Modeling non-CO_2 Greenhouse Gas Emissions and Mitigation & the Importance of a Multi-gas Abatement Strategy

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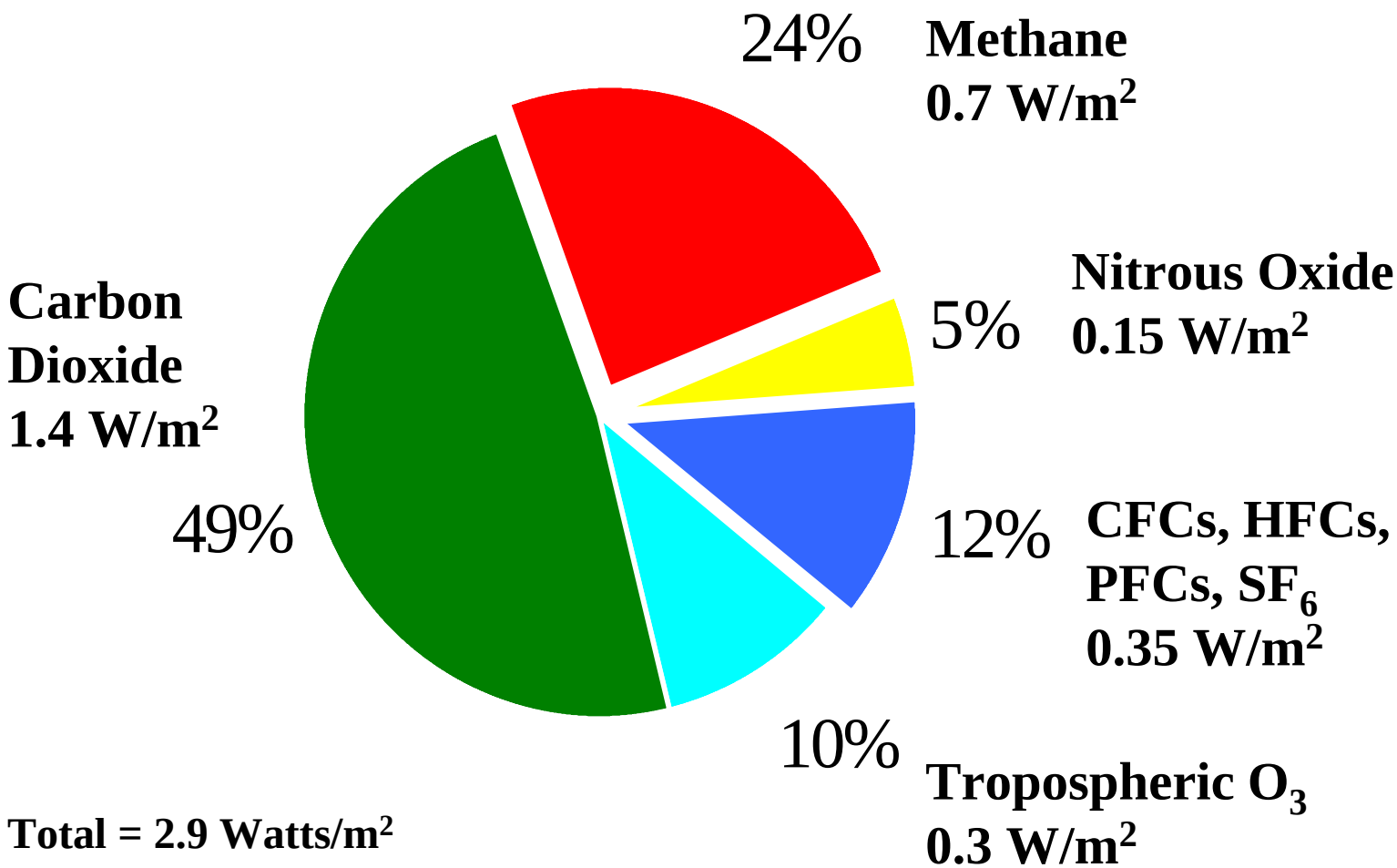
Overview

- » Non-CO_2 Greenhouse Gas Contribution to Climate Change
- » Benefits of Multi-gas Abatement Strategy
- » U.S. and China Estimates and Projections
- » Other Country Emission Estimates and Projections
- » Mitigation Analyses & Marginal Abatement Curves

Contribution of Anthropogenic Gases to Enhanced Greenhouse Effect Since Pre-Industrial Times (measured in Watts/m^2)



Total = 2.9 Watts/m^2

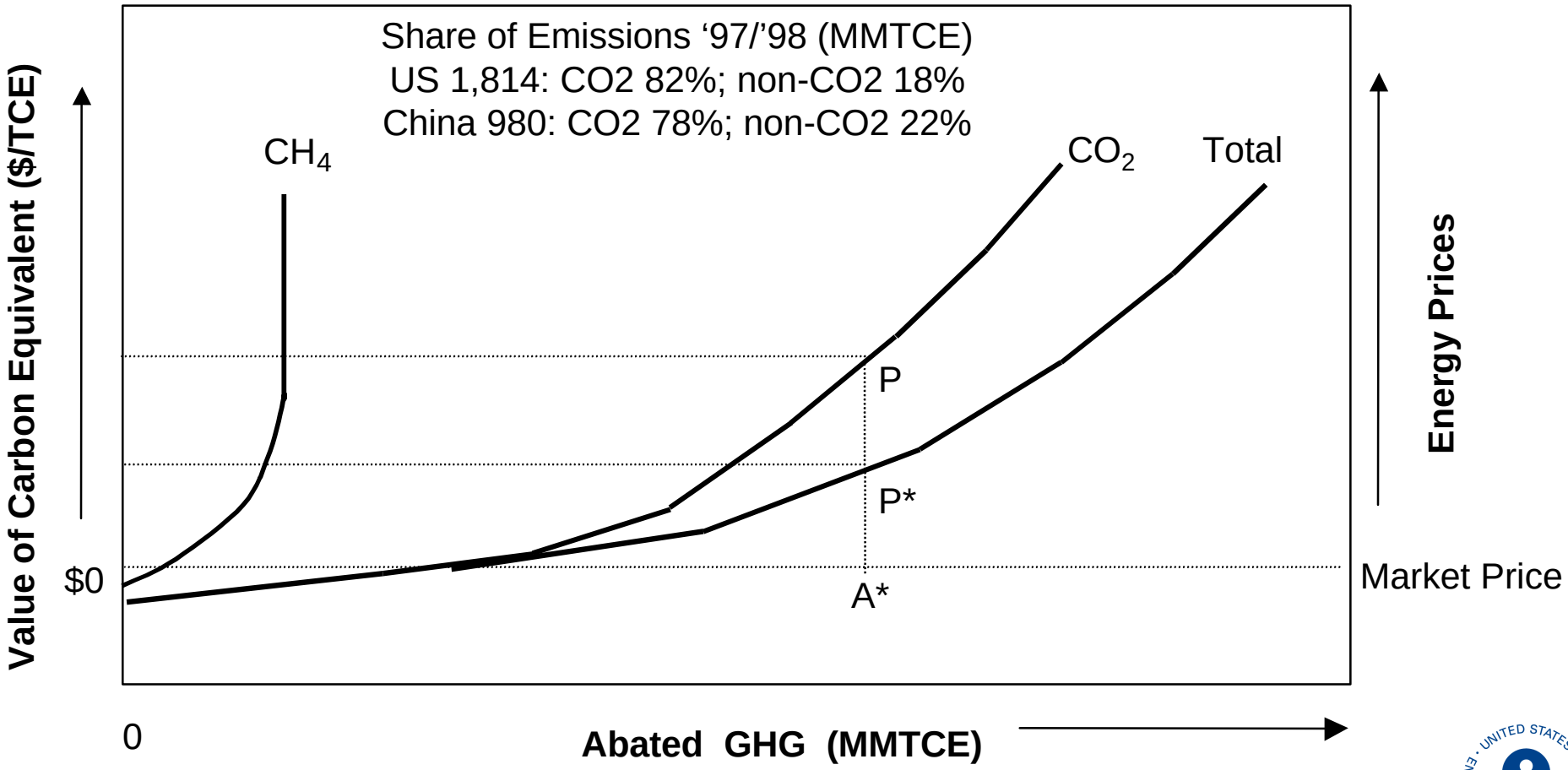
Source: Hansen, 2000

Sources of Non-CO_2 Gases

- Methane -- landfills, natural gas systems, coal mining, livestock manure, ruminant livestock; 100-yr Global Warming Potential (GWP) = 21
- N_20 -- agricultural soils, autos, industrial (adipic & nitric acid production); GWP = 310
- High GWP Gases; GWPs range tens - thousands
  - HFC -- CFC substitutes: refrigeration, A/C, foams, solvents, fire extinguishing, aerosols
  - SF_6 -- electricity generation, magnesium
  - PFCs -- aluminum and semiconductors
  - HFC-23 -- HCFC-22 production

