Appendix C-11

Methane Marginal Abatement Curves for Major Emitting Countries: Importance for International Cost Analyses and Contribution to Greenhouse Gas Mitigation

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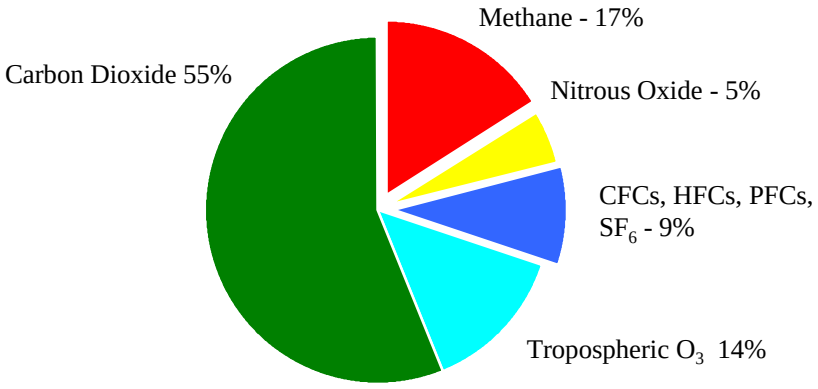
Overview

- » **Methane's Contribution to Climate Change**
- » **Future Methane Emissions**
- » **Benefits of Multi-Gas Abatement Strategy**
- » **Role of Marginal Abatement Curves (MACs)**
- » **Emission Estimates and Projections**
- » **International Marginal Abatement Curves**
- » **Uncertainties and Limitations**
- » **Global Methane MACs**

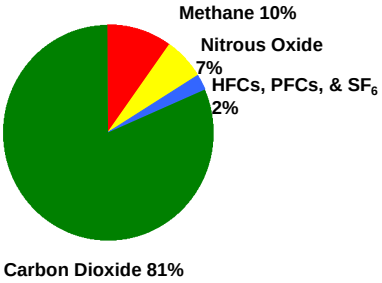
Contribution of Anthropogenic Gases to Enhanced Greenhouse Effect Since Pre-Industrial Times (measured in Watts/m^2)



Total = 2.85 Watts/m^2

Source: IPCC, 1996.

1998 U.S. Greenhouse Gas Emissions Weighted by Global Warming Potential

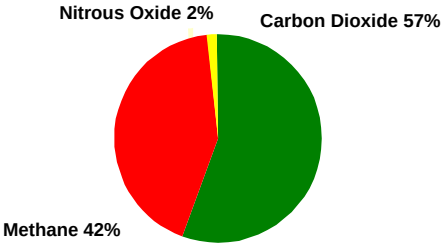


Total Emissions = 1,834.4 MMTCE

Source: ***Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1998.*** **EPA, 2000.**

http://www.epa.gov/globalwarming/emissions/national/download.html

1994 Brazil Greenhouse Gas Emissions Weighted by Global Warming Potential

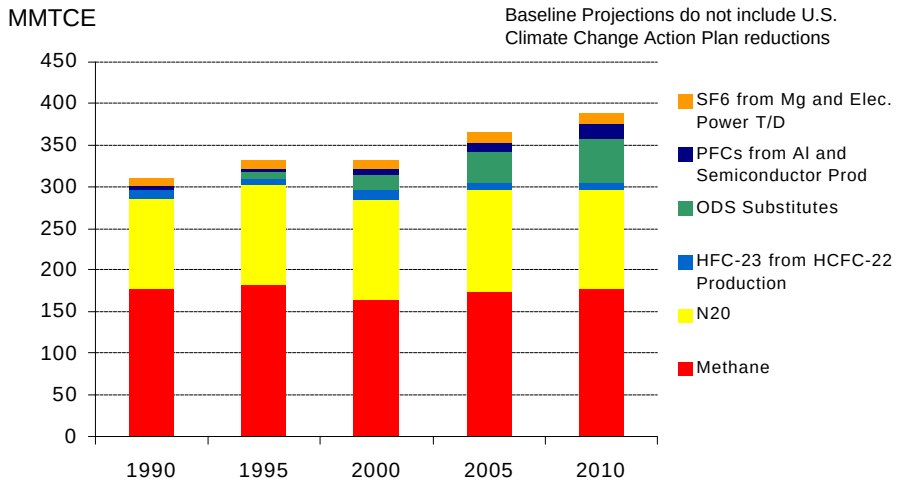


Total Emissions = 136.6 MMTCE

Source: Brazil Ministry of Science and Technology, National Communiation, 1999. http://www.mct.gov.br/clima/ingles/comunic/Default.htm

