BERKELEY LAB

LAWRENCE BERKELEY NATIONAL LABORATORY

U.S. DEPARTMENT OF ENERGY

National Efforts on Energy Efficiency

2022 International Scorecard Symposium Virtual

Nan Zhou , Senior Scientist

Leader, China Energy Group

Energy Technologies Area

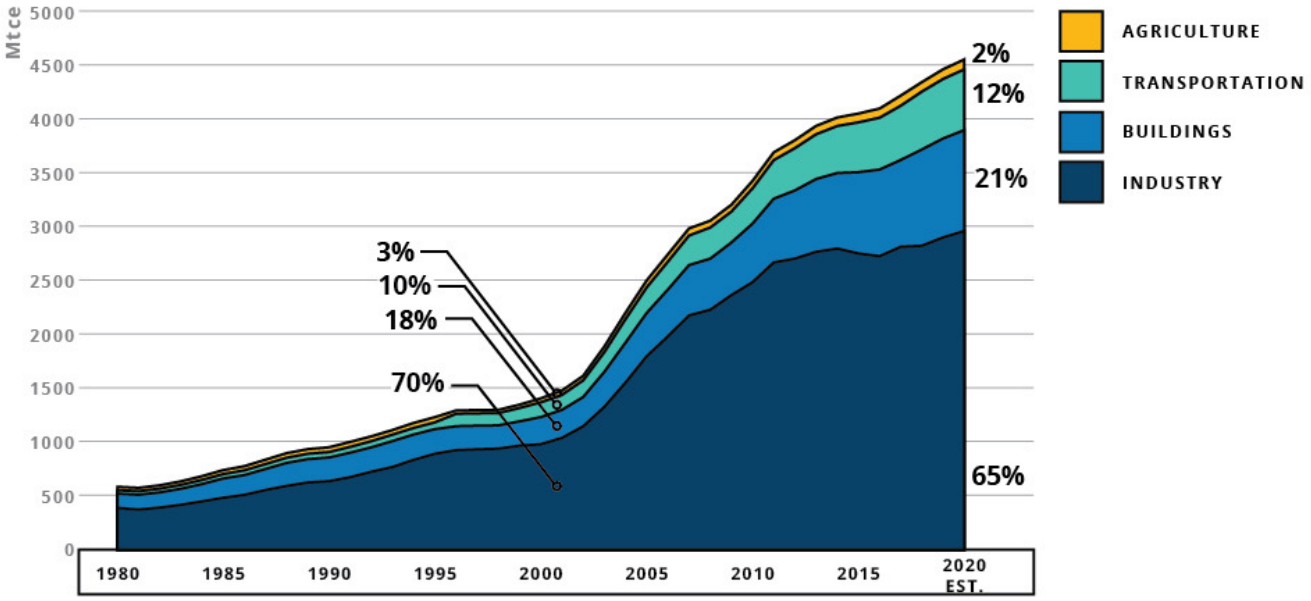
Lawrence Berkeley National Laboratory

April 6, 2022

China's Primary Energy Consumption

	Energy Use Growth Rate
2000	4%
2001	5%
2002	9%
2003	17%
2004	17%
2005	14%
2006	10%
2007	9%
2008	2%
2009	5%
2010	7%
2011	8%
2012	3%
2013	3%
2014	2%
2015	1%
2016	1%
2017	3%
2018	3%
2019	3%
2020	2%

China's Primary Energy Consumption by End-Use Sector (1980-2020)