Illustrative MACs for Methane and Carbon Dioxide

- benefits of multi-gas abatement strategy: lowers marginal and total costs of achieving reductions

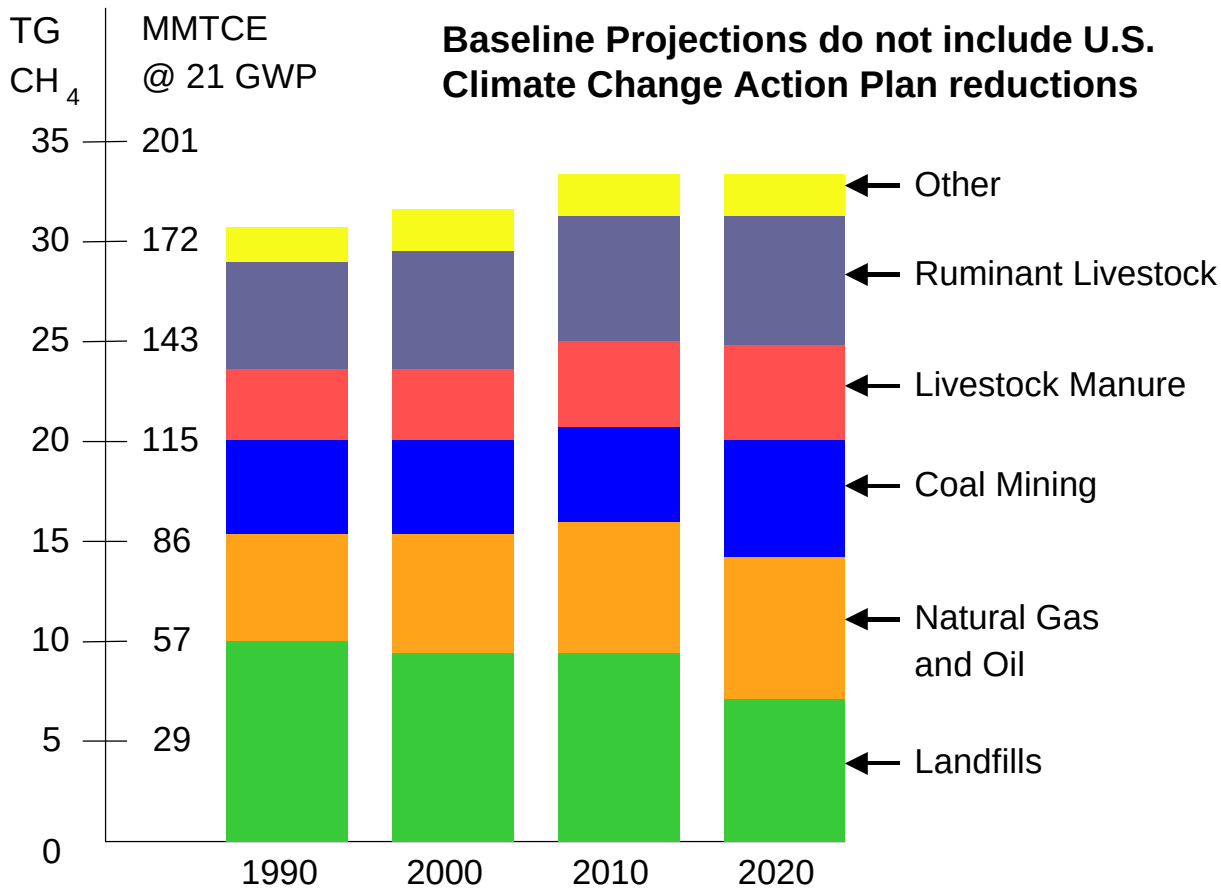


Methane Source and Abatement Technologies

Methane Source (global %)	**Abatement Tech ($ - costed)**
Ruminant Livestock (23%)	Nutrition & Health; Production Enhancing Agents;
Rice Paddies (16%)	Change in growing practices
Natural Gas and Oil Systems (15%)	$ - Maintenance, practices, technologies
Biomass Burning (11%)	NA
Landfills (11%)	$ - Capture use for electricity gen or direct gas use, flares
Coal Mining (8%)	$ - Degasification, pipeline injection, Catalytic oxidation, flares
Domestic Sewage (7%)	Aerobic treatments
Livestock Manure Management (7%)	$ - Digester capture and use for electricity gen

Futute technologies: New catalytic oxidation; Fuel cells; micro-turbines; Methane inhibitors

