Non-CO_2 Mitigation Pathway for China: Preliminary Results

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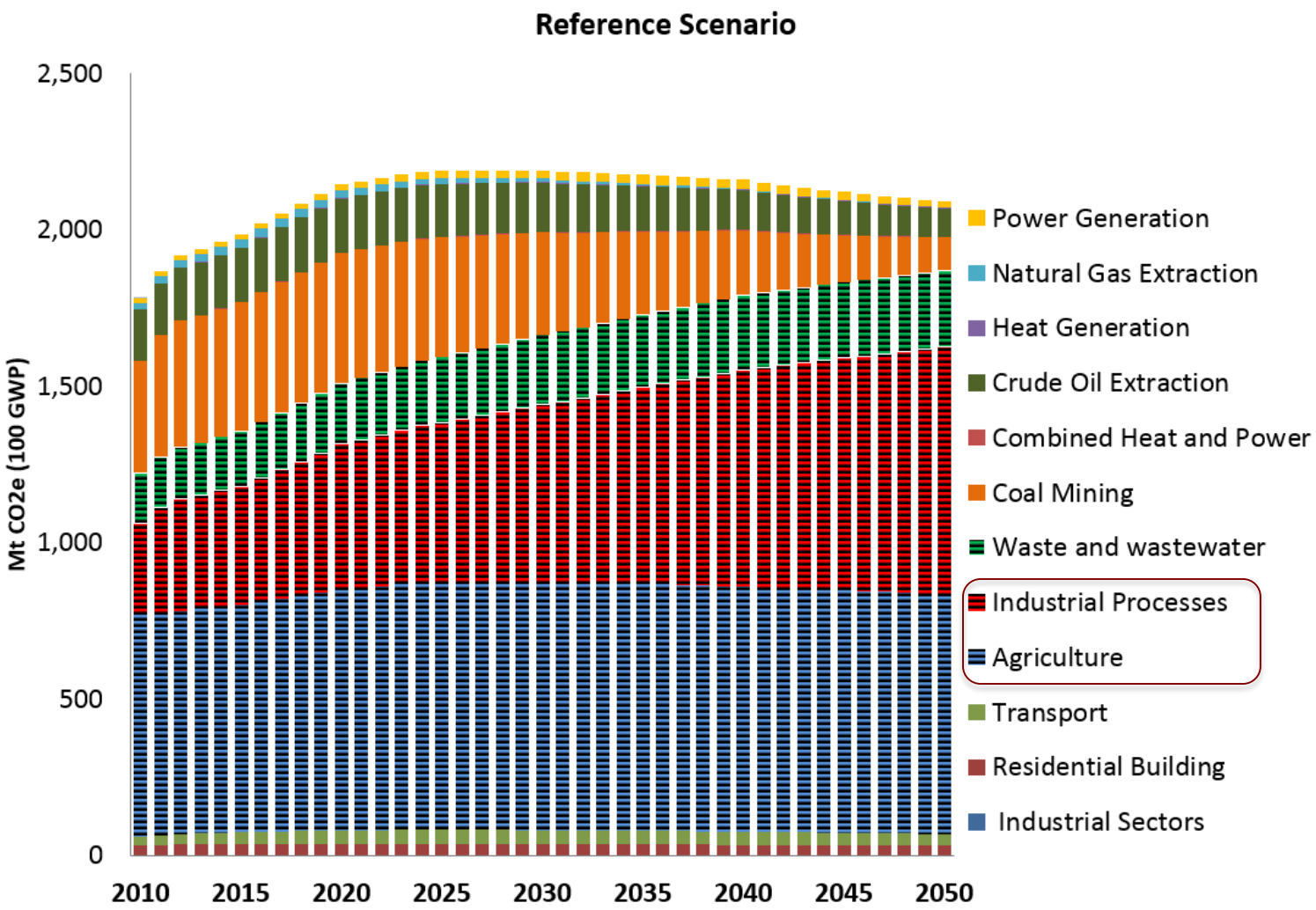
Modeling Study Overview

- **China 2050 DREAM has been under development for 10 years**
- **Two major, full economy 2050 reports have been issued using the model:**
  - 2010-2011 study – one of earliest modeling studies to show a peak and plateau in China's energy and CO_2 emissions at that time
  - Reinventing Fire: China – informed China's 13th FYP, INDCs, US-China negotiations running up to US-China Joint Announcement on Climate Change and the Paris Agreement
- **China 2050 DREAM also used for more specific policy assessments, including:**
  - Evaluation of sectoral policies in buildings, transport and power sectors
  - Evaluation of alternative energy sources, water-energy nexus
- **We added non-energy sector and non-CO_2 greenhouse gases (GHGs) into China 2050 DREAM for our analysis**

Scenario Analysis

- **Reference:** business-as-usual energy and emissions pathway in which only current policies continue to have impact and autonomous technological improvement occurs
- **CO_2 Mitigation:** considers lowered energy demand and CO_2 emissions due to full adoption of cost-effective efficiency and fuel switching by 2050; updated from Reinventing Fire: China study
- **CO_2 Plus Non-CO_2 Mitigation:** considers adoption of additional cost-effective non-CO_2 mitigation measures, with accelerated adoption after 2020

Non-energy sectors, particularly industrial processes and agriculture, are the largest drivers of future non-CO_2 GHGs

