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The Economics of Climate Policy and Investing in Resilient Infrastructure

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Policy Director, The Hamilton Project
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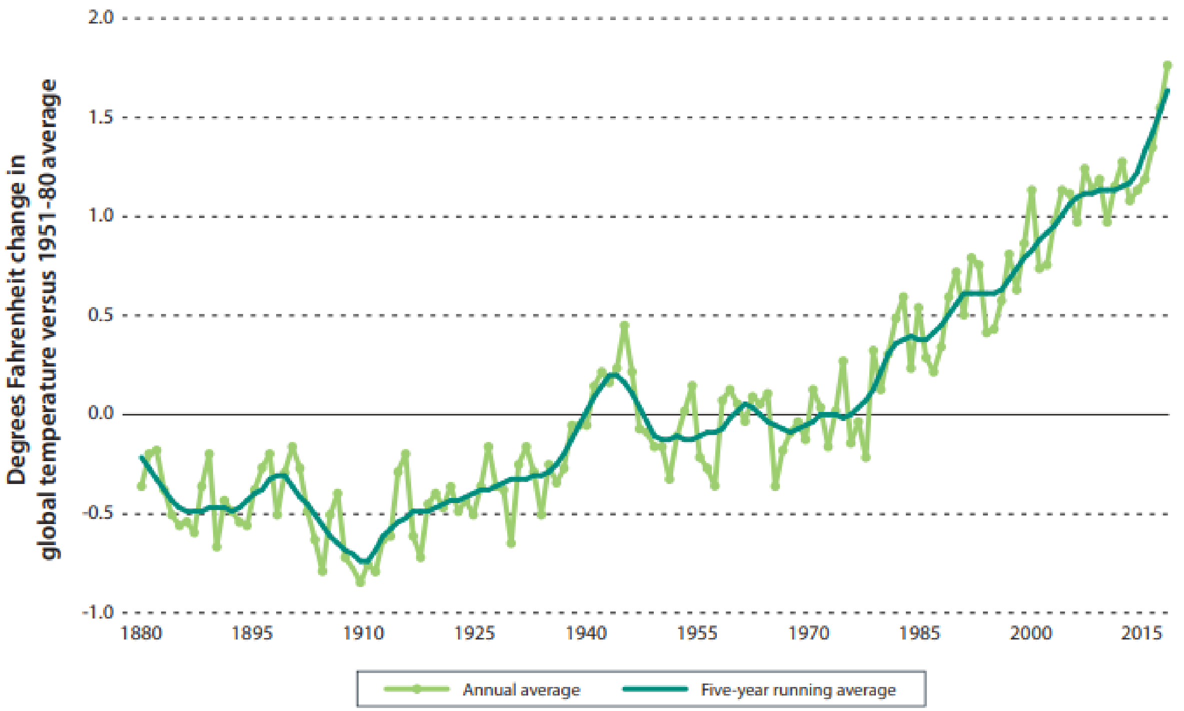
Inforum Outlook Conference

Emissions and Temperature Trajectories

Global temperatures are rising

Global Temperature Change, 1880–2015

Global temperature increase has accelerated in recent decades.



Source: Goddard Institute for Space Studies (GISS) n.d.
Note: Figure illustrates the change in global surface temperature (ocean and land) relative to 1951–80 average temperatures.

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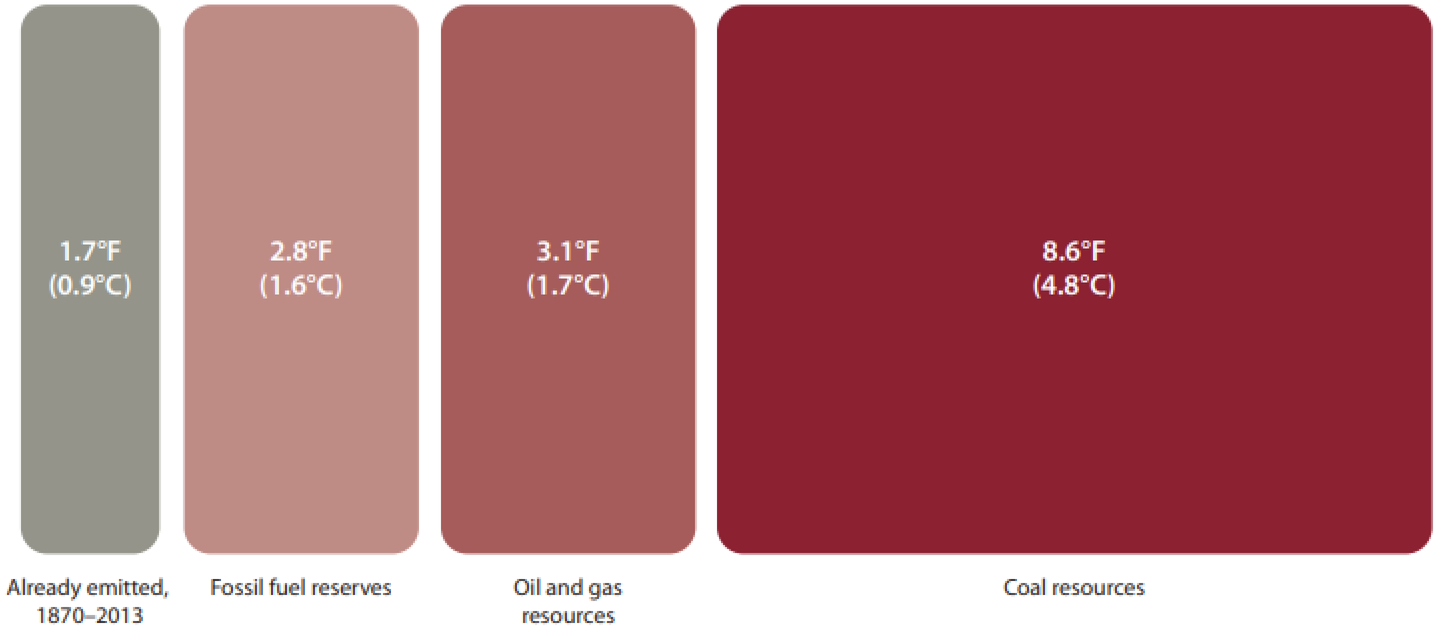
Global temperatures would likely rise by another 14.5°F (8°C) if all remaining global fossil fuel resources were used

Estimated Temperature Impact of Combustion

Remaining fossil fuel resources are very extensive; unrestricted use would have huge effects on the climate.



Source: Greenstone 2015; Greenstone and Stuart 2015; Matthews et al. 2009.
Note: See Greenstone and Stuart (2015) for methodology. Fossil fuel reserves refer to those that can be profitably extracted with current technology and prices. "Oil and gas resources" and "Coal resources" refer to fossil fuel reserves that could be extracted with additional technological progress.

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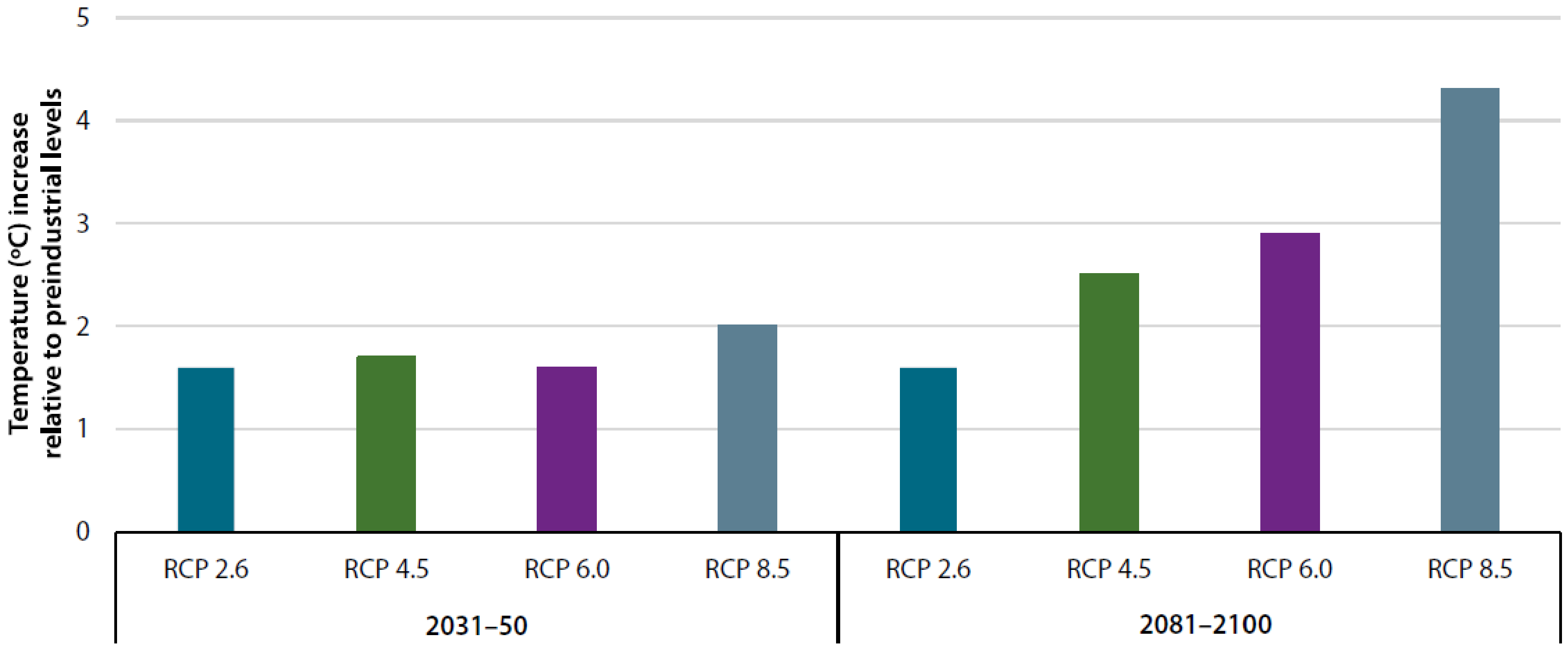
Temperatures and sea levels will rise from climate change

Global Mean Surface Temperature for Selected Climate Scenarios, 2031–50 and 2081–100



Source: Intergovernmental Panel on Climate Change (IPCC) 2019.
Note: "RCP" refers to representative concentration pathways, described in box 1.

