RESOURCES *for the* FUTURE

# The Social Cost of Carbon and US Climate Policy

Scientific and policy considerations

Kevin J. Rennert

Fellow and Director, RFF Social Cost of Carbon Initiative

February 13, 2020

# Resources for the Future is an independent, nonprofit research institution in Washington, DC

OUR MISSION

*"to improve environmental, energy, and natural resource decisions through impartial economic research and policy engagement"*

OUR VISION

*"committed to being the most widely trusted source of research insights and policy solutions leading to a healthy environment and a thriving economy"*



**RFF does not take institutional positions on legislative, regulatory, judicial or other public policy matters.**

# Overview

- What is the Social Cost of Carbon
  - How it’s calculated
  - How it’s used in US policymaking
- Improving the SCC modeling process
  - Using updated scientific and economic literature
  - New open-source computing platform
- US Policy efforts to achieve a net-zero emission US economy by 2050
  - Federal policies
  - State policies

# What is the social cost of carbon (SCC)?

- **Social Cost of Carbon (SCC):** The cost to society of adding one metric ton of CO2 to the atmosphere in a particular year (in US dollars). Equivalently, the SCC estimates the benefit of not emitting one ton of CO2.

# What is the social cost of carbon (SCC)?

- **Social Cost of Carbon (SCC):** The cost to society of adding one metric ton of CO2 to the atmosphere in a particular year (in US dollars). Equivalently, the SCC estimates the benefit of not emitting one ton of CO2.
- **Monetized changes include, but are not limited to:**
  - Changes in net agricultural productivity
  - Energy use
  - Human health
  - Property damage from increased flood risk

# Why do we care?

What are the pros and cons of estimating climate damages in purely economic terms?

# Why is the SCC important?

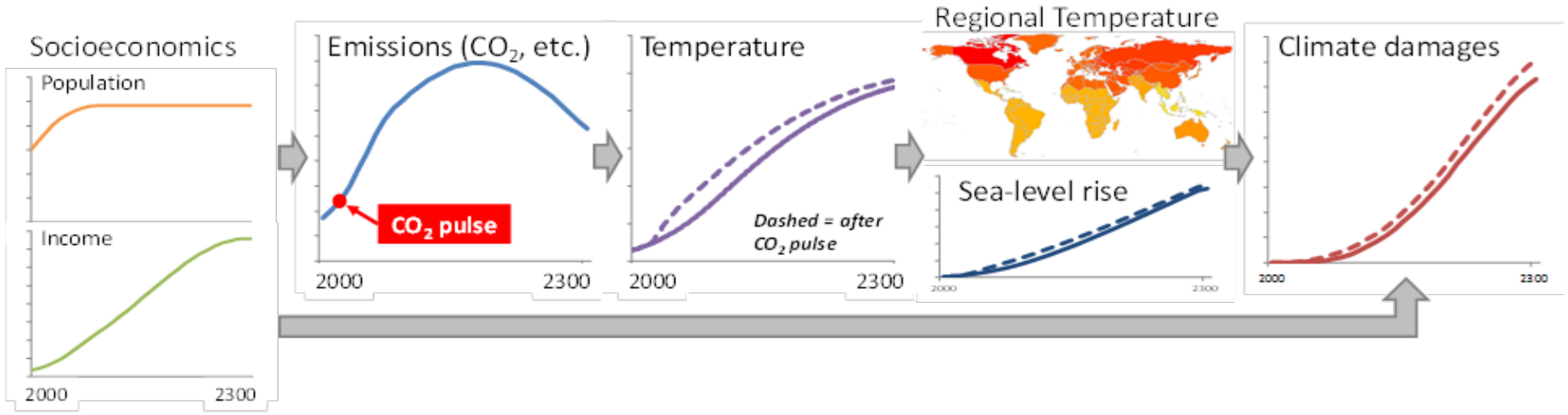
## The Social Cost of Carbon (SCC) is policy-relevant worldwide.

- **SCC estimates inform government policy in the U.S. and abroad:**

  - The federal government has used the SCC in the required benefit-cost analysis of over 150 proposed and finalized rules.
  - The SCC was used to set the level of a federal carbon tax in legislation.
  - New York and Illinois use the SCC as basis for payments to nuclear generators.
  - Colorado, Minnesota, and Washington PUCs requires utilities to use the SCC for resource planning;
  - California AB 197 requires valuing social benefits of emission reductions.
  - Canada adopted the US SCC methodology; Mexico agreed to take similar action.

**Businesses and other non-governmental entities are increasingly looking to value emissions reductions in their policies and planning processes.**

# The 4 steps of social cost of carbon estimation




1. Projections of future population & GDP generate a $CO_2$ emissions path
2. $CO_2$ emissions path leads to predictions of mean global temperature change
3. Temperature change leads to damages, which are monetized and aggregated
4. Damages persist for many decades: discounting is used to sum them into a single present value

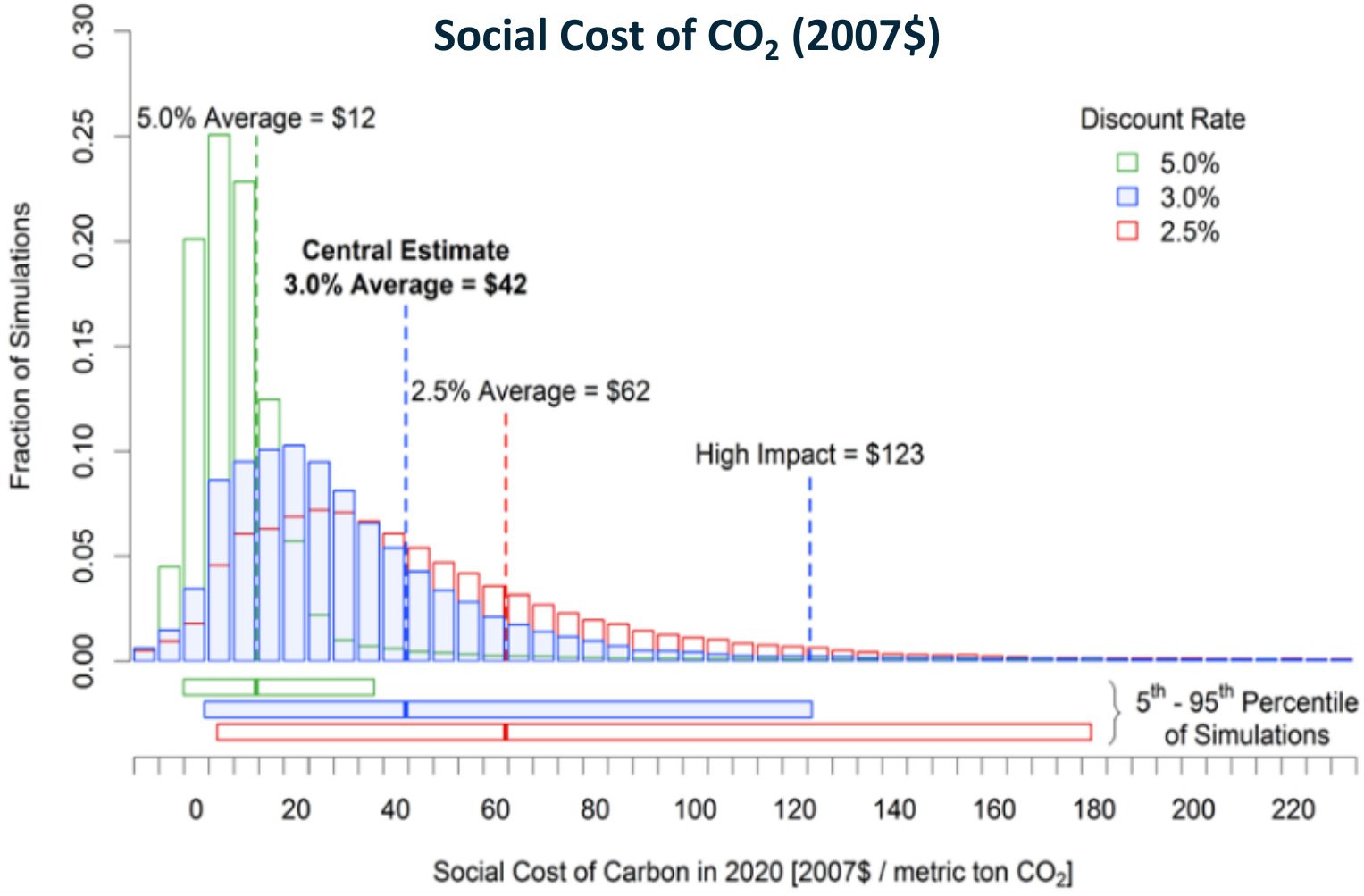
This 4-step procedure is done with both baseline emissions and with a small additional amount (a pulse) of $CO_2$ emissions in a particular year.

