Tackling Short-lived Climate Pollutants: International Experiences and China's Potential Pathways

Jiang Lin, Nina Khanna
UC Berkeley
Lawrence Berkeley National Lab

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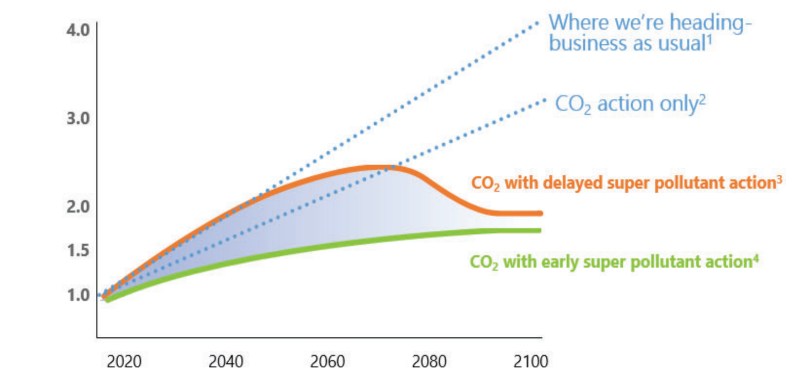
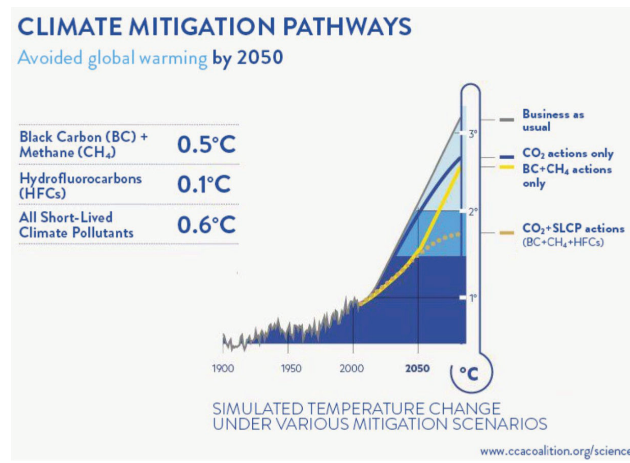
SLCP Reduction and Climate Urgency

- Fast reductions of short-lived climate pollutants (i.e., methane, F-gases including HFCs, black carbon) and N_2O critical to reducing short-term warming trend by more than half over the next few decades
- SLCP reductions could avoid up to 0.6°C of warming by 2050, and is critical to limiting global temperature increase to 1.5°C
- N_2O is 300x more potent than CO_2, contributes to 10% of today's warming, and is the largest depleter of stratospheric ozone not yet controlled by Montreal Protocol
- China has recognized the need to reduce non-CO_2 GHGs by including it in its 2060 neutrality goal



1: NOAA, "Climate Model: Temperature Change (RCP 6.0) – 2006-2100."
2, 3, 4: World Resources Institute, "3 charts explain the most overlooked opportunities to address climate change and poverty." 2018.

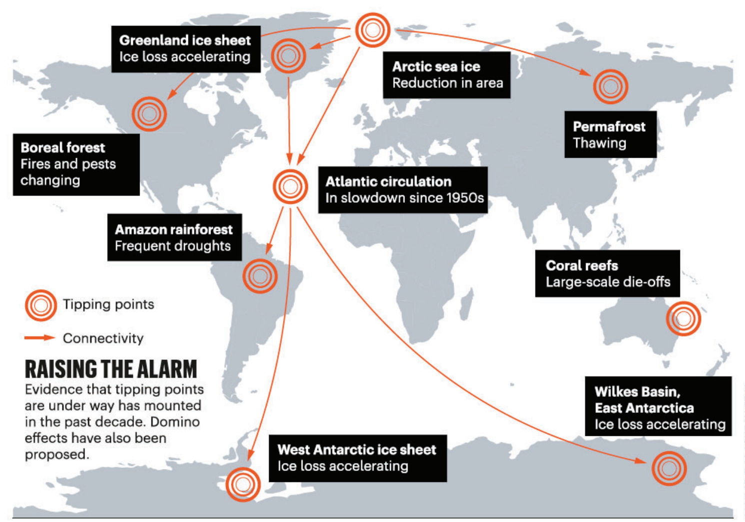


Additional Benefits of SLCP Reduction

Reducing SLCPs slows down self-reinforcing feedbacks and avoids climate tipping points, and provides additional co-benefits* such as:

- Improved air quality and health: 2.4 million avoided deaths globally from outdoor air pollution
- Reduce crop production losses of 50 million tons of crops globally

Figure 2: Climate tipping points



Source: Lenton T. M., Rockstrom J., Gaffney O., Rahmstorf S., Richardson K., Steffen W., & Schellnhuber H. J. (2019) *Climate tipping points—too risky to bet against*, NATURE, Comment, 575(7784):592–595.

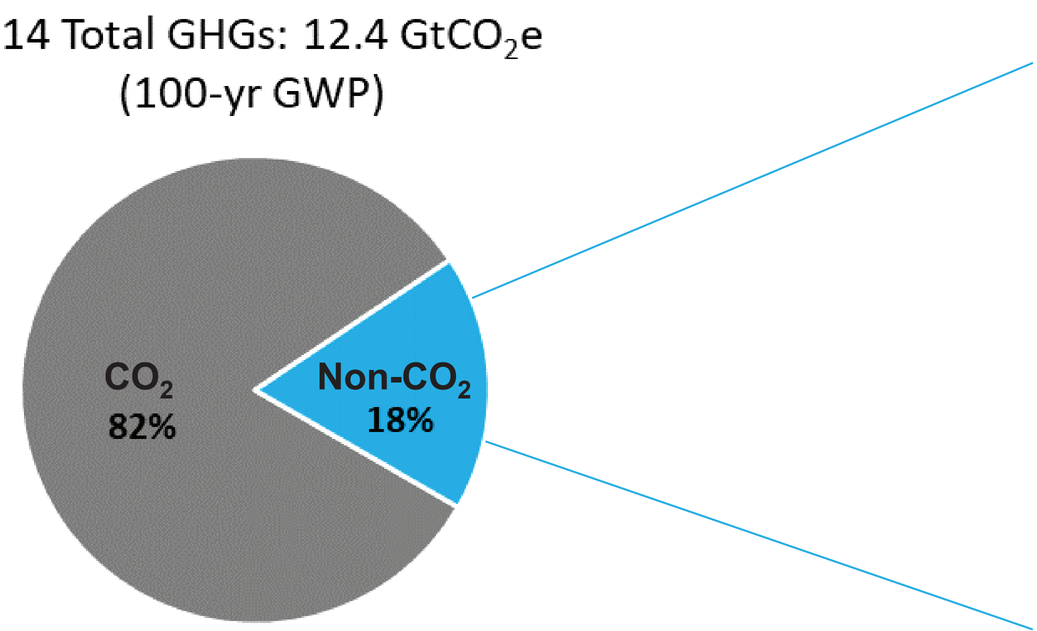
Source: IGSD, 2021, *The Need for Fast Near-term Climate Mitigation to Slow Feedbacks and Tipping Points*.

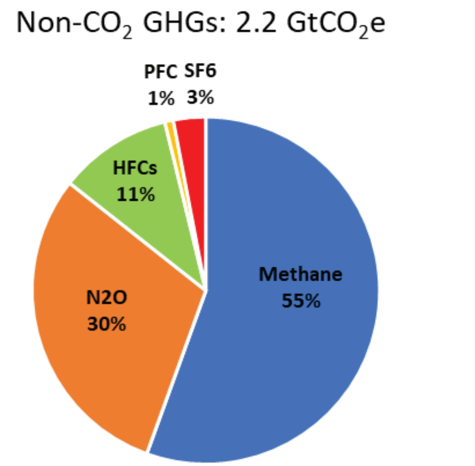
*assumes 90% total potential emissions reductions for black carbon, methane and HFCs can be achieved, from UNEP and WMO analysis.

