An Analysis of Reduction Opportunities for Consumption of HFCs and Comparisons to U.S. Climate Policy Proposals

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Non-CO_2 Greenhouse Gases (NCGG-5)

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Wageningen, The Netherlands

Outline

- Introduction to HFCs
- Proposed U.S. Legislation on HFCs
- Options to Reduce HFC Consumption
- Comparison of Baseline, Reduction to Policy Proposals
- Sensitivity to BAU Projections
- Sensitivity to Reduction Options Applied

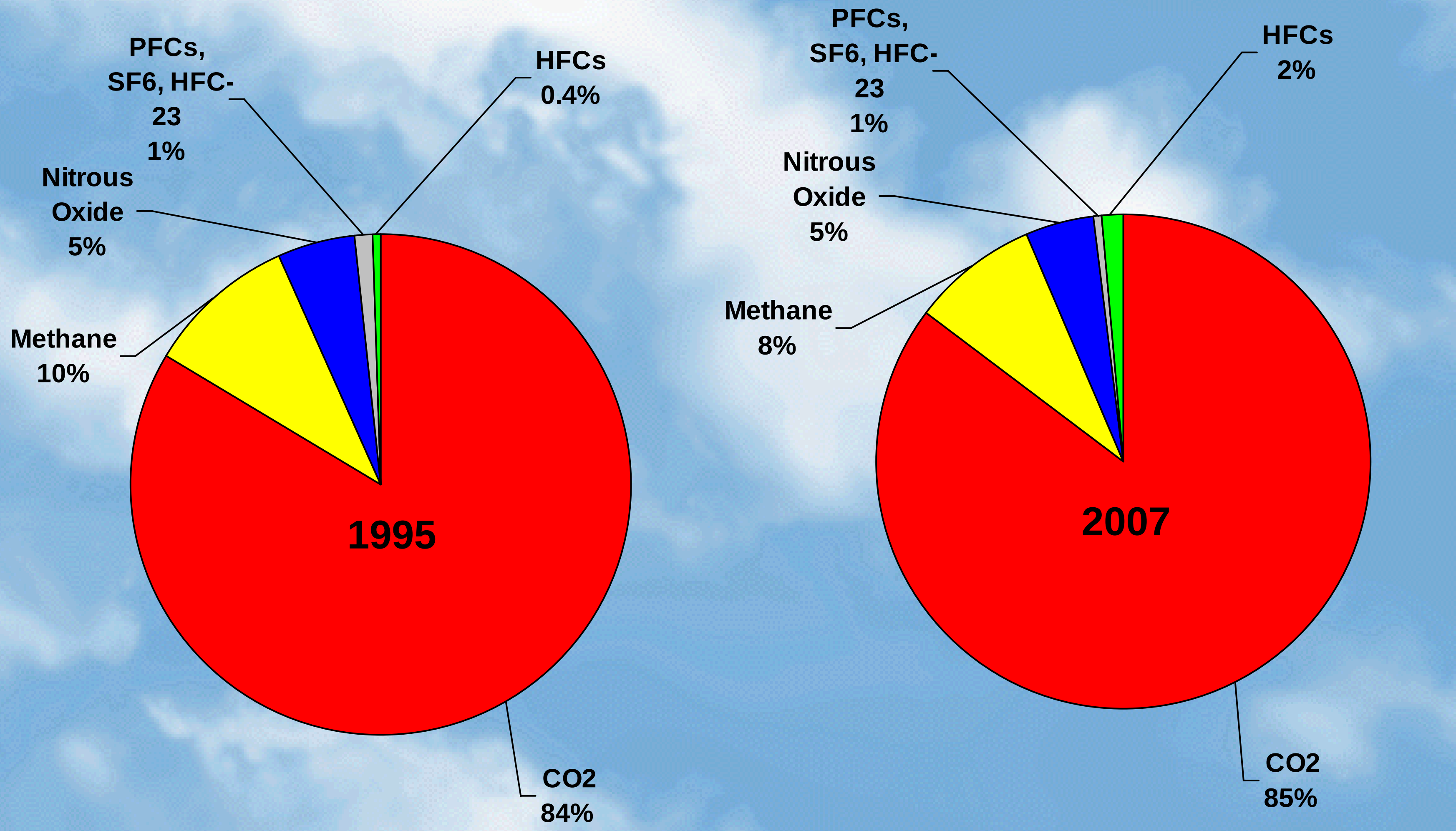
Introduction to HFCs

- HFC-23 byproduct of HCFC-22 production
- HFC-152a used in R-500 blend with CFC
- Used with other F-GHGs in semiconductor manufacturing
- Primarily introduced as ODS substitute in response to Montreal Protocol
  - Refrigeration & air-conditioning
  - Foams, aerosols, solvents, fire extinguishing

Atmospheric Impacts of ODS and HFCs

Chemical	Lifetime (years, AR4)	ODP (MP)	GWP (AR4)	Common Uses
CFC-12	100	1.0	10,890	Mobile AC, domestic refrigerators, foam blowing, metered dose inhalers, aerosol propellant
HFC-134a	14	0	1,430	
CFC-11	45	1.0	4,750	Foam blowing
HFC-245fa	7.6	0	1,030	
Halon 1301	65	10	7,140	Fire suppression (total flooding, aviation)
HFC-227ea	34.2	0	3,220	
HCFC-22 (HFC-23)	12 (270)	0.055 (0)	1,810 (14,760)	Residential, industrial, commercial AC, refrigeration
R-404A	29, 52, 14	0	3,920	Commercial refrigeration
R-410A	4.9, 29	0	2,090	Residential, Commercial AC

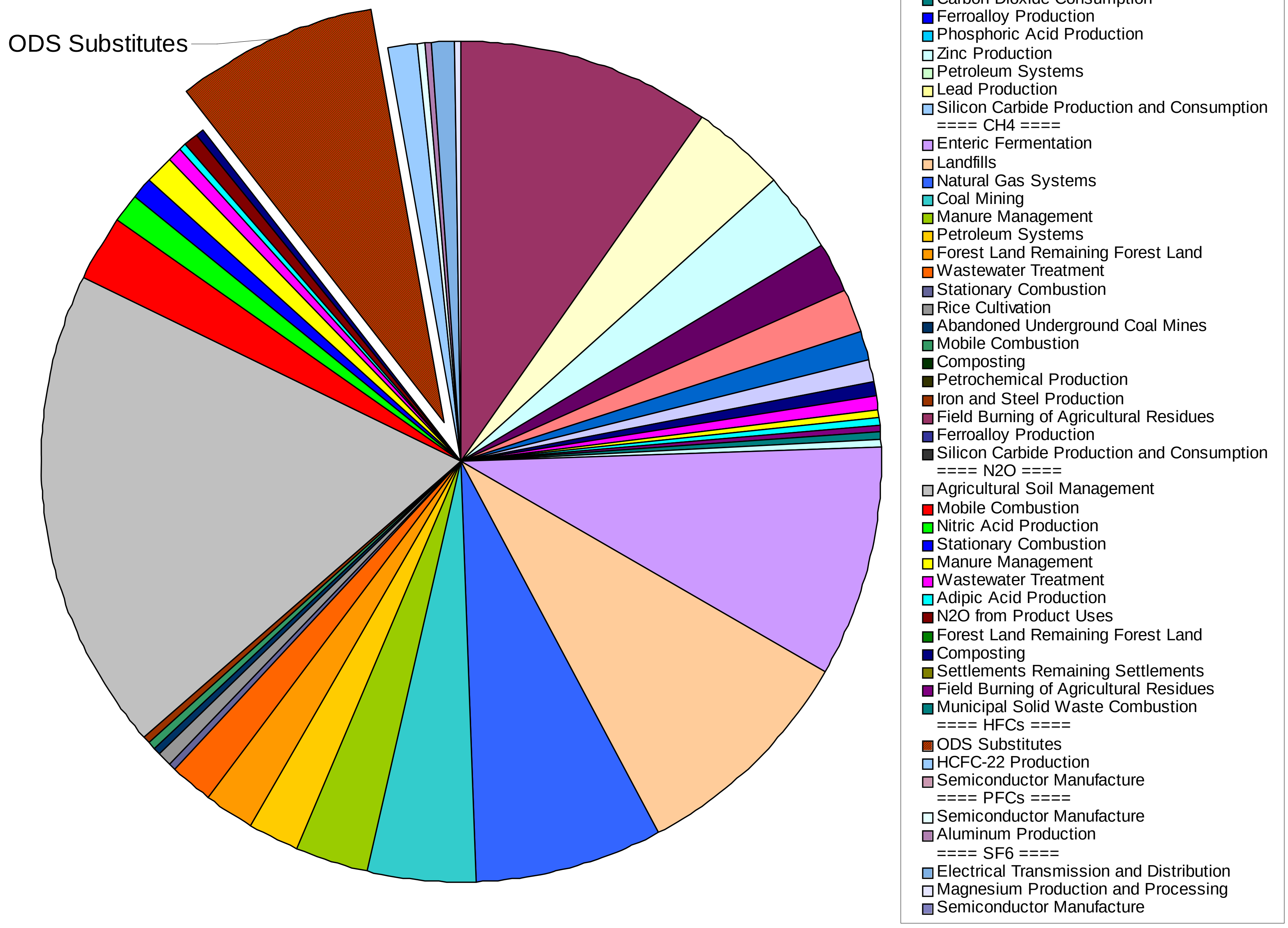
HFCs used as ODS substitutes account for <2% of GHG emissions