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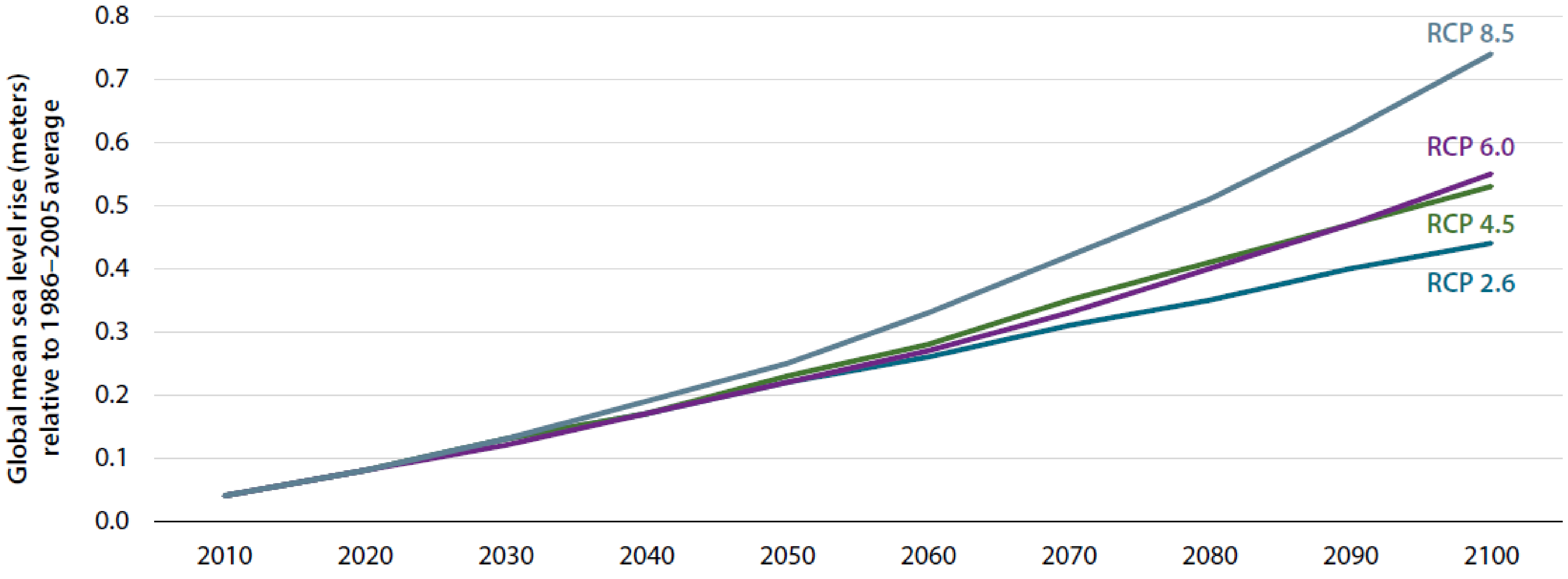
Temperatures and sea levels will rise from climate change

Global Mean Sea Level Rise for Selected Climate Scenarios, 2010–2100



Source: Intergovernmental Panel on Climate Change Data Distribution Centre (IPCC DDC) 2019.
Note: "RCP" refers to representative concentration pathways, described in box 1.

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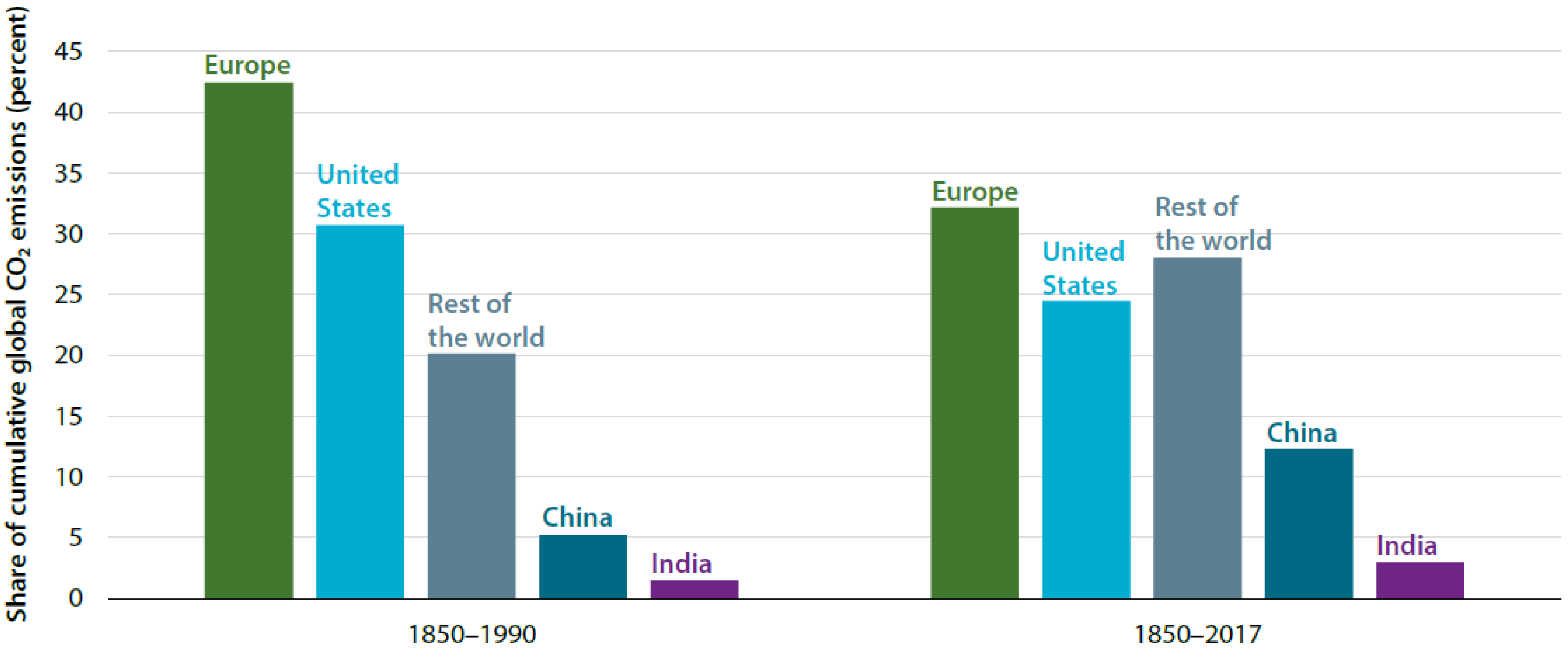
Europe and the United States are historic polluters, but developing countries like China and India are fastest-growing emitters

Share of Cumulative CO_2 Emissions by Geographic Region, 1850–1990 and 1850–2017



Source: Ritchie and Roser 2017; authors' calculations.
Note: "Europe" includes all 50 member countries as determined by the United Nations. "Rest of the world" includes all countries not in another group.

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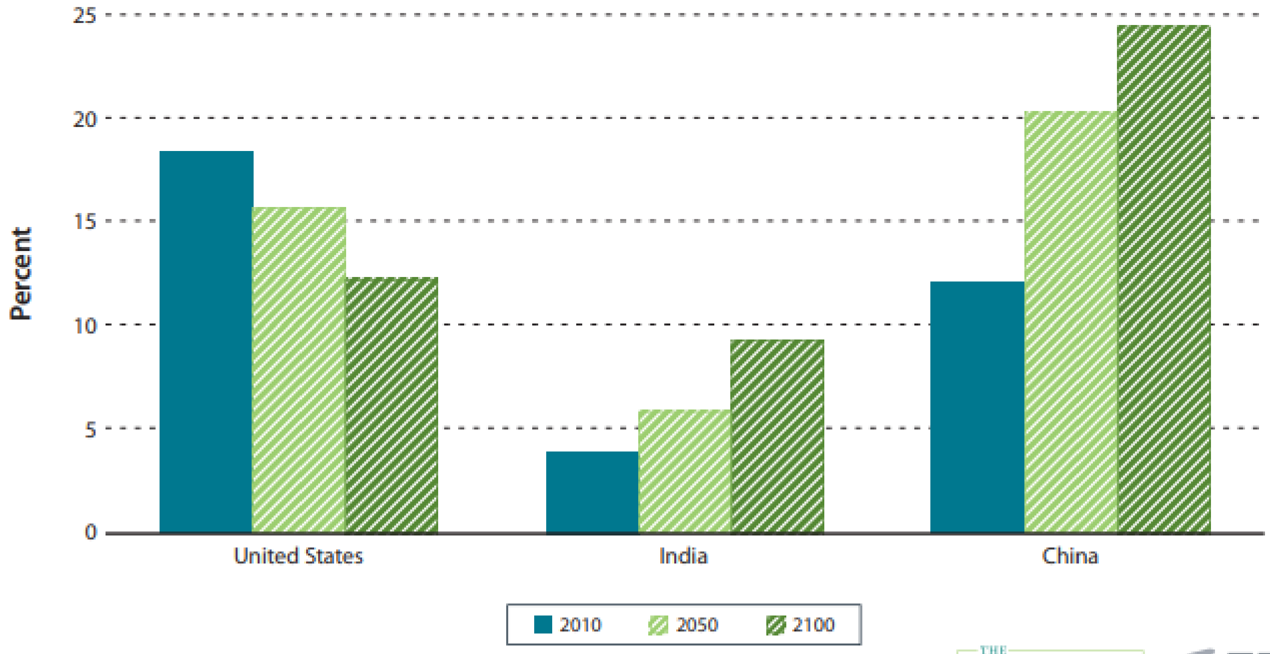
China and India's share of cumulative global GHG emissions is projected to grow substantially by 2100

Share of Cumulative Global GHG Emissions, 2010–2100 (Projected)

By 2100 China and India's shares of cumulative global GHG emissions are expected to be 2.0 and 2.5 times as high as 2010 levels, respectively, while the United States' share of cumulative global GHG emissions is expected to fall to two-thirds of its 2010 level.



Source: EPIC calculations; Climate Interactive n.d.
Note: Cumulative emissions calculated starting in 1850. Striped bars for 2050 and 2100 are projections.

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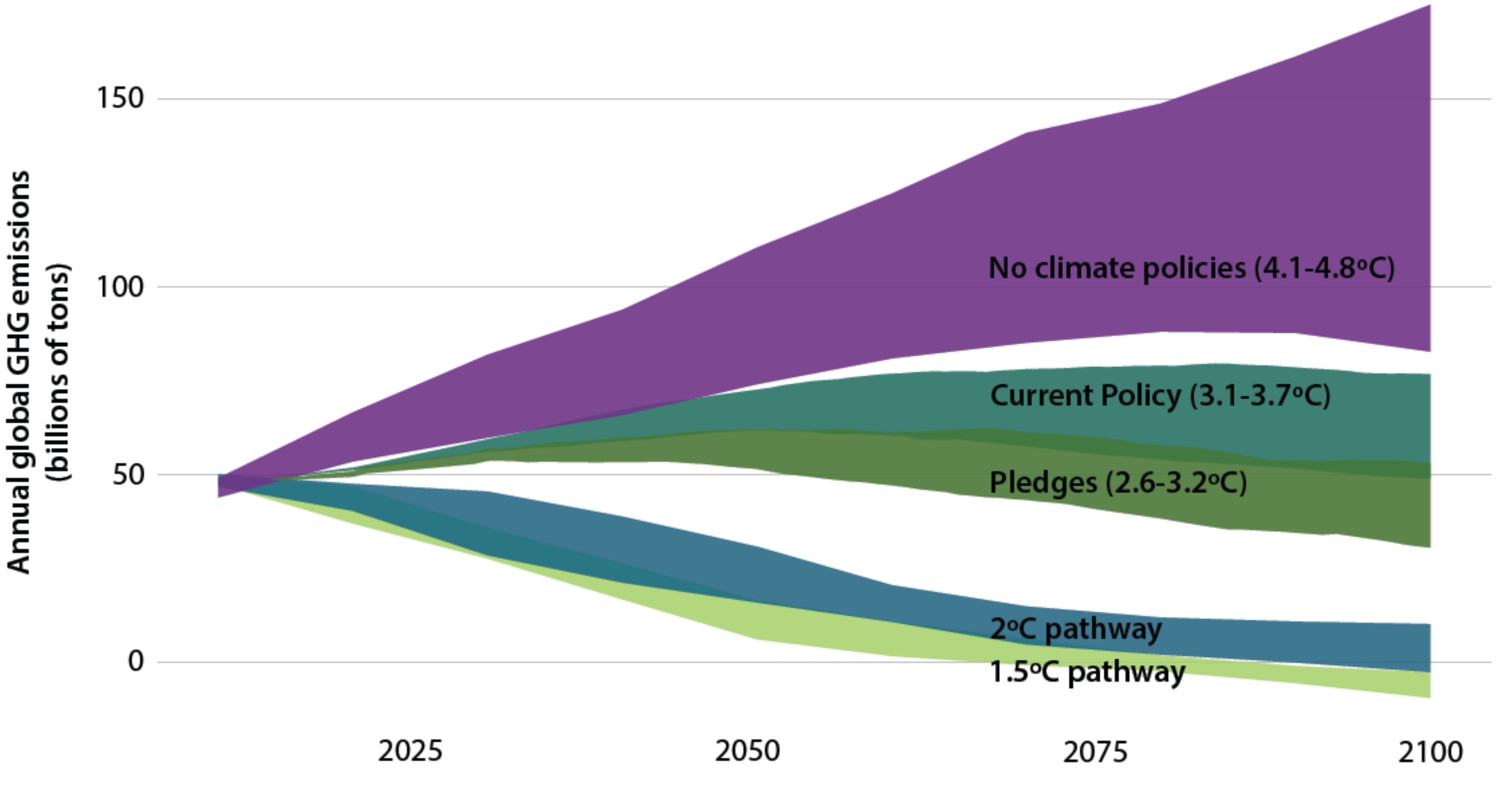
Climate policy can have a big effect on temperatures