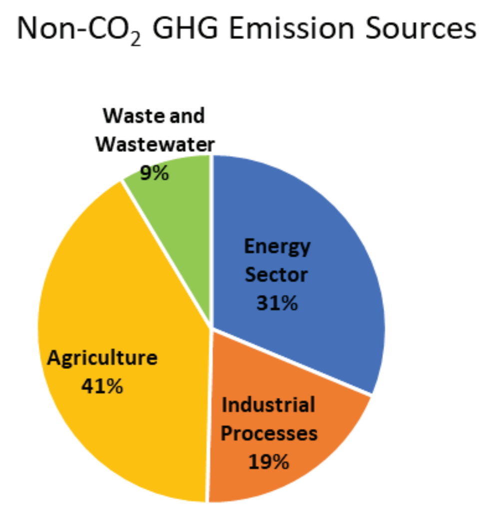
International SLCP Reduction Targets, 2021 (more to come)

	Overarching GHG (including SLCP) Reduction Targets	Methane Reduction Targets	F-Gases Reduction Targets	Black Carbon Reduction Targets
EU	By 2030, reduce net GHG emissions by 55% from 1990 levels (51% from 2005).		By 2030, phase-down F-gas emissions by 67% compared with 2014 levels.	
Canada	By 2030, reduce GHG emissions by 40-45% below 2005 levels (27% from 1990).	By 2025, reduce methane emissions from O&G by 40-45% from 2012 levels	Under Kigali Amendment (ratified), phase-down HFC consumption by 40% in 2024, 70% in 2029, 80% in 2034, and 85% in 2036 from calculated baseline.	
U.S.	By 2030, reduce GHG emissions by 50-52% below 2005 levels (43% from 1990).	By 2025, reduce methane emissions from O&G by 40-45% from 2012 levels	AIM Act requires 85% phase-down in production and consumption of HFC by 2036 from baseline.	
California	By 2030, reduce GHG emissions by 40% below 1990 levels	By 2030, reduce methane by 40% below 2013 levels.	By 2030, reduce F-gas emissions by 40% below 2013 levels.	By 2030, reduce black carbon emissions by 50% below 2013 levels.

Non-CO_2 GHGs accounted for nearly 1/5 of China's total GHGs in 2014







Source: MEE, 2019, *Second Biennial Update on Climate Change*.

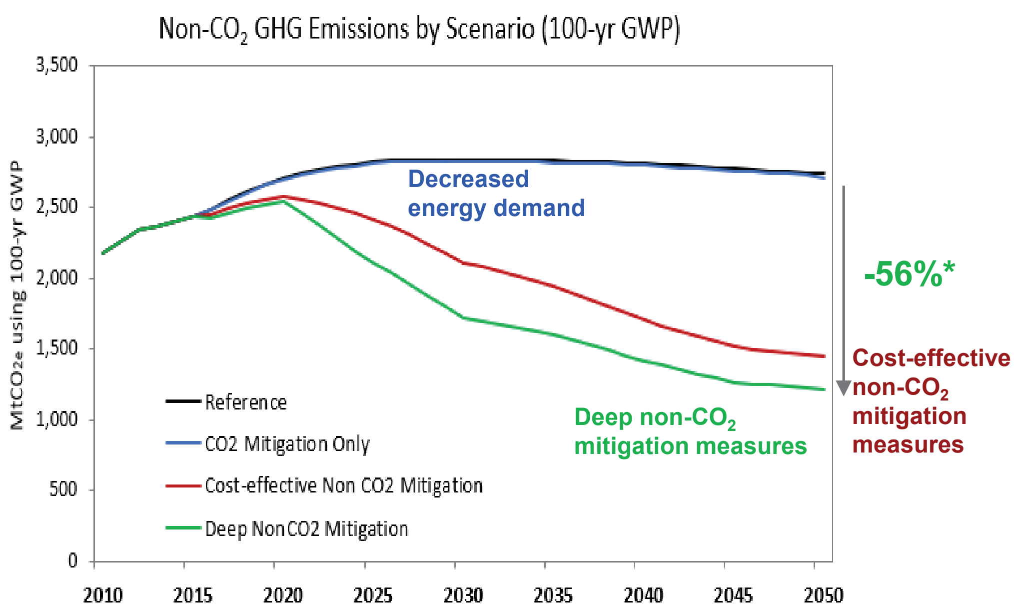
Summary of Greenhouse Gas Scenarios for China Potential Reduction Analysis