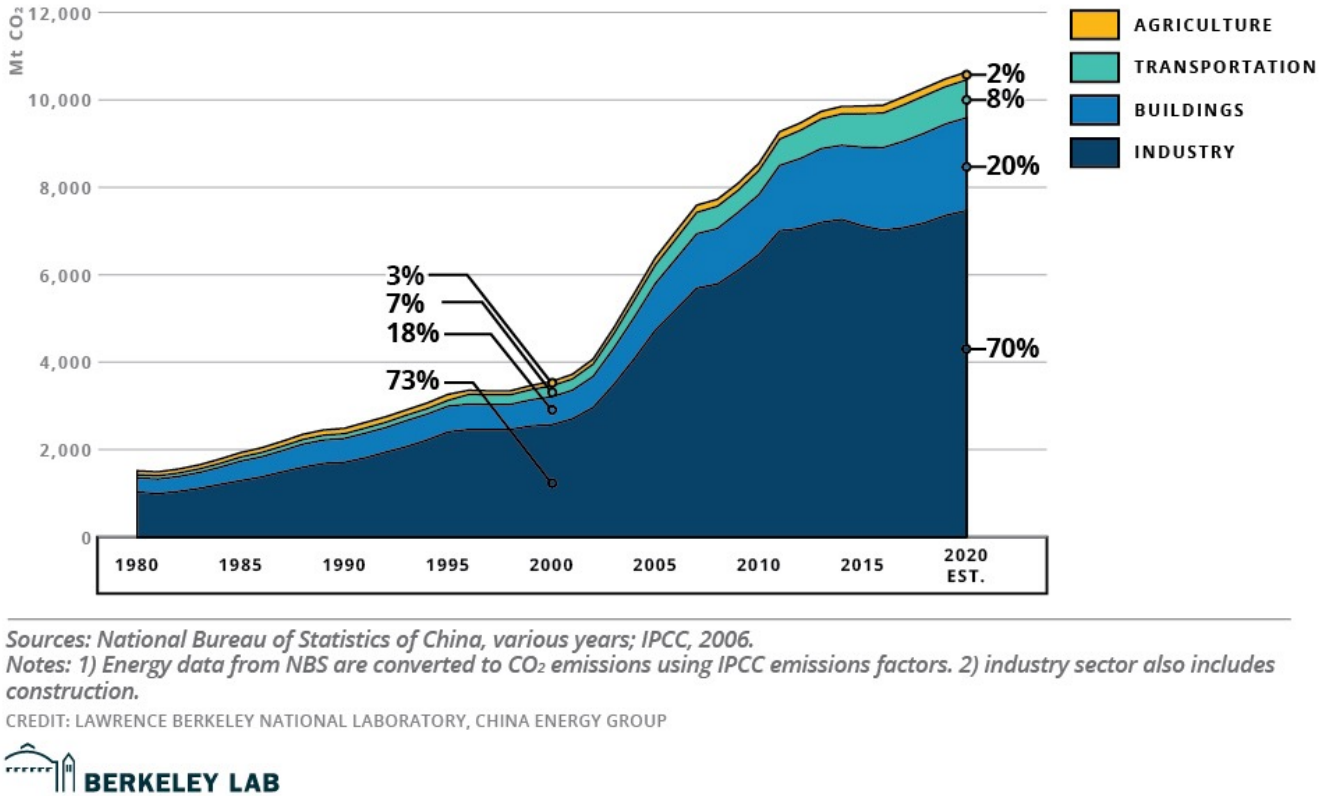
Source: National Bureau of Statistics of China, various years.
Notes: 1) Industry also includes construction sector; 2) primary electricity is converted using the Direct Equivalent Method; 3) 2020 data are estimated based on 2019 sectoral shares.

CREDIT: LAWRENCE BERKELEY NATIONAL LABORATORY, CHINA ENERGY GROUP

BERKELEY LAB

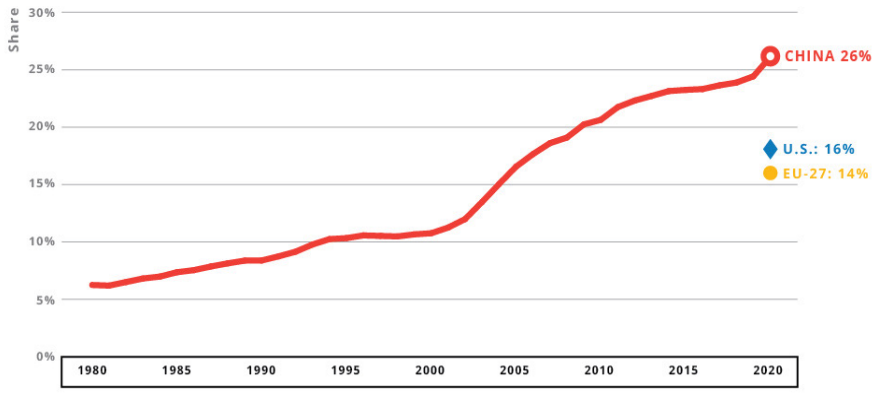
China's Energy-Related CO_2 Emissions

	CO_2 Emissions Growth Rate
2000	3%
2001	5%
2002	9%
2003	18%
2004	17%
2005	14%
2006	10%
2007	9%
2008	2%
2009	5%
2010	6%
2011	8%
2012	2%
2013	3%
2014	1%
2015	0%
2016	0%
2017	2%
2018	2%
2019	2%
2020	1%



China's increasing role in global energy use and CO_2 emissions

Global Share of China's Primary Energy Use (1980-2020)

