Energy Technologies Area Lawrence Berkeley National Laboratory

China's Trajectories beyond Efficiency:

CO_2 Implications of Maximizing Electrification and Renewable Resources through 2050

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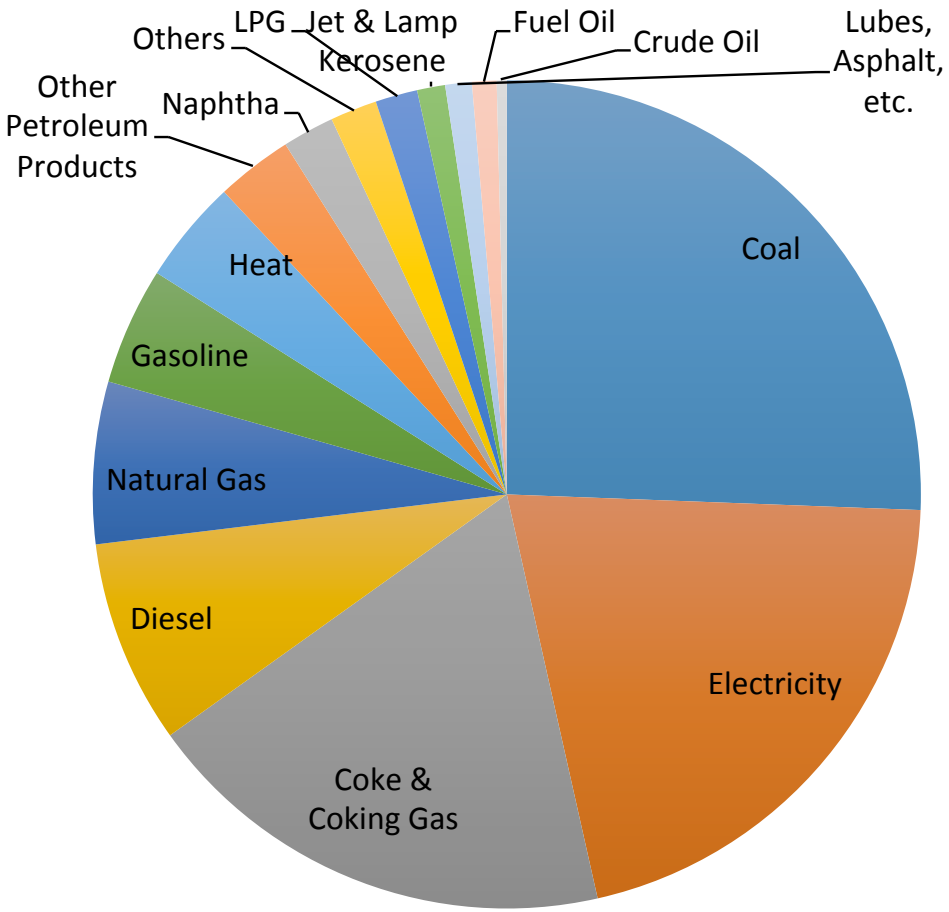
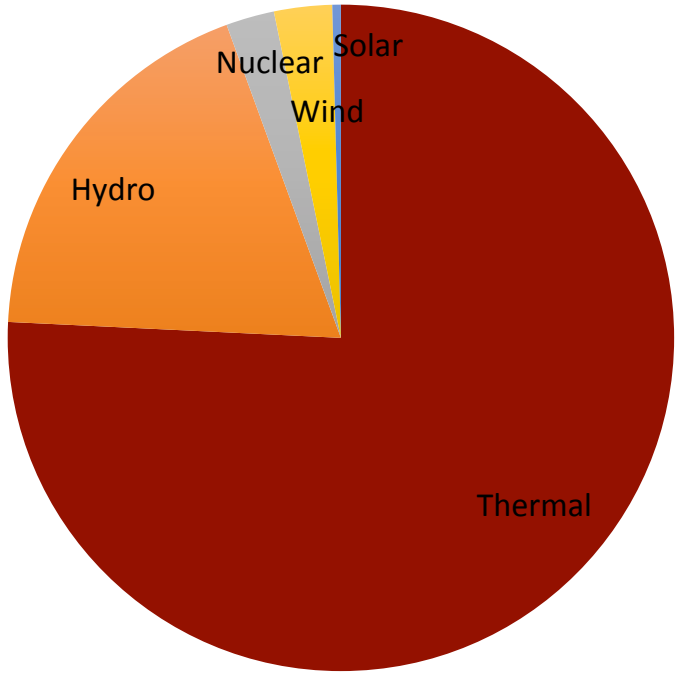
2017 ECEEE Summer Study