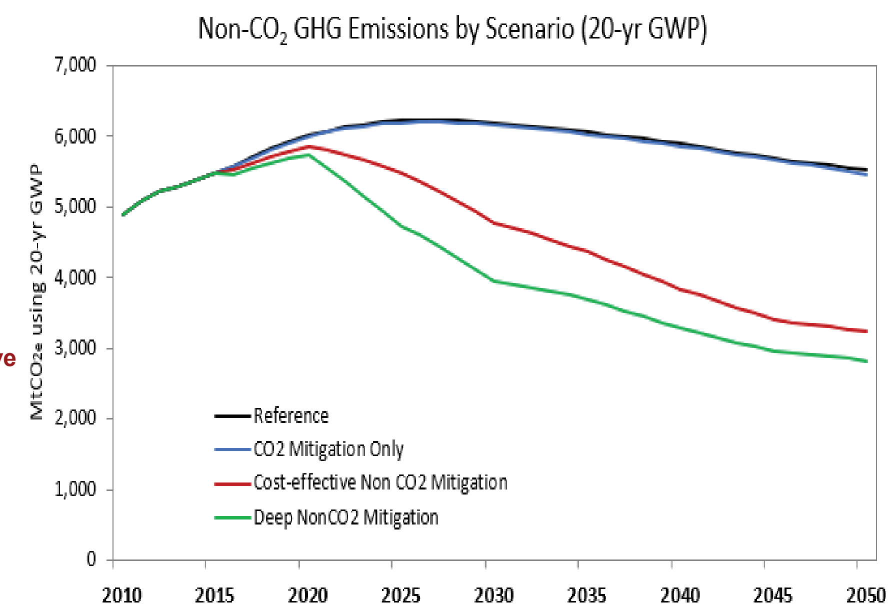
Scenario	Scenario Basis	Sectoral Measures Considered
Reference	A counterfactual baseline scenario that reflects continuous energy efficiency improvement and adoption of cost-effective low carbon technologies to reduce CO_2 emissions in energy sector	Energy sector only, plus HCFC-22 phase out underway under the Montreal Protocol
CO_2 Mitigation Only	A deep CO_2 decarbonization scenario that considers energy-consuming activity reductions, faster and greater adoption of low-carbon fuels (including some in pilot stages) and electrification, to reduce CO_2 emissions in energy sector	Energy sector only
Cost-effective Non-CO_2 Mitigation	Full adoption of key cost-effective (i.e., generally below annualized costs of \$7/tCO_2e reduction) technologies to reduce non-CO_2 emissions by 2050, based on measures evaluated in the cost-effectiveness analysis	Energy sector, plus agriculture, waste, industrial processes [1]
Deep Non-CO_2 Mitigation	Application of additional technically feasible mitigation measures that are generally below \$100/tCO_2e and accelerate the full adoption of all current mitigation measures by 2030	Additional measures in oil industry, wastewater, industrial processes [2]

[1] Measures modeled include methane oxidation and methane recovery from ventilation air in coal mining; green completions; plunger lift systems; leak monitoring and repair; low-bleed, no-bleed, or air pneumatic controllers for natural gas; methane collection, flaring, and recovery of landfill gas for energy use for landfills; humid and intermittent irrigation; improving livestock productivity, manure composting, and reducing nitrogen fertilization in agriculture; thermal oxidation in HCFC-22 production; replacing high-GWP refrigerant with low-GWP refrigerant for room and mobile air conditioners; improved leakage control for commercial air conditioners; commercial and industrial refrigeration; upgrading process control systems in aluminum production and SF_6 recycling; leak detection and repair; equipment refurbishment; and improved SF_6 handling in power systems.

[2] Additional measures modeled include best practices to reduce unintended leakage; recovery and use of vented associated gas for the oil sector; open sewer to aerobic wastewater treatment for wastewater; thermal decomposition and secondary abatement for adipic and nitric acid production, and thermal abatement for semiconductors.