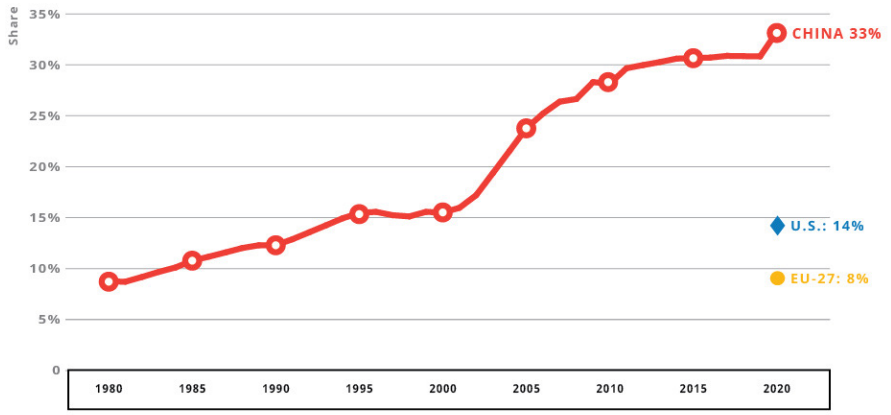


Source: BP, 2021.
Note: According to BP's Statistical Review of World Energy (2021), a time-dependent thermal equivalent method was used to convert primary energy of non-fossil based electricity to standardized energy units. Specifically, between 1965-2000, a constant efficiency of 36% was assumed; between 2000 and 2017, a linear increase from 36% to 40% was assumed; and 2018 onwards, assuming efficiency increases to 45% by 2050.

CREDIT: LAWRENCE BERKELEY NATIONAL LABORATORY, CHINA ENERGY GROUP

BERKELEY LAB

Global Share of China's Energy-Related CO_2 Emissions (1980-2020)



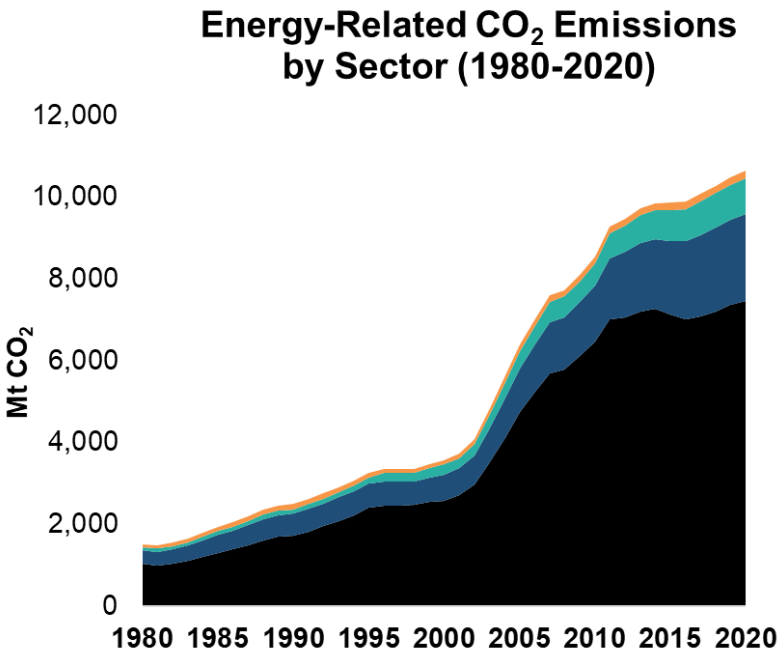
Sources: National Bureau of Statistics of China, various years; IPCC, 2006; International Energy Agency, 2021d.
Note: Energy data from NBS are converted to CO_2 emissions using IPCC emissions factors (IPCC, 2006).

