APPENDIX

Environment Committee

Earth Day Hearing

April 25, 2019

Opening

- Thank you to the committee for inviting me to discuss the environment and the importance of clean energy policies as we celebrate Earth Day.

- Nearly fifty years ago—forty nine, to be exact—we celebrated our first Earth Day. Things are surely better than they were in 1970, but we also have a long way to go to get where we have to be.

- Climate change is upon us and that change is happening much faster than we had realized. We are seeing more extreme weather conditions, like the storms that have hit our state.

- We all remember Hurricane Irene and Super Storm Sandy, which left many without power for days and weeks. At the time the Board conducted an investigation into what went wrong and established more than 100 new utility regulations so that our fellow citizens wouldn't have to deal with anything like that again.

- Fast forward to February and March of 2018.

- Well, we all lived through the triple Nor'easters and we remember them more vividly because they happened more recently. Despite the hard and tireless efforts of the utility workers more than 100,000 New Jersey residents went without power for days.

- Since these storms were relatively less severe than either Irene or Sandy, many did not understand why it took so long to restore their power.

- And quite frankly, what occurred was unacceptable.

- In response, the Board launched a full investigation and ultimately imposed 30 new requirements on the utilities that would improve resiliency and strengthen infrastructure.

- One way of strengthening the infrastructure is through the implementation of Town Center Micro grids, which are designed to keep vital services, such as hospitals and fire stations, operating in case of issues with the main power grid.

- The Board funded and is now in the process of evaluating studies for 12 local governments who want to move forward in developing Microgrids.

- Yet despite all the science that tells us about climate change – despite what we've experienced ourselves – there are still those who do not believe the science nor take seriously the challenges we face.

- Fortunately, I am a cabinet member in an administration that takes climate change and its impact extremely seriously.

Clean Energy Agenda

- When he took office only fifteen months ago, Governor Murphy made clean energy a major focus of his agenda. This was a continuation of what he campaigned on. In fact, he was the first Governor to have campaigned on 100% clean energy. He feels that combatting the impacts of climate change is a responsibility we have, as a society, to protect the future for our children and for our grandchildren.

- In recent years, the effects of climate change have become obvious, even right here in our state. Increases in extreme weather events have impacted municipalities throughout New Jersey, and have left some with irreparable damage.

- We must act now to prevent further destruction to our homes and way of life here in the Garden State – and we are acting.

- With this mindset, in May of last year Governor Murphy signed ground-breaking legislation, sponsored in fact by many of you on the dais [Assembly members Pinkin and McKeon and Senator Smith] —The Clean Energy Act of 2018. The new law gave NJBPU the responsibility to implement important policy initiatives that will help the state achieve its ambitious energy goals. The Governor is calling for 100 percent clean energy by 2050. Some say this is unattainable. I disagree. Not only will we get there, but we must.

- From offshore wind, to solar, to energy storage, to a new energy master plan, the act aims to transform how we power New Jersey.

- Each of the innovative elements of our clean energy agenda are vital for combatting climate change, providing our citizens with a cleaner, healthier environment, and developing a stronger economy boosted by new industries and tens of thousands of green jobs.

Community Solar

- One of the key components of Governor Murphy's clean energy agenda is solar power.

- We are extremely proud of having surpassed 100,000 solar projects completed across NJ. More than 6,000 jobs have been created in our state by the solar industry and the cost of service has been cut in half over the last eight years.

- We are working to ensure that the solar market is properly incentivized at this point in its development. The SREC market was established in order to support the construction and adoption of solar energy at a time when the cost of the new technology was a significant deterrent.

- Over the last eight years, however, the cost of solar has halved, consumers are increasingly aware of its benefits, and adoption has increased.

- The Clean Energy Act, signed by Governor Murphy in May 2018 requires the BPU to effectively transition to a brand new program that will ensure the solar industry remains strong while creating a new incentive program at the right level.

- Earlier this year the Board approved a three-year Community Solar Pilot Program, which just began accepting applications. The Pilot program will provide opportunities for those who previously did not have access to solar due to their home location or economic circumstance. This pilot gives those folks a chance to benefit from this important renewable resource.

- Forty percent of the program's solar projects are allocated to those with low and moderate incomes so that solar can truly become accessible – equitably – to all.

<u>Offshore Wind</u>

- Alongside our solar programs, New Jersey is also a national leader in offshore wind. Our goal is 3,500 megawatts of offshore wind energy by 2030. Late last year the BPU put out the single largest solicitation for offshore wind in the nation, requesting the initial 1,100 megawatts of our goal. We are now in the midst of evaluating the applications and expect to make a decision before the end of June.

- The Governor has also asked my team at the BPU to open additional 1,200 megawatt solicitations in both 2020 and 2022.

- Offshore wind is a crucial piece of our clean energy agenda, and it has the potential to make a massive economic impact. It is our goal to ensure that the offshore wind supply chain be located in

New Jersey. We understand the economic potential the industry offers and will do all that we can to make sure New Jersey receives its benefits.

- This offshore wind program is so important for our clean energy agenda. As we generate more and more wind energy when the turbines are fully operational, what do we do with all of the energy that's generated?

Energy Storage

- The easy answer is we have to find a place to store it so that we can use it when we need to.

- So the final piece of our innovative clean energy puzzle is energy storage.

- The Clean Energy Act requires the state to achieve a goal of 600 megawatts of energy storage by 2021 and 2,000 megawatts by 2030.

- Energy storage systems offer the ability to offset peak loads, stabilize the electric distribution system, and provide emergency back-up power for essential services. These incentives not only strengthen our energy system, but ultimately benefit the ratepayer.

Protecting the Future

- All of these initiatives are clearly imperative for combatting climate change, but they also say something about us. They tell the world and our neighbors what kind of state we want New Jersey to be.

- We are proud of the progress we have made in an incredibly short amount of time – and we are looking forward to rolling out a transformative Energy Master Plan in the coming months.

- It is due to the passion and commitment of our staff that we have come this far in only 15 months after eight years of almost complete inaction on the threat of climate change. There is no more time to lose.

- Governor Murphy's clean energy agenda will deliver us the critical changes we need to ensure New Jersey's sustainable future. We must provide the future residents of this state with a healthy environment to enjoy for years to come. Clean energy is how we do it and, working closely with our partners in the Governor's office, the legislature and at DEP, the BPU is where it happens.

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Statements of

Robert Kopp
Professor, Department of Earth and Planetary Sciences
Director, Rutgers Institute of Earth, Ocean, and Atmospheric Sciences
Rutgers University

Anthony Broccoli
Professor and Chair, Department of Environmental Sciences
Co-Director, Rutgers Climate Institute
Rutgers University

To be presented to:

Joint Hearing of the New Jersey State Senate Environment and Energy Committee and the General Assembly Environment and Solid Waste Committee

April 25, 2019

RUTGERS

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Opening Remarks of Robert Kopp
Professor, Department of Earth and Planetary Sciences
Director, Rutgers Institute of Earth, Ocean, and Atmospheric Sciences
Rutgers University

To be presented to:

Joint Hearing of the New Jersey State Senate Environment and Energy Committee
and the General Assembly Environment and Solid Waste Committee

April 25, 2019

Thank you, Chairman Smith, Chairwoman Pinkin, and committee members for inviting me to speak today.

My name is Robert Kopp. I am a Professor and Director of the Rutgers Institute of Earth, Ocean, and Atmospheric Sciences (EOAS) at Rutgers University.

The Rutgers Institute of Earth, Ocean, and Atmospheric Sciences brings together about 130 faculty from across seven schools at Rutgers University who are working to advance both the fundamental scientific understanding of the Earth as a system and the use of that scientific understanding to advance environmental stewardship.[1]

I am also one of the directors of the Climate Impact Lab[2], a multi-institutional collaboration applying climate modeling and Big Data approaches to assess the economic risks of climate change.

My own research focuses on past and future sea-level change, on the interactions between climate change and the economy, and on the use of climate risk information in decision making.

I served as one of the twenty-nine lead authors of the first volume of the Fourth National Climate Assessment, and I was invited here in part to speak to this assessment.[3] I am also one of the many lead authors of the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (2021), which is due out in 2021. I should note that I'm appearing in my personal capacity, not to represent the US Global Change Research Program, the IPCC, or Rutgers University.

The Fourth National Climate Assessment provides an up-to-date assessment of the scientific understanding of climate change, its current effects on the United States, and its potential future impacts.

It draws out key findings from the massive body of peer-reviewed science to support scientifically informed climate risk management.

[1] For more information: eoas.rutgers.edu
[2] For more information: impactlab.org
[3] Volume 1 is available at science2017.globalchange.gov, and Volume 2 is available at nca2018.globalchange.gov.

Its first volume focuses on the physical science; the second, on Impacts, Risks, and Adaptation. The report's nearly 2000 pages are data-driven and extensively referenced.

Both volumes underwent detailed, transparent review processes, including open reviews by external experts and the general public, and thorough reviews by independent experts convened by the National Academies.

The process of drafting the National Climate Assessment was painstaking and complex, but its fundamental findings are simple and urgent:

1) **Climate change is real, it is happening now, and humans are responsible for it.**

The planet is running a fever: its average temperature has increased by nearly 2°F since 1900.

Global average carbon dioxide concentration are now about 410 parts per million – nearly 50% higher than they were at the start of the Industrial Revolution, and a level not seen on this planet for at least about three million years.

Carbon dioxide's role as a heat-trapping gas has been known since the discoveries of Eunice Foote and John Tyndall in the mid-19th century. Thus, a warming planet should be entirely expected, and many lines of evidence show that humans are responsible for essentially all of the warming since 1950.

2) **Climate change isn't an issue for the distant future – it's already affecting Americans in every region of the country, including here in New Jersey.**

Across the country, heat waves are becoming more frequent, heavy rainfall more intense, and coastal flooding more common as a result of climate change and sea-level rise.

Studies show that climate change intensified the dry, hot summer of 2011 in Texas and Oklahoma, the recent drought in California, and the rainfall of Hurricane Harvey in 2017.

Work that our research group has conducted with colleagues at Climate Central shows that human-caused sea level rise is responsible for about 70% of so-called "nuisance" or "minor tidal" flooding along the Jersey Shore,[4] and ongoing work in collaboration with Climate Central and Stevens Institute of Technology shows that human-caused sea-level rise was responsible for about $5 billion of the $30 billion of damage that Hurricane Sandy caused to New Jersey.[5]

3) **Climate change is not just an environmental challenge; it's an economic challenge, an infrastructure challenge, a public health challenge and a national security challenge.**

As the National Climate Assessment notes, drawing in part on work that my group at Rutgers has conducted in collaboration with our partners in the Climate Impact Lab, "In the absence of more significant global mitigation efforts, climate change is projected to impose substantial damages

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[4] BENJAMIN H. STRAUSS ET AL., UNNATURAL COASTAL FLOODS: SEA LEVEL RISE AND THE HUMAN FINGERPRINT ON U.S. FLOODS SINCE 1950 16 pp. (2016).
[5] B. Strauss et al., *Economic Damages from Hurricane Sandy Attributable to Sea Level Rise Caused by Anthropogenic Climate Change*, in rev. 2019.

on the U.S. economy, human health, and the environment,"[6] particularly in scenarios with limited adaptation.

I've already mentioned some of the quantifiable damages – via nuisance flooding and storm flooding – that climate change and sea-level rise are causing here in New Jersey.

With our partners in the Climate Impact Lab, we are working to improve estimates of a variety of current and future damages that can be traced to climate change, via impact channels that include mortality, labor productivity, agriculture, energy demand, coastal storms, and migration – as well as the expenditures required to limit these impacts.

Work we published four years ago found significant damages to New Jersey through increased energy expenditures and reduced labor productivity, but especially through coastal storms coming on top of rising seas. We projected that, without significant adaptation, by 2050, about $36 billion of current property statewide will likely fall below the high-tide line, and average annual storm damages will most likely double, to nearly $2 billion.[7]

4) **Every additional amount of greenhouse gas emitted makes climate change more severe – and every emission avoided ameliorates the harm.**

In order to stabilize global climate, human emissions of carbon dioxide must be brought as close to zero as possible, with any continued emissions balanced by human removal of carbon dioxide from the atmosphere, whether by expanding forests or using new, little-tested technologies. In other words, to stabilize global climate, net global carbon dioxide emissions must be brought to zero.

How quickly this happens determines how severe climate change gets. The faster we reduce our emissions, the less severe the effects and the lower the risk of unwelcome surprises.

5) **Though the pace is not yet adequate to minimize climate risk, Americans are already starting to respond by reducing emissions and beginning to adapt to climate change impacts.**

As the National Climate Assessment notes, 110 cities, several states, and an increasing number of companies have adopted emissions reduction targets.

The National Climate Assessment also highlights adaptation planning efforts by cities and transport systems, the use of innovative farming techniques to deal with wet and dry extremes, and efforts to manage water scarcity in the drier parts of the country. In New Jersey, it highlights efforts to harden the electric grid, expand living shorelines, incorporate climate data into PATH capital expenditures, and planning efforts coordinated by the New Jersey Climate Change Alliance and the NJ Coastal Management Program's Getting to Resilience initiative.

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[6] J. Martinich et al., *Reducing Risks Through Emissions Mitigation, in* IMPACTS, RISKS, AND ADAPTATION IN THE UNITED STATES: FOURTH NATIONAL CLIMATE ASSESSMENT, VOLUME II 1346–1386, 1347 (C. W. Avery et al. eds., 2018), doi: 10.7930/NCA4.2018.CH29.
[7] TREVOR HOUSER ET AL., ECONOMIC RISKS OF CLIMATE CHANGE: AN AMERICAN PROSPECTUS (2015).

These mitigation and adaptation efforts need to grow dramatically and rapidly to effectively manage climate risk.

As the National Climate Assessment notes, one important way to advance climate risk management is to mainstream climate change into existing decision processes.

For mitigation decisions, the social cost of carbon dioxide, or SCC, is a key tool for mainstreaming climate change. You'll be hearing more about the SCC from my NYU colleagues, Denise Grab and Peter Howard.

The SCC is a metric for measuring how much worse each additional amount of greenhouse gas emitted makes the impacts of climate change.

Measured in dollars per ton of carbon dioxide, it represents an estimate of the present economic value of all the impacts of climate change that touch things people care about – including the impacts I mentioned previously, such as to human health, agriculture, and coastal communities, and also impacts that are harder to value, such as the benefits of intact ecosystems.

As a policy fellow at the Department of Energy ten years ago, I provided technical support to the federal committee that developed the first standardized estimates of the SCC,[8] and subsequently served on a National Academies of Sciences, Engineering, and Medicine committee examining how to improve estimates of the social cost of carbon dioxide.[9]

In the Obama Administration, the SCC was used to improve analyses of the benefits and costs of dozens of regulations, from appliance efficiency standards to power plant emissions rules. By valuing the benefits of carbon emissions reductions, it helped regulations be designed in a more economically efficient manner while ensuring that climate benefits and costs were never neglected in rulemakings.

There is a fair bit of work ongoing in the academic community right now to improve estimates of the SCC, including work by the Climate Impact Lab consortium.

At the moment, though, the last Federal interagency estimates, which were published in 2016, remain a reasonable assessment of the SCC. At a three percent discount rate, this estimate was $51/ton in current inflation-adjusted dollars ($42/ton in 2007 dollars).[10] And while this number will change with emerging research, it is certainly adequate to begin incorporating the SCC into decision making processes in New Jersey, preferably accompanied by a clear pathway for updating in light of emerging research.

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[8] INTERAGENCY WORKING GROUP ON THE SOCIAL COST OF CARBON, UNITED STATES GOVERNMENT, TECHNICAL SUPPORT DOCUMENT: - SOCIAL COST OF CARBON FOR REGULATORY IMPACT ANALYSIS - UNDER EXECUTIVE ORDER 12866 - (2010), https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf.

[9] NATIONAL ACADEMIES OF SCIENCES, ENGINEERING, AND MEDICINE, VALUING CLIMATE DAMAGES: UPDATING ESTIMATION OF THE SOCIAL COST OF CARBON DIOXIDE (2017).

[10] INTERAGENCY WORKING GROUP ON THE SOCIAL COST OF CARBON, UNITED STATES GOVERNMENT, TECHNICAL SUPPORT DOCUMENT: -TECHNICAL UPDATE OF THE SOCIAL COST OF CARBON FOR REGULATORY IMPACT ANALYSIS -UNDER EXECUTIVE ORDER 12866 - (2016), https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc_tsd_final_clean_8_26_16.pdf.

A recent report by students at the Rutgers Bloustein School of Planning and Public Policy highlighted several opportunities for doing so, including in regulatory and BPU decisions and in environmental impact statements.[11]

In conclusion:

The National Climate Assessment shows that:

Climate change is real, it's here, and we humans are responsible for it. To stabilize global climate, we need to bring net global greenhouse gas emissions to zero; the sooner we do this, the smaller the risks – to our economy, health, infrastructure, and security – that we will have to manage. But even with strong emission reductions, there will still be major adaptation challenges ahead. It's therefore essential that climate change become a routine and integrated part of decision-making at all levels – public and private; federal, state, and local.

Thank you for holding this important hearing today. It's encouraging that you are focusing on climate change mitigation, which is central to reducing the substantial risks posed by climate change. Identifying the most effective and efficient approaches for addressing these risks will be great importance to the future of our state. I and my colleagues at Rutgers are ready to help in this endeavor.

[11] ZACH FROIO ET AL., AT WHAT COST? INCORPORATING THE SOCIAL COST OF CARBON INTO STATE-LEVEL POLICIES IN NEW JERSEY (2018), https://bloustein.rutgers.edu/wp-content/uploads/2018/05/2018-At-What-Cost-Final-Practicum-Report-May-2018.pdf.

Opening Remarks of Anthony Broccoli

Professor and Chair, Department of Environmental Sciences
Co-Director, Rutgers Climate Institute
Rutgers University

To be presented to:

Joint Hearing of the New Jersey State Senate Environment and Energy Committee
and the General Assembly Environment and Solid Waste Commitee

April 25, 2019

Good morning, Chairman Smith, Chairwoman Pinkin, and members of the Senate Environmental and Energy Committee and the Assembly Environment and Solid Waste Committee.

My name is Anthony Broccoli and I am a Professor of Atmospheric Science at Rutgers University, Chair of the Department of Environmental Sciences, and Co-Director of the Rutgers Climate Institute. My research is directed at understanding the changes in climate that have happened in the past and will happen in the future.

I am honored by your invitation to come here today and have the opportunity to specifically discuss the effects of climate change as they are being felt and will be felt in New Jersey. My colleague, Dr. Kopp, has described the National Climate Assessment process and highlighted some of its most important findings. With his testimony as a starting point, I will focus on three of the most impactful aspects of climate change for New Jersey: temperature, precipitation, and sea level.

Dr. Kopp noted earlier that global average temperature has risen by approximately 2°F since 1900. According to data analyzed by the National Oceanic and Atmospheric Administration, the last five years have been the five warmest in records of global temperature going back to 1880.

Here in New Jersey, average temperature has risen at a rate of just under 3°F per century, or somewhat faster than the global average. If we look only at the period since 1970, the rate of warming has doubled. Six of the seven warmest calendar years on record have occurred during this decade.

These changes in average temperature have dramatic consequences for the temperature extremes that are experienced here in New Jersey. Statewide temperature averages are available going back to 1895—that's 124 years of data. Looking over that period, we can define an unusually warm month as one that is among the five warmest for that time of year, and an unusually cold month as one that is among the five coldest.