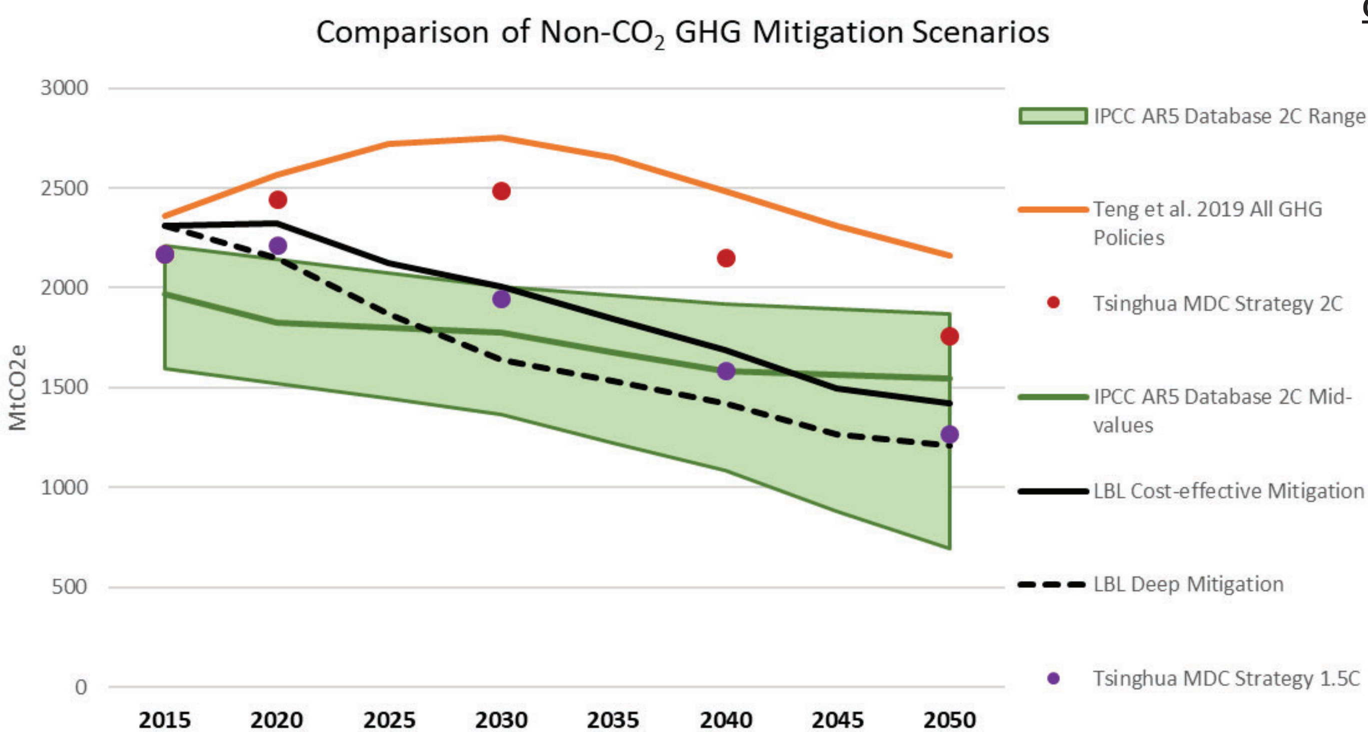
Deep mitigation potential of 56% reduction possible in non-CO2 GHG emissions by 2050; ~35 $GtCO_2e$ cumulative reduction from 2015-50 is possible





*56% reduction potential is comparable to 60% non-CO_2 reduction potential identified for 2050 under a 1.5C scenario by Tsinghua ICCSD

Deeper reductions exist, and can contribute to 2°C-compatible pathway



2015-50 China's Cumulative Non-CO_2 GHG emissions*:

91 $GtCO_2e$

80 $GtCO_2e$

60 $GtCO_2e$

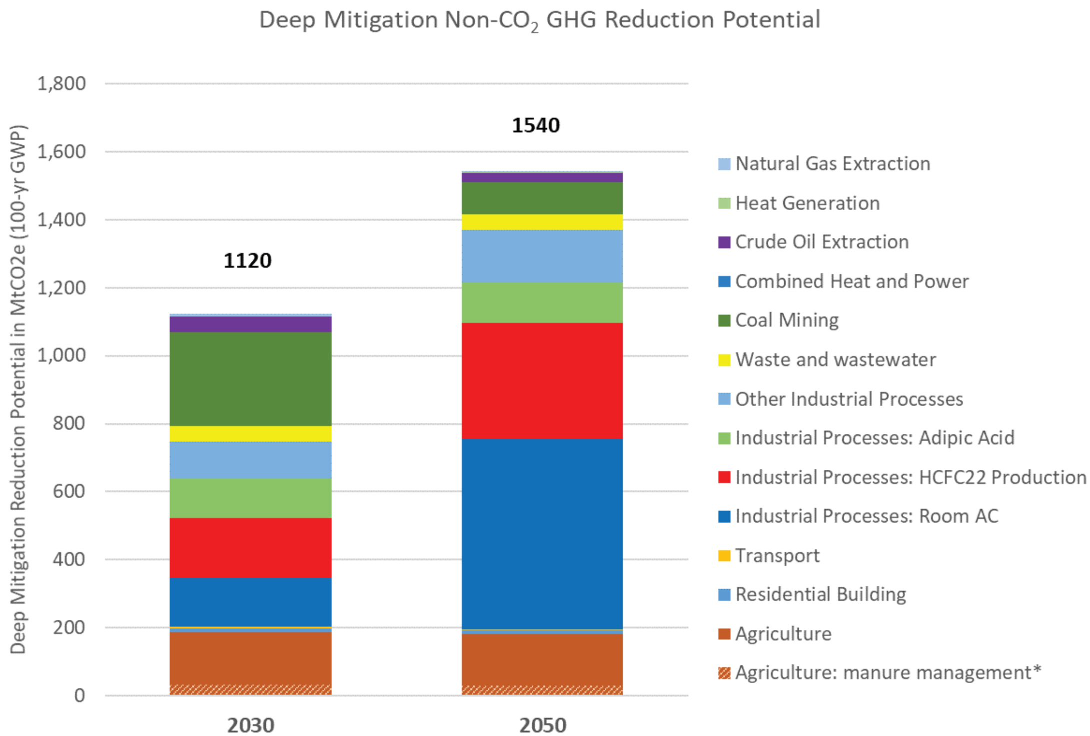
73 $GtCO_2e$

64 $GtCO_2e$

65 $GtCO_2e$

Sources: EPA, 2019, Global Non-CO2 Greenhouse Gas Emission Projections & Mitigation: 2015-2050; Teng F. et al., Environmental Science & Technology, 2019; Monteith and Menon, 2020 and Calvin KV, PL Patel, LE Clarke, GR Asrar, B Bond-Lamberty, R Cui, and A Di Vittorio, K Dorheim, J Edmonds, C Hartin, M Hejazi, R Horowitz, G Iyer, P Kyle, S Kim, R Link, HC McJeon, et al. 2019. "GCAM v5.1: Representing the linkages between energy, water, land, climate, and economic systems." *Geoscientific Model Development* 12, no. 2:677-698. PNNL-SA-137098. doi:10.5194/gmd-12-677-2019; Tsinghua Mid-Century Strategy 2020 analysis. LBL team analysis.
Note: MtCO2e expressed in 100-year GWP values, converted using AR4 GWP values
*Note: where annual values were not available, cumulative non-CO2 GHG emissions from 2015-50 were calculated using linear interpolation between 5-year interval values.

By sector, largest reduction potentials are in HCFC-22 production and room and mobile ACs for F-gases, energy and agriculture for methane, and industrial and agricultural sectors for N_2O