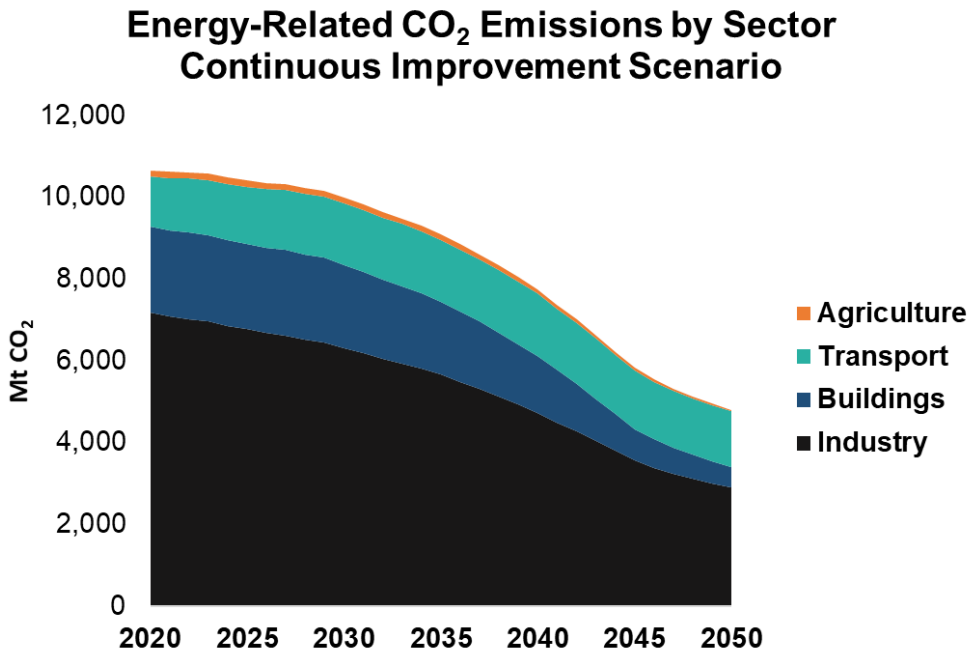
CREDIT: LAWRENCE BERKELEY NATIONAL LABORATORY, CHINA ENERGY GROUP

BERKELEY LAB

China Energy Outlook 2022
Continuous Improvement Scenario

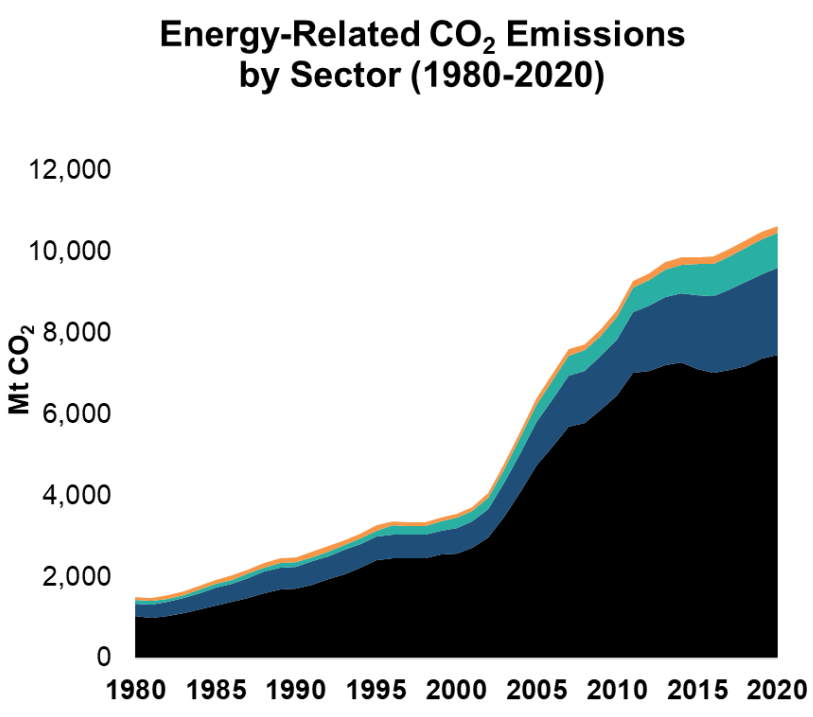
- By adopting today's commercially available, cost-effective technologies, CO_2 emissions can be reduced by 55% from 2020 to 2050; industry and transport sectors remain challenging to decarbonize.

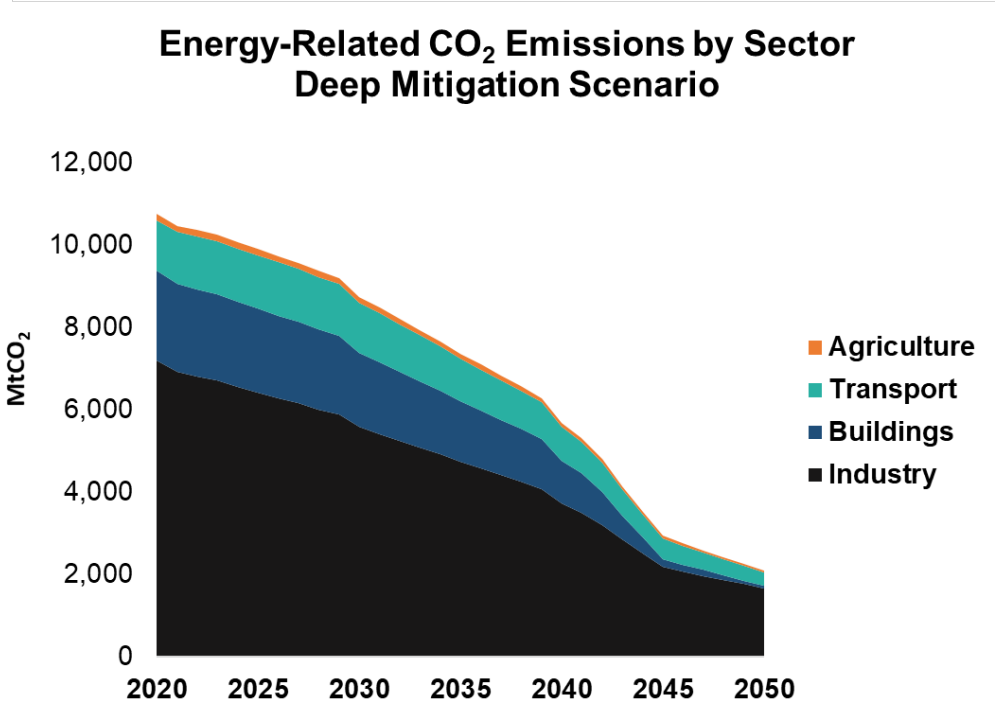




China Energy Outlook 2022
Deep Mitigation Scenario

- Despite implementing aggressive measures, the CEO Deep Mitigation Scenario shows that industry are very challenging to decarbonize, but that buildings are nearly at zero in 2050, and that emissions from transport sector can be reduced to a quarter of today's level but not fully decarbonized.