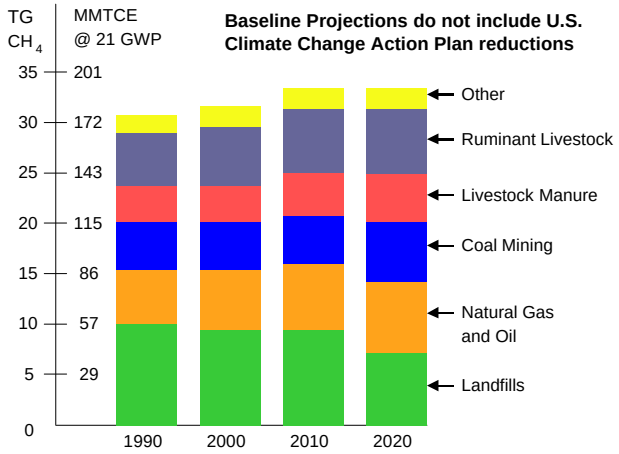
Source: IEA. CO2 emissions for fuel combustion. 1997

U.S. Non-CO_2 Emission Estimates & BAU Projections by Source: 1990 - 2010



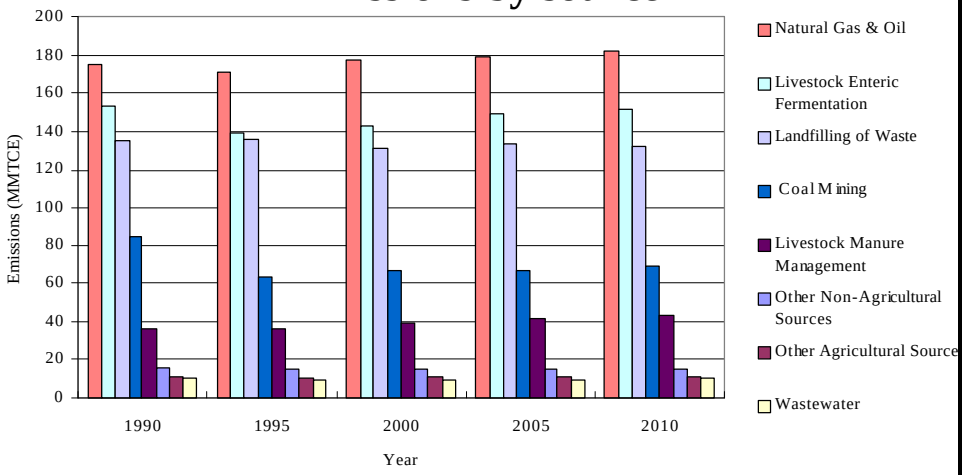
Source: EPA Reports.

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



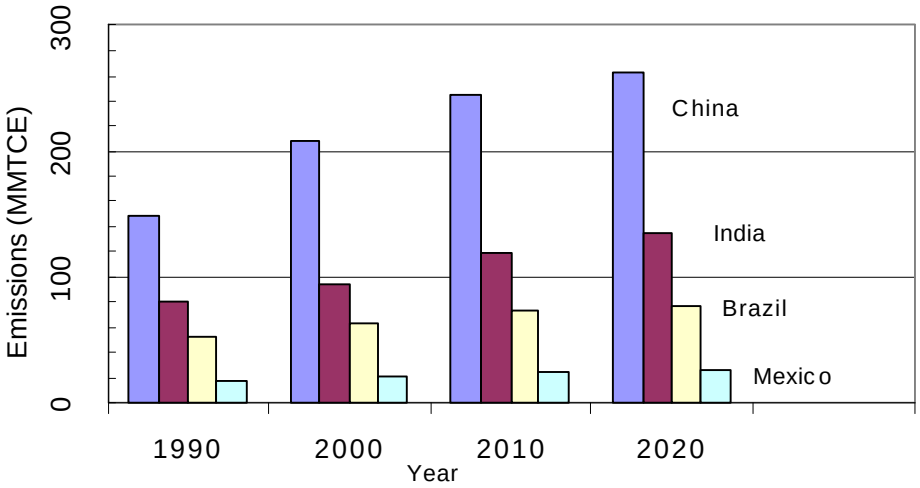
Source: *U.S. Methane Emissions 1990 – 2020: Inventories, Projections, and Opportunities for Reductions,* EPA, 1999