Historical and Projected Annual Global GHG Emissions under Selected Policy Scenarios, 2010–2100



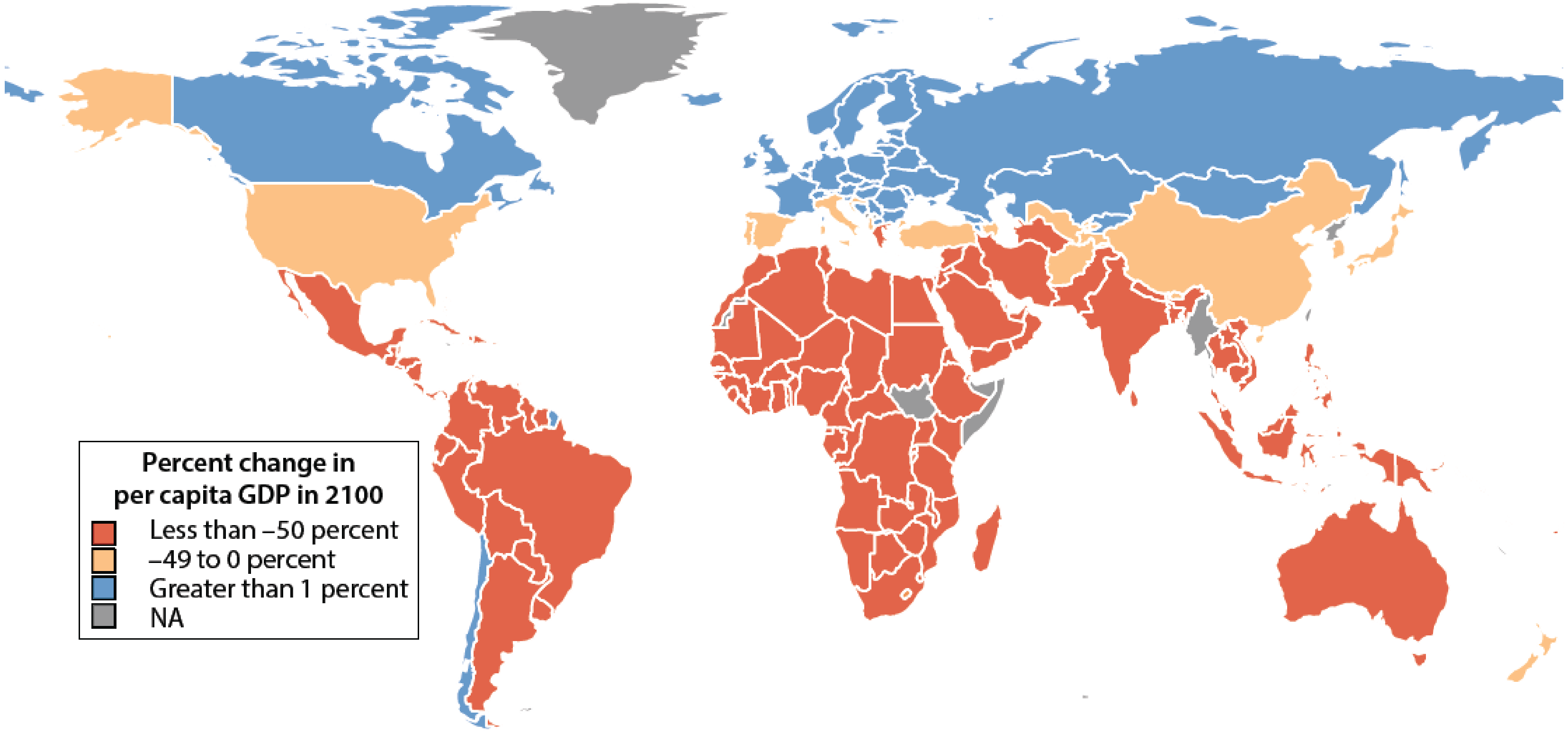
Source: Ritchie and Roser 2017.

Note: These temperature estimates are relative to preindustrial temperatures. "Pledges" refers to the pledges made in the 2015 Paris Agreement.

Economic and Social Effects of Climate Change

GDP effects from climate change will not be shared evenly

Climate Change Effect on per Capita GDP in 2100 by Country



Source: Burke, Hsiang, and Miguel (2015); authors' calculations.
Note: Country-level estimates for GDP per capita in 2100. Figure assumes RCP 8.5, which corresponds to roughly 3.2°C to 5.4°C of warming. GDP loss is associated with the warming from a baseline of 1980–2010 average temperatures. As explained in Burke, Hsiang, and Miguel (2015), estimates include growth-rate effects over the period through 2100.

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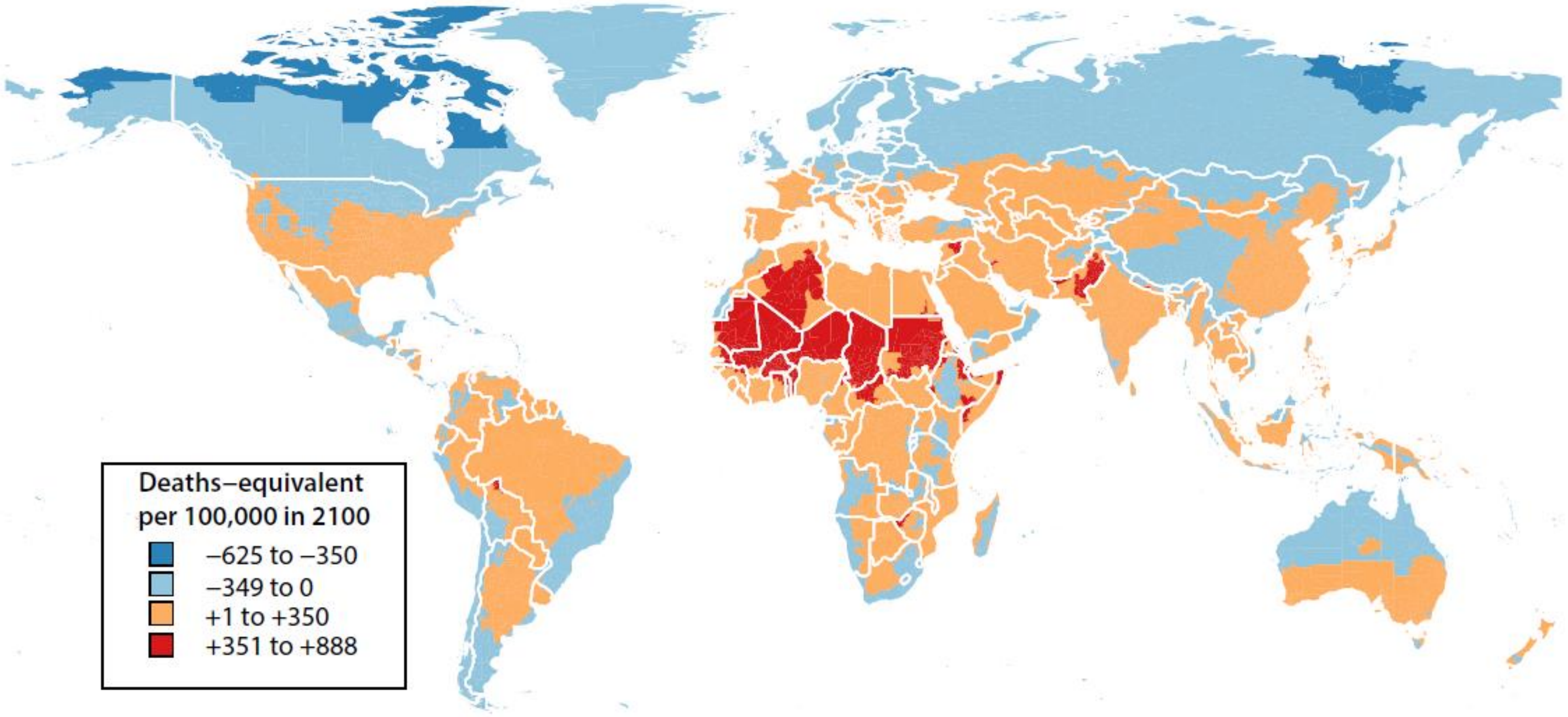
Mortality impacts will be largest in equatorial countries

Mortality Impacts from Climate Change in 2100 by Region



Source: Carleton et al. 2018; authors' calculations.

Note: The map shows impact-region estimates for mortality rates in 2100. Figure assumes the mean estimate under RCP 8.5, which corresponds to roughly 3.2°C to 5.4°C of warming. Negative values refer to lives saved from climate change (e.g., fewer deaths as a result of fewer dangerously cold days).