U.S. Methane Emission Estimates & Projections by Source: 1990 - 2020

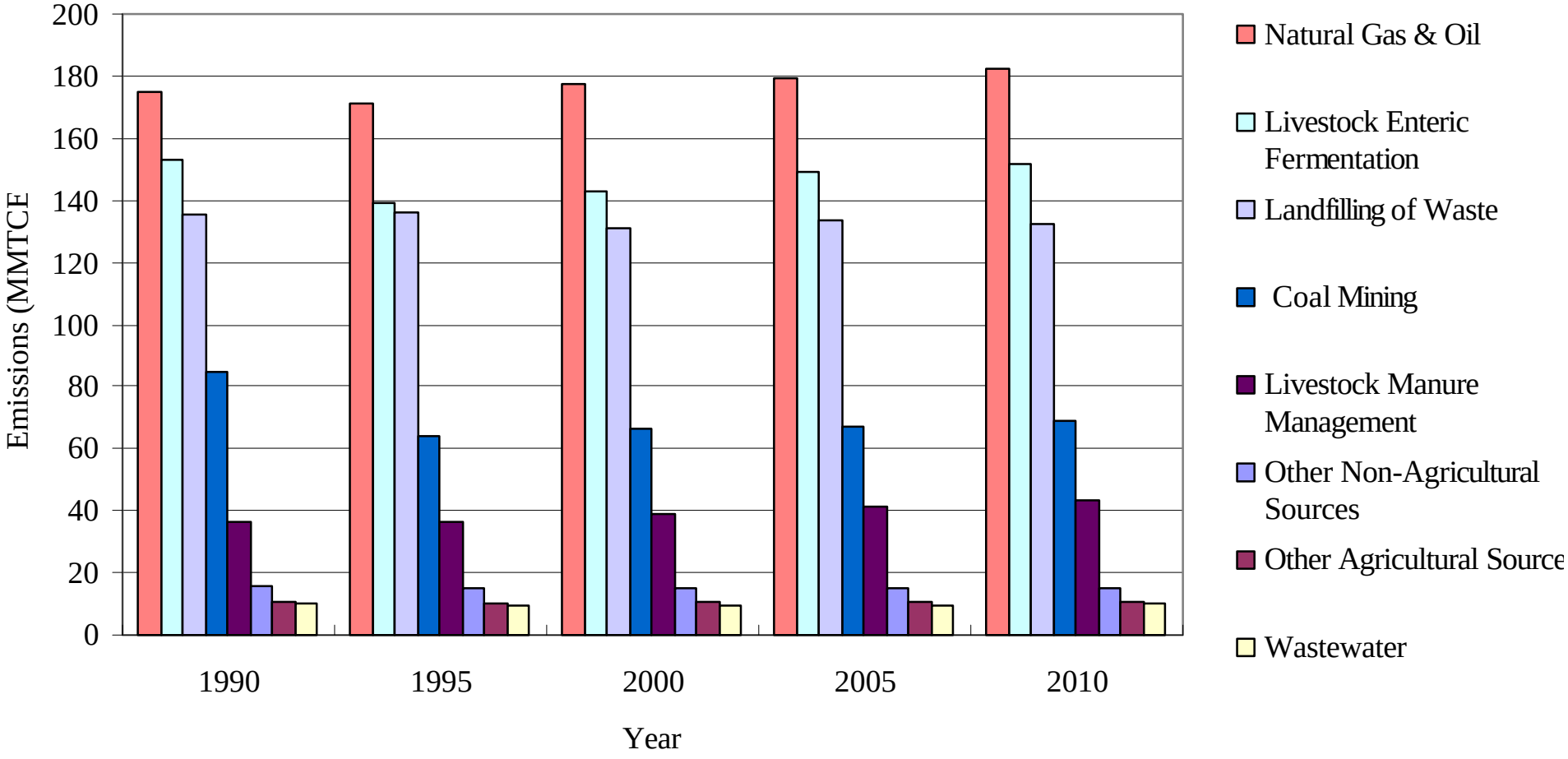


Source: *U.S. Methane Emissions 1990 – 2020: Inventories, Projections, and Opportunities for Reductions,* EPA, 1999

US Methane Emission Estimates

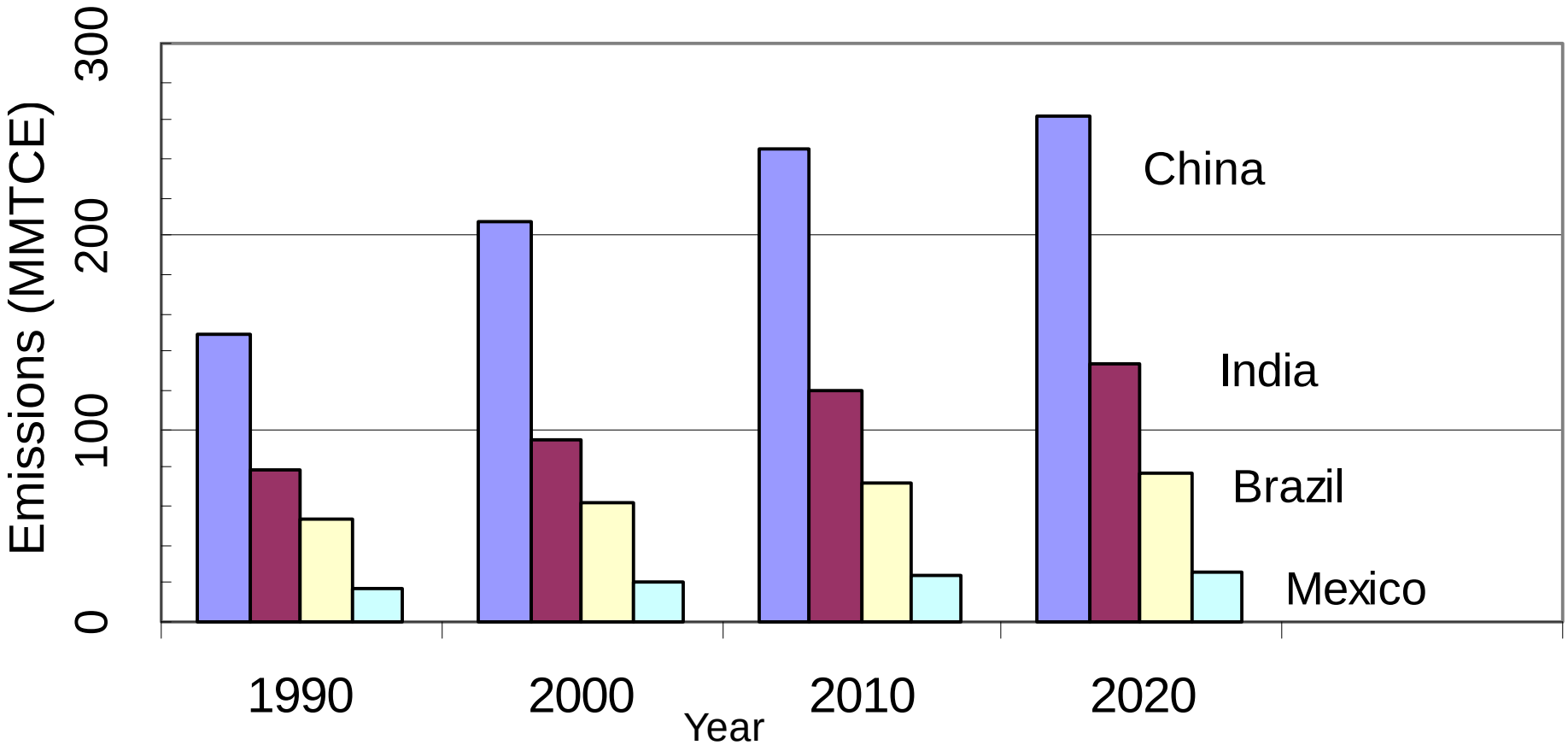
- Landfills, natural gas, coal, manure, ruminants
- Industry-specific data available through EPA voluntary programs