Since the beginning of the 21st century, unusually warm months have outnumbered unusually cold months 40 to 0 since 2000. That's right—based on historical standards, no month has been one of the five coldest for that time of year, but 40 months have been among the five warmest. In 2018, for example, New Jersey experienced its 2nd-warmest February, 4th-warmest May, a tie for the warmest August, and the 3rd-warmest September.

Short-term fluctuations in weather patterns are making some months colder than the long-term average and others warmer. But warm extremes and cold extremes are no longer equally likely. As the world continues to warm, future climate will feature more frequent and longer heat waves and fewer cold temperature extremes, and this trend is expected to continue in the decades to come as the concentrations of heat-trapping gases continue to increase.

A warmer world will also lead to more a more active water cycle. More heat energy available at the surface of the land and ocean will increase evaporation into the atmosphere, just as a container of water left outside will evaporate more quickly on a hot day than a cold day. The globally averaged evaporation has to be balanced by precipitation, accelerating the global water cycle.

We have seen an upward trend in annual precipitation in New Jersey of just over 2 inches per century since statewide records began in 1895. This trend is small compared with the year-to-year variability of precipitation. By the end of this century, projections from the National Climate Assessment indicate that statewide precipitation could increase by 10-20% in winter and spring and by less than 10% in summer and fall.

But increases in the total amount of precipitation don't tell the whole story. The frequency of heavy precipitation events, such as those New Jersey experienced in Hurricanes Floyd and Irene, has been increasing. In the U.S., two-day rainstorms that had one chance in five of occurring in the first half of the 20th century—the so-called five-year storm—have happened 30-50% more often in the last two decades. Climate projections gives us reason to expect this trend will continue, as heavy precipitation events are anticipated to become more intense and more frequent as temperature increases, with implications for the frequency of inland flooding along New Jersey's rivers and streams.

During the past twenty years, the great ice sheets that cover most of Greenland and Antarctica have been shrinking, as have almost all mountain glaciers throughout the world. The melting ice adds water to the oceans, which is one of the causes of sea level rise. Over the 20th century, global sea level rose about 7 inches. But sea level rise is accelerating. If we look at just the past 25 years, the rate of global sea level rise has increased to over 12 inches per century.

Sea level rise along the New Jersey coast has been more rapid than the global average because the land is sinking at the same time that water levels are rising. At Atlantic City, where records extend back to 1912, sea level has risen by an average rate of 1.5 inches per decade. As the ocean continues to warm and glaciers and ice sheets continue to melt, sea level rise is expected to accelerate. According to a recent report produced by a team of scientists under the auspices of the New Jersey Climate Change Alliance, estimates of sea level rise on the New Jersey coast relative to the year 2000 range from 6 to 13 inches by 2030, 13 to 21 inches by 2050, and 20 to 54 inches by end of this century, with the values in 2100 dependent on future carbon dioxide emissions.

The most serious impacts of sea level rise will be felt when the strong onshore winds from coastal storms, both hurricanes and wintertime nor'easters, push water toward the coastline. There is high confidence that coastal flooding from future storms is likely to be more frequent and more severe, as rising sea levels raise the baseline for flooding events. For example, as Prof. Kopp noted in his testimony, human-caused sea-level rise caused a larger area to be flooded during Hurricane Sandy and was responsible for about $5 billion of the $30 billion of damage that Sandy caused in New Jersey. The future rise in sea level will likewise increase the areas at risk of coastal flooding.

Addressing these risks will involve the need to make impactful decisions about a future in which we know the broad outlines of climate change, but have an imperfect knowledge of the details. It is important that the decisions that we make, here in New Jersey and elsewhere, should be informed by the best available knowledge. At Rutgers, faculty and students from many departments, schools, and campuses are engaged in research that will lead to a better understanding of the risks we face and the solutions that are available.

Rutgers scientists study the changes in climate and sea level that have occurred in the past in an effort to better understand the mechanisms that drive them. They use computer models to study the processes that drive changes in the atmosphere and ocean. They monitor conditions on land and in the coastal waters, using automated weather stations, ocean gliders, radar, and satellites. They study the effects of climate change on fisheries and on the forests of the Pinelands. Sea level rise projections produced at Rutgers have been adopted in states including California, Oregon, Washington, Maryland, and Delaware. Other research topics include the vulnerability of our residents to climate change and the impacts of climate change on agriculture here in the Garden State.

Rutgers is also deeply involved in research on the production, storage, and use of energy, including the development of alternative energy sources such as bioenergy, solar, water, and especially, wind. Wind energy is an especially promising avenue for a coastal state like New Jersey, as anyone who has spent time at the Jersey Shore has probably noticed that winds are stronger over the ocean. Rutgers is also engaged in research on battery technology, green buildings, and energy-efficient transportation and supply chain management, to name but a few examples.

All of these efforts are motivated by a desire to address what is arguably the most important environmental issue of the 21st century. To the committee chairs and to the committee members, I thank you again for the opportunity to talk with you today and provide an overview of this important issue.

Statements of

Jeanne Herb
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Marjorie Kaplan
Associate Director, Rutgers Climate Institute
Rutgers University

To be presented to:

Joint Hearing of the New Jersey State Senate Environment and Energy Committee
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April 25, 2019

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Opening Remarks of

Marjorie Kaplan
Associate Director, Rutgers Climate Institute
Rutgers University

and

Jeanne Herb
Director, Environmental Analysis and Communications Group
Edward J. Bloustein School of Planning and Public Policy
Rutgers University

To be presented to:

Joint Hearing of the New Jersey State Senate Environment and Energy Committee and the General Assembly Environment and Solid Waste Committee

April 25, 2019

Thank you, Chairman Smith, Chairwoman Pinkin, and committee members for inviting us to speak today.

My name is Marjorie Kaplan, I am Associate Director of the Rutgers Climate Institute at Rutgers University.

The Rutgers Climate Institute brings together 100 affiliated faculty and staff from 13 schools across Rutgers in the natural and social sciences, the humanities, engineering, law, and medicine. We seek to understand the mechanisms that drive climate change; its human and social dimensions; and to inform and educate society about it through research, education and in service to New Jersey.[1]

I am also the liaison for Rutgers University to the US Department of Agriculture, Northeast Climate Hub that works to build collaborations and connect stakeholders to climate-related resources for agricultural producers and foresters in the 12 Northeastern States. [2]

I facilitate development of climate research as well as conduct applied research related to resiliency planning, climate policy analysis, and extension education.

Along with my colleague, Jeanne Herb, who will introduce herself as well, we co-facilitate the New Jersey Climate Change Alliance, a nonpartisan and diverse collective of organizations and

[1] For more information: climatechange.rutgers.edu
[2] For more information: climatehubs.oce.usda.gov/hubs/northeast

individuals that share the goal of advancing science-informed climate change strategies and policy at the state and local levels in New Jersey.[3]

We are both appearing here in our personal capacity and not to represent Rutgers University.

My name is Jeanne Herb and I thank you for inviting me here today. I am Director of the Environmental Analysis and Communications Group at the Edward J. Bloustein School of Planning and Public Policy at Rutgers University. The Environmental Analysis and Communications Group is a multidisciplinary team of researchers and practitioners that advances strategies and approaches designed to build communities that are healthier, greener, equitable, resilient and more prosperous. Through research, technical assistance to communities and decision-makers, policy analyses, and facilitation of collaborative and participatory efforts, EAC develops and deploys evidence-based strategies that inform planning, policies and decision-making at the state, regional and local levels.[4]

We will first, share with you results of a Rutgers-Eagleton Poll released this morning conducted on Climate Change Attitudes in New Jersey. Then we will switch gears to provide you with some brief collective observations regarding climate change in New Jersey that we understood were not being addressed by others offering testimony today.

Rutgers-Alliance Poll

The poll just mentioned was conducted on behalf of the New Jersey Climate Change Alliance. Alliance members were particularly interested in understanding current status of New Jerseyans concern about climate change; what they know about it; where they obtain information about it; what their policy preferences are; and who should pay for addressing climate change.

Two-thirds of New Jerseyans are concerned about the effects of climate change on their life, family members, and people around them (37 percent "very concerned" and 37% "somewhat concerned"). Their level of knowledge about climate change varies with more people reporting higher knowledge on the causes, environmental impacts and how it may affect them in the future but lower knowledge on how to prepare. New Jerseyans "frequently" get their information on climate change from mass media (53 percent); followed by social media (29 percent); followed by other people (18 percent); just one in ten cite "frequently" getting news from local community organizations or state government.

Related to policy, more New Jerseyans favor state government addressing climate change by offering incentives (45 percent) to reduce greenhouse gas emissions rather than imposing limits (29 percent). Yet, when asked who should pay to make NJ more resilient to climate change, 62 percent of respondents want fuel producers and heavy users that cause the most greenhouse gas emissions to pay a "major share"of the cost and another 22% say they should pay a "minor share". Forty-three percent believe state government should pay a "major share" from the taxes it collects; another 35% believe state government should pay a "minor share." Only 6 percent of respondents feel residents should fund efforts to address climate change through a charge on

[3] For more information: njadapt.rutgers.edu

[4] For more information: eac.rutgers.edu

their utility bills, while 45 percent say residents should pay a minor share and the same percentage say residents should pay no share at all through a charge on their utility bills. A majority is also against paying more in taxes to make infrastructure in the state more weather resistant (54 percent against, 40 percent in favor). There is however, general support for helping those whose homes were damaged by extreme weather to relocate or rebuild – especially for those living in lower and middle income areas. New Jerseyans are split when it comes to whether or not the government should have the power to prohibit homeowners from rebuilding in flood-prone areas (50 percent should, 43 percent should not, 7 percent don't know).

Residents however, are largely in favor of helping low-income households meet energy efficiency standards, supporting energy efficient building standards for low-income rental housing (79 percent "strongly support" or "somewhat support" vs. 16 percent "strongly oppose" or "somewhat oppose") and requiring utilities to provide financial incentives to help low-income customers cover the costs of energy-savings improvements to their homes (50 percent "strongly support" and 30 percent "somewhat support" vs. 18 percent "strongly oppose" or "somewhat oppose"). New Jerseyans are amenable to paying (28 percent "strongly support" and 27 percent "somewhat support") an additional $0.50/month on their electricity bills if it means helping low income households make their homes more energy efficient.

A majority of New Jerseyans support more local activity (by a margin of 55 percent to 7 percent), believing their mayor and local government should be doing more rather than less to address climate change. One in five residents say they would seriously consider buying an electric car in the near future. Among those who would not, the main barriers are charging capabilities and the lack of a place to charge their car at home.

The Rutgers-Alliance poll asked about issues related to both emissions reductions and resiliency. Professor Kopp spoke about the first volume of the Fourth National Climate Assessment, but we would also like to mention, Volume II, which draws a direct connection between warming and impacts that affect lives, communities, and livelihoods that are already being felt here.[5] The severity of future impacts will depend largely on actions taken to reduce GHG emissions and our ability to integrate climate adaptation strategies into existing investments, policies, and practices. This holistic thinking is particularly salient in light of our poll results that show New Jersey citizens are concerned about climate change yet they perceive they are least knowledgeable about how to prepare for its impacts. Further, given that NJ citizens favor action to address climate change but some mixed results on ways to do it, we thought that it might be helpful to use this opportunity to briefly sum up what we know and what we don't know that may help frame some opportunities.

What we know

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[5] Jay, A., D.R. Reidmiller, C.W. Avery, D. Barrie, B.J. DeAngelo, A. Dave, M. Dzaugis, M. Kolian, K.L.M. Lewis, K. Reeves, and D. Winner, 2018: Overview. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA. doi: 10.7930/NCA4.2018.CH1)

We know how the climate has been changing globally and locally and how its is projected to change as described by Professor Kopp and Professor Broccoli. We also know that the largest contributor to greenhouse gas emissions in the state are transportation, electricity generation, and residential, commercial and industrial fuel use of which heating and cooling are significant uses.[6] To address this, as you know, New Jersey has the Global Warming Response Act statutory limit of 80% reduction of greenhouse gas emissions from 2006 levels by 2050 and that this limit is similar to the long-term U.S. vision to reduce greenhouse gas emissions under the Paris Agreement[7] (which the United States cannot officially exit until November 4, 2020). To achieve New Jersey's 2050 limit we need to reduce emissions by 75% below today's levels.[8][9]

We can learn from other states' holistic approach to climate mitigation and adaptation that provides for coordination across state government. These "leading" states have mandates to and work very closely in partnership with their respective state university that can provide expertise, address research gaps, and educate students and professionals who then become part of the local and regional workforce to address the multi-faceted challenges climate change brings. The work Rutgers led on behalf of the Alliance on sea-level rise mentioned by Professor Broccoli[10] has formed the technical basis for a project with the State to develop a regional resilience plan in the 15 municipalities in Monmouth County[11].

As we implement emission reduction strategies, we should ensure that the mechanisms we employ or infrastructure we build can withstand future climate change impacts. Through our work with the Alliance, we have addressed issues sector-by-sector as climate change impacts every facet of society, including the built and natural environment. We have seen firsthand the utility of such a cross-sector transdisciplinary model. In developing a tool to show water levels from sea-level rise we can use with municipal practitioners, we also envision functionality that would allow these practitioners to look at other climate impacts such as high heat or flooding. Further, we are building aspects of such tools for other end users such as foresters who might want to know the carbon sequestration potential of a certain area. The carbon sequestration aspect might be a mitigation application, but such a tool will also include identification of tree species we expect to survive into the future and thus it is also an adaptation tool. Thinking holistically and across sectors, provides for these kinds of very fruitful collaborations.

We know that stakeholder engagement is a very critical facet of the work we do, and clearly we have seen this in several states in which stakeholders are heavily involved in developing various climate-related plans.

We know that decision makers and constituencies from various sectors have concerns and want to be a part of the solution but these are complex issues and they need assistance.

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[6] Ibid.
[7] Pacyniak, G., et al. 2017.An Examination of Policy Options for Achieving Greenhouse Gas Emissions Reductions in New Jersey. doi:10.7282/T30C4ZPZP.
[8] Ibid.
[9] nj.gov/dep/aqes/oce-ghgei.html.
[10] Kopp et al. 2016. Assessing New Jersey's Exposure to Sea-level Rise and Coastal Storms: Report of the New Jersey Climate Adaptation Alliance Science and Technical Advisory Panel.
[11]

We know reducing emissions provides co-benefits to health and local economies. For example, water conservation reduces energy consumption, emissions, and also can achieve more resiliency in times of drought. Tree cover and urban greenways increase thermal comfort and help with storm water management, improve air quality, recreational opportunities, and property values. [12]

We know that the people that are most vulnerable to climate change are often those that least contribute to the problem and may have the most difficulty in adapting. [13] We also know that climate change disproportionately impacts the health of low-income communities and communities of color and that many of the systems that are sources of greenhouse gas emissions also frame conditions that are social determinants of health.[14]

We know that what gets measured gets managed.

We know that states and cities are leaders on climate change.[15] [16]

Very briefly, we have some collective thoughts based on our research as well as engagement with our Alliance, on a few highlights of what we would like to know, that we hope could inform a dialogue on opportunities.

<u>What We Would Like to Know</u>

In 2017 we issued a report on policy options for achieving emissions reductions in NJ.[17] Since that time, the New Jersey landscape for addressing emissions reductions in the electricity sector, with clear ramifications for the transportation sector, has dramatically changed with passage of the Clean Energy Act of 2018 (P.L. 2018, Chapter 17), Executive Order 7, Executive Order 28, as examples. Therefore, our observation on this front is that it will be very helpful for these initiatives to inform where we are quantitatively with respect to the 75% emissions reductions needed to meet New Jersey's 2050 limit.

Another option that might inform public discourse could be what would putting a price on carbon in New Jersey look like and how might this help pay for some of what our poll showed New Jerseyans desired government to do and not do.

We would like to have a more granular vulnerability assessment of all climate impacts across New Jersey by sector, population, and geography, including communities, natural resources, and historic resources to enhance planning for climate change. In relation to mitigation, we certainly

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[12] USGCRP, 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018

[13] Foster, S. et al. 2019. New York City Panel on Climate Change Report Chapter 6: Community-Based Assessments of Adaptation and Equity. doi.org/10.1111/nyas.14009

[14] Rudolph, L., Harrison, C., Buckley, L. & North, S. 2018. Climate Change, Health, and Equity: A Guide for Local Health Departments. Oakland, CA and Washington D.C., Public Health Institute and American Public Health Association.

[15] usclimatealliance.org/state-climate-energy-policies

[16] www.c40.org

[17] Pacyniak, G., et al. 2017.An Examination of Policy Options for Achieving Greenhouse Gas Emissions Reductions in New Jersey. doi:10.7282/T30C4ZPZP

would like to ensure that our energy infrastructure would not only get us to the 2050 goal, but that it is resilient.

Building on work we published in 2017[18], note that we are planning a convening on Health Equity in June to further a dialogue on the opportunities for addressing health and promoting greater health equity to address mutual upstream drivers of climate change and health inequities and we are pleased to be partnering with the State Health Department on this convening.

Lastly, we would like to be able to answer the question, "Are we better prepared than we were during Hurricane Sandy?" and we are not yet certain we can answer this question.

Again, we would like to thank the committee chairs and committee members for providing the opportunity to share our insights with you today.

[18] Moran, D. et al. 2017. New Jersey Climate and Health Profile Report. New Jersey Climate Adaptation Alliance. New Brunswick, Rutgers University. njadapt.rutgers.edu/resources/draft-new-jersey-climate-and-health-profile-report

Testimony to Joint Hearing on Climate Change

Senate Environment & Energy Committee and Assembly Environment & Solid Waste Committee

Jad Daley, President and CEO of American Forests

April 25, 2019

Chairman Smith, Chairwoman Pinkin, and Members of the Committees:

Thank you very much for the opportunity to speak with you today about the critical issue of forests and climate change. As a New Jersey native, born and raised here in Mercer County, I am excited by New Jersey's strong leadership on this issue and to have the opportunity to speak with you about ways that leadership can grow in the future.

For those not familiar with my organization, American Forests, we are the nation's first forest conservation organization founded in 1875. That means we pre-date the U.S. Forest Service by 30 years, and in fact were the catalyst for creating the Forest Service in 1905 and the other major laws and institutions that guide forest management and conservation in America today.

Most relevant to today's hearing, for more than a year American Forests has been supporting New Jersey and its fellow members of the U.S. Climate Alliance to explore climate change mitigation opportunities through "Natural and Working Lands", which has included not only forests but also agricultural lands and wetlands. We just formalized a new two-year scope of work to continue this support as a formal "Impact Partner" to the Alliance. I will focus on forests in my testimony today, but many of the same policymaking principles I will touch on also apply to those other land types.

Our support for the U.S. Climate Alliance included hosting a Learning Lab last July in Washington, DC for delegations from each Alliance state. New Jersey's delegation included a powerful cross section of state institutions, led by state personnel such as State Forester John Sacco and representatives from Rutgers, Duke Farms and New Jersey Audubon. This team birthed exciting ideas about how to maximize land management for carbon capture in New Jersey, and how that could be linked to policy. I will touch on these kinds of ideas today.

You have already heard a lot of information this morning, so I will focus my testimony into 5 key points to be concise.