Developed Country BAU Methane Emissions by source



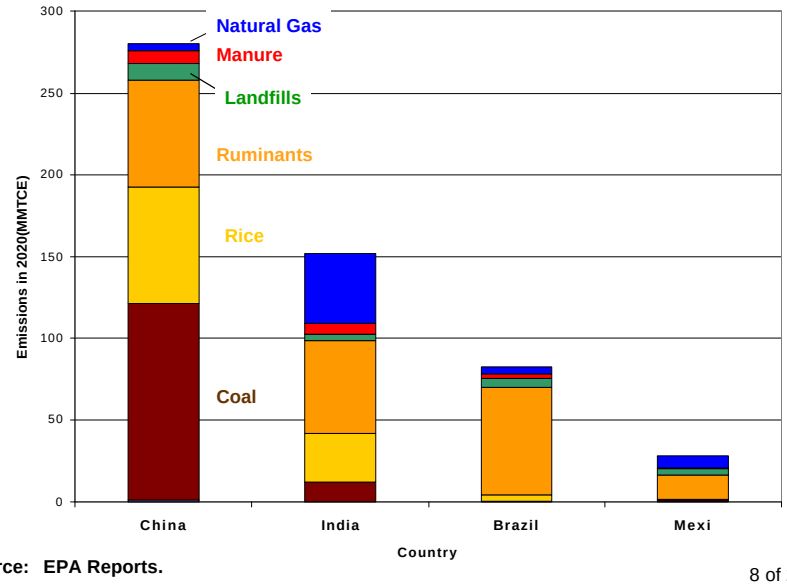
Source: EPA Reports.

Methane BAU Projections for China, India, Brazil, & Mexico



Source: EPA Reports.

Emissions in 2020 for key developing countries



Source: EPA Reports.

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

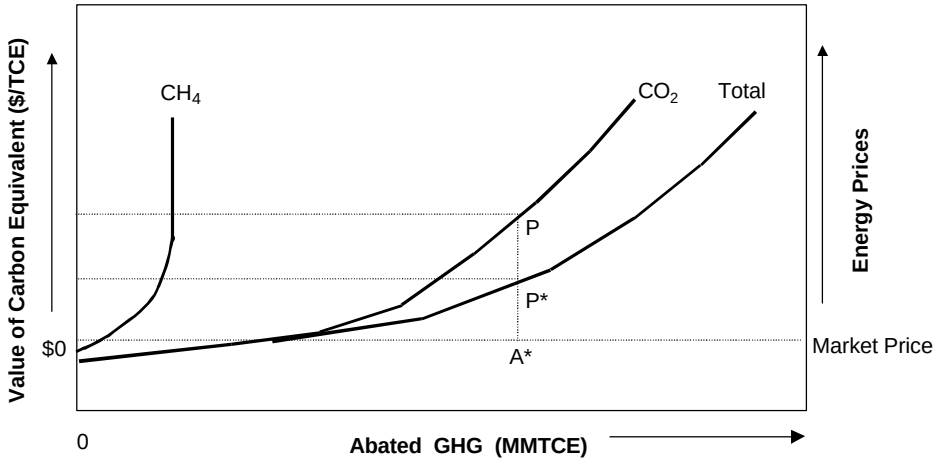
Science, 29 Oct 99: "Costs of multi-greenhouse gas reduction targets for the U.S."

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.

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 generation

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

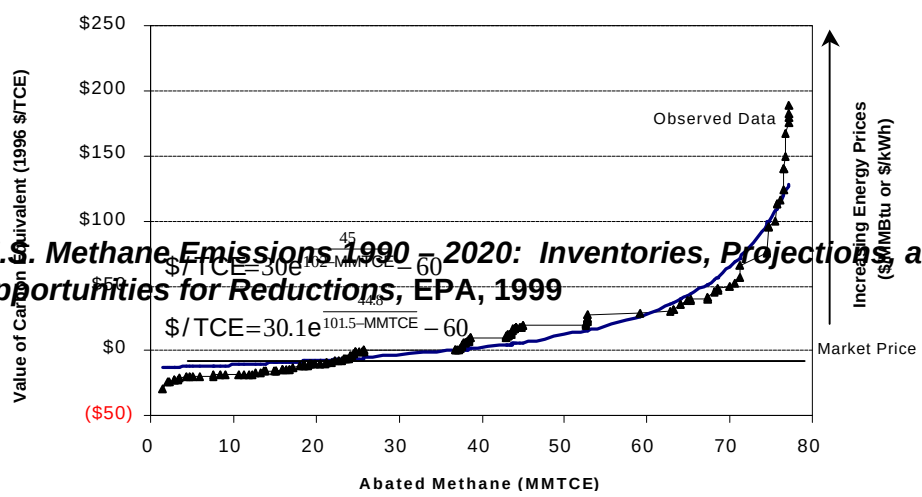
EPA's Cost Analysis Methodology

- 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 rate (4%, 8%, 15% or 20%)