Key Energy and Emissions Goals

China's recent national policies related to energy efficiency remain largely the same and somewhat retrogressive, the energy intensity in the 14th FYP is set at 13.5% below 2015 level, while the previous 13th FYP had a 15% below 2015 level target – less room for efficiency improvements

Indicators	13th FYP Goal (2016-2020)	2020 Actual Performance	14th FYP Goal (2021-2025)	Paris Agreement NDCs	Proposed New NDCs	Xi Jinping Announcement
Energy Intensity (e/GDP) reduction	15% below 2015 level	13.3%	13.5%			
Carbon intensity (CO_2/GDP) reduction	18% below 2015 level	18.1%	18%	60% to 65% below 2005 by 2030	Over 65% below 2005 by 2030	
Share of non-fossil fuels in primary energy*	~15%	15.6%	20%	Around 20% in 2030	Around 25% in 2030	
CO_2 emissions peaking				Around 2030 and making best efforts to peak earlier	Before 2030	Before 2030
Installed capacity of wind and solar power (GW)					1,200 GW by 2030	
Coal peaking			Before 2030			Phase down starting 2025
Carbon neutrality						Before 2060

* The energy value of primary electricity (e.g., renewables, nuclear) converted using China's own Power Plant Coal Consumption method in which electricity sources are converted to standard units based on the average heat rate of Chinese coal-fired power plants each year. For a comparison of China's electricity conversion method to those use internationally, see Lewis et al., 2015.

2020-2021 Policy Update

China has set continued efficiency improvement targets for Buildings, Transport, and Industry sectors

Cross-Sector

- 2030 carbon peaking and 2060 carbon neutrality goal
- 14th Five-Year Plan
- Green Stimulus Spending
- Green Belt and Road Initiative
- Greater Bay Area Development Plan

Energy Supply

- Launch of the national emission trading system (ETS) for power
- 1200 GW renewables target by 2030
- China coal use to peak in 2025
- Regional power curtailment

Buildings

- 14th Five-Year Plan: pilot program for building energy efficiency, promote codes and standards for ultra-low and near-zero energy buildings, RE, and electrification
- Green cooling action plan in 2019

Transport

- 14th Five-Year Plan: promote a green, intelligent, and multimodal transport system
- Development Plan for the New Energy Vehicle Industry (2021-2035)
- New energy vehicle subsidies extended

Industry

- Industry CO_2 peaking and carbon neutrality plans
- Strictly control steel production capacity
- High quality development of steel industry
- Normalization of cement production curtailment
- Ultra-low emissions standards for steel, cement, and other industries

*The pilot program for building energy efficiency in cities, will focus on the Jing-Jin-Ji region, Yangtze River Delta, Pearl River Delta, and other key economic regions.

Key Targets for Building Sector in China's 14th FYP

Indicator	2020	2025	Requirement
Urban green buildings new construction (%)	50	100	Binding
Existing building green retrofits (100 million m^2)	N/A	2	Anticipated
Energy efficiency improvement of urban new construction (%)	N/A	15	Binding
Ultra-low energy buildings (million m^2)	N/A	20	Anticipated
Heating energy intensity for buildings in northern urban areas (kgce/m^2)	N/A	14	Anticipated
Total primary energy consumption in the building sector (100 Mtce)	N/A	13	Anticipated
Prefabricated buildings in urban new construction (%)	15	30	Anticipated
Building utilization of renewable energy sources to replace fossil fuel energy (%)	6	8	Anticipated
Rate of electrification in buildings	N/A	50%	Anticipated

Note: 1 kgce = 8.14 kWh, 1 kBtu/ft^2 = 3.15 kWh/m^2

Improving Energy Efficiency in China's Cement Industry

- Energy efficiency and emission reductions in the cement industry have been supported by strong national and sectoral policies

Policies	Supply Side Reform	Energy Saving	Environmental Protection	Technology Promotion	Financial Incentives
National	Phasing out backward capacity	National energy intensity reduction targets	National emission reduction targets	Energy conservation and low carbon technology promotion catalogues	Energy-saving and emission reduction retrofits rewards Tax incentives from CDM
Cement Industry	Cement industry access regulation	Sectoral energy intensity targets Minimum energy performance standards	Clean production of cement	Clean production technologies promotion plan for cement	Differential pricing