**SCC is the per-ton difference in present value of damages due to the pulse.**

# Why (and when) did the US federal government start caring about the SCC?

# US Federal government estimation of the SCC (2010-2016)

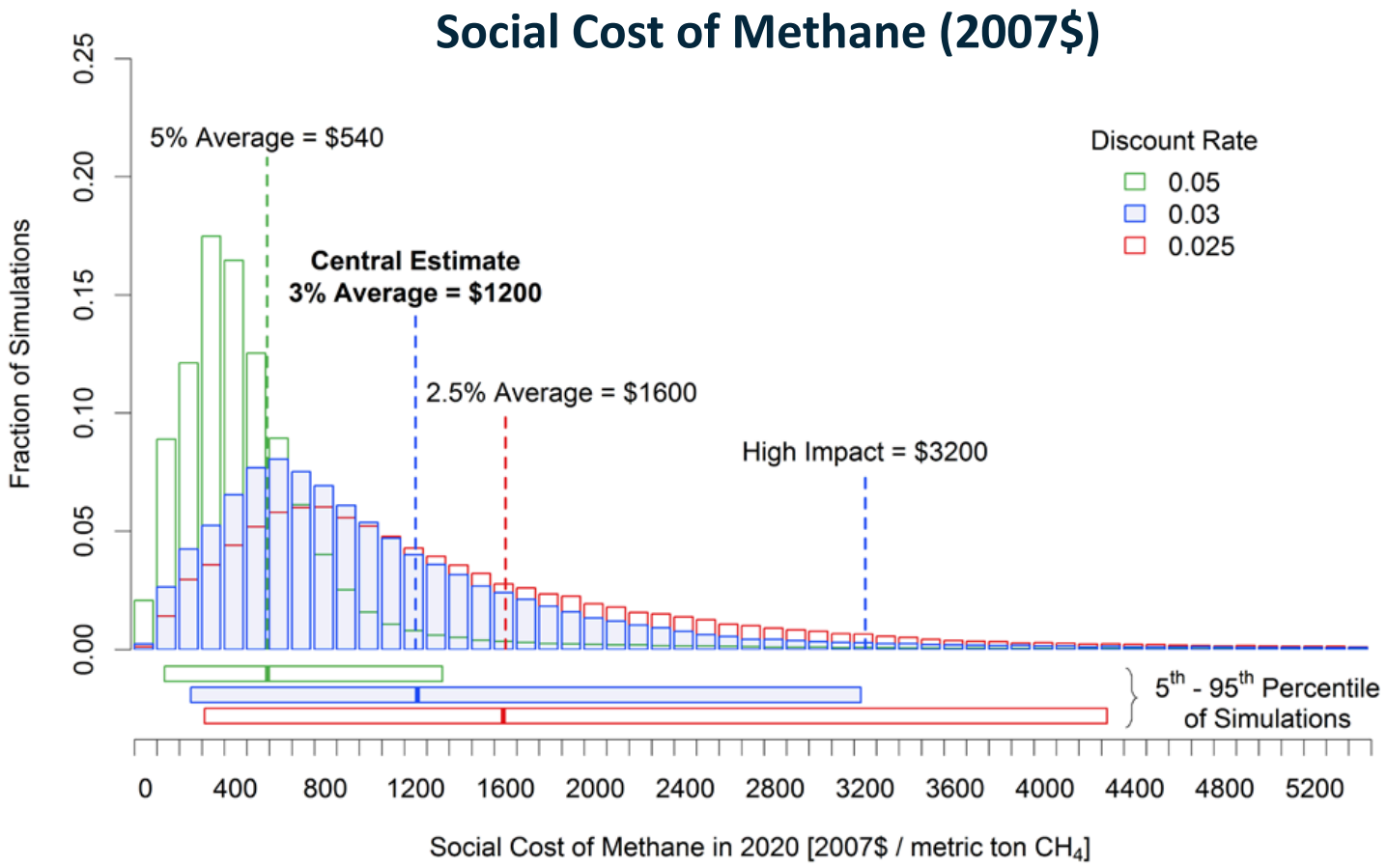
- The *Interagency Working Group on the Social Cost of Carbon* (IWG) used:
- three integrated assessment models from the peer-reviewed literature (DICE, FUND, and PAGE)
- five socioeconomic-emissions scenarios
- a probability distribution for the equilibrium climate sensitivity
- three different constant discount rates (2.5%, 3.0%, 5.0%).




Source: 2016 IWG Technical Support Document

# US Federal government estimation of the SCC (2016):
## Social Cost of Methane and Social Cost of Nitrous Oxide

- In 2016 the federal government officially released estimates of the social cost of methane (SC-$CH_4$) and social cost of nitrous oxide (SC-$N_2O$)
- SCC models were tailored to reflect the atmospheric residence time, radiative forcing, and other effects of $CH_4$ and $N_2O$.




Source: 2016 IWG Technical Support Document

# Value-based judgements in SCC estimation

Whose damages contribute to the estimate?

# Value-based judgements in SCC estimation

Whose damages contribute to the estimate?

How much are effects on future generations valued?

# Current status of the federal SCC

*Credit: Stephen Crowley/The New York Times*

*The US federal government has:*

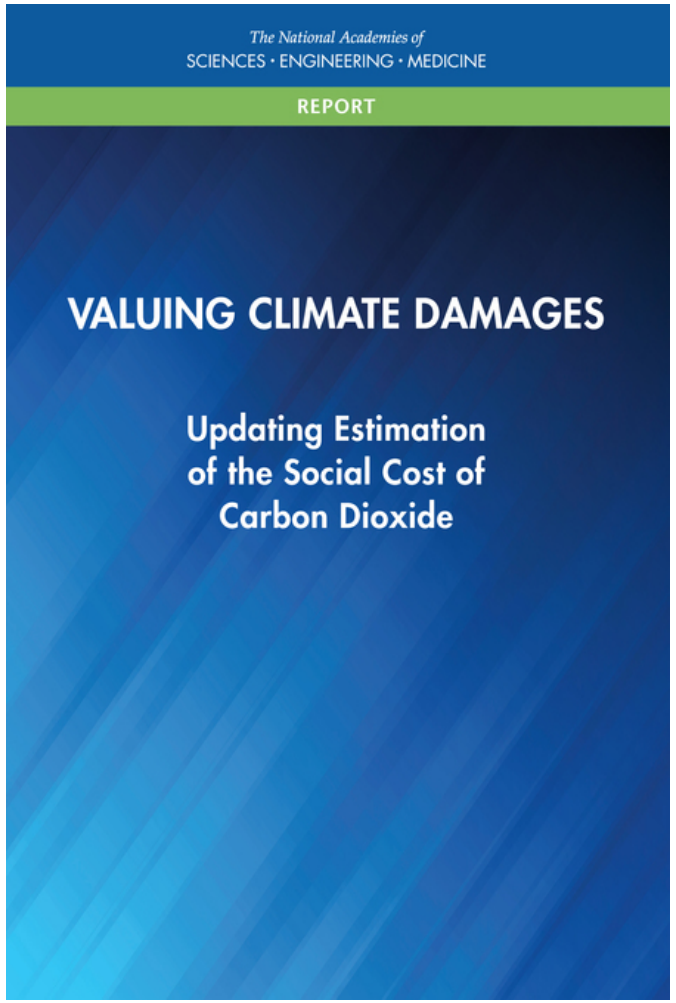
- moved away from the previous estimates and process for improving them;
- modified the IWG methodology to generate interim, domestic-only estimates incorporating a higher discount rate.

**Interim estimates are $1 - $8 per ton of carbon dioxide.**

# Improving the SCC estimation methodology

RFF's Social Cost of Carbon Initiative

# Improving the SCC estimation methodology

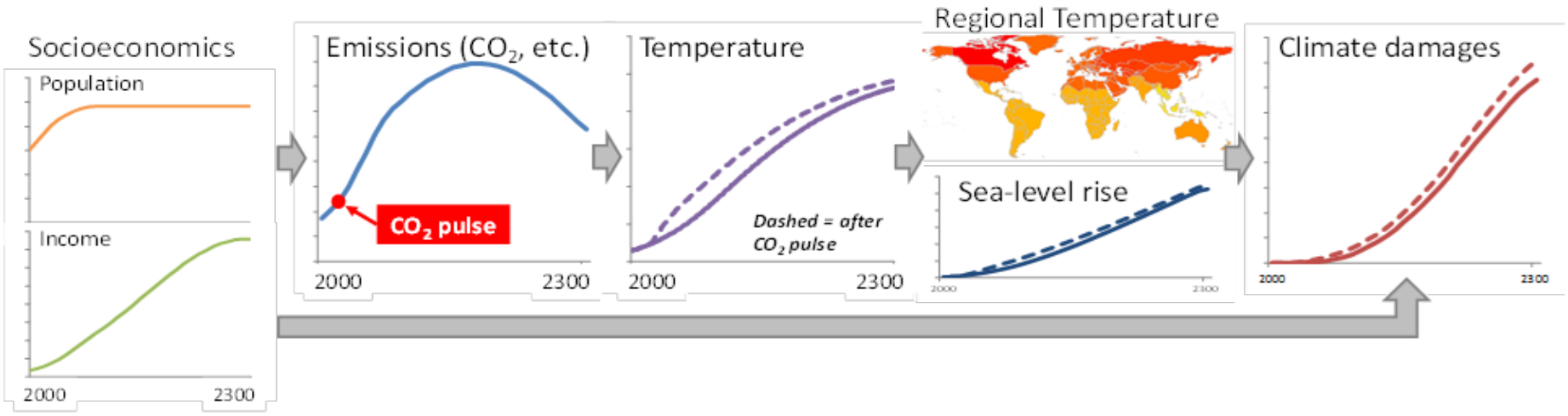



- In 2017 The National Academies of Sciences provided comprehensive recommendations to improve the scientific basis and transparency of SCC estimates.

# Overview of RFF's Social Cost of Carbon Initiative

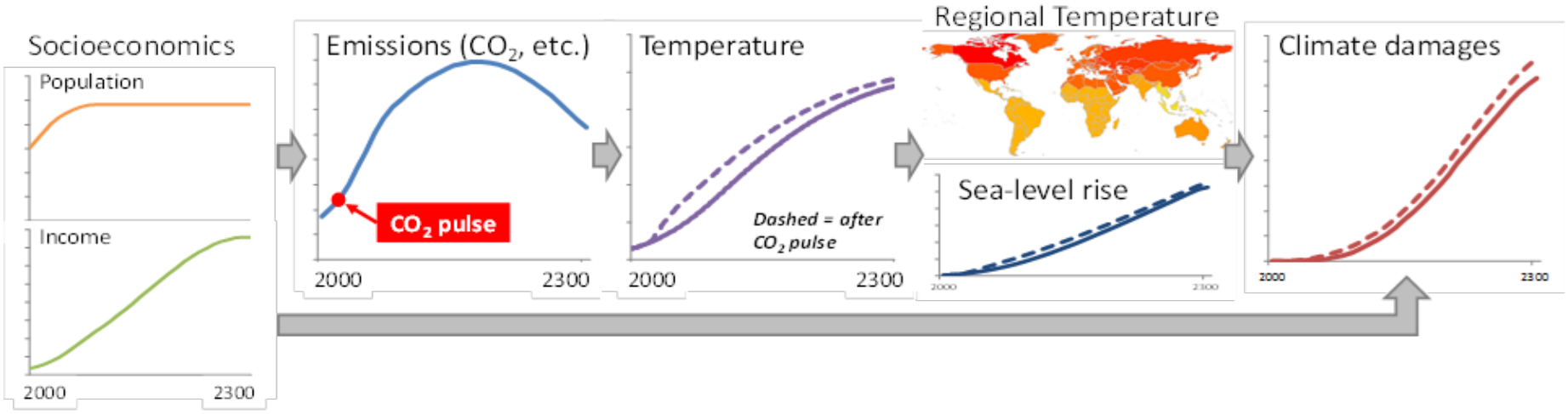
- **Improve** the scientific basis for the SCC estimates in accordance with the NAS recommendations and deliver a transparently updated SCC with associated uncertainty bounds.
- **Develop** freely available, open-source software tools for SCC estimation to promote transparency and serve as a common platform for SCC development by the scientific community.
- **Grow and inform** the public, scientific and user communities through extensive outreach and engagement.