China's energy system is coal-based

China Final Energy Consumption (2014): 3139 Mtce



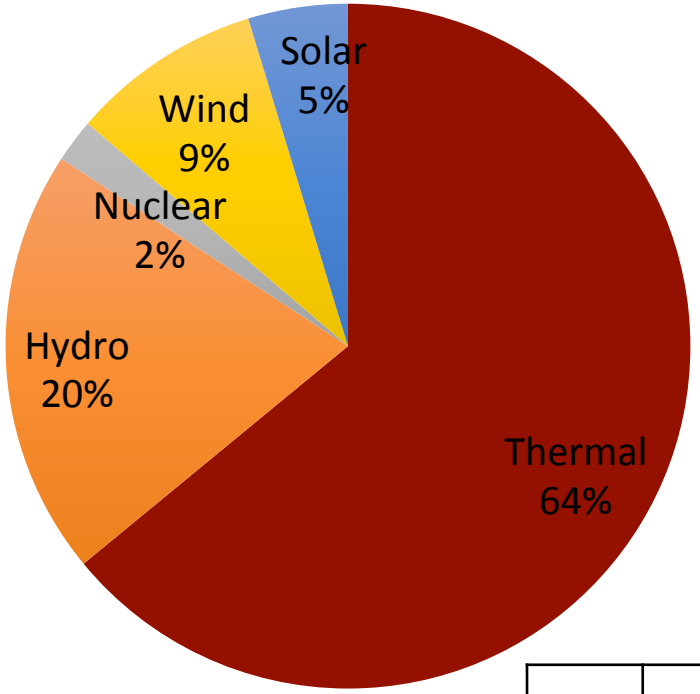
Electricity: 21% of total



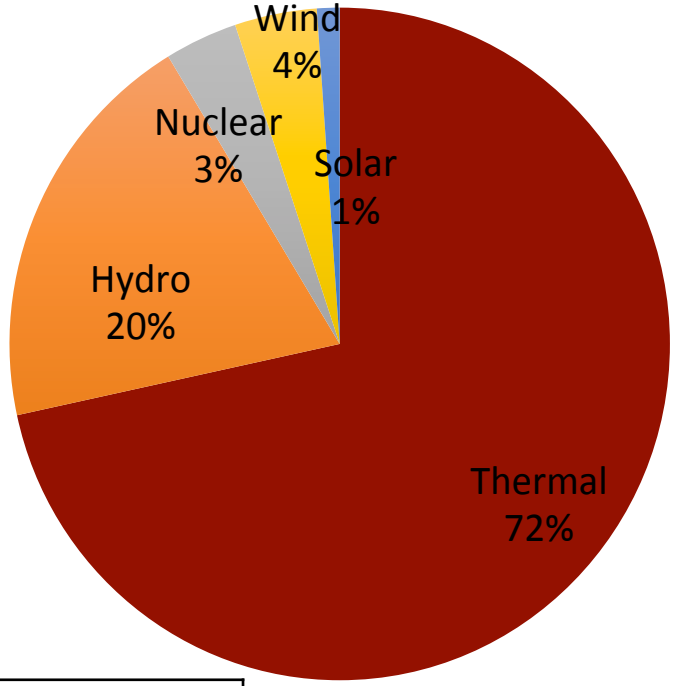
Source: China National Bureau of Statistics

Thermal installed capacity and generation dominates China's power system

Installed Capacity by Fuel in 2016 (GW)



Power Generation by Fuel in 2016 (TWh)

