Clean Energy Transition in the Developing World

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MIT Energy Initiative – External Advisory Board Meeting

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Karplus Group research spans multiple scales to study how society can enable clean energy transitions around the world

Nations & regions:
Designing policy and institutions

- Implementation of Paris pledges
- Politically-viable transition strategies
- Air quality co-benefits of climate policy

Energy systems:
Incentivizing technology and behavior change

- Clean energy targets in China and India
- Enablers of solar PV diffusion in Africa
- Electrification of transportation

Business strategy:
Drivers of energy decisions in organizations

- Climate policy impact on firms
- Drivers of firm regulatory compliance
- Effects of information and disclosure

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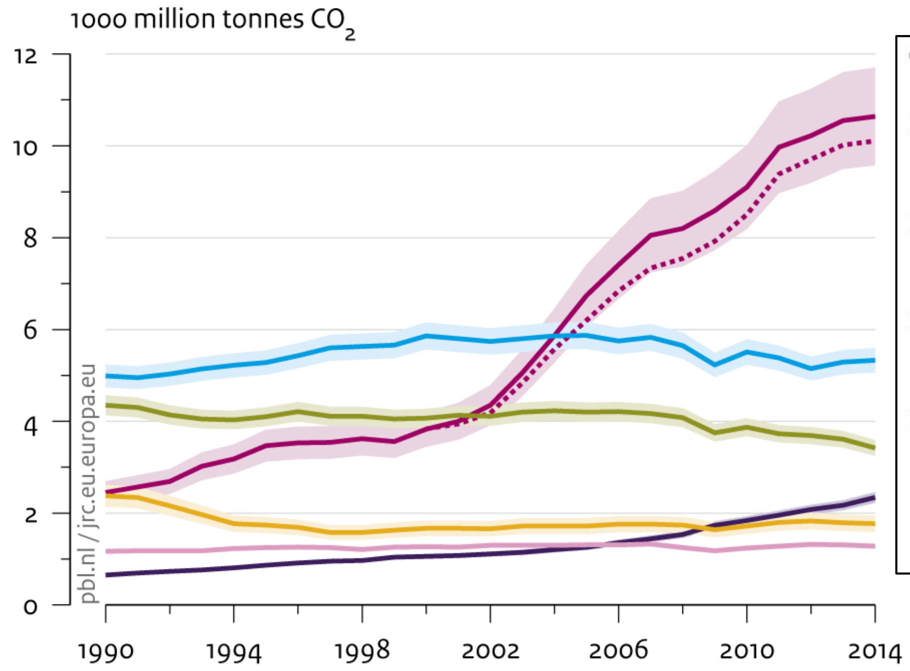
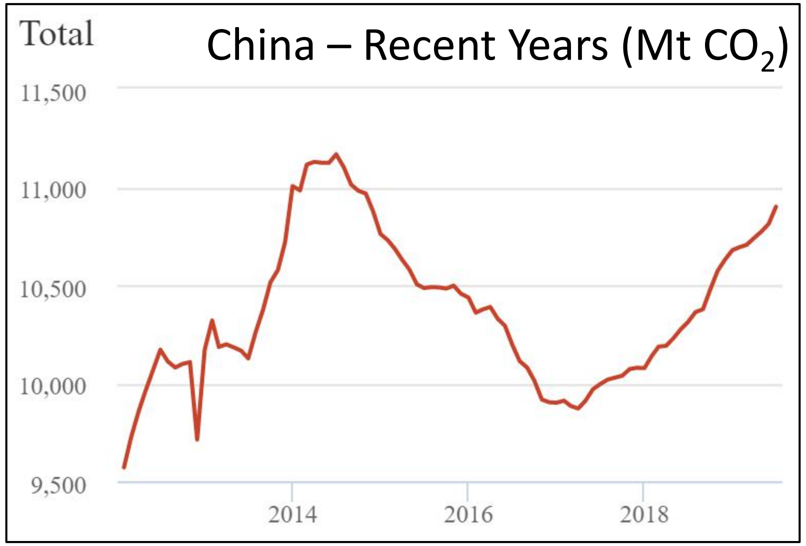
Climate Change Mitigation: The Role of China

China is the world’s largest energy user and CO_2 emitter – outcomes in China have global consequences.

CO_2 emissions from fossil-fuel use and cement production in the top 5 emitting countries and the EU





Source: Carbon Brief (2019).

Source: EDGAR 4.3 (JRC/PBL, 2015) (1970-2012; notably IEA 2014 and NBS 2015); FT2014 (2013-2014): BP 2015; GGFR 2015; USGS 2015; WSA 2015

To assess the impact of climate policy in China we developed the Regional Emissions Air Quality Climate and Health (REACH) Framework

Policy Scenarios

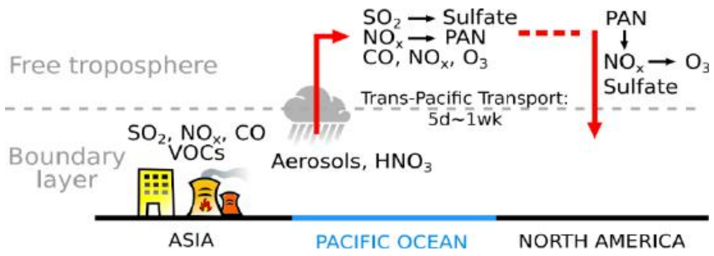
1 Energy-Economic Model
China Regional Energy Model (C-REM)

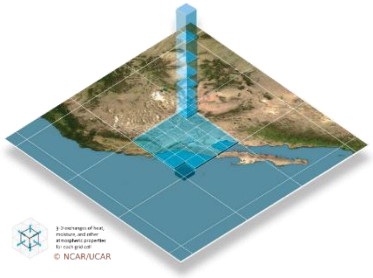
2 Projected Emissions
REAS emissions inventory

