Global Mitigation of Non-CO_2 Greenhouse Gases: 2010 - 2030

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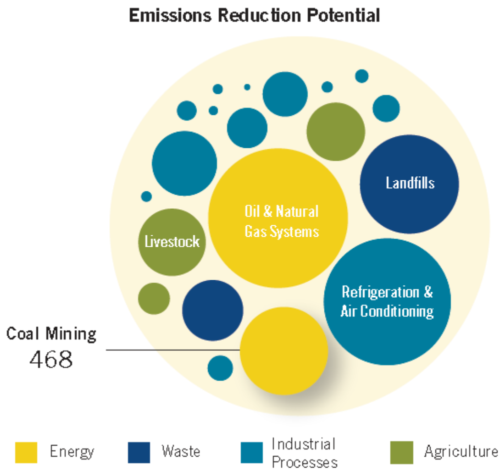
Snowmass Workshop
July, Aspen, CO



With Thanks to Shaun Ragnauth

Non-CO_2 Global Mitigation Report: 2010-2030 Background

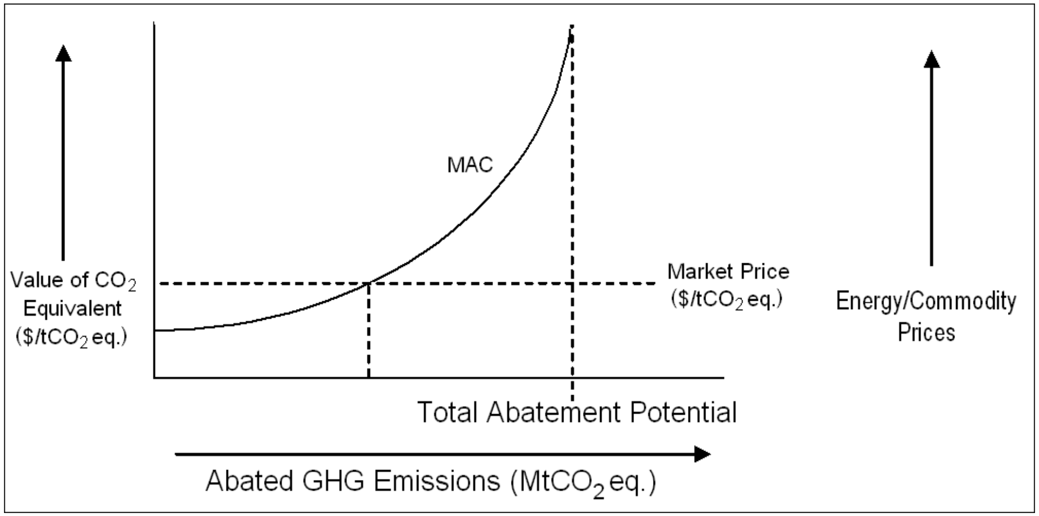
- USEPA has developed a comprehensive global mitigation analysis for non-CO_2 GHGs, covering:
  - All non-CO_2 greenhouse gases (methane, nitrous oxide, high GWP gases)
  - All emitting sectors (energy, waste, agriculture, and industrial processes)
    - Coal mining (CH_4)
    - Oil and natural gas systems (CH_4)
    - Solid waste management (CH_4)
    - Wastewater (CH_4, N_2O)
    - Specialized industrial processes (N_2O, PFCs, SF_6, HFCs)
    - Agriculture (CH_4, N_2O).
  - Global coverage – disaggregated at the country level
  - 2010 – 2030
- Coupled with baseline emission projections from EPA's non-CO_2 projections report
- Has undergone an external peer review process
- Builds on work started in 1999
  - 2001 & 1999 EPA reports on CH_4 and N_2O domestic mitigation potential
  - Stanford Energy Modeling Forum – EMF-21
  - 2006 Global Mitigation of Non-CO_2 Greenhouse Gases
- Provides improved data to better understand the costs and opportunities for reducing non-CO_2 greenhouse gas emissions.

Global Mitigation of Non-CO_2 Greenhouse Gases
(USEPA, 2013)

Data Sources and Models

- Data sources
  - Emissions baseline:
    - Domestic - U.S. Inventory of Greenhouse Gases and Sinks
    - International regions - Global Anthropogenic Non-CO2 Greenhouse Gas Emissions: 1990-2030
  - Emissions projections:
    - Global Anthropogenic Non-CO2 Greenhouse Gas Emissions: 1990-2030 (EPA 430-D-11-003)
    - Sector specific models for agriculture sources
      - DayCent (croplands), IMPACT (livestock), DNDC (rice)
  - Labor, energy and commodity prices:
    - Labor - U.S. BLS
    - Energy - EIA – AEO 2010, International Energy Statistics
    - Materials – UNCTAD Statistical Database
  - Mitigation and cost estimates:
    - Sector specific engineering and cost studies
    - Industry reported and supplied data
    - U.S. EPA Clean Watersheds Needs Survey
- Models
  - MAC model (EPA)
    - GAMS based model allows for fast updates to MACs based on new projections, cost, mitigation data, or other updated parameters
  - DNDC Model (Applied Geosolutions/UNH): Rice mitigation
  - DayCent Model (University of Colorado): Croplands
  - IMPACT Model (IFPRI)
  - Vintaging Model (EPA)

Mitigation Cost Analysis Methodology



– Bottom-up analysis of mitigation option breakeven prices

– Determines at what carbon price a mitigation option becomes economically viable

– Breakeven price is where NPV (benefits of the option) = NPV (costs of implementing the option)

– Breakeven price points form a marginal abatement curve (MAC), reflecting the economic potential for mitigation at various carbon prices

Methodology Continued – Abatement Options

- Abatement option emission reduction

  Technical Effectiveness * Baseline Emissions = Emission Reduction

  - Technical effectiveness determined by
    - Technical applicability
      - Portion of sector wide baseline option is applicable to
    - Market share
      - Avoids double counting of competing options
    - Reduction efficiency
      - Technically achievable abatement from an option

Technical Applicability (%)	X	Market Share[a] (%)	X	Reduction Efficiency (%)	=	Technical Effectiveness (%)				
						Technical Effectiveness (%)	X	Baseline Unit Emissions ($MtCO_2e$)	=	Unit Emission Reduction ($MtCO_2e$)
Percentage of total baseline emissions from a particular emissions source to which a given option can be potentially applied.		Percentage of technically applicable baseline emissions to which a given option is applied; avoids double counting among competing options		Percentage of technically achievable emissions abatement for an option after it is applied to a given emissions stream		Percentage of baseline emissions that can be reduced at the national or regional level by a given option.		Emissions stream to which the option is applied		Unit emission reductions