Source: USEPA, GHG Inventory, 2009

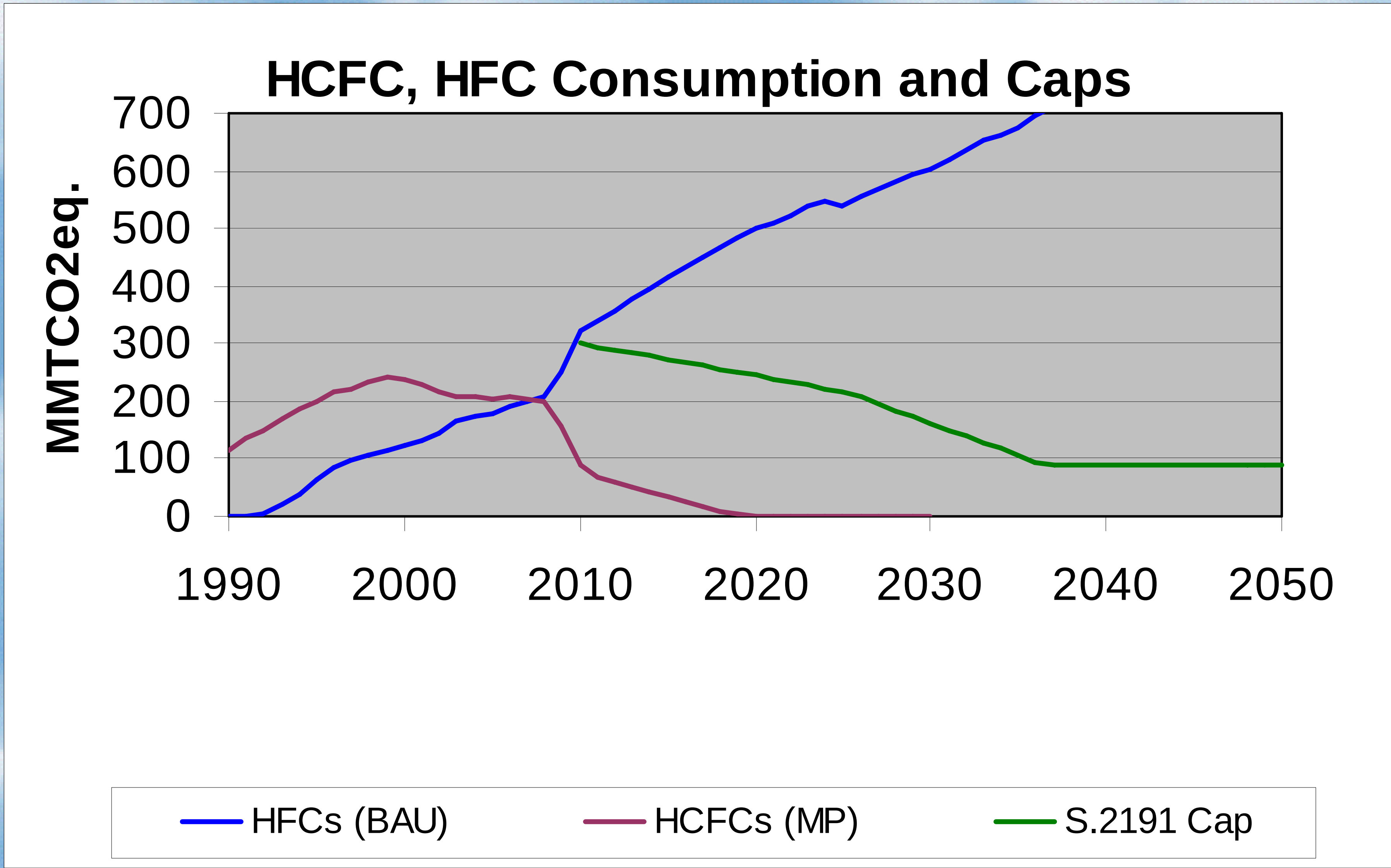
U.S. GHG Emissions (2006)

excluding Fossil Fuel Combustion



Proposed U.S. Legislation

- Some early bills did not address HFCs (Feinstein-Carper, Alexander-Lieberman)
- Some early bills included HFCs in the basket of other gases (McCain-Lieberman)
- Recent bills have treated HFCs separately
  - Late entry (Markey)
  - Extend ODS Regulations (several)
  - Separate HFC cap (several)