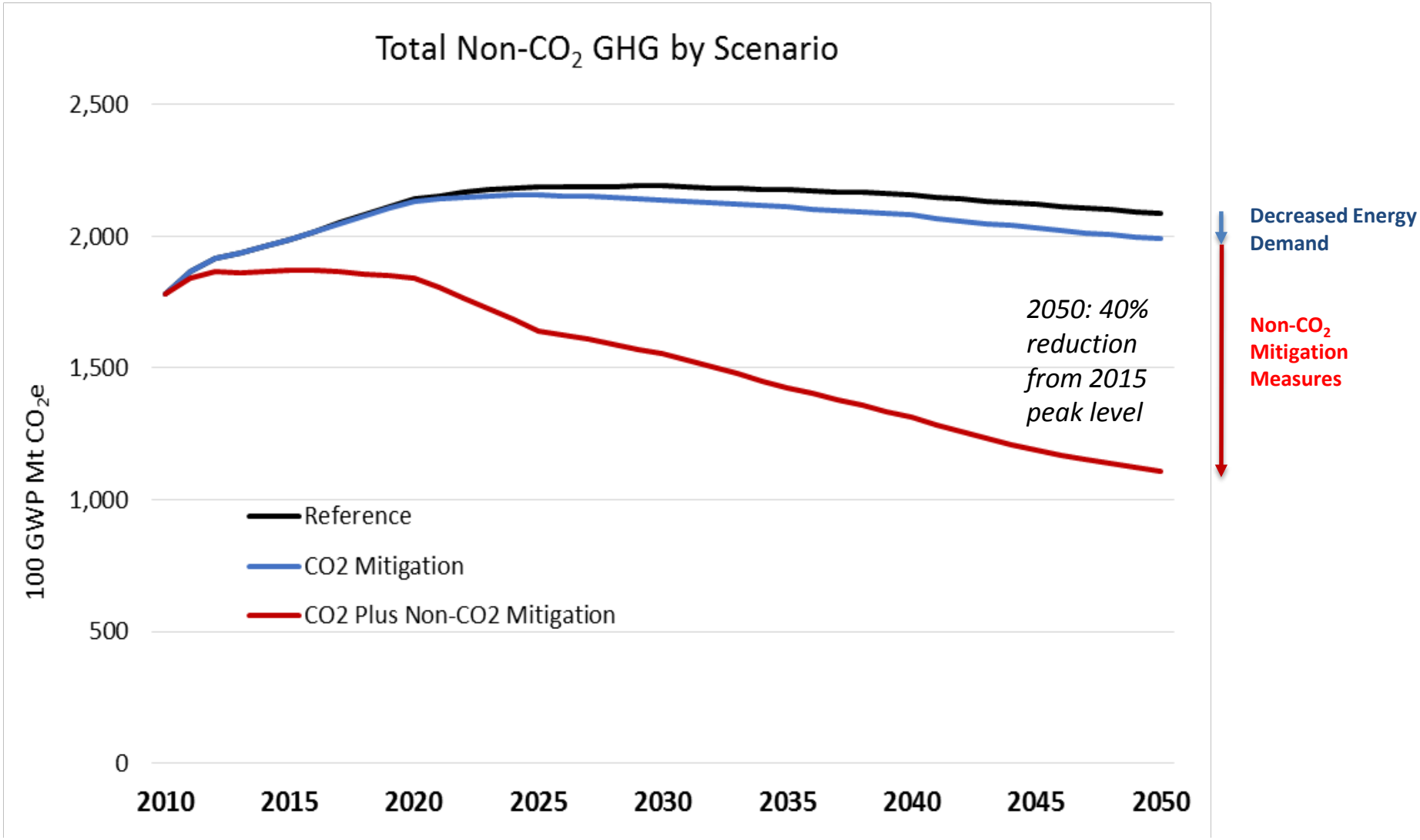


Summary of Preliminary Mitigation Scenario

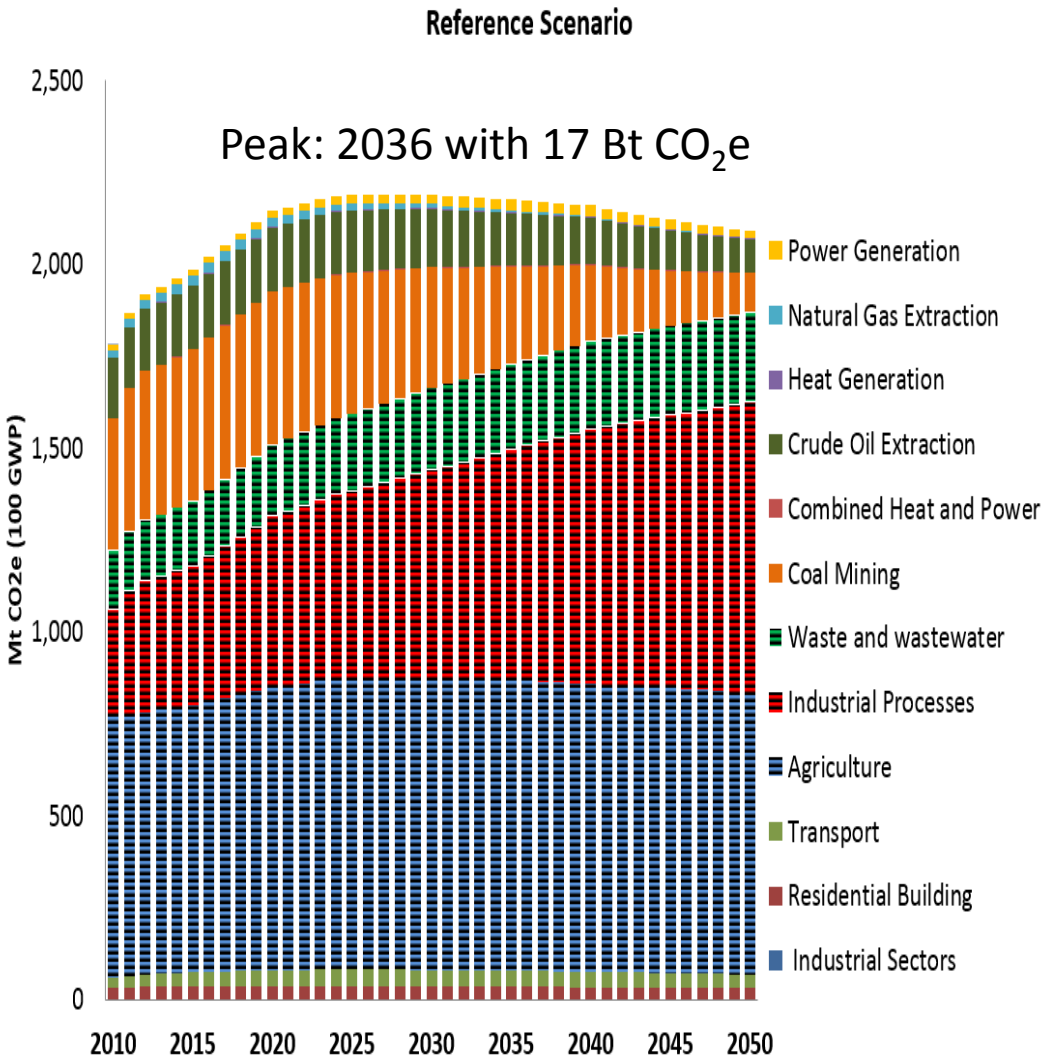
Quantified cost-effective non-CO_2 mitigation measures for:

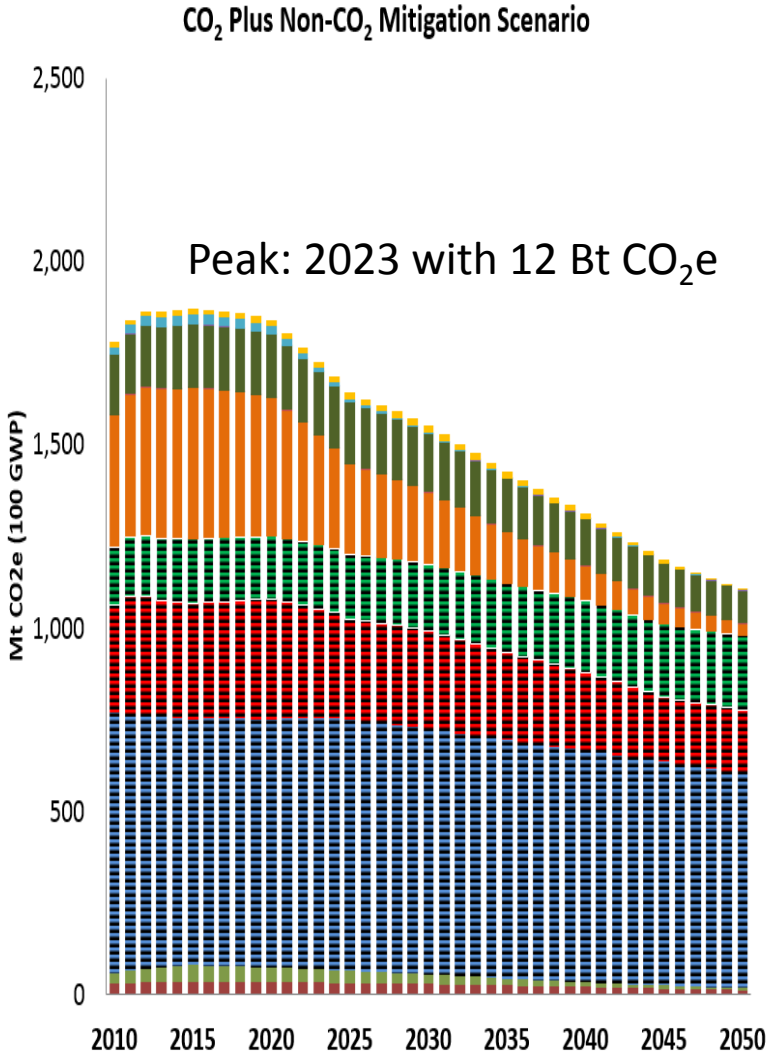
- Methane (CH4):
  - **Energy-related:** Coal Mining, Natural Gas Extraction and T&D
  - **Waste:** Landfill Waste
  - **Agriculture:** Rice Cultivation, Livestock Enteric Fermentation, Manure Management
- Nitrous Oxide (N2O):
  - **Agriculture:** Crop Management/Fertilizer
- HFCs: Mobile and Room ACs, HCFC-22 Production
- PFCs: Aluminum Production
- SF6: Power Generation

