Toxic Air Pollution as a Sustainability Challenge

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India air pollution at 'unbearable levels', Delhi minister says

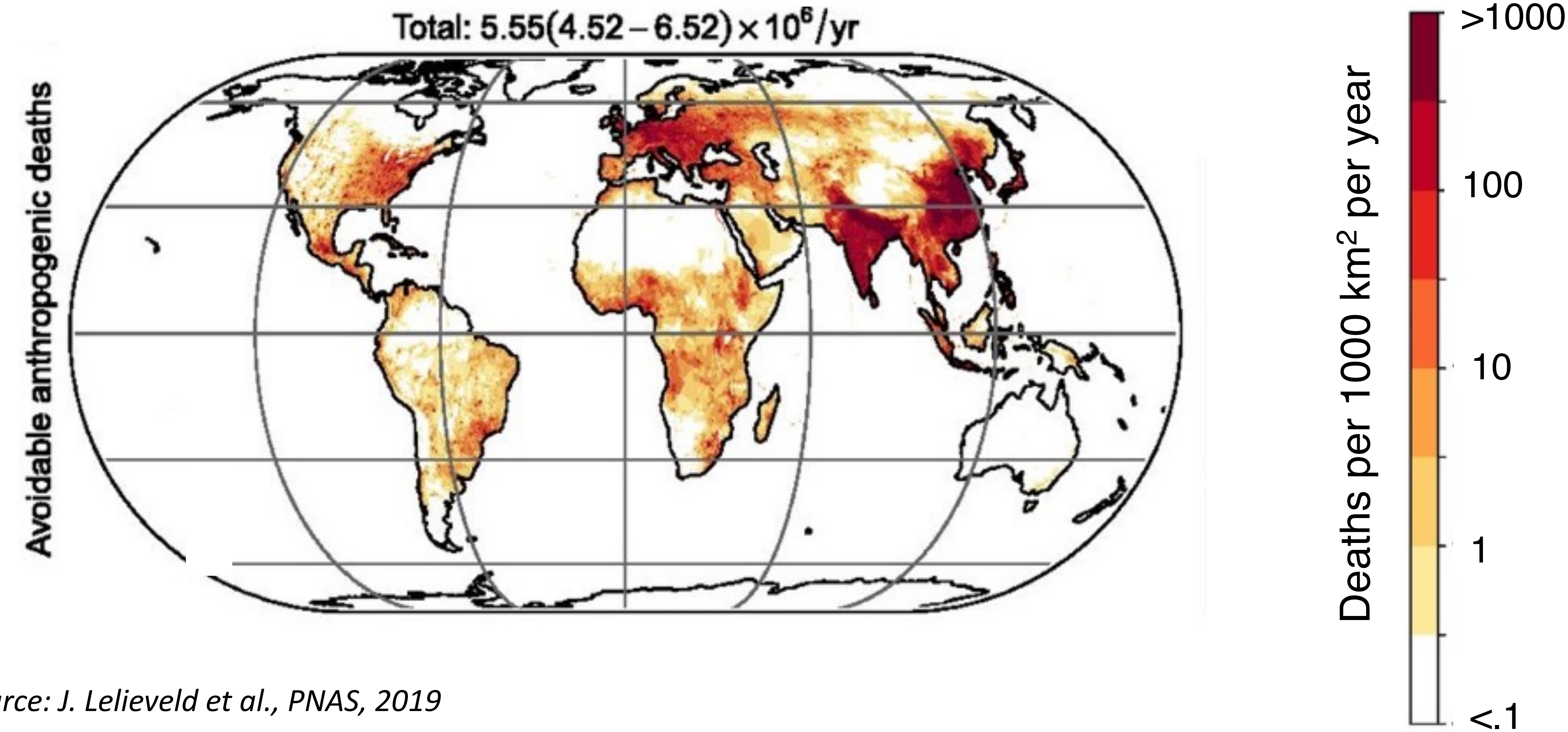
4 November 2019

Share

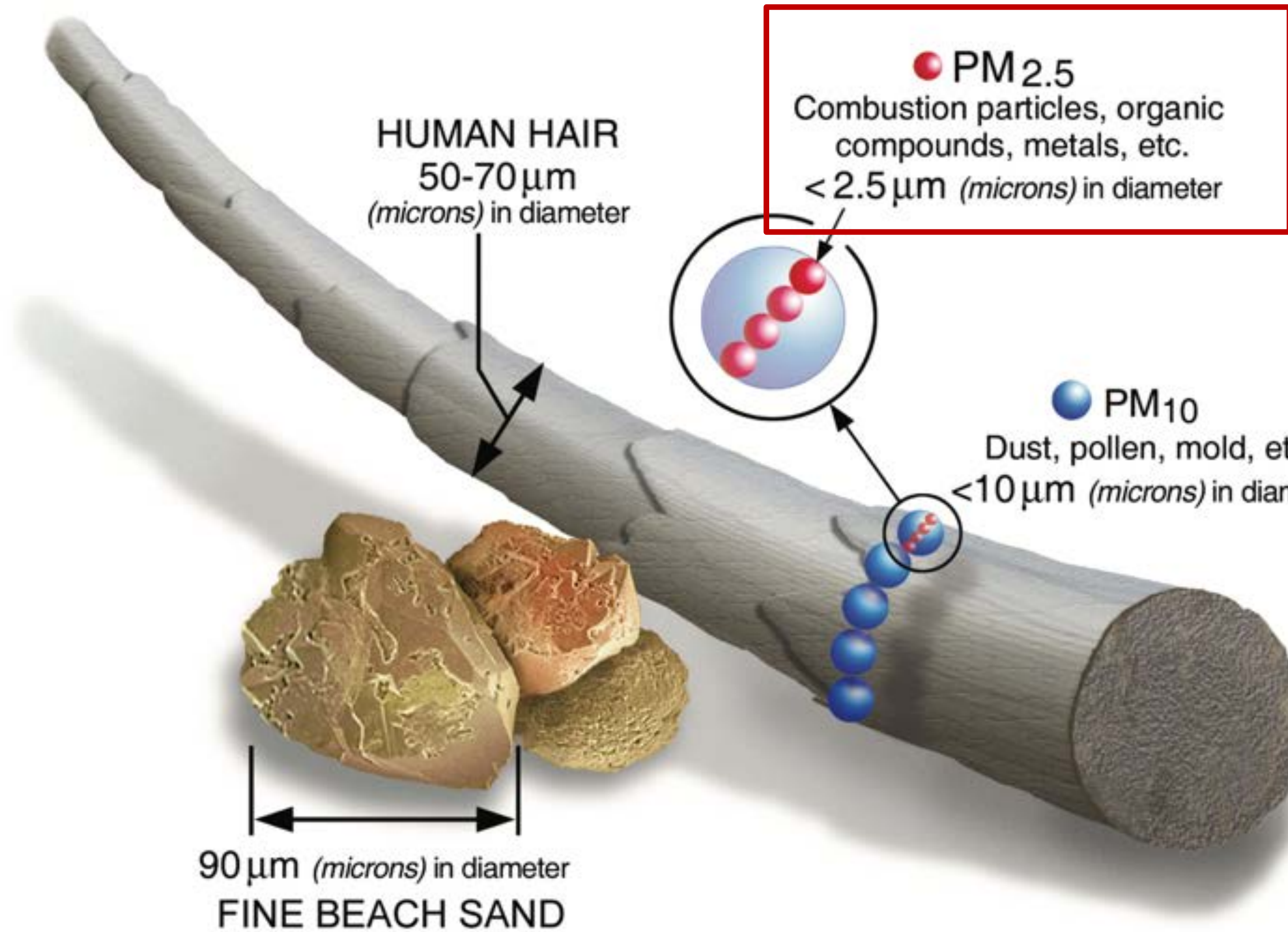
Air quality in Delhi has deteriorated into the "hazardous" category

Air pollution in the north of India has "reached unbearable levels," the capital Delhi's Chief Minister Arvind Kejriwal says.