- Common drivers of future emissions include human population growth, GDP per capita and and energy production and consumption
  - Reference Case of the Annual Energy Outlook prepared by the Energy Information Administration (DOE, 2001)

Industrialized Country BAU Methane Emissions by source



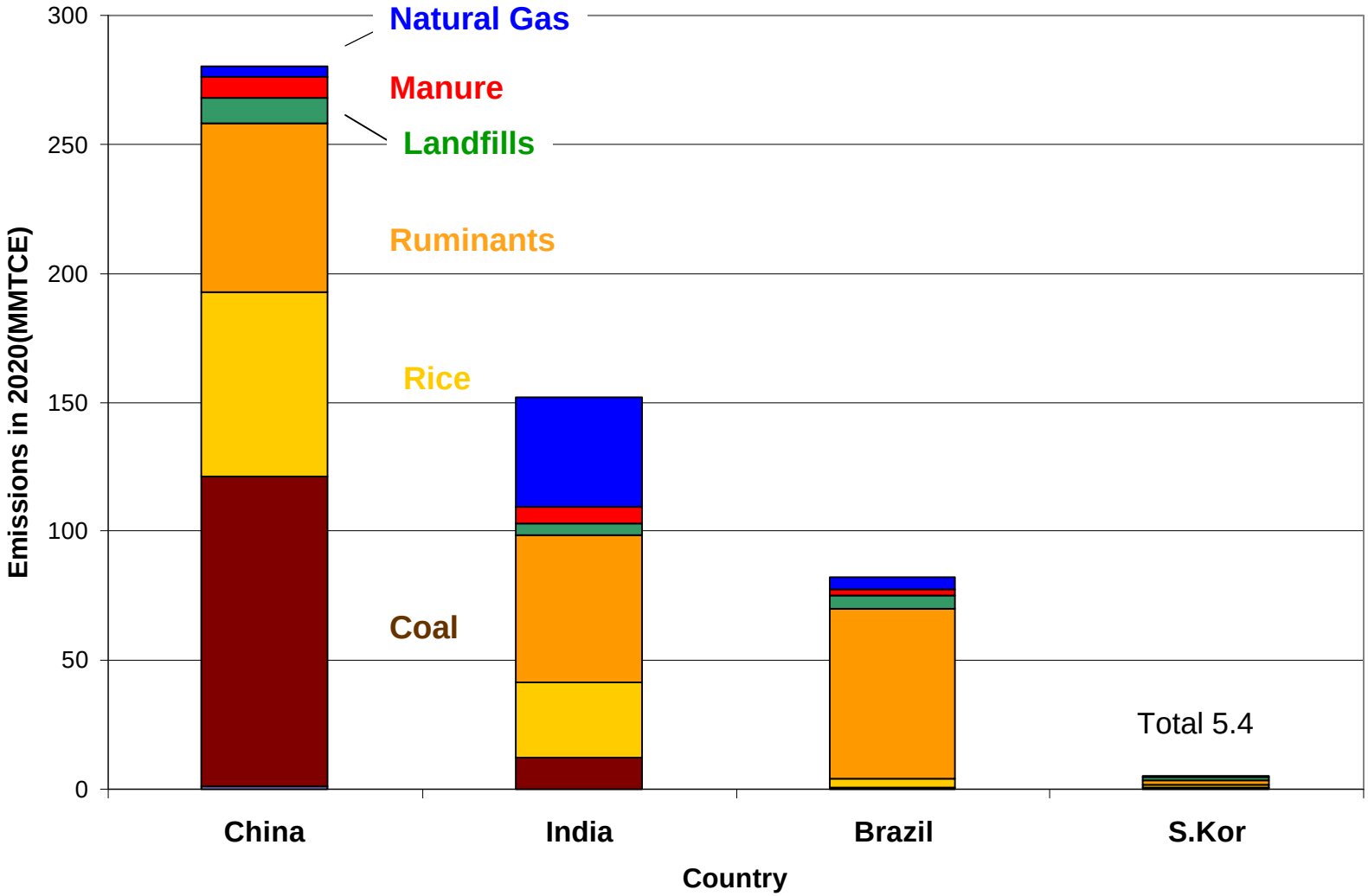
Source: Compiled in EPA Reports.