HCFC, HFC Consumption and Caps
MMTCO2eq.
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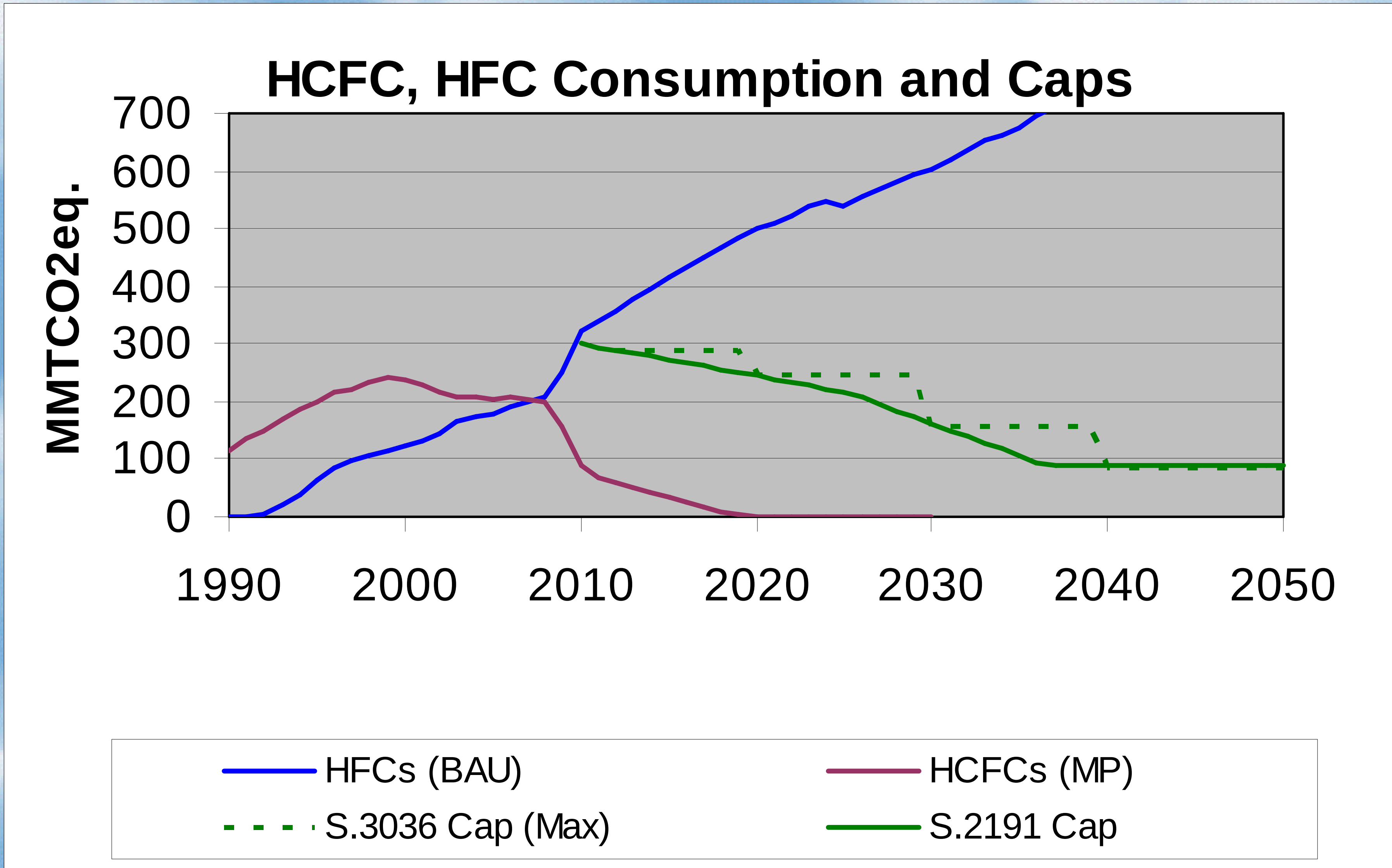
HFCs (BAU)
HCFCs (MP)
S.2191 Cap



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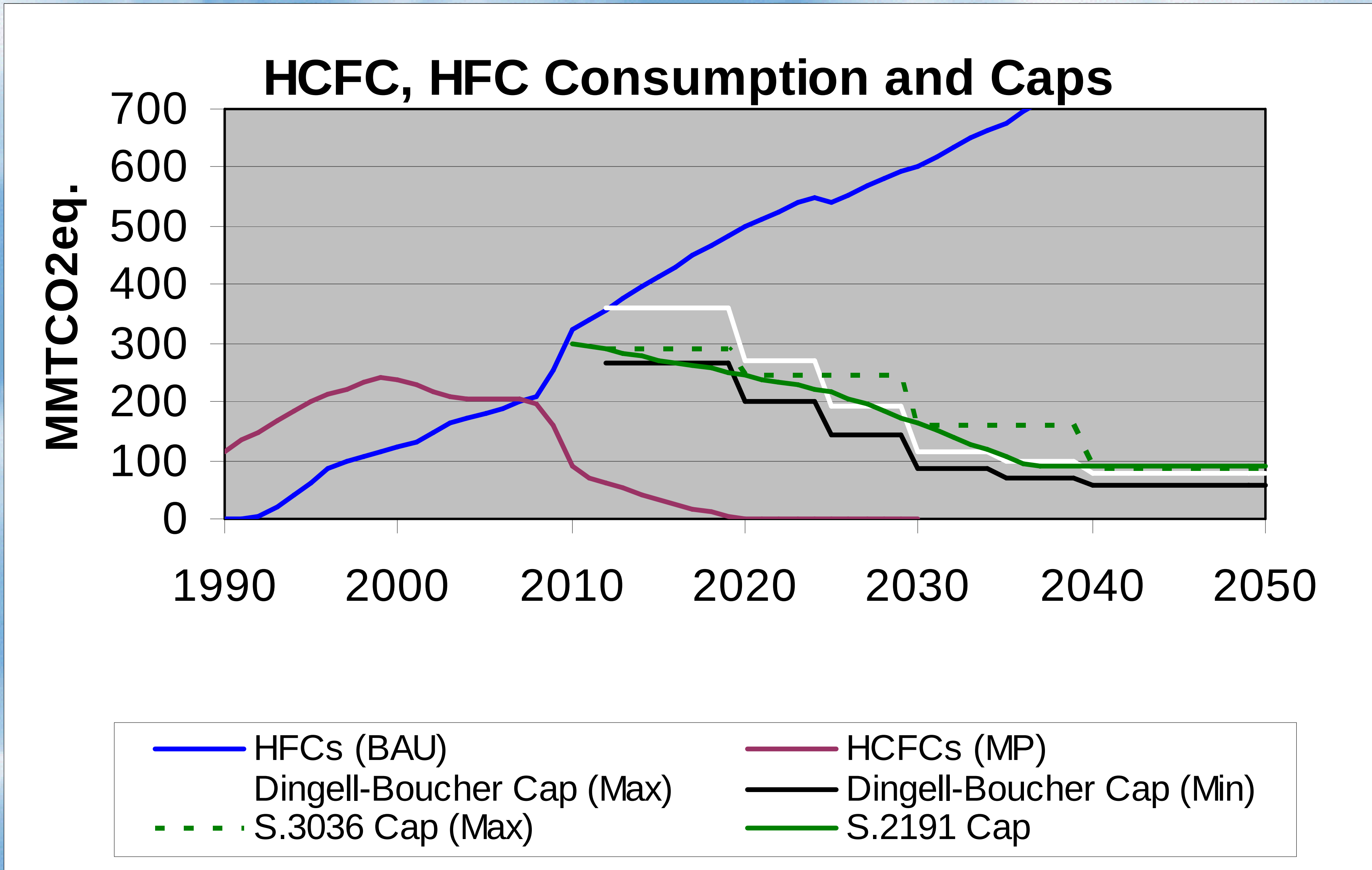
S.3036 Cap (Max)
S.2191 Cap