Non-CO_2 GHGs expected to decline rapidly after 2020, but could grow after full saturation of cost-effective mitigation measures in 2030

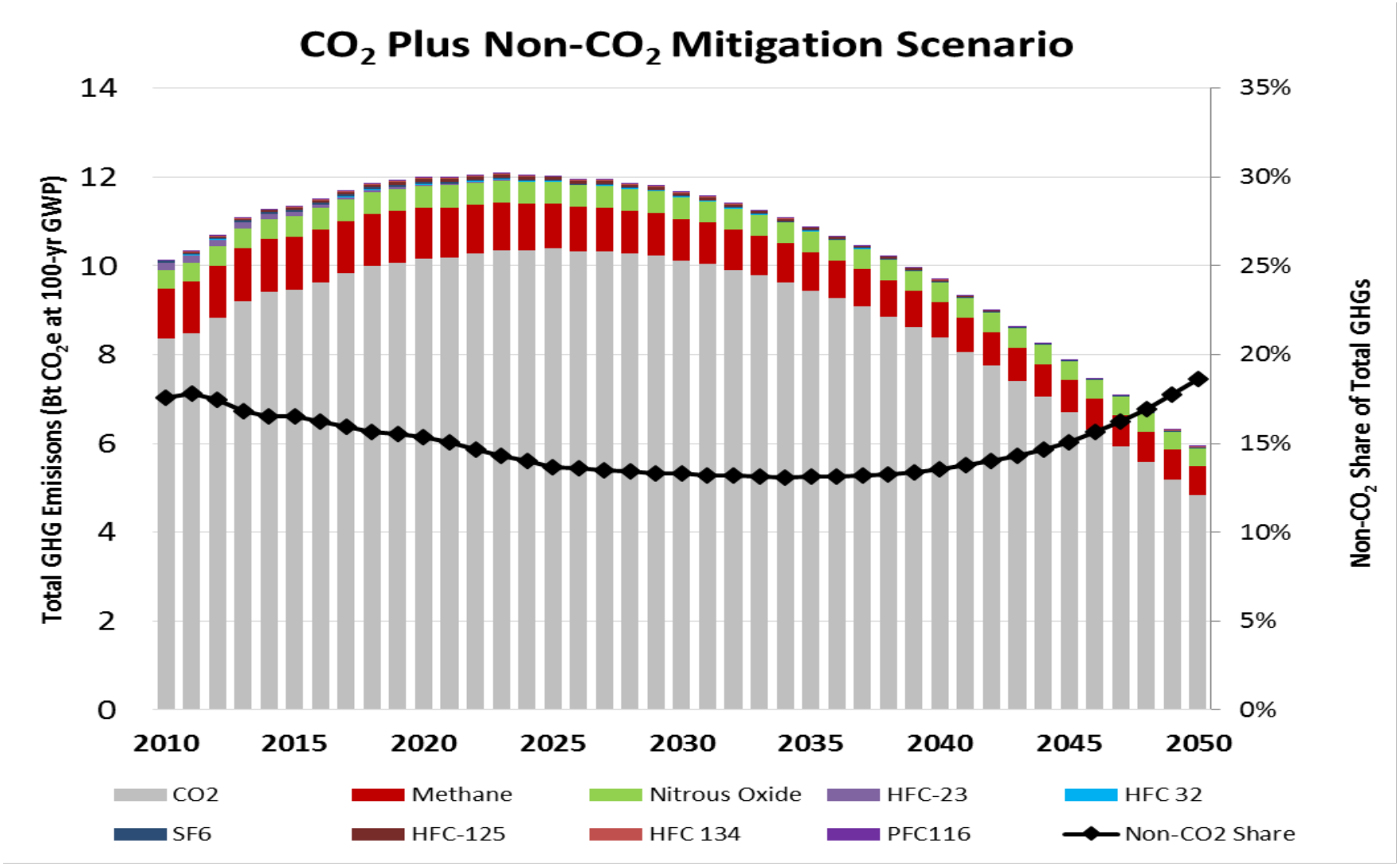


Cost-effective CO_2 and non-CO_2 mitigation measures will help China's total GHG emissions peak 13 years earlier



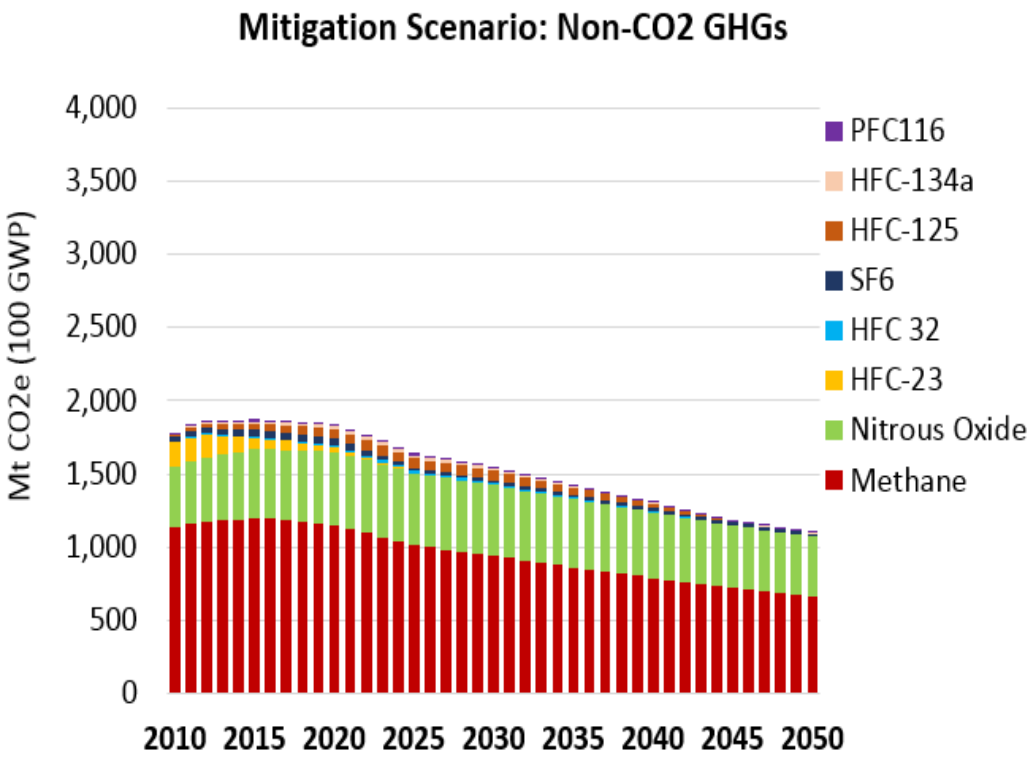


Non-CO_2 share of total GHGs increases slightly from 17% in 2010 to 19% in 2050, with CH_4 and N_2O as the largest gases