Methane Projections for China, India, Brazil, & Mexico



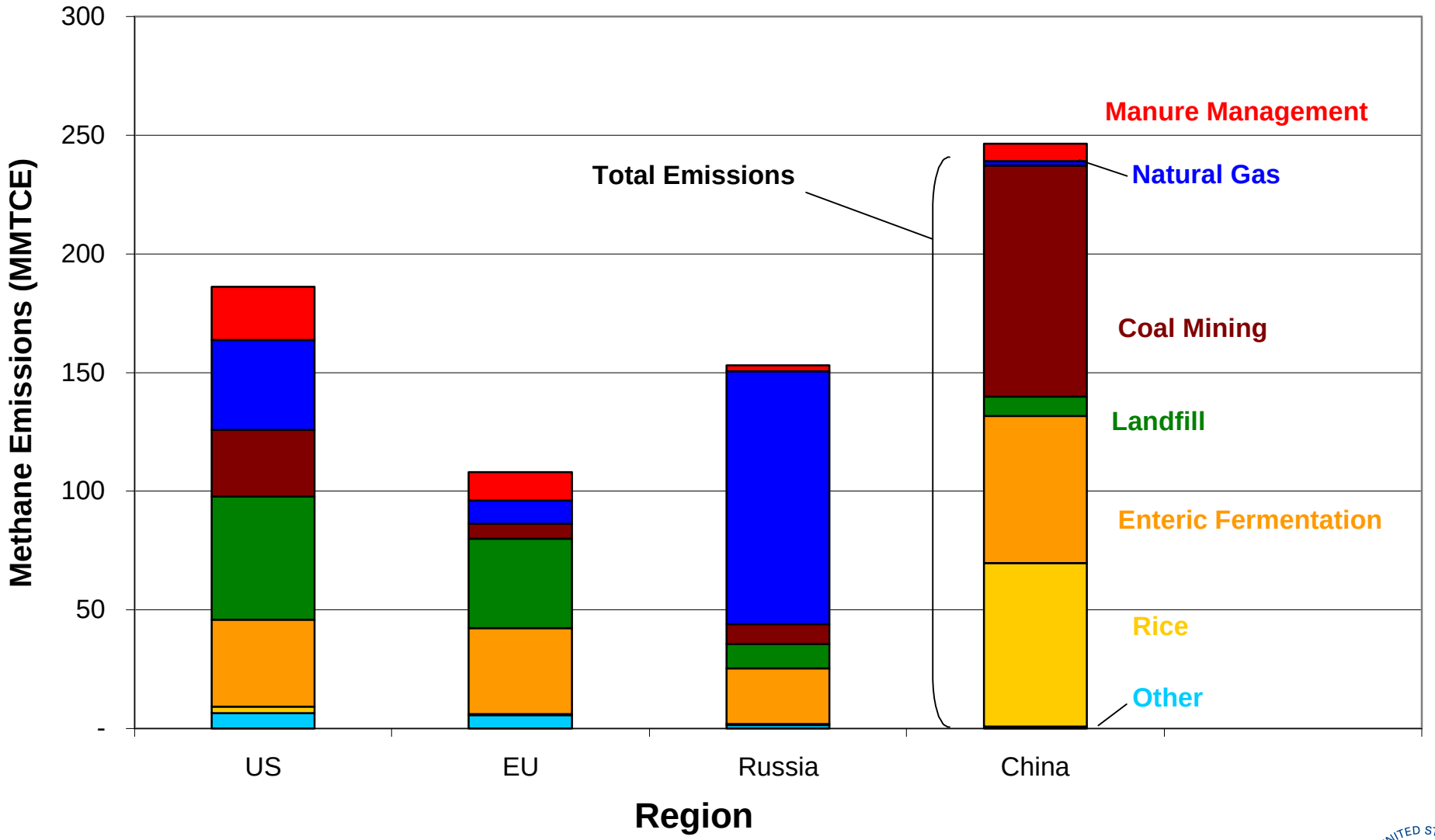
Source: Compiled in EPA Reports.

Methane Emissions in 2020



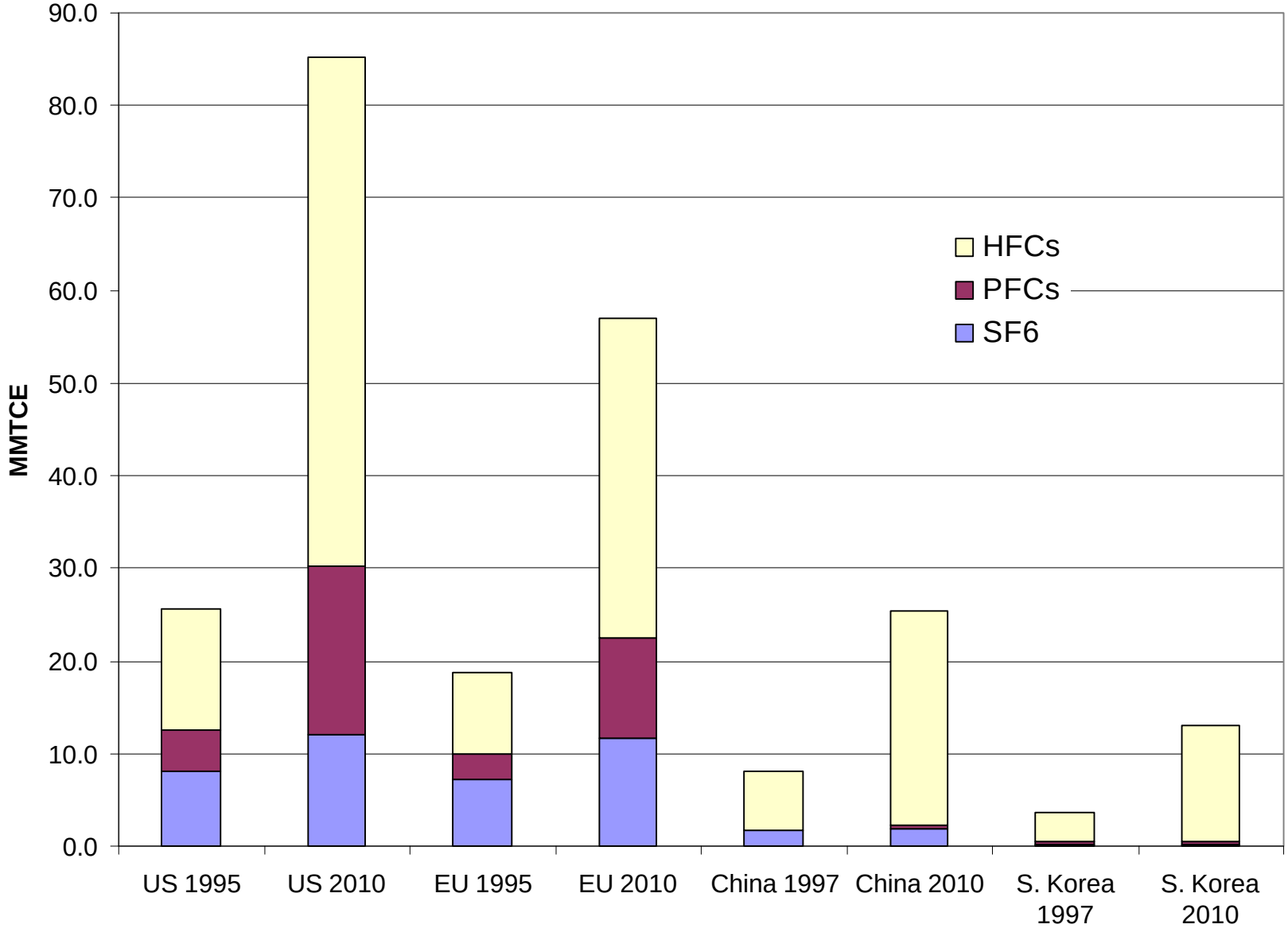
Source: Compiled in EPA Reports.