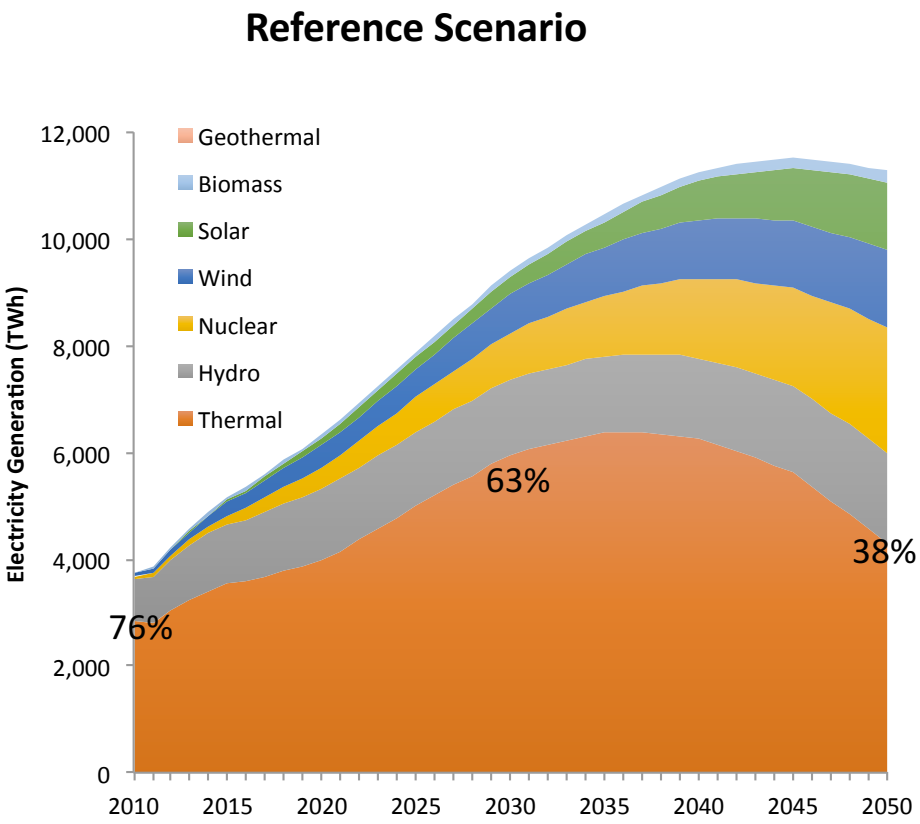


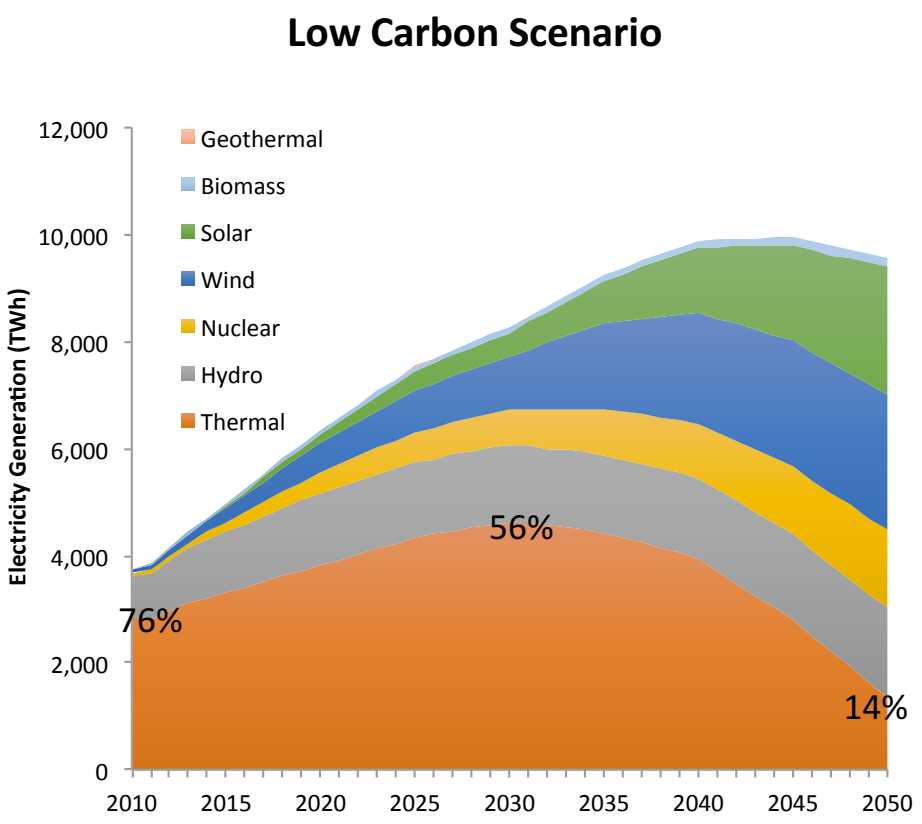
	Installed Capacity (GW)	Power Generation (TWh)
Thermal	1054	4289
Hydro	332	1181
Nuclear	34	213
Wind	149	241
Solar	77	66
Total	**1646**	**5990**

First Priority: Decarbonization of the power system

China's electricity generation has huge potential in decarbonization

China's Electricity Generation by Fuel





Source: Khanna, N. et al. 2017. "China's Trajectories beyond Efficiency: CO_2 Implications of Maximizing Electrification and Renewable Resources through 2050." 2017 ECEEE Summer Study Conference Proceedings (forthcoming).

Overview of China 2050 DREAM Modeling Methodology

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:* 2020, 2020 energy, CO_2 intensity reduction
  - *Long-term strategic planning:* 2050 development pathways

Capabilities & 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

Key Outcomes

- 2010-2011 study - only modelers to show a peak and plateau in China's energy and CO_2 emissions
- 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

Second Priority: Electrification of the economy and Additional Renewables

Scenarios are developed to evaluate impact of electrification and renewables

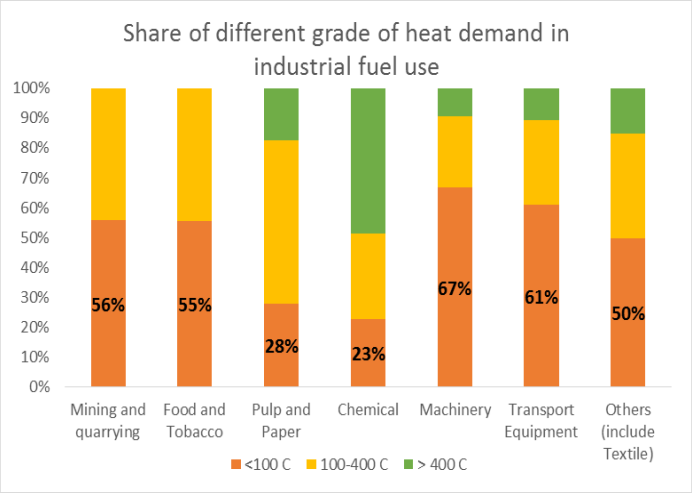
- Reference:
  - Only considers policies in place as of 2010 with autonomous efficiency improvements and limited fuel switching
- Cost-effective Efficiency and Renewables:
  - Includes additional cost-effective efficiency improvements and fuel switch in demand and supply-side
- Maximum Electrification:
  - Maximized (additional) electrification in buildings for cooling, industry and transport
- Maximum Deployment of Renewable Energy:
  - Additional adoption of renewable heat and biomass in industry, solar in buildings