# The NAS recommended improvements for each step of the SCC estimation process




1. Socioeconomic projections
2. Climate model
3. Damage calculations
4. Discounting

# The NAS recommended improvements for each step of the SCC estimation process




1. Socioeconomic projections
2. Climate model
3. Damage calculations
4. Discounting

# The *Interagency Working Group* Approach

- Relied on 5 EMF scenarios for projections to 2100; mechanically extended to 2300
- Averaged results from each scenario

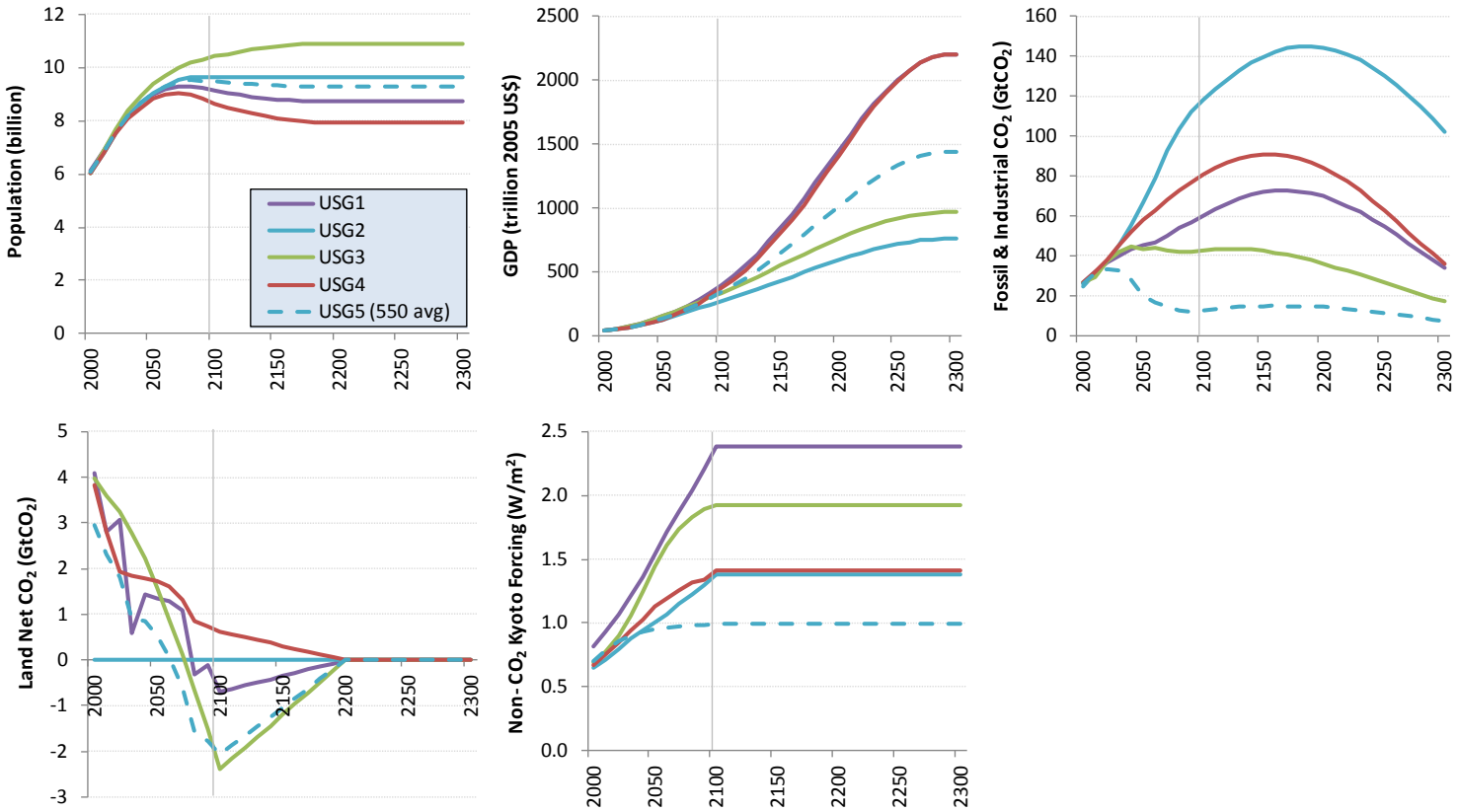
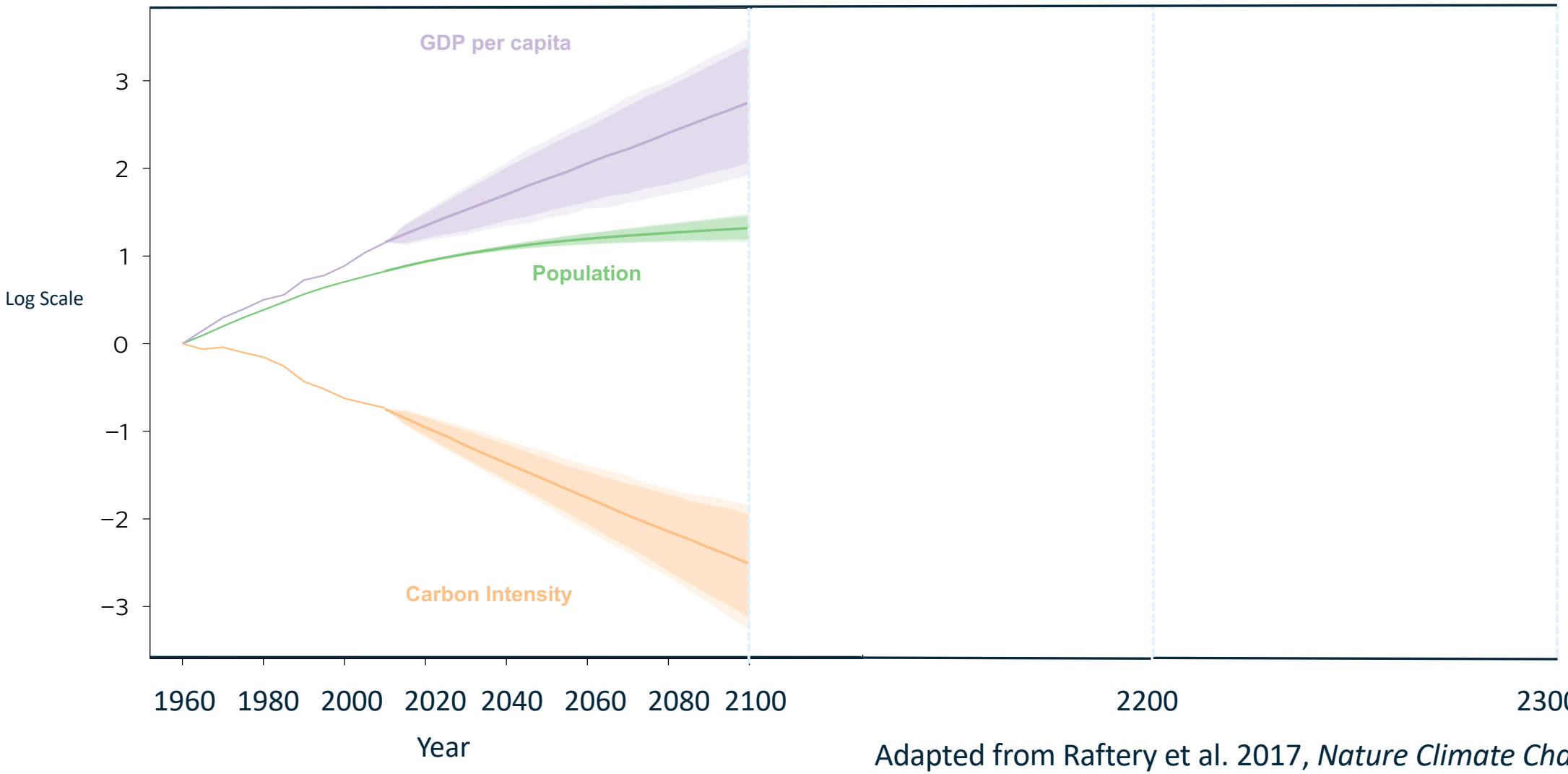



**Figure 4-2**
**USG global socioeconomic, emissions, and forcing inputs to 2300**

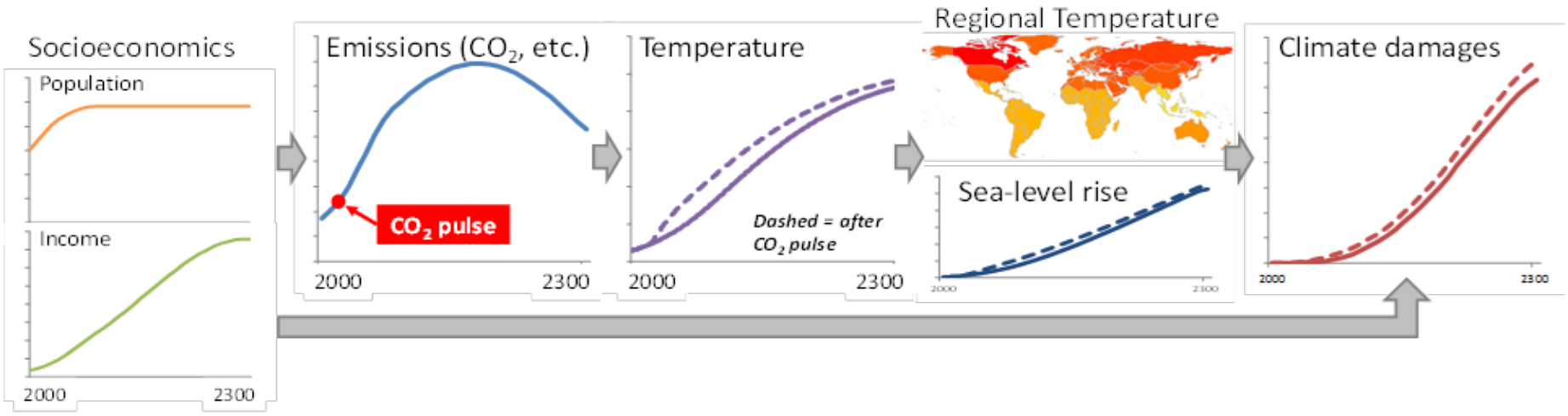
Source: Rose et al. 2014, *Understanding the Social Cost of Carbon: A Technical Assessment*