Avoidable deaths from human emissions



Source: J. Lelieveld et al., PNAS, 2019



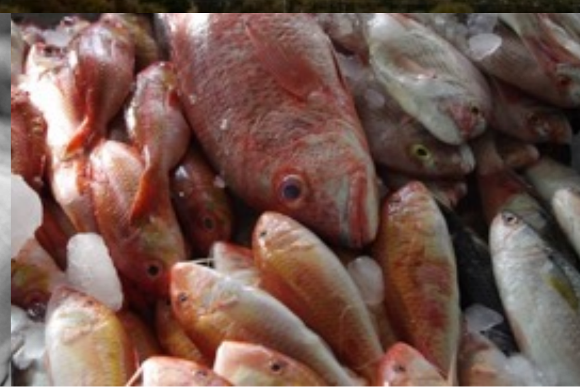
Emitted directly and formed in the atmosphere (non-linear chemical reactions)

Source: US EPA

Mercury: A long-lived toxic air pollutant

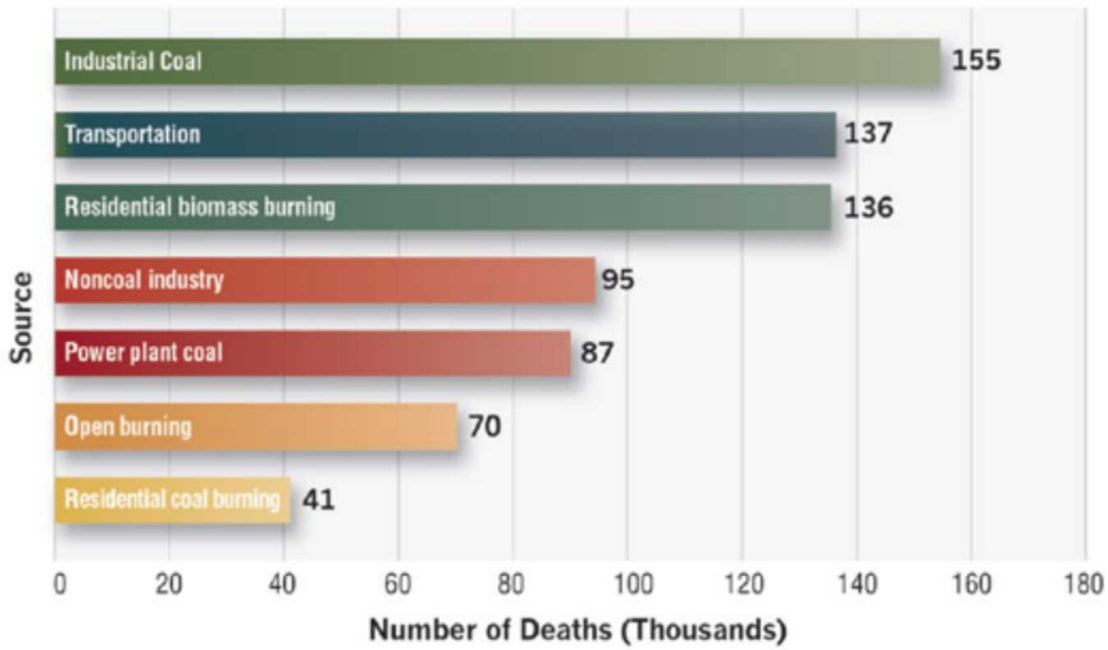

Flickr/JonPinder cc


Photo: W. Eugene Smith

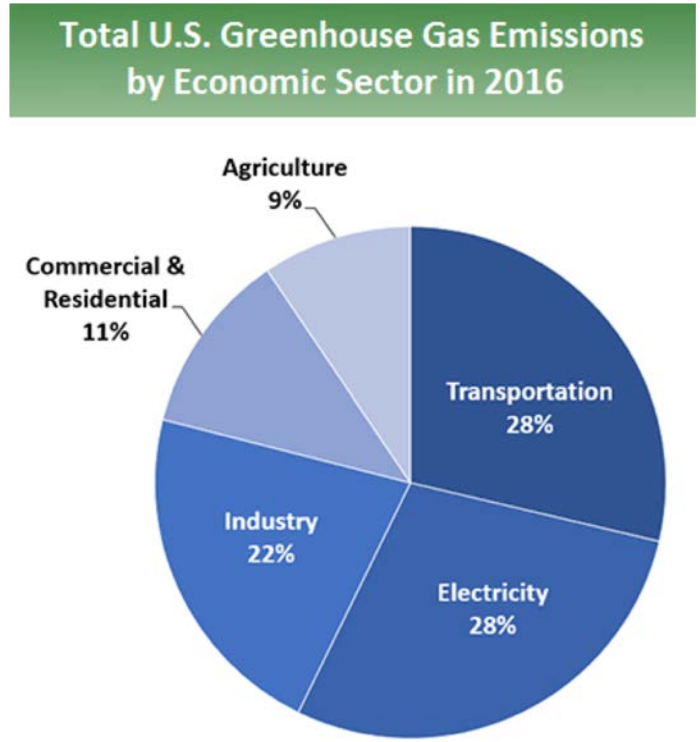


Air pollution and greenhouse gases come from common sources

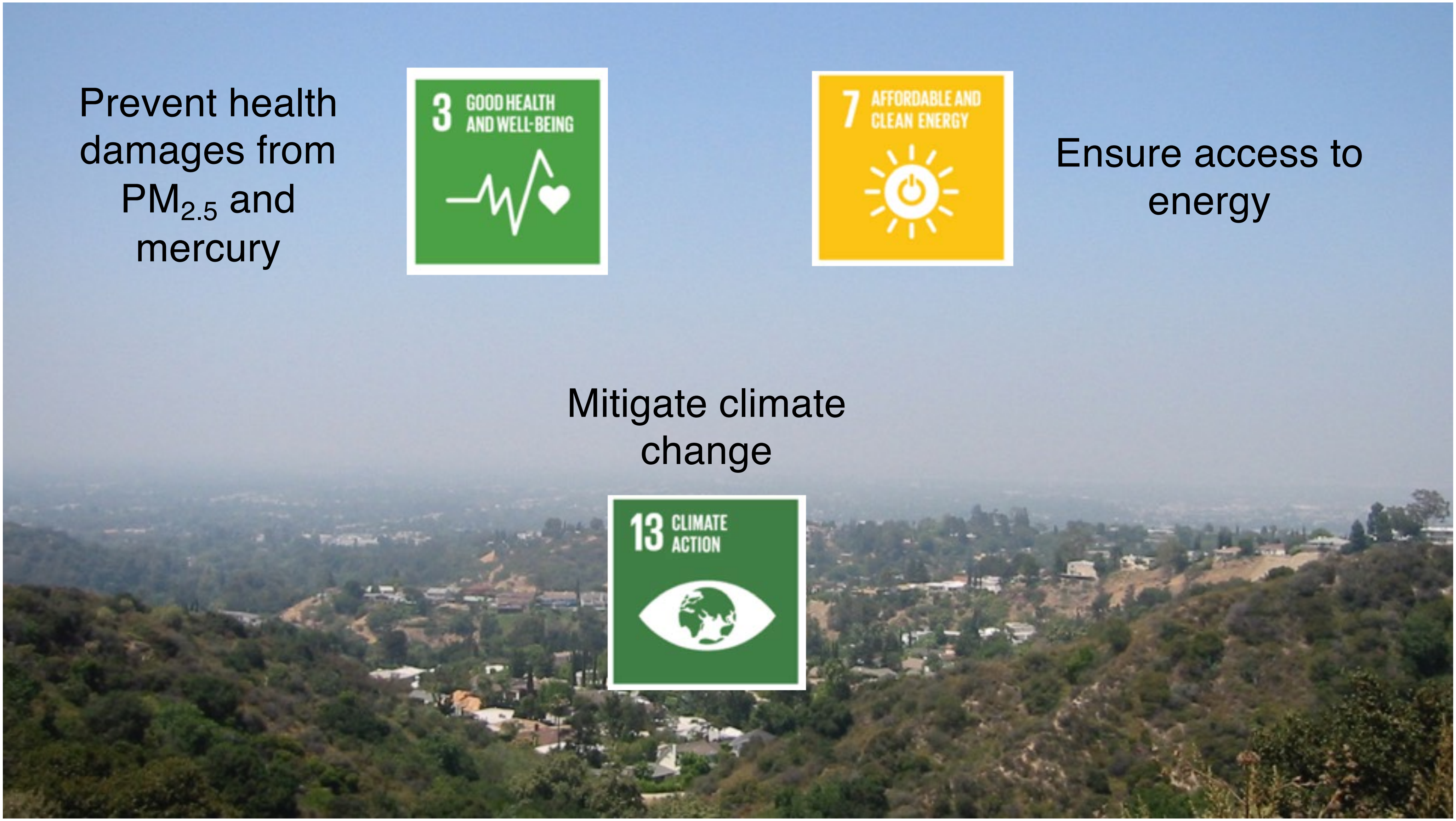
Source contributions to air pollution mortality in China



Source: HEI, 2018



Source: US EPA


Prevent health damages from $PM_{2.5}$ and mercury
3 GOOD HEALTH AND WELL-BEING
7 AFFORDABLE AND CLEAN ENERGY
Ensure access to energy
Mitigate climate change
13 CLIMATE ACTION


SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
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5 GENDER EQUALITY
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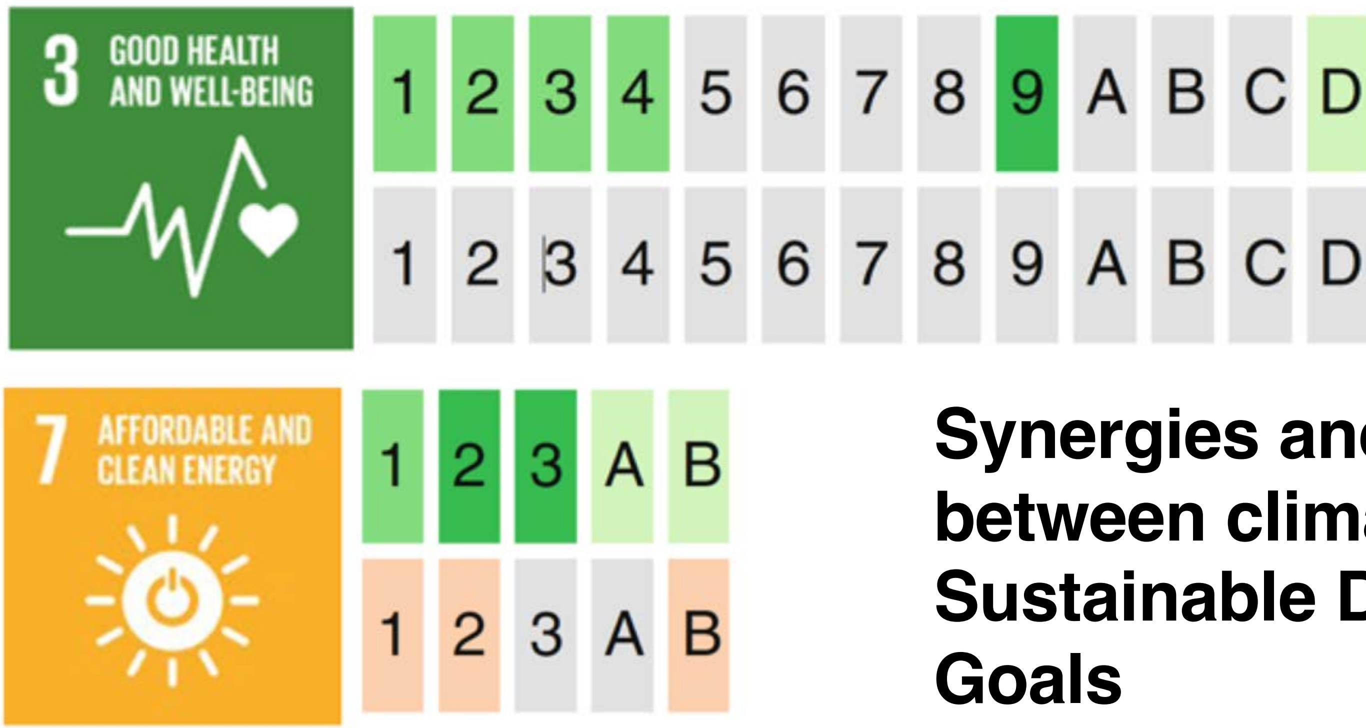
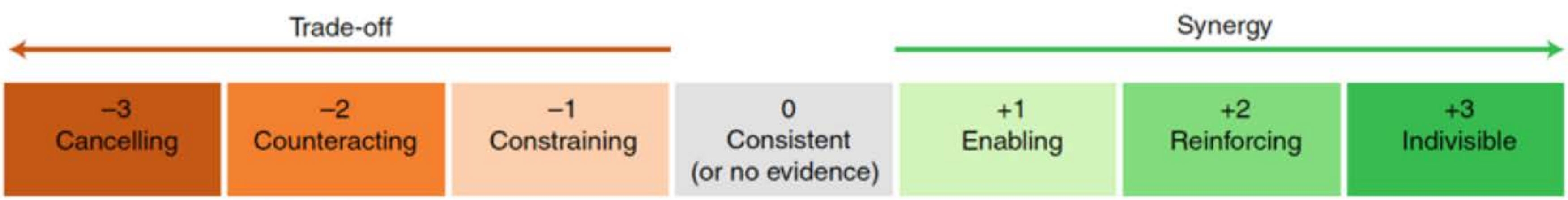
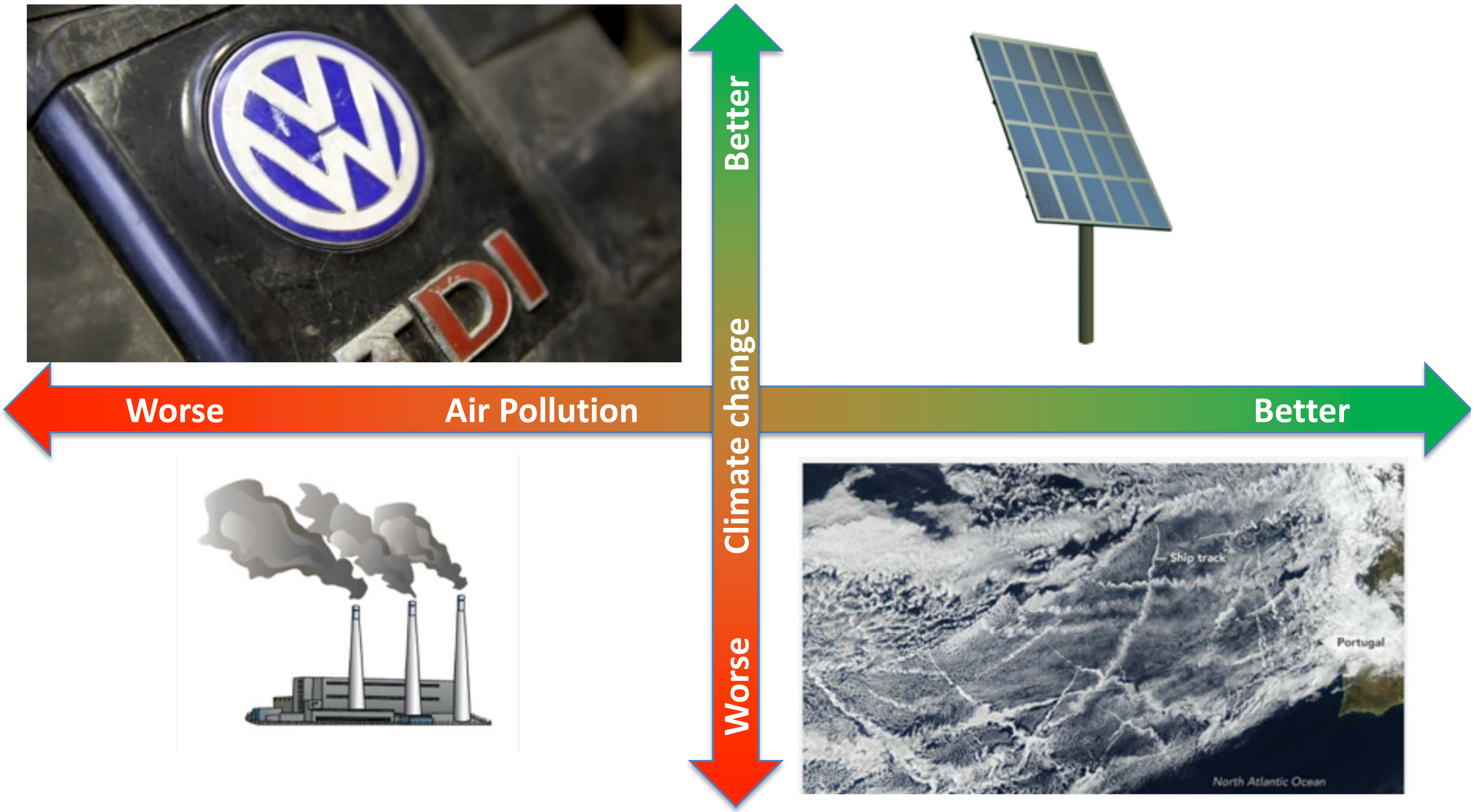
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS



Synergies and trade-offs between climate action and Sustainable Development Goals



Nerini et al., *Nature Sustainability,* 2019



TDI
Better
Climate change
Worse
Worse
Air Pollution
Better
Ship track
Portugal
North Atlantic Ocean