1. **The United States is already using forests to act on climate change, and so is New Jersey.**

I often hear that we need to make our forests a climate solution, as though we just woke up and realized that trees absorb carbon dioxide and now need to use this power. This perception is compounded by widely cited international statistics about the rate of "deforestation" and the fact that poorly managed or even exploited forests in other countries can make their nation's forests a large source of carbon emissions, instead of a sink.

If you only remember one number from my presentation, remember this one: America's forests and forest products are a large net sink for our carbon emissions, absorbing almost 15 percent of our national carbon emissions from burning fossil fuels. That means the capture and storage of carbon in our forests dramatically outpaces any emissions from our forests due to factors such as conversion for

In total their projections suggest that our forest carbon sink will quickly level off and begin to decline in annual carbon capture in the coming decade, if we do not take action. The remainder of my testimony will focus on the actions we need to take.

3. Powering our forest carbon sink means playing offense and defense.

When people raise the issue of forest carbon, they often immediately jump to carbon offsets, as though this unique financial incentive mechanism is the only way to stimulate more carbon capture in our forests. This is a damaging and thought limiting mindset, because offsets are a clunky mechanism that present serious limitations in the kind of forest practices that can be incentivized, and the type and scale of landownerships that can be included. Just as an example, the California carbon offset market has funded virtually no projects to replant forests even though science tells us this is the single most powerful strategy to increase forest carbon capture. That is because these projects do not "pencil out" financially for offsets, not because they fail to deliver carbon gains.

So, I want to encourage you to frame your thinking in what American Forests and our partners call "Carbon Offense and Carbon Defense", and to use any and all policy means to advance those two types of activity. Let me explain.

Carbon offense is our shorthand for actions primarily intended to rev up the carbon capture in a particular forest. This includes actions like replanting forests and other actions that stimulate regrowth of lost or diminished forests, and changing the way a particular forest is managed to more vigorously absorb and store carbon. This can include actions such as adjusting the length of time between timber harvests.

Carbon defense is our shorthand for actions that primarily prevent emissions from forests. An easy example I have already mentioned is conserving forests from conversion for other uses including development. But for New Jersey this would also include actions such as more active and creative use of prescribed fire in the Pinelands to prevent larger and more intense fires later, or more aggressively managing the state's urban forests and hardwood forests in the Highlands to reduce loss of trees to vines, invasive species, and pests. In some cases the state will simply need to help its forests transition in a changing climate, preferentially managing for tree species better suited to future conditions. Too often this "carbon defense" has been overlooked because of the focus on more carbon capture—a hangover from carbon offset markets and the types of offset projects like "Improved Forest Management" that have succeeded in that context. This tunnel vision ignores the reality that avoiding a ton of emissions from our forests is just as important as capturing an additional ton through forest growth.

So, the right approach for New Jersey is to look at its many diverse forest types, including urban forests, and to develop a comprehensive menu of forest practices in each of these settings that will lead to a positive carbon result, either by stimulating carbon capture, reducing emissions, or both.

4. Put special attention on urban forests and wood utilization.

The two secret weapons for forest-climate mitigation are urban forests and wood products, and New Jersey can lead on both. Let me explain:

- Urban forests are an overlooked source of carbon sequestration nationally, providing about roughly one-seventh of our total forest carbon sink. In New Jersey, perhaps not surprisingly, development, timber harvest, or wildfire. The size of this sink changes slights from year to year but is holding steady at well of 700 million metric tons of carbon dioxide equivalent.

This is critical context, because our strategy should be determined by our baseline of what is happening today. In this case, that means, "How do we keep a good thing going?"

New Jersey is part of this success. Surprisingly for many people, the vast majority of net forest carbon sequestration in the United States is occurring in our eastern forests. There is a simple reason: Our forests have been growing back rapidly for decades, and our forest types and climate do not lead the same level of forest emissions from mortality and wildfire in the western states.

In the most recent U.S. Forest Inventory and Analysis, New Jersey's roughly 2 million acres of forests, including urban forests, provided a net sink of 2.6 million metric tons of carbon dioxide. This was equivalent to 2.4 percent of the state's carbon emissions from combustion of fossil fuels. While this is a small forest sink relative to some states, it is actually quite considerable when you consider the state's land area and land types, level of urbanization, and other factors. Consider for example that the tree species found in the Pinelands do not have a particularly high rate of natural carbon capture, and inevitably will have more emissions through prescribed fire and wildfire than hardwood forests.

By way of contrast, Colorado has 24.5 million acres of forest, but the state is a net source (not sink) of carbon emissions from forests due to a combination of pest infestations, wildfire, and other factors. Colorado is one of six western states that are actually sources of emissions from forests. So New Jersey is looking good!

Further, New Jersey is to be commended for having led the way on critical forest carbon strategies such as "keeping forests as forests" through land conservation. Green Acres might not have been birthed as a climate change strategy, but the reality is that this program's role in conserving forests from being converted for development both avoids emissions that would have occurred at the time of forest conversion and keeps those forests capturing and storing carbon each year. Further, when the state entered the Regional Greenhouse Gas Initiative (RGGI) it authorized a portion of RGGI proceeds for land-based carbon mitigation projects. Few other RGGI states included land in this way, and this shows an attention to land-based mitigation that is commendable.

2. **Past carbon sink returns do not guarantee future performance.**

Consider this like your own carbon investment advisory. The strong performance of the U.S. forest carbon sink in recent decades now faces some significant headwinds that we need to overcome. Two USDA researchers, John Coulston and David Wear, have led future projections to assess what might happen to our forest carbon sink in the future. They particularly highlight two challenges:

- The impacts of climate change on forest health are increasing rapidly, weakening and killing forests as well as increasing the intensity and extent of wildfire. This forest health decline, if left unaddressed, is projected to dramatically reduce net carbon capture through forest growth.

- In recent decades, the amount of land coming into forest such a abandoned or converted agricultural land has roughly balanced out forestland lost to other uses. Again, if left unaddressed, his trend is projected to change dramatically, with much more forest lost to the demands of our still growing population and significantly less land becoming forest.

urban forests are an even higher percentage of the net forest carbon sink. But the huge hidden climate benefit from urban forests is saving energy. The U.S. Forest Service found that the way that urban forests moderate temperatures (cooler in the summer, warmer in the winter) reduces residential energy use for heating and cooling by an average of 7.2 percent nationally, saving consumers over $7 billion each year and millions of tons of carbon emissions. (Study can be found at: https://www.nrs.fs.fed.us/news/release/trees-reduces-building-energy-use) American Forests has just launched a new national initiative working with the U.S. Forest Service and other partners to maximize this energy saving and therefore carbon saving potential through urban trees. New Jersey is extremely well-positioned to make this a major focus of forest-climate strategy, and we stand ready to help with technical assistance resources and funding implementation of an urban forest climate strategy by combining enhanced public funding with private contributions from our more than 200 corporate partners and the development of City Forest Credits.

- Wood products not only store carbon, again about one-seventh of our total forest carbon sink, but also require less energy to manufacture than alternative materials. The "substitution effect" of using wood in the place of other construction materials is another hidden forest climate mitigation opportunity.

5. Use an "all of the above" policy approach.

As I mentioned previously, too often thinking on forest carbon policy has simply equated to "create an offsets market." Offsets do have a place in the policy toolbox, and it would be worth exploring if RGGI could ever develop a truly effective offsets market for forests.

But much more interesting for New Jersey, in our opinion, is how to use more traditional policy levers to stimulate the "carbon offense and carbon defense" that fits this state. Here are our key suggestions for exploration, which align very well with the policy development already being led the state and its many strong partners in this space:

- **Leverage public forestlands.** New Jersey has an incredible wealth of public forests in all corners of the state, from state lands to county and municipal lands. The state and local governments can direct that these lands be optimized to for climate mitigation while maintaining other public uses like water supply protection and recreation. Our organization has strong models for how to do this drawn from past efforts led by the U.S. Forest Service and others. The state's own forestlands can play a particularly important role as demonstration sites to inform other public and private forest landowners in New Jersey on how to take action.

- **Ramp up investment in urban forests.** The state can play a key role in stimulating urban forestry, from increased tree planting to better tree care and municipal tree policies that protect the urban trees we already have. This includes helping cities and towns think creatively about public spaces like streets and parks, and ways to use these spaces to increase urban tree canopy. The state should explore developing robust technical assistance and financial incentives to help municipal officials and their partners to ramp up urban forests in public and private spaces, and to leverage the significant green jobs opportunity in this work that can be targeted to benefit people in underserved urban communities.

- **Create simple and accessible financial incentives for private forest owners.** With a comprehensive menu of forest practices that are beneficial for climate mitigation, New Jersey can provide financial incentives through the tax code and our state programs that pay landowners for undertaking key practices that would not otherwise be required by law. Unlike offsets, this simple approach can be used at any scale, enabling smaller landowners to participate. This is key in New Jersey given the lack of large forest ownerships.

- **Provide climate-informed technical assistance.** Simply providing better access to climate-informed forest management principles, including the menu of practices I have mentioned, can stimulate positive gains even without additional financial incentive. The state should prioritize increased agency capacity through the New Jersey Forest Service to engage with private landowners, municipal agencies, and others who might not easily have access to this information or the ability to apply it to their lands.

- **Support wood utilization with building codes and incentives for low lifecycle buildings.** New Jersey is a state with substantial and ongoing construction. Thinking about ways to support and incentivize use of wood in place of materials like steel will support both forest product utilization from management of the state's forests as well as forests in other states that are part of our overall U.S. forest carbon sink. There are many models for this kind of wood utilization leadership around the country, particularly in the Northwest, and strong desire from leaders in the construction industry like Skanska that have been advancing this agenda through their own practices.

In closing, I want to commend New Jersey for its extremely strong climate change leadership in all respects, and the impressive way in which the state and its partners are making forests and other lands part of the solution. American Forests stands ready to help in any way possible, and I look forward to your thoughts and questions.

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5 Ways to Deliver America's Forests for Climate

By Jad Daley, President & CEO of American Forests

These are heady days for people in the U.S. forest sector. After a decade of trying to communicate how much forests and forest products can help solve climate change, it has been thrilling to see world and U.S. leaders quickly come to the consensus that forests can deliver as much as one-third of the emissions reductions needed to avoid the worst.

Consider these most recent developments:

- The new Intergovernmental Panel on Climate Change report focused on the urgent need to pull carbon dioxide from the atmosphere as a complement to reducing emissions, and highlighted forests as the only proven way to accomplish these "negative emissions" at scale.
- The Global Climate Action Summit held in San Francisco this September put forests center stage for two days, championed as a climate solution by world leaders, U.S. governors and leading scientists, as well as actors Harrison Ford and Alec Baldwin. No global climate gathering in history has given forests such a prominent role.

For those of us in the U.S. forest sector, this is fantastic news. America has sometimes taken its forests for granted, and this new understanding of forests as a climate solution creates new opportunities for more supportive public policies, private investment and stronger markets for forest products.

But there is also a potential concern: many of the new converts come with only a partial understanding of the carbon dynamics in the forest sector and how our forests here in the U.S. are dramatically different from those in other countries when it comes to delivering climate change solutions.

Here are five ways to deliver America's forests as a resilient and lasting climate solution:

1. Recognize the Current Climate Benefits of U.S. Forests

Thanks to America's advanced standards for forestry and conservation practices, our forests and forest products already capture and store almost 16 percent of U.S. carbon emissions each year. How much is that? Equal to half of all the emissions reductions pledged by the U.S. under the Paris Climate Accord. New policies and investment should not confuse U.S. forests with other countries that are dealing with massive deforestation, often driven by poorly controlled forestry and agriculture.

2. Wood Is Good for Storing Carbon

You can think of forest products as an extension of the carbon storage capacity of forests. How much? U.S. wood products store carbon each year equivalent to almost 2 percent of U.S. emissions. This benefit becomes even more potent when you add in the emissions avoided when wood is used in place of more energy-intensive building materials like steel. That is why we must promote working forests that produce wood products as part of U.S. climate strategy.

3. Urban Forests Are Key for Climate

It might surprise you to learn that America has 130 million acres of urban forests, and that these trees capture and store carbon equivalent to more than 1.5 percent of U.S. emissions each year. Urban forests also reduce energy use for heating and cooling by 7.2% nationwide, with savings to consumers of $7.8 billion dollars. We need to rapidly scale up urban forests and target "energy saving trees" to places where they will have the most benefit.

4. Climate Stress is Killing Our Forests

From California's mega drought to Colorado's pine beetle infestations to the violent hurricanes that have devastated urban and rural forests alike in Florida, forests across the country are being weakened and even killed by traditional forest stresses supercharged by climate change. We need to help our forests adapt to harsher conditions by actively "pre-storing" them for climate resilience, and in some cases helping forests adapt by carefully transitioning to a new mix of tree species.

5. Our Forests Hold a Swing Vote

We have important choices to make. America's forest carbon sink could grow even larger if we invest in actions like speeding up reforestation, new financial incentives for private forest owners, more active public land management and stronger use of forest products. But there is equal urgency to invest in science-based forestry to protect our forests from climate change. If we fail to keep our forests healthy, they could actually swing from a net sink to a net source of carbon emissions in many places.

American Forests and our partners in the Forest-Climate Working Group are focused on making U.S. forests a firm "yes vote" for climate action, with a goal to capture 30 percent of U.S. emissions in our forests by 2050. We know this goal is achievable based on strong science like the U.S. Mid-Century Strategy for Deep Decarbonization—but only if we invest in the right actions for our forests.

It is time for America to embrace its forests and forest products like never before, from consumers and citizen advocates to all levels of government. We don't have a moment to lose. Let's just make sure that we act by embracing our already strong U.S. forest sector, and leverage the powerful capacity we already have in place to deliver forest-climate solutions across America.

Forests must stand tall in any Green New Deal

A "Green New Deal" is a breath of fresh air for the climate change conversation. Scaling up climate action that creates jobs for people in need offers something for everyone, from struggling rural communities to disadvantaged urban areas.

Just one problem: many of its champions are overlooking the huge potential of forests to contribute to climate action and related green jobs. The Green New Deal cannot meet its goals for climate action nor diversity, equity and inclusion without a major role for forests and other natural climate solutions.

My organization, American Forests, has experience putting the "green" into the original New Deal. The inspiration for the Civilian Conservation Corps (CCC) included American Forests' leadership in putting Americans to work creating war gardens and planting trees during and after World War I. In honor of our group's contributions, I have a pen in my office used by President Franklin Delano Roosevelt in 1933 to sign the bill creating the CCC.

While many people know the CCC built bridges, dams and recreational facilities, fewer know that its original focus was actually forestry and other natural resources management. The CCC employed more than 3 million people in the national forests and planted more than 3 billion trees. This is exactly the kind of action we need today to make forests part of a Green New Deal.

Understanding why forests are key to solving climate change is complicated and deserves some explanation. Thanks to the way all trees and forests naturally pull carbon dioxide from the air, a process known as "carbon sequestration," our forests and forest products here in America already capture 15 percent of our carbon emissions each year.

Trees and forests also slow climate change by cooling our communities in the summer and insulating them in the winter. The U.S. Forest Service estimates urban and community forests reduce energy use for heating and cooling by 7.2 percent, reducing carbon emissions and saving more than $7 billion for consumers each year.

But this natural climate solution is at grave risk, because climate change is also killing our forests with drought and extreme storms, forest pests, disease and rampant wildfire. Trees killed by climate change are emitting increasing volumes of carbon emissions — almost 5 percent of our national emissions, and rising fast.

That's where the Green New Deal comes in. We can play "carbon offense" by expanding forests with tree planting and adjusting forest management to increase carbon capture.

This must be matched with equally vigorous "carbon defense" through actions such as thinning fire-prone forests and fighting pest outbreaks to help avert human disasters such as the California wildfires. Scaling up this hands-on work, guided by the latest climate science, can create a huge wave of green jobs that can't be computerized or outsourced, in urban forests and rural landscapes alike.

To provide a sense of scale, forests in the U.S. already directly employ almost 1 million people and indirectly support another 1.7 million jobs. One of the key growth opportunities is in urban forestry: City governments and private tree care companies have tens of thousands of open positions across the country. Investing in urban forests will require even more workers than today — exactly the kind of "green jobs" and climate justice sought in the Green New Deal.

Urgent action will also open up opportunities for rural residents, who can find work thinning overstocked forests, generating wood products that store carbon and replanting forests lost to drought and fire. The University of Oregon found that for every $1 million dollars invested in critical forest restoration activities, 30 people can be employed.

Across the country, private forest landowners and manufacturers are already hungry for workers, as demand for wood products grows and the rural workforce shrinks due to larger demographic trends.

The path forward is clear. First, Green New Deal champions need to talk about forests and other land-based green jobs with the same urgency and enthusiasm that they show for technology-based climate solutions.

Second, with political consensus around the work ahead, and replanting trees, thinning and other active management of our public lands, we can create new incentives for private forest owners to manage for carbon capture and wood products.

Then, we need to go to work linking people with these forest career paths, addressing the rural workforce shortage and bringing new opportunities to distressed communities. The people who most need these green jobs may not always be the easiest to find, and might bring barriers to overcome like criminal records or struggles with addiction. These barriers can be overcome, if we are willing to create the right ladder of opportunity into forest sector employment.

A powerful bipartisan base of forest supporters awaits. As the wildfires taught us, we have no choice. For a Green New Deal to be the "real deal," it must embrace forests.

Jad Daley is president and CEO of American Forests, the oldest national conservation organization.