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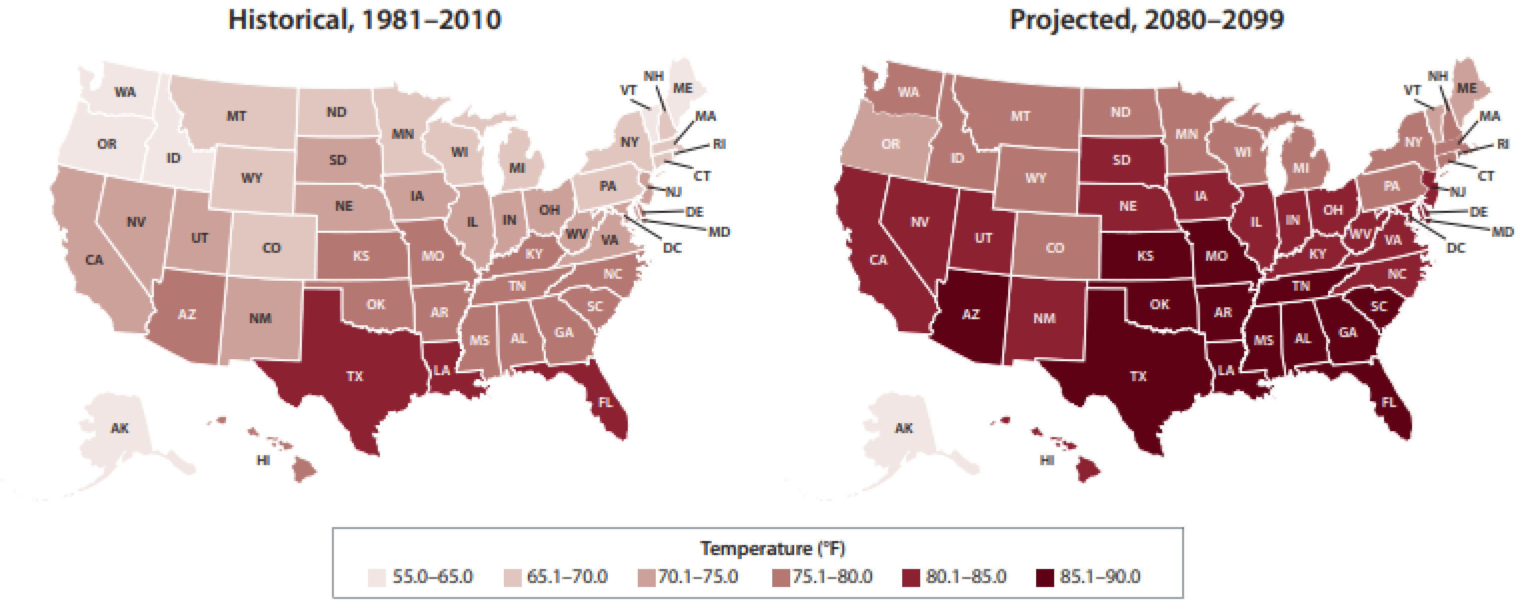
Every U.S. state is projected to experience increasing temperatures

Average Summer Temperature by U.S. State, Historical and Projected, Based on Current CO_2 Emissions Trajectory

The number of states with average summer temperatures greater than 80°F (26.7°C) will increase from 3 to 31 by 2080–99.



Source: Climate Prospectus n.d.
Note: "Current CO_2 emissions trajectory" refers to the representative concentration pathway 8.5, representing a continuation of recent global emissions growth rates and atmospheric concentrations of CO_2. The average of the months of June, July, and August is taken to calculate average summer temperature.

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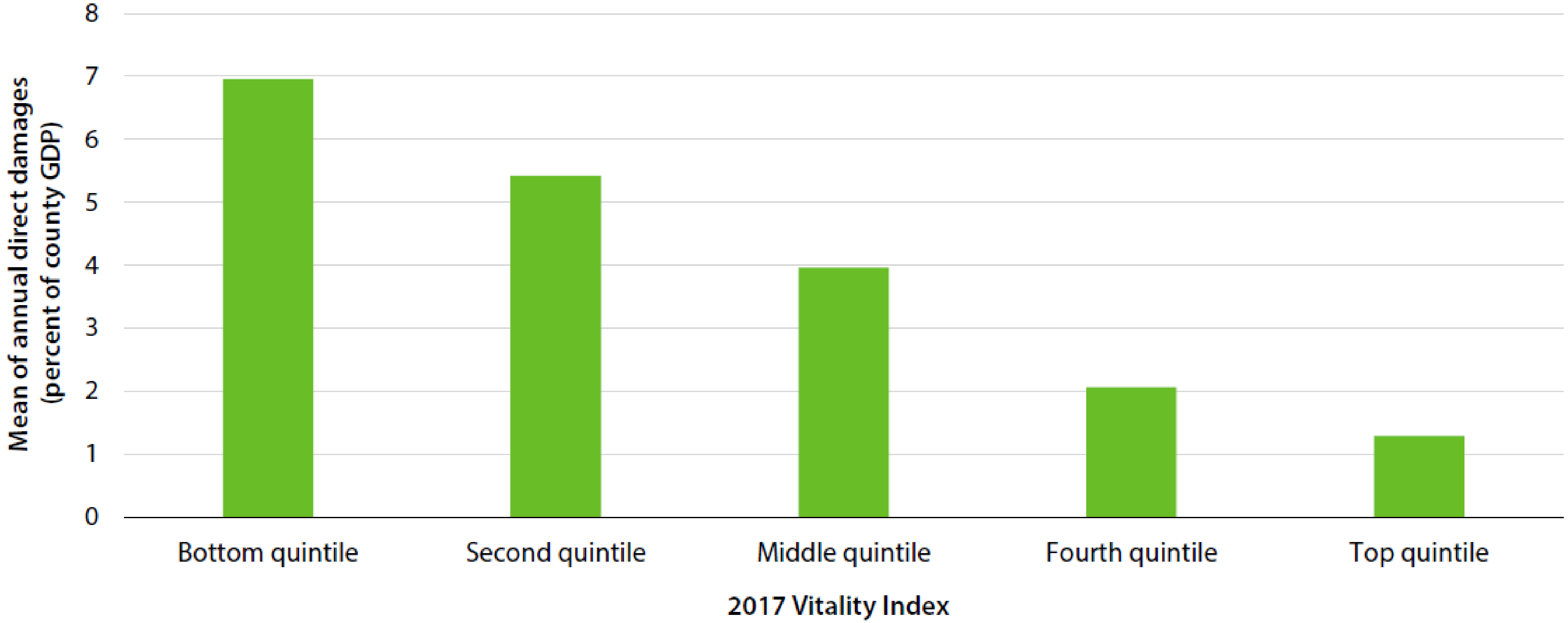
Poor counties in the United States will be hit particularly hard

Economic Damages to U.S. Counties from Climate Change in 2080–99 by Quintile of Economic Vitality Index



Source: Hsiang et al. 2017; Nunn, Parsons, and Shambaugh 2018; authors' calculations.

Note: Vitality quintiles are population-weighted. Figure assumes the mean estimate for average annual GDP loss during 2080–99 under RCP 8.5, which corresponds to roughly 3.2°C to 5.4°C of warming relative to preindustrial levels.

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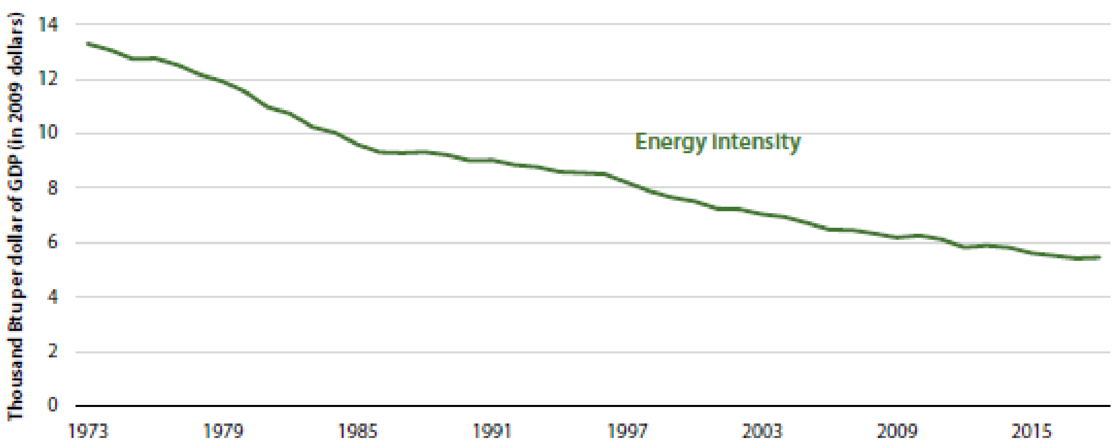
Growing Use of Renewables

U.S. economic activity is getting less energy-intensive and less carbon-intensive

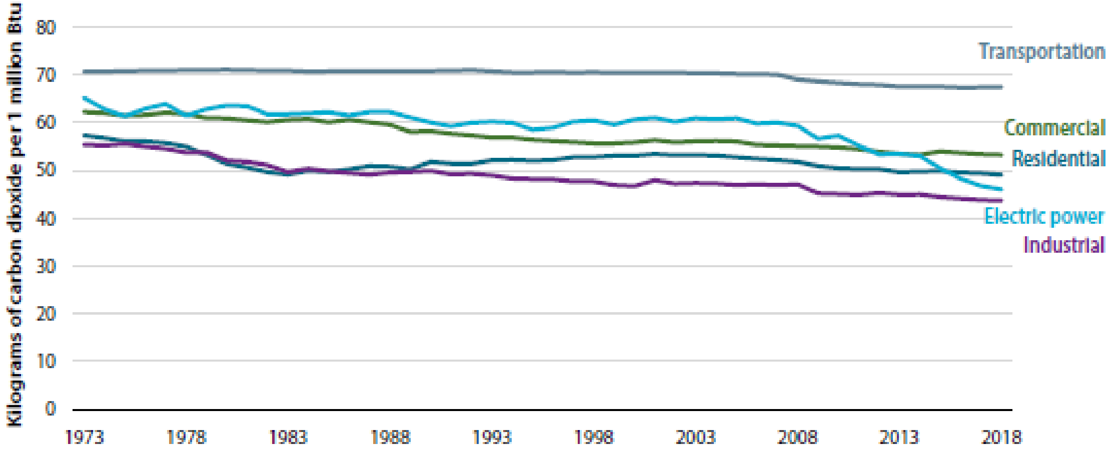
Energy Consumption Per Dollar of Real GDP, 1973–2018



Source: EIA 2019c.

Note: GDP is measured in chained 2009 dollars. Btu refers to British thermal unit. Energy intensity is the amount of energy required to produce a unit of economic output.

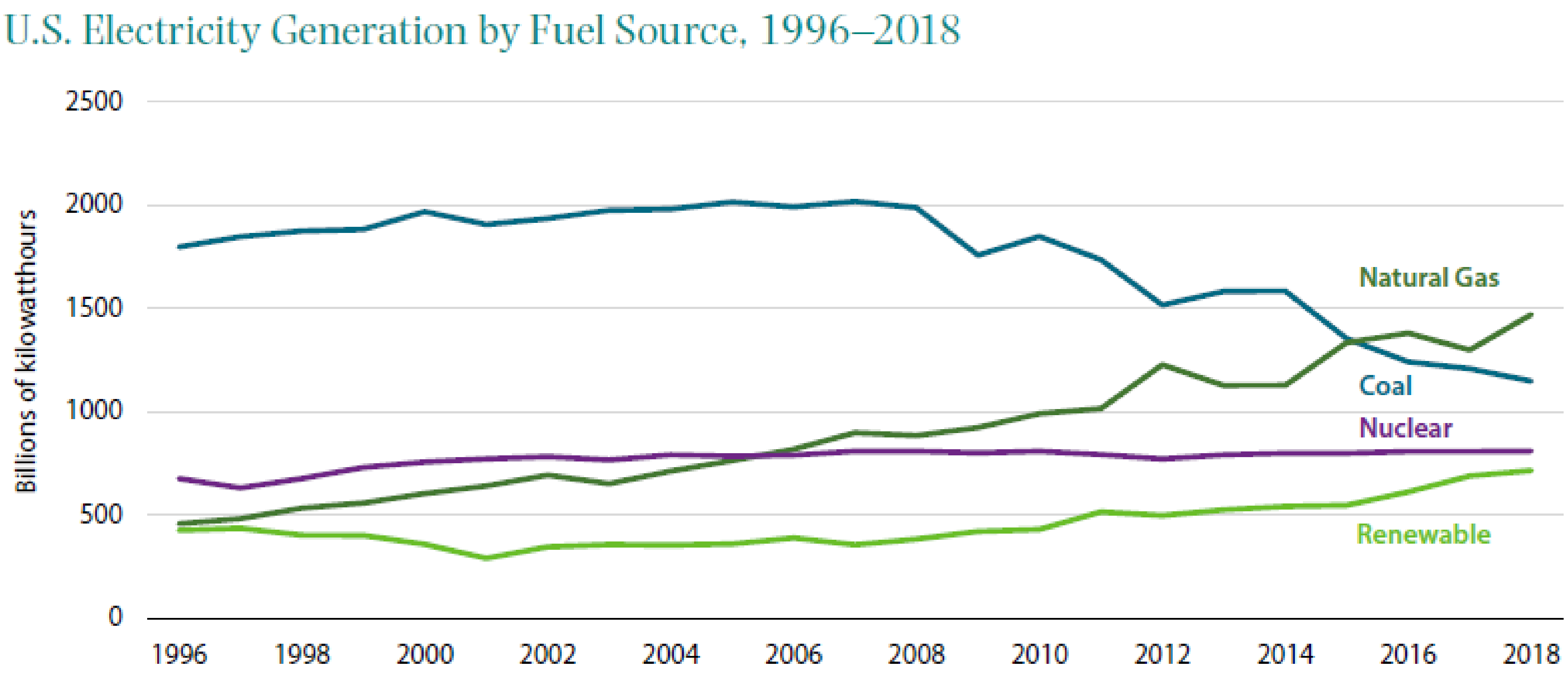
Carbon Intensity of Energy Use by Sector, 1973–2018



Source: EIA 2019c.