Methane Emissions by Sector for Select Regions Based on 2010 Baseline Emissions



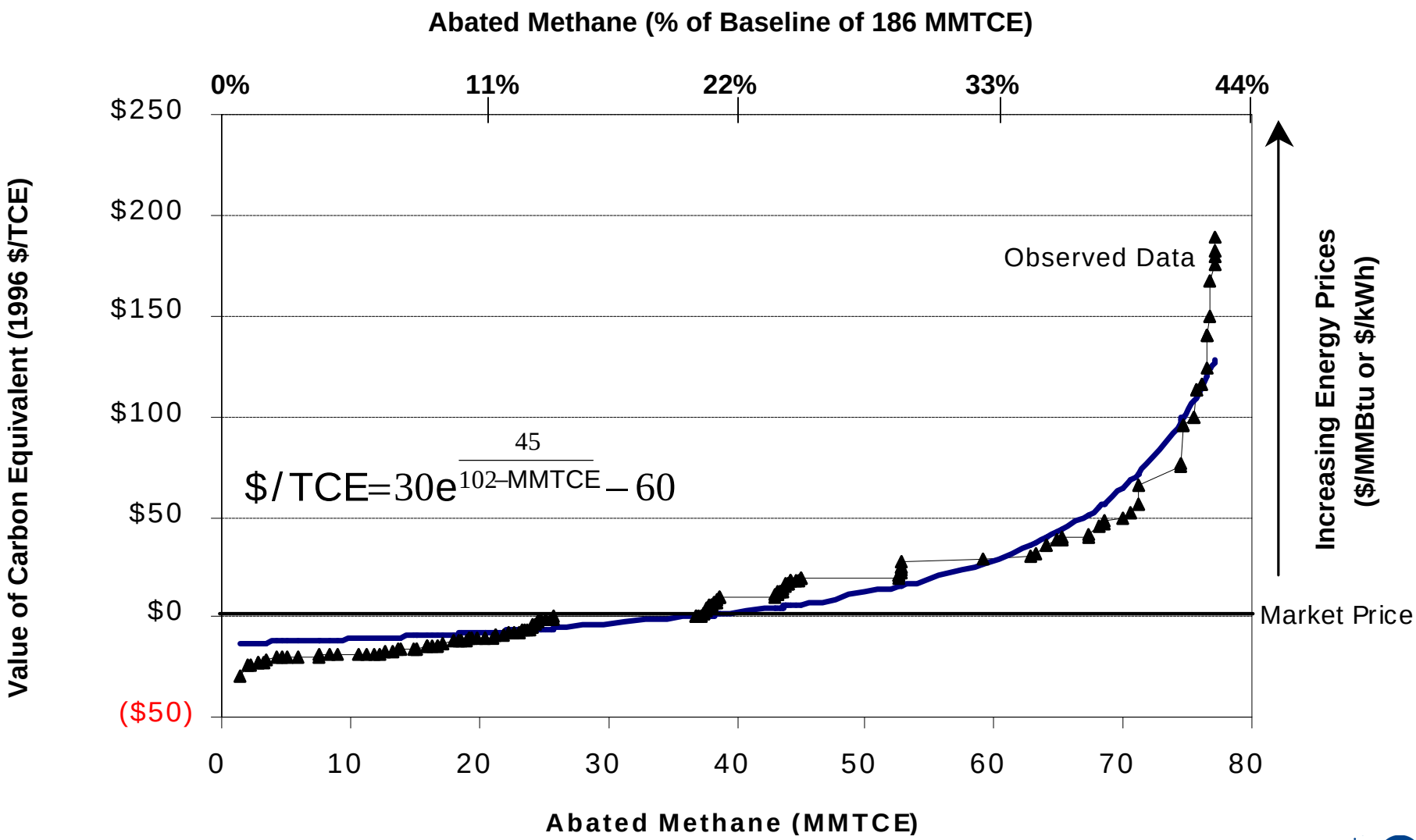
Source: Compiled in EPA Reports.

High GWP (F gases) 1995/97 & 2010



Source: EPA Reports.

U.S. Methane Marginal Abatement Curve for 2010 (major sources except ruminants)



Source: ***U.S. Methane Emissions 1990 – 2020: Inventories, Projections, and Opportunities for Reductions,*** **EPA, 1999**

EPA's Cost Analysis Methodology

- Identify emission reduction technologies and practices
- Estimate achievable savings (GHG reductions) from each technology/practice
- Investigate costs of each technology/practice (capital, O&M costs) and economic life
- Solve for carbon-equivalent price for the savings that yield an NPV of $0 at selected discount rates

Methane Marginal Abatement Curve (MAC)

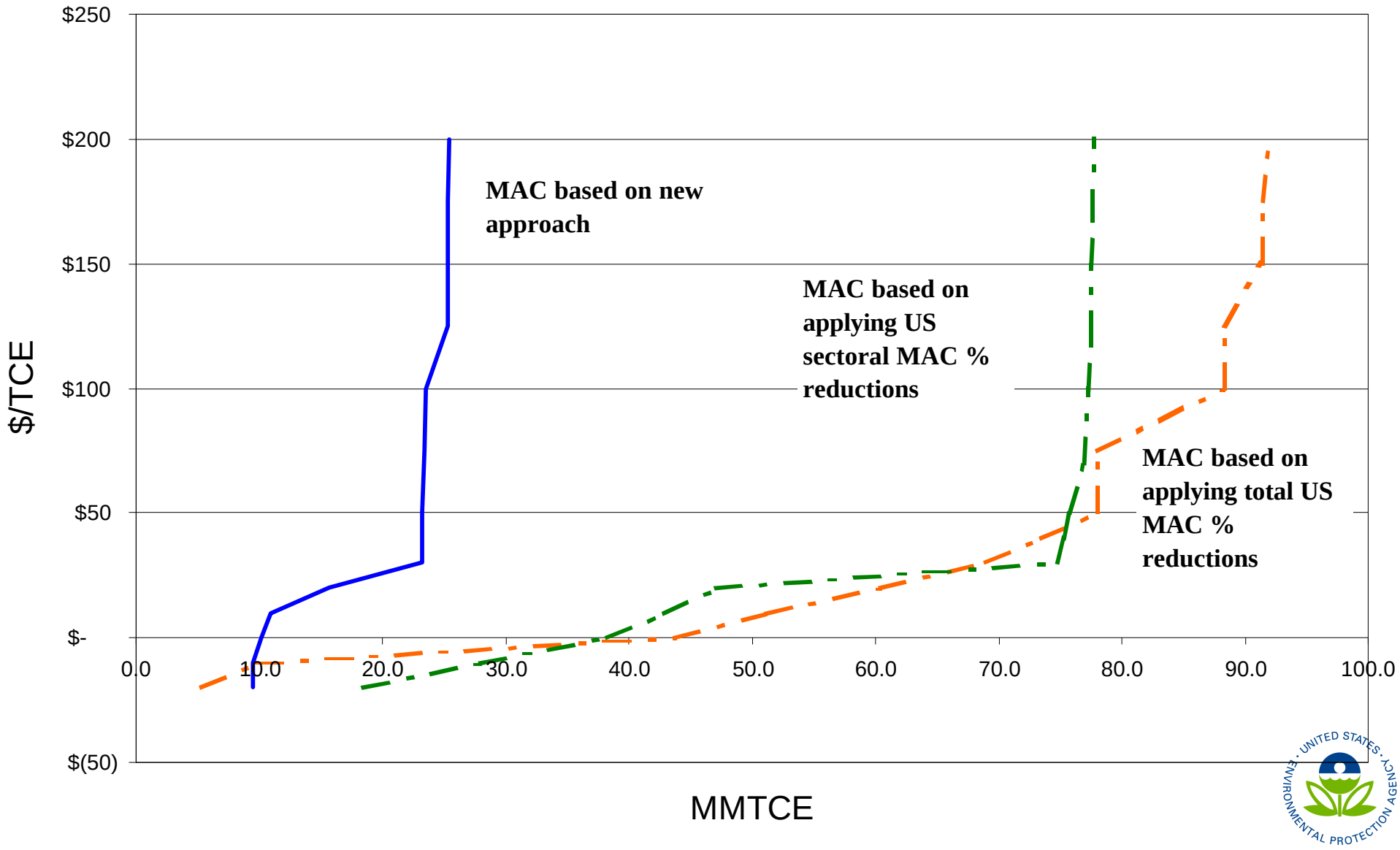
- Landfills, natural gas systems, coal mines, and manure management sectors
- Methodology and data validated by experience with EPA methane voluntary programs
- Uses field cost data or a “model” system for benefit-cost calculations
- Comprehensive, based on over 280 observations yielding amount of abated methane and unit cost/price ranging from ($20) to $200 / ton of carbon equivalent