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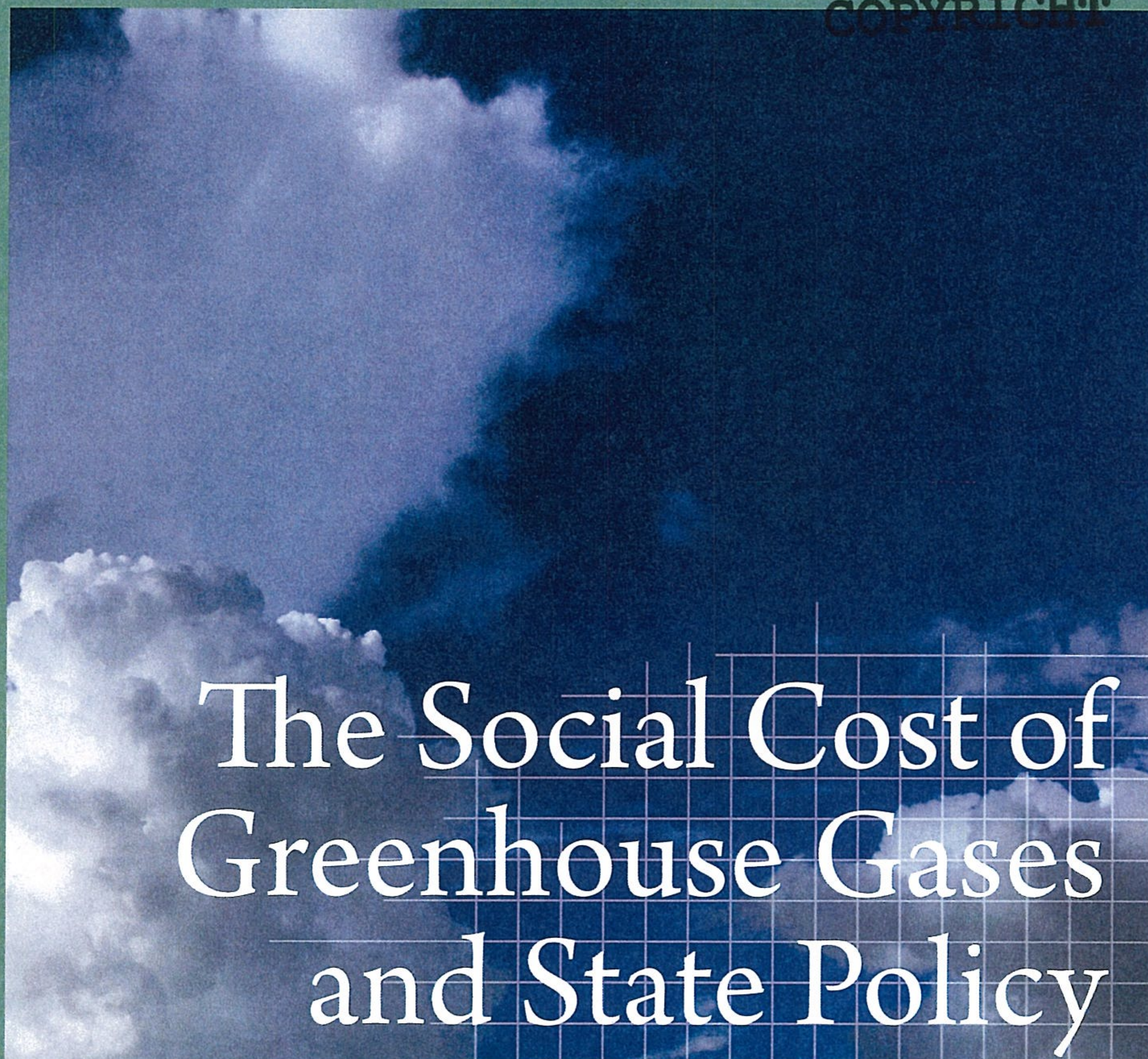

The Social Cost of Greenhouse Gases and State Policy

A Frequently Asked Questions Guide

Institute *for* Policy Integrity
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October 2017
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32

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Table of Contents

34x

Executive Summary

Scientists predict that climate change will have, and in some cases has already had, severe consequences for society, like the spread of disease, decreased food security, and coastal destruction. These damages from emitting greenhouse gases are not reflected in the price of fossil fuels, creating what economists call "externalities." **The social cost of carbon (SCC) is a metric designed to quantify and monetize climate damages, representing the net economic cost of carbon dioxide emissions.** Simply, the SCC is a monetary estimate of the damage done by each ton of carbon dioxide that is released into the air. The SCC can be used to evaluate policies and guide decisions that affect greenhouse gas emissions.

At the federal level, the SCC has been used by numerous agencies for regulatory impact analysis and in environmental impact statements; however, the SCC can also be used across a range of other areas, including electricity ratemaking, resource management policy and royalty setting, setting emissions caps, and establishing a carbon price. States should use the SCC in a number of different contexts to aid in making rational policy decisions in a transparent manner. Many states are already using the SCC in their decisionmaking.

The best estimates of the SCC for states to draw from are currently the 2016 estimates from the federal government's Interagency Working Group on the Social Cost of Greenhouse Gases (IWG), despite the fact that this group was recently disbanded. The 2016 IWG estimates are based on the most up-to-date science and economics and were arrived at through an academically rigorous, transparent, and peer-reviewed process. The National Academies of Science, Engineering and Medicine (NAS) conducted a thorough review of the IWG estimates in 2016, and a group of scholars at the nongovernmental organization Resources for the Future has begun a project to update the SCC based on the NAS recommendations.

State decisionmakers can benefit from an understanding of several issues related to the SCC, including discount rates, time horizons, and the global nature of the IWG estimate. States should also know that the IWG calculated additional estimates specifically for the social cost of methane and the social cost of nitrous oxide, which are more precise quantifications of the social costs of emissions of those greenhouse gases than simply multiplying the SCC by the global warming potential of those gases, and can be used in all of the scenarios where the SCC can be used.

There are many misguided critiques of the SCC made by those who would prefer less regulation of greenhouse gases, but this should not deter decisionmakers from using the SCC. In fact, there are a wide range of resources that decisionmakers can use while exploring how and why to use the SCC.

What Is the SCC?

Scientists predict that climate change will have, and in some cases has already had, severe adverse consequences for society, like the spread of disease, decreased food security, and coastal destruction. These damages from emitting greenhouse gases are not reflected in the price of fossil fuels, creating what economists call "externalities." **The social cost of carbon (SCC) is a metric designed to quantify and monetize climate damages, representing the net economic cost of carbon dioxide emissions.** Simply, the SCC is a monetary estimate of the damage done by each ton of carbon dioxide[1] that is released into the air.

The SCC can be used to evaluate policies and guide decisions that affect greenhouse gas emissions.

What is the best estimate of the SCC for states to use?

The federal government's Interagency Working Group on the Social Cost of Greenhouse Gases (IWG), which operated from 2009-2017, remains the best source for SCC estimates. Its methodology, and why its estimates are the best available values for the SCC, are discussed below. Values for the social cost of other greenhouse gases are also discussed in a later section.

Table 1 is from the Interagency Working Group's 2016 Technical Support Document and shows the SCC estimates, in 2017 dollars, at five-year intervals. In all of the IWG technical support documents, their figures are given in 2007 dollars, but the values presented here in Table 1 are inflated to current (2017) dollars for ease of reference.

Table 1: Social Cost of CO_2 (in 2017 dollars per metric ton of CO_2)[2]

Year of Emission	Average estimate at 5% discount rate	Average estimate at 3% discount rate—IWG's Central Estimate	Average estimate at 2.5% discount rate	High Impact Estimate (95th percentile estimate at 3% discount rate)
2020	$14	**$50**	$74	$148
2025	$17	**$55**	$82	$166
2030	$19	**$60**	$88	$182
2035	$22	**$66**	$94	$202
2040	$25	**$72**	$101	$220
2045	$28	**$77**	$107	$236
2050	$31	**$83**	$114	$254

1 Note that a metric ton (2,204 pounds, also known as the tonne) is slightly different from both a short ton (2,000 pounds) and a long ton (2,240 pounds). There are many ways to conceptualize a metric ton (2,204 pounds) of carbon dioxide. A metric ton of carbon dioxide is how much a typical car emits after 2,397 miles or about 15% of a typical home's emissions from electricity use for a year (*see* EPA Greenhouse Gas Equivalencies Calculator at https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator). An important distinction is that, because carbon dioxide consists of carbon and oxygen, 3.67 metric tons of carbon dioxide is equivalent to 1 metric ton of carbon.

2 Interagency Working Grp. on Soc. Cost of Greenhouse Gases, Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12,866 (2016) [hereinafter TSD 2016], at 4, *available at* https://www.obamawhitehouse.gov/sites/default/files/omb/inforeg/scc_tsd_final_clean_8_26_16.pdf.

Note that the value of the SCC increases over time. This is because the further in the future greenhouse gases are emitted, the greater the damages they will cause, due to the effects of accumulation. Therefore, it is important to calculate the full stream of climate effects, i.e., to take into consideration the emissions from every year of a policy, so that these increasing damages are reflected. The importance of calculating a full stream of future effects, rather than choosing only one year for analysis, is discussed in a later section.

What's included in the SCC number? What isn't?

The numbers in Table 1 reflect climate damages as estimated by combining three "Integrated Assessment Models"—specifically, DICE, FUND, and PAGE. These models translate carbon dioxide emissions into changes in atmospheric greenhouse concentrations, atmospheric concentrations into changes in temperature, and temperature changes into economic damages.[3]

DICE calculates the effect of temperature on the global economy using a global damage function that is not disaggregated by impacts to specific sectors.[4] Alternately, PAGE, looks at economic, noneconomic, and catastrophic damages. Finally, FUND considers a number of specific market and nonmarket sectors, including: agriculture, forestry, water, energy use, sea level rise, ecosystems, human health, and extreme weather.[5]

Quantified impacts represented in the models include: changes in energy demand (via cooling and heating); changes in agricultural output and forestry due to alterations in average temperature, precipitation levels, and CO_2 fertilization; property lost to sea level rise; increased coastal storm damage; changes in heat-related illnesses; some changes in disease vectors (e.g. malaria and dengue fever); changes in fresh water availability; and some general measures of catastrophic and ecosystem impacts.

It is important to note, however, that these models omit or poorly quantify some highly significant damage categories, and therefore, the SCC values in Table 1 should be considered lower-bound estimates of the actual costs of marginal carbon emissions. In fact, many experts believe the IWG SCC values are severe underestimates (even while endorsing their continued use for the time being as the best currently available estimates).

Damages that are poorly quantified or omitted from the IAMs are listed in Table 2.

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3 Interagency Working Grp. on Soc. Cost of Carbon, Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12,866 (2010) [hereinafter TSD 2010], at 5, *available at* https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf.

4 TSD 2010, *supra* note 3, at 6.

5 TSD 2010, *supra* note 3, at 7.

Table 2: Damages Omitted from the SCC[6]

Category	Specific Impacts Missing from the SCC*
Health	Respiratory illness from increased ozone pollution, pollen, and wildfire smoke
	Lyme disease
	Death, injuries, and illness from omitted natural disasters and mass migration
	Water, food, sanitation, and shelter
Agriculture	Weeds, pests, and pathogens
	Food price spikes
	Heat and precipitation extremes
Oceans	Acidification, temperature, and extreme weather impacts on fisheries, species extinction and migration, and coral reefs
	Storm surge interaction with sea level rise
Forests	Ecosystem changes such as pest infestations and pathogens, species invasion and migration, flooding and soil erosion
	Wildfire, including acreage burned, public health impacts from smoke pollution, property losses, and fire management costs (including injuries and deaths)
Ecosystems	Biodiversity***, habitat**, and species extinction**
	Outdoor recreation** and tourism
	Ecosystem services**
	Rising value of ecosystems due to increased scarcity
	Accelerated decline due to mass migration
Productivity and economic growth	Impacts on labor productivity and supply from extreme heat and weather, and multiple public health impacts across different damage categories
	Impacts on infrastructure, capital productivity, and supply from extreme weather events, and diversion of financial resources toward climate adaptation
	Impact on research and development from diversion of financial resources toward climate adaptation
Water	Availability and competing needs for energy production, sanitation, and other uses
	Flooding
Transportation	Changes in land and ocean transportation
Energy	Energy supply distributions
Catastrophic impacts and tipping points	Rapid sea level rise**
	Methane releases from permafrost**
	Damages at very high temperatures**
	Unknown catastrophic events

[6] Peter Howard, Cost of Carbon Project. Omitted Damages: What's Missing From the Social Cost of Carbon (2014), *available at* http://costofcarbon.org/reports/entry/omitted-damages-whats-missing-from-the-social-cost-of-carbon [hereinafter "Omitted Damages"].

Category	Specific Impacts Missing from the SCC*
Inter- and intra-regional conflict	National security
	Increased violent conflicts from refugee migration from extreme weather, and food, water, and land scarcity

* Climate impacts that have been largely unquantified in the economics literature and are therefore omitted from SCC models.

** These impacts are represented in a limited way in one or more of the SCC models: 1) they may be included in some models, and not others; 2) they may be included only partially (e.g., only one or several impacts of many in the category are estimated); 3) they may be estimated using only general terms not specific to any one damage—in these instances, estimated damages are usually very small relative to their potential magnitude, and relative to the impacts explicitly estimated in the models. See complete report for details.

*** While technically represented in SCC models through extrapolations from small temperature changes, there are no available climate damage estimates for large temperature changes, and these may be catastrophic.

Is there a state-specific SCC we can use?

No, there is no SCC estimate that only reflects climate damages to individual states. No models can accurately calculate a domestic-only, let alone a state-only SCC (see more below). Furthermore, as detailed in the next section, it is in your state's best interest to use an estimate of the global damages of a ton of CO_2. Your state benefits tremendously from actions of other states and other countries to mitigate climate change, and for numerous reasons discussed below, the use of a global SCC helps encourage reciprocal policy choices. Your state's citizens and businesses also have financial and other interests that extend far beyond your physical borders. If all states or countries used jurisdiction-specific numbers, the result would be significant underregulation.

Why should our state use a global number?

Not only is it best economic practice to estimate the global damages of U.S. greenhouse gas emissions in regulatory analyses and environmental impact statements, but no existing methodology for estimating a "domestic-only" value is reliable or complete. If a state agency is required to provide a domestic-only estimate, the existing, deficient methodologies must be supplemented to reflect international spillovers to the United States, U.S. benefits from foreign reciprocal actions, and the extraterritorial interests of U.S. citizens including financial interests and altruism. The same applies to any attempt to use a state-specific SCC value.

From 2010 through 2016, federal agencies based their regulatory decision and National Environmental Policy Act (NEPA) reviews on global estimates of the social cost of greenhouse gases. Though agencies often also disclosed a "highly speculative" range that tried to capture exclusively U.S. climate costs, emphasis on a global value was recognized as more accurate given the science and economics of climate change, economic practices, and consistency with U.S. strategic goals.[7]

To avoid a global "tragedy of the commons" that could irreparably damage all countries, including the United States, every government worldwide should ideally set policy according to the global social cost of greenhouse gases.[8] Because greenhouse pollution does not stay within geographic borders but rather mixes in the atmosphere and affects the climate

7 *See generally* Peter Howard & Jason Schwartz, *Think Global: International Reciprocity as Justification for a Global Social Cost of Carbon*, 42 Columbia J. Envtl. L. 203 (2017) [hereinafter "Howard & Schwartz 2017"].

8 *See* Garrett Hardin, *The Tragedy of the Commons*, 162 Science 1243 (1968) ("[E]ach pursuing [only its] own best interest . . . in a commons brings ruin to all."), 1244.

worldwide, each ton emitted by the United States or a particular U.S. state not only creates domestic harms, but also imposes large externalities on the rest of the world. Conversely, each ton of greenhouse gases abated in another country benefits the United States along with the rest of the world. A Policy Integrity report, "Foreign Action, Domestic Windfall," calculates that global actions on climate change—particularly by Europe, and including efforts of the United States and other countries—already benefited the United States by over $200 billion as of 2015. Furthermore, the report finds that, as of 2015, climate policies worldwide—including efforts by Europe, Canada, and many other countries, as well as U.S. policies from the time—could generate upwards of $2 trillion in direct benefits to the United States by 2030.[9]

If all countries set their greenhouse emission levels based on only domestic costs and benefits, ignoring the large global externalities, the aggregate result would be substantially sub-optimal climate protections and significantly increased risks of severe harms to all nations, including the United States. The same concept would apply to state policies where global externalities are not taken into account. Thus, basic economic principles demonstrate that the United States stands to benefit greatly if all countries apply global social cost of greenhouse gas values in their regulatory decisions and project reviews. Indeed, the United States stands to gain hundreds of billions or even trillions of dollars in direct benefits from efficient foreign action on climate change.[10]

Therefore, a rational tactical option in the effort to secure an economically efficient outcome is for the United States and individual states to continue using global social cost of greenhouse gas values.[11] The United States is engaged in a repeated strategic dynamic with several significant players—including the United Kingdom, Germany, Sweden, and others—that have already adopted a global framework for valuing the social cost of greenhouse gases.[12] For example, Canada and Mexico have explicitly borrowed the U.S. estimates of a global SCC to set their own fuel efficiency standards.[13] States have also entered into this international dynamic, with California coordinating with Canada on its cap-and-trade program and with a coalition of states and cities agreeing to uphold the pledges from the Paris Agreement. For the United States or any individual state to now depart from this collaborative dynamic by selecting to a domestic-only estimate could undermine the country's long-term interests and could jeopardize emissions reductions underway in other countries, which are already benefiting all 50 U.S. states and territories.

There are significant, indirect costs to trade, human health, and security likely to "spill over" to the United States as other regions experience climate change damages.[14] Due to its unique place among countries—both as the largest economy with trade- and investment-dependent links throughout the world, and as a military superpower—the United States is particularly vulnerable to effects that will spill over from other regions of the world. Spillover scenarios could entail a

[9] Peter Howard & Jason Schwartz, Inst. for Pol'y Integrity, Foreign Action, Domestic Windfall: The U.S. Economy Stands to Gain Trillions from Foreign Climate Action (2015), at 2, *available at* http://policyintegrity.org/files/publications/ForeignAction-DomesticWindfall.pdf.

[10] *Id.*

[11] *See* Robert Axelrod, The Evolution of Cooperation 10-11 (1984) (on repeated prisoner's dilemma games).

[12] *See* Howard & Schwartz 2017, *supra* note 7, at 260.

[13] *See* Heavy-Duty Vehicle and Engine Greenhouse Gas Emission Regulations, SOR/2013-24, 147 Can. Gazette pt. II, 450, 544 (Can.), *available at* http://canadagazette.gc.ca/rp-pr/p2/2013/2013-03-13/html/sor-dors24-eng.html ("The values used by Environment Canada are based on the extensive work of the U.S. Interagency Working Group on the Social Cost of Carbon."); Jason Furman & Brian Deese, *The Economic Benefits of a 50 Percent Target for Clean Energy Generation by 2025*, White House Blog (June 29, 2016) (summarizing the North American Leader's Summit announcement that U.S., Canada, and Mexico would "align" their SCC estimates).

[14] Indeed, the integrated assessment models used to develop the global SCC estimates largely ignore inter-regional costs entirely, *see* Omitted Damages, *supra* note 6; though some positive spillover effects are also possible, such as technology spillovers that reduce the cost of mitigation or adaptation, *see* S. Rao et al., *Importance of Technological Change and Spillovers in Long-Term Climate Policy*, 27 Energy J. 123, 123–39 (2006); overall spillovers likely mean that the U.S. share of the global SCC is underestimated, *see* Jody Freeman & Andrew Guzman, *Climate Change and U.S. Interests*, 109 Columbia L. Rev. 1531 (2009).

variety of serious costs to the United States as unchecked climate change devastates other countries. Correspondingly, mitigation or adaptation efforts that avoid climate damages to foreign countries will radiate benefits back to the United States as well.[15]

For more details on the justification for a global value of the social cost of greenhouse gases, see Peter Howard & Jason Schwartz, *Think Global: International Reciprocity as Justification for a Global Social Cost of Carbon*.[16] Another strong defense of the global valuation as consistent with best economic practices appears in a letter published in the March 2017 issue of *The Review of Environmental Economics and Policy*, co-authored by Nobel laureate Kenneth Arrow.[17]

How and why states should use the SCC?

Why should my state use the SCC?

As noted above, the SCC is a tool for internalizing externalities; specifically, it provides a monetary value for the cost of carbon emissions that will result from a particular decision. Without having this value on hand, a decisionmaker is faced with imperfect, incomplete information and may struggle to make a policy choice that maximizes net social welfare. The economic literature supports monetizing climate effects to achieve these goals because monetization helps put the impact of climate damages in context.

If an analysis only qualitatively discusses the effects of global climate change, decisionmakers and the public will tend to overly discount that specific action's potential contribution. Without context, it is difficult for decisionmakers and the public to assess the magnitude and climate consequences of a proposed action. Quantification of these emissions and the monetization of their effects makes it easier to compare costs and benefits.