# NAS recommendation: shift from discrete socioeconomic scenarios to distributions of projections



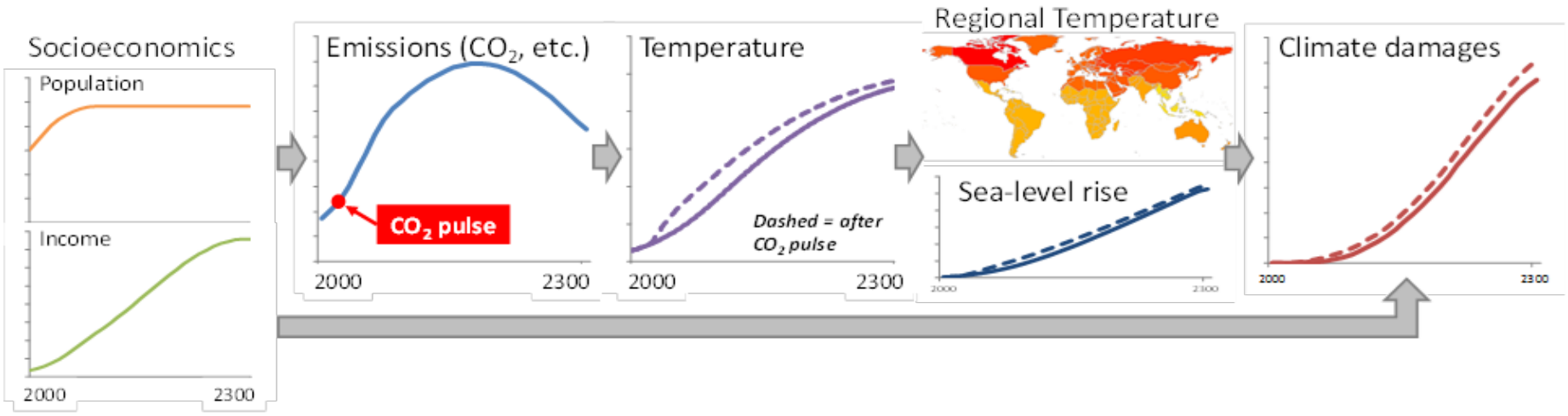

Adapted from Raftery et al. 2017, *Nature Climate Change*

# The NAS recommended improvements for each step of the SCC estimation process



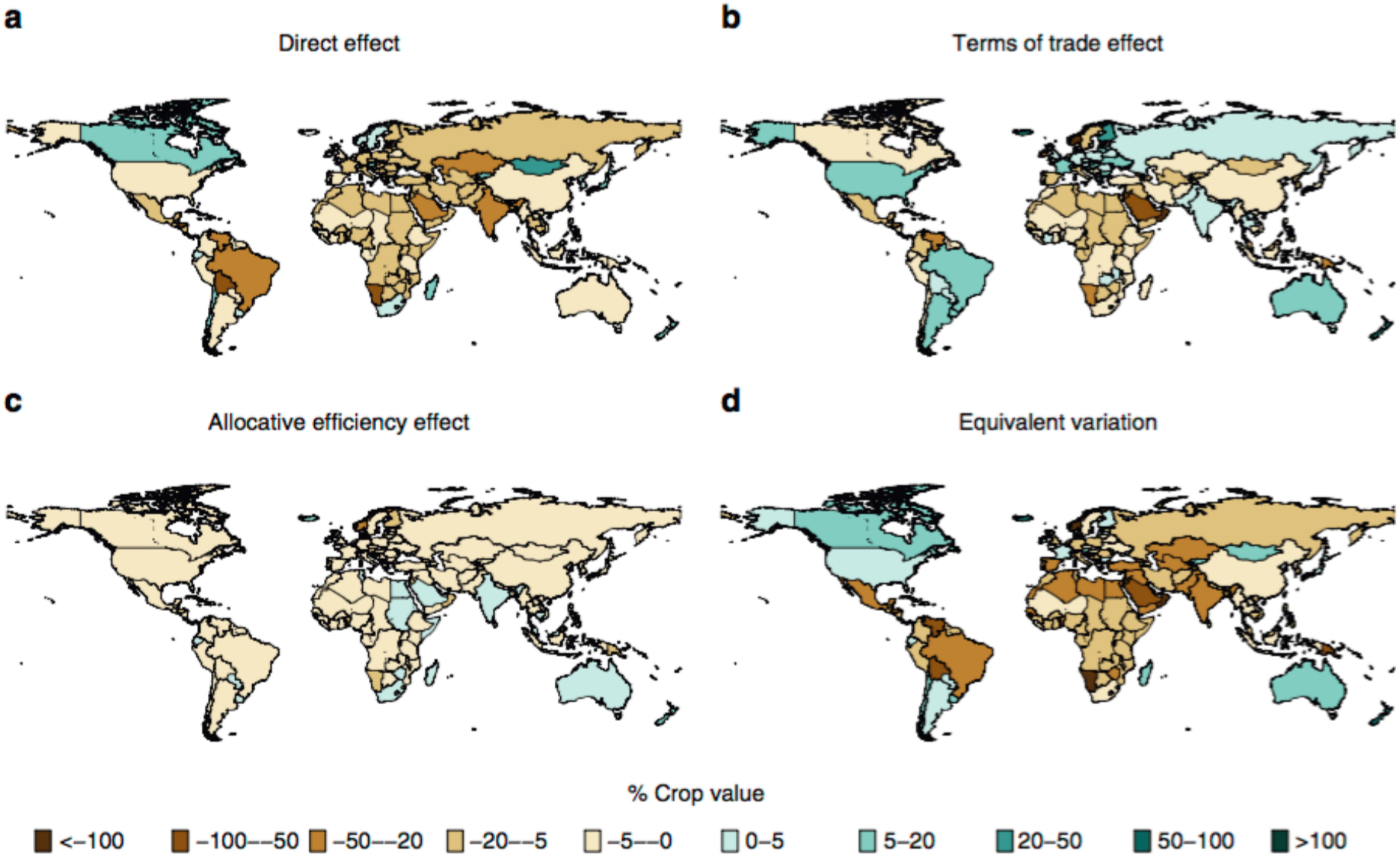

1. Socioeconomic projections
2. Climate model
3. Damage calculations
4. Discounting

# The NAS recommended improvements for each step of the SCC estimation process



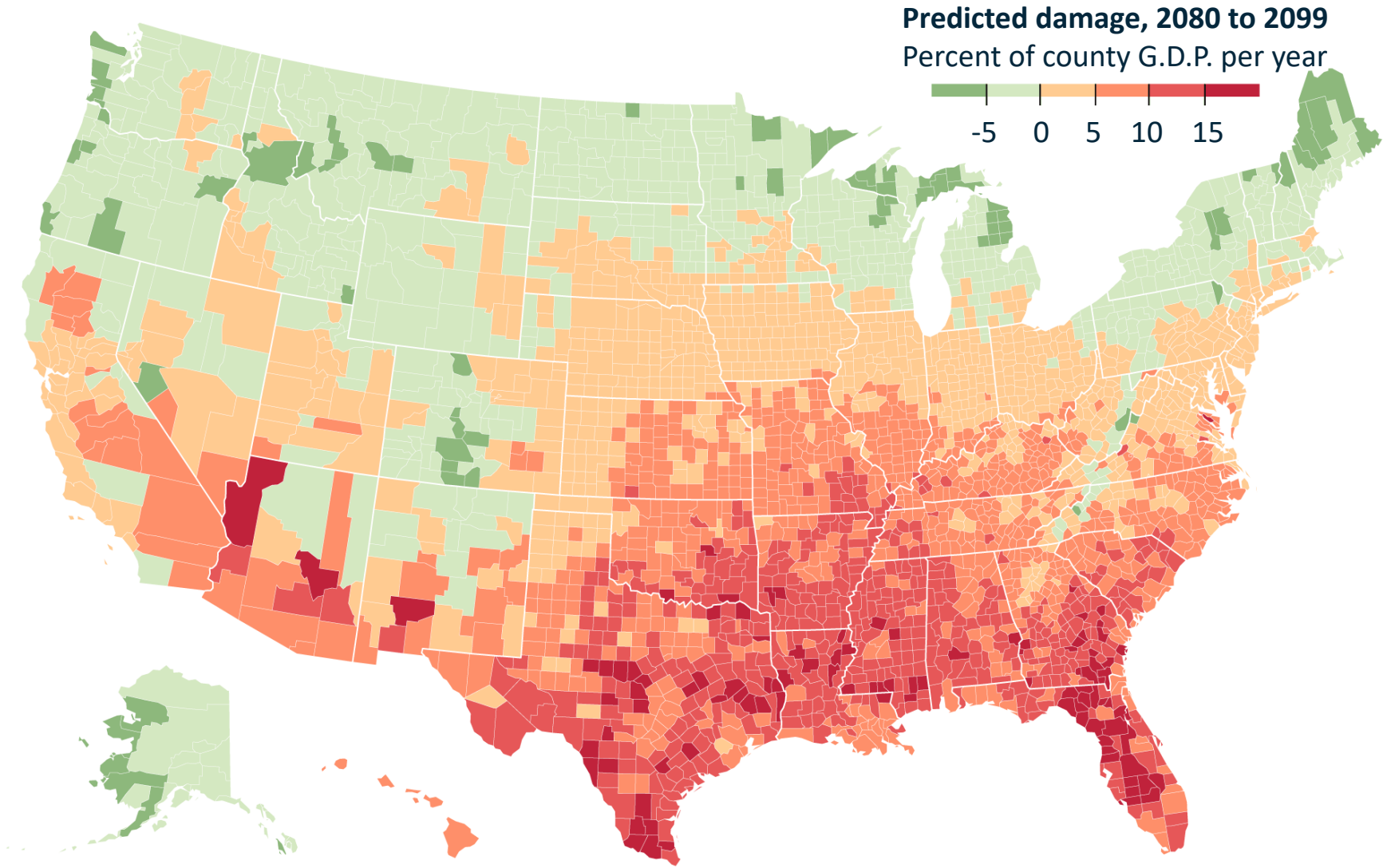

1. Socioeconomic projections
2. Climate model
3. Damage calculations
4. Discounting

# Moore et al. 2017: Regional agricultural damage functions with global coverage, incorporating regional interactions.



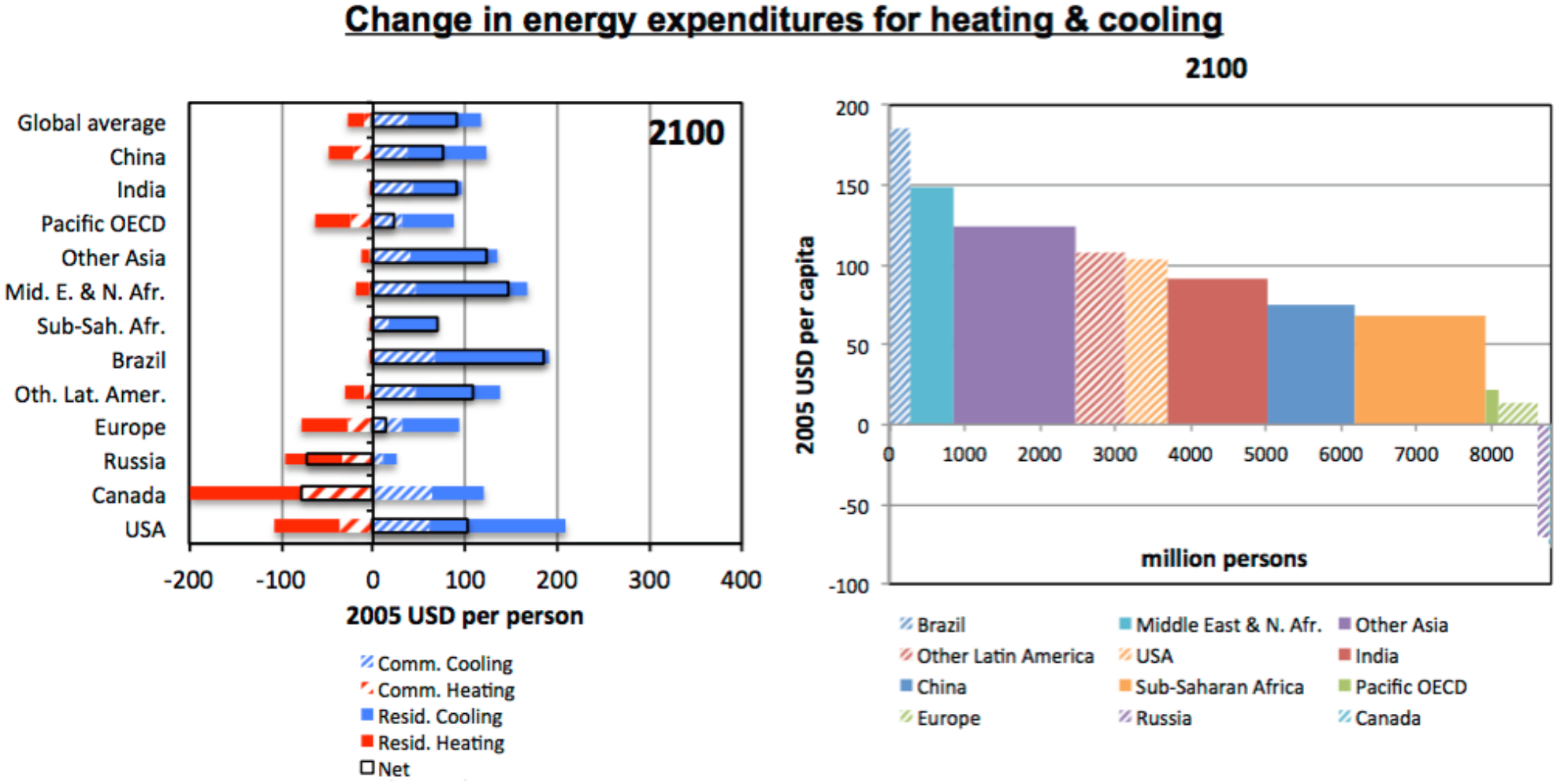

*Source:* Moore et al. 2017, *Nature Communications.*

# Climate Impact Lab: Spatially explicit, probabilistic, empirically derived estimates of economic damage from climate change.



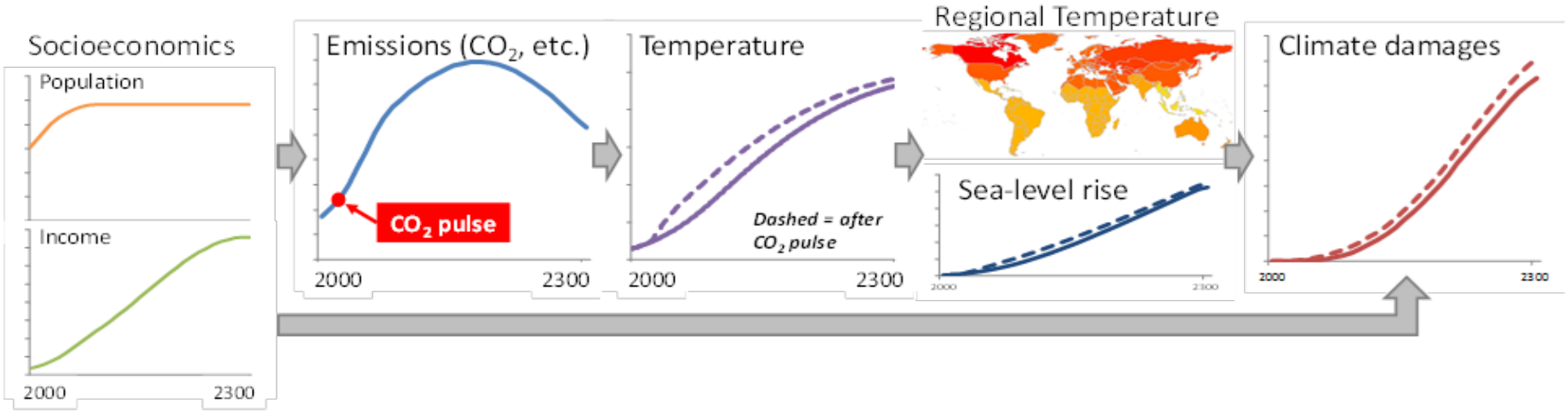

*Source: New York Times* – adapted from Solomon Hsiang et al. Science 2017;356:1362-1369

# Clarke et al.: Energy damages derived from a detailed process integrated assessment model.




*Source:* Leon Clarke presentation to the Third Meeting of the National Academies Committee on Assessing Approaches to Updating the Social Cost of Carbon, 11/13/2015.

# The NAS recommended improvements for each step of the SCC estimation process

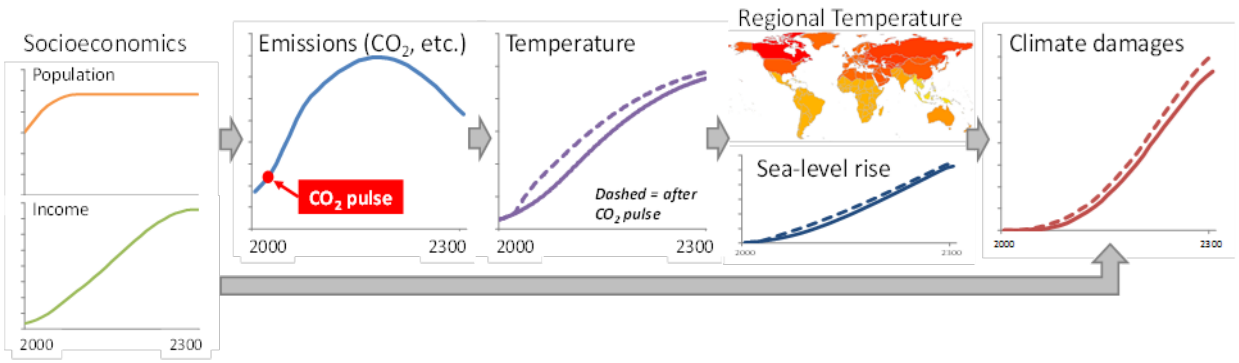



1. Socioeconomic projections
2. Climate model
3. Damage calculations
4. Discounting

# Discounting

| Discount Rate | Global SCC ($ per ton $CO_2$) |
|---|---|
| 2.5% | 75 |
| 3% | 50 |
| 5% | 14 |
| 7% | 5 |

# The NAS recommended an open, modular framework to improve transparency




1. **Socioeconomic projections**
2. **Climate model**
3. **Damage calculations**
4. **Discounting**