Methane (MAC)

- Rank order of individual opportunities by cost per emissions reduction
- $0/ton CE set to market price of abated GHG
  - for methane this is an energy price
- Any point along a MAC represents the marginal cost of abating an additional unit of methane

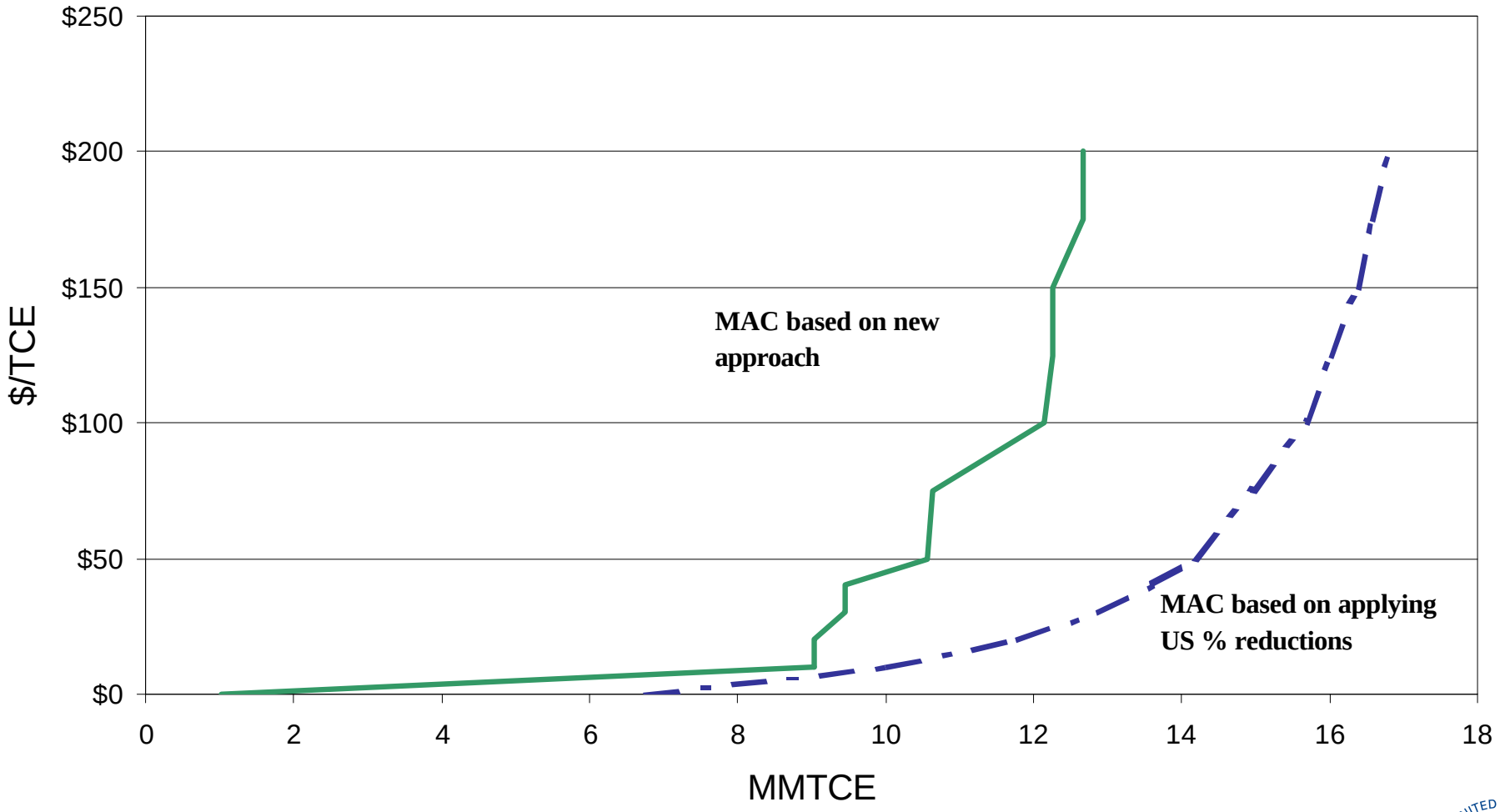
China Methane MAC for 2010

Modeled vs Applying US Percent Reductions

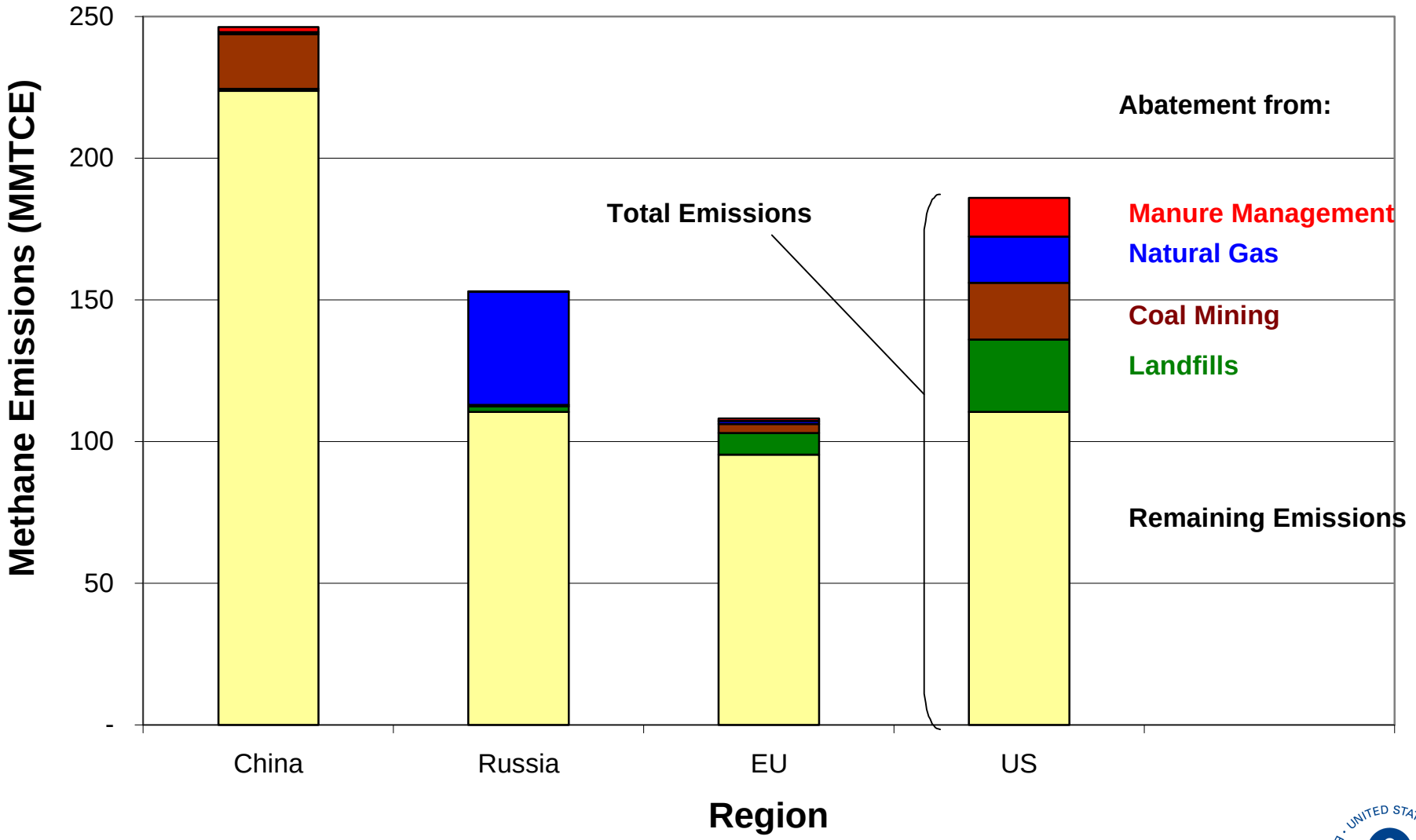


China HGWP MAC for 2010

Modeled vs Applying US Percent Reductions

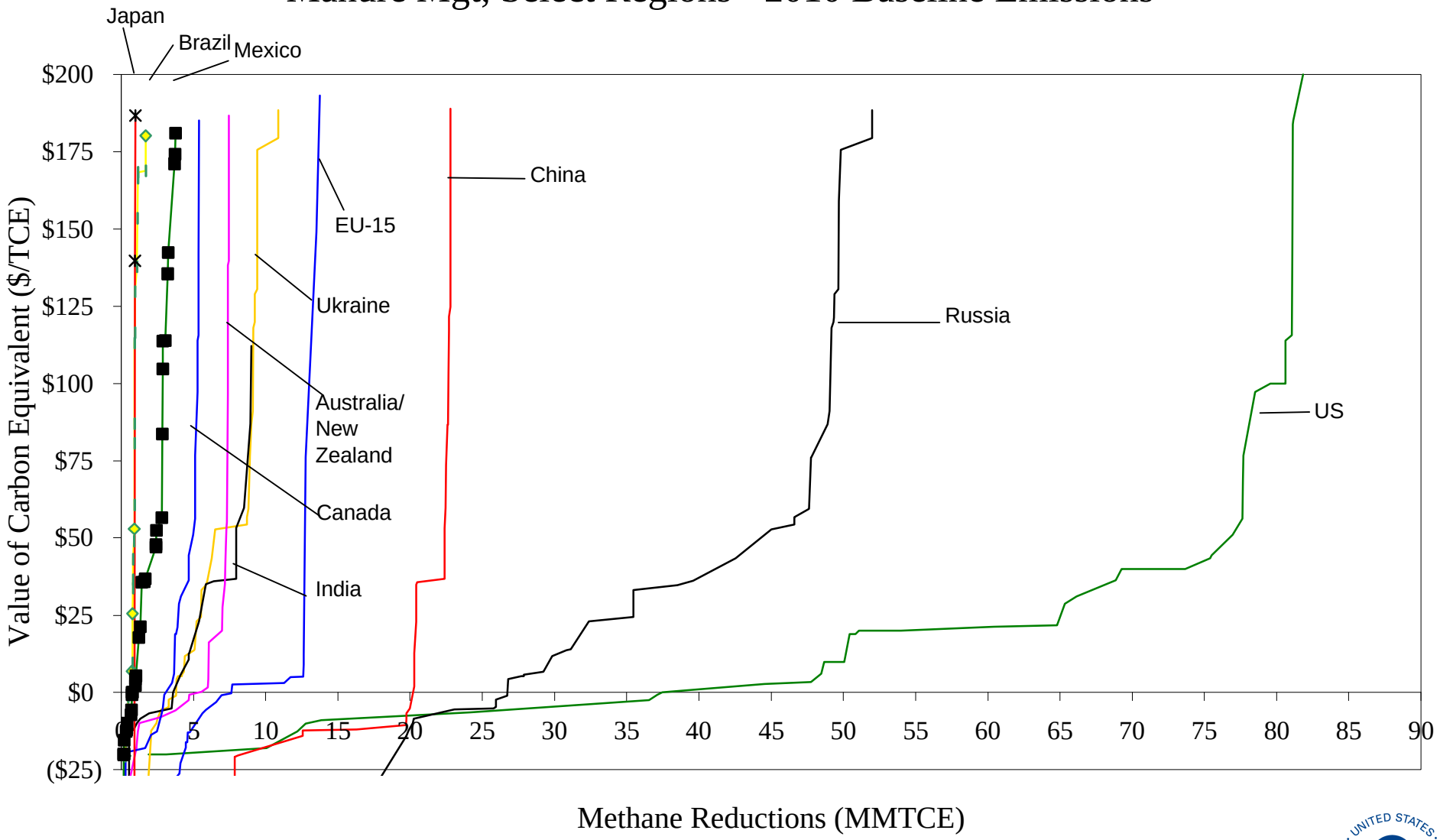


Methane Reductions by Sector Based on 2010 Baseline Emissions and a Carbon Price of $50/TCE