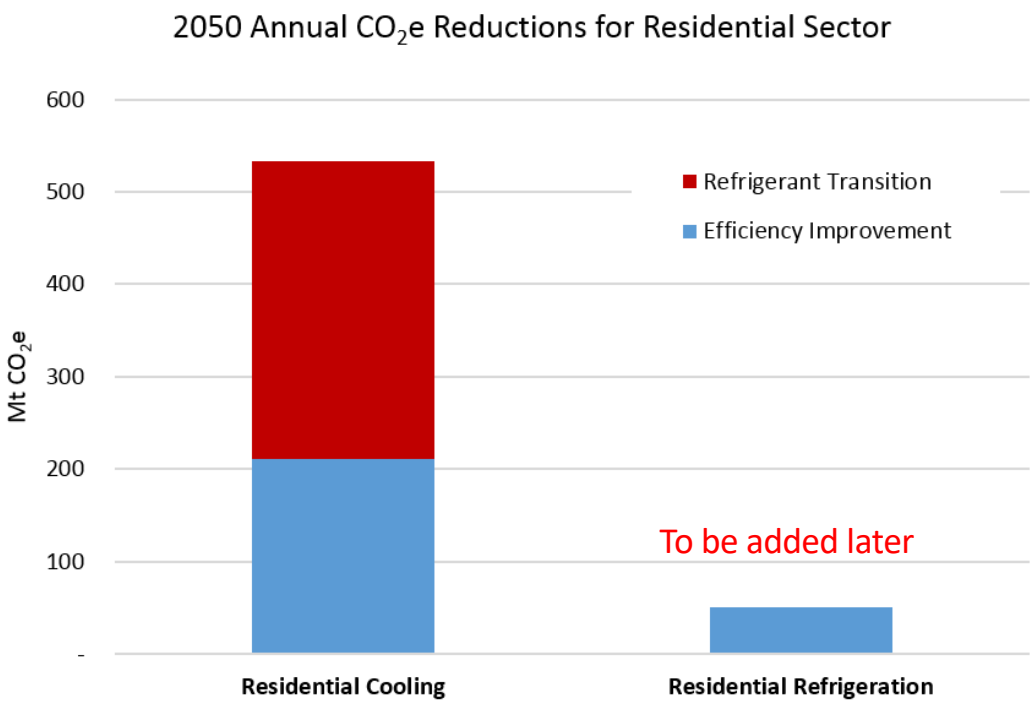
Improving Energy Efficiency in China's Cement Industry

- Waste Heat to Power
  - Driven by credits from the Clean Development Mechanism and domestic tax incentives initially and supported by a national mandate on new clinker capacities, reaching over 80% adoption rate in 2015

Source: ICF 2014.

- Other key energy-efficiency technologies have played important roles in improving energy efficiency and also reducing air pollutant emissions:
  - multi-channel coal burner, high-efficient cooler, optimization for energy-saving grinding, vertical mill for finish grinding, and energy-saving monitoring and optimization system for NSP kilns

Refrigerant transition can provide significant additional CO_2e emissions reductions in China's residential sector



Note: some autonomous efficiency improvement and power sector decarbonization are considered in evaluating CO_2 emissions reductions from efficiency improvement. Refrigerant transition reductions calculated based on analysis from Shah et al. 2015 but with updated AC stock and power sector fuel mix.

Joint projects with China National Institute of Collaboration (CNIS) since 2016 on revising energy efficiency standards for residential room AC and commercial variable refrigerant flow (VRF) ACs:

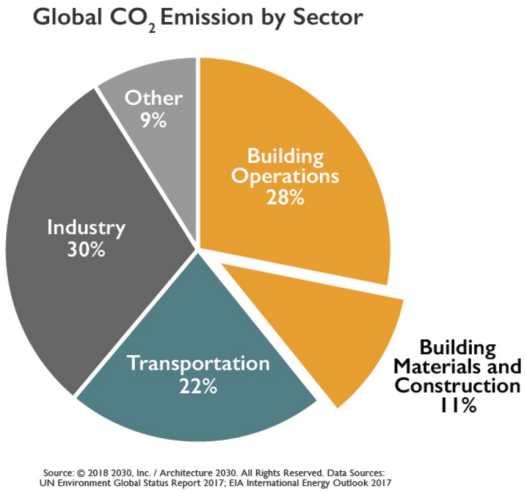
More efficient variable-speed and less efficient fixed-speed room air conditioners were covered by the same standard for the first time in newest room AC standard

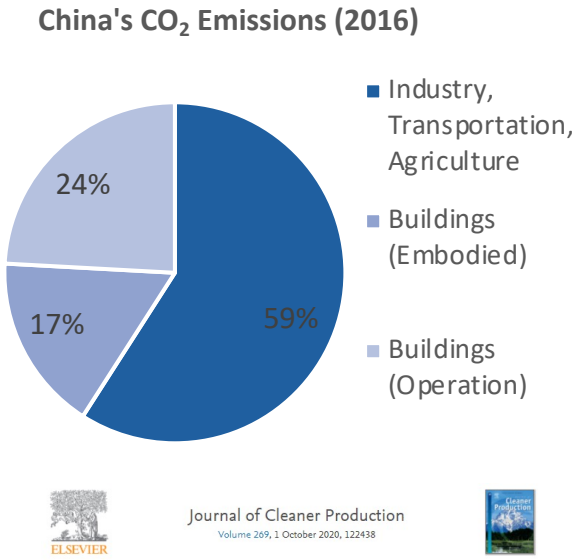
China adopted Green Cooling Action Plan in 2019