3 Atmos. Chemistry model
GEOS-Chem

4 Health Effects
Uses latest estimates from Chinese sources

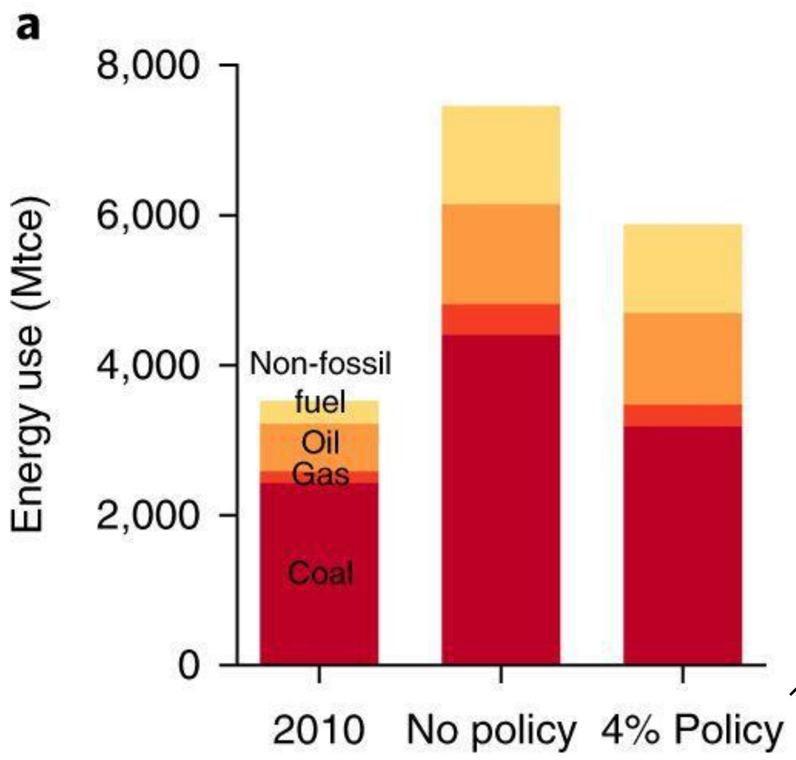
Air Quality





Source: Li et al. 2018, *Nature Climate Change*. (Karplus & Selin Groups Collaborative Research)

Changes in energy use in the 4% Policy scenario compared to the No Policy scenario in 2030

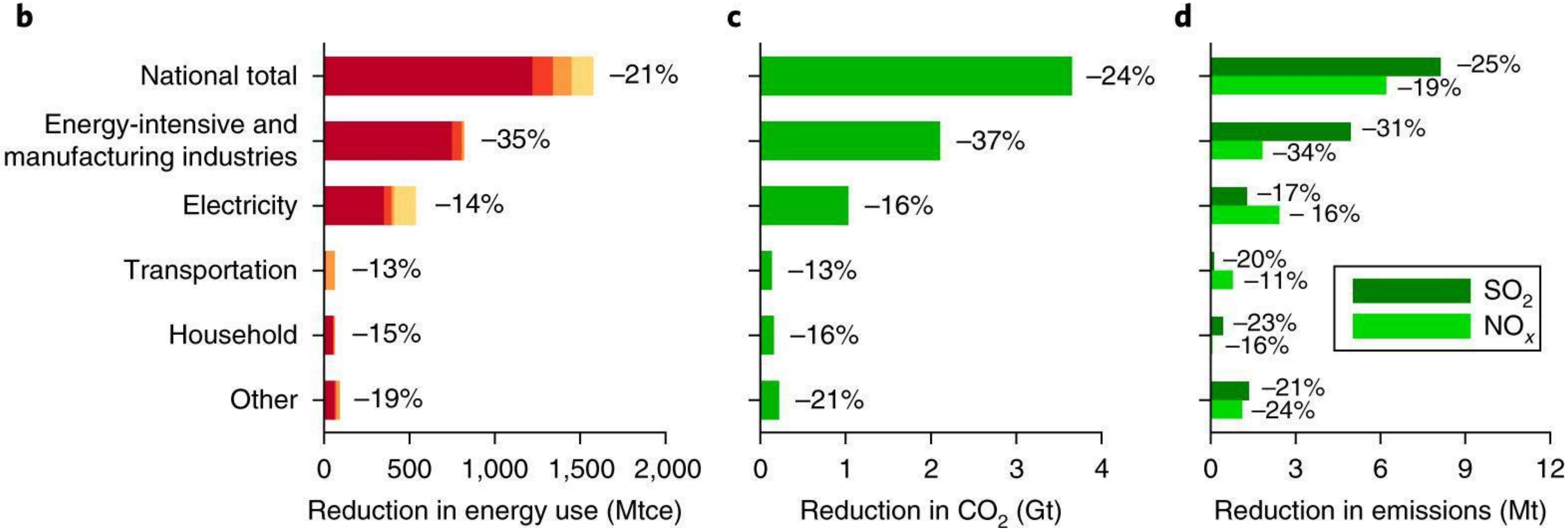


4% Policy – 4% annual reduction in the CO_2 intensity of China's economy, achieved via a CO_2 price.

a Change in energy use at the national level in different future scenarios.