S. Methane Marginal Abatement Curve (major sources except ruminants

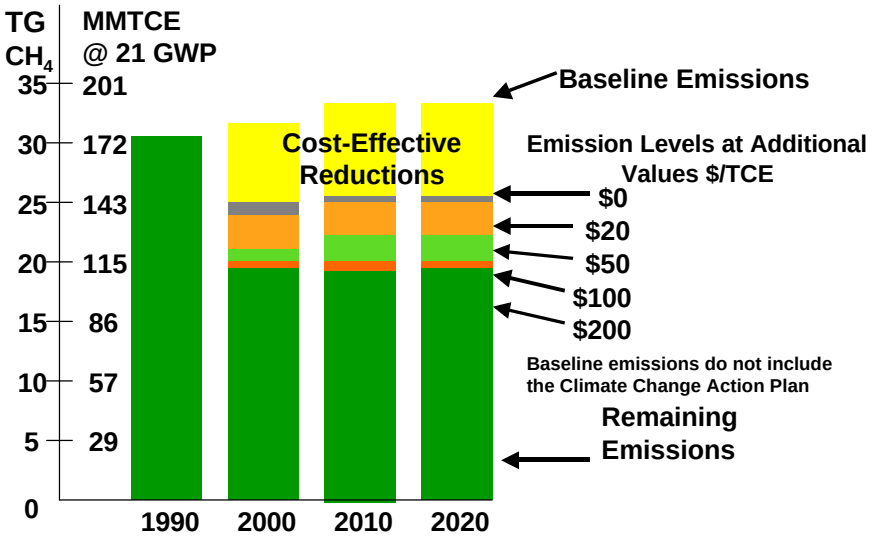
U.S. Methane Marginal Abatement Curve (MAC)

- 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



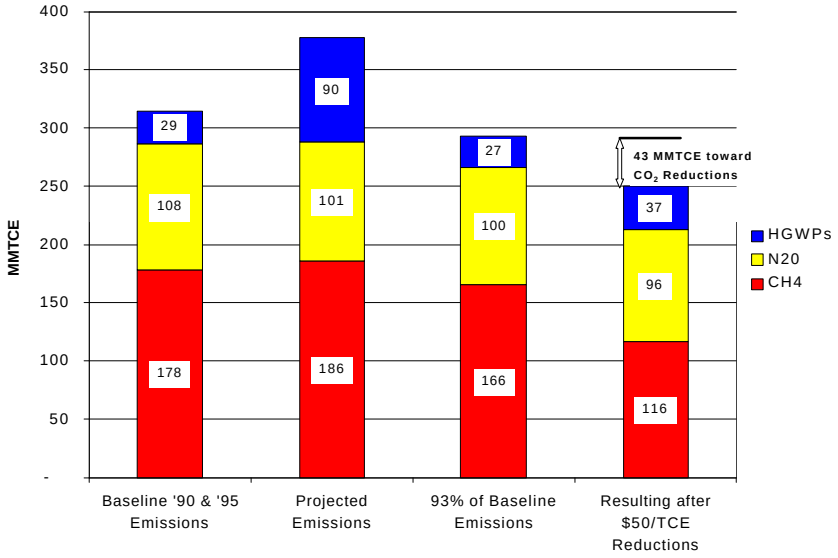
***U.S. Methane Emissions 1990 – 2020: Inventories, Projections, and Opportunities for Reductions*, EPA, 1999**

Projected Methane Emission Reductions



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

Contribution of Non-CO2 GHGs to Reduction Targets in the U.S. for 2010



Source: EPA Reports.