Example Mitigation Options Modeled

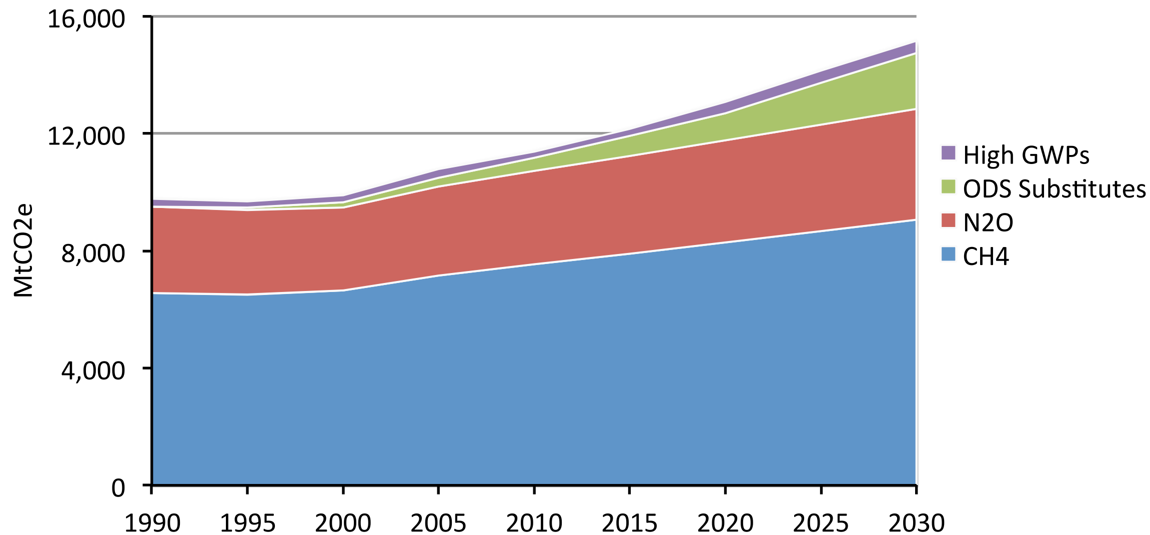
Table C-1: Example Break-Even Prices for Natural Gas and Oil System Technology Options in 2010

Abatement Measure	System Component/ Process	Reduced Emissions (tCO_2e)	Annualized Capital Costs ($\$/tCO_2e$)	Annual Cost ($\$/tCO_2e$)	Annual Revenue ($\$/tCO_2e$)	Tax Benefit of Depreciation ($\$/tCO_2e$)	Break-Even Price ($\$/tCO_2e$)	Incremental Reduction ($MtCO_2e$)
Oil and Gas Production								
Convert gas pneumatic controls to instrument air	Pneumatic device vents	71.0	$335.68	$441.41	$10.01	$82.50	$684.58	15.29
Directed inspection & maintenance at gas production facilities	Chemical injection pumps	15.2	$0.00	$440.34	$10.01	$0.00	$430.33	0.44
Directed inspection & maintenance at gas production facilities	Deepwater gas platforms	6,687.0	$0.00	$7.48	$10.01	$0.00	−$2.53	0.21
Directed inspection & maintenance at gas production facilities	Non-associated gas wells	2.8	$0.00	$289.00	$10.01	$0.00	$279.00	0.97
Directed inspection & maintenance at gas production facilities	Pipeline leaks	5.0	$0.00	$16.44	$10.01	$0.00	$6.43	1.78
Directed inspection & maintenance at gas production facilities	Shallow water gas platforms	1,584.6	$0.00	$21.04	$10.01	$0.00	$11.03	2.57
Flaring instead of venting on offshore oil platforms	Offshore platforms, shallow water oil, fugitive, vented and combusted	7,929.0	$4,584.45	$627.65	$10.01	$929.86	$4,272.24	8.94
Install flash tank separators on dehydrators	Dehydrator vents	18.1	$402.90	$0.00	$10.01	$122.18	$270.71	0.75
Installing catalytic converters on gas fueled engines and turbines	Gas engines - Exhaust vented	36,389.4	$0.06	$0.12	$0.00	$0.01	$0.16	2.55
Installing electronic starters on production field compressors	Compressor starts	2.7	$266.82	$2,172.15	$10.01	$65.58	$2,363.39	0.07
Installing plunger lift systems in gas wells	Non-associated gas wells	2.4	$1,042.59	−$5,818.60	$10.01	$316.18	−$5,102.19	0.82
Installing plunger lift systems in gas wells	Well clean ups (LP Gas Wells)	423.25	$5.87	−$32.73	$10.01	$1.78	−$38.65	29.93
Installing plunger lift systems in gas wells	Gas well workovers	0.8	$2,960.86	−$16,524.21	$10.01	$897.92	−$14,471.28	0.01
Installing surge vessels for capturing blowdown vents	Compressor BD	0.8	$43,398.61	$34,987.60	$10.01	$8,802.49	$69,573.71	0.02
Installing surge vessels for capturing blowdown vents	Vessel BD	0.0	$2,088,733.32	$1,683,919.51	$10.01	$423,655.25	$3,348,987.59	0.01

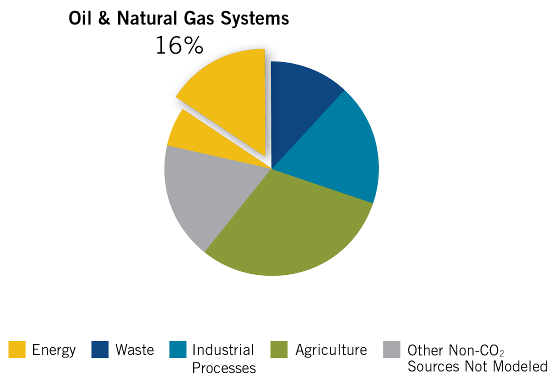
(continued)

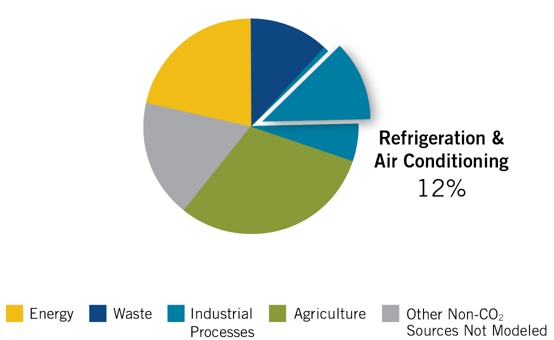
Baseline and Projections

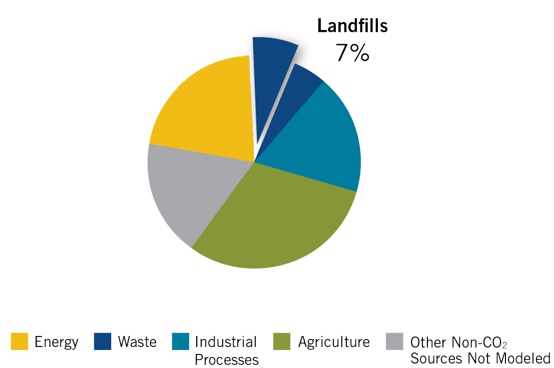
- Non-Ag sectors utilize USEPA 2012 global projections
- Ag sector projections are based on DNDC, DayCent, and IFPRI IMPACT
- 2030 projected non-CO_2 GHG emissions is over 15 Gt
- Top emitting sectors in 2030:

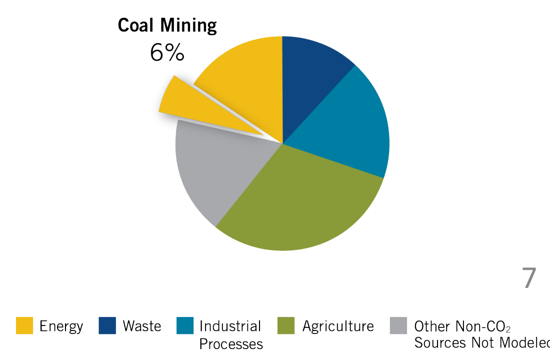


Source: *Global Anthropogenic Non-CO_2 Greenhouse Gas Emissions: 1990-2030. USEPA, 2012*



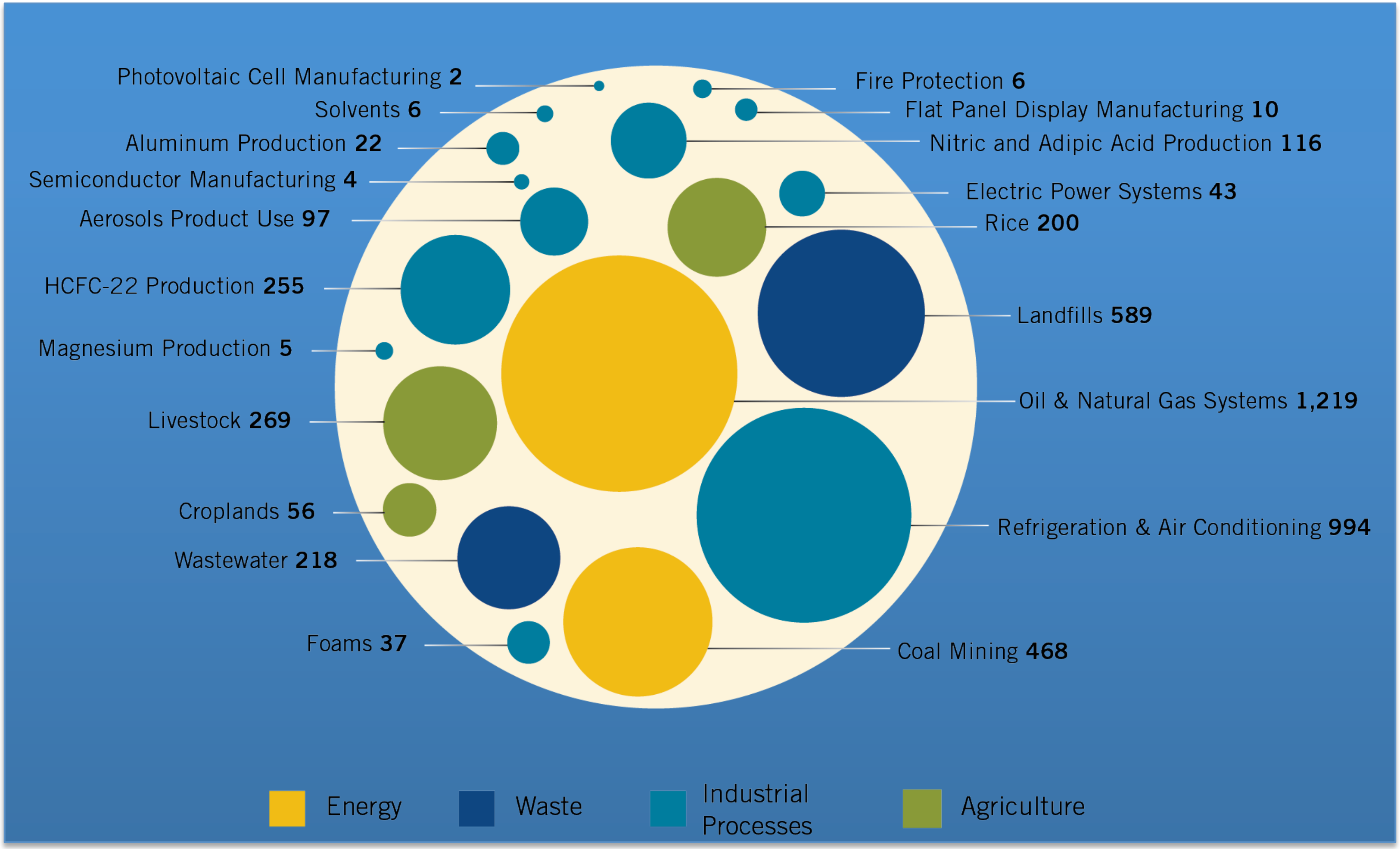






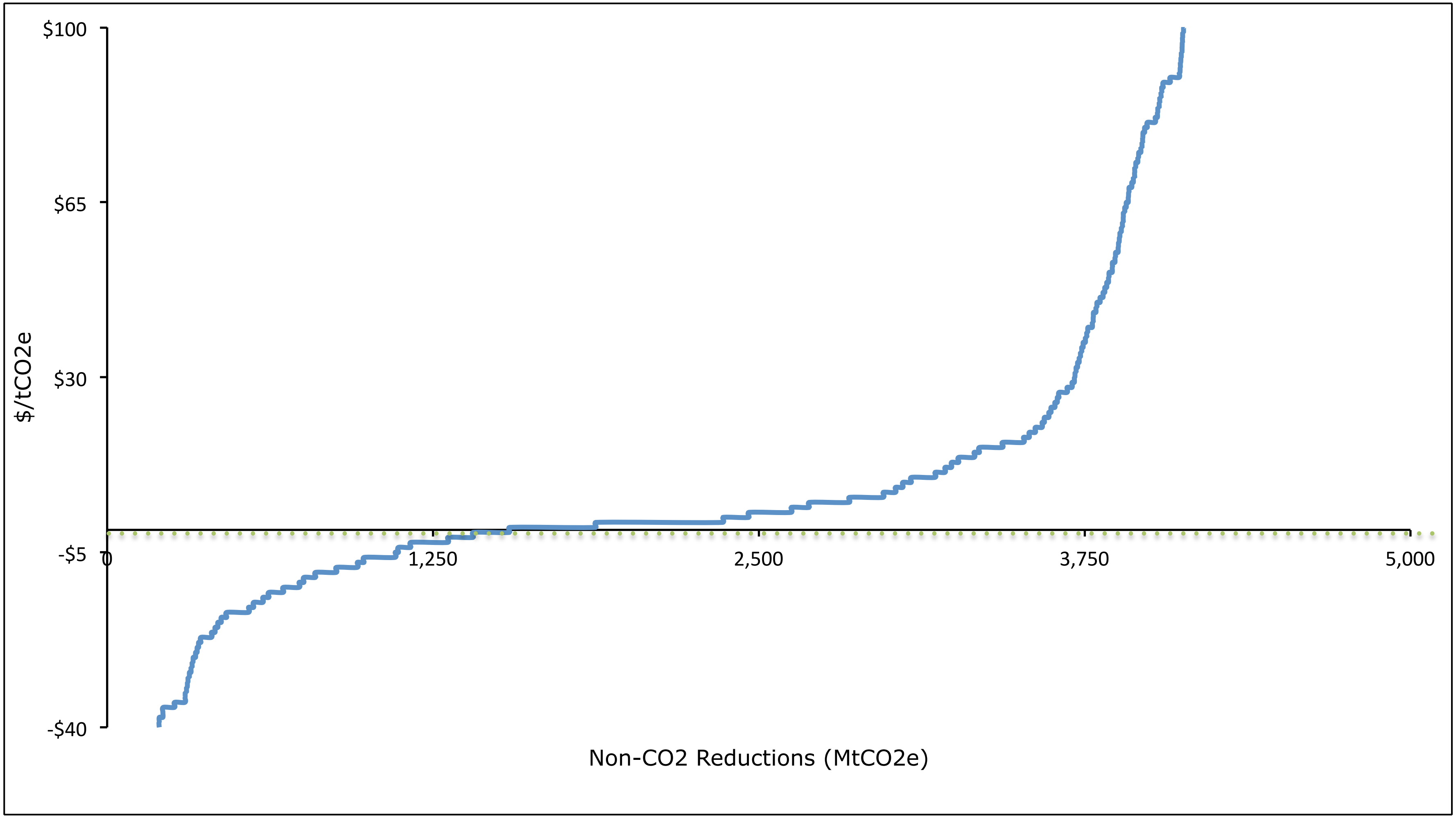
Key Findings

- Total technically feasible global mitigation from non-CO_2 GHG sources in 2030 is over 3,500 $MtCO_2e$