Source: Li et al. 2018, *Nature Climate Change*. (Karplus & Selin Groups Collaborative Research)

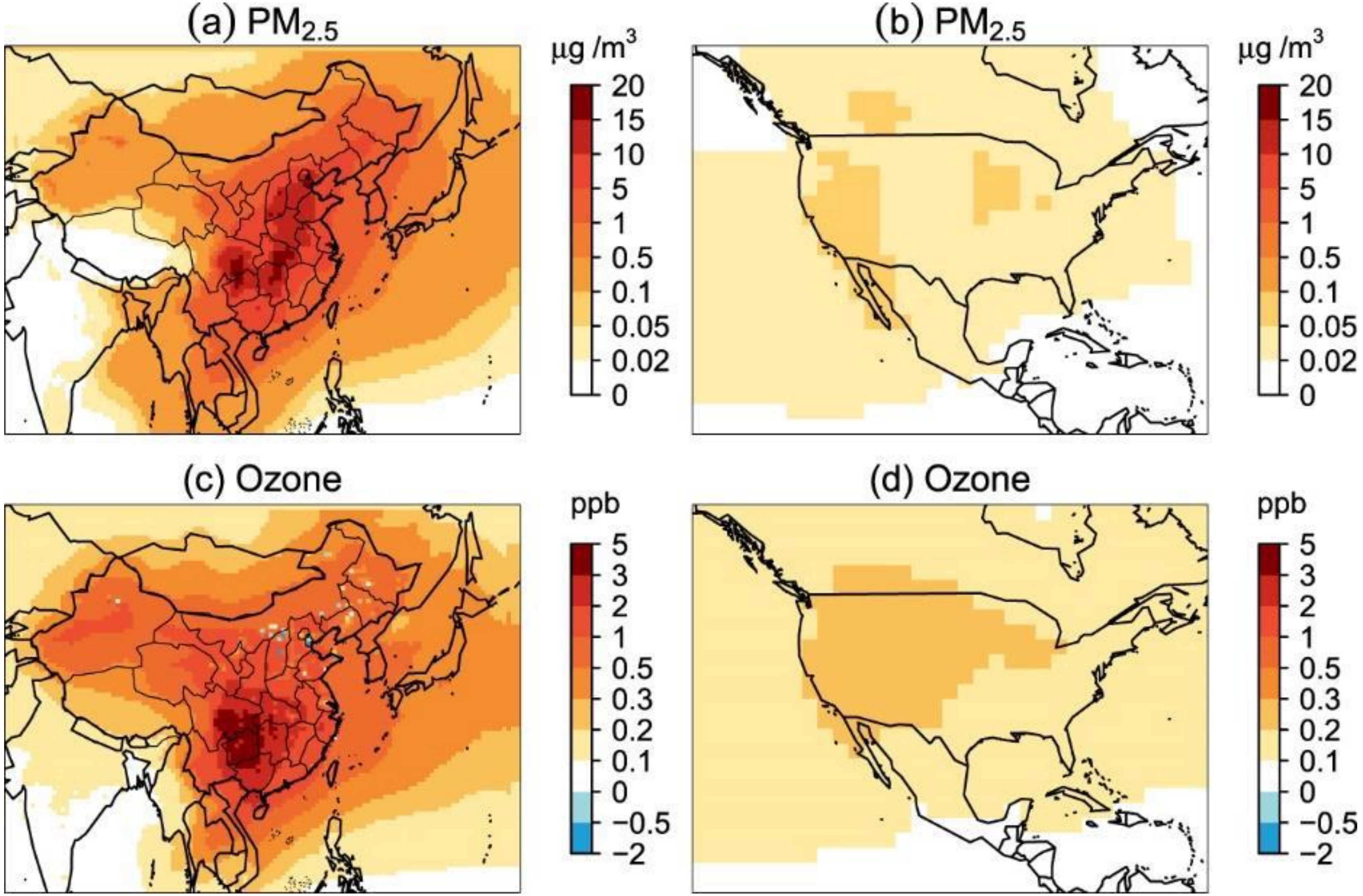
Changes in energy use, CO_2, and air pollutant emissions, by sector.



Change in energy use at the sectoral (**b**) level. Mtce, million tons of coal equivalent. **c**,**d**, Sectoral reductions in CO_2 (**c**) and SO_2 and NO_x (**d**) emissions (with percentage changes to the right of each bar) in the 4% Policy scenario compared to the No Policy scenario in 2030.

Source: Li et al. 2018, *Nature Climate Change*. (Karplus & Selin Groups Collaborative Research)

4% Policy achieves reductions in $PM_{2.5}$ and ozone in China and abroad



Premature deaths avoided,
4% Policy scenario:

China:
ozone: 54,300 (37,100-71,000)
$PM_{2.5}$: 95,200 (78,500-112,000)

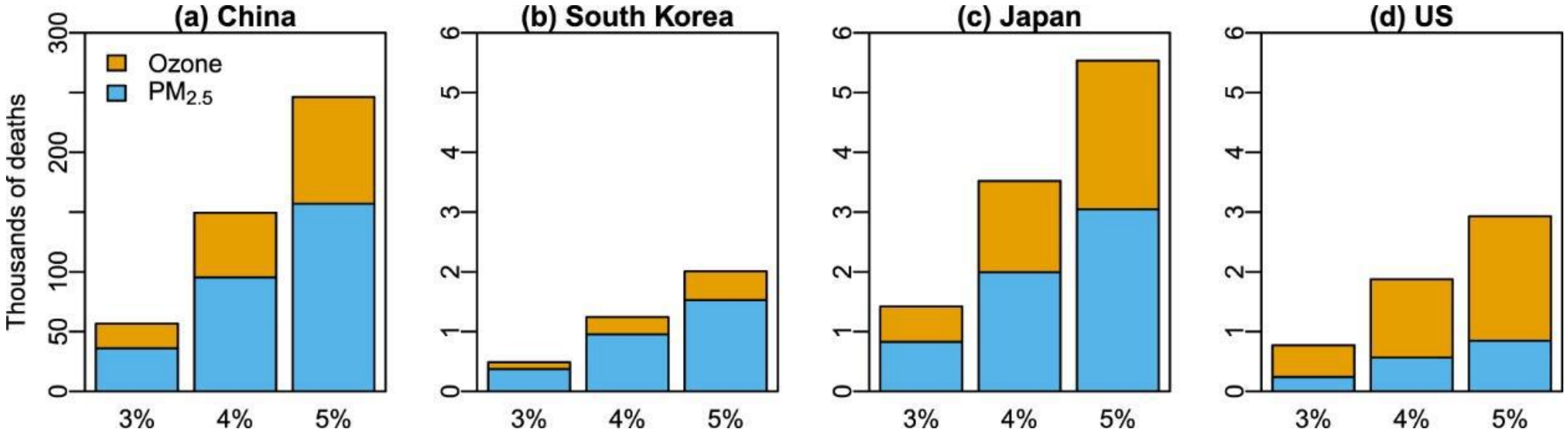
South Korea: 1200 (900-1600)
Japan: 3500 (2800-4300)
United States:* 1900 (1400-2500)

* US avoided deaths are equivalent to 4%–17% of the estimated health co-benefits from *domestic* climate policy in the US in 2030.