Questions

1. How do policies and strategies interact, and can they achieve multiple sustainability goals simultaneously?

2. How can engineering research inform practical actions towards sustainability?

A Systems Approach to Informing Sustainability Challenges

Environment

Technologies

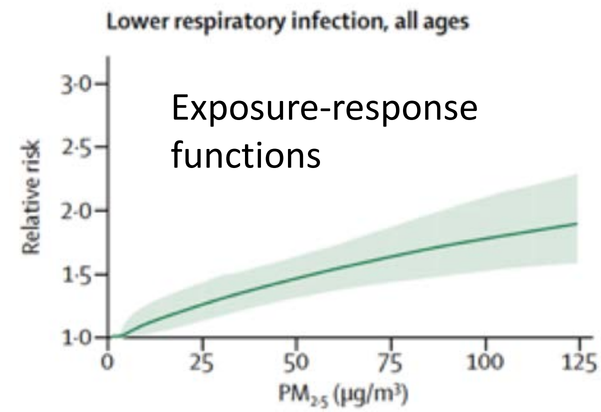
People

Institutions &
Policies

A Systems Approach to Informing Sustainability Challenges

Regional and global-scale climate and atmospheric chemistry models

Figure: http://bit.ly/2K7gvIt,



Exposure-response functions

Figure: Cohen et al., 2017

Emissions inventories and technology options

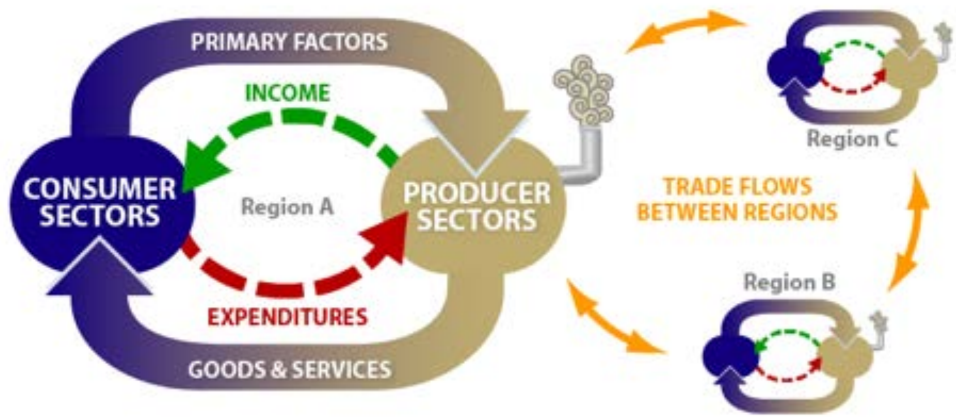


Figure: MIT EPPA Model

Policy context, production-consumption, and monetary flows

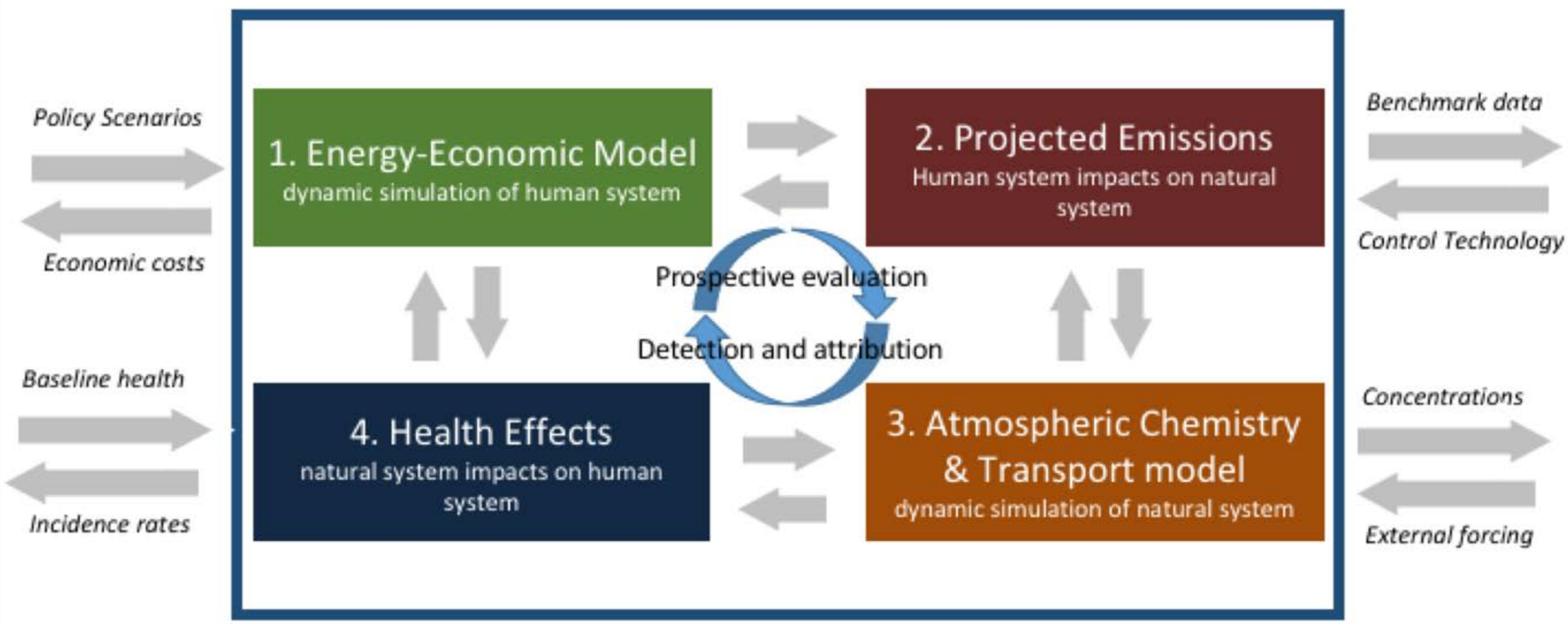
Mingwei Li, PhD 2019,
MIT Department of
Earth, Atmospheric, and
Planetary Sciences
(now postdoc, Princeton)

M. Li, D Zhang, C. T. Li, K. M. Mulvaney, N. E. Selin, and V. J. Karplus. 2018. "Air Quality Co-Benefits of Carbon Pricing in China." Nature Climate Change, 8:398-403.

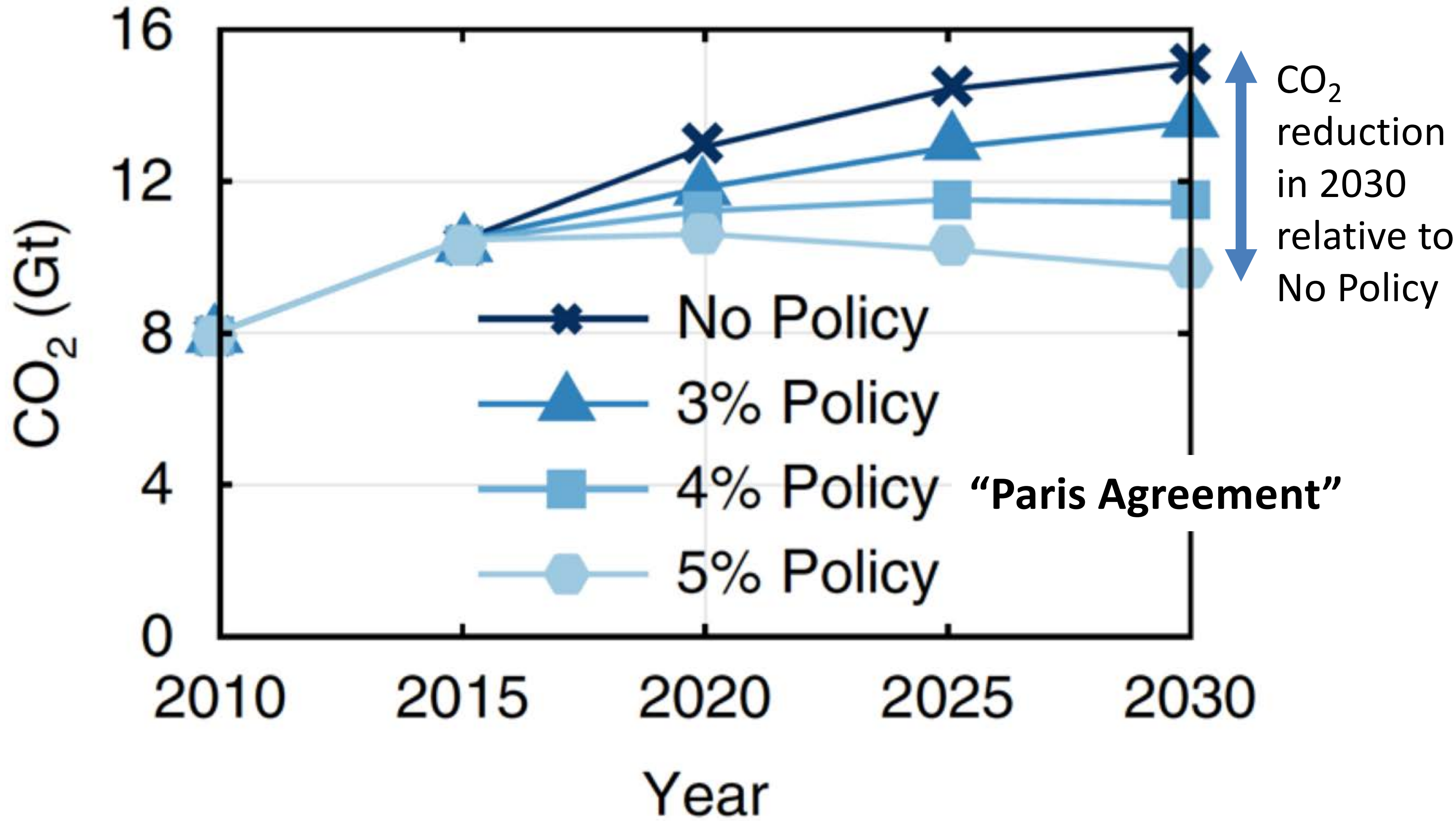
How will China's Paris Agreement commitments affect air pollution?