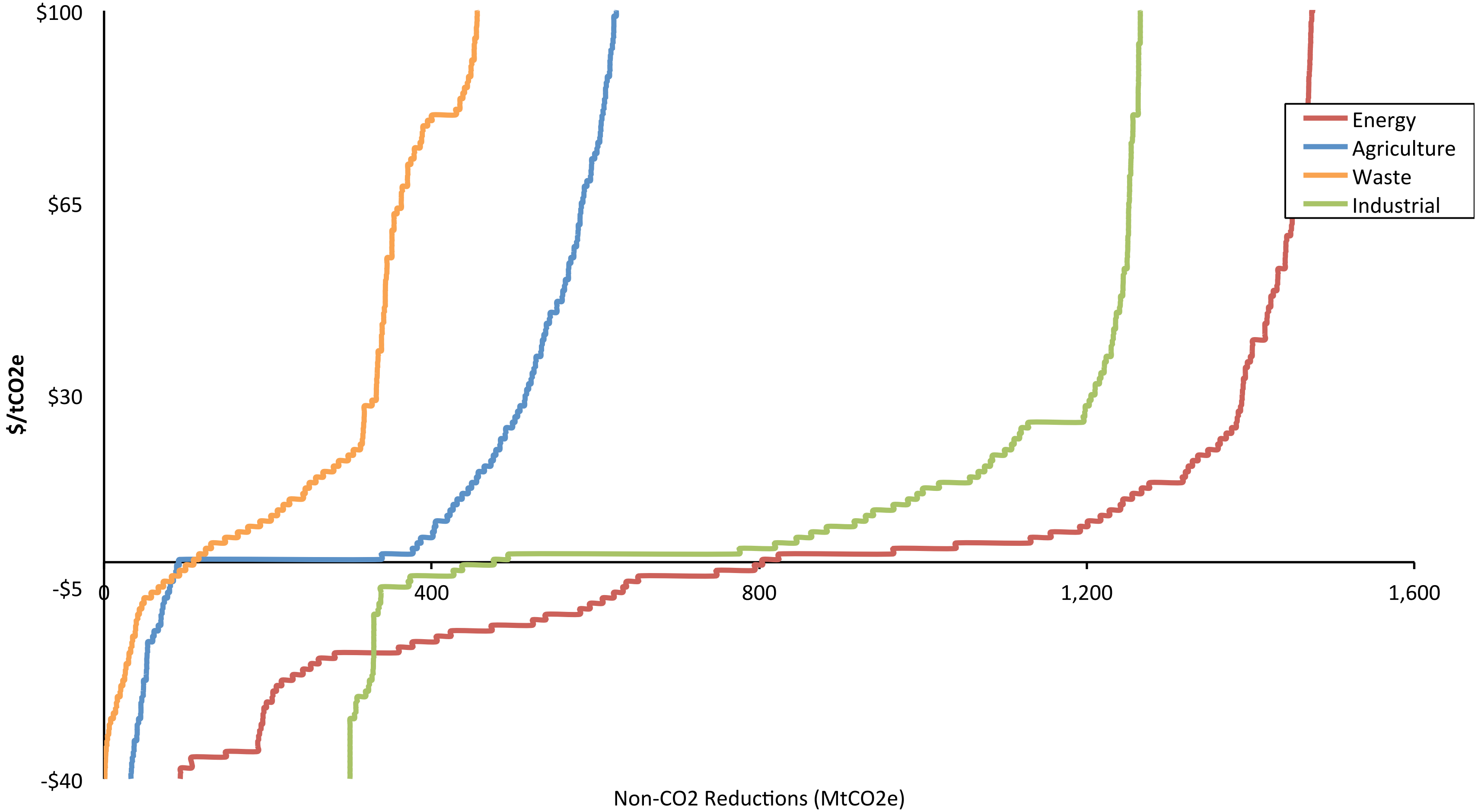
Aggregate Results – Global MAC (2030)

Worldwide cost-effective mitigation potential is 1,772 $MtCO_2e$ in 2030



Aggregate Results – MACs by Sector (2030)

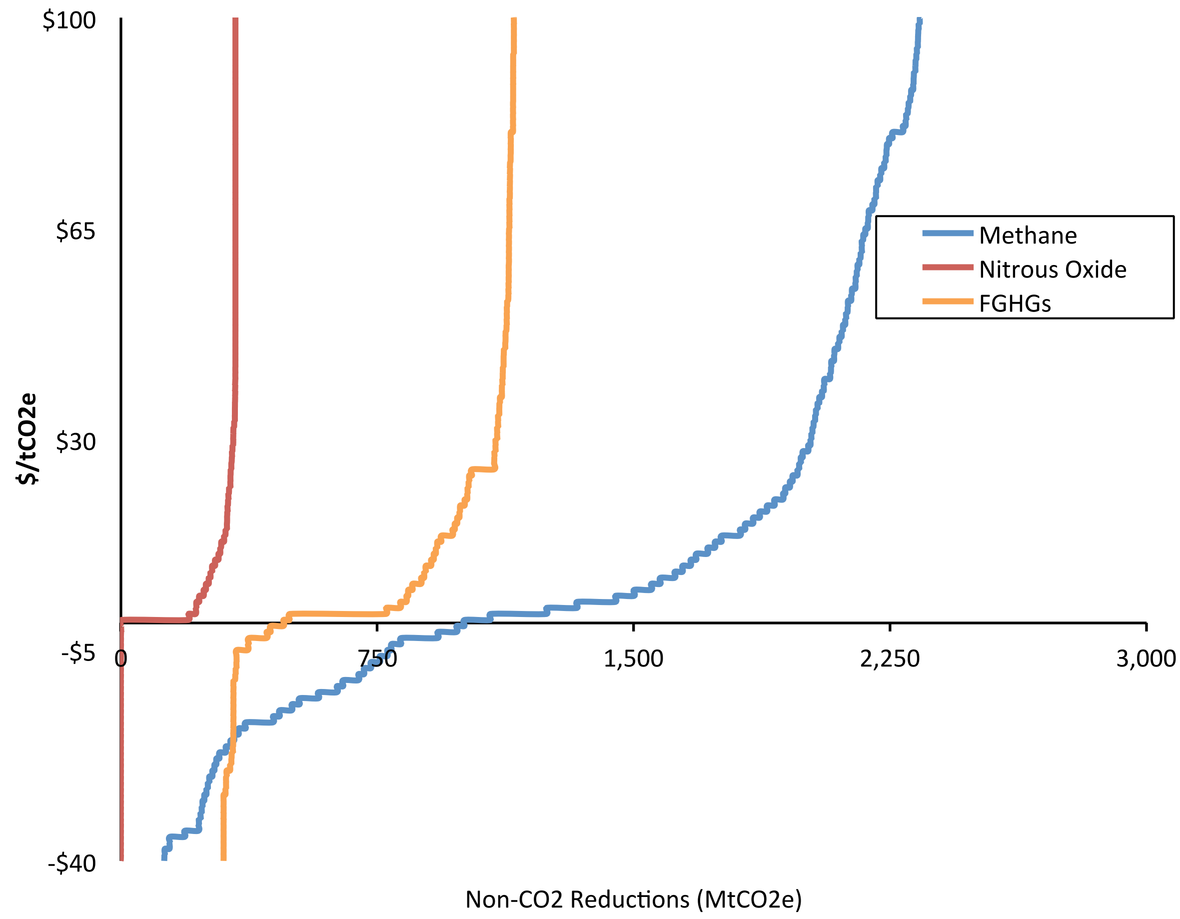
Globally, the sectors with the greatest potential for mitigation of non-CO_2 greenhouse gases are the energy and industrial process sectors.