**An open-source computational platform:**

- Easy to use
- Support a modularized workflow
- Improve transparency

# Software platform: The Mimi Framework

**https://www.mimiframework.org/**

- Open source on Github, implemented in the Julia programming language as a registered Julia package
- Provides an accessible, easy-to-use interface for building and running Integrated Assessment Models
  - Readability and modularity
- Also provides support for more advanced features such as Monte Carlo simulations and Sobol analysis
- Actively monitor a forum to support any questions or issues: https://forum.mimiframework.org/

# US Climate Policy Efforts Toward a Net-Zero 2050 Economy

# Primary US Federal Policy Approaches for Reducing Emissions:

## Economy-wide Carbon Pricing

- Implement economy-wide or sectoral **carbon tax** or **cap and trade**

## Sectoral Policies

- Tradeable performance standards (e.g. Clean Electricity Standard, low carbon fuel standard)
- Building codes

## Federal Tax Incentives

- Extend or expand existing clean energy tax credits
- Repeal tax incentives for fossil fuels

# 116th Congress introduced legislation:
# Eight Economy-Wide Carbon Pricing Proposals

- **Carbon Tax Proposals**
  - Energy Innovation and Carbon Dividend Act (Rep. Ted Deutch and 58 cosponsors)
  - American Opportunity Carbon Fee Act of 2019 (Sens. Sheldon Whitehouse, Brian Schatz, Martin Heinrich, Kirsten Gillibrand)
  - Stemming Warming and Augmenting Pay Act (Reps. Francis Rooney, Dan Lipinski)
  - Raise Wages, Cut Carbon Act (Reps. Dan Lipinski, Francis Rooney)
  - Climate Action Rebate Act (Sen. Chris Coons)
  - America Wins Act (Sen. John Larson)
  - MARKET CHOICE Act (Reps. Brian Fitzpatrick, Salud Carbajal, Scott Peters, Francis Rooney)
- **Cap-and-Trade Proposals**
  - Healthy Climate and Family Security Act (Chris Van Hollen)