Source: Li et al. 2019, *Environmental Research Letters*. (Karplus & Selin Groups Collaborative Research)

More stringent policy would increase co-benefits, largely due to ozone reduction in the U.S.

Avoided $PM_{2.5}$- and ozone-related premature deaths under three climate policy scenarios relative to No Policy in China (a) and three downwind countries (b)–(d) in 2030.



Ozone-related deaths are calculated using the concentration-response function in Turner et al. (2016). Note different scale for panels (b)–(d).

Source: Li et al. 2019, *Environmental Research Letters*. (Karplus & Selin Groups Collaborative Research)

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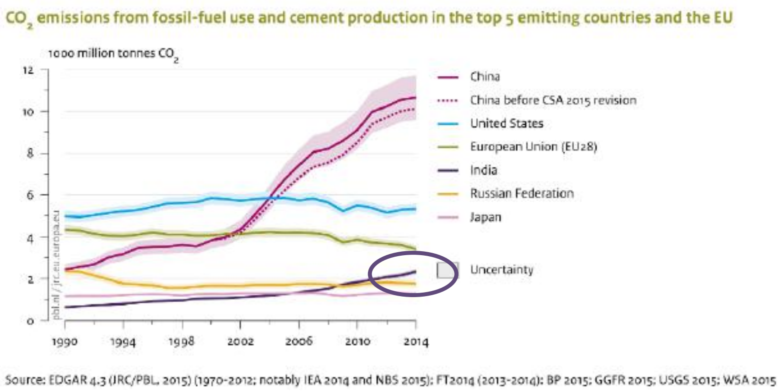
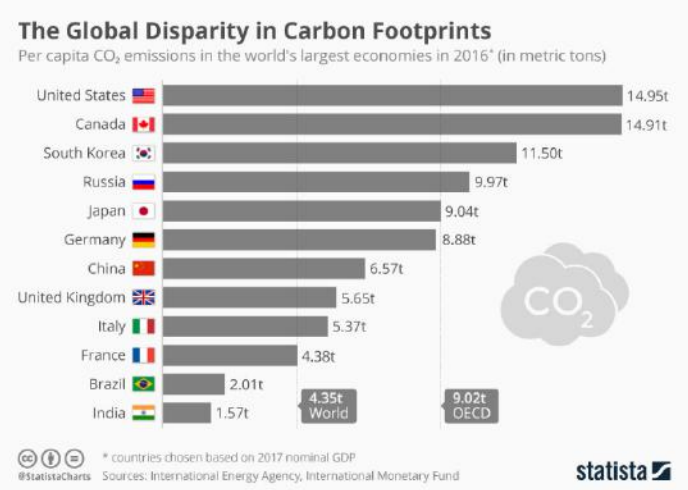
How cost-effective is a non-fossil energy target in India? It depends…

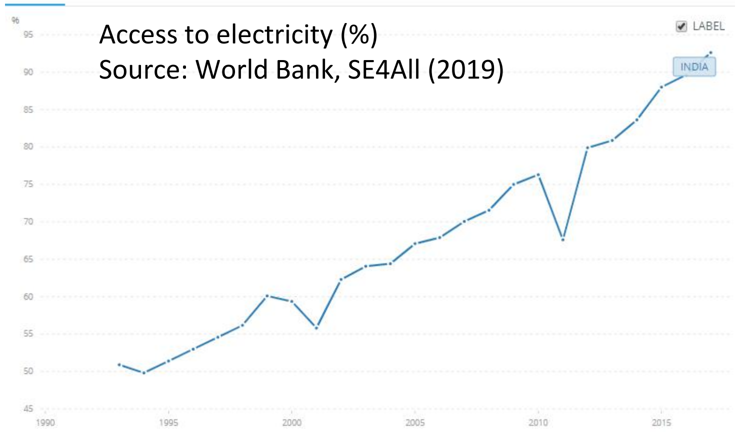
India is the ***third largest*** emitter of CO_2 in the world…

But India's per capita emissions are 1/3 of the global average…

and ~8% of the population lacks access to electricity.







India's Nationally Determined Contributions (NDCs) to the Paris Agreement

- To obtain about **40 percent** cumulative electric power installed capacity from **non-fossil fuel** based energy resources by **2030** with the help of transfer of technology and low cost international finance including from Green Climate Fund (GCF).
- Reduce the **emissions intensity** of GDP by 33 to 35 percent by 2030 from its 2005 level.