Aggregate Results – MACs by GHG (2030)

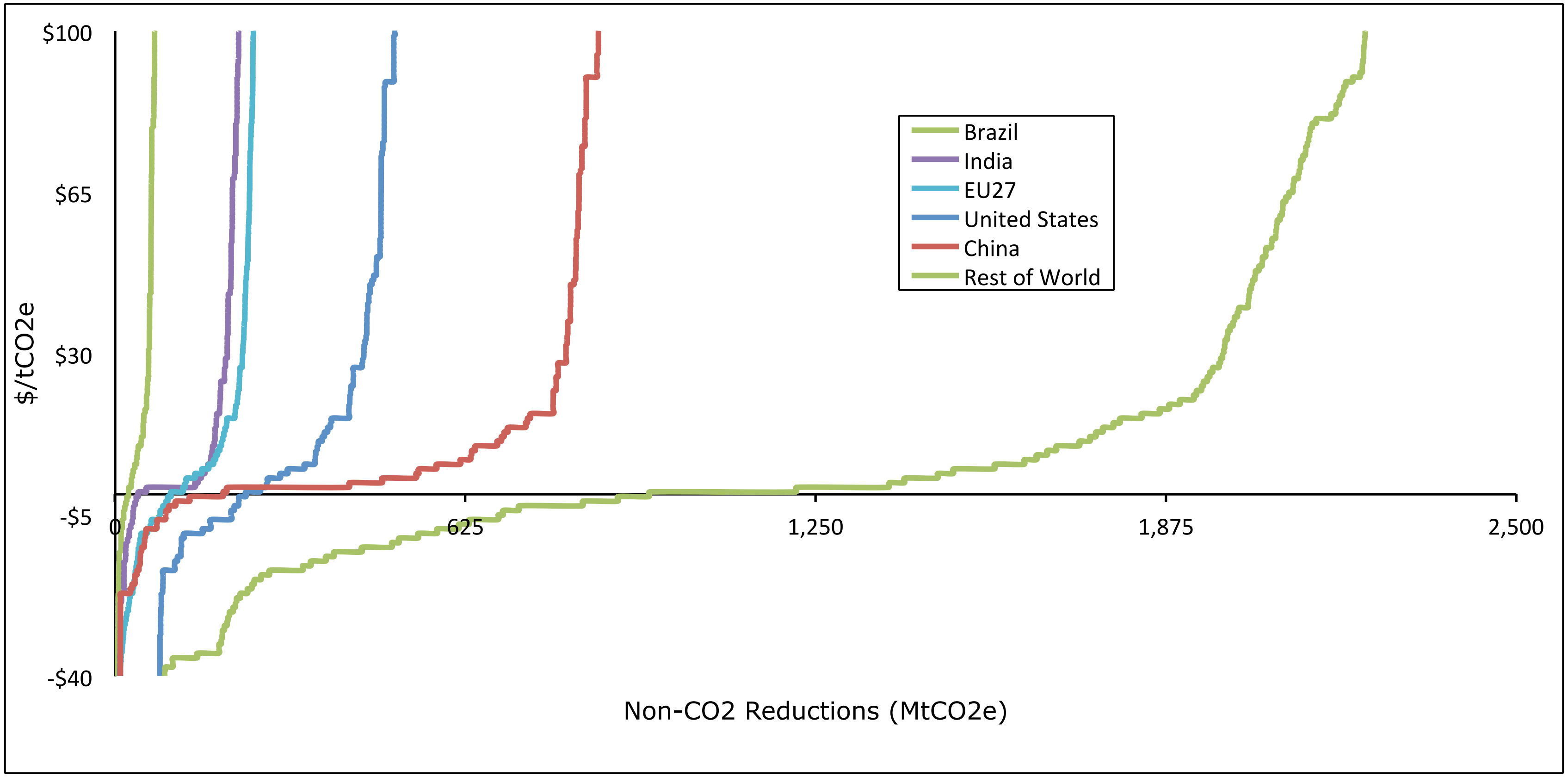
Methane mitigation has the largest potential among non-CO_2 greenhouse gases.

- At a cost-effective level, the potential for methane mitigation is greater than 1000 $MtCO_2eq$.
- The potential for reducing methane emissions grows two-fold as the breakeven price rises from $0 to $20/$tCO_2eq$.
- While less than that of methane, nitrous oxide and high-GWP gases exhibit significant cost-effective mitigation potential.



Aggregate Results – MACs by Region (2030)

- China and the U.S. are the top two contributors to global mitigation potential with cost effective mitigation of 249 and 165 $MtCO_2e$ respectively.