Analytical Framework for International MACs

For Each Country, Source-Specific Options were applied by

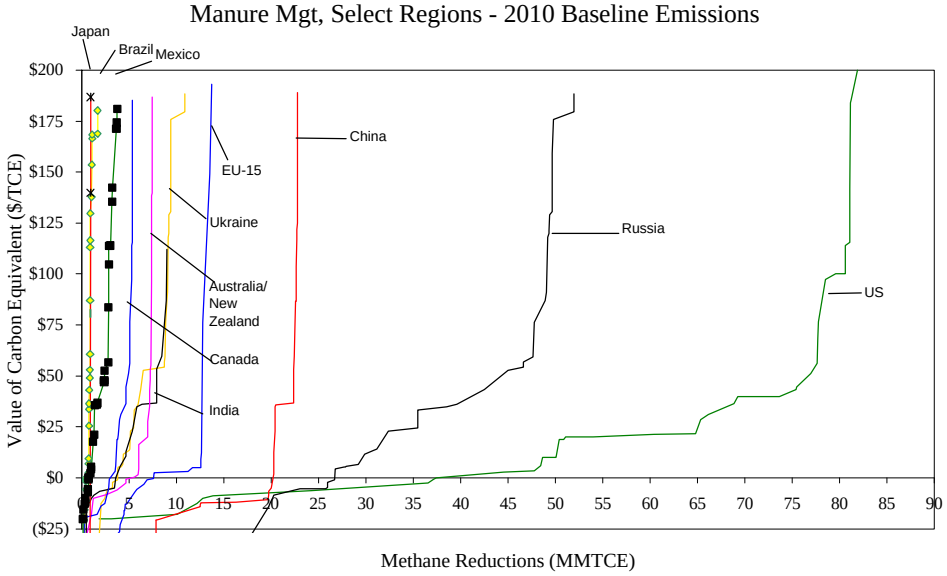
Applicability (% of the total emissions in a category) - A	Technical Effectiveness (% reduction) - B	Economic Feasibility Factor - C	National (% reduction) = A*B*C	Estimated Incremental Emissions Reduction (MMTCE/yr)

Marginal Cost calculated by

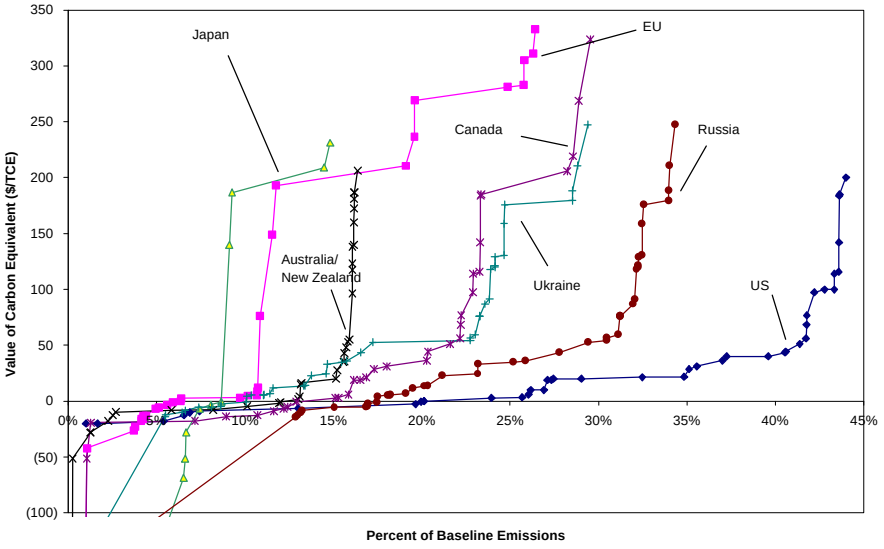
Project Lifetime (years)	Fixed Cost ($/TCE) X	Variable Cost ($/TCE) Y	Cost Offset ($/TCE) Z	Marginal Abatement Cost ($/TCE)

$/TCE = X + Y - Z

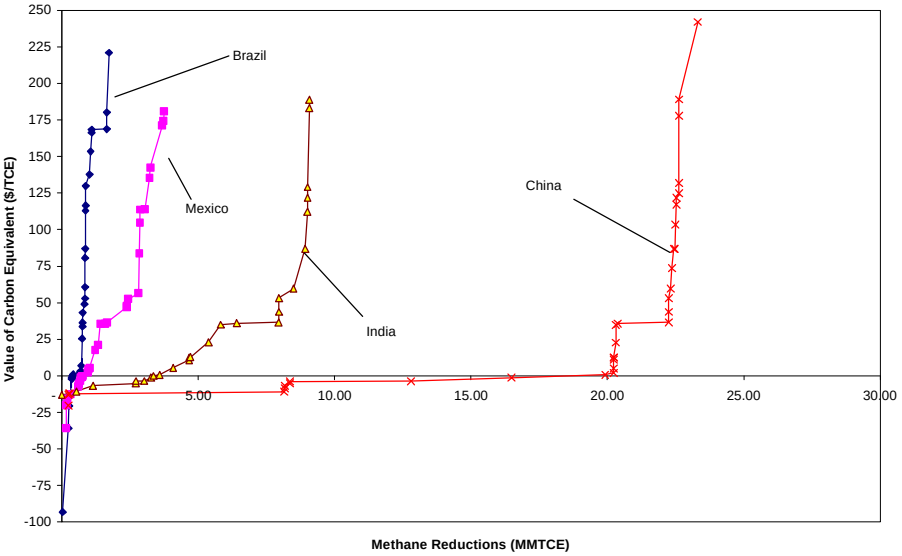
Methane Marginal Abatement Curves for Coal, Natural Gas, Landfills, & Manure Mgt, Select Regions - 2010 Baseline Emissions