A Systems Approach to Informing Sustainability Challenges

REACH (Regional Emissions, Air Quality, Climate and Health) framework

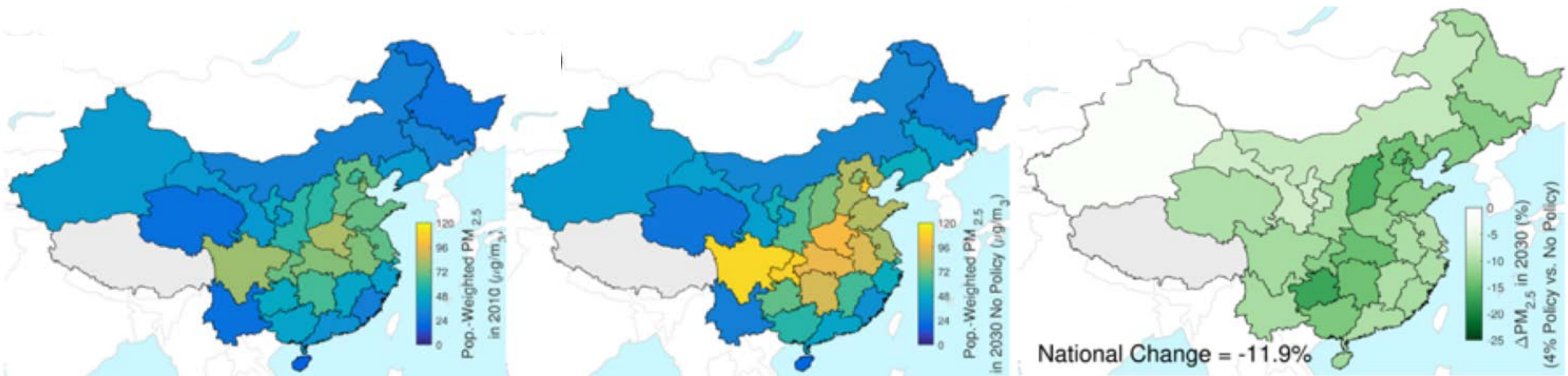


CO_2 emissions from China: scenarios



Paris Agreement has air pollution benefits

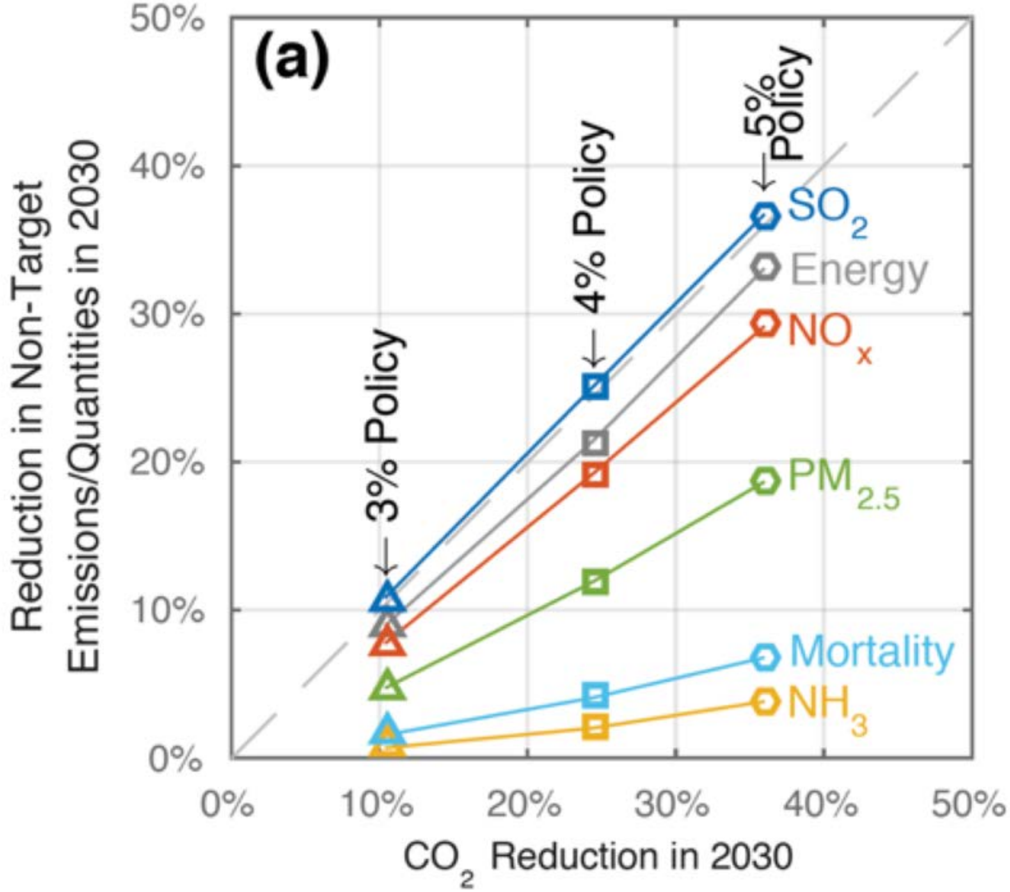
2010 **2030: No Policy** **Policy: % Change**



-11.9% population-weighted concentration of $PM_{2.5}$

95,000 premature deaths avoided

$PM_{2.5}$ impacts as a function of CO_2 intensity reductions in China

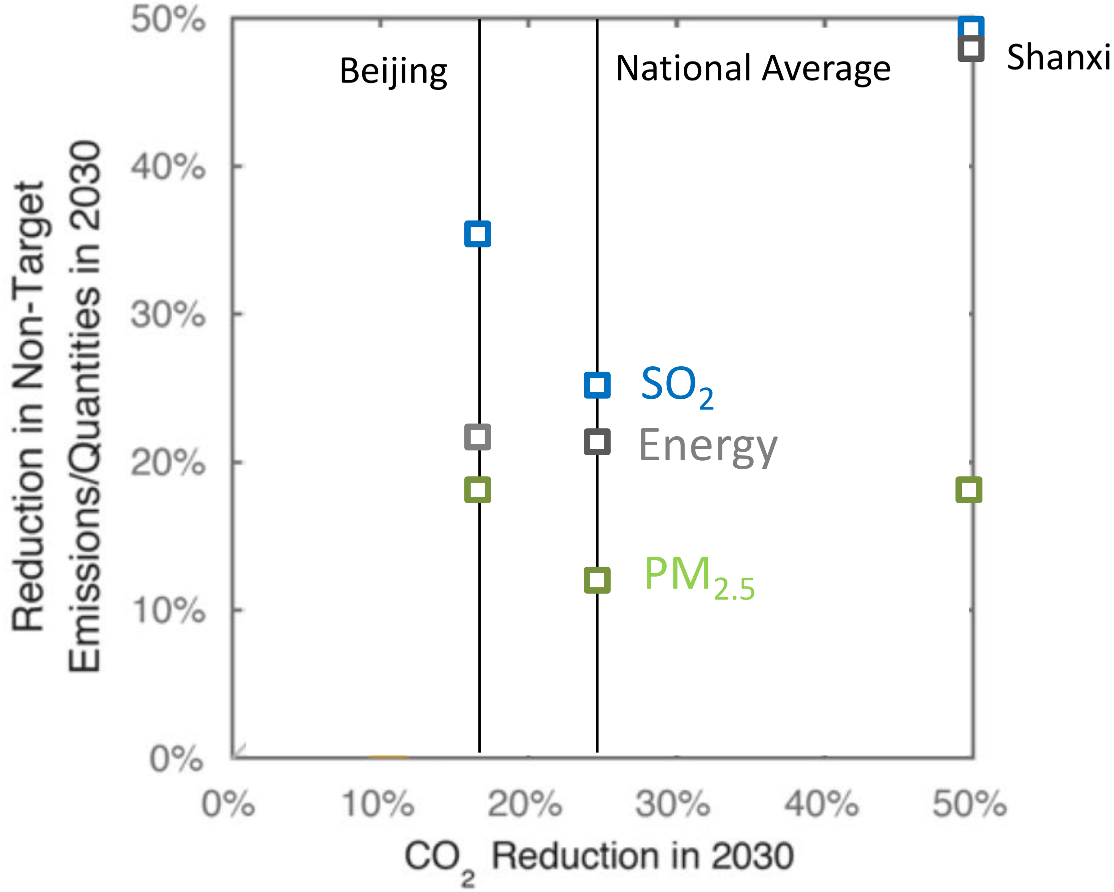


(relative to no policy)

SO_2, NO_x, NH_3 combine in the atmosphere to form $PM_{2.5}$. The chemical process can be non-linear.