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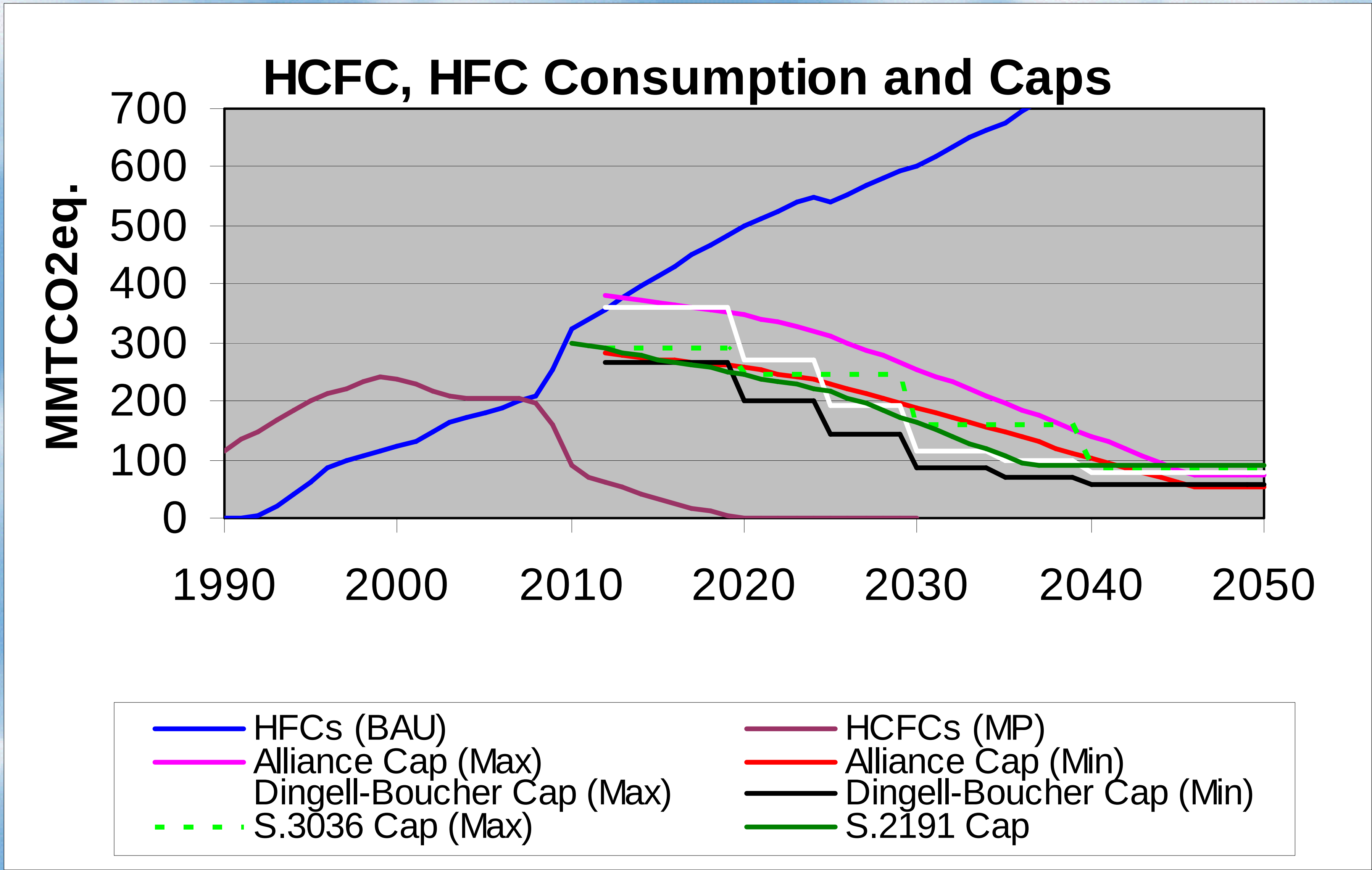
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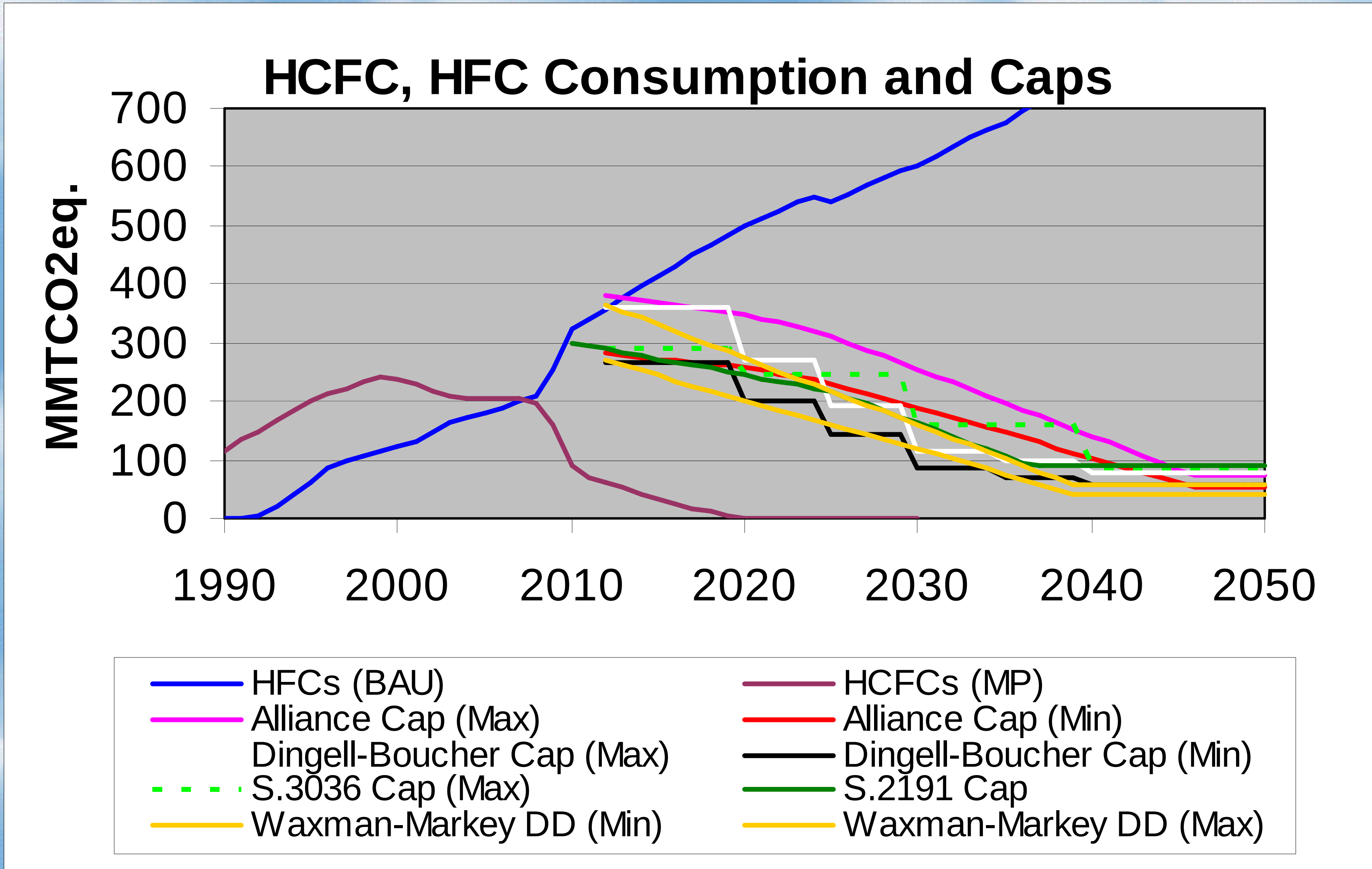