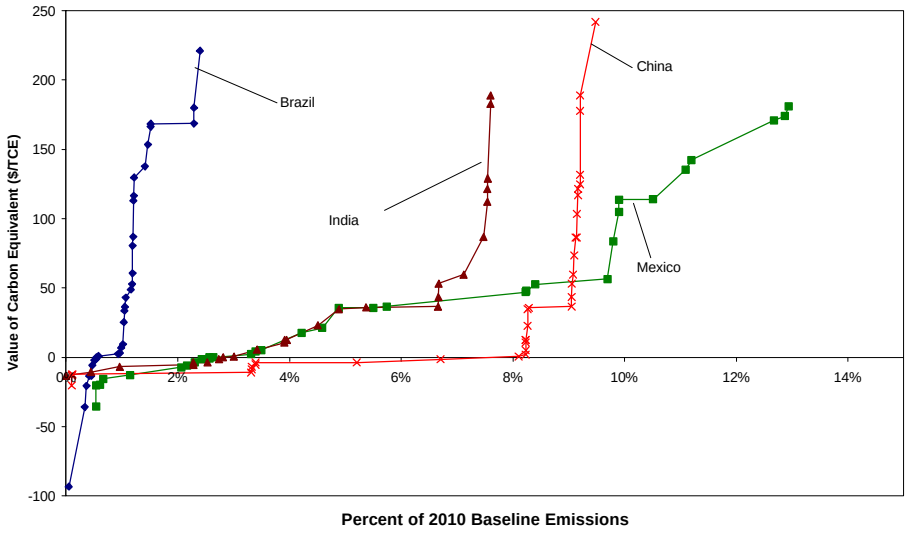
Percent of Emissions Abated for Select Regions based on 2010 Baseline Emissions



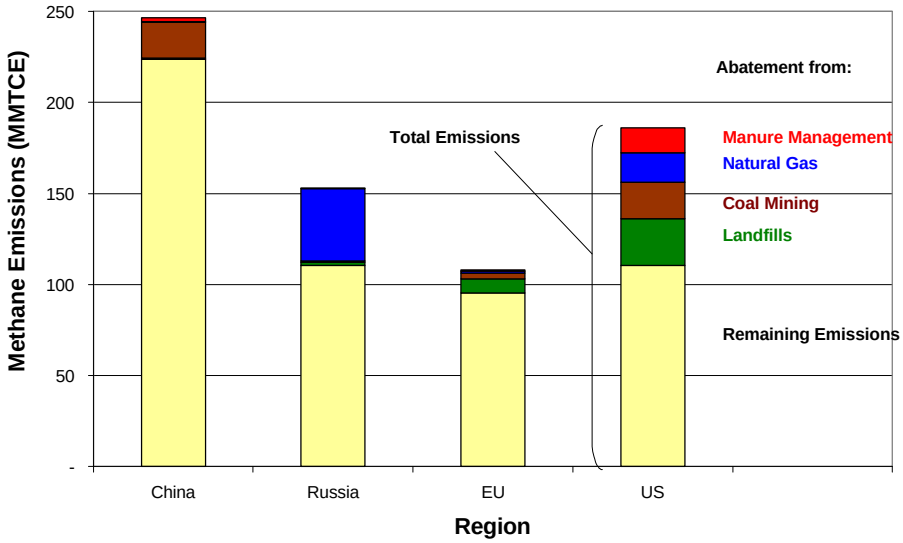
Methane MACs based on 2010 Baseline Emissions for China, India, Brazil, and Mexico



Percent of 2010 Baseline Methane Emissions Abated for Select Developing Countries



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



Source: EPA Reports.

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
  - 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

For More Information:

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