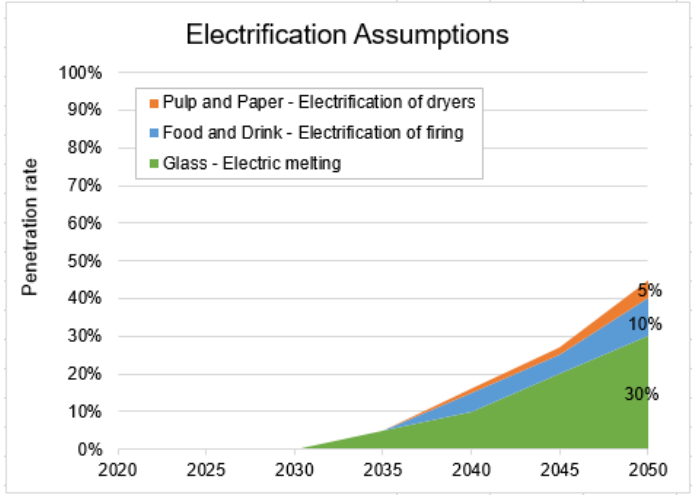
Key Assumptions in Maximum Electrification Scenario

	2010	2050 Reference	2050 Maximum Electrification
Transport			
Passenger Vehicles	0% EV shares	10% EV share in private cars, 30% EV share in taxis and fleet car markets	75% EV share in private cars, 100% EV share in taxi and fleet car markets
Trucks	0% plug-in hybrid diesels	0% plug-in hybrid diesels	18% plug-in hybrid diesel share in medium-duty trucks, 50% plug-in hybrid diesel share in light-duty trucks
Industry			
Glass Industry	0% electric melting	0% electric melting	30% electric melting to replace fossil fuel melting
Food and Beverage Industry	0% electrification of firing	0% electrification of firing	10% electrification of firing to replace coal-firing
Pulp and Paper Industry	0% electric dryers	0% electric dryers	5% electric dryers to replace heat dryers
Commercial Buildings			
Heating	1.5% air source heat pump	10-25% share for air source heat pump depending on climate zone	40-90% share for air source heat pump depending on climate zone
Cooling	0.5% ground source heat pump share	0% ground source heat pump share	20-25% share for ground source heat pump depending on climate zone
Water Heating	0% heat pump water heater share	0% heat pump water heater	48% heat pump water heaters
Residential Buildings			
Heating	1.5% air source heat pump	10%-80% share for air source heat pump depending on climate zone	40-100% share for air source heat pump depending on climate zone

Maximum Renewable Deployment Scenario include additional non-conventional renewable deployment in buildings and industry