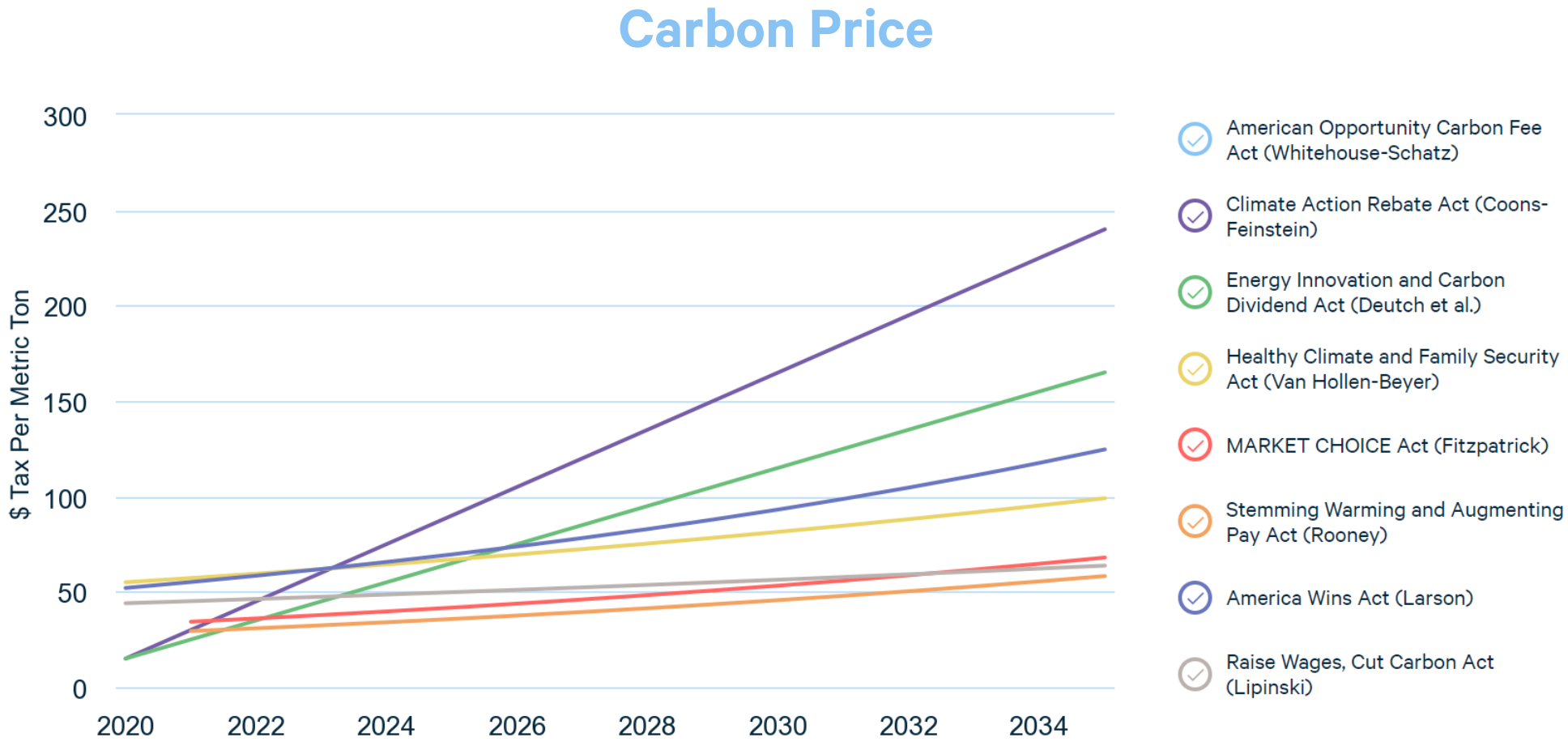
# RFF's Carbon Pricing Calculator

RFF employs sophisticated models of the economy to evaluate the effects of these bills in detail.

**RFF's Carbon Pricing Calculator** provides a web interface for easy exploration of the results and alternate policy options.

**www.rff.org/CPC**

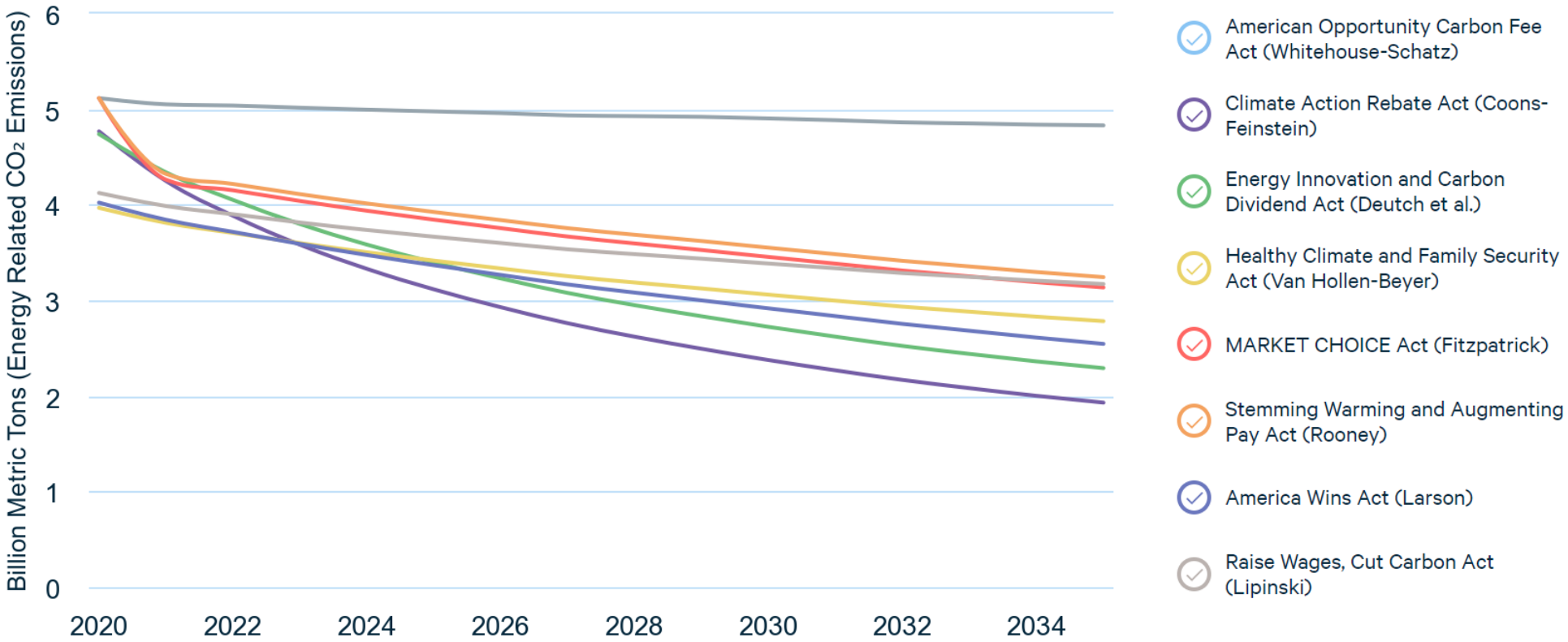
# Stringency of the carbon pricing proposals varies




Source: Goulder-Hafstead E3 model

# But all proposals put US on path to meet Paris target

## US Energy-Related $CO_2$ Emissions




Source: Goulder-Hafstead E3 model

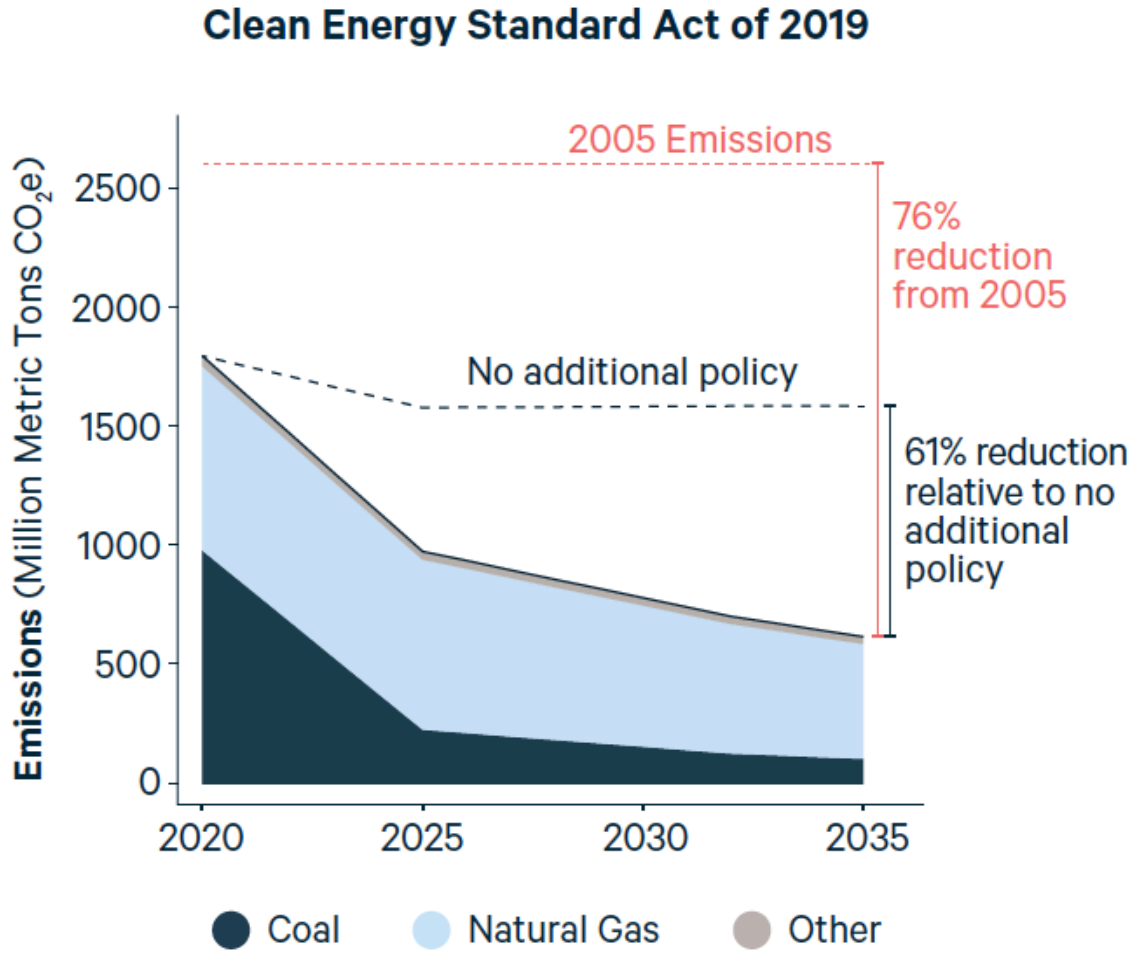
# House Energy and Commerce Committee:

## CLEAN Future Act

- Collection of sectoral policies to drive US to 100% net-zero economy by 2050
- All government agencies directed to issue regulations in line with net-zero 2050 target
- 100% clean energy standard for power sector
- Increasing fuel economy standards
- States are required to submit plans to EPA to reach 2050 and interim targets

# A Clean Energy Standard (CES) could yield large emissions reductions at low cost

- A CES is a power sector–only policy like a traditional renewable portfolio standard, expanded to allow for other low-carbon generation.
- A CES can yield significant reductions and approach the economic efficiency of carbon pricing.
- Proposed CES legislation is projected to reduce emissions 61% while increasing nationally averaged retail electricity costs by 4% in 2035.