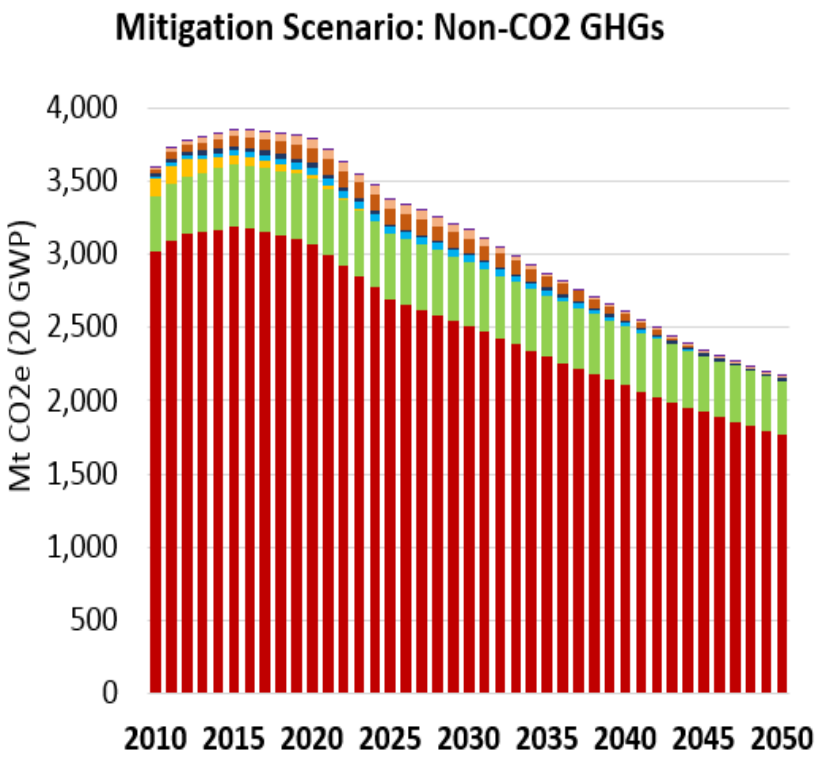
Methane and N_2O dominate non-CO_2 GHG emissions

100 GWP



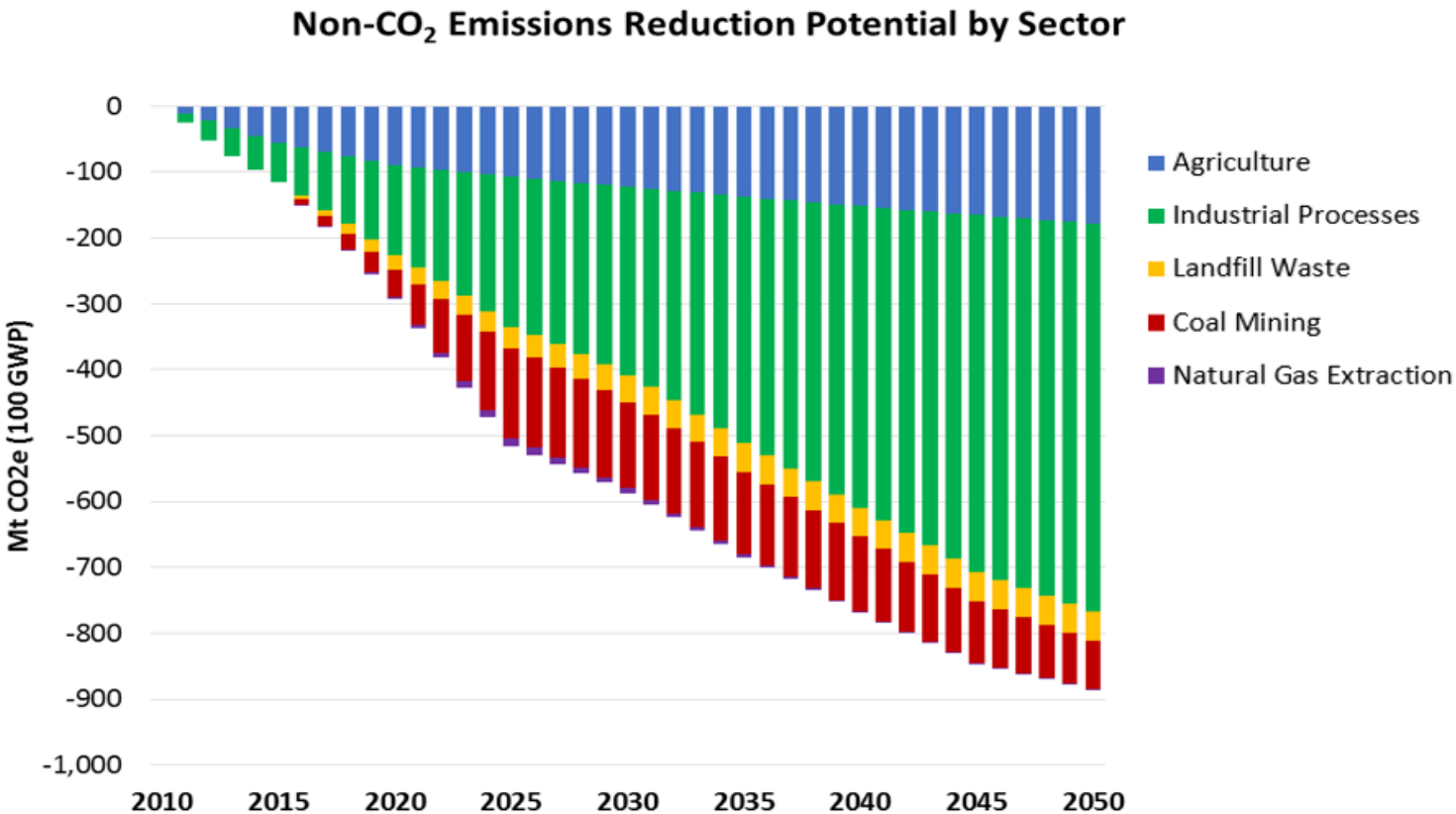
Non-CO_2 share of total GHGs: 17% in 2010 to 19% in 2050

20 GWP



Non-CO_2 share of total GHG: 30% in 2010 to 31% in 2050

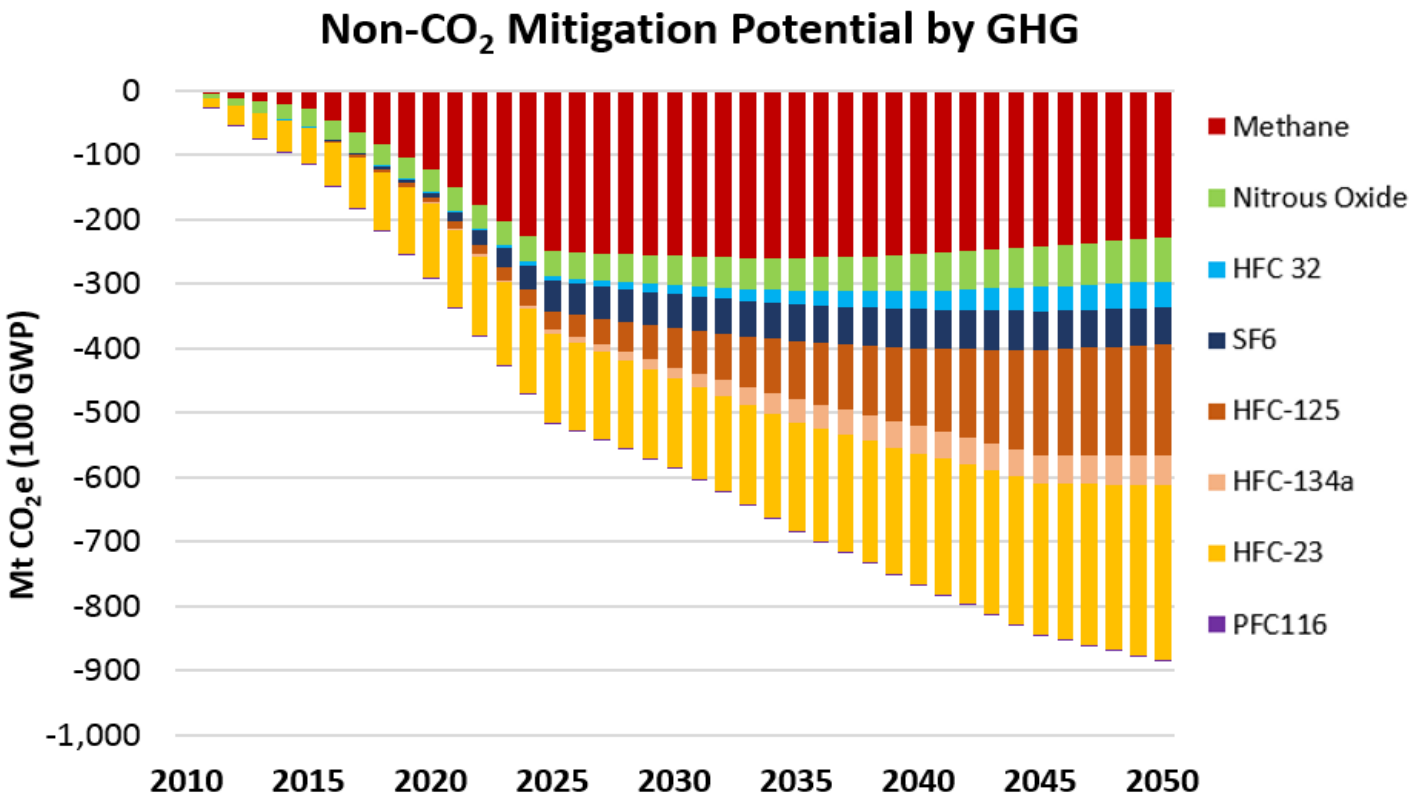
By sector, industrial processes hold largest mitigation potential, followed by agriculture and coal mining