Industry: low-temperature renewable heat and biomass

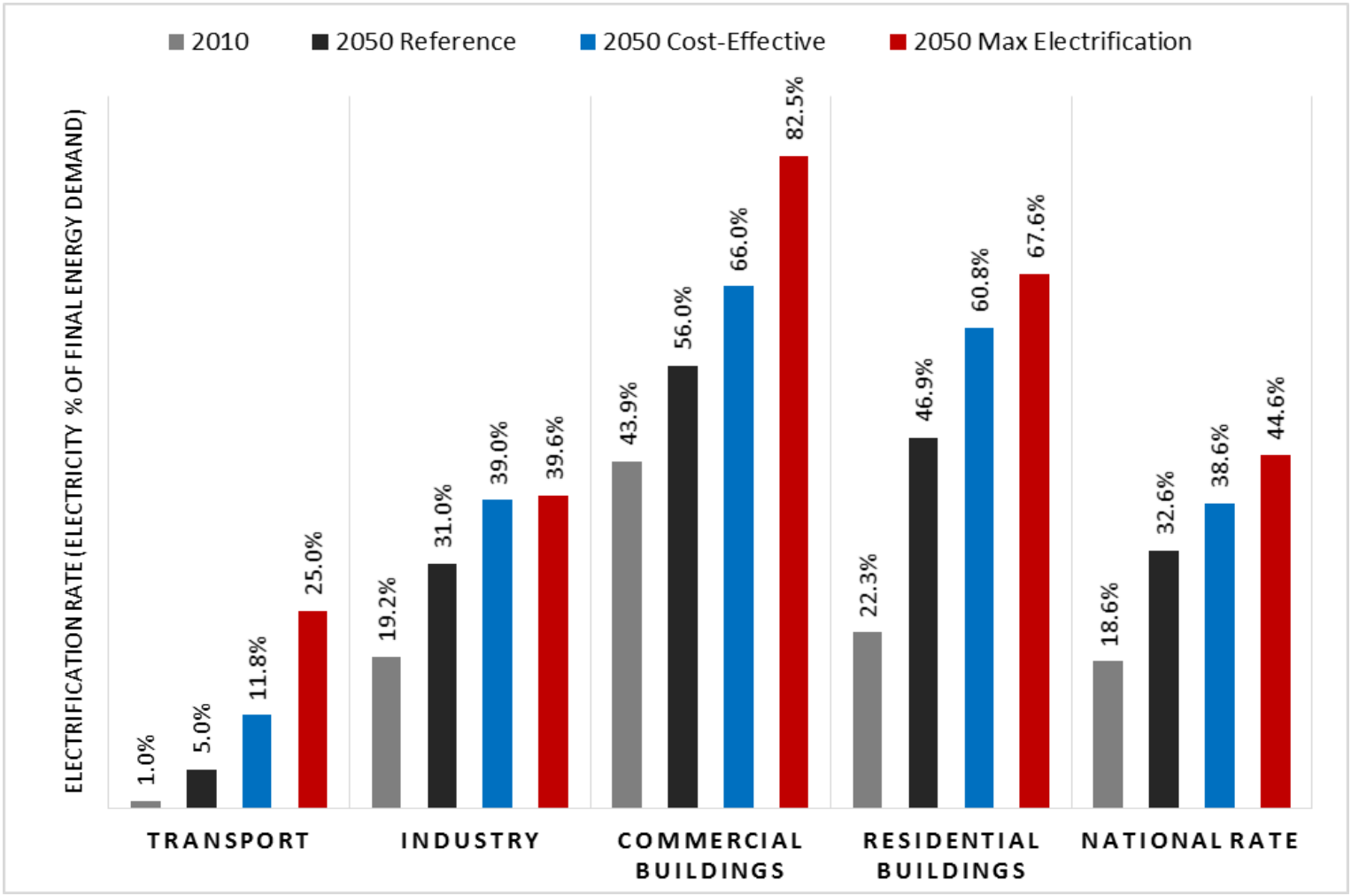




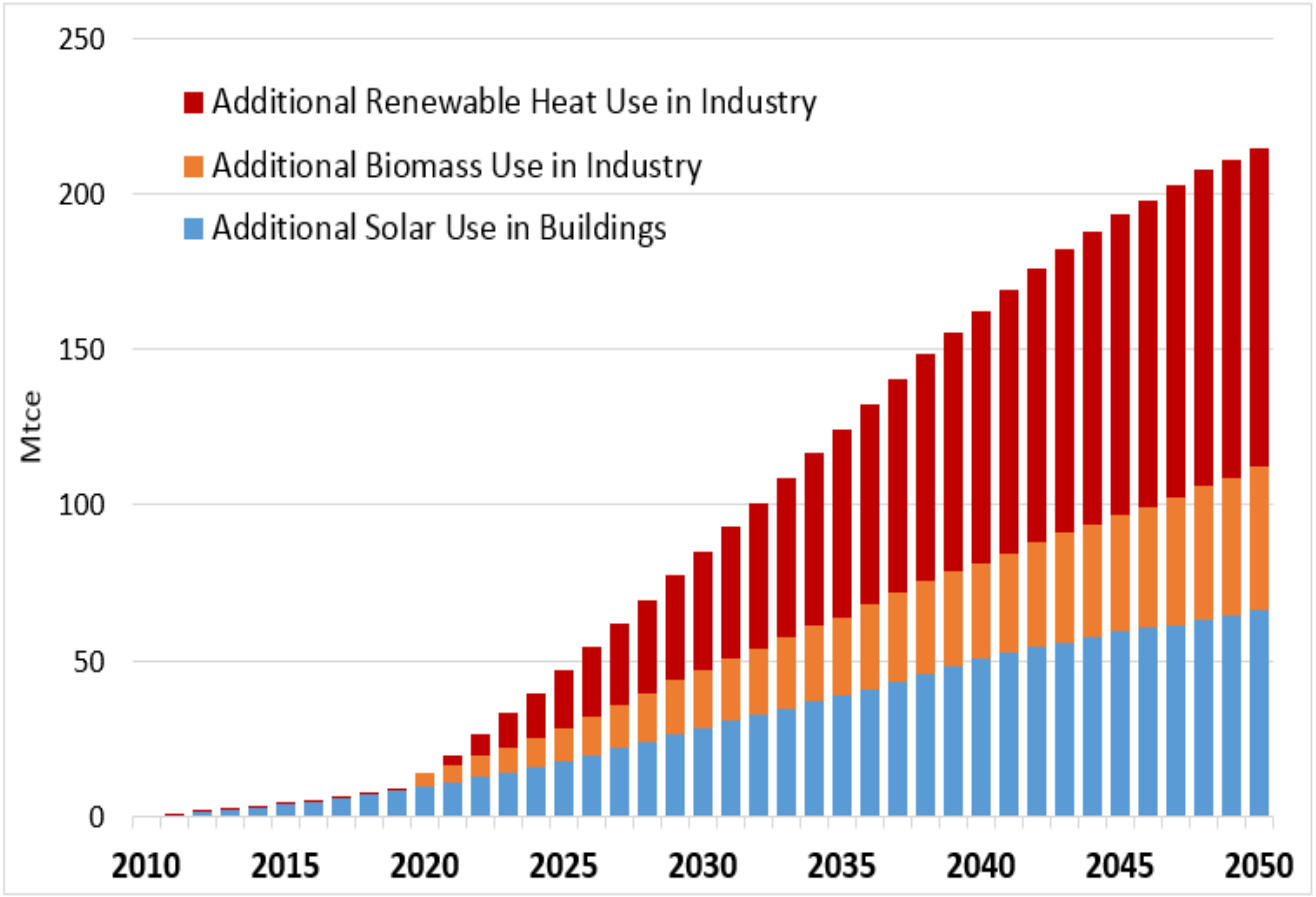
Commercial Buildings: maximize adoption of solar thermal technologies for heating, cooling and water heating