$PM_{2.5}$ also has non-anthropogenic sources that contribute to **mortality.**

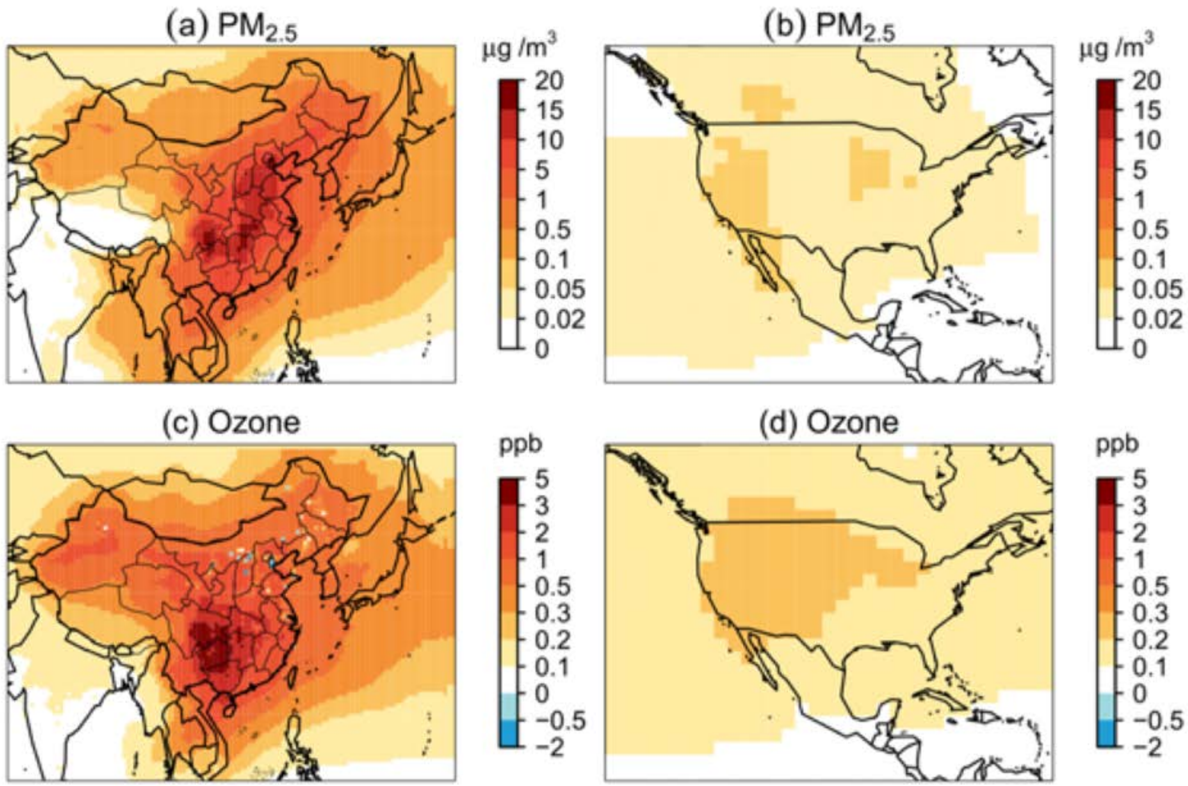
Provincial impacts differ from the national average (4% policy)



Beijing: low-cost CO_2 abatement opportunities also reduce SO_2 emissions via **economics**

Shanxi: coal producer
Reductions in SO_2 do not translate into $PM_{2.5}$ due to **non-linear chemistry**

Reduced pollution and mortalities from Chinese climate policy



Mortalities avoided:

China: 95,200
Korea: 1,000
Japan: 2,000
US: 600

China: 54,300
Korea: 300
Japan: 1,500
US: 1,300

For comparison: U.S. Cross-state Air Pollution Rule (2016) avoids roughly 20 mortalities from ozone.

M. Li, D. Zhang, C.-T. Li, N. E. Selin, and V. J. Karplus. 2019. "Co-benefits of China's climate policy for air quality and human health in China and transboundary regions in 2030." Environmental Research Letters, 14, 084006.

Emil Dimanchev,
M.S. In Technology and Policy, MIT, 2018

E. Dimanchev, S. Paltsev, M. Yuan, D. Rothenberg, C. Tessum, J. Marshall, and N. E. Selin. 2019. "Health co-benefits of sub-national renewable energy policy in the U.S." Environmental Research Letters, 14, 085012.

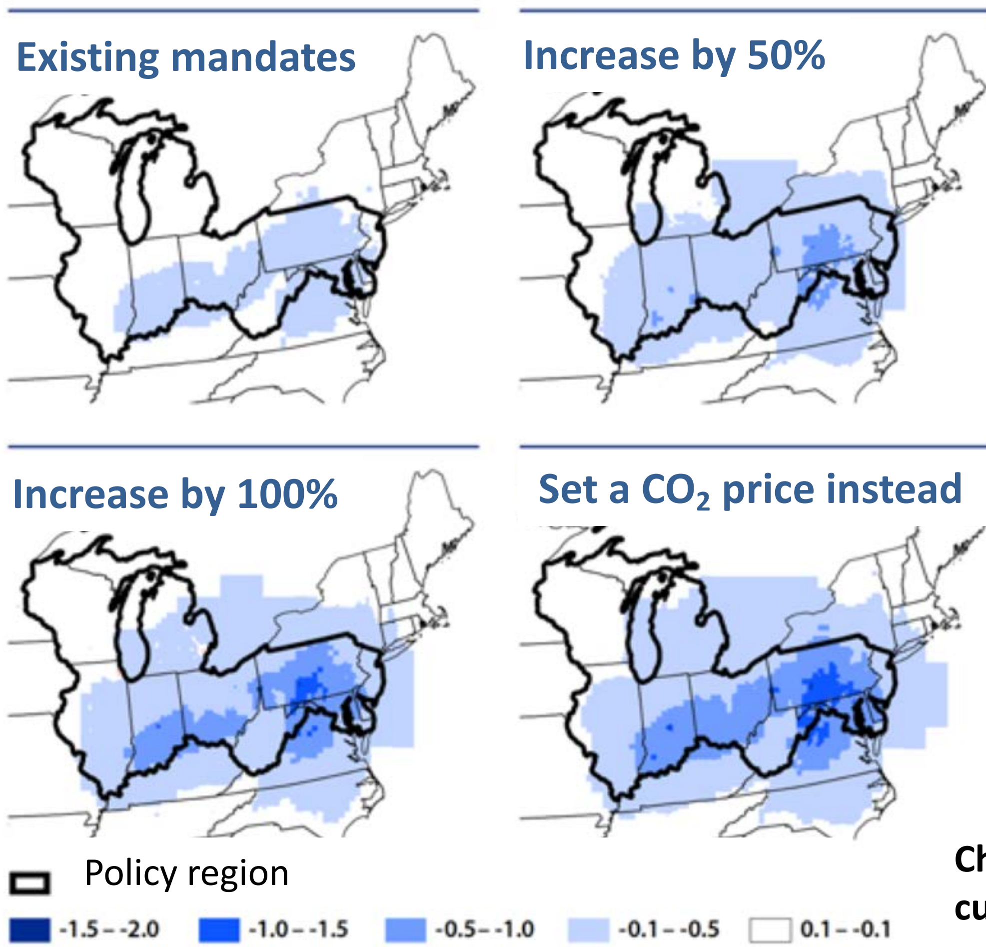
What about in the US? Will renewable energy policies benefit air pollution?

$PM_{2.5}$ impacts of renewable energy policies in Midwest U.S.