Monetization provides much-needed context for otherwise abstract consequences of climate change. It allows decisionmakers and the public to weigh all costs and benefits of an action—and to compare alternatives—using the common metric of money. Monetizing climate costs, therefore, better informs the public and helps "brings those effects to bear on [an agency's] decisions."[18] The tendency to ignore non-monetized effects is the result of common but irrational mental heuristics like probability neglect. For example, the phenomenon of probability neglect causes people to reduce small probabilities entirely down to zero, resulting in these probabilities playing no role in the decision-making process.[19] This heuristic applies even to events with long-term certainty or with lower-probability but catastrophic consequences, so long as their effects are unlikely to manifest in the immediate future. Weighing the real risks that, decades or centuries from now, climate change will fundamentally and irreversibly disrupt the global economy, destabilize earth's ecosystems, or compromise the planet's ability to sustain human life is challenging; without a tool to contextualize such risks, it is far easier to ignore them. Monetization tools like the social cost of carbon (and the social cost of other greenhouse gases) are designed to solve this problem: by translating long-term costs into present values, concretizing the harms of climate change, and giving due weight to the potential of lower-probability but catastrophic harms.

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15 *See* Freeman & Guzman, *supra* note 14, at 1563-93.

16 Howard & Schwartz 2017, *supra* note 7.

17 Richard Revesz, Kenneth Arrow et al., *The Social Cost of Carbon: A Global Imperative*, 11 Review of Environmental Economics and Policy 172 (2017).

18 *See* Baltimore G. & E. Co. v. NRDC, 462 U.S. 87 (U.S. 1983) at 96.

19 Cass R. Sunstein, *Probability Neglect: Emotions, Worst Cases, and Law* (John M. Olin Law & Economics, Working Paper No. 138, 2001), *available at* http://ssrn.com/abstract=292149.

Finally, the SCC enables regulators and policymakers to take into account the effect of their decisions on society as a whole, as climate change is a global problem. This consideration can encourage reciprocal actions from other actors, including other U.S. states and other countries. We discuss more above why the "global" SCC estimates are the best ones.

What are the possible applications of the SCC in state policymaking?

Even though the IWG estimates were developed for use in regulatory analysis, there is wide support for use of the SCC in other contexts. The SCC is useful for evaluating nearly all energy regulations and environmental rules and actions. In general, using the SCC allows us to compare the costs of limiting carbon dioxide pollution to the costs of climate change. The SCC should be used in all appropriate instances, including but not limited to rulemaking that addresses greenhouse gas emissions, electricity ratemaking and regulation, natural resource valuation and royalty setting, regulatory cost-benefit analysis for climate actions, environmental impact statements, and setting carbon emissions caps or taxes.

In market-based emissions reduction schemes, the SCC should be fully internalized to allow the environmental attributes of clean energy resources to be more accurately valued and to ensure carbon-free resources are not under-valued. For states that are members of the Regional Greenhouse Gas Initiative (RGGI), for example, a state-level effort to price carbon should take into account the SCC minus the RGGI price of carbon. Note that if the RGGI carbon price were as high as the SCC, then this additional step would not be necessary.

The SCC can also allow state policymakers to compare the costs and benefits of a proposal or set the stringency of a regulation. If a state wants to set a greenhouse gas emissions cap, for example, legislators can use the SCC to determine what the cap should be. Overall, using the SCC gives states information on which measures will ultimately improve societal well-being vis-à-vis climate change.

Finally, using the SCC to gauge the climate impacts of coal and natural gas leases can help determine new royalty rates, helping the states to improve their leasing programs. Using the SCC can help ensure that taxpayers get a fair deal out of the use of their state's lands, rather than having a disproportionate amount of benefits fall to privates companies while costs fall to the public.

The emissions from my state/this leasing decision/this regulation/this project are so small, does the SCC still apply?

The SCC absolutely still applies. The argument that individual projects are too small to monetize misunderstands the tools available for valuing climate effects. The social cost of greenhouse gases protocols were developed to assess the cost of actions with "marginal" impacts on cumulative global emissions, and the metrics estimate the dollar figure of damages for one extra ton of greenhouse gas emissions.[20] The integrated assessment models used to derive the estimates work by first running a climate-economic-damage calculation for a baseline scenario, and then adding a single additional unit of greenhouse gas emissions to the model and rerunning the calculation. The approach assumes that the marginal damages from increased emissions will remain constant for small emissions increases relative to gross global emissions.[21] In other words, the monetization tools are in fact perfectly suited to measuring the marginal effects—that is, the effects of one additional unit—of emissions from smaller-scale decisions, as well as from nationwide policies.

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20 TSD 2010, *supra* note 3, at 1.
21 *Id.* at 2.

Which states are already using the SCC, and how?

It may be helpful for state decisionmakers to understand how other states have begun to use the SCC to date. States including—but not limited to—California, Colorado, Illinois, Minnesota, Maine, New York, and Washington have all begun using the federal SCC in energy-related analysis, recognizing that the SCC is the best available estimate of the marginal economic impact of carbon emission reductions. Several states and municipalities have used the SCC in the context of renewable energy decisionmaking, and Illinois and New York State have used the SCC to assess the value of the avoided carbon emissions from using nuclear generation rather than fossil fuel generation.

California

California uses the SCC in the Air Resources Board's scoping plan for the state's updated climate change policy. In the January 2017 draft of the scoping plan, the economic analysis uses the IWG SCC with a range of discount rates (2.5-percent to 5-percent).[22] Two companion bills were passed in the California legislature in the summer of 2016 to renew the policy, one of which mandates the Air Resources Board to consider the "social costs of greenhouse gases" in the analysis that underlies the new policy's accompanying regulations.[23] The Board is still finalizing the scoping plan as of October 2017.

The use of the SCC is also being discussed in a proceeding on the value of integrated distributed energy resources at the California's Public Utilities Commission.[24]

Colorado

In March 2017, the Colorado Public Utilities Commission ordered that the Public Service Company of Colorado, also knowns as Xcel Energy, take into account the IWG's social cost of carbon in its Energy Resource Plan (ERP).[25] ERPs include information on costs associated with generation resources, as well as alternatives. Advocates for the use of the "federally developed" SCC noted that the Colorado PUC had considered externalities, like public health effects, in other ERP proceedings. The PUC has authority under §40-2-123(1)(b), C.R.S to include such considerations in resource planning. One SCC advocate, Western Resource Advocates (WRA), argued that §40-2-123(1)(b) should be read to permit the Colorado PUC to "consider two distinct categories: (1) the likelihood of new environmental regulation; and (2) the risk of higher future costs associated with the emission of greenhouse gas pollution." The Colorado PUC ultimately agreed with WRA's reading and cited it as support for their decision.[26]

Illinois

Illinois has recently used the SCC in its "zero emissions credit" (ZEC) policy. In late 2016, the state legislature passed a comprehensive energy bill, which included provisions for valuing the social benefits of energy from zero-emissions

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22 Cal. Air Res. Bd., The 2017 Climate Change Scoping Plan Update: The Proposed Strategy for Achieving California's 2030 Greenhouse Gas Target (Jan. 20, 2017).

23 Cal. Health & Safety Code §§ 38562.5 & 38562.7.

24 Rulemaking to Create a Consistent Regulatory Framework for the Guidance, Planning, and Evaluation of Integrated Distributed Energy Resources ("IDER") (Rulemaking No. 14-10-003).

25 Colorado PUC, Decision No. C17-0316, In the Matter of the Application of Public Service Company of Colorado for Approval of its 2016 Electric Rersource Plan, Proceeding No. 16A-0396E, *available at* https://www.dora.state.co.us/pls/efi/efi_p2_v2_demo.show_document?p_dms_document_id=863402.

26 *Id.* at 84.

44x

facilities. This bill uses the SCC to make this calculation, using an SCC value of $16.50/MWh, based on the IWG SCC estimates.[27]

Maine[28]

Maine enacted the Act to Support Solar Energy Development in Maine during its 2014 legislative session.[29] Section 1 of the Act states that it is "in the public interest to develop renewable energy resources, including solar energy, in a manner that protects and improves the health and well-being of the citizens and natural environment of the State while also providing economic benefits to communities, ratepayers and the overall economy of the State."[30] Section 2 of the Act instructs the Public Utilities Commission to determine the value of distributed solar energy generation in the State, evaluate implementation options, and deliver a report to the Legislature. Maine has a statute that calls for calculating "the societal value of the reduced environmental impacts of the energy."[31] Maine uses the federal SCC, as well as other monetized costs and benefits, to make this calculation. Because carbon costs are already partially embedded in existing energy valuation as a result of carbon emissions caps under RGGI, the net SCC is calculated by subtracting the embedded carbon allowance costs from the total SCC. The Maine Public Utilities Commission uses the federal SCC, with a "central" 3-percent discount rate estimate.

Maine's statute requires the PUC to assess how to maximize social welfare in its policy options. Maine addresses this requirement by weighing market costs and benefits with the monetized values of societal benefits in a cost-benefit analysis.[32]

Minnesota

The Minnesota Public Utilities Commission is statutorily mandated to consider externalities for all proceedings.[33] Between 1993, when this provision was enacted, and 2014, Minnesota used its own methodology to determine the costs of $PM_{2.5}$, SO_2, NO_x, and CO_2.[34] In 2014, after environmental advocacy groups filed a motion requesting that the Minnesota Public Utility Commission update these figures, the commission referred the issue to the Office of Administrative Hearings to assess how to value externalities, including whether the state should use the federal SCC.[35]

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27 20 I.L.C.S. 3855 §§ 1-75(d-5)(1)(B). ("(i) Social Cost of Carbon: The Social Cost of Carbon is $16.50 per megawatthour, which is based on the U.S. Interagency Working Group on Social Cost of Carbon's price in the August 2016 Technical Update using a 3% discount rate, adjusted for inflation for each year of the program. Beginning with the delivery year commencing June 1, 2023, the price per megawatthour shall increase by $1 per megawatthour, and continue to increase by an additional $1 per megawatthour each delivery year thereafter.")

28 For more details, *see* Maine Public Utilities Commission, Maine Distributed Solar Valuation Study (2015) [hereinafter "MPUC Distributed Solar Valuation Study"], *available at* http://www.maine.gov/mpuc/electricity/elect_generation/documents/MainePUCVOS-FullRevisedReport_4_15_15.pdf.

29 Maine P.L ch. 562 (Apr. 24, 2014) (codified at 35-A M.R.S.A. §§ 3471-3474).

30 *Id.* at § 3472(1).

31 *Id.* at § 2(1).

32 MPUC Distributed Solar Valuation Study, *supra* note 28, at 4.

33 ("The [Public Utilities] commission shall, to the extent practicable, quantify and establish a range of environmental costs associated with each method of electricity generation. A utility shall use the values established by the commission in conjunction with other external factors, including socioeconomic costs, when evaluating and selecting resource options in all proceedings before the commission, including resource plan and certificate of need proceedings.") 2016 Minnesota Stat. § 216B.2422 subd. 3.

34 State of Minnesota, Office of Administrative Hearings, In the Matter of the Further Investigation into Environmental and Socioeconomic Costs Under Minnesota Statutes Section 216B.2422, Subdivision 3, Docket No. OAH 80-2500-31888, MPUC E-999/CI-14-643, Findings of Fact, Conclusions, and Recommendations: Carbon Dioxide Values, 2-3 (Apr. 15, 2016) [hereinafter "Minnesota Opinion"].

35 *Id.* at 4.

45x

The Administrative Judge who reviewed the matter[36] recommended that "the Commission adopt the Federal Social Cost of Carbon as reasonable and the best available measure to determine the environmental cost of CO_2, establishing a range of values including the 2.5 percent, 3.0 percent, and 5 percent discount rates . . . ."[37]

The decision to use the federal SCC, with some adjustments, was recently upheld, and the Minnesota PUC will use a range of $9.05 to $43.06 per short ton by 2020. Notably, Minnesota has decided to adjust the federal SCC estimates by using a range between the IWG's "central" 3-percent estimate and a lower bound that uses a 5-percent discount rate and a shortened timeline of only 100 years. As discussed below, uncertainty does not support the argument for shortening the time horizon for the SCC.

New York

The New York Public Service Commission first used the SCC in January 2016 in the benefit-cost analysis order for the Reforming the Energy Vision proceeding. The PSC chose the SCC, as opposed to other methods suggested by commenters, as the tool to monetize marginal climate damage costs in the benefit-cost analysis of a resource portfolio. New York's Clean Energy Standard and accompanying Zero Emissions Credit ("ZEC") take into account the SCC in calculating the value of using emission-free nuclear power, rather than carbon-emitting fossil fuel power.[38] The New York Public Service Commission's program is designed to compensate nuclear plants based directly on the value of the carbon-free attributes of their generation.[39]

The commission recognized that the federal SCC is the "best available estimate of the marginal external damage of carbon emissions."[40] It then designed the ZEC based upon the difference between the average April 2017 through March 2019 projected SCC, as published by the IWG in July 2015 and a fixed baseline portion of the cost that is already captured in the market revenues received by the eligible nuclear facilities under RGGI.[41] The New York Public Service Commission uses the federal SCC, with a "central" 3-percent discount rate estimate.[42] This approach was upheld in June 2017 by the United States District Court for the Southern District of New York.[43]

Washington

In April 2014, Governor Jay Inslee issued an executive order on climate change. Executive Order 14-04 on Washington Carbon Pollution Reduction and Clear Energy Action requires the state's agencies to "[e]nsure the cost-benefit tests for energy-efficiency improvements include full accounting for the external cost of greenhouse gas emissions."[44] With these requirements in mind, the Washington State Energy Office, in consultation with the Washington State Department of Ecology, recommended that all state agencies use the federal SCC estimates.

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36 The Matter of the Further Investigation into Environmental and Socioeconomic Costs Under Minnesota Statutes Section 216B.2422, Subdivision 3.

37 Minnesota Opinion, *supra* note 34, at 123.

38 *See* Proceeding on Motion of the Commission to Implement a Large-Scale Renewable Program and a Clean Energy Standard, New York Public Service Comm'n Case No. 15-E-0302, Order Establishing a Clean Energy Standard 131 (Aug. 1, 2016) [hereinafter "CES Order"].

39 Denise Grab & Burcin Unel, "New York's Clean Energy Standard Is a Key Step Toward Pricing Carbon Pollution Fairly," Utility Dive (Aug.18, 2016), *available at* http://www.utilitydive.com/news/new-yorks-clean-energy-standard-is-a-key-step-toward-pricing-carbon-pollut/424741/.

40 CES Order, *supra* note 38, at 134.

41 *Id.* at 129.

42 New York State Department of Public Service's Staff White Paper on Benefit-Cost Analysis in the Case No. 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision.

43 Coalition For Competitive Electricity et al v. Zibelman et al. (S.D.N.Y., Jul. 27, 2017).

44 State of Washington, Exec. Order 14-04 at 6, *available at* http://www.governor.wa.gov/sites/default/files/exe_order/eo_14-04.pdf.

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The Energy Office noted that the federal SCC estimates do not capture the total cost of emitting carbon dioxide into the atmosphere (total future climate damages), and because of omitted damages and uncertainty about the full scope of the consequences of climate change, the Office recommended using the lower 2.5-percent discount rate.[45]

The Energy Office supports using the 2.5-percent discount rate for a number of reasons.[46] First, the 2.5-percent discount most closely matches with the existing Office of Financial Management real discount rate of 0.9 percent. Second, the IWG models focus only on the damages of climate change that can be easily monetized and since the trend seems to be that additional impacts are monetized with each federal SCC update, Washington can stay ahead of this trend by choosing the lowest IWG discount rate. Third, because the discount rate applied to greenhouse gas emissions is an "intergenerational" discount rate applied to society as a whole, the discount rate used in this context should be substantially lower than private sector discount rates. Fourth, there is a higher risk associated with underestimating the SCC than with overestimating it. Fifth, Washington State wants to lead on climate issues, so it makes sense for the Energy Office to put forth the higher associated SCC.

Washington state agencies have begun following the recommendation of the state's energy office and using a 2.5-percent discount rate for their economic analyses involving greenhouse gas emissions. The Department of Ecology uses the 2010 IWG estimates, with a value of $78 per metric ton for 2020 emissions.[47]

My state already has a climate policy or a renewable energy policy in place, so why should we still use the SCC?

There is nothing that should prevent a state from using the SCC, even if there is already a climate or renewable energy policy, like a renewable portfolio standard (RPS) or clean energy standard (CES). In fact, states can use the SCC in setting RPSs or CESs or other renewable resource mandates. RPSs and CESs alone can be economically problematic, as such policies effectively "'pick winners" in electricity markets. The first-best public policy tool to promote clean energy resources and achieve greenhouse gas reductions is to use a carbon price that would lead the power generators that use dirtier energy resources to internalize the externalities caused by greenhouse gas emissions fully. Using a carbon price to achieve greenhouse gas reductions would be the least-cost way of achieving carbon emission reductions compared to other alternatives.[48] However, using the SCC to set the standard can make RPSs or CESs more efficient. When state agencies are determining standards, the SCC and other externalities, including other societal costs and benefits, should be incorporated into the analysis. We elaborate on this process below.

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[45] Washington State Department of Commerce, Social Cost of Carbon: Washington State Energy Office Recommendation for Standardizing the Social Cost of Carbon When Used for Public Decision-Making Processes, at 3 (2014).

[46] *Id.* at 3-5.

[47] *See, e.g.,* State of Washington, Department of Ecology, Preliminary Cost-Benefit and Least-Burdensome Alternative Analysis: Chapter 173-442 WAC Clean Air Rule & Chapter 173-441 WAC Reporting of Emissions of Greenhouse Gases (2016), at 38, *available at* https://fortress.wa.gov/ecy/publications/documents/1602008.pdf; inflated from 2007 dollars to 2017 dollars.

[48] Erik Paul Johnson, *The Cost Of Carbon Dioxide Abatement From State Renewable Portfolio Standards*, 36 Res. Energy Econ. 332, 349–50 (2014); Karen Palmer & Dallas Burtraw, *Cost-Effectiveness Of Renewable Electricity Policies*, 27 Energy Econ. 873, 893 (2005); Carolyn Fischer, Richard G. Newell, Environmental And Technology Policies For Climate Migration, 55 J. of Envtl. Econ. Mgmt. 142, 160 (2008) (finding that lowest cost emissions reductions come from a combination of an emissions price with a small "learning subsidy").

Are the federal IWG numbers still the best?

The "central" SCC estimate of around $50 per ton of CO_2[49] is the best currently available estimate for the external cost of carbon dioxide emitted in the year 2020. Of course, there is uncertainty over the science and economics of climate change. This uncertainty is due to the complexity of the climate system, the difficulty of placing a monetary value on environmental services, the long time horizon over which climate change occurs, and the unprecedented amount of carbon emissions that have entered the atmosphere since the industrial revolution. As science and economics improve and progress, this uncertainty will decline, but uncertainty can never be fully eliminated from future predictions. The fact that there is uncertainty does not mean that there is no social cost of carbon dioxide emissions. If anything, this uncertainty implies that we should take stronger action, as discussed in the below section on uncertainty.[50]

We discuss at length below why the IWG estimates still represent the best methodology and are based on the best available science and economics. Recent executive orders do not change this fact.

How were the IWG numbers developed?

A federal court ruling spurred the development of the SCC. A 2008 ruling by the U.S. Court of Appeals for the Ninth Circuit required the federal government to account for the economic effects of climate change in a regulatory impact analysis of fuel efficiency standards.[51] As a result, President Obama convened the Interagency Working Group on the Social Cost of Greenhouse Gases (IWG) in 2009 to develop an SCC value for use in federal regulatory analysis.