Note: Carbon intensity is a measure of how much carbon dioxide is emitted when producing a unit of energy.

Renewables are a growing source of electricity



Source: U.S. Energy Information Administration (EIA) 2019.

Note: "Renewable" includes conventional hydropower, wind, wood biomass, waste biomass, geothermal, and solar.

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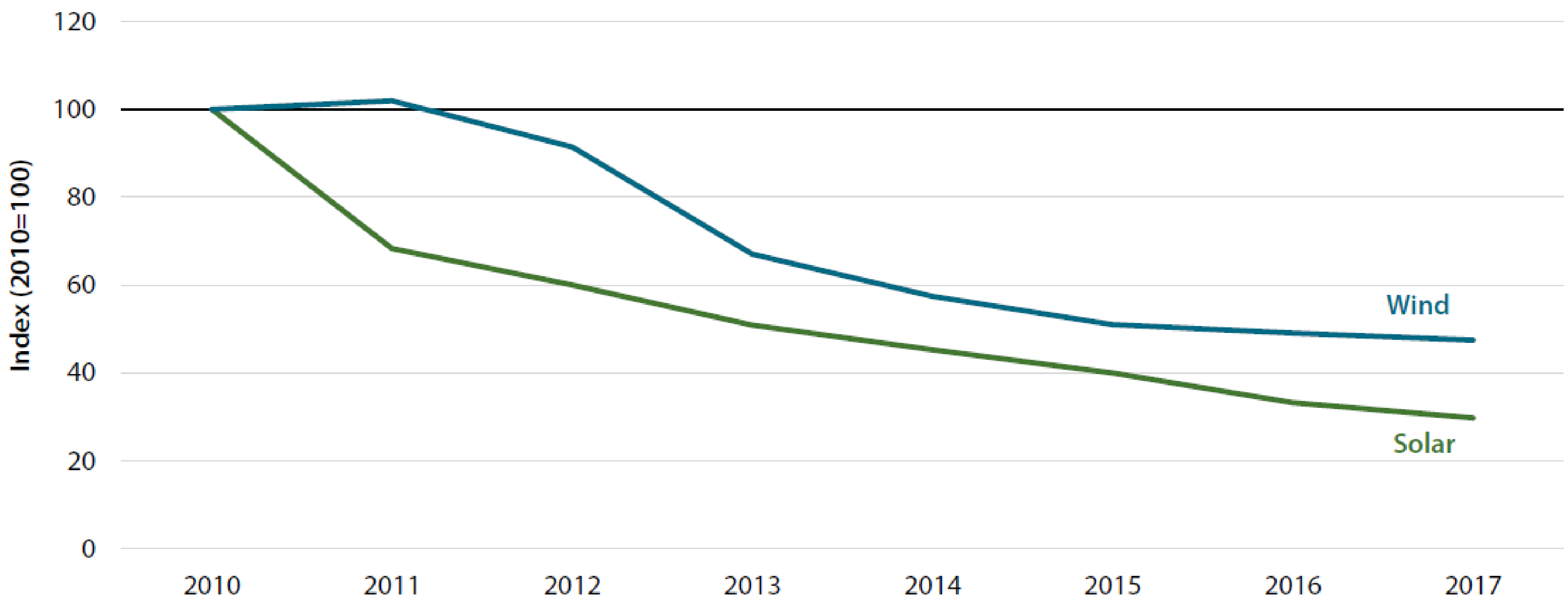
Renewables are getting cheaper

Change in Levelized Cost of Energy for Solar and Wind, 2010–17



Source: Bolinger and Seel 2018; Wiser and Bolinger 2018.
Note: These estimates are for the unsubsidized costs (i.e., they do not include federal tax credits). Levelized cost of energy (LCOE) is a common metric of energy production that allows for comparison across different sources of energy. The LCOE measures the lifetime costs of a given project per unit of energy produced.

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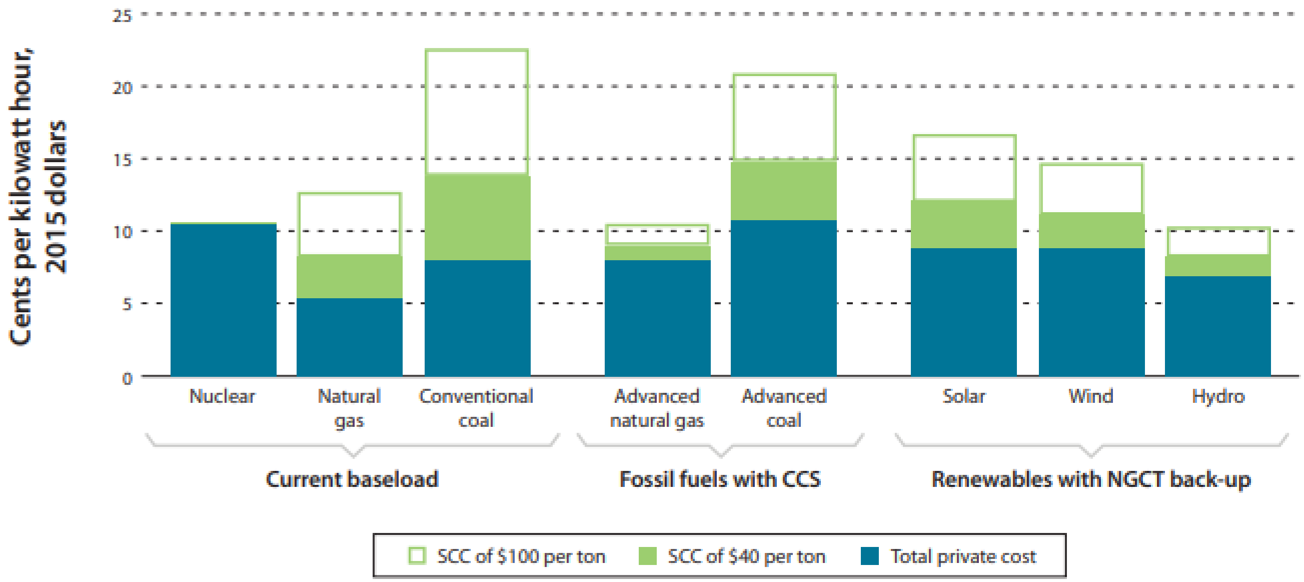
But the prices we pay for fossil fuels do not reflect their social costs

Private and Social Cost of Energy for New Plants in 2023 (Projected)

At a carbon price of $100 per ton, hydroelectric power is the least expensive source of electricity.



Sources: EPIC analysis based on data from Du and Parsons 2009; EIA 2013, 2014a, 2014b, 2015; EPA 2015a, 2015b, 2016a; FRED Economic Data 2016; Greenstone and Looney 2012; IRS 2016; Marten, Kopits, Griffiths, Newbold, and Wolverton 2014; NREL 2014; National Academy of Sciences 2010.

Note: CCS = carbon capture and storage; NGCT = natural gas combustion turbine; SCC = social cost of carbon. The levelized cost of electricity is the present value of the total cost of building and operating a generating plant over its economic life, converted to equal annual payments. Costs are levelized in real dollars. Since the costs of renewables reflect the inclusion of a combined cycle natural gas turbine to balance intermittency, the use of the NGCT with renewables produces CO_2 emissions and, therefore, social costs.

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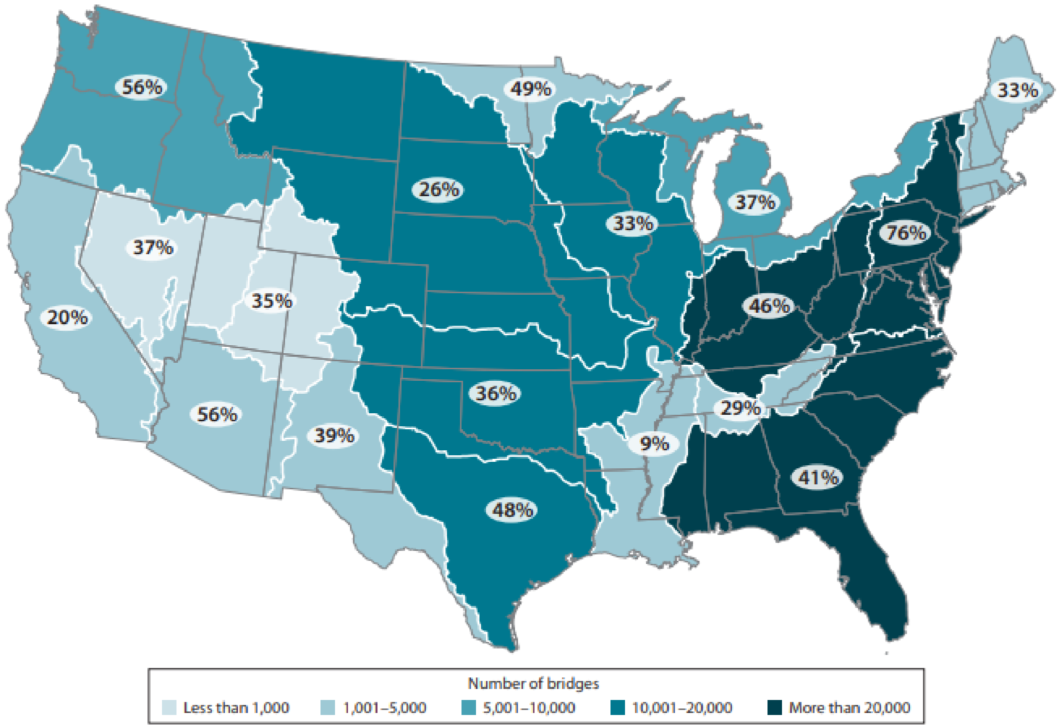
Policy Solutions:

Investments in Resiliency (Matthew Kahn)

Much of U.S. infrastructure is vulnerable to the effects of climate change

Bridges Identified as Vulnerable Due to Projected Climate Change, 2051–2100

Many vulnerable bridges are located in the eastern United States.



Source: EPA 2015c.
Notes: Estimated number of vulnerable bridges in each of the 2-digit hydrologic unit codes (HUCs) of the contiguous U.S. in the period from 2051–2100 under the Reference scenario using the IGSM-CAM climate model. The map also shows the percentage of inland bridges in each HUC that are vulnerable due to climate change.