13% renewables

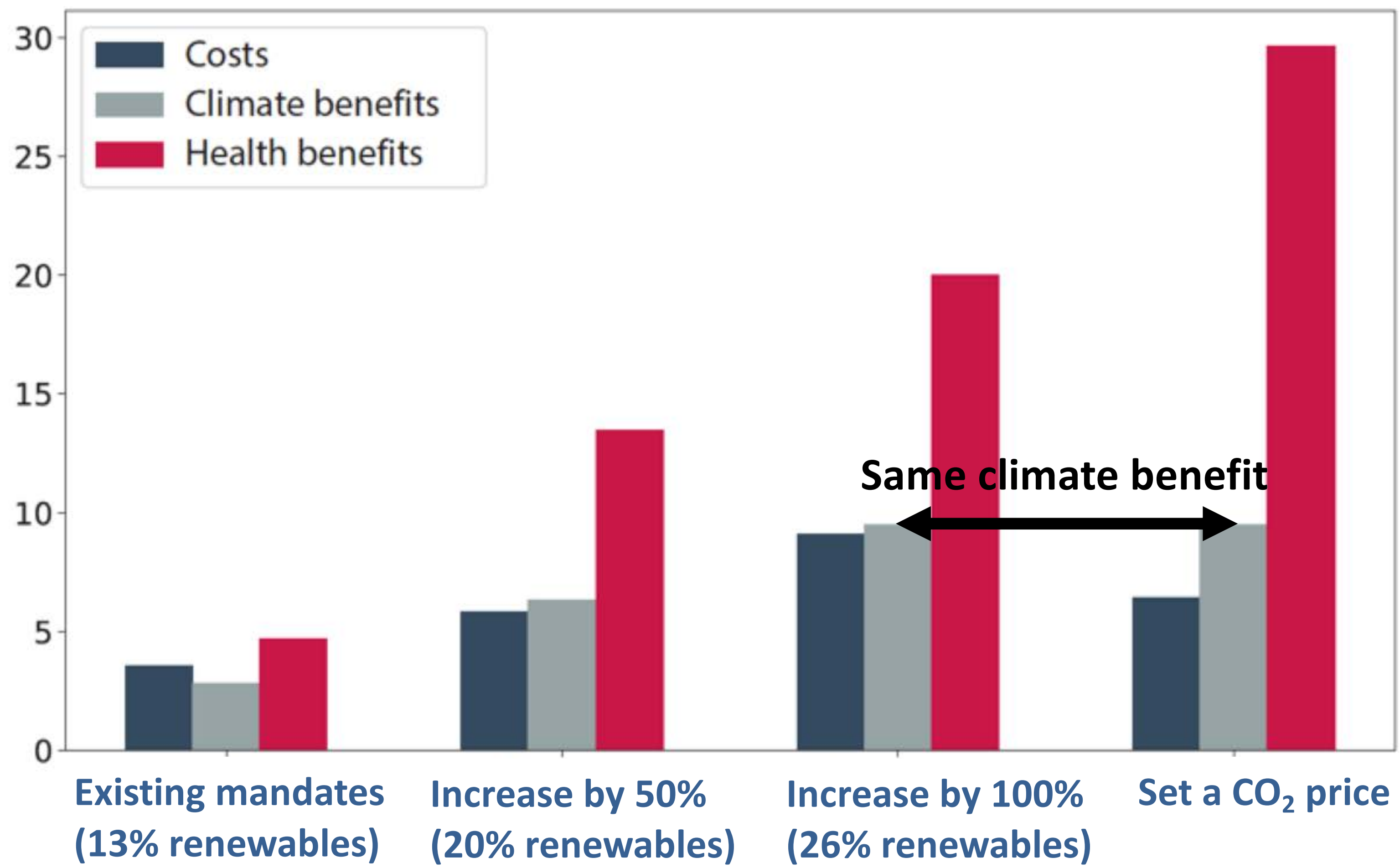
20% renewables

26% renewables



Change in $PM_{2.5}$, micrograms per cubic meter, relative to no policy case

Costs and benefits ($US billions, relative to no policy)

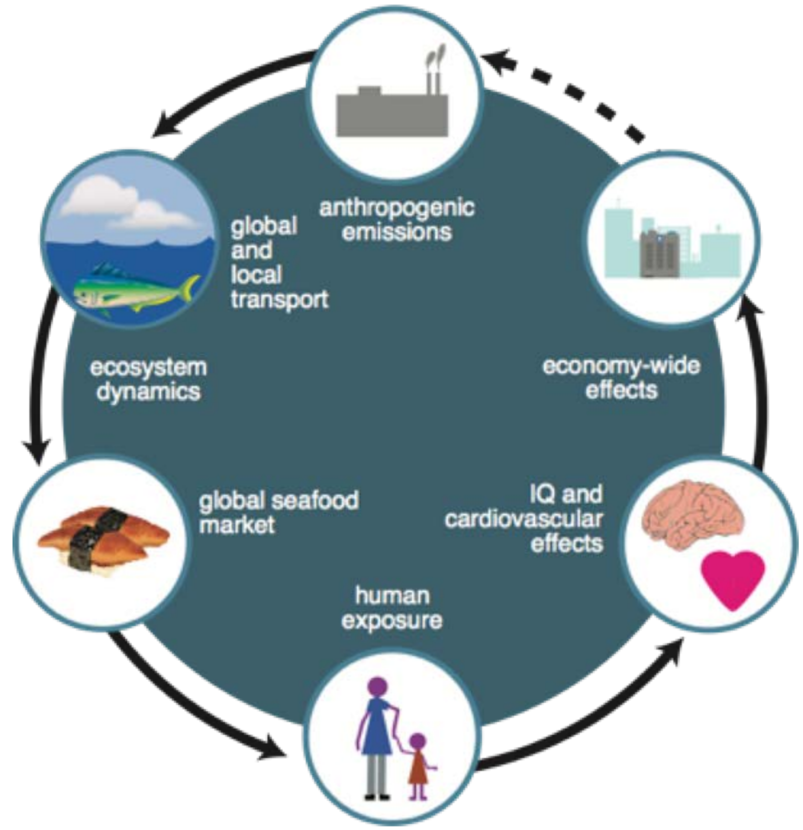


Amanda Giang, PhD ‘17 Engineering Systems, MIT, now Assistant Professor, University of British Columbia

A. Giang and N.E. Selin, 2016. “Benefits of Mercury Controls for the United States,” Proceedings of the National Academy of Sciences, 113(2), 286-291.

What are the benefits of reducing longer-lived air pollutants like mercury?

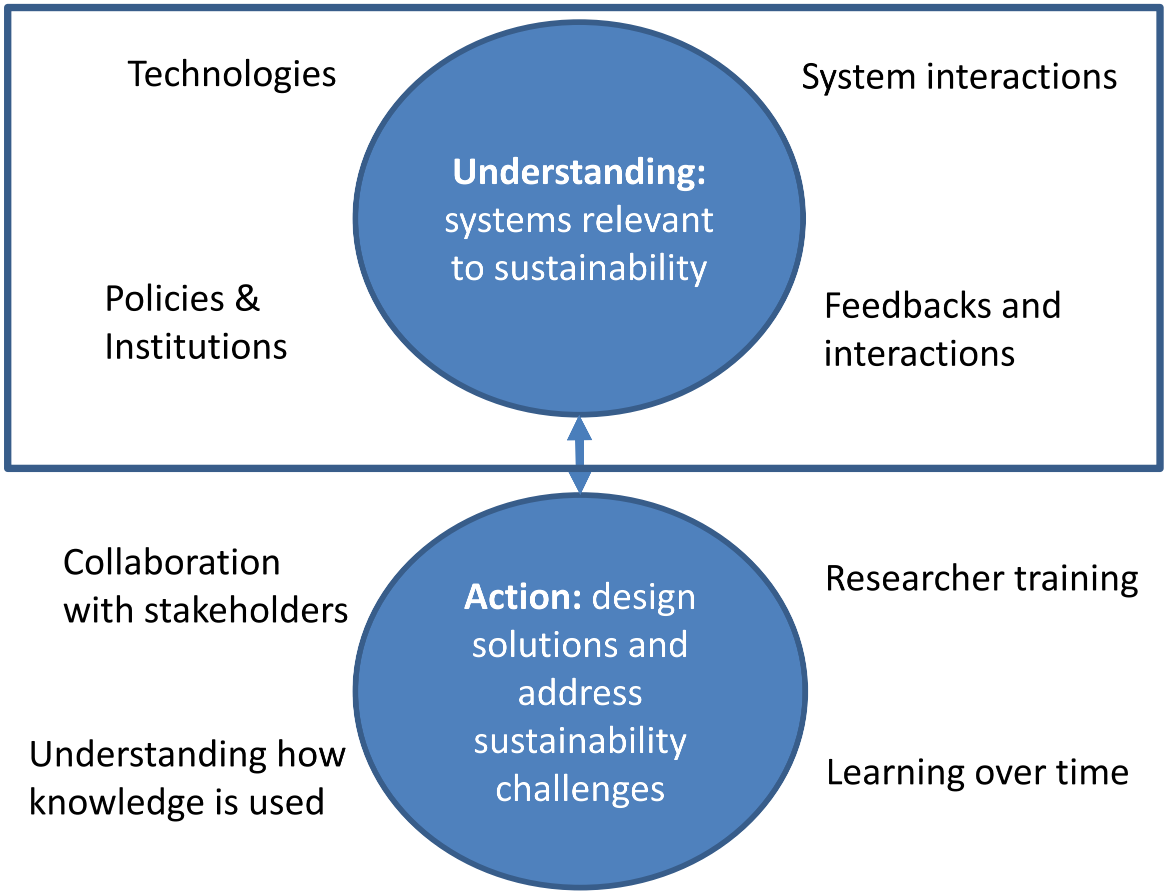
U.S. Supreme Court on the Mercury and Air Toxics Standards: “the quantifiable benefits from the resulting reduction in hazardous-air-pollutant emissions would be **$4 to $6 million** a year” (Michigan v. EPA, 2015)



Our work: benefits to 2050 estimated at **$3.7 billion/year**

Giang and Selin, 2016

Bridging understanding and action for sustainability: an engineering perspective



Adapted from Clark et al., PNAS, 2016

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Understanding how knowledge is used