We simulate three future climate policy scenarios, based on India's Paris pledge

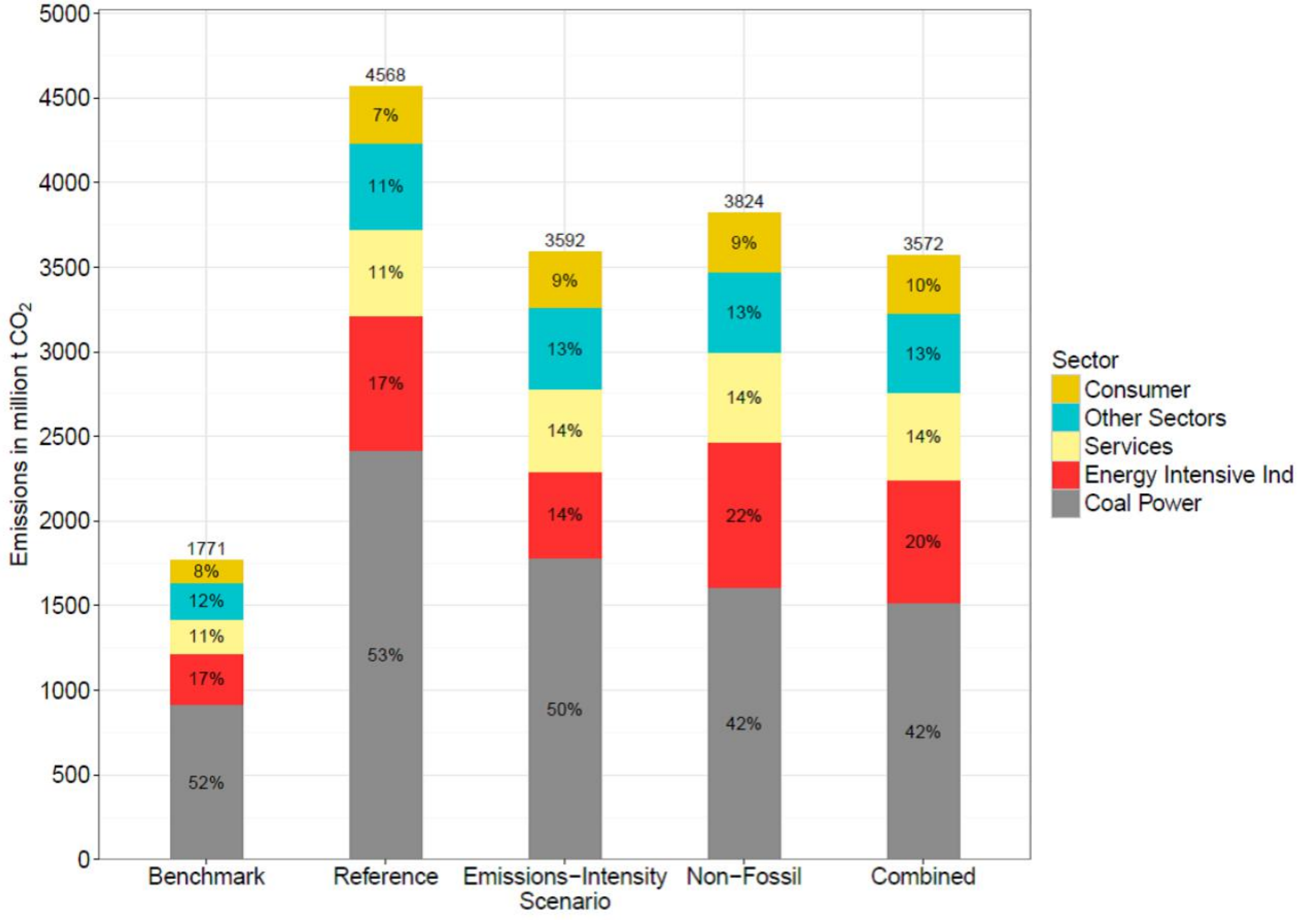


Figure 4. Emissions by sector in 2030 under different scenarios.

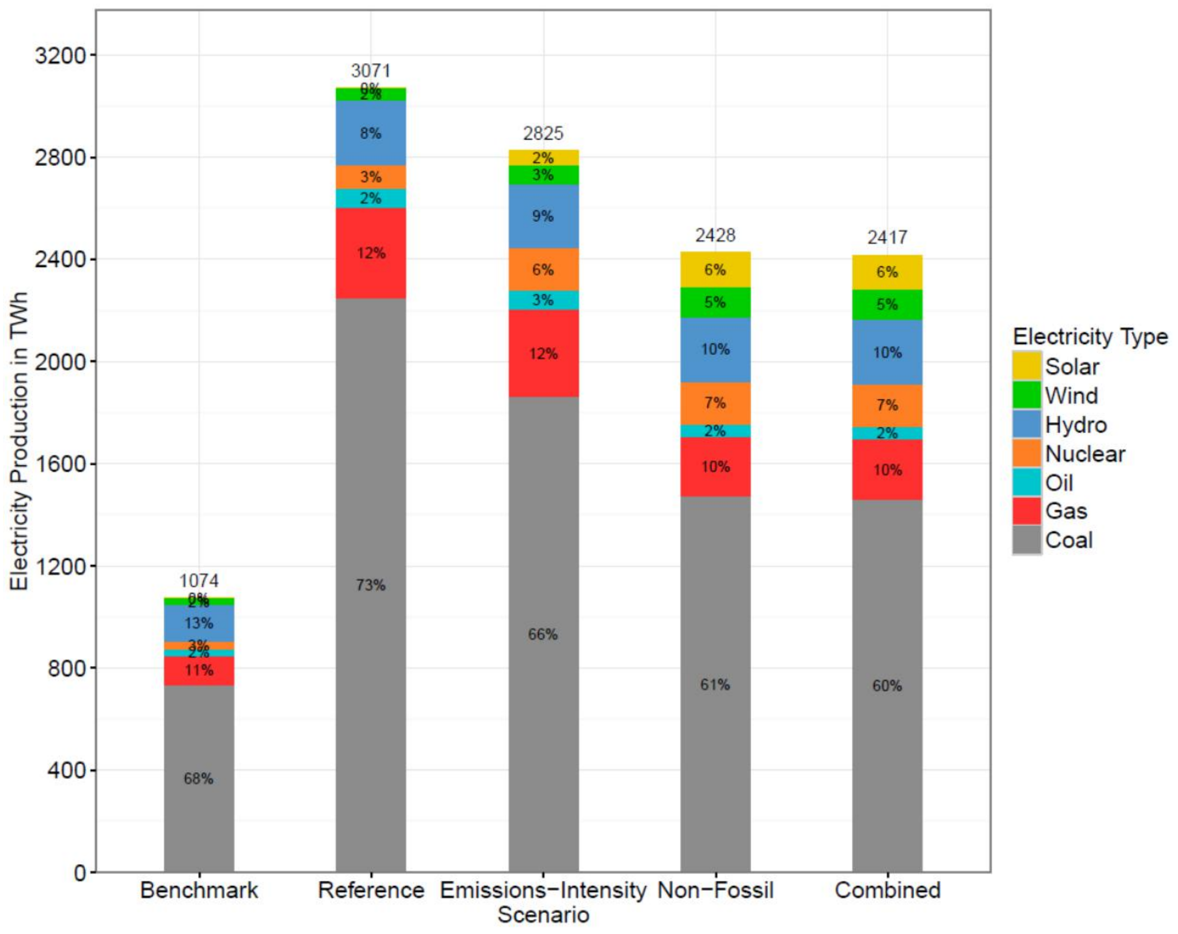


Figure 5. Electricity mix in India in 2030 under different scenarios.