Mitigation Reduction % of Total Emissions

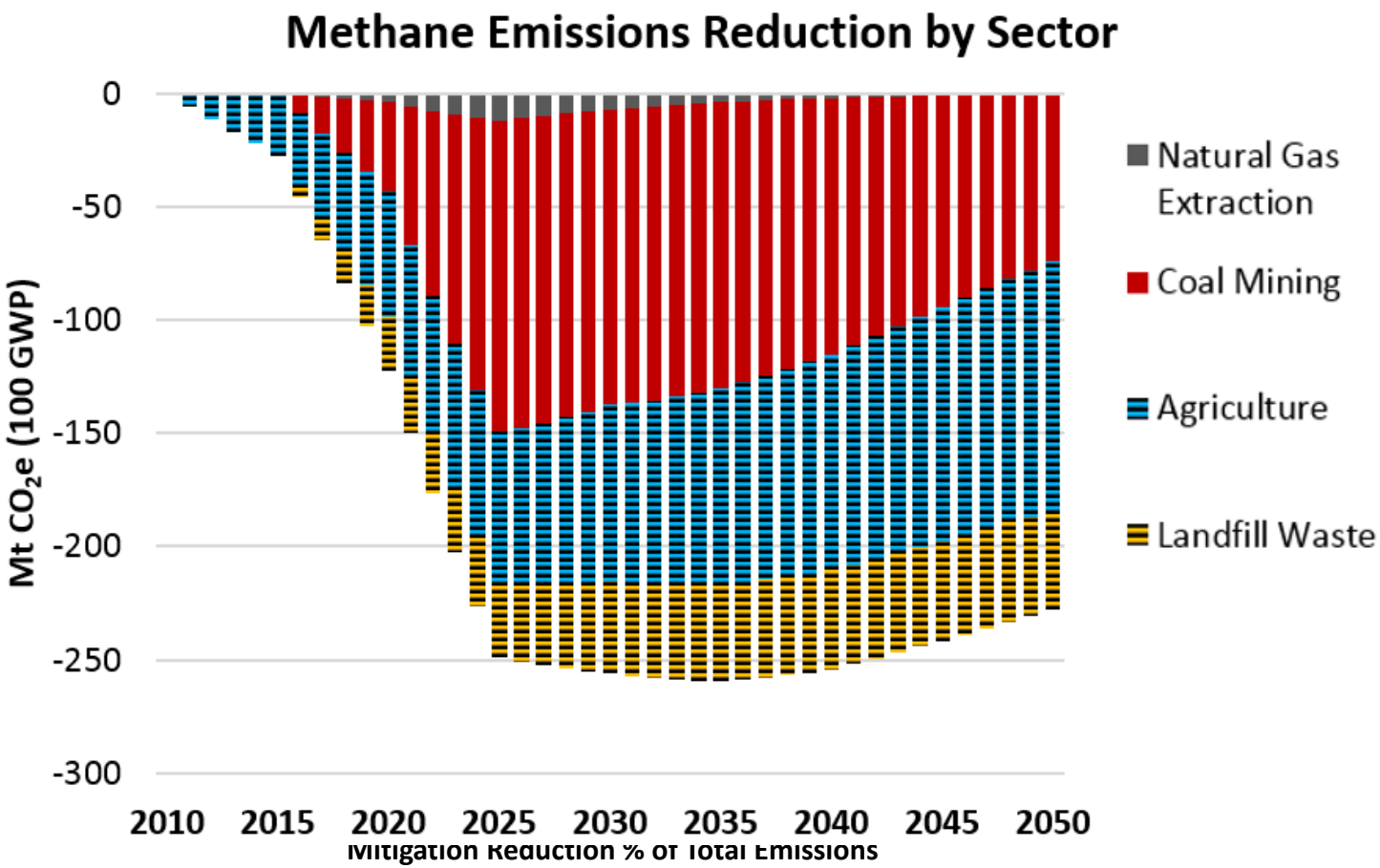
	2020	2030	2040	2050
Non Energy: Agriculture	-12%	-16%	-19%	-23%
Non Energy: All Industrial Processes	-29%	-52%	-68%	-77%
Non Energy: Waste and wastewater	-12%	-18%	-18%	-18%
Coal Mining	-10%	-40%	-55%	-70%
Natural Gas Extraction	-13%	-66%	-66%	-66%

Largest non-CO_2 mitigation potential exists for methane for most years, followed by HFC-23 reduction



	2020	2030	2040	2050
Methane	-10%	-21%	-24%	-26%
Nitrous Oxide	-6%	-9%	-11%	-14%
HFC-23	-80%	-100%	-100%	-100%
HFC 32	-10%	-50%	-80%	-100%
SF6	-14%	-72%	-72%	-72%
HFC-125	-10%	-50%	-80%	-100%
HFC 134	-4%	-45%	-91%	-91%
PFC116	-15%	-15%	-14%	-14%

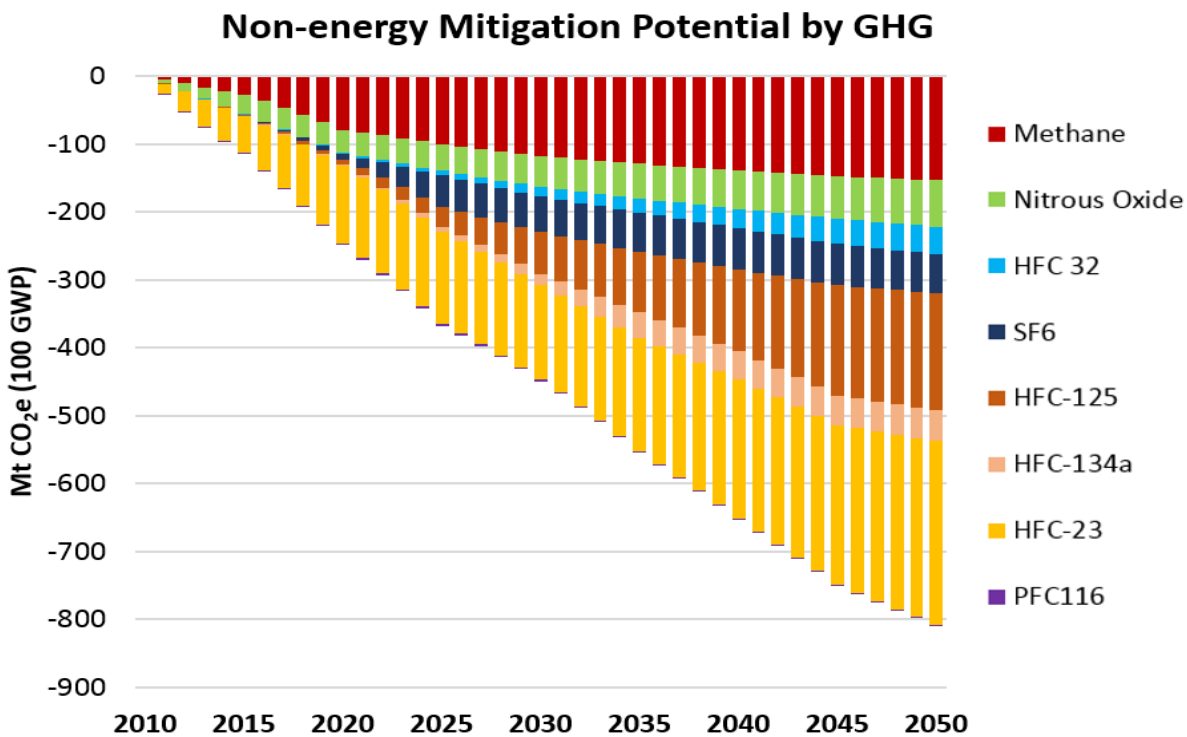
Largest methane mitigation potential is in coal mining and agriculture