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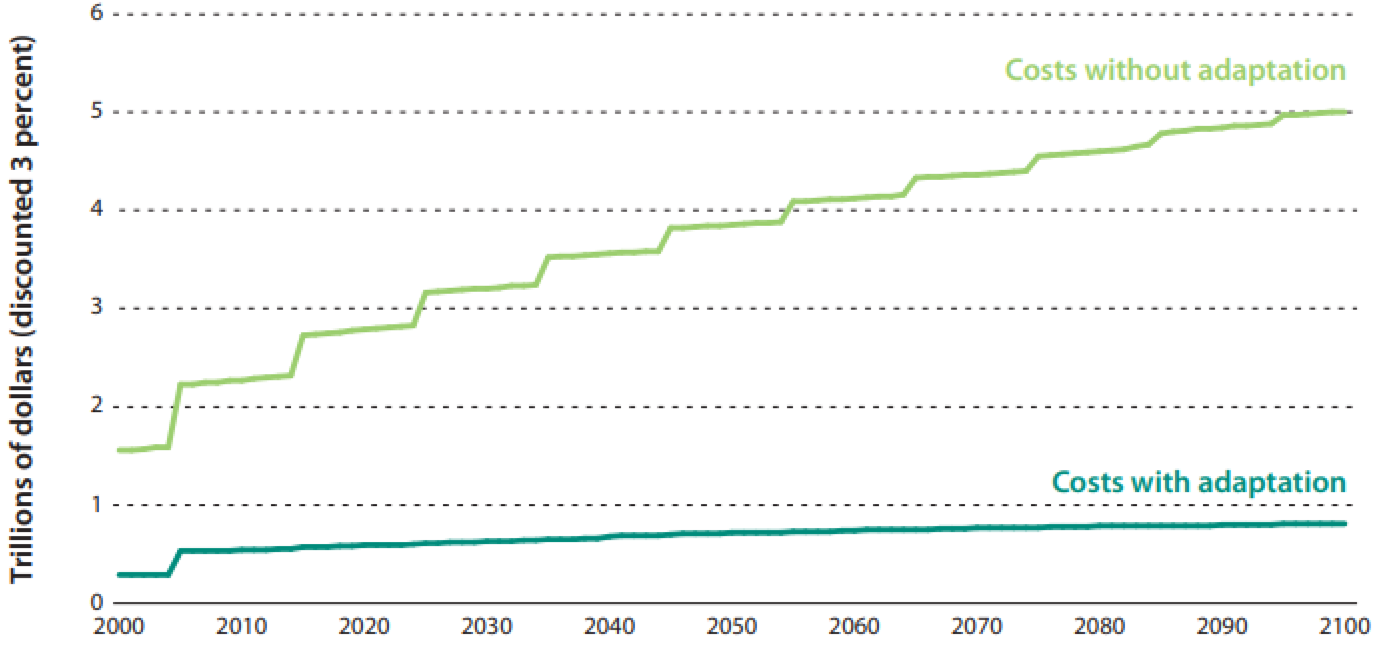
Investments in climate adaptation would greatly lower the burden of climate change

Cost of Sea-level Rise and Storm Surge to Coastal Property, by Response

Adaptation investments would prevent trillions of dollars of cumulative costs related to sea-level rise and storm surge.



Source: EPA 2015c.
Notes: The step-wise nature of the graph is due to the fact that storm surge risks are evaluated every ten years, beginning in 2005. Costs with adaptation include the value of abandoned property, residual storm damages, and costs of protective adaptation measures.

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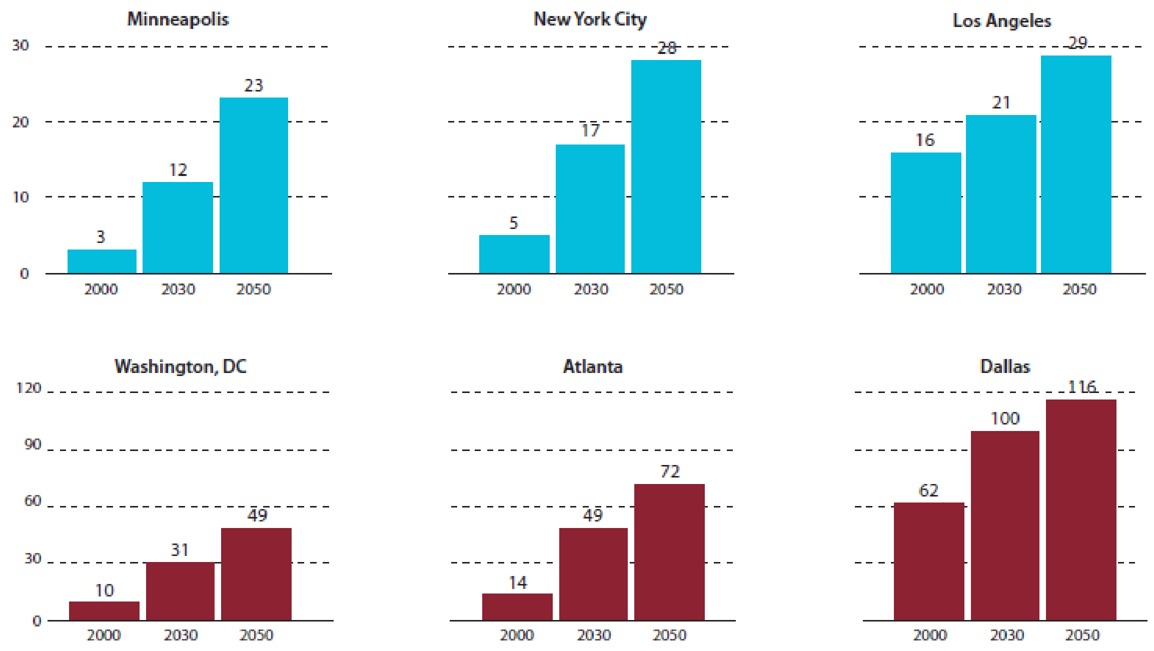
Different places are exposed to very different climate costs and risks

Projected Number of Days per Year with Heat Index Above 104°F for U.S. Cities



Source: Climate Central 2016.

Note: Blue bars are on a y-axis with a maximum of 30 days. Red bars are on a y-axis with a maximum of 120 days. Days with a heat index above 104°F are referred to as "danger days" in Climate Central report. Annual average danger day count based on current emissions trends. Projected temperature and humidity calculations come from Climate Central analysis of CMIP5 multi-model ensemble dataset.

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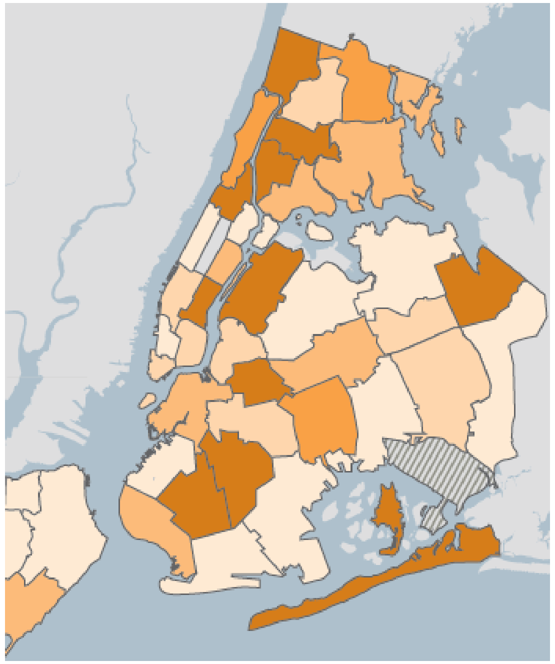
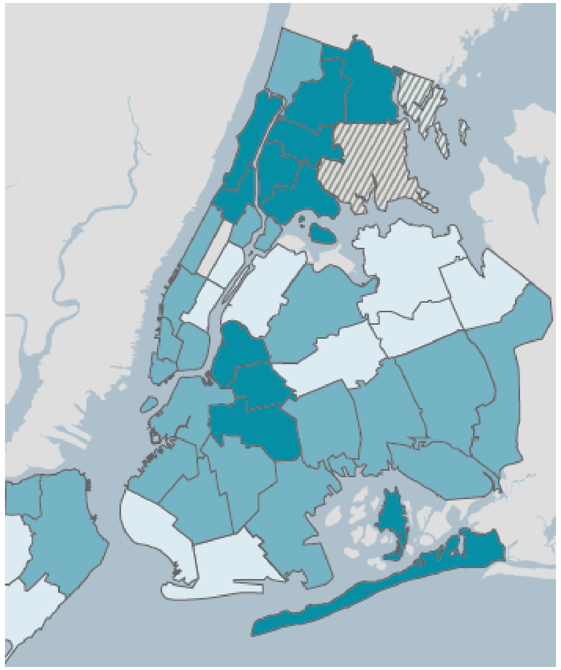
City-level investments in resiliency will be vital

Mortality Rate Ratios for Seniors during Days of Extreme Heat, New York City



1.00 | 1.01 – 1.04 | 1.05 – 1.08 | 1.09 – 1.12 | 1.13 – 1.41 | Insufficient data

Percent of Seniors Who Do Not Use Air Conditioning, New York City



5% – 14% | 14.1% – 25% | 25.1% – 43% | Insufficient data

Source: Klein-Rosenthal, Kinney, and Metzger 2014.

Note: Senior is defined as age 65 and older. The Mortality Rate Ratio for seniors age 65 and older (MRR65+) shows excess mortality (ratios above 1.00) during very hot days (maximum heat index = 100 °F +) compared to all May through September days, 1997–2006. Regions are divided by New York City United Hospital Fund (UHF) neighborhoods (n=42).

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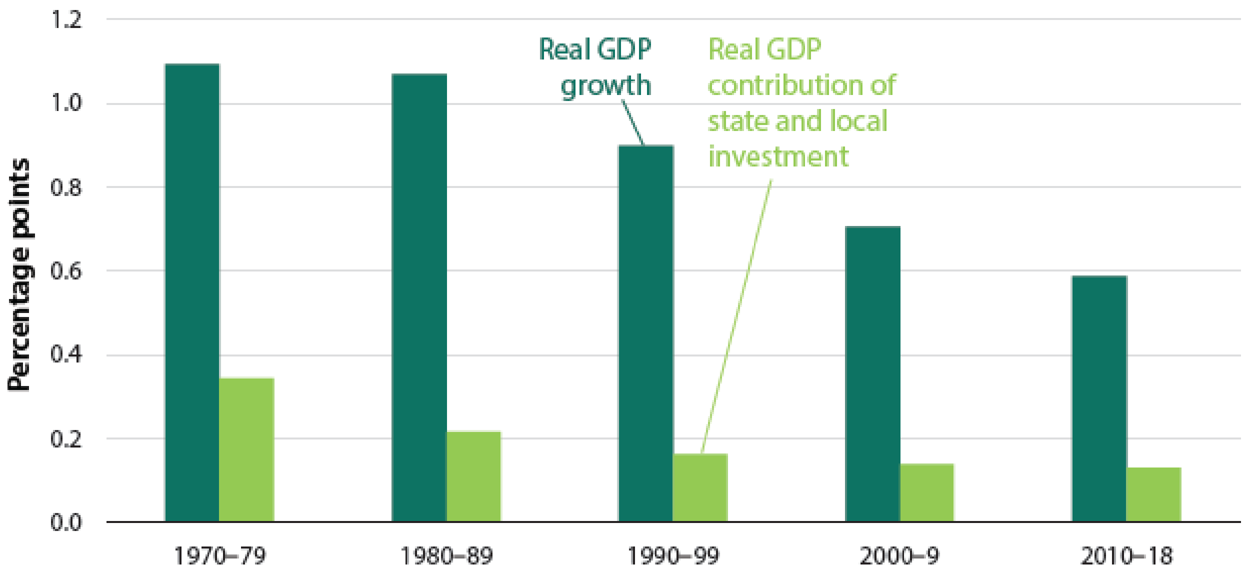
Infrastructure investment can be an important part of stabilization policy

State and Local Infrastructure Contribution to Quarterly Fluctuations in Real GDP, 1970–2018



Source: Bureau of Economic Analysis [BEA] 1970–2018c, 1970–2018d; author's calculations.