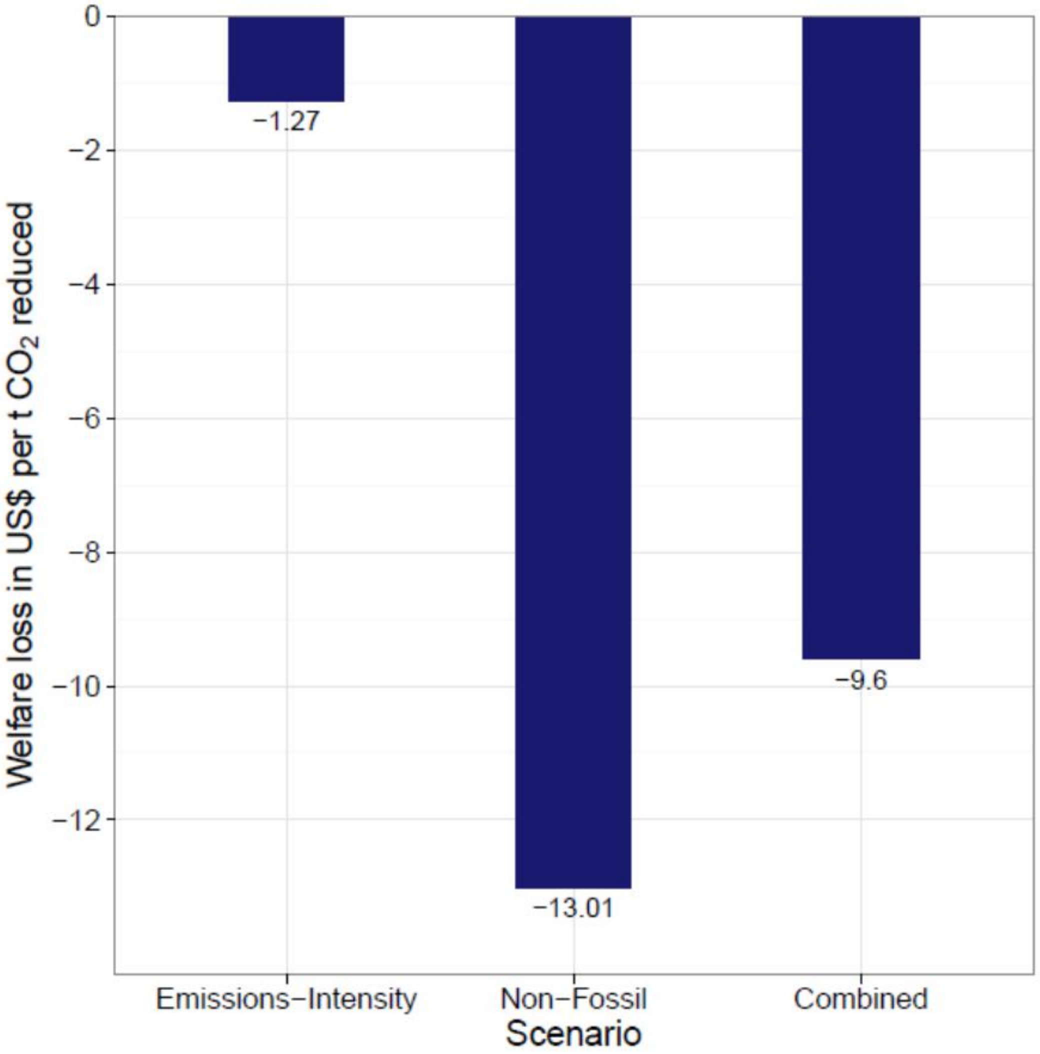
Emissions-Intensity Scenario: Economy-wide **carbon price** that reduces **emissions intensity** of GDP by 30% in 2030

Non-Fossil: An RPS that forces non-fossil electricity sources to comprise 28% of electricity production in 2030