Coal mines

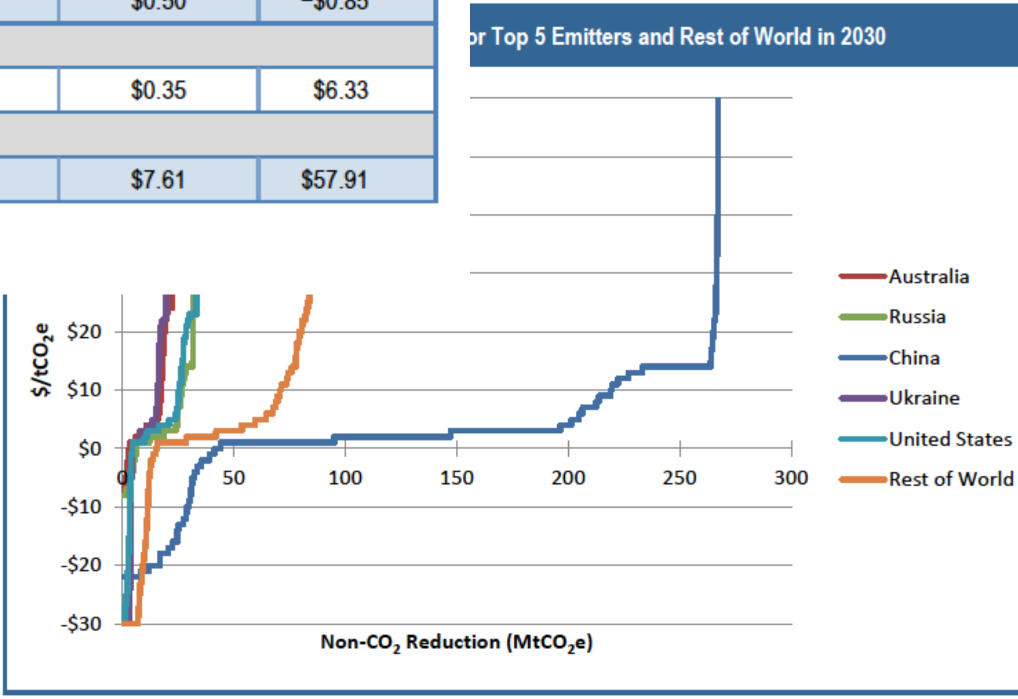
- US: 100+ coal mines explicitly captured. International: representative dataset.

Table 1-5: Example Break-Even Price Calculation for Coal Mine Abatement Measures

Abatement Option	Reduced Emissions (tCO_2e)	Annualized Capital Costs[b] ($/$tCO_2e$)	Net Annual Cost[a] ($/$tCO_2e$)	Tax Benefit of Depreciation ($/$tCO_2e$)	Break-Even Price[b] ($/$tCO_2e$)
Energy End Uses					
Pipeline Injection	99,629	$18.5	−$19.5	$3.76	−$4.69
Electricity Generation	130,338	$38.7	−$33.0	$7.84	−$2.18
On-Site Direct Use	249,175	$2.5	−$2.8	$0.50	−$0.85
Excess Gas Flaring					
Enclosed Flare System	298,333	$1.7	$5.0	$0.35	$6.33
Combustion of VAM					
VAM Oxidation	46,430	$37.5	$28.0	$7.61	$57.91

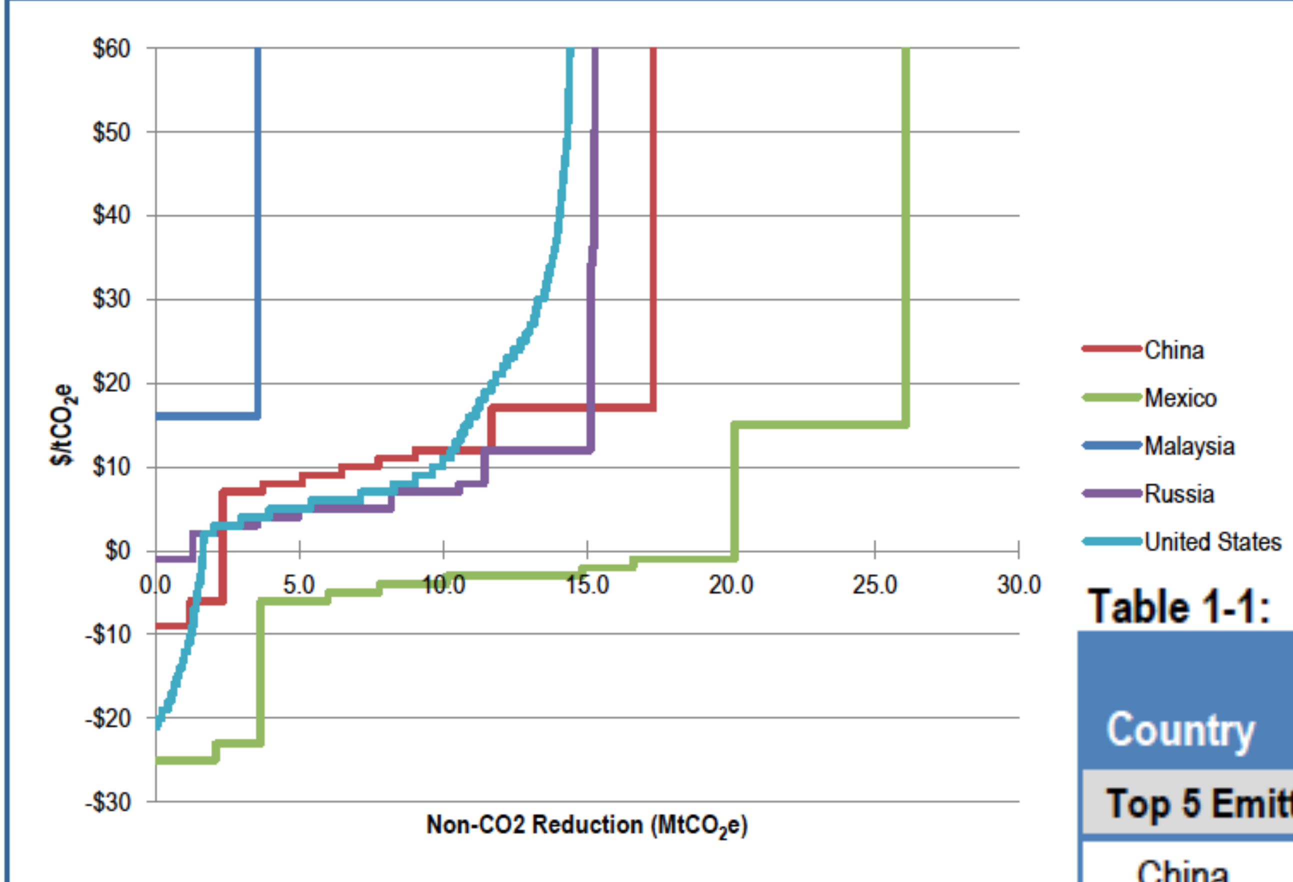
[a] Assumes tax rate = 40%; discount rate = 10%, technical lifetime = 15 years

[b] AEO 2010 Energy prices; dry natural gas ($/Mcf); electricity $/kWh); and coal ($/ton)