The SCC was developed through an academically rigorous, regularly-updated, and peer-reviewed process. The SCC values were developed using the three most widely cited climate economic impact models that link physical impacts to the economic damages of carbon dioxide emissions. All of these IAMs—DICE, FUND, and PAGE[52]—have been extensively peer reviewed in the economic literature.[53] The newest versions of the models were also published in peer-reviewed literature.[54] The IWG gives each model equal weight in developing the SCC values.[55] The IWG also used peer-reviewed inputs to run these models.[56] The IWG conducted an "extensive review of the literature . . . to select three sets of input parameters for these models: climate sensitivity, socio-economic and emissions trajectories, and discount rates."[57] For each parameter, the IWG documented the inputs it used, all of which are based on peer-reviewed literature.[58]

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[49] For 2020 emissions in 2017 dollars, from TSD 2016, Table 2, inflated with the Bureau of Labor Statistics Inflation Calculator, *available at* https://data.bls.gov/cgi-bin/cpicalc.pl.

[50] William D. Nordhaus, *Projections and Uncertainties about Climate Change in an Era of Minimal Climate Policies*. National Bureau of Economic Research (2016), *available at*: http://www.nber.org/papers/w22933.pdf.

[51] Ctr. for Biological Diversity v. Nat'l Highway Traffic and Safety Admin., 538 F.3d 1172 (9th Cir. 2008).

[52] More specifically: DICE (Dynamic Integrated Climate and Economy), developed by William D. Nordhaus (more information *available at* http://www.econ.yale.edu/~nordhaus/); PAGE (Policy Analysis of the Greenhouse Effect), developed by Chris Hope; and FUND (Climate Framework for Uncertainty, Negotiation, and Distribution), developed by Richard Tol (more information *available at* http://www.fund-model.org/). *See* TSD 2010, *supra* note 3, at 5.

[53] *See* TSD 2010, *supra* note 3, at 4-5.

[54] *See* TSD 2016, *supra* note 2, at 6; *see also* William Nordhaus, *Estimates of the Social Cost of Carbon: Concepts and Results from the DICE-2013R Model and Alternative Approaches*, 1 J. Ass'n Envtl. & Resource Economists 273 (2014).

[55] TSD 2016, *supra* note 2, at 5.

[56] *Id.* at 5-29.

[57] *Id.* at 6.

[58] *See* TSD 2010, *supra* note 3, at 12-23.

48x

The analytical methods that the IWG applied to its inputs were also peer-reviewed, and the IWG's methods have been extensively discussed in academic journals.[59]

The IWG's analytical process in developing the SCC was transparent and open, designed to solicit public comment and incorporate the most recent scientific analysis. Beginning in 2009, the Office of Management and Budget and the Council of Economic Advisers established the IWG, composed of scientific and economic experts from the White House, Environmental Protection Agency, and Departments of Agriculture, Commerce, Energy, Transportation, and Treasury, to develop a rigorous method of valuing carbon dioxide reductions resulting from regulations.[60] In February 2010, the IWG released estimated SCC values, and an accompanying Technical Support Document that discussed the IAMs, their inputs, and the assumptions used in generating the SCC estimates.[61] In May 2013, after all three IAMs had been updated and used in peer-reviewed literature, the IWG released revised SCC values, with another Technical Support Document.[62] The U.S. Government Accountability Office examined the IWG's 2010 and 2013 processes, and found that these processes were consensus-based, relied on academic literature and modeling, disclosed relevant limitations, and incorporated new information via public comments and updated research.[63]

To further enhance the academic rigor of the process, the IWG requested that the NAS undertake a review of the latest research on modeling the economic aspects of climate change to help the IWG assess the technical merits and challenges of potential approaches for future updates to the SCC.[64] In mid-2016, the NAS issued an interim report to the IWG that recommended against conducting an update to the SCC estimates in the near term, but that included recommendations about enhancing the presentation and discussion of uncertainty regarding particular estimates.[65] The IWG responded to these recommendations in its most recent Technical Support Document from 2016,[66] which included an addendum on the social cost of methane and the social cost of nitrous oxide.[67] The NAS issued a report in January 2017 that contained a roadmap for how SCC estimates should be updated.[68] In the 2017 report, the NAS recommended future improvements to the IWG three-model methodology, but in the meantime, the NAS supported the continued near-term use of the existing social cost of greenhouse gas estimates based on the DICE, FUND, and PAGE models, as used by federal agencies to

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59 *See, e.g.*, Michael Greenstone *et al.*, *Developing a Social Cost of Carbon for U.S. Regulatory Analysis: A Methodology and Interpretation*, 7 Rev. Envtl. Econ. & Pol'y 23 (2013); Frank Ackerman & Elizabeth Stanton, *Climate Risks and Carbon Prices: Revising the Social Cost of Carbon*, Econ.: The Open-Access, Open-Assessment E-Journal (Apr. 2012), at 6 (reviewing the IWG's methods and stating, "[T]he Working Group analysis is impressively thorough.")

60 TSD 2010, *supra* note 3, at 2-3.

61 *See generally* TSD 2010, *supra* note 3.

62 *See* Interagency Working Group on the Social Cost of Carbon, Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (2013) [hereinafter TSD 2013].

63 Gov't Accountability Office, Regulatory Impact Analysis: Development of Social Cost of Carbon Estimates (2014) [hereinafter Gov't Accountability Office].

64 *See* TSD 2016, *supra* note 2, at 2.

65 National Academies of Sciences, Engineering and Medicine, Assessment of Approaches to Updating the Social Cost of Carbon: Phase 1 Report on a Near-Term Update (2016) [hereinafter NAS First Report].

66 TSD 2016, *supra* note 2.

67 Interagency Working Group on Social Cost of Greenhouse Gases, United States Government, Addendum to Technical Support Document on Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866: Application of the Methodology to Estimate the Social Cost of Methane and the Social Cost of Nitrous Oxide (2016) [hereinafter "TSD 2016 Addendum"], *available at* https://www.obamawhitehouse.gov/sites/default/files/omb/inforeg/august_2016_sc_ch4_sc_n2o_addendum_final_8_26_16.pdf.

68 The National Academy of Sciences accepted public comment during its review process. Policy Integrity submitted comments during that process. Institute for Policy Integrity, Recommendations for Changes to the Final Phase 1 Report on the Social Cost of Carbon, and Recommendations in Anticipation of the Phase 2 Report on the Social Cost of Carbon (Apr. 29, 2016) [hereinafter "Policy Integrity NAS comments"] *available at* http://policyintegrity.org/documents/Comments_to_NAS_on_SCC.pdf.

date.[69] The SCC estimates will need to be updated over time to reflect the best-available science and changing economic conditions, and, as we discuss below, a nongovernmental organization Resources for the Future plans to undertake this project based on the NAS 2016 and 2017 recommendations.

How have the IWG numbers been used to date?

The IWG numbers have been used extensively in federal regulatory analysis, on more than one hundred occasions since the first estimates were published in 2010.[70] In fact, the mandate for federal agencies to use the IWG SCC values was ended only recently, on March 28, 2017, with Executive Order 13,783. The SCC has, in fact, been used in a range of contexts aside from federal regulatory impact analysis, which we discuss above.

Who has endorsed the IWG numbers?

The IWG SCC numbers have been endorsed or otherwise supported by the NAS, the Government Accountability Office, and the federal courts. The NAS has supported the continued near-term use of the existing social cost of greenhouse gas estimates based on the DICE, FUND, and PAGE models, as federal agencies have done to date.[71] Additionally, the Government Accountability Office found in 2014 that the estimates derived from these models and used by federal agencies are consensus-based, rely on peer-reviewed academic literature, disclose relevant limitations, and are designed to incorporate new information via public comments and updated research.[72] In fact, the social cost of greenhouse gas estimates used in federal regulatory proposals and EISs have been subject to approximately 100 distinct public comment periods.[73] The economics literature confirms that estimates based on these three IAMs remain the best available estimates.[74] Finally, in 2016, the U.S. Court of Appeals for the Seventh Circuit held the estimates used to date by agencies are "reasonable," and other courts have supported agencies' use of these values.[75]

Did a recent Trump Executive Order delegitimize the IWG numbers?

Absolutely not. While the IWG was disbanded and its guidance was withdrawn, which is unfortunate, the IWG still used the best data, the best models, and the best methodologies that are currently available. Accordingly, the IWG estimates are still the best numbers for states to use and still the only numbers endorsed by the NAS.

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69 Specifically, NAS concluded that a near-term update was not necessary or appropriate and the current estimates should continue to be used while future improvements are developed over time. NAS First Report, *supra* note 66.

70 Howard & Schwartz 2017, Appendix A; Jane A. Leggett. *Federal Citations to the Social Cost of Greenhouse Gases*, Congressional Research Service (Mar 21, 2017), *available at* https://fas.org/sgp/crs/misc/R44657.pdf.

71 Specifically, NAS concluded that a near-term update was not necessary or appropriate and the current estimates should continue to be used while future improvements are developed over time. NAS First Report, *supra* note 66.

72 Gov't Accountability Office, *supra* note 63.

73 Howard & Schwartz 2017, *supra* note 7, at Appendix A.

74 E.g., Richard G. Newell *et al.*, *Carbon Market Lessons and Global Policy Outlook*, 343 Science 1316 (2014); Bonnie L. Keeler *et al.*, *The Social Costs of Nitrogen*, 2 Science Advances e1600219 (2016); Richard L. Revesz *et al.*, *Global Warming: Improve Economic Models of Climate Change*, 508 Nature 173 (2014) (co-authored with Nobel Laureate Kenneth Arrow, among others).

75 *See e.g.* Zero Zone v. Dept. of Energy, No. 14-2147 (7th Cir., Aug. 8, 2016), at 44 (finding that the agency "acted reasonably" in using global estimates of the social cost of carbon, and that the estimates chosen were not arbitrary or capricious); High Country Conservation Advocates v. U.S. Forest Service (D. Colo., June 27, 2014); Western Organization of Resource Councils v. U.S. Bureau of Land Management (D. Mont., Jan. 25, 2017).

If the Trump administration comes out with a new number, should we use it?

Only if the number is consistent with best practices and reflects the best available literature and the recommendations of the NAS panel. If a new number uses a discount rate higher than 5-percent, selects only one of the three IAMs used by the IWG or an IAM that does not take into account nonmarket damages, if it only uses a domestic number, or if it dramatically shortens the time horizon, for example, that would be inconsistent with best practices and should not be followed by the states.

How will the numbers be updated?

In May 2017, the environmental economics think tank, Resources for the Future (RFF), launched a program to update the SCC based on the recommendations made by the NAS.[76] The new initiative contains several key elements. RFF will create a new integrated framework for the estimation process and revise some of the socioeconomic projections to better reflect uncertainty. RFF will also convene domestic and international actors and conduct educational outreach on how to use the SCC. States should consider looking to RFF for new SCC estimates in the coming years.

Are there other estimates of the SCC?

While states should be careful not to cherry-pick a single estimate from the literature, it is noteworthy that various estimates in the literature are consistent with the numbers derived from a weighted average of DICE, FUND, and PAGE—namely, with a central estimate of about $50 per ton of carbon dioxide, and a high-percentile estimate of about $148, for year 2020 emissions (in 2017 dollars, at a 3-percent discount rate). The latest central estimate from DICE's developers is $104 (at a 3-percent discount rate);[77] from FUND's developers, $14;[78] and from PAGE's developers, $148, with a high-percentile estimate of $386.[79]

Similarly, a comparison of international estimates of the social cost of greenhouse gases suggests that a central estimate of $50 per ton of carbon dioxide is a very conservative value. Sweden places the long-term valuation of carbon dioxide at $168 per ton; Germany calculates a "climate cost" of $171 per ton of carbon dioxide in the year 2030; the United Kingdom's "shadow price of carbon" has a central value of $118 by 2030; Norway's social cost of carbon is valued at $106 per ton for year 2030 emissions; and various corporations have adopted internal shadow prices as high as $82 per ton of carbon dioxide.[80]

All of this—not to mention the omitted damages that are not included in the SCC—suggests, again, that the IWG estimates, while still the most reliable and most endorsed numbers for federal and state-level U.S. policymaking, should be treated as a lower bound.

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[76] Resources for the Future, "Updating and Improving the Social Cost of Carbon," *available at* http://www.rff.org/research/collection/updating-and-improving-social-cost-carbon; Nat'l Acad. Sci., Eng. & Medicine, Valuing Climate Damages: Updating Estimates of the Social Cost of Carbon Dioxide 3 (2017) [hereinafter "NAS Second Report"].

[77] William Nordhaus, *Revisiting the Social Cost of Carbon*, Proc. Nat'l Acad. Sci. (2017) (estimate a range of $21 to $141).

[78] D. Anthoff & R. Tol, *The Uncertainty about the Social Cost of Carbon: A Decomposition Analysis Using FUND*, 177 Climatic Change 515 (2013).

[79] C. Hope, *The social cost of CO_2 from the PAGE09 model*, 39 Economics (2011); C. Hope, *Critical issues for the calculation of the social cost of CO_2*, 117 Climatic Change, 531 (2013). Values inflated to 2017 dollars.

[80] *See* Howard & Schwartz 2017, *supra* note 7, at Appendix B. All figures in 2017 USD.

51x

What methodological choices went into the IWG numbers?

Which models?

Economists estimate the SCC by linking together a global climate model and a global economic model. The resulting models are called Integrated Assessment Models, or IAMs. This integration helps economists take a unit of carbon emissions and translate that into an estimate of the cost of the impact that emissions have on our health, well-being, and quality of life in terms of dollars. The models are based on the best available science and economics from peer-reviewed publications.

The IWG uses the three most–cited models, which are William Nordhaus' DICE model (Yale University), Richard Tol's FUND model (Sussex University), and Chris Hope's PAGE model (Cambridge University).

Why did the IWG select a 3% discount rate as a "central" estimate?

The IWG produced four different SCC estimates by using different discount rates. According to the IWG's 2010 Technical Support Document, the 3-percent discount rate estimate is considered the central estimate because it uses the central (i.e., middle) discount rate and is based on an average or mean, rather than worse-than-expected, climate outcome. The use of this "central" discount rate is supported by surveys of experts.[81] The IWG further argues that the 3% is consistent with OMB's Circular A-4 guidance, corresponds to the correct discounting concept (i.e., the consumption rate of interest) when damages are measured in consumption-equivalent units, and roughly corresponds to the after-tax riskless interest rate.

The central estimate is an "average" or mean estimate in the sense that the IWG ran its models thousands of times using slightly varying assumptions to reflect uncertainty, and equally weighted the results to produce a mean average. It is important to note that the SCC is an average estimate of marginal damages, and not an average estimate of average damages. In other words, the SCC is the average estimate of the marginal impacts caused by an additional unit of greenhouse gases. It is not appropriate to interpret the SCC as an estimate of the average damages of all greenhouse gases ever emitted. It is how much the next unit of emissions will cost us.

First, what is a discount rate?

It is easiest to explain the idea of discount rates with a simple example: If offered $1 now or $1 in a year, almost everyone would choose to receive the $1 now. Most individuals would only wait until next year if they were offered more money in the future. The discount rate is how much more you would have to receive to wait until next year. Similarly, if individuals were asked to pay $1 now or $1 next year, most individuals would choose to pay $1 later. Most individuals would only pay now if they were asked to pay more money in the future. The discount rate is how much more you would have to pay in the future to be willing to pay $1 in the present.

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[81] Peter Howard & Derek Sylvan, *Expert Consensus on the Economics of Climate Change, Institute for Policy Integrity Report* (Dec. 2015); M.A. Drupp, *et al., Discounting Disentangled: An Expert Survey on the Determinants of the Long-Term Social Discount Rate* (London School of Economics and Political Science Working Paper, May 2015) (finding consensus on social discount rates between 1-3%).

Why is the discount rate important?

The discount rate is one of the most important inputs in models of climate damages, with plausible assumptions easily leading to differences of an order of magnitude in the SCC. The climate impacts of present emissions will unfold over hundreds of years. When used over very long periods of time, discounting penalizes future generations heavily due to compounding effects. For example, at a rate of 1 percent, $1 million 300 years hence equals over $50,000 today; at 5 percent it equals less than 50 cents.[82] The discount rate changed by a factor of five, whereas the discounted value changed by more than five orders of magnitude. Depending on the link between climate risk and economic growth risk, even a rate of 1 percent may be too high.[83] Uncertainty around the correct discount rate pushes the rate lower still.[84]

Why is the IWG correct to exclude a 7% discount rate?

The IWG correctly excluded a 7-percent discount rate, a typical private sector rate of return on capital, for several reasons. First, typical financial decisions, such as how much to save in a bank account or invest in stocks, focus on private decisions and use private rates of return. However, here we are concerned with social discount rates because emissions mitigation is a public good, where individual emissions choices affect public well-being broadly. Rather than evaluating an optimal outcome from the narrow perspective of investors alone, economic theory would require that we make the optimal choices based on societal preferences (and social discount rates). Second, climate change is expected to affect primarily consumption, not traditional capital investments.[85] Guidelines of the federal Office of Management and Budget note that in this circumstance, consumption discount rates are appropriate.[86] Third, 7 percent is considered much too high for reasons of discount rate uncertainty and intergenerational concerns (further discussed below). Fourth, interest rates are at historic lows, with no indication of increasing, so traditional rates of return used to guide discount rate selection are too high at the present time.[87]

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[82] Dallas Burtraw & Thomas Sterner, *Climate Change Abatement: Not "Stern" Enough?* (Resources for the Future Policy Commentary Series, Apr. 4, 2009), *available at* http://www.rff.org/Publications/WPC/Pages/09_04_06_Climate_Change_Abatement.aspx.

[83] "If climate risk dominates economic growth risk because there are enough potential scenarios with catastrophic damages, then the appropriate discount rate for emissions investments is lower tha[n] the risk-free rate and the current price of carbon dioxide emissions should be higher. In those scenarios, the "beta" of climate risk is a large negative value and emissions mitigation investments provide insurance benefits. If, on the other hand, growth risk is always dominant because catastrophic damages are essentially impossible and minor climate damages are more likely to occur when growth is strong, times are good, and marginal utility is low, then the "beta" of climate risk is positive, the discount rate should be higher than the risk-free rate, and the price of carbon dioxide emissions should be lower." Robert B. Litterman, *What Is the Right Price for Carbon Emissions?*, Regulation, Summer (2013) 38-43, at 41 *available at* http://www.cato.org/sites/cato.org/files/serials/files/regulation/2013/6/regulation-v36n2-1-1.pdf.

[84] *See* "Isn't there too much uncertainty around the SCC to use it?" on page 23.

[85] "There are two rationales for discounting future benefits—one based on consumption and the other on investment. The consumption rate of discount reflects the rate at which society is willing to trade consumption in the future for consumption today. Basically, we discount the consumption of future generations because we assume future generations will be wealthier than we are and that the utility people receive from consumption declines as their level of consumption increases . . . . The investment approach says that, as long as the rate of return to investment is positive, we need to invest less than a dollar today to obtain a dollar of benefits in the future. Under the investment approach, the discount rate is the rate of return on investment. If there were no distortions or inefficiencies in markets, the consumption rate of discount would equal the rate of return on investment. There are, however, many reasons why the two may differ. As a result, using a consumption rather than investment approach will often lead to very different discount rates." Maureen Cropper, *How Should Benefits and Costs Be Discounted in an Intergenerational Context?*, 183 Resources 30, at 33.

[86] *See* Office of Mgmt. & Budget, *Circular A-4*, Nat'l Archives (Sept. 17, 2003), *available at* https://georgewbush-whitehouse.archives.gov/omb/circulars/a004/a-4.html [https://perma.cc/GSV8-TAUR], at 33.