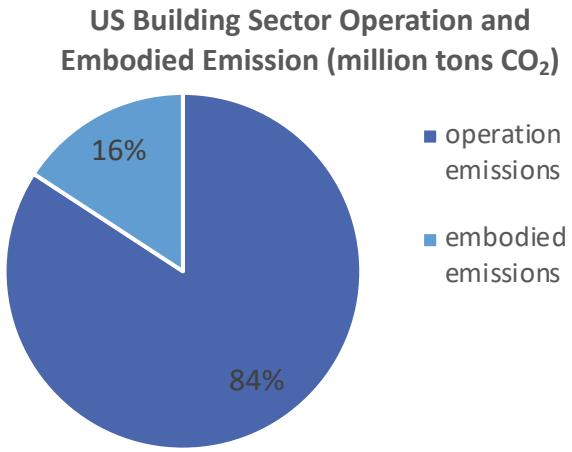
Global Cooling Prize 2021 – Gree was one of two winners

Reducing embodied emissions in the buildings sector is critical as building operation becomes more efficient and low-carbon

- Building materials embodied emissions accounts for 11% of global CO_2 emissions
  - 17% of China's total CO_2 emissions
  - 40% of China's buildings sector emissions (including both operation and embodied emissions)
  - 84% of US buildings sector emissions (including both operation and embodied emissions)
- Limited studies to model embodied emissions
  - Lack of detailed embodied emissions breakout in the U.S. and China
  - Need tools and models to assess embodied emissions







Many Current and Emerging Options to Reduce Embodied Emissions in the Cement Industry