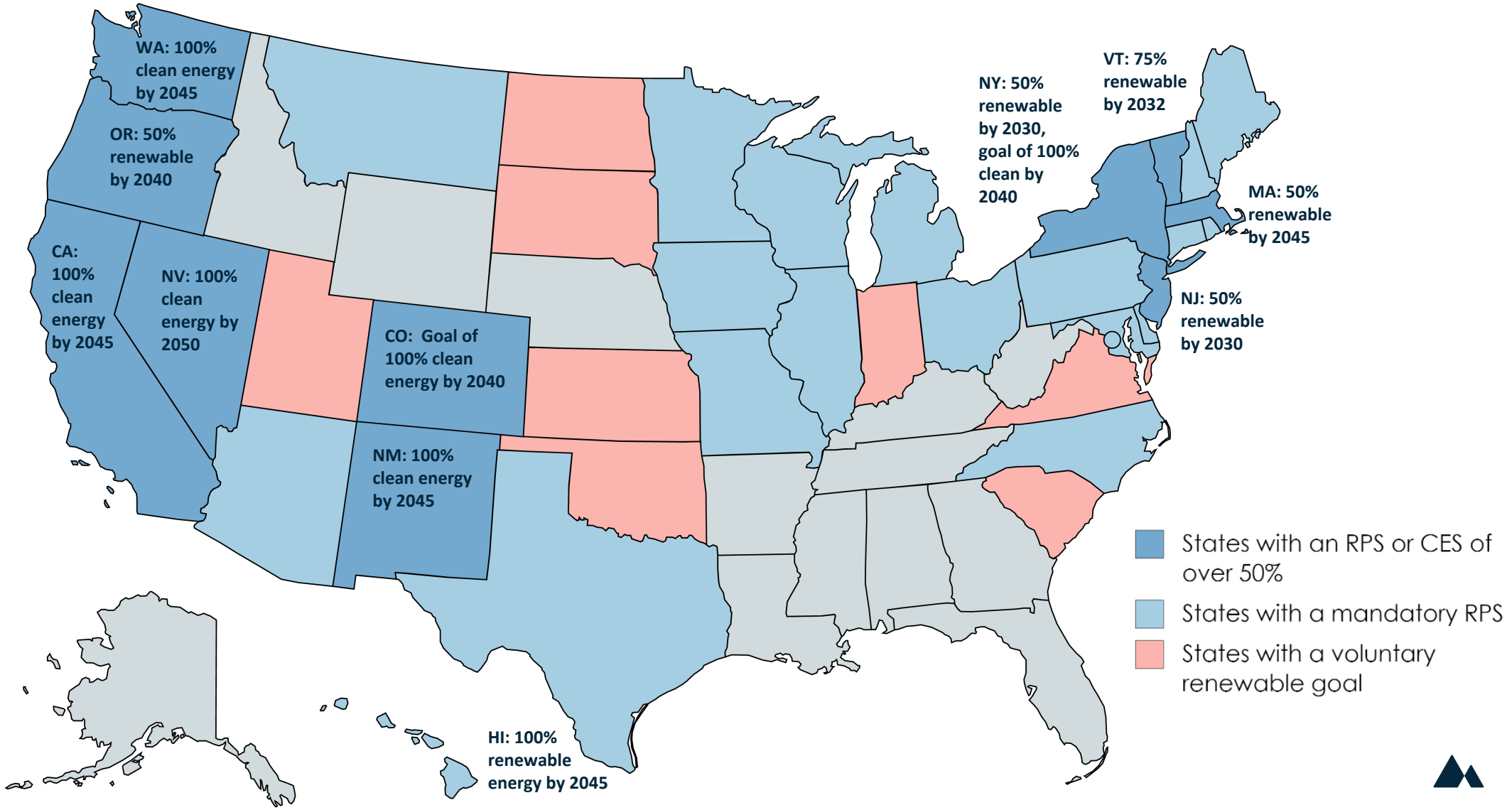


# Federal Tax Incentives

- Currently >40 different energy tax incentives, many of them technology specific and temporary, requiring periodic renewal.
- Examples for clean electricity:
  - Production Tax Credit for producing renewable electricity
  - Investment Tax Credit for building renewable facilities
  - Tax credit for sequestering CO2
- Examples for transportation:
  - Low carbon fuels credits
  - EV vehicle purchase credits
- Proposals have been offered to extend these credits, but also to replace them wholesale with a technology-neutral, emissions-based incentive.

# State activities to address climate change

# Existing Policies: State renewable policies



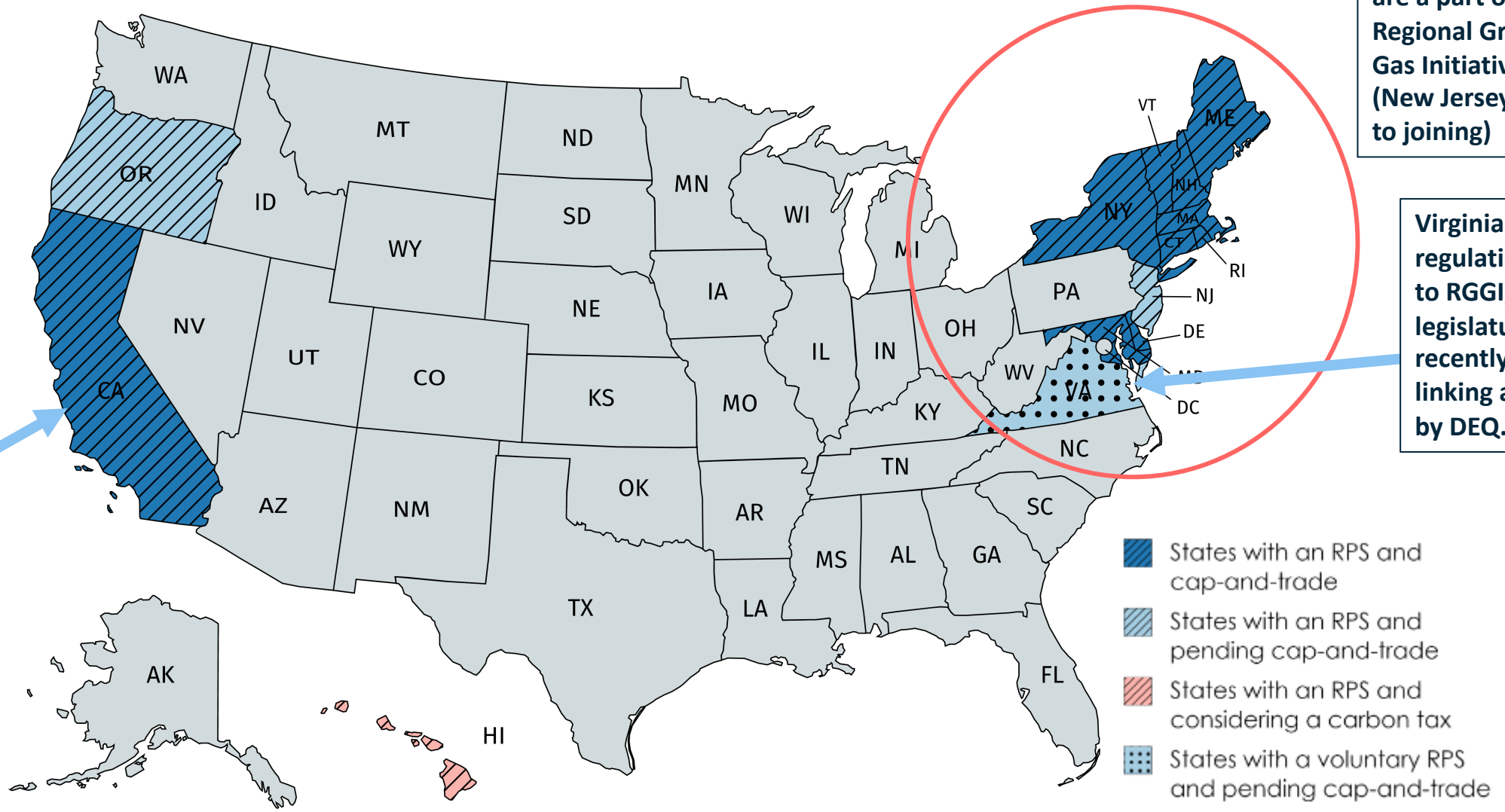

Created with mapchart.net ©

# Existing Policies: States with carbon policies

**9 Northeast States are a part of the Regional Greenhouse Gas Initiative (RGGI) (New Jersey is close to joining)**

**Virginia finalized regulation to link to RGGI, but legislature recently defunded linking activities by DEQ.**

**CA is part of the Western Climate Initiative (WCI) trading program with some Canadian Provinces**



# Conclusions

- The social cost of carbon is a highly influential metric, and efforts are well underway to overhaul it to improve its scientific basis, characterization of uncertainty, and transparency.
- There is significant, state-level US policy activity to address climate change, and the stage is being set for a renewed push on ambitious federal climate legislation.

RESOURCES *for the* FUTURE

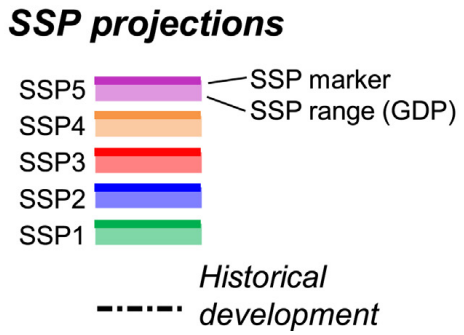
# Thank you.