Combined: A combination of both the Emission-Intensity and Non-Fossil Scenarios

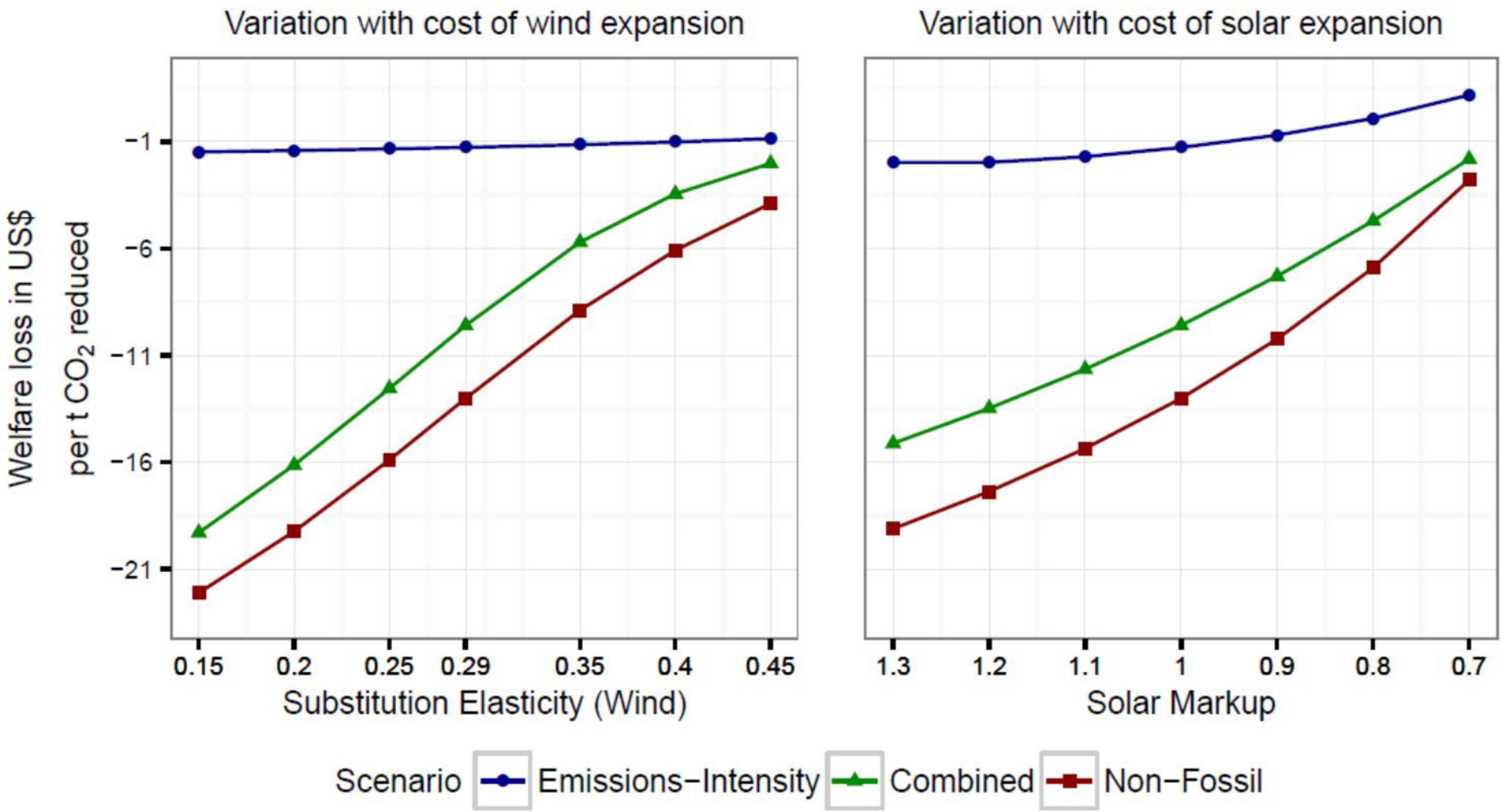
Source: Singh et al., 2019, *Climate Change Economics*.

An economy-wide CO_2 price is far less costly per ton CO_2 reduced, compared to non-fossil electricity targets



Source: Singh et al., 2019, *Climate Change Economics*.

However, policy comparison depends on assumptions about the relative cost of targeted energy sources (renewables)



Source: Singh et al., 2019, *Climate Change Economics*.

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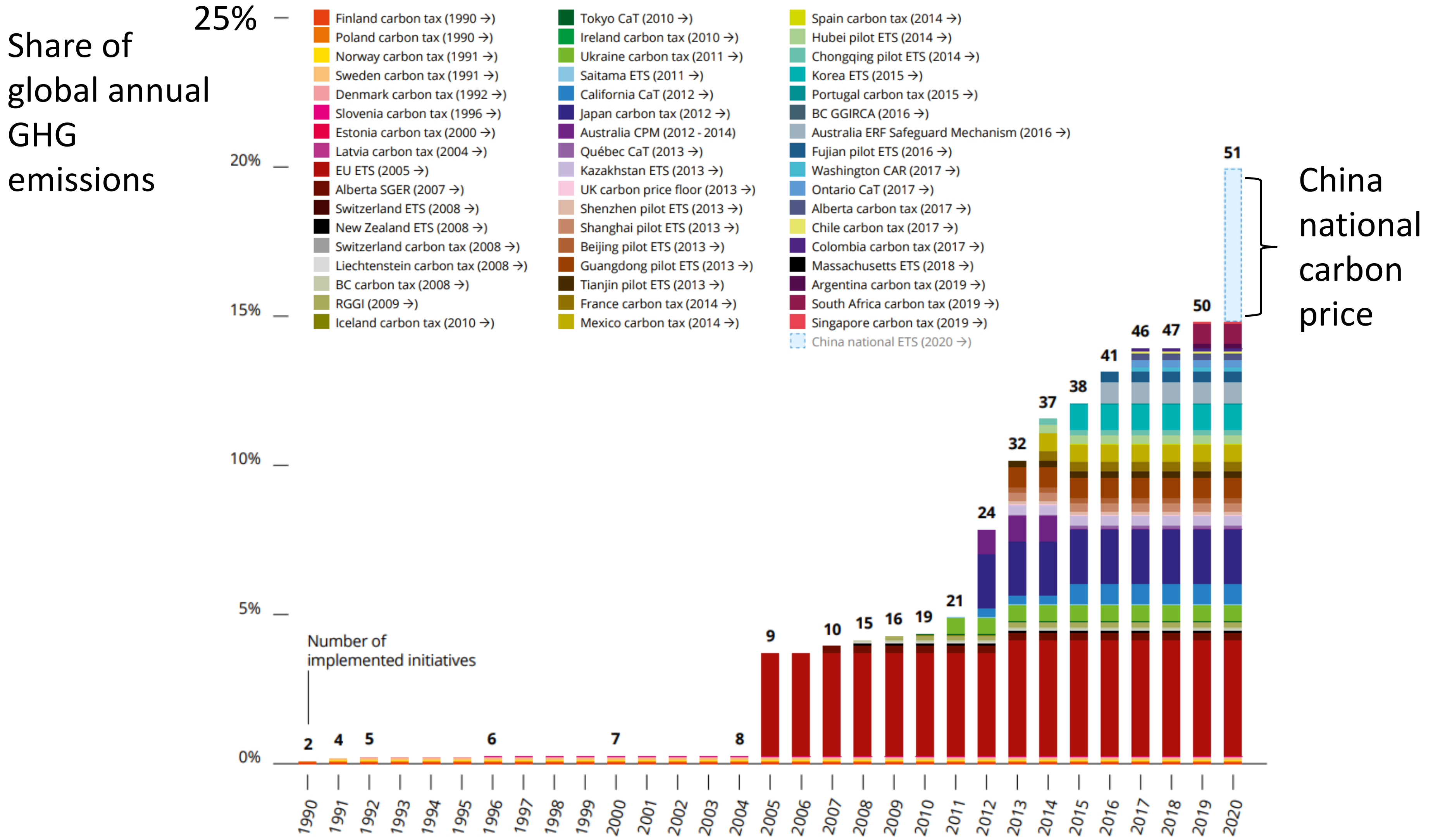
A carbon price in China would increase the share of global emissions under CO_2 pricing from 15% to 20%