- Heating: solar thermal heating share increase to 8% by 2050
- Cooling: solar thermal AC share increase to 15-30% (depending on climate zone) by 2050
- Water heating: solar water heater increase to 30% by 2050

Significant potential for electrification across all sectors, but electricity still only accounts for 45% of final energy use with maximized electrification



Additional fossil fuel displacement feasible by maximizing renewable adoption in demand sectors

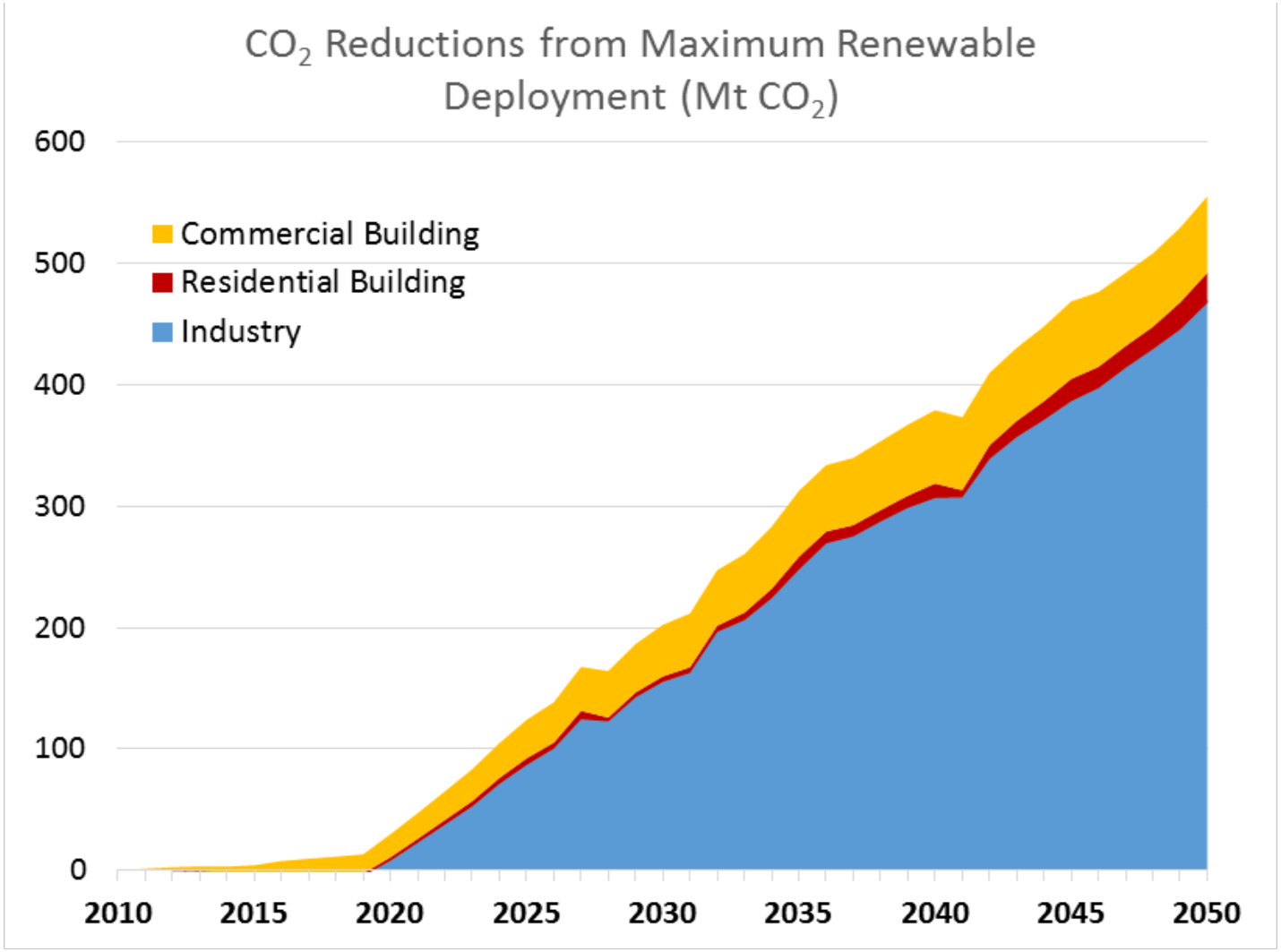


By 2050, additional renewables can displace annually:

- 85 Mtce Coal
- 7 Mtce Coke
- 54 Mtce Natural Gas
- 45 Mtce Heat
- 26 Mtce Electricity

Note: 1 Mtce = 29.27 petajoules

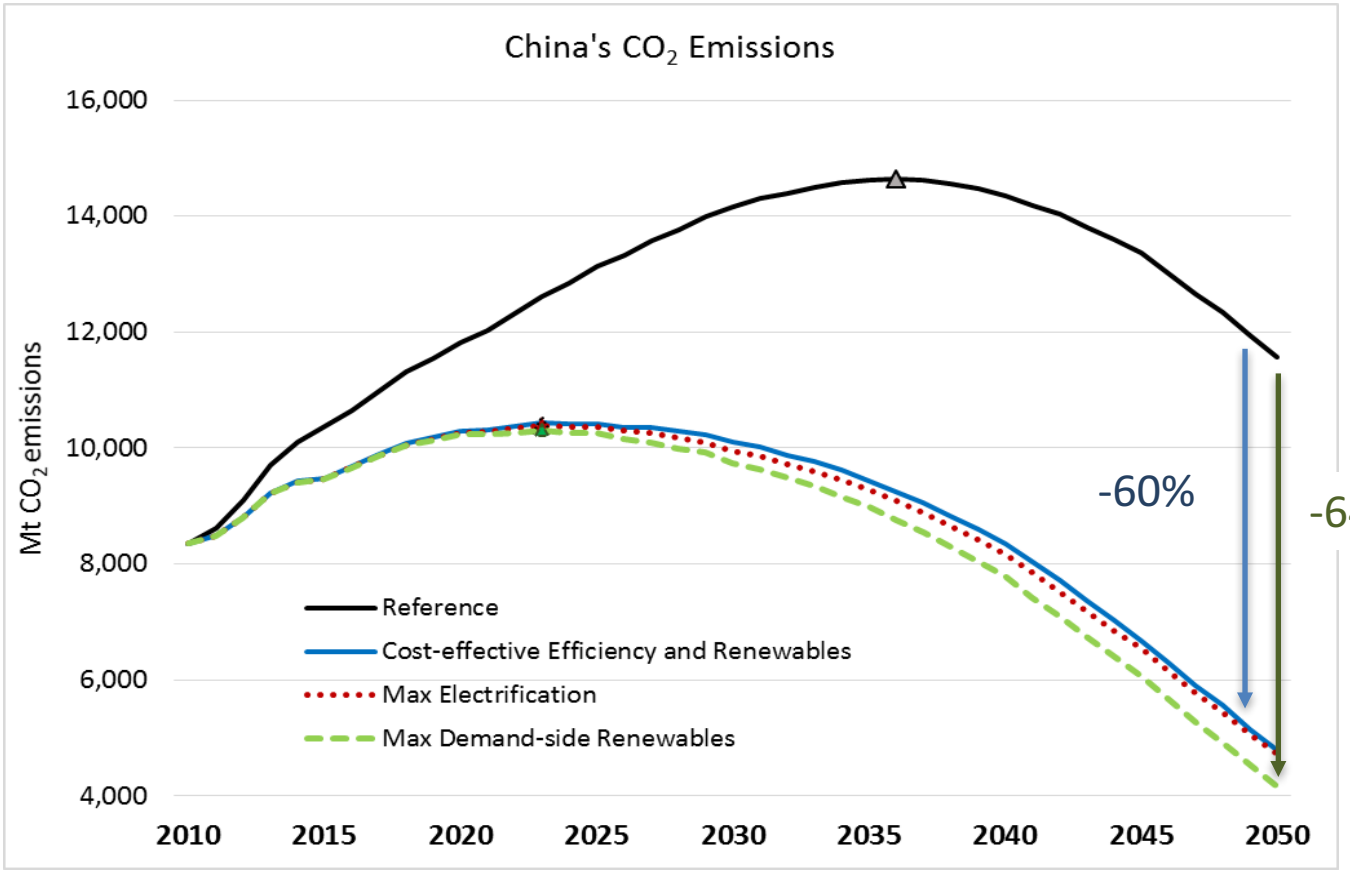
550 Mt CO_2 can be displaced annually beyond cost-effective fuel switching by Max Renewable Deployment by 2050