Landfills

Figure 1-4: Marginal Abatement Cost Curve for Top 5 Emitters in 2030

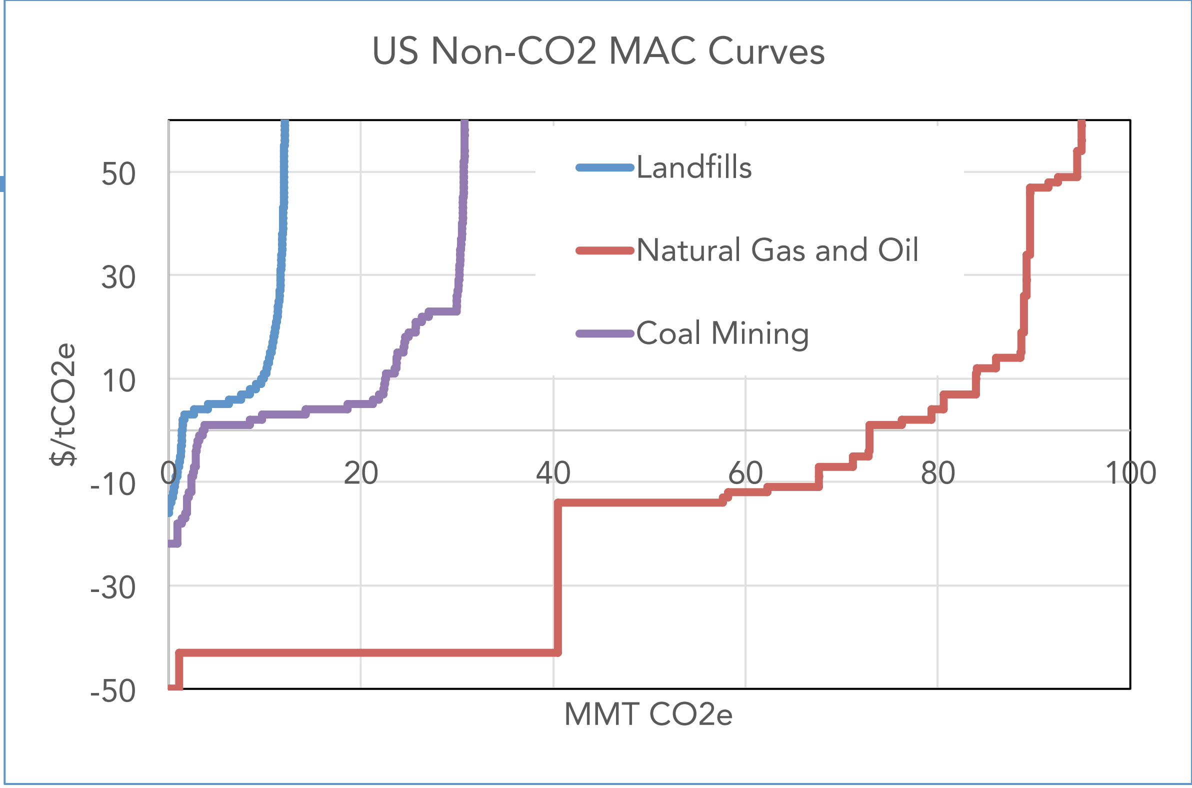


- Abatement options:
  - Burning for power
  - Flaring
  - Diversion before landfilling

Table 1-1: Projected Baseline Emissions

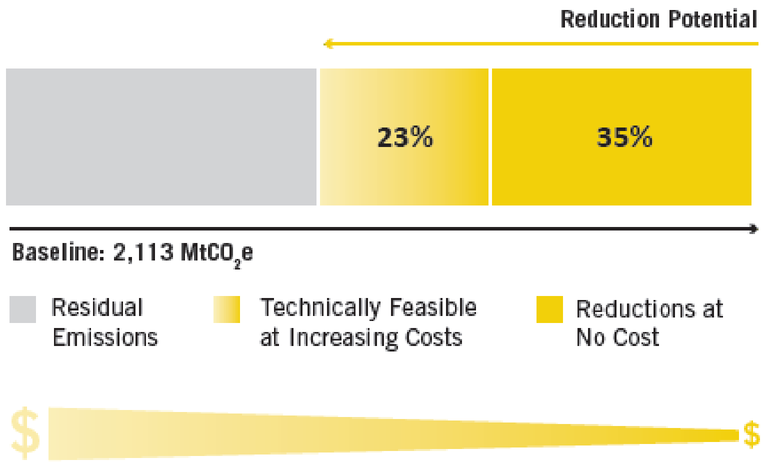
Country	2010
Top 5 Emitting Countries	
China	47.1
Malaysia	29.9
Mexico	56.4
Russia	47.2
United States	129.7

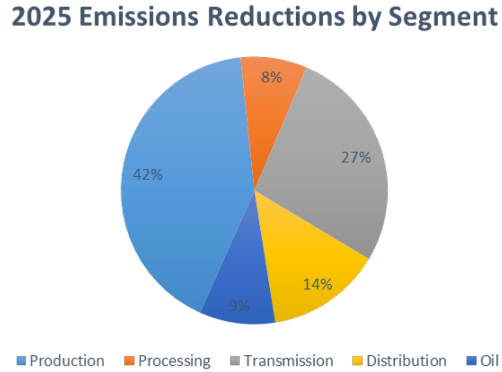
US MACs in 2020



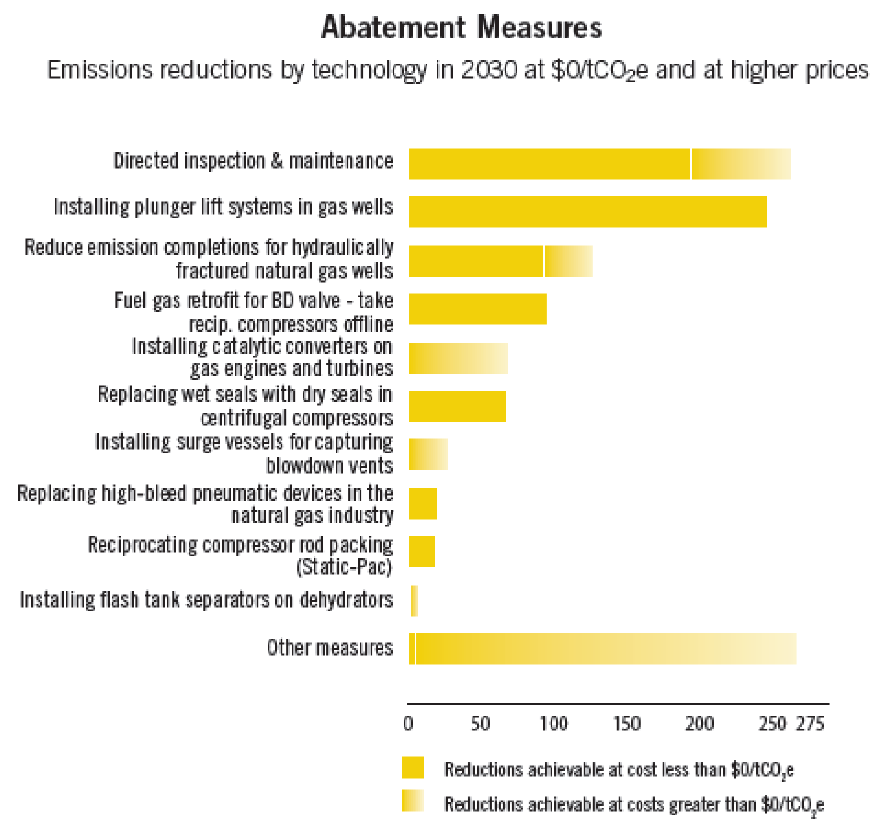
- These MACs take into account abatement programs that have already been implemented. For comparison, the projected abatement and emissions in 2020 from these sectors (Climate Action Report #s) are:
  - Landfills: 183 MMT from regulations, 16 MMT from LMOP
    - Projected emissions in 2020: 101 MMT (MAC report: 128)
  - Oil and Gas: 40 MMT from regs, 22 from Natural Gas STAR
    - Projected emissions in 2020: 140 MMT (MAC report: 282)
  - Coal Mining: 9 MMT from CMOP
    - Projected emissions in 2020: 65 MMT (MAC report: 70)

Model Results – Oil and Gas (2030)





- Model outputs abatement potential disaggregated by segment and mitigation option
- Mitigation potential
  - Model evaluates over 100 mitigation options across four oil/gas segments
  - Maximum global mitigation potential in 2030 is over 1,200 MtCO2e, 58%
  - $5/tCO2e global mitigation is over 800 MtCO2e



Prior Study Comparison

- Compared to EPA 2006 Non-CO_2 Mitigation Report, total aggregate abatement potential is 5% higher
  - Drivers include
    - Model updates
    - New sectors and abatement options
    - Updated inputs (energy prices, capital costs, O&M costs, etc.)