[87] Council of Econ. Advisers, Discounting for Public Policy: Theory and Recent Evidence on the Merits of Updating the Discount Rate at 1 (CEA Issue Brief, 2017) [hereinafter "CEA Brief"], *available at* https://obamawhitehouse.archives.gov/sites/default/files/ page/files/201701_cea_discounting_issue_brief.pdf.

What is a declining discount rate?

The IWG chose as one of its discount rates an estimate based upon declining discount rates. The 2.5-percent discount rate was included by IWG as a constant-rate approximation of a declining discount rate.[88] Since the IWG undertook its initial analysis, a consensus has emerged among leading climate economists that a declining discount rate should be used for climate damages to reflect long-term uncertainty in interest rates.[89] Arrow *et al* (2013) presents several arguments that strongly support the use of declining discount rates for long-term benefit-cost analysis.

But perhaps the best reason is the simple fact that there is considerable uncertainty around which interest rate to use: uncertainty in the rate points directly to the need to use a declining rate, as the impact of the uncertainty grows exponentially over time.[90] The uncertainty about future discount rates could stem from a number of reasons particularly salient to climate damages, including uncertainties in future economic growth, consumption, and the interest rate used by consumers.

Why should the central IWG estimate be interpreted as a lower bound?

A number of factors might result in using a SCC value that is higher than the estimate based on a 3-percent discount rate. Recent research has shown that the appropriate discount rate for intergenerational analysis may be even lower than that reflected in the SCC analysis, which would result in a higher SCC.[91] A jurisdiction might decide that the uncertainty associated with climate damages warrants using a discount rate that declines over time, leading to a higher SCC.[92] A consensus has emerged among leading climate economists that a declining discount rate should be used for climate damages to reflect long-term uncertainty in interest rates, and the NAS January 2017 recommendations to the IWG support this approach.[93] Furthermore, a number of types of damage from climate change are missing or poorly quantified in the federal SCC estimates, meaning that **the federal SCC estimate associated with a 3-percent discount rate should be interpreted as a lower bound on the central estimate.**[94]

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[88] TSD 2010, *supra* note 3, at 23 ("The low value, 2.5 percent, is included to incorporate the concern that interest rates are highly uncertain over time. It represents the average certainty-equivalent rate using the mean-reverting and random walk approaches from Newell and Pizer (2003) starting at a discount rate of 3 percent. Using this approach, the certainty equivalent is about 2.2 percent using the random walk model and 2.8 percent using the mean reverting approach. Without giving preference to a particular model, the average of the two rates is 2.5 percent. Further, a rate below the riskless rate would be justified if climate investments are negatively correlated with the overall market rate of return. Use of this lower value also responds to certain judgments using the prescriptive or normative approach and to ethical objections that have been raised about rates of 3 percent or higher.")

[89] The arguments here are primarily based on: Kenneth J. Arrow *et al., Determining Benefits and Costs for Future Generations,* 341 SCIENCE 349 (2013); Kenneth J. Arrow *et al., Should Governments Use a Declining Discount Rate in Project Analysis?,* REV ENVIRON ECON POLICY 8 (2014); Richard G. Newell & William A. Pizer, *Discounting the Distant Future: How Much Do Uncertain Rates Increase Valuations?,* 46 J. ENVTL. ECON. & MGMT. 52 (2003); Maureen L. Cropper *et al., Declining Discount Rates,* AMERICAN ECONOMIC REVIEW: PAPERS AND PROCEEDINGS (2014); S.K. Rose, D. Turner, G. Blanford, J. Bistline, F. de la Chesnaye, and T. Wilson. *Understanding the Social Cost of Carbon: A Technical Assessment.* EPRI Report #3002004657 (2014).

[90] Martin L. Weitzman, *Gamma Discounting,* 91 AM. ECON. REV. 260, 270 (2001) [hereinafter "Weitzman 2001"].

[91] CES Order, *supra* note 38; CEA Brief, *supra* note 87.

[92] *See* Weitzman 2001, *supra* note 90. Kenneth J. Arrow *et al., Determining Benefits and Costs for Future Generations,* 341 SCIENCE 349 (2013); Kenneth J. Arrow *et al., Should Governments Use a Declining Discount Rate in Project Analysis?,* 8 REV ENVIRON ECON POLICY 1 (2014); Maureen L. Cropper *et al., Declining Discount Rates,* 104 AM. ECON. REV. 538 (2014); Christian Gollier & Martin L. Weitzman, *How Should the Distant Future Be Discounted When Discount Rates Are Uncertain?* 107 ECONOMICS LETTERS 3 (2010). Policy Integrity further explores the use of declining discount rates in its recent comments to the National Academies of Sciences. Policy Integrity NAS comments, *supra* note 68.

[93] NAS Second Report, *supra* note 76.

[94] *See* OMITTED DAMAGES, *supra* note 6; Revesz *et al.* 2014, *supra* note 74.

As we discussed above, Washington State agencies have begun following the recommendation of the state's energy office and using a 2.5-percent discount rate for their economic analyses involving greenhouse gas emissions, for a number of reasons, including that the damages omitted from the IWG estimates and the uncertainty surrounding climate consequences warrant more dramatic action.[95]

Why did the IWG select a 300-year time horizon?

In 2017, NAS issued a report stressing the importance of a longer time horizon for calculating the social cost of greenhouse gases, the rationale for which is also included in the 2016 IWG Technical Support Document. The report states that, "[in the context of the socioeconomic damage, and discounting assumptions, the time horizon needs to be long enough to capture the vast majority of the present value of damages."[96] The report goes on to note that the length of the time horizon is dependent "on the rate at which undiscounted damages grow over time and on the rate at which they are discounted. Longer time horizons allow for representation and evaluation of longer-run geophysical system dynamics, such as sea level change and the carbon cycle."[97] In other words, after selecting the appropriate discount rate based on theory and data (in this case, 3 percent or below), analysts should determine the time horizon necessary to capture all costs and benefits that will have important net present values at the discount rate. Therefore, a 3 percent or lower discount rate for climate change implies the need for a 300-year horizon to capture all significant values. NAS reviewed the best available, peer-reviewed scientific literature and concluded that the effects of greenhouse gas emissions over a 300-year period are sufficiently well established and reliable as to merit consideration in estimates of the social cost of greenhouse gases.[98]

The best available science and economics thus supports a 300-year time horizon for climate effects. We note that, so far one state, Minnesota, has chosen a different time horizon. For the reasons above, this should not be considered a best practice.[99]

Why did the IWG recommend a global rather than domestic estimate?

As we discussed above, the IWG recommends using a global estimate for a number of reasons. Generally, a global number is appropriate because climate change is a global phenomenon and emissions that occur in one part of the world affect other parts of the world. The same is true for avoided emissions. Simply, if all countries set their greenhouse emission levels based on only domestic costs and benefits, ignoring the large global externalities, the aggregate result would be substantially sub-optimal climate protections and economically inefficient policies.

Why did the IWG develop separate numbers for methane and nitrous oxide, rather than just adjusting by their global warming potential?

The IWG has also developed robust federal estimates of the **social cost of methane (SCM)** and **social cost of nitrous oxide (SCN_2O)**. Methane and nitrous oxide are two important, and potent, greenhouse gases. Prior to the IWG's work

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[95] *See, e.g.*, State of Washington, Department of Ecology, Preliminary Cost-Benefit and Least-Burdensome Alternative Analysis: Chapter 173-442 WAC Clean Air Rule & Chapter 173-441 WAC Reporting of Emissions of Greenhouse Gases 38 (2016), *available at* https://fortress.wa.gov/ecy/publications/documents/1602008.pdf.

[96] NAS Second Report, *supra* note 76, at 77.

[97] *Id.*

[98] NAS First Report, *supra* note 66, at 32.

[99] See for more information, "Isn't there too much uncertainty around the SCC to use it?" on page 23.

55x

on social costs for the emission of these pollutants, the SCC was multiplied by the Global Warming Potential (GWP) of each gas.[100] But, according to the IWG:

> "While GWPs allow for some useful comparisons across gases on a physical basis, using the [SCC]...to value the damages associated with changes in CO_2-equivalent emissions is not optimal...because non-CO_2 GHGs differ not just in their potential to absorb infrared radiation over a given time frame, but also in the temporal pathway of their impact on radiative forcing, which is relevant for estimating their social cost but not reflected in the GWP."[101]

In other words, because the GWP of each GHG changes over the lifetime of the gas, multiplying the SCC by the GWP in any particular year is inaccurate. The SCM and SCN_2O methodologies build directly on the IWG's SCC methodology, and replace the less accurate methodology of multiplying the SCC by these gases' relative global warming potential. The same rigorous, consensus-based, transparent process used for the federal SCC has shaped the federal SCM and federal SCN_2O estimates. Just as the federal SCC likely underestimates the true social cost of carbon, the federal SCM and SCN_2O are **likely to underestimate the true social cost of these other greenhouse gases** due to omitted damages and uncertainties regarding the scope of the effects in the underlying models.[102] Nonetheless, **the 2016 IWG SCM and SCN_2O are the best available estimates of the social costs associated with the emission of those greenhouse gases.**

Table 3: Social Cost of Methane Estimates (in 2017 dollars per metric ton)[103]

Year of Emission	Average estimate at 5% discount rate	Average estimate at 3% discountrate—IWG's Central Estimate	Average estimate at 2.5% discount rate	95th percentile estimate at 3% discount rate
2020	$648	$1440	$1920	$3839
2025	$780	$1680	$2159	$4439
2030	$912	$1920	$2399	$5039
2035	$1080	$2159	$2759	$5879
2040	$1200	$2399	$3119	$6598
2045	$1440	$2759	$3359	$7318
2050	$1560	$2999	$3719	$8038

[100] TSD 2016 Addendum, *supra* note 67, at 2 ("The potential of these gases to change the Earth's climate relative to CO_2 is commonly represented by their 100-year global warming potential (GWP). GWPs measure the contribution to warming of the Earth's atmosphere resulting from emissions of a given gas (i.e., radiative forcing per unit of mass) over a particular timeframe relative to CO_2. As such, GWPs are often used to convert emissions of non-CO_2 GHGs to CO_2-equivalents to facilitate comparison of policies and inventories involving different GHGs.")

[101] TSD 2016 Addendum, *supra* note 67, at 2.

[102] Alex L. Marten et al, *Incremental CH_4 and N_2O Mitigation Benefits Consistent with the U.S. Government's SC-CO_2 Estimates.* 15 CLIMATE POLICY 272 (2015). 15(2): 272-298 (2015, published online, 2014) [hereinafter "Marten et al."]; Environmental Defense Fund, Institute for Policy Integrity at New York University School of Law, Natural Resources Defense Council, and Union of Concerned Scientists Comments on EERE-2015-BT-STD-0016, Energy Conservation Standards for WICF Refrigeration System and EERE-2014-BT-STD-0031, Energy Conservation Standards for Residential Furnaces (Nov. 7, 2016).

[103] TSD 2016 Addendum, *supra* note 67, at 7.

Table 4: Social Cost of Nitrous Oxide Estimates (in 2017 dollars per metric ton)[104]

Year of Emission	Average estimate at 5% discount rate	Average estimate at 3% discountrate—IWG's Central Estimate	Average estimate at 2.5% discount rate	95th percentile estimate at 3% discount rate
2020	$5639	**$17,996**	$26,393	$46,788
2025	$6598	**$20,395**	$28,793	$52,787
2030	$7558	**$22,794**	$32,392	$58,785
2035	$8878	**$25,194**	$34,791	$65,984
2040	$10,078	**$27,593**	$38,390	$71,982
2045	$11,397	**$29,993**	$40,790	$79,180
2050	$13,197	**$32,392**	$44,389	$86,379

The SCM and SCN_2O were developed more recently, so have a shorter history of being used by federal—or state—agencies, but the figures were approved by the IWG and appear in an addendum to the group's 2016 Technical Support Document. They were also peer-reviewed by the EPA and by academic journals.[105] For other greenhouse gases beyond methane and nitrous oxide, adjusting the SCC with the gases global warming potential is fine. In fact, for now, it is the best option for state decisionmakers.

Common (but misguided) critiques of the SCC

Aren't there benefits of carbon dioxide emissions?

There are benefits to carbon dioxide, and some of these benefits, such as potential increases in agricultural yields, are captured in the SCC estimate. These benefits reduce the magnitude of the SCC. Other benefits that are the result of climate change are omitted, including the lower cost of supplying renewable energy from wind and wave sources, the increased availability of oil due to higher temperatures in the Arctic, and fewer transportation delays from snow and ice. However, omitted negative impacts almost certainly overwhelm omitted benefits.[106] As a consequence, $50 should be interpreted as a lower-bound central estimate.

The other benefits from the use of carbon fuels that are unrelated to climate change (such as economic output) are omitted from the SCC, but they are always included in any analysis in which the SCC is used. In a benefit-cost analysis, the cost of regulations, such as the potential loss of output, is always balanced against the benefits of carbon reductions as partially measured by the SCC.

If we adapt to climate change or develop new technologies, then won't the value of avoiding emissions be zero?

No. Adaptation and technological change are included in the IAMs already, explicitly or implicitly. In fact, DICE and FUND may overestimate the potential for adaptation by assuming high levels of costless adaptation. Additional research

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[104] *Id.*

[105] Marten et al., *supra* note 102.

[106] Revesz *et al.* 2014, *supra* note 74; Omitted Damages, *supra* note 6.

57x

on adaptation—particularly the ability of technological change and climate impacts to lower and raise, respectively, the cost of adaptation—is necessary. According to the 2010 IWG Technical Support Document,[107] future research may lead to an increase or decrease in future damages. But even under the overly optimistic assumptions about adaptation made by some models, in none of the IAMs is adaptation effective enough to significantly eliminate climate damages.

Isn't there too much uncertainty around the SCC to use it?

Absolutely not. Decisionmakers should not throw up their hands because of uncertainty. As the Ninth Circuit has held: "[W]hile the record shows that there is a range of values, the value of carbon emissions reduction is certainly not zero."[108] On the whole, uncertainty suggests an even higher SCC than estimated.

Uncertainty around climate change generally warrants more stringent climate policy and raises the SCC. Current integrated assessment models (IAMs) used to calculate the SCC show that the net effect of uncertainty about economic damage resulting from climate change, costs of mitigation, future economic development, and many other parameters raises the SCC compared to the case where models simply use our current best guesses of these parameters.[109] Even so, IAMs still underestimate the impact of uncertainty on the SCC by ignoring fundamental features of the climate problem: the irreversibility of climate change, society's aversion to risk and other social preferences, and many catastrophic impacts.[110] The next generation of numerical models designed to capture these features of the climate problem currently focus on the optimal tax (i.e., the SCC on the optimal emissions path) and require key simplifying assumptions, though existing results indicate that uncertainty leads to an increase in the optimal tax under uncertainty for realistic parameter values. Rather than being a reason not to take action, if anything, uncertainty increases the SCC and should lead to more stringent policies to address climate change.

While the 2016 IWG estimate is the best available SCC figure, it likely represents a lower bound for the costs of climate change because the models that are used to get the estimates leave out several categories of climate damages, which we discussed earlier. Again, damages currently omitted from the models include, but are not limited to, the effects of climate change on fisheries; the effects of increased pest, disease, and fire pressures on agriculture and forests; and the effects of climate-induced migration. Additionally, these models omit the effects of climate change on economic growth and the rise in the future value of environmental services due to increased scarcity.[111]

Uncertainty is also no reason to shorten the SCC time horizon. In 2017, NAS issued a report stressing the importance of a longer time horizon for calculating the social cost of greenhouse gases. The report states that, "[i]n the context of the socioeconomic, damage, and discounting assumptions, the time horizon needs to be long enough to capture the vast majority of the present value of damages." The report goes on to note that the length of the time horizon is dependent "on the rate at which undiscounted damages grow over time and on the rate at which they are discounted. Longer time

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[107] TSD 2010, *supra* note 3, at 30. *Also see*, Omitted Damages, *supra* note 6, at 42-43.

[108] *Ctr. for Biological Diversity* 548 F.3d, *supra* note 51, at 1200.

[109] Richard S. Tol, *Safe policies in an uncertain climate: an application of FUND*, Global Environmental Change, 9(3), 221-232 (1999); Peterson, S. (2006). Uncertainty and economic analysis of climate change: A survey of approaches and findings. Environmental Modeling & Assessment, 11(1), 1-17; TSD 2016, *supra* note 2.

[110] Robert S. Pindyck, *Uncertainty in environmental economics*, Review of Environmental Economics and Policy (2007), 1(1), 45-65; A. Golub *et al.* Uncertainty in integrated assessment models of climate change: Alternative analytical approaches. Environmental Modeling & Assessment (2014), 19(2), 99-109; D. Lemoine, & I. Rudik. Managing Climate Change Under Uncertainty: Recursive Integrated Assessment at an Inflection Point. Annual Review of Resource Economics(2017) 9:18.1-18.26.

[111] *See* Omitted Damages, *supra* note 6, for a more complete list.

58x

horizons allow for representation and evaluation of longer-run geophysical system dynamics, such as sea level change and the carbon cycle." In other words, after selecting the appropriate discount rate based on theory and data (in this case, 3% or below), analysts should determine the time horizon necessary to capture all costs and benefits that will have important net present values at the discount rate. Therefore, a 3% or lower discount rate for climate change implies the need for a 300-year horizon to capture all significant values. NAS reviewed the best available, peer-reviewed scientific literature and concluded that the effects of greenhouse gas emissions over a 300-year period are sufficiently well established and reliable as to merit consideration in estimates of the social cost of greenhouse gases.[112]

Didn't the noted economist Robert Pindyck say the SCC numbers were flawed?

Not really, because he actually wants higher numbers. Robert Pindyck wrote a brief article[113] and released a working paper[114] shortly after the 2013 update to the IWG's SCC estimates, in which he criticizes the SCC. However, Pindyck actually advocates for an even higher SCC. He says: "My criticism of IAMs should not be taken to imply that because we know so little, nothing should be done about climate change right now, and instead we should wait until we learn more. Quite the contrary." He goes on to explain that being proactive will benefit society in the longterm. "One can think of a GHG abatement policy as a form of insurance: society would be paying for a guarantee that a low-probability catastrophe will not occur (or is less likely)."[115] Pindyck actually enforces the idea we discussed above, namely that the uncertainty underlying the SCC is no reason to not use the IWG estimates, but rather that decisionmakers who are interested in taking into account the climate effects of particular options should use the SCC as a starting point. In fact, Pindyck's own best estimate of the SCC is between $80 to $100, and goes up to $200.[116] Many groups cite Pindyck when criticizing the SCC, but fail to mention that his conclusion actually supports a robust accounting of climate damage externalities in decisionmaking.

Technical guidance: how do we apply the SCC in our analyses?

What should we choose as our central estimate?

The IWG SCC estimates are not a single number, but instead a range of four estimates, based on three discount rates, plus a 95th percentile estimate that represents catastrophic, low-probability outcomes.[117] Discount rates allow economists to measure the value of money over time—the tradeoff between what a dollar is worth today and what a dollar would be worth in the future.[118] Higher discount rates result in a lower SCC; if future climate damages are discounted at a high rate,

[112] NAS Second Report, *supra* note 76.

[113] Robert S. Pindyck, *Pricing Carbon When We Don't Know the Right Price,* Regulation (Summer 2013). *Available at* https://object.cato.org/sites/cato.org/files/serials/files/cato-video/2013/6/regulation-v36n2-1-2.pdf.