Note: For each series, we calculate the average absolute value of quarterly growth over the course of a decade. Data are not yet available for 2019.

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Policy Solutions:

Carbon Pricing

Emissions abatement options have widely varying costs

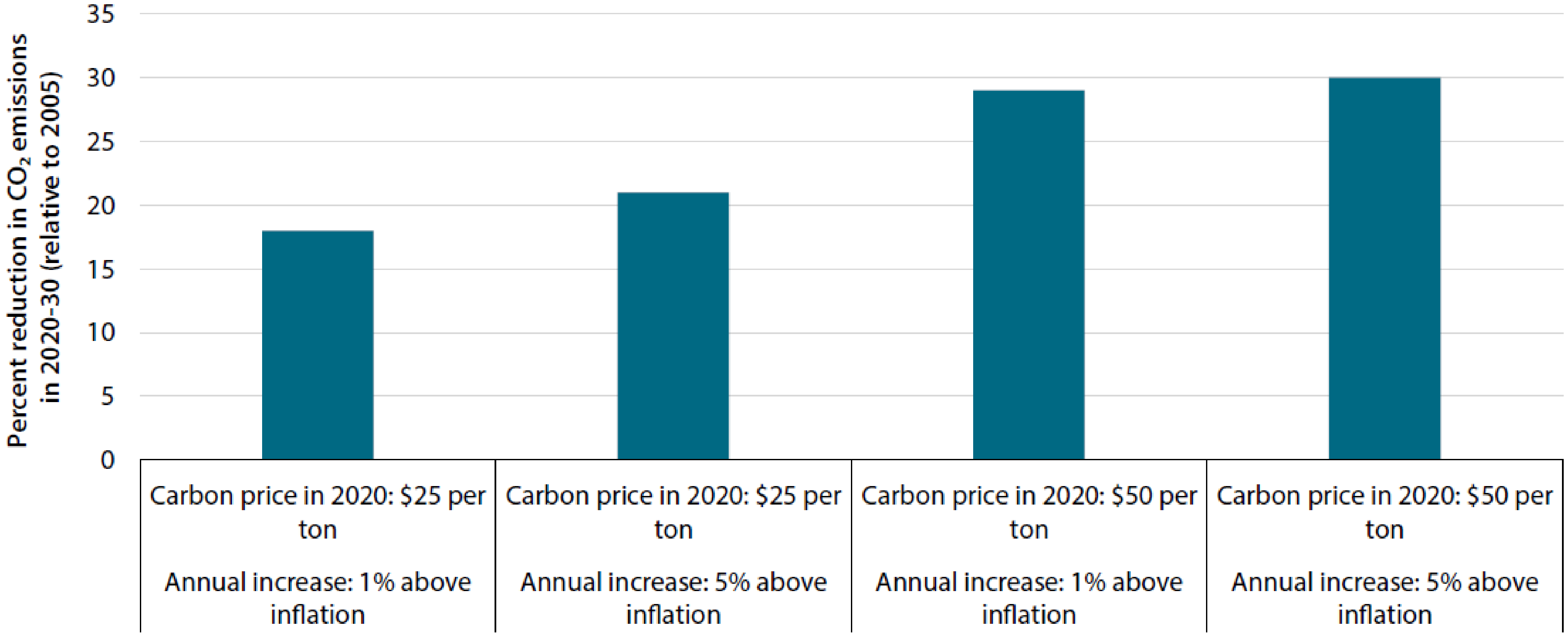
Average Abatement Costs for Selected Policy Options

		Low estimate	High estimate
Agriculture	Reforestation	1	10
	Agricultural emissions policies	51	67
	Livestock management policies	73	73
Clean energy	Renewable portfolio standards	0	195
	Wind energy subsidies	2	266
	Clean Power Plan	11	11
	Renewable fuel subsidies	102	102
	Low carbon fuel standard	102	2971
	Solar photovoltaics subsidies	143	2151
Energy efficiency	Behavioral energy efficiency	-195	-195
	CAFE Standards	-110	318
	Cash for Clunkers	277	430
	Weatherization assistance program	359	359
Fossil fuel	Methane flaring regulation	20	20
	Reducing federal coal leasing	34	70

Source: Gillingham and Stock 2018; authors' calculations.
Note: The values were updated to 2018 dollars using the CPI-U-RS. This table applies a different categorization of selected policy approaches than was used in Gillingham and Stock (2018).

A U.S. carbon price would reduce emissions in the short-term

Cumulative CO_2 Reductions for Selected Carbon Price Paths, 2020–30



Source: Barron et al. 2018.
Note: These values refer to the average estimates in Barron et al. 2018.

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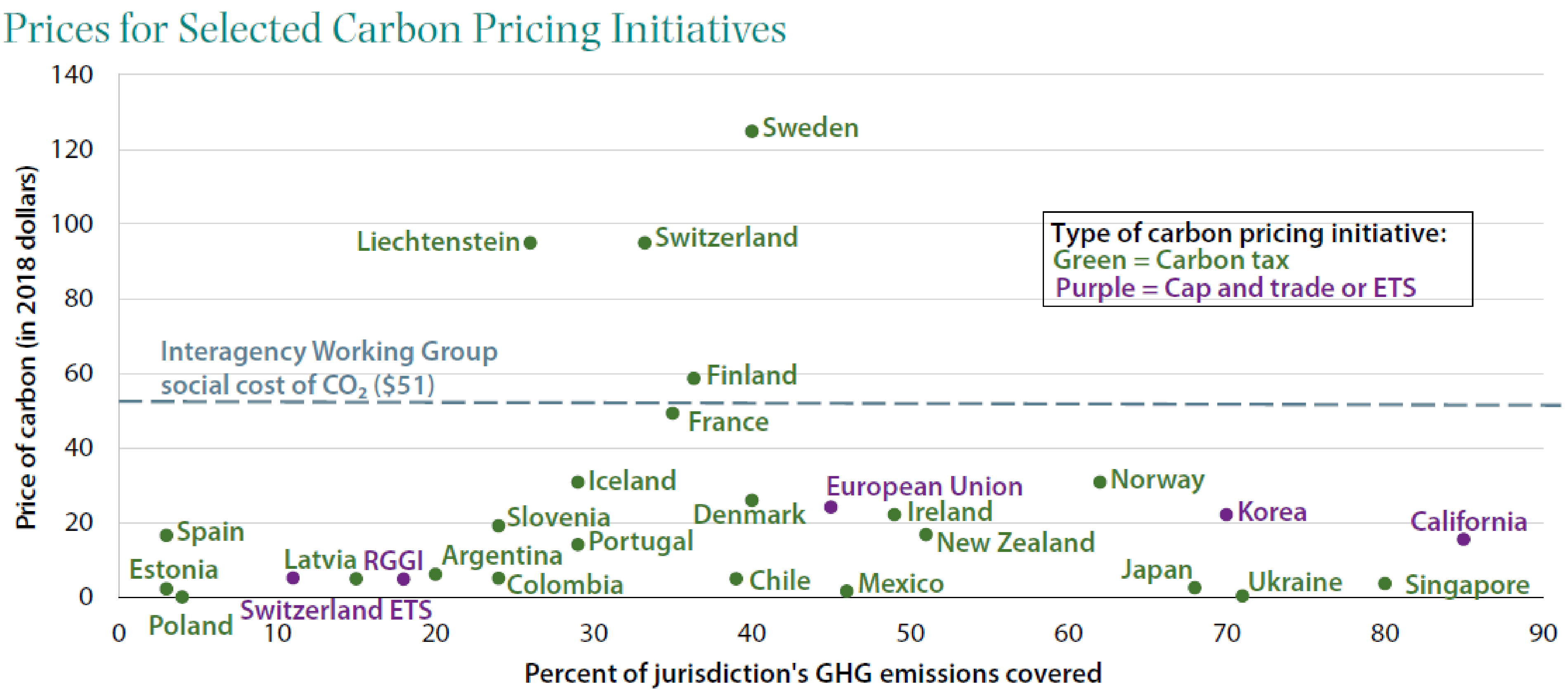
More than 50 carbon pricing initiatives globally



Source: World Bank 2019.

Note: All values are adjusted to 2018 dollars using the CPI-U-RS. This chart shows selected subnational, national, and regional programs. For Mexico and Norway, their point represents the average between their upper and lower carbon prices. For Denmark, the point represents the carbon price for fossil fuels. For Finland, the point represents the price for fossil fuels except transportation fuel. For Argentina, the point represents most liquid fuels.

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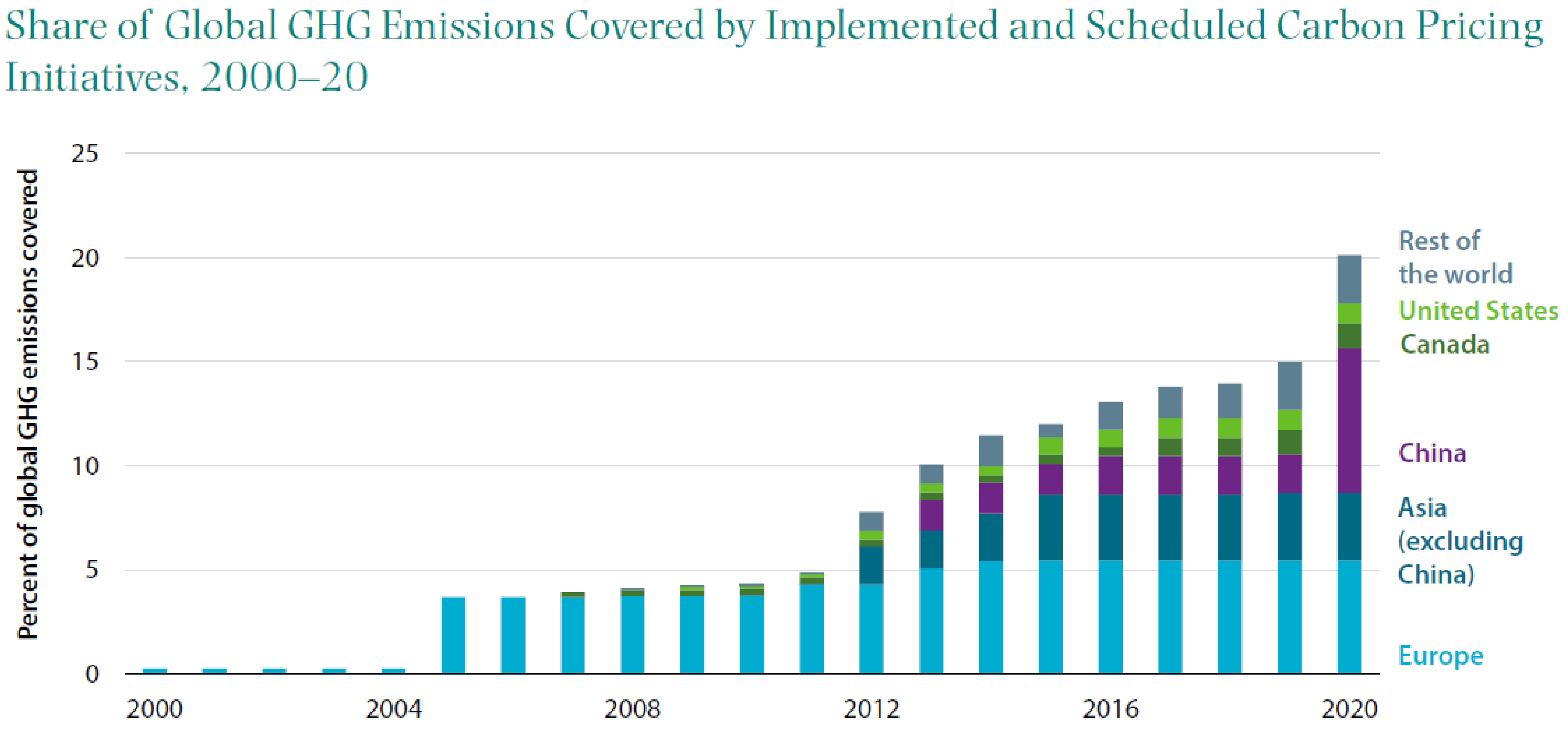
But only 15% of all emissions are covered



Source: World Bank 2019.
Note: Emissions regarded as priced are those subject to an explicit price as part of a carbon tax or cap and trade system. Emissions subject to an indirect price through other regulatory policies are not considered to be priced.