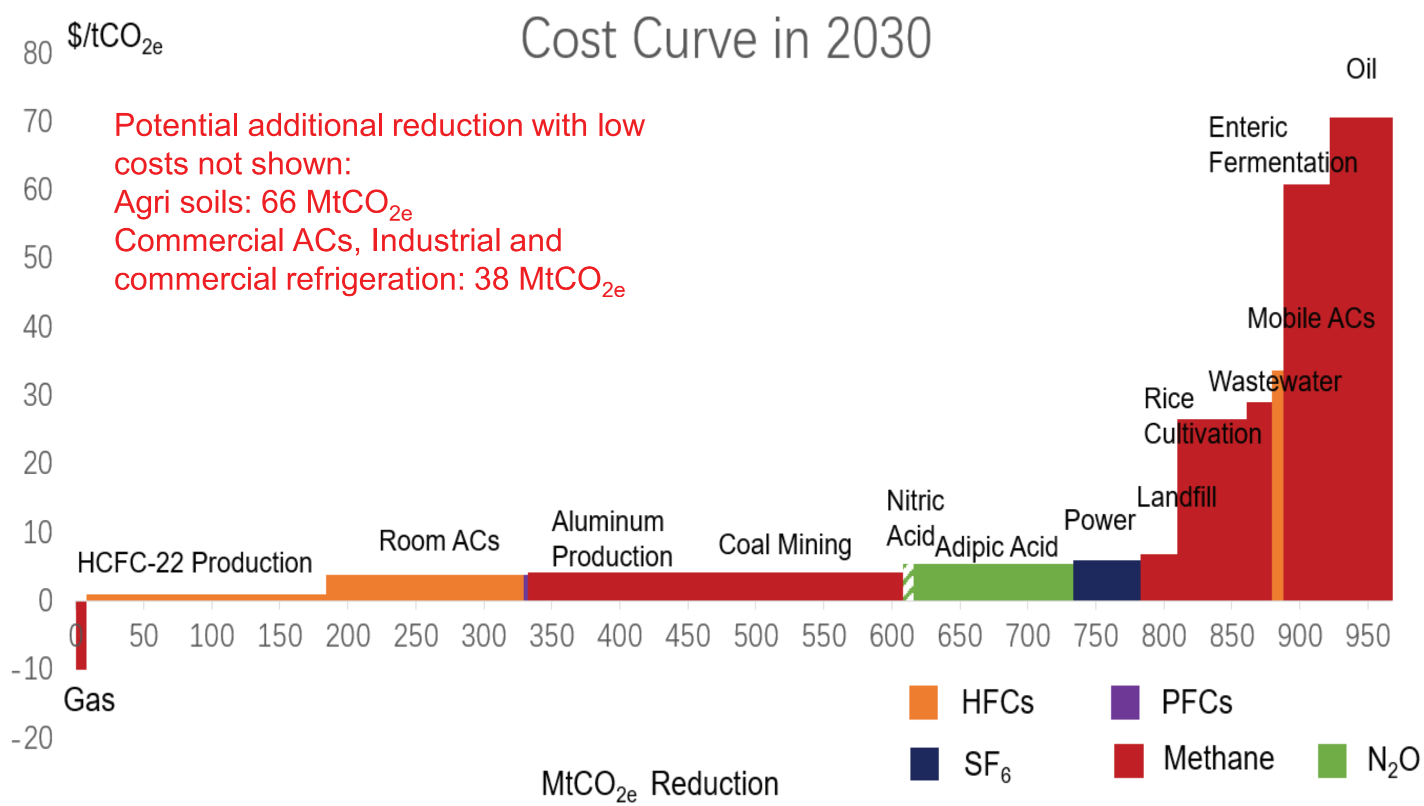
*Note: Manure management in agriculture has highly uncertain abatement costs and are not considered in the reduction potential for possible target-setting.

Tsinghua's 1.5C scenario identified non-CO_2 reduction potential of 1,096 $MtCO_2e$ in 2030.