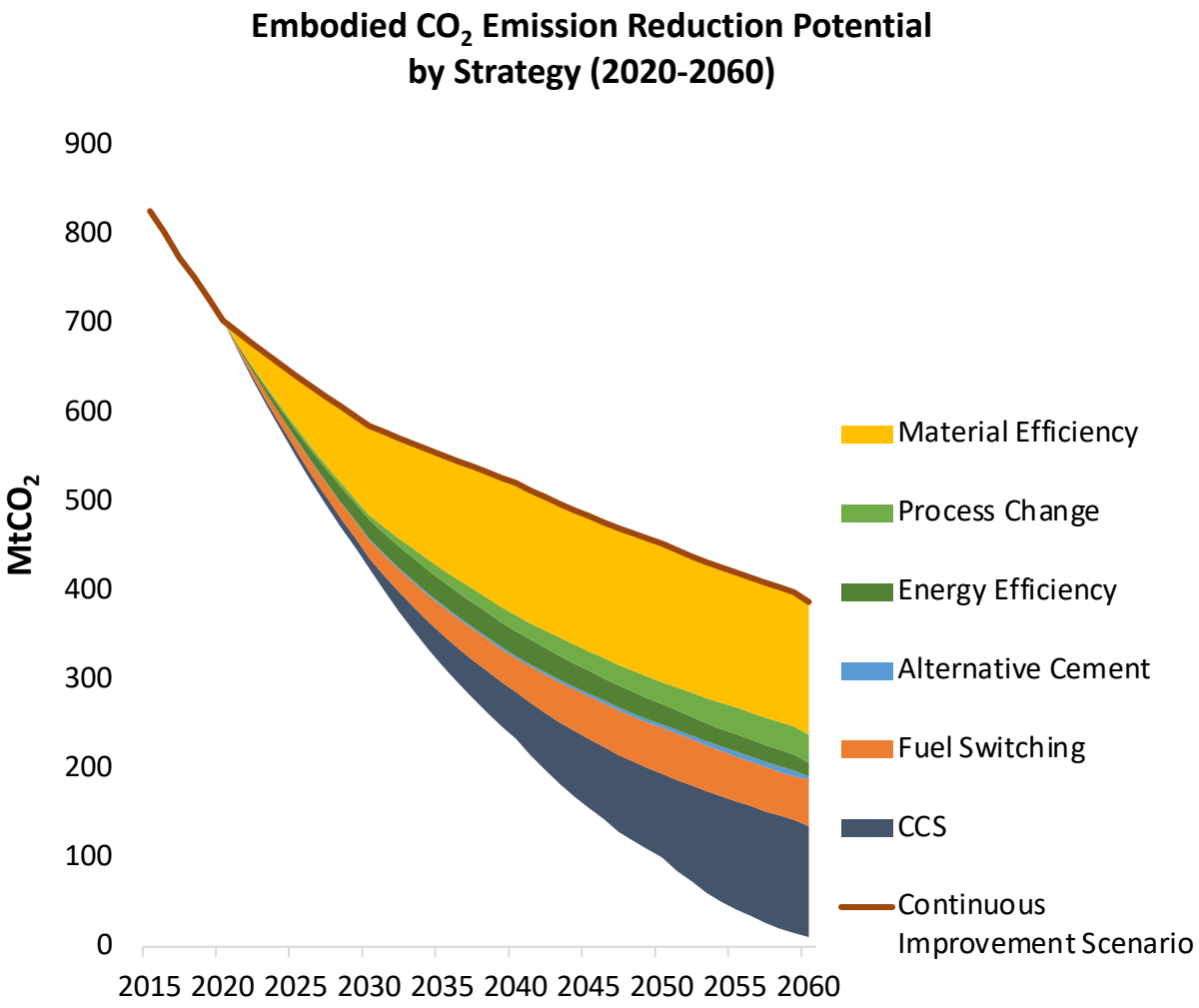

Material Management/ Demand Reduction	Energy Efficiency	Electrification	Fuel Switching and CCUS
•Extending building lifetime by using higher quality, high performance, and longer life materials/products	•Component (e.g., raw material grinding, kiln, finishing grinding) and system energy efficiency	•Expand electricity end-use applications (e.g. electrify industrial heat processes)	•Alternative fuels for feedstocks and low/high temp heat
•Prefab construction •Additive manufacturing/ 3D printing •Design optimization •Optimizing cement content in concrete	•Smart energy management	•On-site or grid power generation using solar PV and wind turbines	•Solar thermal; geothermal
•Material substitution: alternative materials (e.g., mass timber for commercial buildings) and construction •Green cements based on new material/chemistry	•Waste heat recovery and use	•High-temperature electric heating (e.g., plasma heating; concentrated solar heating)	•Carbon capture, use, and storage (CCUS)
•Reducing construction wastes •Recycle concrete into recycled concrete aggregates	•Integrative design/system optimization	•Electrochemical calcination process	•Hydrogen as fuel

Commercial, cost effective measures

Commercial but not yet widely adopted or piloted

R&D not piloted, not considered in the model

Pathways to reduce embodied emissions of building materials in China



- Before 2030: material efficiency plays the biggest role, representing 63% of all CO_2 reductions
  - Extending building lifetime
  - Increased adoption of prefabricated buildings
  - Improved building design
- Between 2030-2060:
  - Material efficiency continues to have the largest impact, 40% of total CO_2 reductions by 2060
  - CCS plays a bigger role in the longer term, esp. for cement, 33% by 2060
  - Fuel switching – using green H_2 and renewable heat – and process change is critical, esp. for steel, 14% by 2060

Thank you!

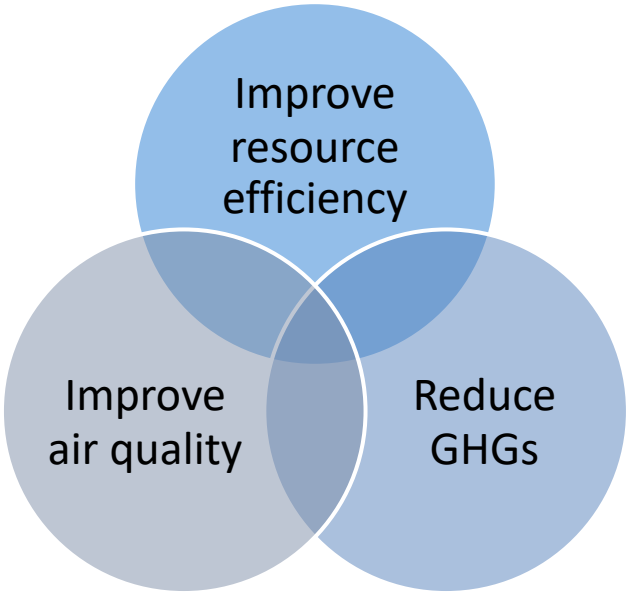
Questions?

Nan Zhou
Nzhou@lbl.gov

China Energy Group
Energy Technologies Area
Lawrence Berkeley National Laboratory

China's 14th Five Year Plan (2021-2025)

- 14th Five-Year Plan
  - Continued target-setting on reducing energy intensity and carbon intensity
  - By 2025: 30% of production capacity in key industries reach energy-efficiency benchmark levels
    - Industries: steel, aluminum, cement, flat glass, oil refining, ethylene, ammonia, calcium carbide
    - Benchmarks are published by the central government
- New policy "Action Plan for CO2 Peaking before 2030"
  - Emphasized on "Strict energy-efficiency requirements to promote energy conservation and carbon reduction in key sectors"



Indicator	13th FYP Goals (2016-2020)	Actual 2020 Performance	14th FYP Goals (2021-2025)
Energy Intensity reduction (e/GDP) below 2015 level	15%	13.30%	13.50%
CO_2 intensity reduction (CO_2/GDP) below 2015 level	18%	18.10%	18%