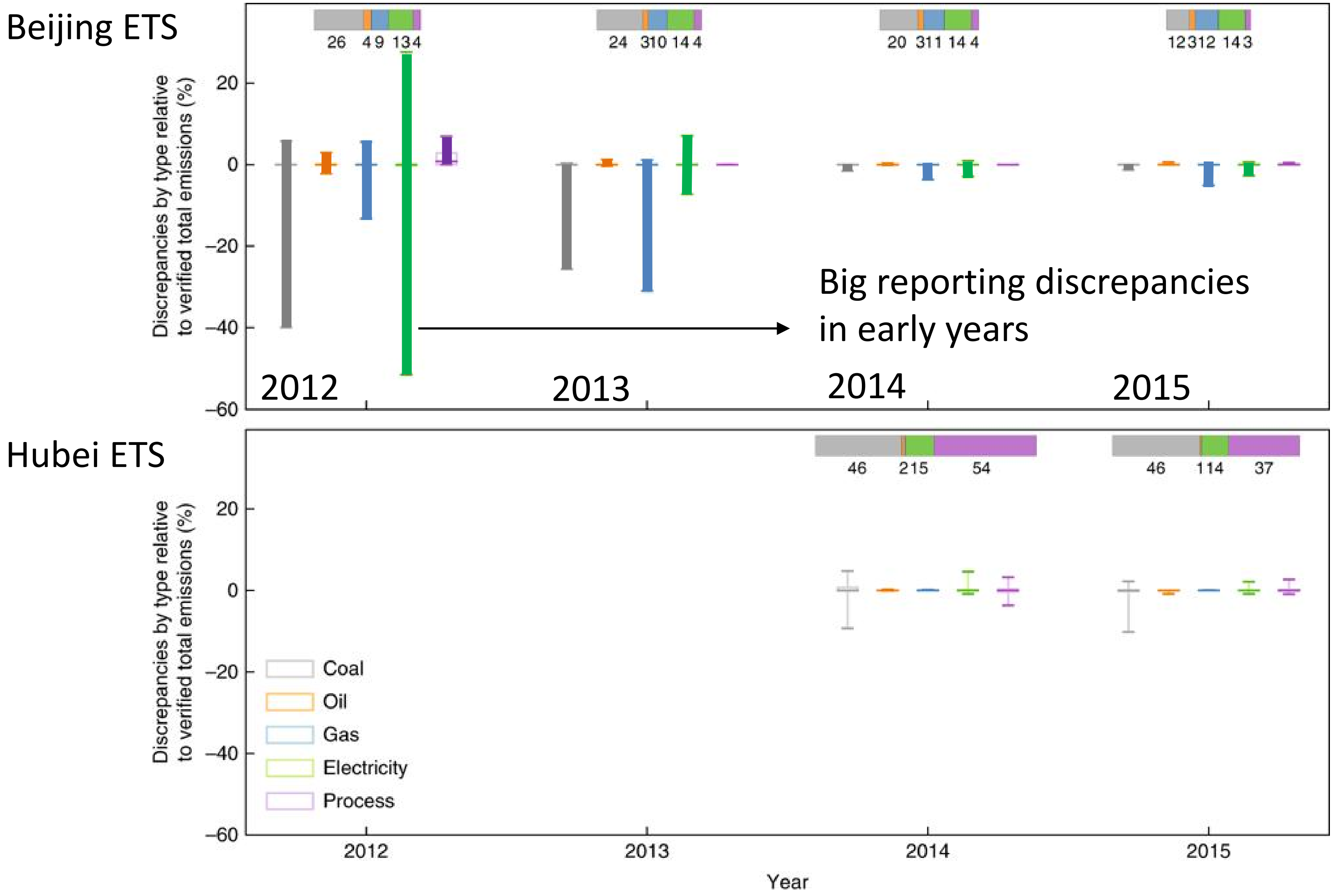
Source: World Bank, 2018.

At full scale China's ETS will cover ~7,000 large enterprises in energy-intensive sectors (>10,000 tce / >20,000 t CO_2)

Industry	Code	Main Products
Petrochemicals	2511 2614	Refined oil products Ethylene
Chemicals	261 262 263 265	Calcium carbide Synthetic ammonia Methanol Other
Building materials	3011	Cement clinker
	3041	Plate glass
Iron and Steel	3120 3140	Crude steel Steel rolling & processing
Non-ferrous metal processing	3216	Aluminum electrolysis
	3211	Copper smelting
Pulp & paper	2211 2212 2221	Pulp Paperboard
Electricity	4411	Power generation Power and heat co-generation
	4420	Electricity grid
Aviation	5611 5612 5631	Passenger air transport Cargo air transport Airports

Source: Tsinghua University, 2016.

Evidence from China's CO_2 emissions trading pilots: Firms need time to build emissions reporting capabilities



Based on firm-level CO_2 emissions accounting data for China's pilot emissions trading systems.

Source: Zhang et al., 2019, *Nature Climate Change*. (Karplus & Zhang Groups Collaborative Research)

Thank you!

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