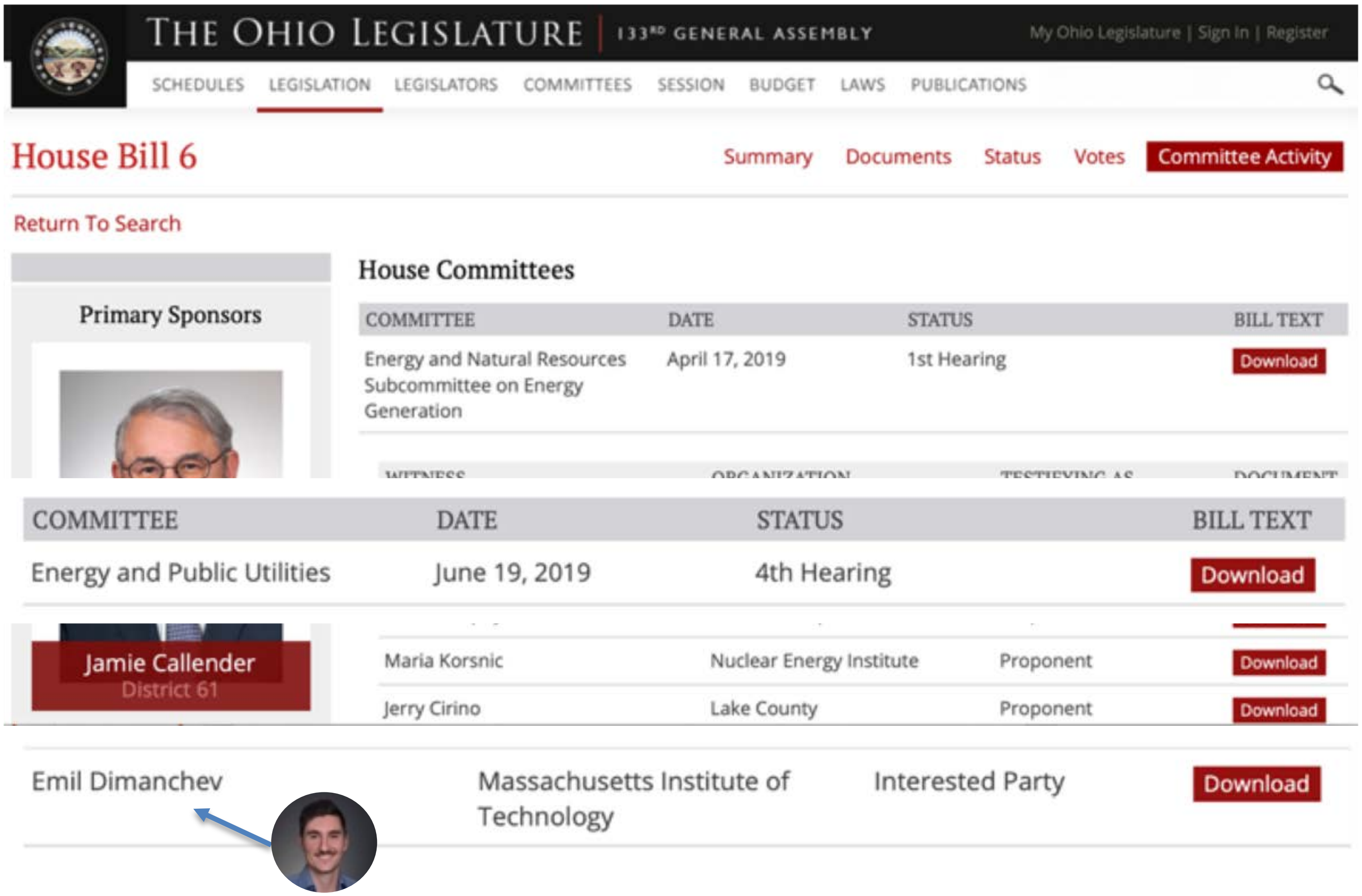
May 21, 2019, U.S. House of Representatives

U.S. efforts to roll back Mercury and Air Toxics Standards

Information about the benefits of policies – and cost of rolling them back – important to account for in legal and regulatory procedure.

https://energycommerce.house.gov/committee-activity/hearings/hearing-on-undermining-mercury-protections-epa-endangers-human-health

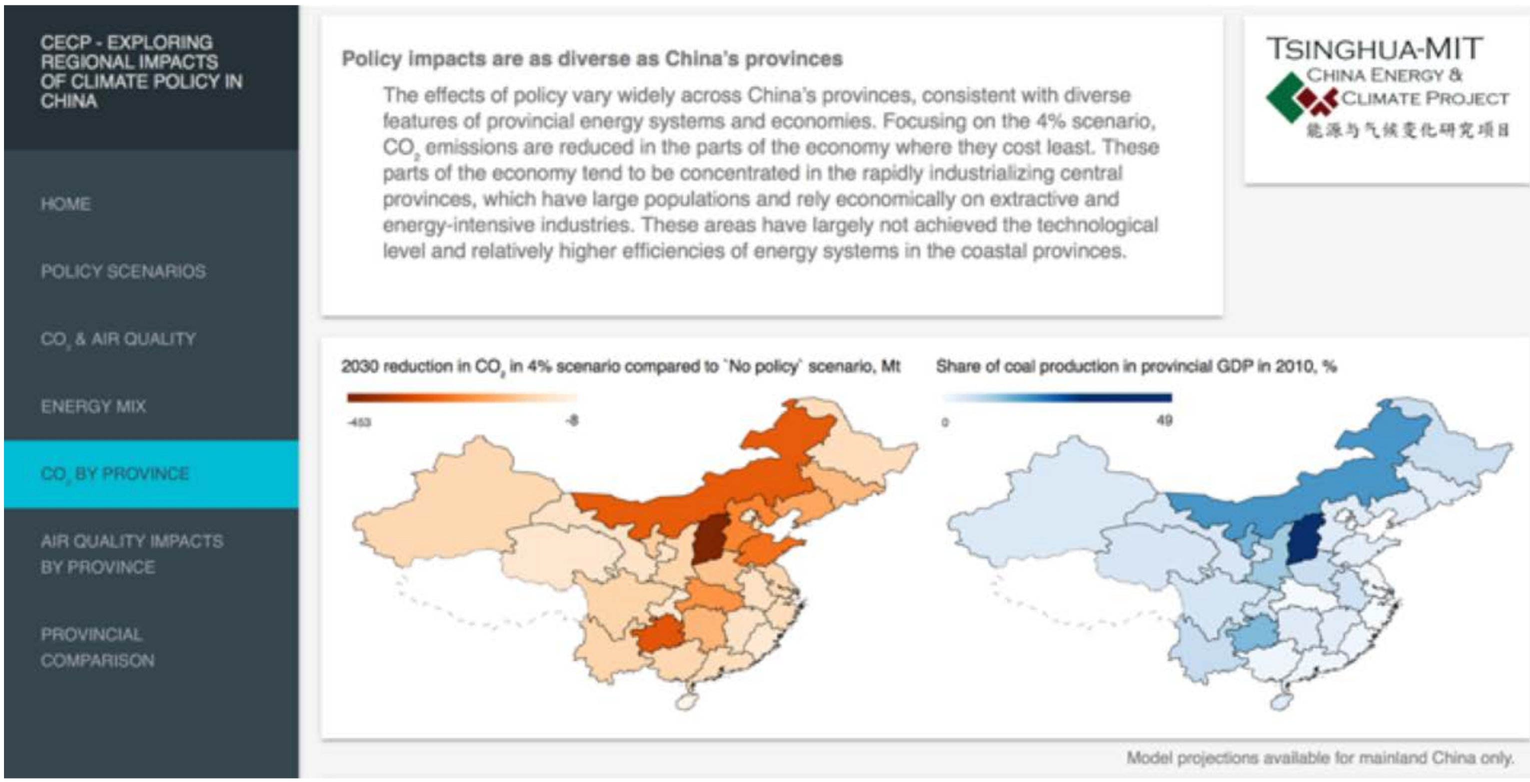
Understanding how knowledge is used



Researcher training

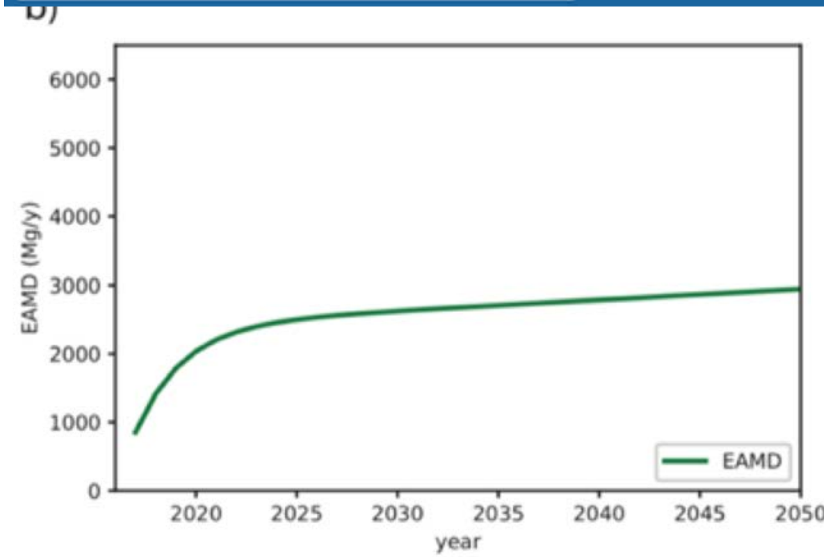
http://policylab.mit.edu

Collaboration with stakeholders



See: http://cecp.mit.edu

Learning over time



”Effective Anthropogenic Mercury Deposition,” a new metric that accounts for long-term impact of present-day emissions

N. E. Selin. 2018. "A proposed global metric to aid mercury pollution policy." Science 360(6389):607-609.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SUSTAINABLE DEVELOPMENT GOALS

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Publication links and more info at: http://mit.edu/selingroup