More solar heating, cooling and water heating

Biomass & Renewable Heat

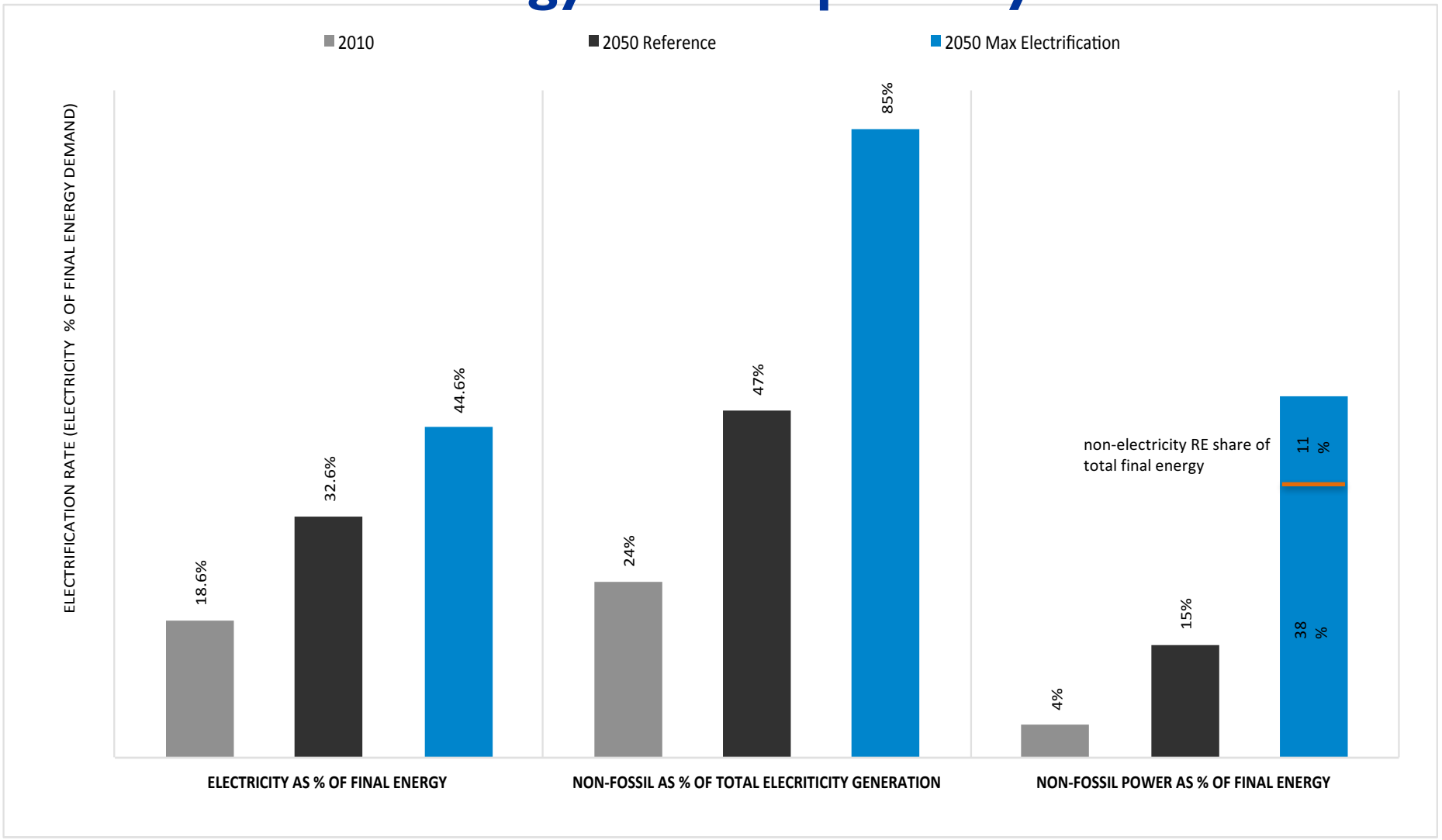
CO_2 could peak as early as 2023 with maximized efficiency, electrification and renewables



Cumulative CO_2 reductions beyond cost-effective efficiency and renewables to 2050:

- Max Electrification: 3.98 Gt CO_2
- Max Renewables: 13.2 Gt CO_2

Non-fossil power could reach 30% of China's total final energy consumption by 2050



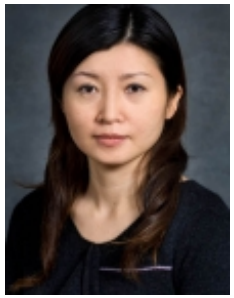
Conclusions and Policy Implications

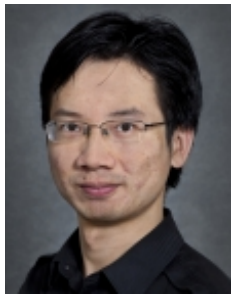
- China can achieve its 2030 CO_2 peaking target through several pathways, and reduce annual CO_2 by 60+% by 2050
- China's CO_2 emissions can peak as early as 2023 with only cost-effective efficiency and fuel switching, but must overcome barriers including:
  - Lack of resources and knowledge for efficiency improvements
  - Distorted tariff and energy prices
  - Regional unemployment concerns and limited alternatives for fuel switching in some sectors
- Additional research needed to disentangle impact of cost-effective efficiency versus fuel switching, supply-side vs. demand-side electrification

Significant policy shifts needed to achieve additional CO_2 reductions from maximizing renewables and electrification:

- Interdependence between electrification and decarbonization of power sector, which requires resolving existing challenges and renewable integration
- Supporting policies and programs including subsidies, pilots can help promote distributed demand-side renewable technologies
- Greater awareness and capacity building on low temperature renewable heat use in industrial sectors needed – more crucial to start now given large scale and decentralized nature of Chinese industries

Thank You!



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