Mitigation Reduction % of Total Emissions

	2020	2030	2040	2050
Natural Gas Extraction	-13%	-66%	-66%	-66%
Coal Mining	-10%	-40%	-55%	-70%
Non Energy: Agriculture	-12%	-16%	-20%	-24%
Non Energy: Waste and wastewater	-13%	-20%	-20%	-19%

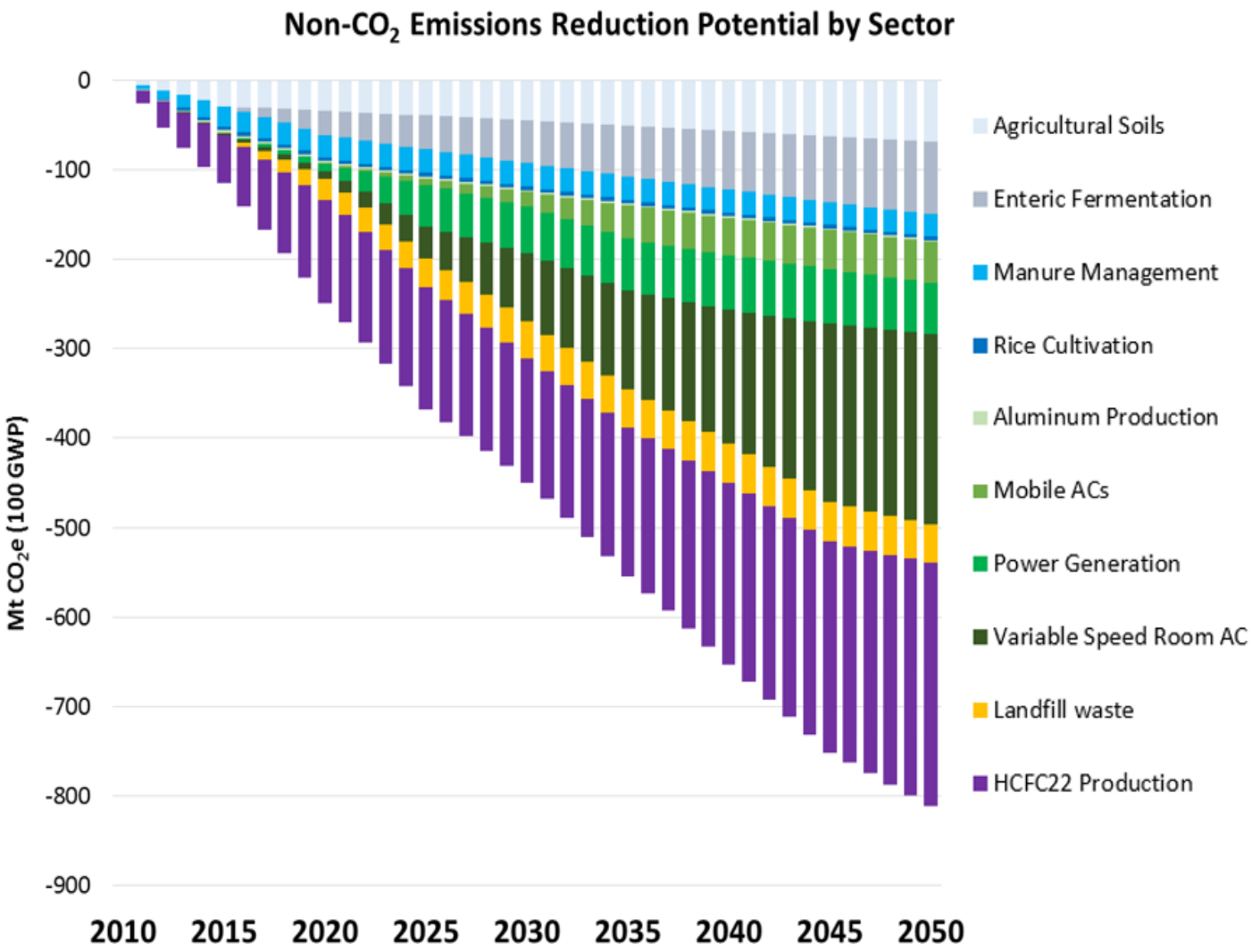
Largest non-energy mitigation potential is also in methane and HFC-23



Mitigation Reduction % of Total Emissions

	2020	2030	2040	2050
Methane	-12%	-17%	-20%	-22%
Nitrous Oxide	-7%	-10%	-12%	-15%
HFC-23	-80%	-100%	-100%	-100%
HFC 32	-10%	-50%	-80%	-100%
SF6	-14%	-72%	-72%	-72%
HFC-125	-10%	-50%	-80%	-100%
HFC 134	-4%	-45%	-91%	-91%
PFC116	-15%	-15%	-14%	-14%

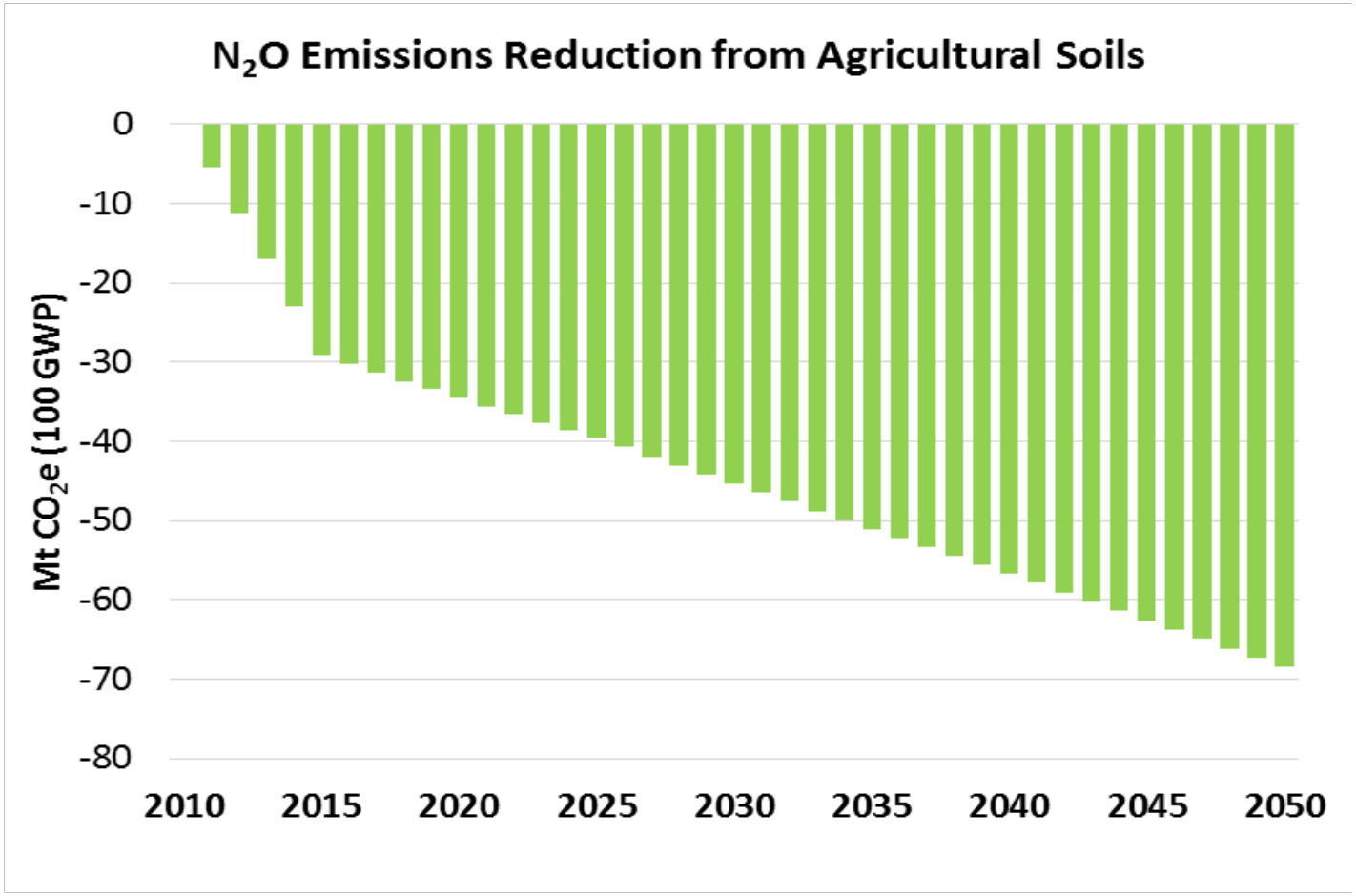
Largest non-energy non-CO_2 mitigation reduction potential is in industrial processes, especially in thermal oxidation during HCFC 22 production