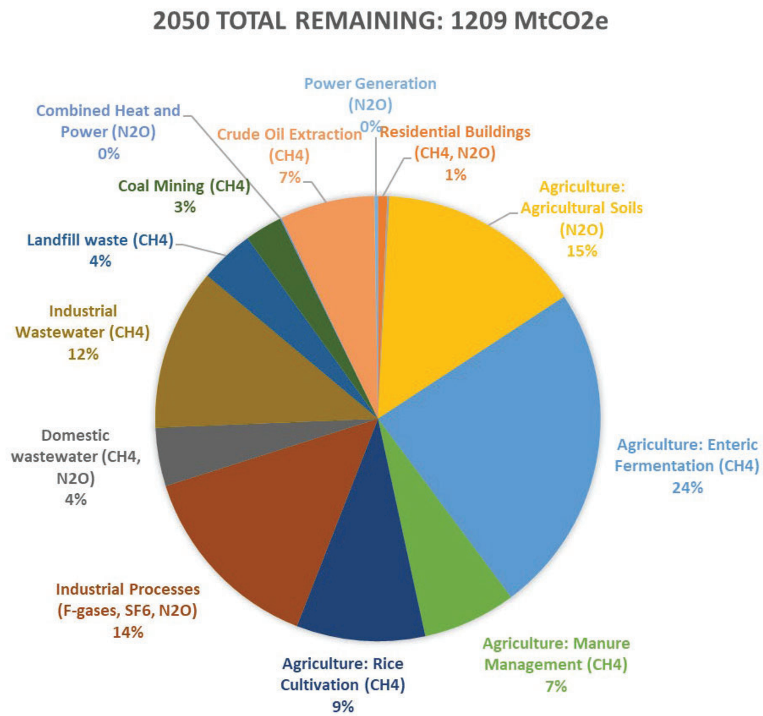
Potential Near-term and 2030 Goals for China Involving Specific Climate Pollutants/Non-CO_2 GHGs (30-40% reduction)

Potential China Goals	2025	2030 (total 1080 $MtCO_2e$)
Methane	Consider adopting Oil and Gas Methane Protocol Coal mines: 25% emissions reduction compared to 2015 levels	35-40% methane emissions reduction compared to 2015 levels across all sectors, including: • Energy: 55% reduction • Agricultural: 20% reduction • Waste: 19% reduction
F-gases	HFC-23: near complete destruction of HFC-23 associated with HCFC-22 production for non-controlled feedstock use to the extent feasible 50% new Room AC units and 90% new mobile AC adopt low-GWP refrigerants Power: 30% SF_6 emissions reduction compared to 2015 levels PFCs: 15% emissions reduction compared to 2015 levels	30% emissions reduction compared to 2015 levels across all HFCs (excluding HFC-23), including: • Room and mobile ACs: 50% reduction • Commercial ACs and Refrigeration, Industrial Refrigeration: 30% reduction Power: 58% SF_6 emissions reduction
N_2O	Agricultural: 10% emissions reduction (fertilizer usage) compared to 2015 levels Industrial: adopt cost-effective reduction measures as practically feasible	40% emissions reduction compared to 2015 levels, including: • Industrial: 94% reduction • Agricultural: 22% reduction
Black carbon	Consideration of the following measures: • Residential heating: expand clean heating as much as technically and economically feasible	Consideration of the following measures: • New standards for off-road diesel vehicles • Accelerate retirement of small capacity coal boilers

About 970 $MtCO_2e$ of non-CO_2 emissions could be reduced in 2030 at an average abatement cost of \$10/tCO_2e



Methane accounts for 65% of remaining emissions in 2050 under Deep Reduction scenario, followed by N_2O with 22% share



Note: Tsinghua ICCSD identified 1271 $MtCO_2e$ remaining non-CO_2 GHGs in 2050 in their 1.5C scenario.

Conclusions and Near-term Policy Implications

- Largest potential: the industrial sector (F-gases and N_2O)
  - Possible Early action (low mitigation costs)
  - A well-established multilateral policy framework: Montreal Protocol and the Kigali Amendment
  - Complementary policies (simultaneous improvement in energy efficiency can further reduce costs)
- Addressing methane in coal mining, oil and gas, and waste sector
  - Good timing to join/harmonize with international oil and gas methane protocols
  - Significant potential in coal mining sector, with large safety co-benefits
  - Global policies moving from voluntary practices to regulated standards

Conclusions and Policy Implications

- Methane is the largest remaining non-CO_2 GHG in 2050
- Addressing methane and N_2O in the agricultural sector
  - Highly decentralized and require the participation of millions of farmers
  - Consider yields and material inputs
  - Need robust institutional mechanisms to disseminate cost-effective mitigation options while promoting behavioral changes to traditional farming practices
  - Limited international experiences
- Potential new technologies (e.g., plant-based protein) and behavioral change such as dietary trends also needed to reach climate neutrality
- Significant uncertainties due to lack of local data, thus need to strengthen MRV system, with help from remote sensing technologies

Thank you!

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Lawrence Berkeley National Laboratory
http://china.lbl.gov

Jiang Lin
J_lin@lbl.gov
+1-510-495-8886