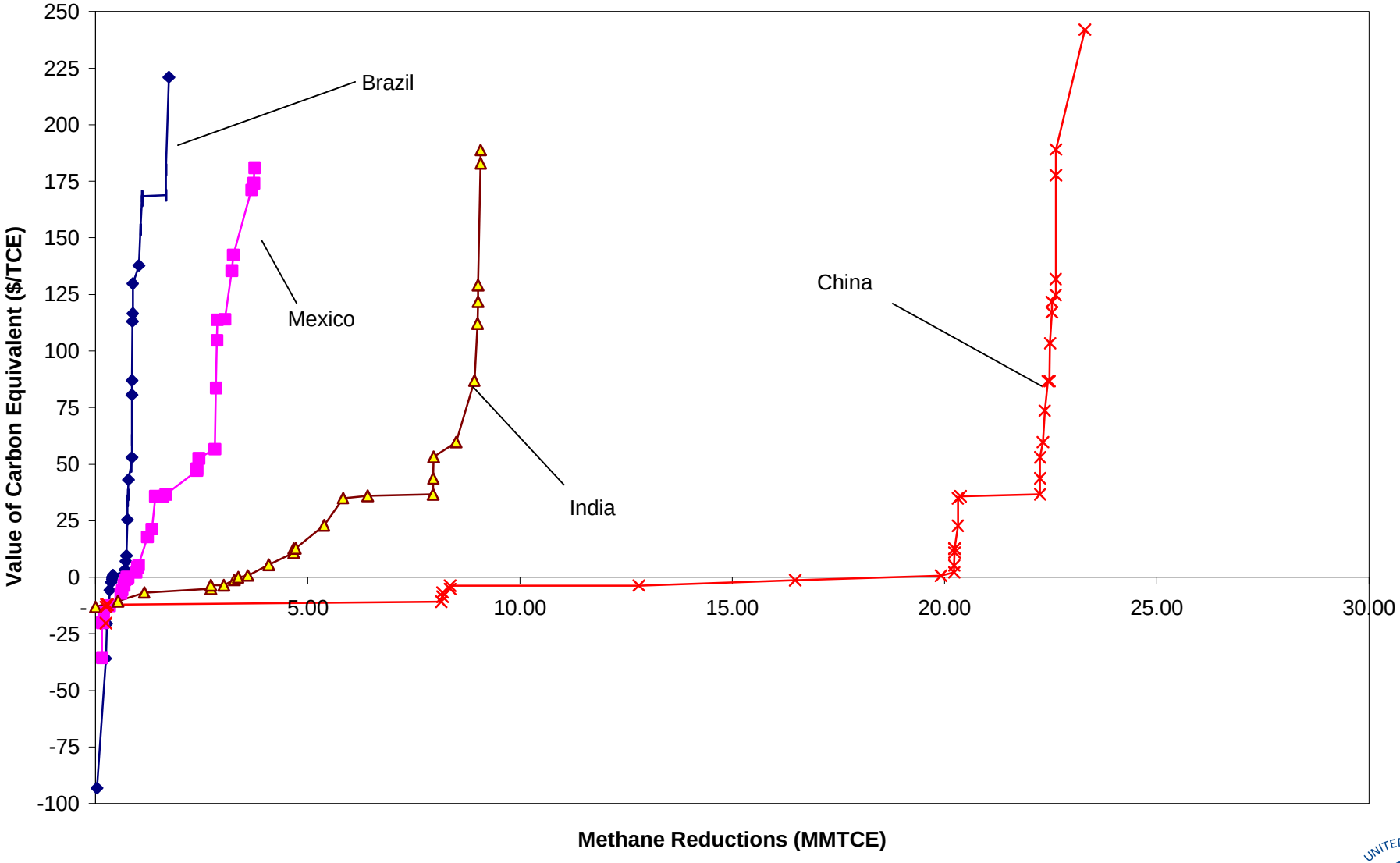


Source: EPA Reports.

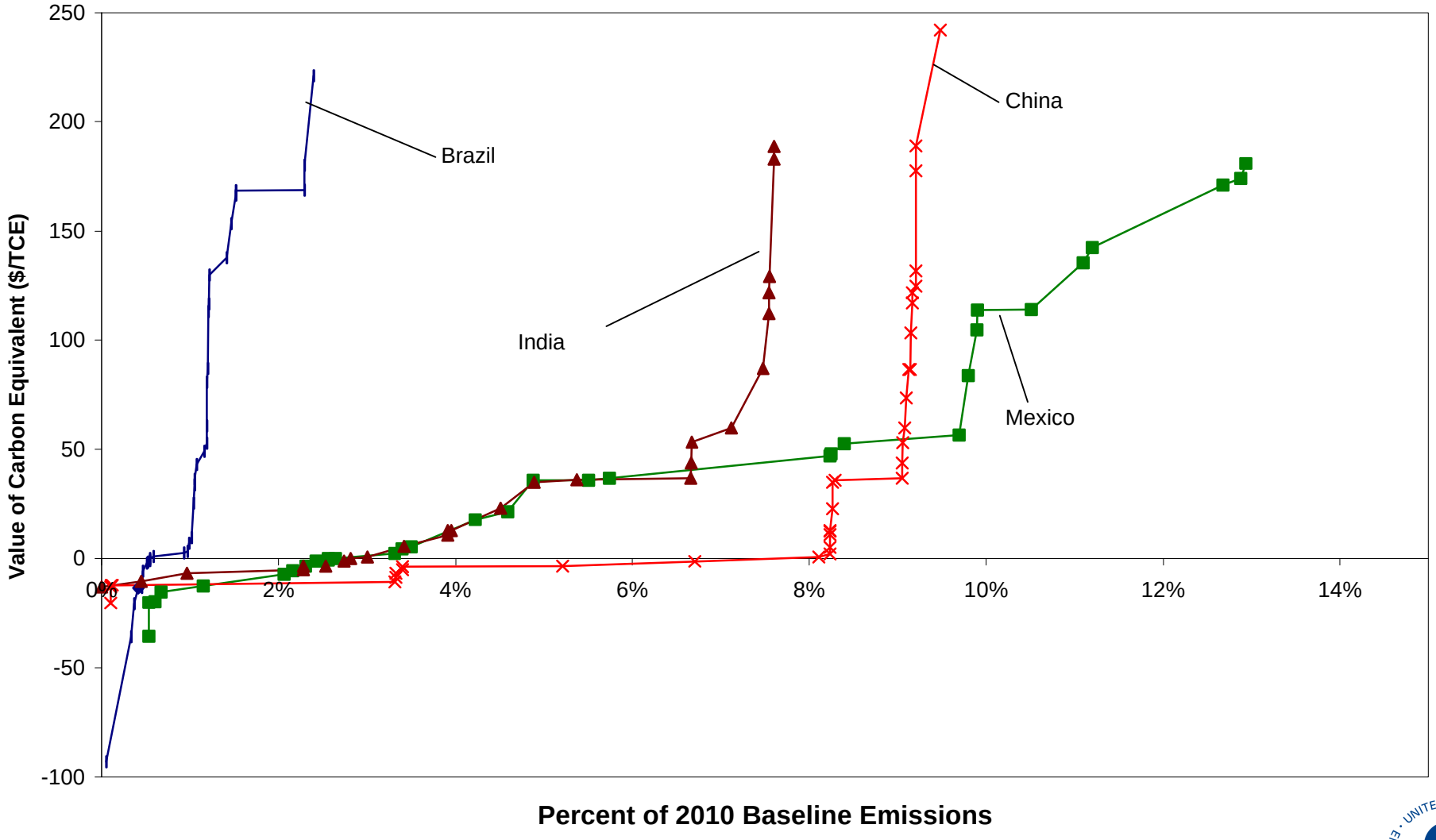
Methane Marginal Abatement Curves for Coal, Natural Gas, Landfills, & Manure Mgt, Select Regions - 2010 Baseline Emissions



Methane MACs based on 2010 Baseline Emissions for China, India, Brazil, and Mexico



Percent of 2010 Baseline Methane Emissions Abated for Select Developing Countries



Methane Analysis Uncertainties and Limitations

- Size and scale of methane sources over time
- Major focus on currently available technologies
- Lack of data on some of the technologies currently used by industry

Issues in Developing Global Methane MACs

- Analytical Scenarios
  - U.S. or EU level data & analyses
  - Russia, China, South Korea
  - Brazil, Mexico
  - Regional groups, e.g., SE Asia
- Transparency of analyses
- Similarity and selections of options

Issues in Developing Global Methane MACs - continued

- Industry / Social perspective, i.e., discount rates and taxes
- Standardization of costs
- Policies and measures in baseline
- Data quality and availability
- Technology innovation & diffusion

International non-CO_2 GHG Network

- Coordinated between US EPA MSB, IEA GHG R&D office in UK, and European Commission Environment DG
- First, organizational meeting in Brussels June 14-15, 2001; focusing on emission and cost analyses methodologies; coverage of key regions, countries; representation of sectors; incorporation into macro-economic models
- Next meeting at the 3rd Non-CO2 Conference, Netherlands, January 2002; looking to broaden participation from other countries, especially developing countries from Asia & Latin America

For More Information

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Nature, 7 Oct 99: "Multi-gas Assessment of the Kyoto Protocol."

By J. Reilly, R. Prinn, J. Harnisch, J. Fitzmaurice, H. Jacoby, D. Kicklighter, P. Stone, A. Sokolov, and C. Wang at MIT

- Looked at all GHG: CO_2, CH_4 , N_2O and HGWPs & sinks
- Showed that the inclusion of sinks and abatement opportunities from Non- CO_2 gases could reduce the cost of meeting the Kyoto Protocol by 60%
- In 2010, for Annex B as a whole, the benefit of a multi-gas approach would be about $38 billion/year
- For the U.S. alone, the benefit would be about $25 billion/year, a 40 percent reduction in costs from a CO_2 only control approach
- Suggests that 100-year GWPs fail to capture important time horizon and climate-chemistry effects

Science, 29 Oct 99: "Costs of multi-greenhouse gas reduction targets for the U.S."

By K. Hayhoe, A. Jain, H. Pitcher, C. MacCracken, M. Gibbs, D. Wuebbles, R. Harvey, and D. Kruger

- Looked at CH_4 and CO_2 reductions
- Multi-gas approach to meet greenhouse gas emission targets can
  - increases the control options
  - can lower the national costs of meeting international agreements
- Based on EPA MACs, it's estimated that for short-term targets CH_4 can offset CO_2 reductions and reduce U.S. costs by more than 25% relative to strategies involving CO_2 alone.