recycling	25	Near 0
Magnesium Production and Processing	SO_2	4.2	Near 0.65
Use of Electrical Equipment	Leak Detection and Repair	3.5	Near 1

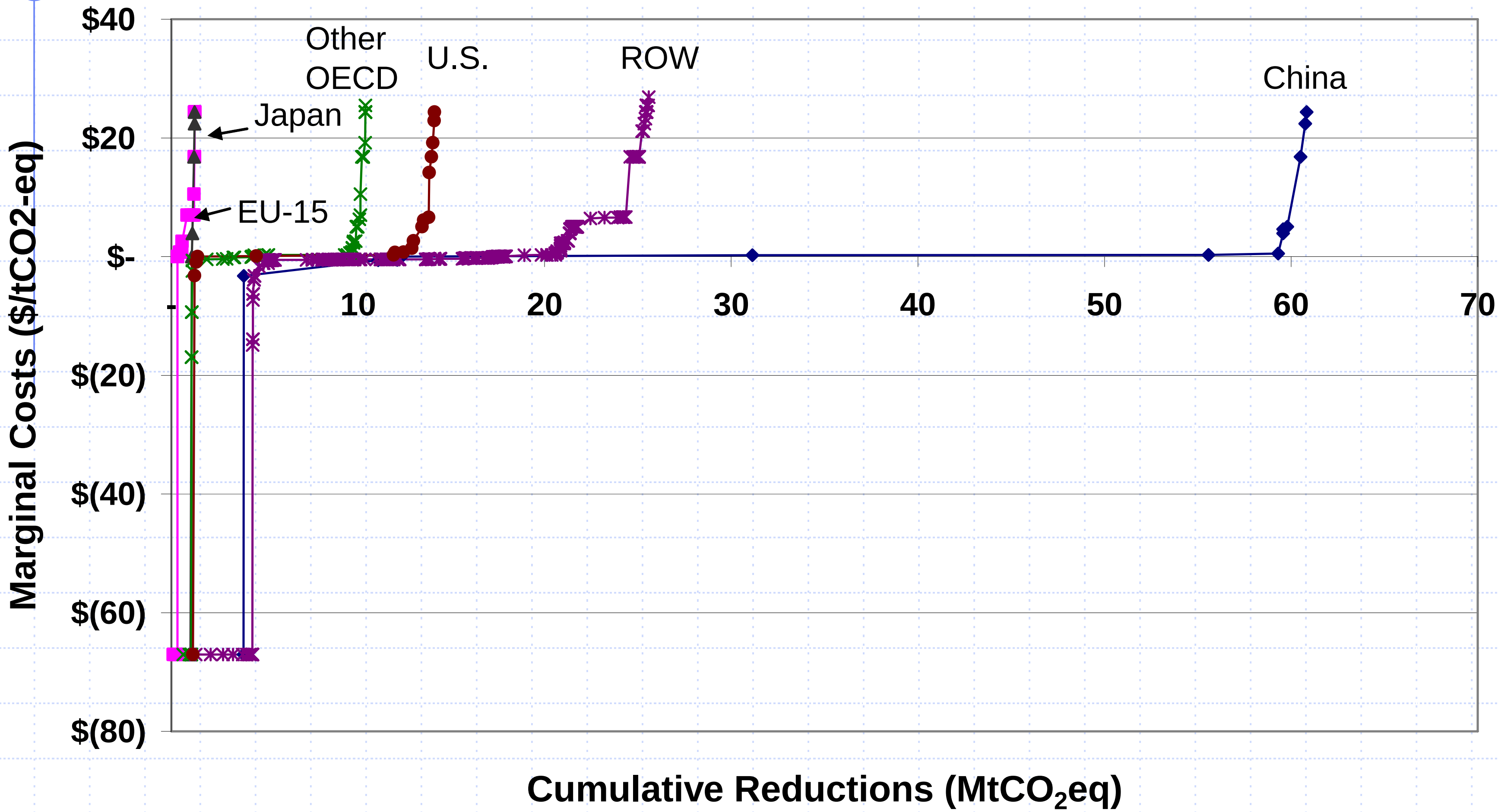
2020 No-Action and Technology-Adoption MACs for Use of Electrical Equipment



2020 No-Action and Technology-Adoption MACs for Magnesium



2020 High-GWP Industrial Technology Adoption MACs by Region



Uncertainties

- RAND data for utilities only shows part of the world. Imports from/exports to China or Russia would affect results.
- Relationship between emissions and net electricity consumption can vary considerably.
- Chinese use of SF_6 for primary assumed 10%; could be higher or lower.
- Emissions sensitive to control efforts:
  - Higher if industry goals are not met.
  - Lower if developing countries lower emission rates (e.g., through CDM).

Conclusions

- Industrial (not ODS sub) high-GWP emissions are expected to decline in developed countries and to increase in developing countries. Driven by
  - Emission controls in developed countries
  - Higher growth rates of activity in developing countries
- Largest reduction opportunities are also in developing countries
- Even in Technology-Adoption Scenario, large and inexpensive reduction opportunities remain.