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Waxman-Markey DD (Min)
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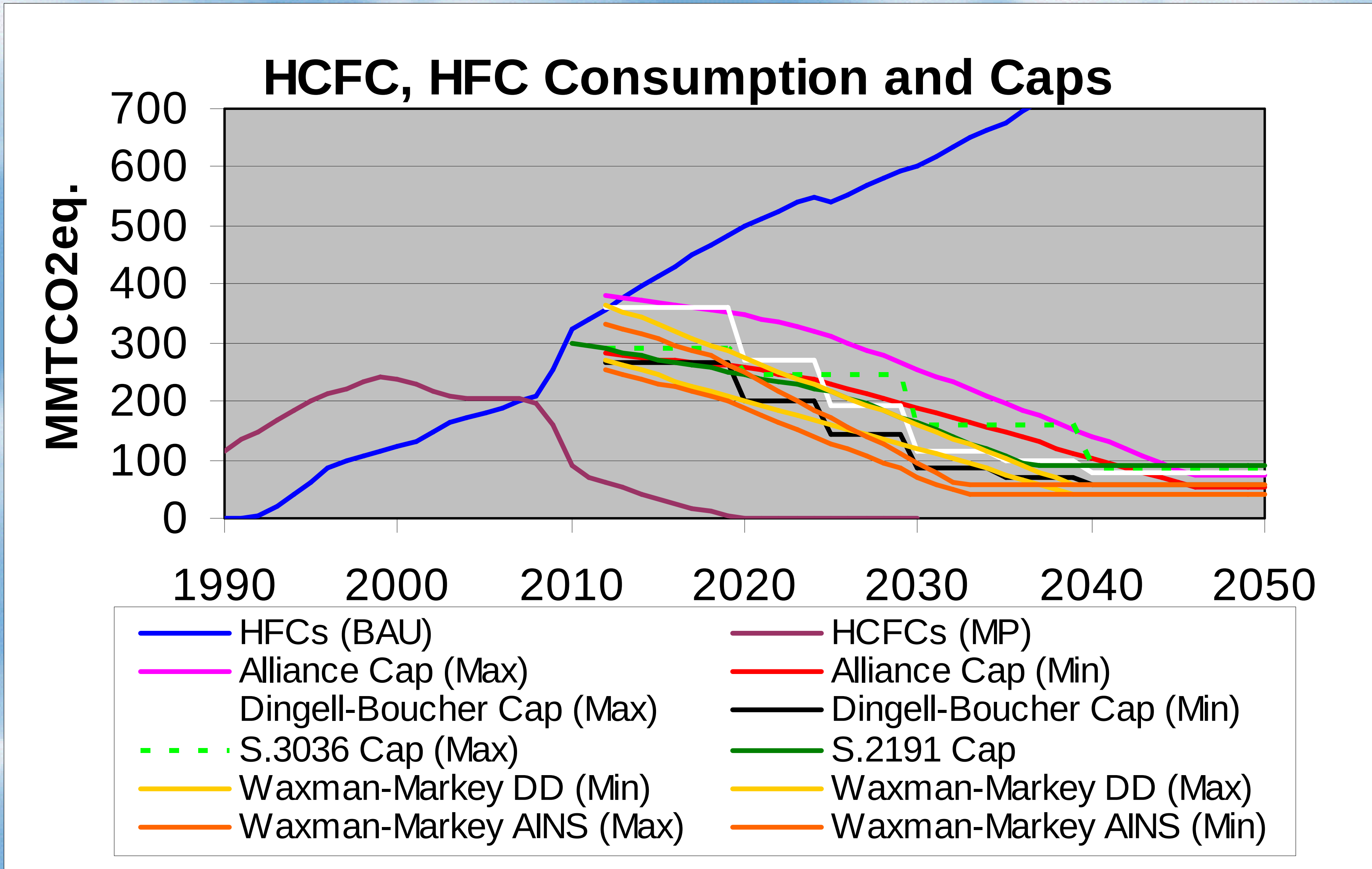
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Waxman-Markey AINS (Max)
Waxman-Markey AINS (Min)

Alternatives Available Today

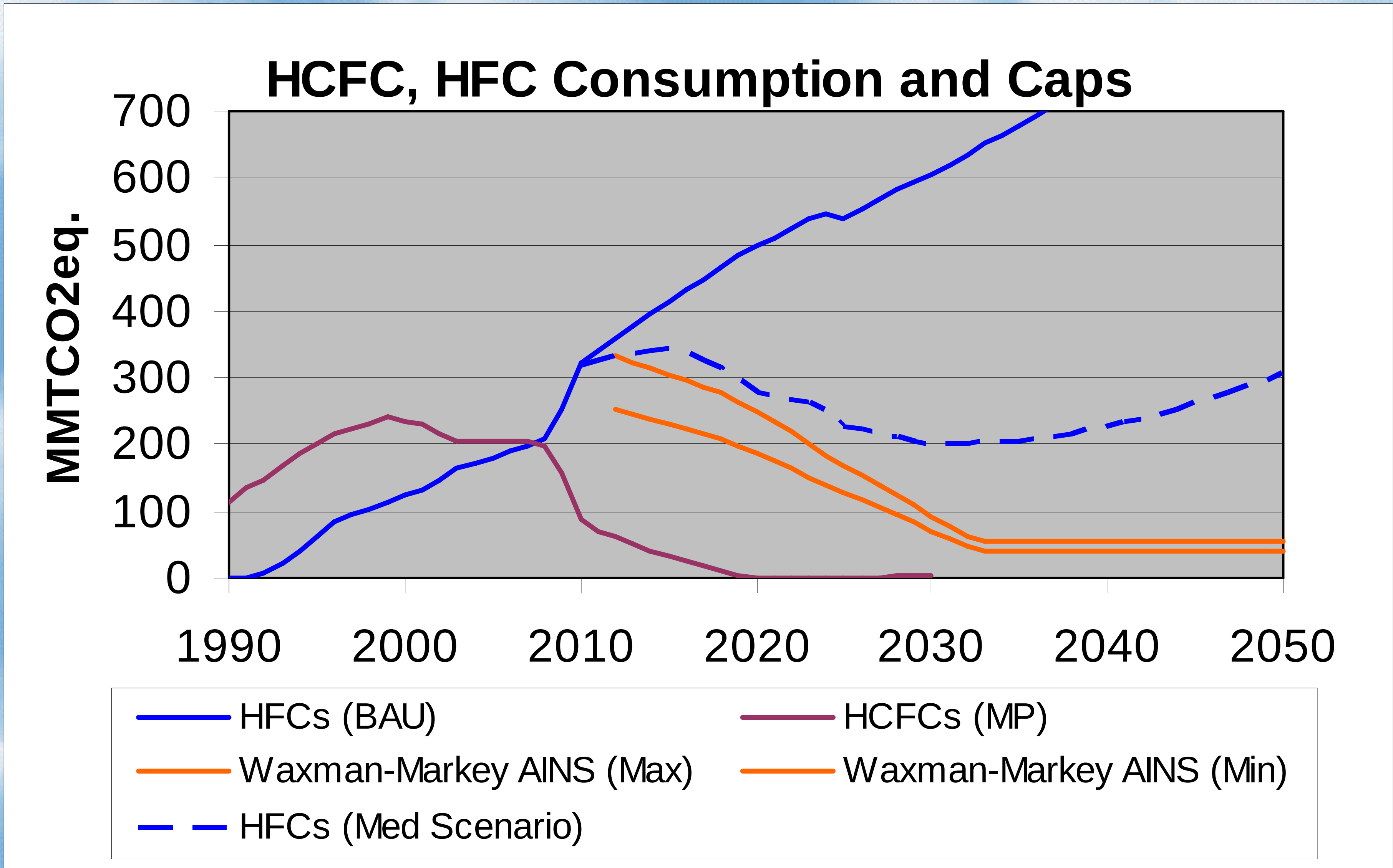
- Aerosols
  - Replace HFC-134a with HFC-152a (90%)
    [CO_2eq reduction where applied]
  - Hydrocarbons (100%)
  - Not-in-Kind (Pumps, Roll-Ons, etc.) (100%)
  - MDIs: Dry Powder Inhalers (100%)
- Fire Protection
  - Inert Gases (100%)
  - Water Mist (100%)
  - Fluorinated Ketones (99.97%)
- Solvent Cleaning
  - Aqueous / Semi-Aqueous (100%)
  - HFEs (82-96%)