Mitigation Reduction % of Total Emissions

2020	2030	2040	2050
-13%	-17%	-22%	-27%
-10%	-17%	-23%	-30%
-24%	-24%	-24%	-24%
-3%	-3%	-3%	-3%
-15%	-15%	-15%	-15%
-4%	-45%	-91%	-91%
-14%	-72%	-72%	-72%
-10%	-50%	-80%	-100%
-39%	-63%	-67%	-71%
-80%	-100%	-100%	-100%

N_2O mitigation potential in agricultural soils is from reduced fertilizer application and increased fertilizer use efficiency



Mitigation Reduction % of Total Emissions

	2020	2030	2040	2050
Agriculture: Agricultural Soils	-13%	-17%	-22%	-27%

Conclusions and Policy Implications

- A 40% cost-effective mitigation potential for non-CO_2 GHGs by 2050.
- Largest potential: the industrial sector
  - a well-established policy framework: Montreal Protocol and the Kigali Amendment
  - Co-control or complementary policies
- Methane in coal mining and waste sector
  - Involves participation from diverse stakeholders and large numbers of companies
  - Policies evolve from voluntary practices to regulated standards
  - China to develop pilots

Conclusions and Policy Implications

- Methane and N_2O the agricultural sector
  - Highly decentralized
  - 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
  - Need more research

Research Summary

- Calibrated historical emissions with Tsinghua collaborators twice, updated to reflect latest 2012 GHG inventory data
- Met with multiple sectoral experts in Beijing on mitigation measures

Outreach and Policymaker Engagement

- Presented initial results at the 3rd Sino-U.S. Energy and Environment Summit (supported through the U.S.-China EcoPartnerships program) in Changsha on Dec. 4-5, 2017
- Shared technical summary report with experts, currently undergoing review
- Initial discussion with NCSC on collaboration on non-CO2 research
- Tsinghua collaborators already part of MCS team led by NCSC

Next Steps

- In-depth cost-effectiveness assessment for non-CO2 mitigation measures specifically for China
- Assess additional non-CO_2 mitigation measures and mitigation potential for China
- Incorporate non-conventional gas extraction and evaluate mitigation potential
- Develop policy recommendations and strategies for non-CO_2 mitigation in China in collaboration with Chinese stakeholders

Acknowledgments

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Thank You!

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Overview of China 2050 DREAM Model

History

- Developed by CEG in 2005, and continually updated and refined based on our long-term collaboration with Chinese partners

Motivation and Purpose

- Few global energy models of energy demand by end-use
- China needs a model with end-use detail to plan and evaluate energy efficiency policies, programs and targets for:
  - *Short-term:* 2015, 2020 energy and CO_2 intensity reduction targets
  - *Long-term strategic planning:* 2050 development pathways

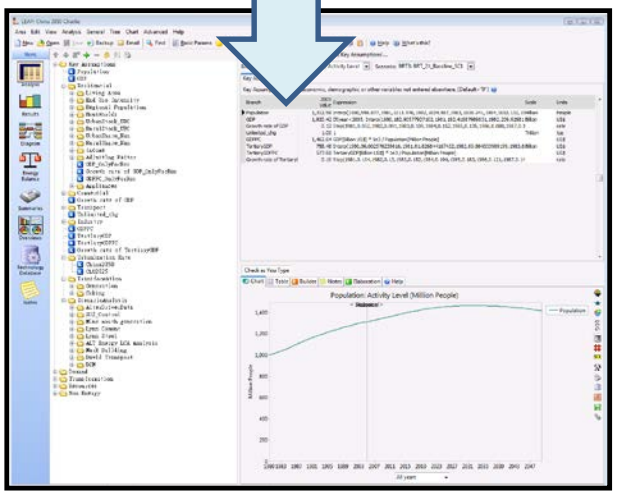
Strengths

- Bottom-up model of energy demand by end-use captures:
  - Stock turnover models
  - Potential for efficiency improvement by technology
  - Energy, CO_2 and SO_2 emissions impacts of efficiency programs and technology trends
- Energy intensity reduction potential disaggregated by:
  - End use sector
  - Saturation, usage
  - Technology size/scale