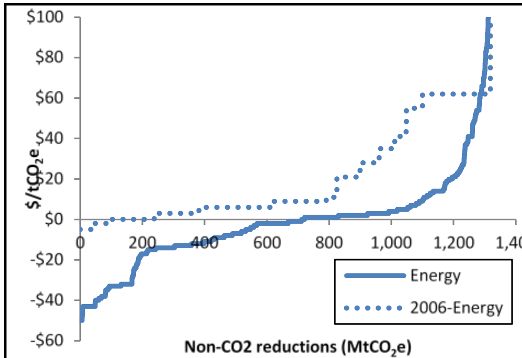


Figure 13a. Energy Sector MACs for 2020

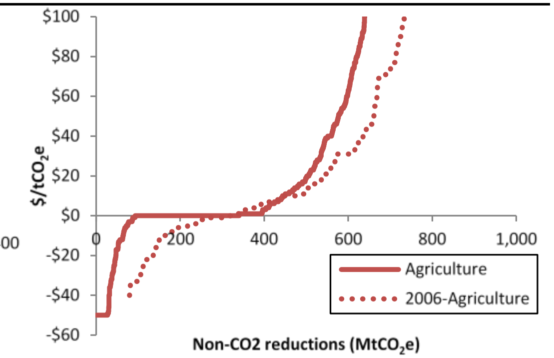


Figure 13b. Agricultural Sector MACs for 2020

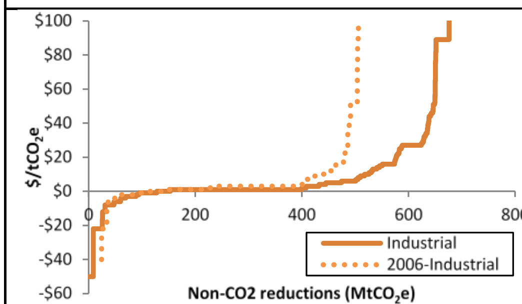


Figure 13c. Industrial Sector MACs for 2020

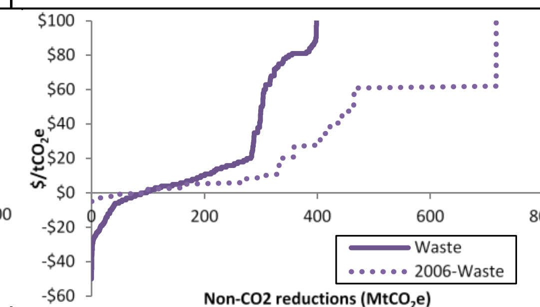


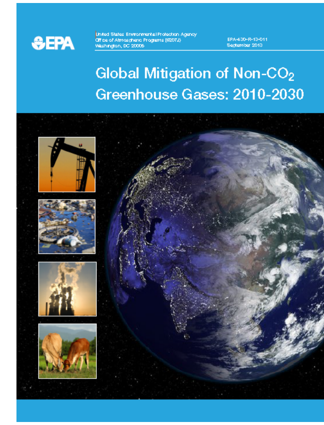
Figure 13d. Waste Sector MACs for 2020

Summary

- Limitations
  - Technological Change
  - Transaction Costs
  - Regional Data
  - Indirect GHG reductions
- Data annex of the mitigation report provides sector-by-sector projections and mitigation abatement cost data for 10 countries & 6 regions for 2010, 2020 and 2030
  - Aggregated into CO2 equivalents, but most sectors are single gas
  - Takes into account available information on abatement measures already implemented
  - Updated web tool in development, nearing release
- Oil and Gas in the US, coal mining in China are examples of major sources of relatively low cost abatement potential for methane
- Despite potential for project level cost savings and environmental benefits, barriers to mitigating CH_4 emissions continue to exist:
  - Traditional industry practices
  - Regulatory and legal issues
  - Uncertain investment climate
- Report and data set can feed in to a number of climate analytical needs
  - CGE modeling
  - Analysis of cost and availability of mitigation opportunities
  - Climate policy analysis

More Information

- Mitigation Report available on the web at:
http://www.epa.gov/climatechange/EPAactivities/economics/nonco2mitigation.html



- Projections Report available on the web at:
http://www.epa.gov/climatechange/EPAactivities/economics/nonco2projections.html

- Climate Action Report available on the web at:
http://www.state.gov/e/oes/rls/rpts/car6/

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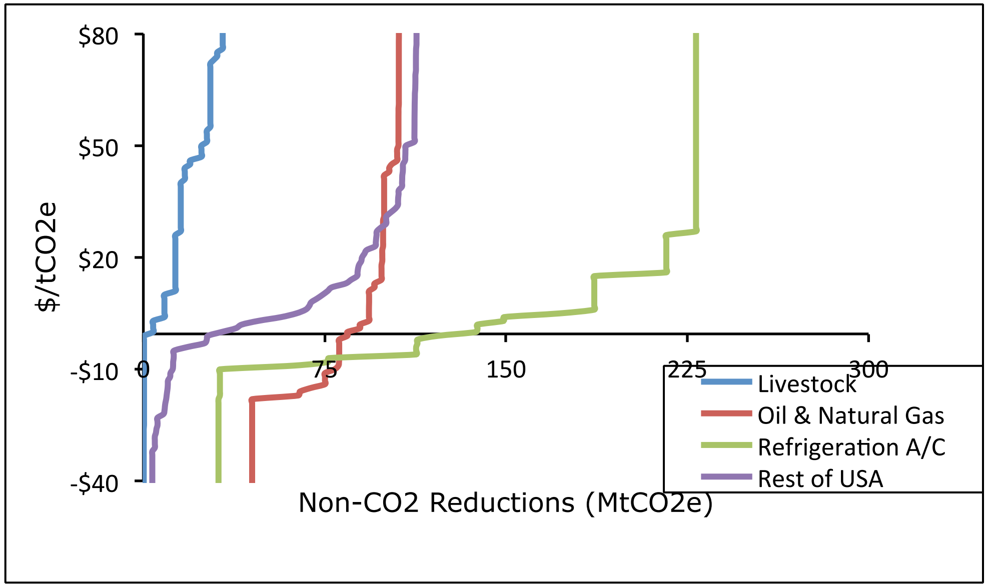
MACs - U.S. and China

U.S. 2030 MAC



China 2030 MAC