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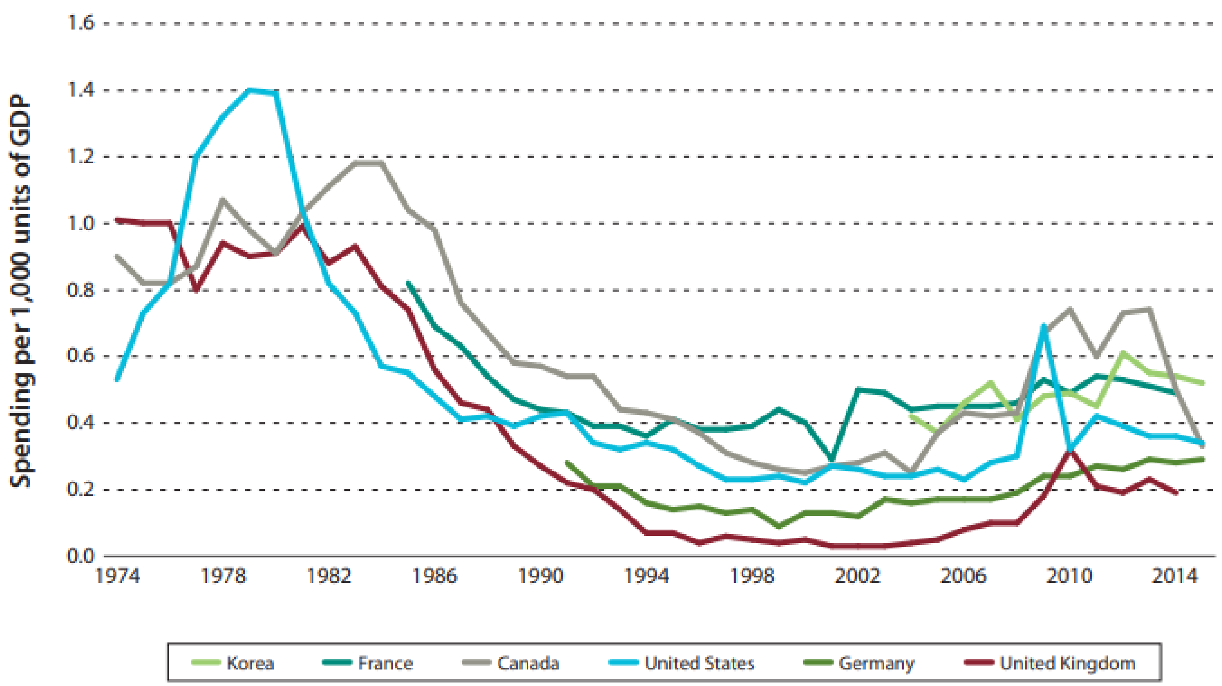
Policy Solutions:
R&D Investments (David Popp)

Public investment in energy R&D remains well below 1970s and 1980s levels

Public Spending on Energy-Related Research and Development, 1974–2015

Public energy investments have followed a similar pattern across countries.



Source: IEA n.d.

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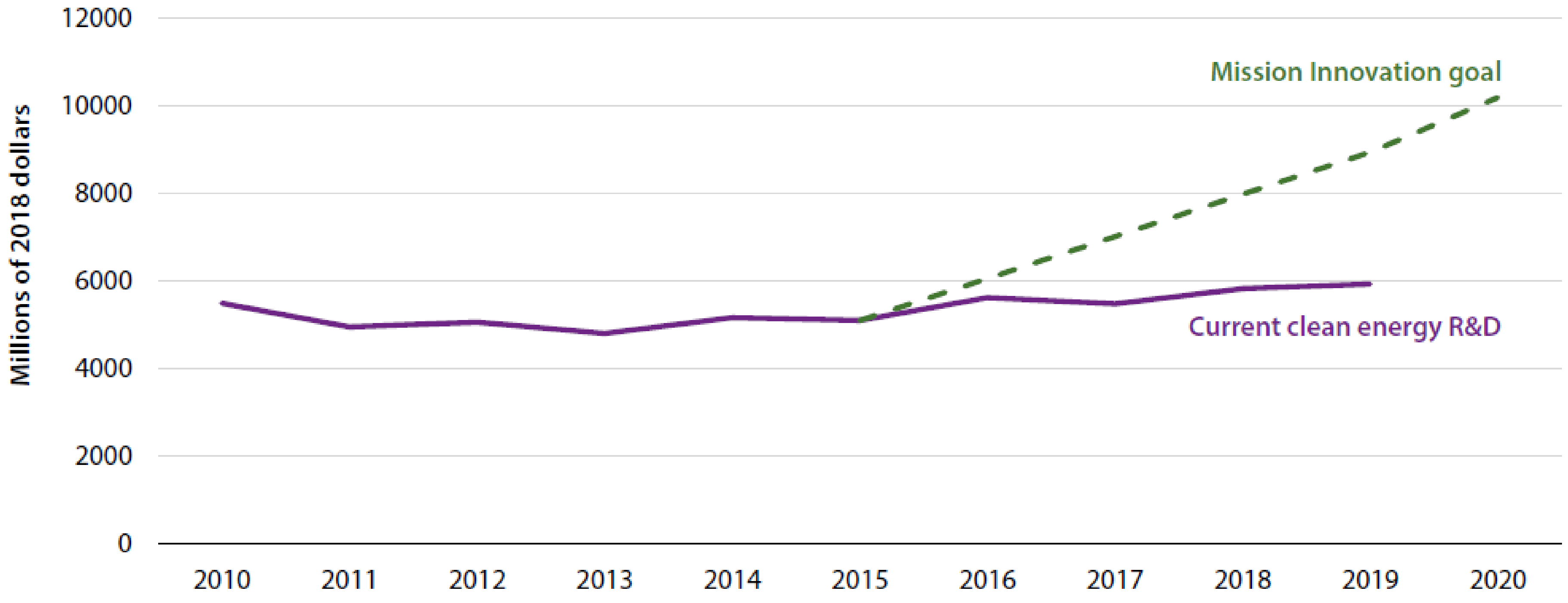
Recent spending on clean energy R&D has been flat

Current U.S. Clean Energy Research and Development vs. Mission Innovation Goals, 2010–20



Source: Gallagher and Anadon 2018; U.S. DOE 2019; author's calculations.

Note: Figures are in millions of 2018 USD. "Current Clean energy R&D" includes DOE spending on basic energy sciences, carbon sequestration, energy efficiency, hydrogen energy, renewable energy, electricity transmission and distribution, nuclear, and ARPA-E. "Mission Innovation Goal" shows the path needed to achieve a doubling of clean energy R&D by 2020.

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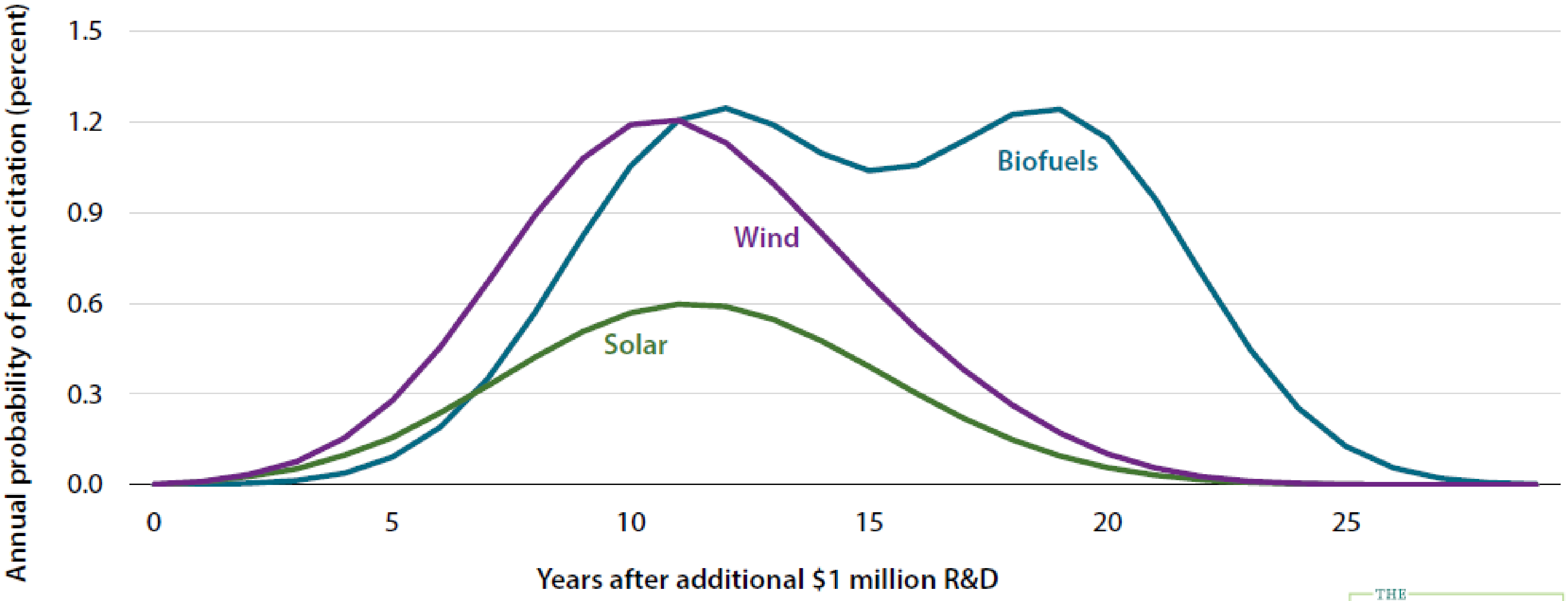
Clean energy R&D investments require years to pay off

Annual Probability of Patent Citation from $1 Million of Additional Energy Research and Development



Source: Shambaugh, Nunn, and Portman 2017 based on Popp 2016.

Note: Model estimated using citations to journal articles published between 2000 and 2009.

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