Model capabilities

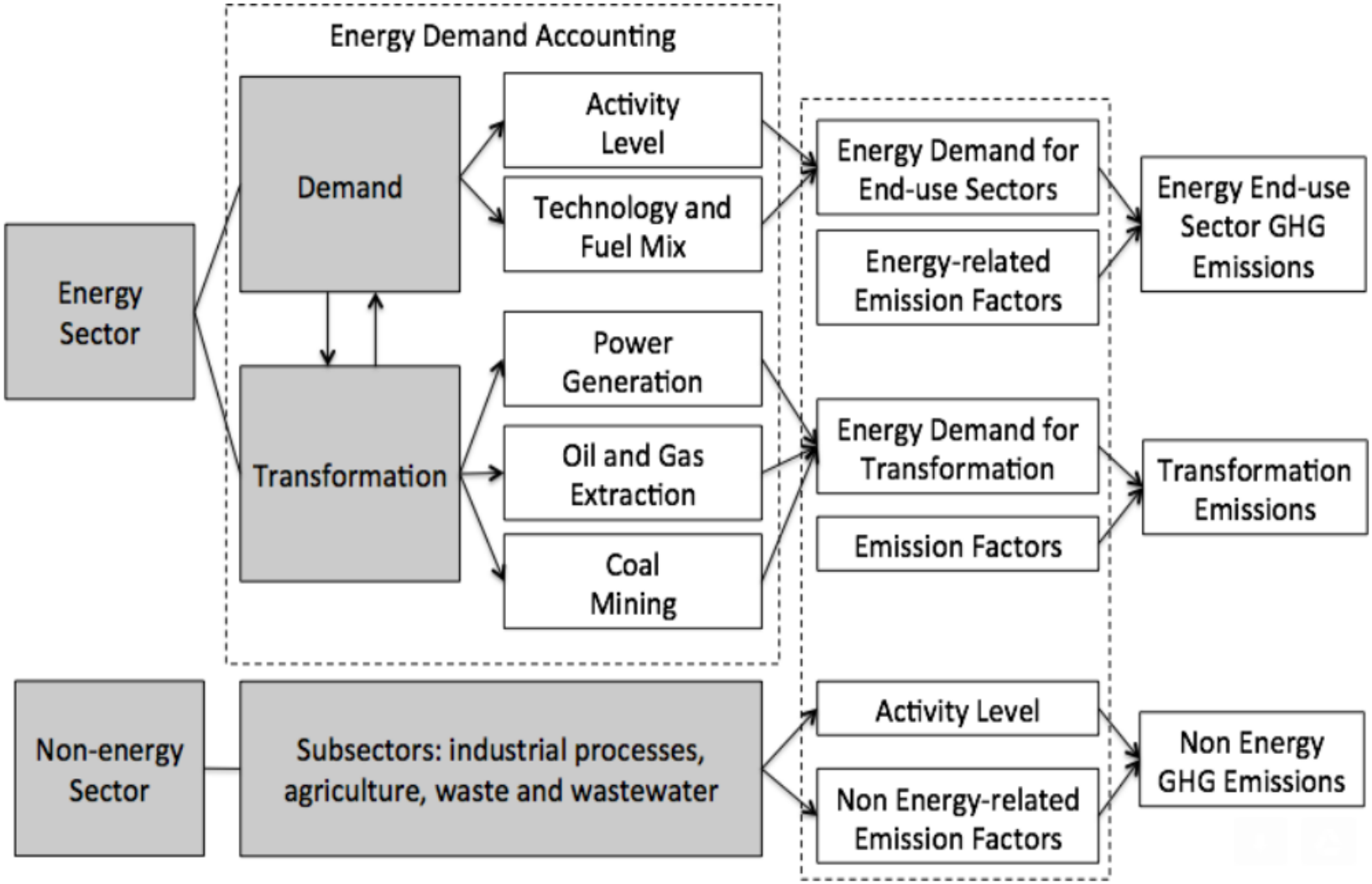
- **Macroeconomic and physical drivers determine energy demand outlook for:**
  - Residential buildings: urban and rural households by 3 climate zones, 5 vintage
  - Commercial buildings: 6 different building types by 3 climate zones, 5 vintages
  - Industry: 12 energy-intensive industries and 18 light industries
  - Transport: 17 passenger and freight transport modes
- **Energy transformation modules provide energy supply to meet demand:**
  - Power generation module with customizable dispatch order
  - Detailed modules to simulate energy consumed by energy conversion industries, e.g., coal mining, natural gas extraction, oil refining and extraction
  - Resource constraints modeled with coal, oil, gas supply curves
  - Fossil fuel resource quality modeled with Energy Return on Energy Investment (EROEI)
- **Non-energy Sector with non-energy activity and non-CO_2 emissions**
  - Agriculture
  - Industrial Processes
  - Waste and wastewater

Inputs
Macroeconomic data, demand drivers, technologies, scenarios



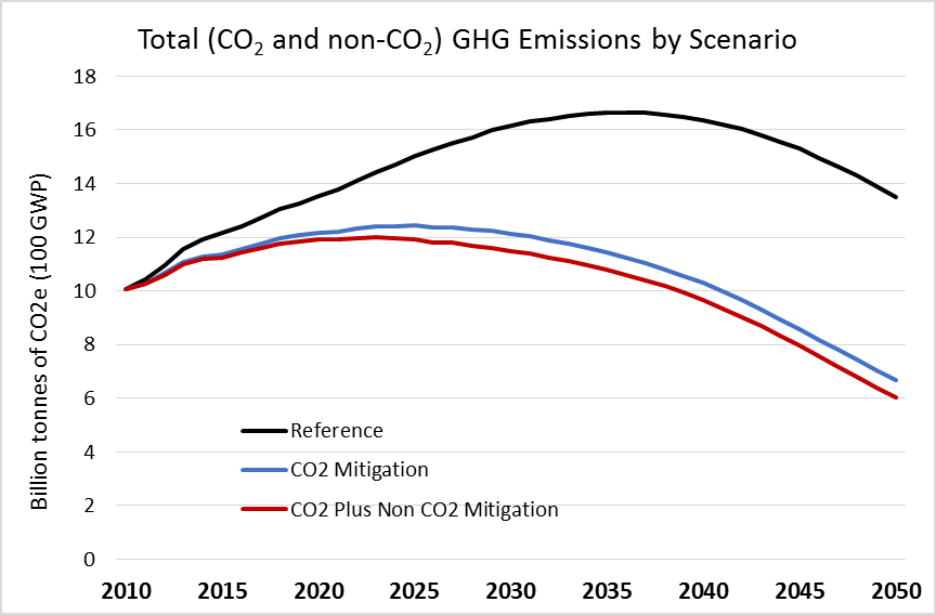
Outputs
Primary and final energy, emissions, savings potential

Model Structure and Framework

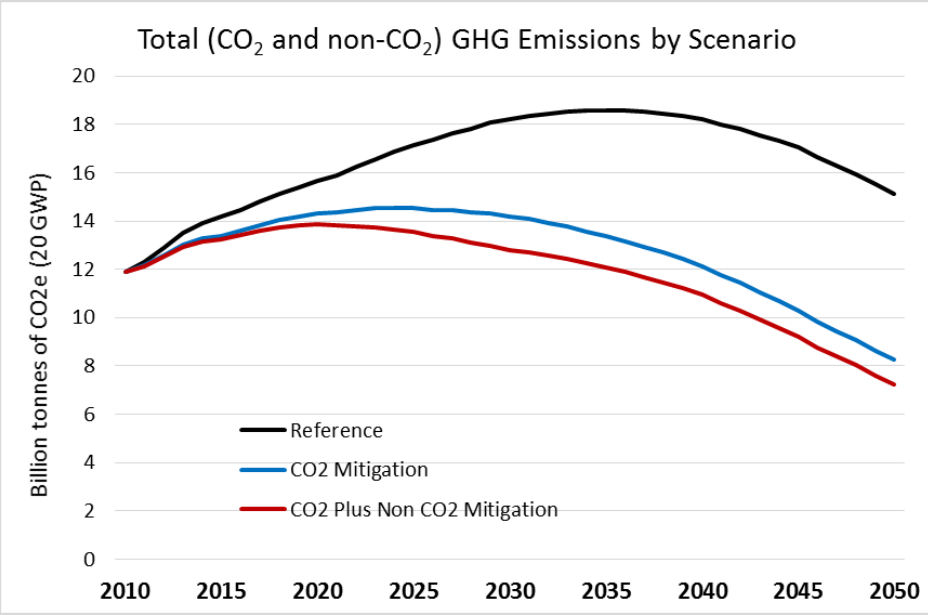


Non-CO_2 mitigation measures can reduce further reduce total GHGs, resulting in earlier total GHG peak

100 GWP



20 GWP



Sources of industrial processes non-CO_2 GHGs

- HFCs sources:
  - HFC-23: byproduct of HCFC-22 production, used in very low temperature refrigeration, blend in fire suppression, plasma etching and cleaning in semi-conductor production
  - HCFC-22: consumption for both feedstock (expected to grow continuously, used as feedstock in other HFCs production and polymers, Teflon, etc.) and non-feedstock (which is phased out under Montreal Protocol) uses
  - HFC-25: 50% blend by weight of R410a for variable-speed room ACs
  - HFC-132: 50% blend by weight of R410a for variable-speed room Acs
  - HFC-134a: HFC refrigerant for mobile ACs, blend component, propellant in inhalers and aerosols and foam blowing agent
- PFCs sources:
  - PFC116: byproduct of primary aluminum production
  - PFC116: used in plasma etching and cleaning in semi-conductor production
- SF6 source
  - Insulator in electric power equipment
- N2O source
  - Nitric acid: production of fertilizers, explosives, plastics, dyes