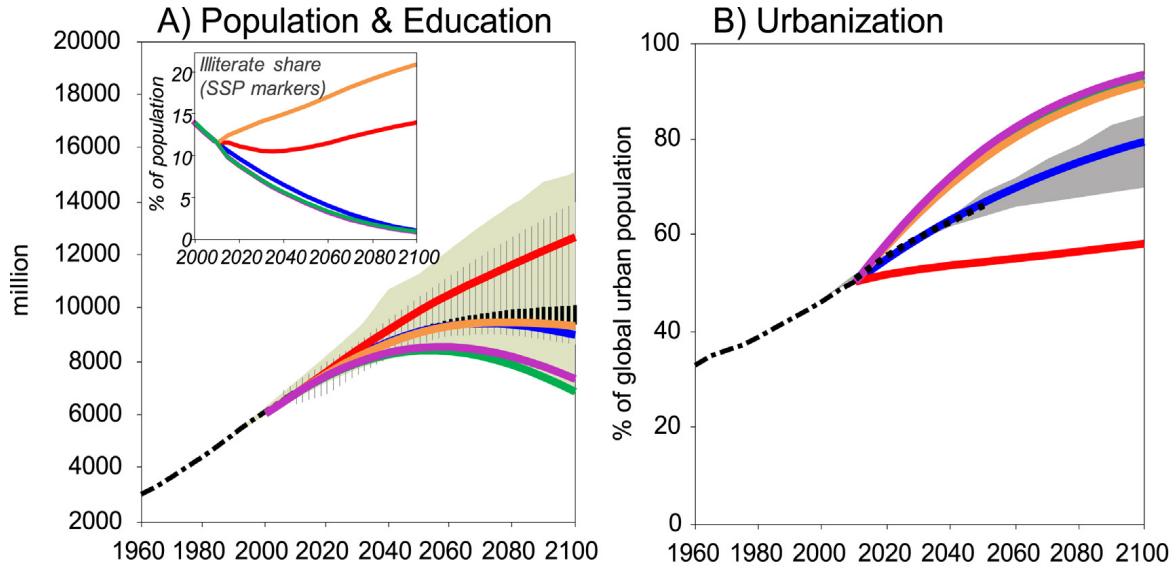
Kevin Rennert (rennert@rff.org)

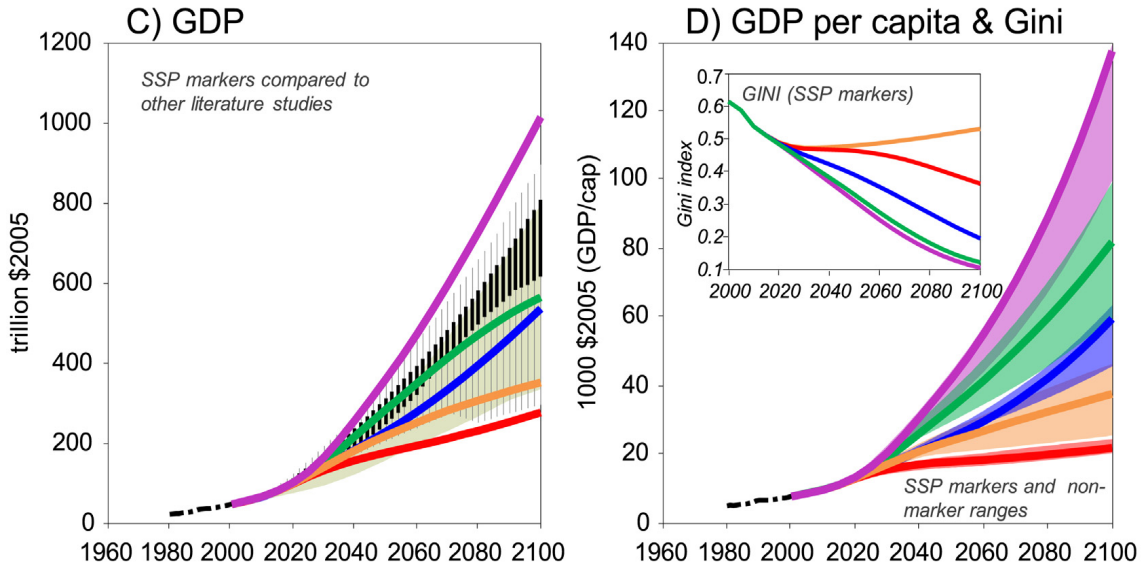
Social Cost of Carbon Initiative: www.rff.org/SCC
Carbon Pricing Calculator: www.rff.org/CPC

# Shared Socioeconomic Pathways

- Narrative-based socioeconomic scenarios
- Designed to provide socioeconomic complement to climate change scenarios and inform IPCC outputs
- Scenarios extend to the year 2100
- Scenarios are not associated with probability of occurrence



# Climate module

**The SCC initiative will develop and implement a climate module that:**

- captures the relationships between GHG emissions, atmospheric concentrations, and global mean surface temperature change over time, along with their uncertainty.
- provides a response to long-term forcing trajectories as well as a pulse of CO2 emissions that is similar to the response provided by more complex simulations.

- **We have currently implemented and are evaluating a number of models on the platform, including the FAIR model, the SNEASY model with the BRIC sea level rise component, among others, to serve as the basis for further development.**

# Scholarly History of the SCC

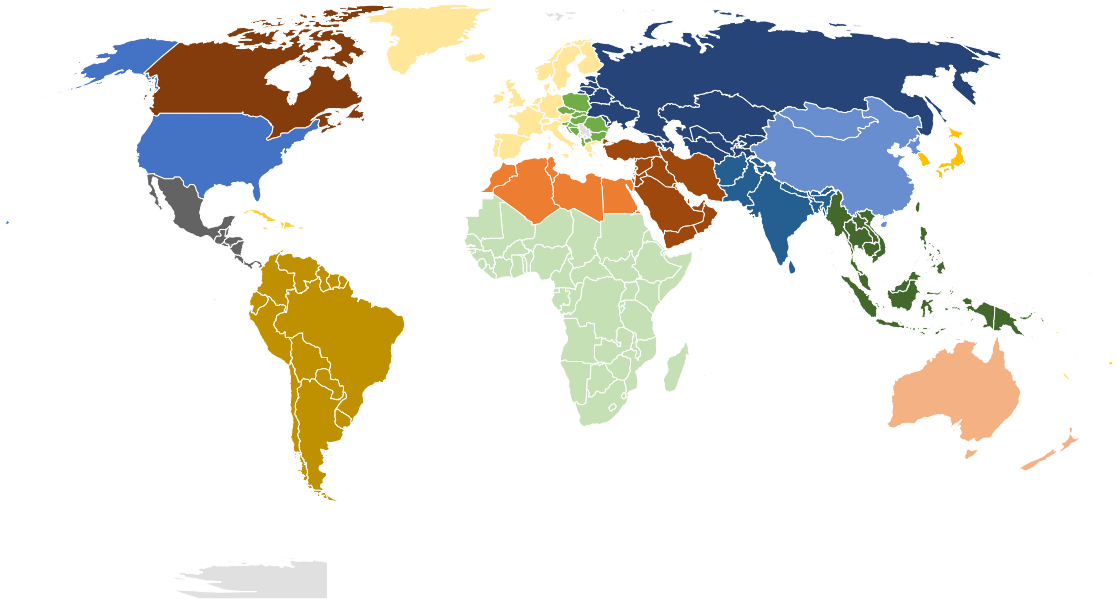
Typically estimated in the context of a global optimal carbon price using an Integrated Assessment Model (IAM)

- Nordhaus (1992): **$5/ton $CO_2$e in 2015$**
- Pearce et al. (1996) review of SCC estimates: **$3-62/ton** $CO_2$e for 2001-2010 period
- Tol (2005) review of 103 SCC estimates from 28 studies:
  - **$4/ton $CO_2$e (median), $25 (mean), $96 ($95^{th}$ percentile)**
- Stern Review (2007): **$102 / ton $CO_2$e**
- Tol (2008): 211 SCC estimates from 50 studies
  - **$8/ton (median), $29 (mean), $0-105 ($5^{th}$ – $95^{th}$ percentile)**
- Nordhaus (2016): **$31/ton** $CO_2$e in 2015

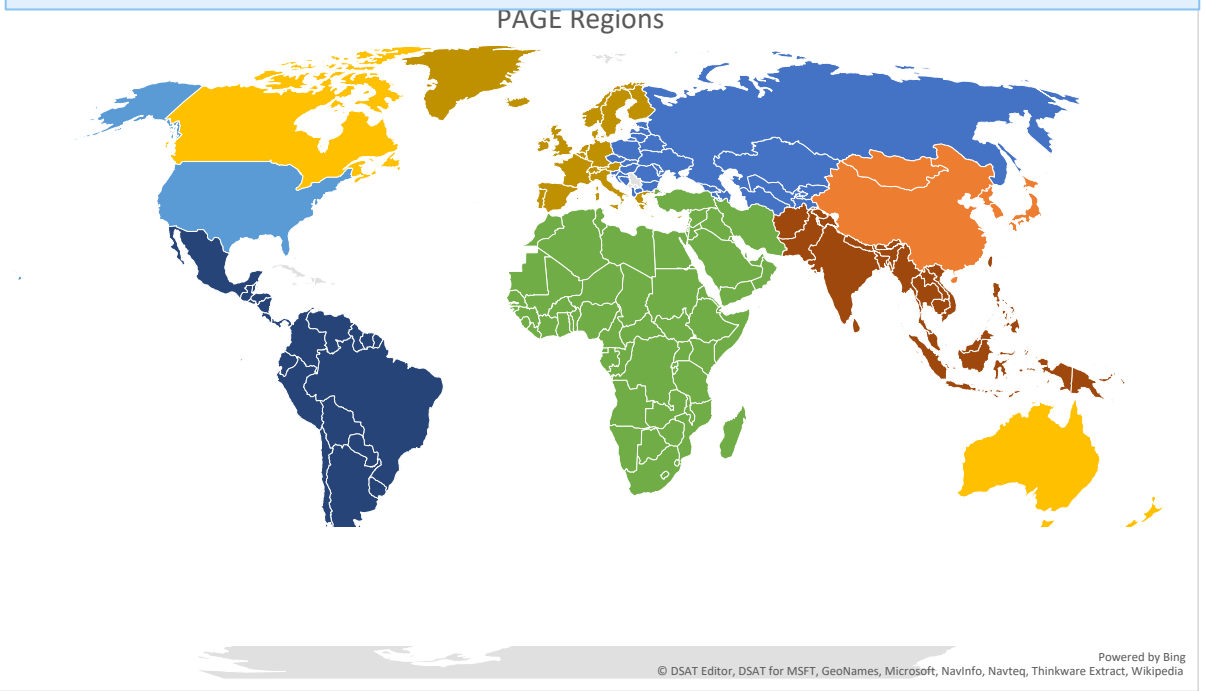
# Overview of 3 primary SCC Integrated Assessment Models

DICE Model: 1 region (i.e. global average)

FUND Model: 16 regions




PAGE Model: 8 regions



# Incremental Damages in DICE, FUND, and PAGE