Alternatives Available Today

- Foam Blowing
  - Most end-uses: hydrocarbons, CO_2, water (100%)
  - Appliance foam: capture/destroy at disposal (~90%)
- Refrigeration & Air Conditioning
  - All end-uses: recovery/recycling (10-100%)
  - All end-uses: leak repair (10-100%)
  - Supermarkets: low-charge, low-leak techs. (90+%)
  - Auto AC: enhanced HFC-134a system (50%)
  - Residential & commercial AC, chillers: microchannel heat exchangers (35-40%)
  - Chillers, cold storage: ammonia (100%)

Alternatives Available Shortly

- Aerosols & Foam Blowing
  - HFO-1234ze (99.4-99.6%)
- Fire Protection
  - Expanded market for current options (99.97-100%)
- Solvent Cleaning
  - Other low-GWP chemicals (~90%)
- Refrigeration & Air Conditioning
  - Auto AC: HFO-1234yf, CO_2 (99.7-99.9%)
  - Bus, Train AC?: HFO-1234yf, CO_2
  - Home refrigerator/freezers, stand-alone commercial refrigerator/freezers, window units, dehumidifiers, beverage coolers, vending machines, ice makers: hydrocarbons, CO_2, HFO-1234yf (99.7-100%)



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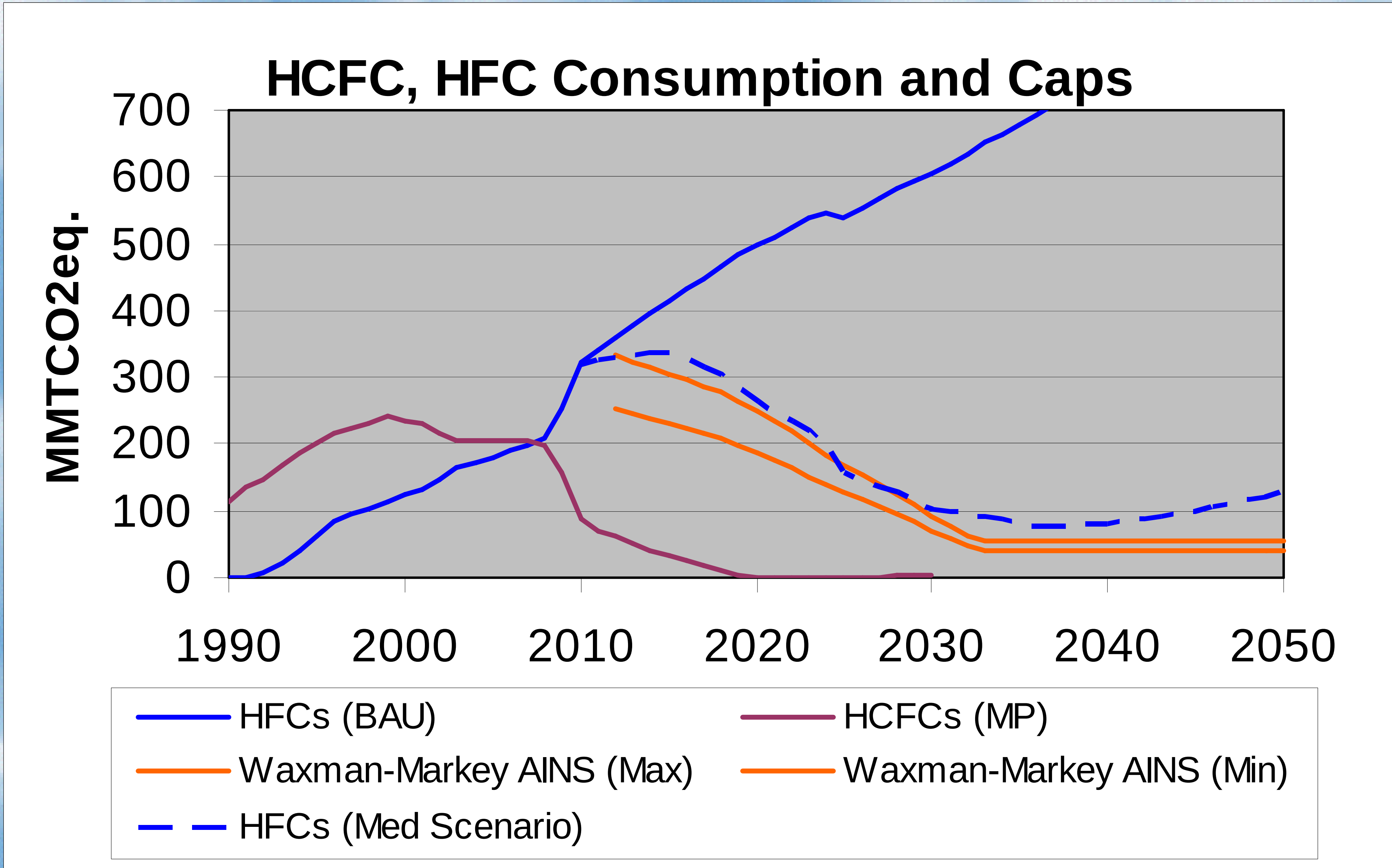
HFCs (Med Scenario)

Sensitivity to Reduction Options

- Many reduction options are here today (recovery, HCs, low-charge/low-leak technologies, HFEs, etc.)
- Many are likely to be available soon (HFOs in mobile AC, aerosols?, others?)
- Assuming current growth patterns, to reach deep cuts, more options and alternatives will be needed

Alternatives Available 10+ Years?

- Aerosols
  - MDIs: Injections / tablets (100%)
- Fire Protection
  - Other low-GWP chemicals (~90%)
- Foam Blowing
  - All end-uses: expanded capture/destruction at manufacture & disposal (~90%)
- Refrigeration & Air Conditioning
  - Transport refrigeration: hydrocarbons, ammonia, low-GWP blends (~50-100%)
  - Residential & commercial AC, chillers, retail food: blends with low-GWP chemicals (~50-90%)
- And more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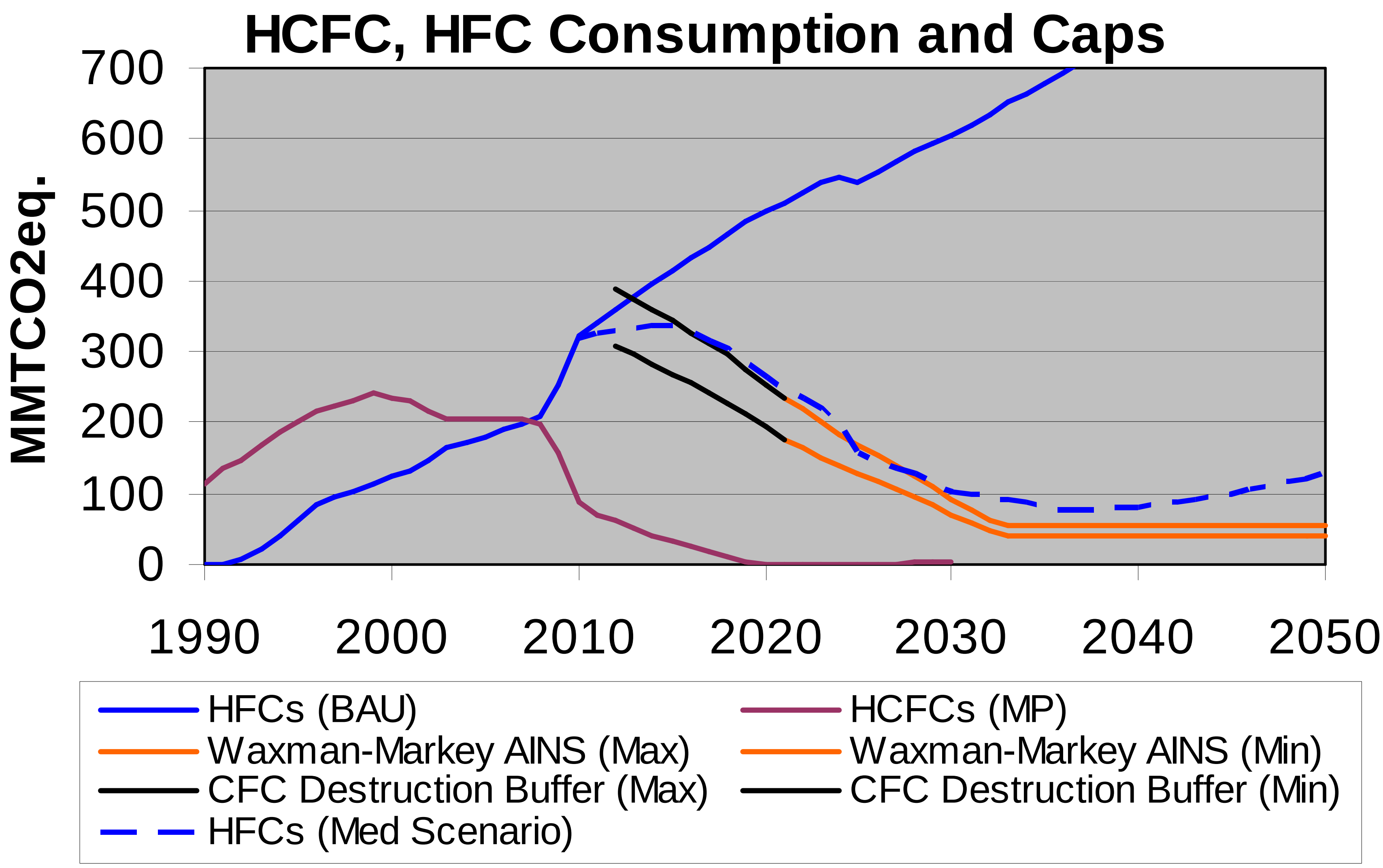
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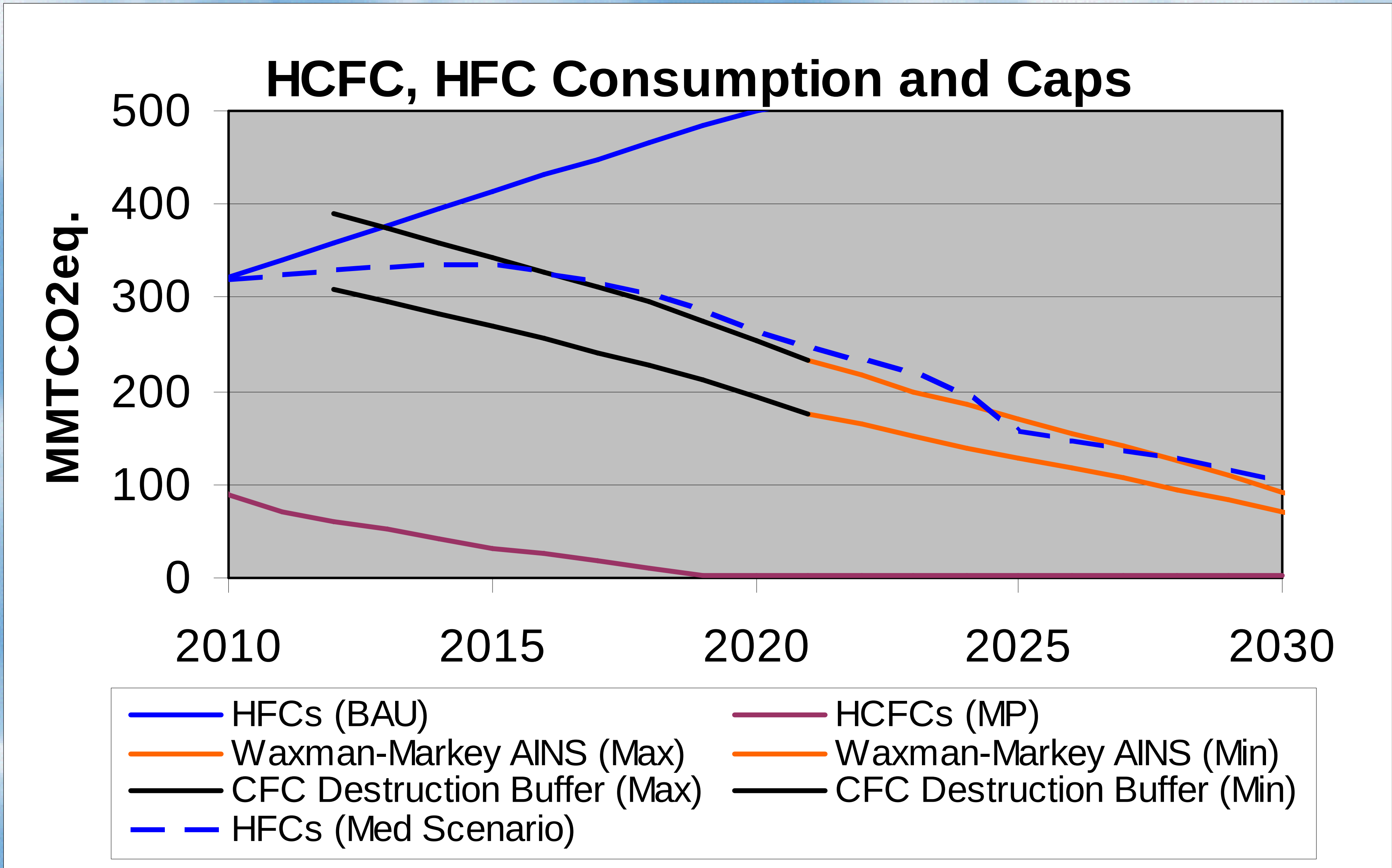
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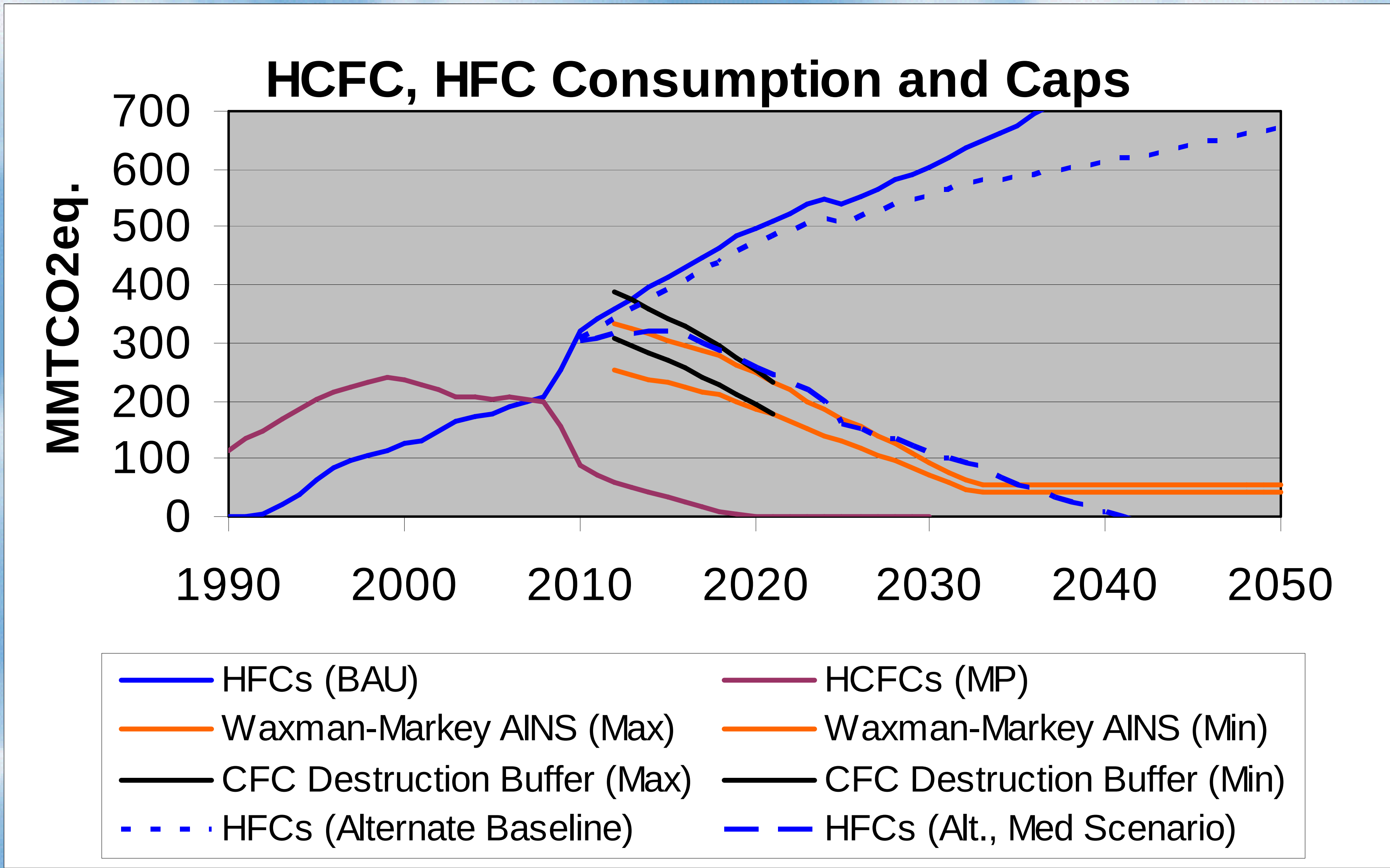
Sensitivity to BAU Projections

- Caps are defined at the start
  - Some proposals set the cap (e.g., Boxer starts at 289 MMTCO_2eq cap in 2012)
  - Some calculate cap based on historical data (e.g., Waxman-Markey uses 2004-06 HFC+HCFC data, but sets maximum at 370)
- Maximum consumption over time is thus defined, but needed reductions depends on BAU
- Fast-changing sectors, BAU difficult to predict
  - Recent economy decline (e.g., car sales)
- Will HFC growth continue, slow down e.g. to match population growth (<1% in U.S.)?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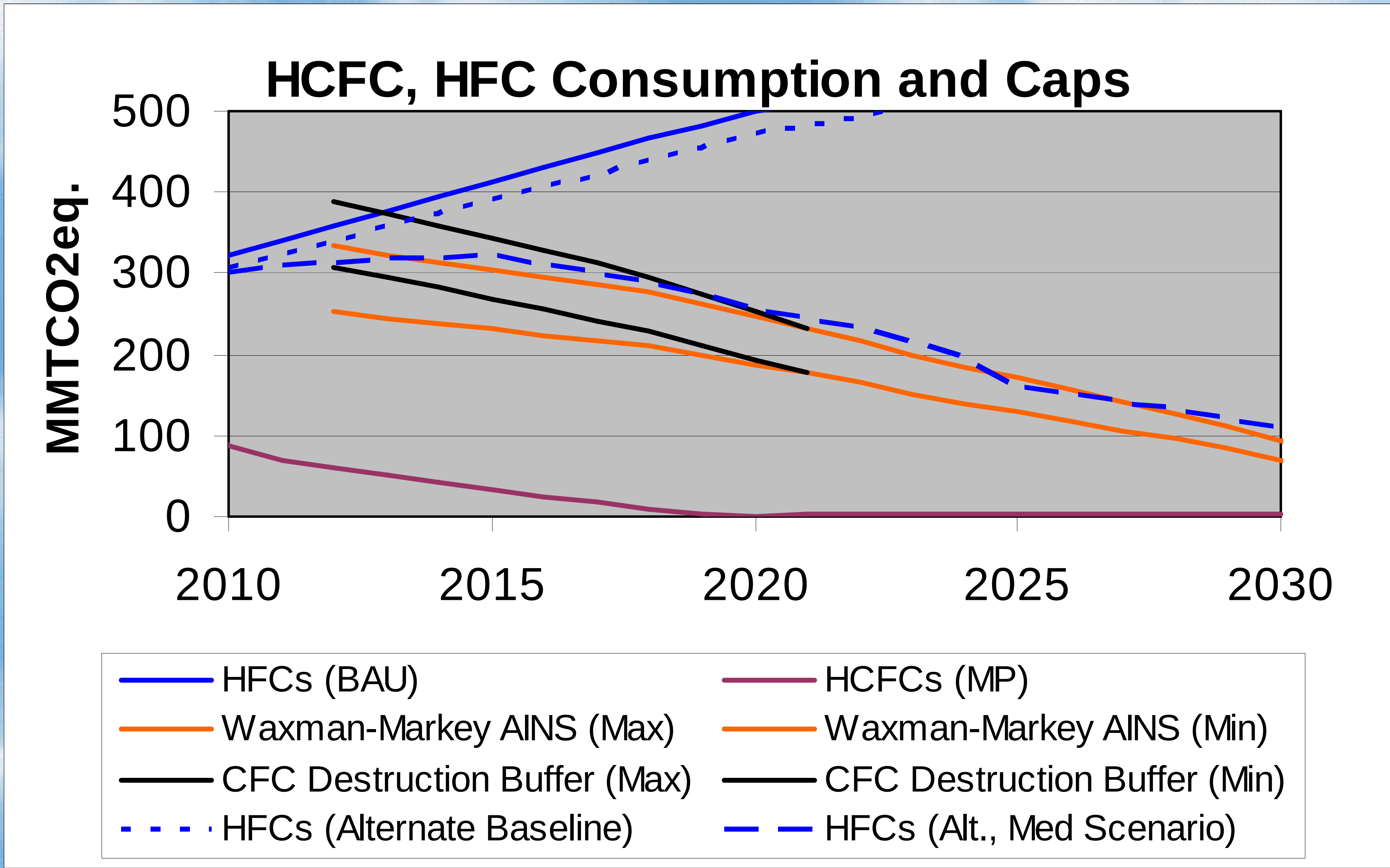
HFCs (Alt., Med Scenario)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Summary

- HFCs are a small portion of greenhouse gases, but important:
  - Growing rapidly
  - Used primarily as substitutes for ozone-depleting substances
- Recent U.S. legislation proposals treat HFCs separately
- Meeting policies will require a suite of options
  - Many are available today
  - More are “in the pipeline”
  - Policies and costs will likely drive others
- Assessment of reduction scenarios sensitive to
  - Baseline market at policy start (e.g., 2012)
  - Growth over time, especially after HCFC phaseout
  - Technology options available

Thank You

- Questions?

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