[114] Robert Pindyck, "Climate Change Policy: What do the Models Tell Us?" Working Paper 19244. National Bureau of Economic Research (July 2013), *available at* http://www.nber.org/papers/w19244.pdf.

[115] *Id.* at 16.

[116] *Id.*

[117] TSD 2010, *supra* note 3; TSD 2013, *supra* note 62; Interagency Working Group on the Social Cost of Carbon, Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (2015); TSD 2016, *supra* note 2.

[118] If offered $1 now or $1 in a year, almost everyone would choose to receive the $1 now. Most individuals would only wait until next year if they were offered more money in the future. The discount rate is how much more you would have to receive to wait until next year.

 59x

we would be placing less value on avoiding those damages today. The IWG uses discount rates of 5, 3, and 2.5 percent.[119] The fourth value is taken from the 95th percentile of the SCC estimates corresponding to the 3-percent discount rate, which represents catastrophic but unlikely situations.[120] Note that application of the 95th percentile value was not part of an effort to show the probability distribution around the 3-percent discount rate; rather, the 95th percentile value serves as a methodological shortcut to approximate the uncertainties around low-probability but high-damage, catastrophic, or irreversible outcomes that are currently omitted or undercounted in the economic models.

Frequently, agencies will conduct their economic analyses using a range of SCC values.[121] Often, other analyses focus on a "central" estimate of the SCC.[122] The IWG recommends using a 3% discount rate. However, Washington State, for example, selected the 2.5% discount rate as its "central" estimate, for reasons discussed above.

Choosing the most appropriate discount rate is crucial to obtaining the best SCC estimate. A policymaker might decide that the uncertainty associated with climate damages warrants using a discount rate that declines over time, leading to a higher SCC. A consensus has emerged among leading climate economists that a declining discount rate should be used for climate damages, to reflect long-term uncertainty in interest rates.[123] The National Academy of Sciences January 2017 recommendations to the IWG support this approach.[124] Furthermore, as noted above, **the federal SCC estimate associated with a 3-percent discount rate should be interpreted as a lower bound.**[125]

Can we just calculate damages from a single year of emissions?

No. The values of the SCC in the IWG analysis are calculated by adding up the streams of future effects from a ton of emissions in the year of anticipated release, with discount rates reflecting the passage of time between the anticipated release and the future effects. It is necessary to include in the analysis emissions for each year that a plan, action or project is in place, because the SCC increases over time.

How does discounting work?

The IWG's SCC values represent the damages associated with each additional ton of carbon dioxide emissions released *from the perspective of the year of emission*. It is necessary when conducting a policy analysis *at the present time* about policies that affect greenhouse gas releases *in the future* to make sure that the SCC values are translated into the *perspective*

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[119] The IWG correctly excluded a 7% discount rate, a standard private sector rate of return on capital, in its SCC calculations for two main reasons. First, typical financial decisions, such as how much to save in a bank account, focus on private decisions and use private rates of return. However, in the context of climate change, analysts are concerned with social discount rates because emissions mitigation is a public good, where individual emissions choices affect public well-being broadly. Second, climate change is expected to primarily affect consumption, not traditional capital investments.

[120] *See* Environmental Defense Fund, Institute for Policy Integrity at New York University School of Law, Natural Resources Defense Council, and Union of Concerned Scientists. Comments on Proposed Exception to the Colorado Roadless Rule (RIN 0596-AD26) and Supplemental Draft Environmental Impact Statement (November 2015) to Forest Service; Council on Environmental Quality; Office of Information and Regulatory Affairs to describe importance of 95th percentile value.

[121] *See, e.g.,* Energy Conservation Program: Energy Conservation Standards for Miscellaneous Refrigeration Products, 81 Fed. Reg. 75,194 (Oct. 26, 2016); Cross-State Air Pollution Rule Update for the 2008 Ozone NAAQS, 81 Fed. Reg. 74,504 (Oct. 26, 2016).

[122] *See, e.g.,* Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision, Order Establishing the Benefit Cost Analysis Framework, New York Public Service Comm'n Case No. 14-M-0101 (Jan. 21, 2016) ["BCA Order"].

[123] *See* Weitzman 2001, *supra* note 90; Kenneth J. Arrow *et al.* 2013, *supra* note 92; Kenneth J. Arrow *et al.*, 2014, *supra* note 92; Maureen L. Cropper *et al.* 2014, *supra* note 92; Christian Gollier & Martin L. Weitzman 2010, *supra* note 92. Policy Integrity comments to NAS, *supra* note 68.

[124] NAS Second Report, *supra* note 76.

[125] *See* Omitted Damages, *supra* note 6; Richard L. Revesz *et al.* 2014, *supra* note 74.

60x

of the year of the policy decision. The proper way to accomplish this translation is by using the discount rate to convert the effects of emissions from the year of release into the present value.

Imagine a policy has costs today and would decrease emissions in the year 2025. The IWG estimates for 2025 are how much those reductions are worth to people in year 2025, looking at cumulative effects over a 300-year period and discounting back to the year 2025. But because we prefer present consumption over future consumption, how we'd value that today isn't the same as how people in year 2025 would value it. Still, we need to discount from year 2025 back to today.

What about inflation?

Separate from the discounting considerations, which reflect the resource tradeoffs facing the actors in the relevant year of action, currency tends to inflate over time. The IWG's calculations for the SCC are based upon 2007 dollars, but the purchasing power of the dollar has gone down since then, meaning that $1 in 2007 is worth $1.20 in 2017.[126] It is important to ensure that the analysis is consistent across time frames and makes sense to decisionmakers. Thus, before any calculations are done, the analysts should account for inflation by converting all of the SCC values from 2007 dollars into dollars for the year the analysis is taking place (currently, 2017).

So once we multiply emissions by the SCC and discount back, are we done?

Not quite. It is still best to include a qualitative description of omitted damages. Best practices for regulatory analysis require including all costs and benefits, even the hard-to-monetize ones. Include a qualitative description to emphasize that the SCC is a lower bound on damages.

And what are all of the steps put together?

To make the calculation, the SCC figure should be multiplied by the projected avoided emissions to provide a figure for the monetized benefits of an action's or project's avoided greenhouse gas emissions. Specifically, you should:

1. Convert the SCC values from 2007 dollars to the year of analysis, using a consumer price index inflation calculator[127] (if the values have not yet been converted);
2. Determine the avoided emissions for each Year X between the effective date and the end date of 2030;
3. Multiply the quantity of avoided emissions in Year X by the corresponding SCC in Year X,[128] to calculate the monetary value of damages avoided by avoiding emissions in Year X;[129]
4. Apply the same discount rate used to calculate the SCC to calculate the present value of future effects of emissions from Year X;[130]

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[126] *See* CPI Inflation Calculator, http://data.bls.gov/cgi-bin/cpicalc.pl?cost1=1&year1=2007&year2=2017.

[127] *See* CPI Inflation Calculator, http://data.bls.gov/cgi-bin/cpicalc.pl.

[128] In general, the SCC goes up over time because greenhouse gases accumulate, exacerbating the effects of climate change—and therefore the harm from each additional unit of emissions—over time. TSD 2010, *supra* note 3, at 28.

[129] The SCC for a given year encompasses the effects that a ton of carbon dioxide, once emitted in that year, will have stretching into the future over a 300-year time frame. TSD 2010, *supra* note 3, at 25.

[130] Using a consistent discount rate for both the SCC (assessed from the perspective of the actors in the year of emission) and the net present value calculation (assessed from the perspective of the decisionmaker) is important to ensure that the decisionmaker is treating emissions in each time frame similarly. The decisionmaker should not be overvaluing or undervaluing emissions in the present as compared to emissions in the future. NAS First Report, *supra* note 66.

 61x

5. Sum these values for all relevant years between the effective date and the end date to arrive at the total monetized climate benefits of the plan's avoided emissions;[131] and
6. Qualitatively describe in the final discussion of the climate benefits all of the other damages that have been omitted from the SCC.

State agencies could conduct these calculations with a single, central discount rate for the SCC, or the agency could conduct the analysis several times, using a range of discount rates for the SCC, being sure to use the selected discount rate in step 4 for each different iteration.

Because the SCC has been used in a number of federal regulatory impact analyses and environmental impact statements, there are a number of examples from which states can learn how to conduct their own SCC analysis.[132]

How is the SCC used in an analysis with other discount rates?

In its Phase 1 report, NAS recommended that the SCC be used with a "consistent" discount rate in cost-benefit analysis.[133] "Consistent" should be interpreted to mean "compatible" and based on the same theoretically-sound methodology (i.e., theoretically consistent): for example, applying a higher discount rate (say 3%) to other costs and benefits may be "consistent" with a lower discount rate (say 2.5%) for the SCC, to account for the greater uncertainty with respect to climate change relative to more short-run benefits and costs. This approach is appropriate when climate uncertainty exceeds the short-run uncertainty captured by most benefit-cost analysis in which the SCC is applied.

What other resources exist?

- Omitted Damages: What's Missing from the Social Cost of Carbon (2014) by Peter Howard
- Think Global, International Reciprocity as Justification for a Global Social Cost of Carbon (2016) by Jason Schwartz and Peter Howard
- Best cost estimates of greenhouse gases (2017) by Richard Revesz, Michael Greenstone, Michael Hanemann, Thomas Sterner, Peter Howard, Jason Schwartz
- Global Warming: Improve Economic Models of Climate Change (2014) by Richard L. Revesz, Kenneth Arrow *et al.*
- The Social Cost of Carbon: A Global Imperative (2017) by Richard L. Revesz, Jason A. Schwartz, Peter H. Howard, Kenneth Arrow, Michael A. Livermore, Michael Oppenheimer, and Thomas Sterner
- Flammable Planet: Wildfires and the Social Cost of Carbon (2014), by Peter Howard
- Recent comments by Policy Integrity, EDF, NRDC, and Union of Concerned Scientists on the SCC
- Assessment of Approaches to Updating the Social Cost of Carbon: Phase 1 Report on a Near-Term Update (2016), National Academies of Sciences

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131 Steps 4 and 5 combined are equivalent to calculating the present value of the stream of future monetary values using the same discount rate as the SCC discount rate.

132 *See, e.g.*, Energy Conservation Program: Energy Conservation Standards for Commercial Refrigeration Equipment 79 Fed. Reg. 17,726, at 17,728, 17,773, 17,779, 17,811 (Mar. 28, 2014); U.S. Department of Energy, Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment 12-22, 13-4 to 13-5, 14-2 (2014).

133 NAS First Report, *supra* note 66, at 49.

62x

- Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide (2017), National Academies of Sciences
- Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (2010), Interagency Working Group on the Social Cost of Greenhouse Gases
- Revised: Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (2013), Interagency Working Group on the Social Cost of Greenhouse Gases
- Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis (2016), Interagency Working Group on the Social Cost of Greenhouse Gases Under Executive Order 12866 Addendum to Technical Support Document on Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866: Application of the Methodology to Estimate the Social Cost of Methane and the Social Cost of Nitrous Oxide (2016), Interagency Working Group on the Social Cost of Greenhouse Gases

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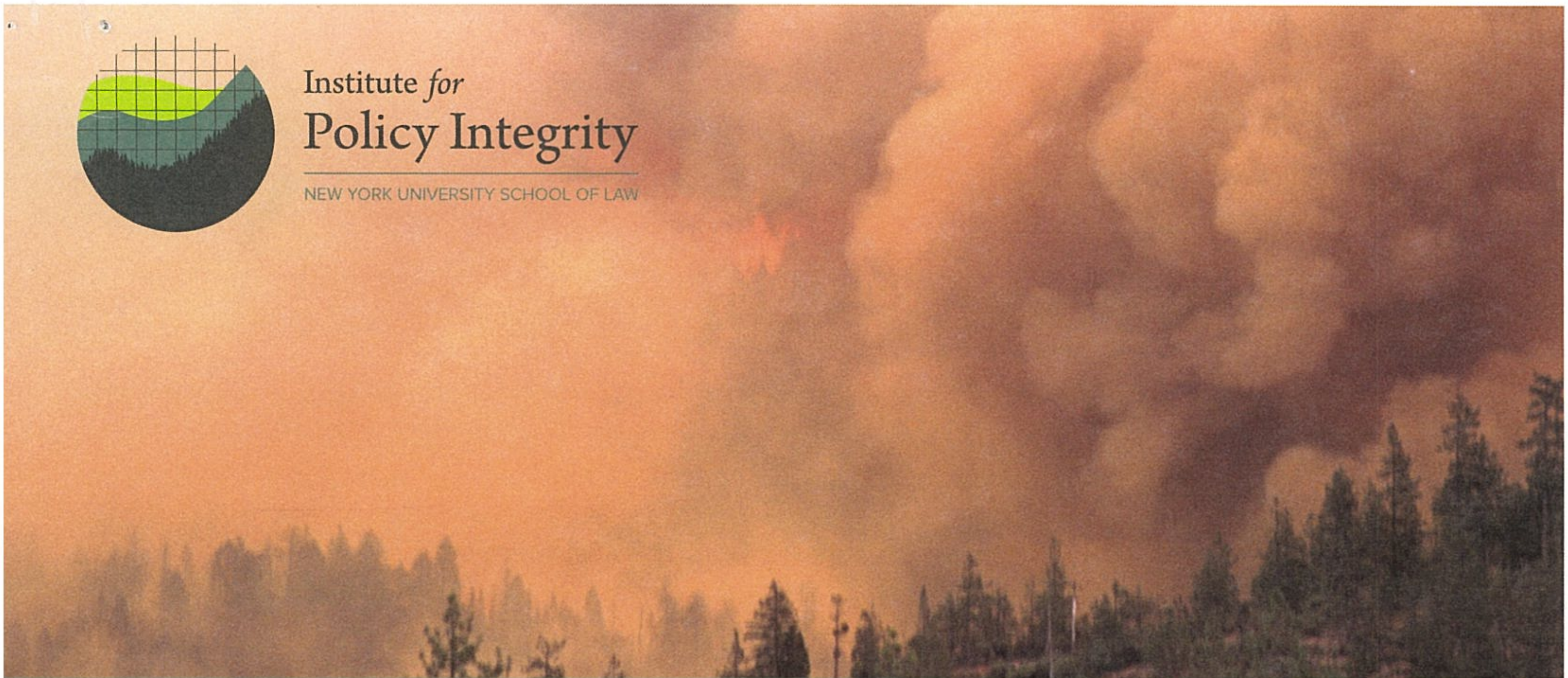

A Lower Bound: Why the Social Cost of Carbon Does Not Capture Critical Climate Damages and What That Means for Policymakers

FEBRUARY 2019

The social cost of carbon (SCC) developed by the Obama-era Interagency Working Group (IWG) is currently the best available estimate for the damages done by each additional ton of greenhouse gas emissions, and this tool has been used by many federal and state policymakers to evaluate and craft climate-related policies.[1] However, the SCC does not account for many of the severe consequences of climate change identified by the Intergovernmental Panel on Climate Change (IPCC).[2] This means that we should treat the most recent (2016) IWG SCC estimates, such as the "central" estimate of about $51 per ton of carbon dioxide,[3] as a lower bound when we monetize climate damages to assess policies that affect greenhouse gas emissions.[4]

Introduction

Under the Obama administration, the U.S. government convened a group of experts from several federal agencies to develop a range of monetary values that captures the expected damages of greenhouse gas pollution. Their work from 2010 through 2016 delivered estimates that were based on the best available science and economics.[5] While these SCC estimates include a number of categories of expected climate damages, they are partially missing the costs of extreme weather and other climate damages that the IPCC emphasizes in its latest state-of-the-climate report, the Fifth Assessment Report (AR5).[6] Set at around $51 per ton of carbon dioxide emissions, the "central"[7] SCC estimate

141X

Photo © Bureau of Land Management Oregon and Washington developed by the Obama-era Interagency Working Group on the Social Cost of Greenhouse Gases (IWG), has been used to make decisions about greenhouse gas pollution standards and other policies.[8] The SCC helps gauge whether the benefits of controlling carbon emissions outweigh the costs of limiting pollution. But because SCC estimates omit the costs of so many expected damages, the pollution limits policymakers set are often less stringent than they should be.

What the IPCC Predicts

The IPCC, made up of almost 200 renowned scientists from around the world, is tasked with assessing the latest peer-reviewed information on climate change in order to provide governments with policy guidance. The last assessment report from the IPCC, AR5, was released in 2014. AR5 highlights many advancements in our understanding of climate science, including the nature and magnitude of risks and impacts associated with climate change (the previous assessment report was released in 2007).[9] Covering 12,000 peer reviewed scientific and economic research articles, AR5 emphasizes that, while average temperature increases are important, it is extreme weather and broad economic, public health, and ecosystem changes that are particularly damaging, and particularly costly.[10]

In 2018, the IPCC also released a special report on keeping warming below 1.5 degrees Celsius.[11] The 2018 special report tells us that we could reach 1.5 degrees of warming as soon as 2030; in this scenario, the world will likely experience many of these disruptive or catastrophic consequences of climate change sooner than previously thought. This is complicated by the fact that the United States and other countries around the world have not taken adequate steps to reduce emissions in order to limit warming below 2 degrees Celsius, much less below 1.5 degrees. Moreover, the models used by the IWG may not account for the potential of an accelerated timeline. This leaves Americans extremely vulnerable.

Why It Matters

The SCC has been used in a number of important decisionmaking contexts.[12] While the IWG SCC was developed for use in federal regulatory analysis, it has also been featured in analysis for projects on federal lands and used by states for electricity regulation and climate policy.

The economic models that underlie the IWG's SCC estimate, known as integrated assessment models (IAMs), were the most up-to-date tools available during the IWG's work.[13] But these models only partially account for, or omit altogether, many significant impacts of climate change, including many which the IPCC stressed were very destructive. (Our 2014 report, *Omitted Damages*, explains in detail what the IAMs are missing and how it affects the IWG estimates.)[14]

A number of climate impacts are difficult to quantify or monetize, and models of these effects need further development; therefore, many significant damages are not fully included in the IAMs.[15] The IWG SCC estimates are based on models that place no value on some major climate impacts like increased fire risk, the geographic spread of pests and pathogens, slower economic growth, mass extinctions, large-scale migration, increased social and political conflict, violence borne of resource scarcity, and the loss of coral reefs and other aquatic life. This implies that society would not pay a penny to avoid sticking the next generation with these phenomena. These omissions result in a very significant underestimate of the IWG SCC.[16]

The IAMs do a good job of measuring the direct costs of average temperature increases, but a poor job of capturing other critical climatic and ecosystem changes that could lead to very large economic losses. Specifically, the IAMs struggle to capture the interactions between large ecosystem and climate changes - or "impact drivers" as the IPCC calls them. For

142x

example, the IPCC projects both higher seas and more frequent hurricanes, both of which are included in the economic models. But when combined, these changes lead to more significant storm surges, and the potentially large damages from this interaction is omitted. And because the IAMs are entirely missing many other key ecosystem and climate changes identified by the IPCC, the IWG cost estimates that rely on these models are missing them too.[17]

The IAMs also fail to account for other variables discussed in AR5, such as the role of social factors in projecting climate impacts. For example, income inequality, political representation, and prevalence of violence will all affect the nature of climate damages. Additionally, non-climate stressors, such as over-pumping of groundwater, are important determinants of the magnitude of climate impacts, and the models do not address these pressures adequately (and in some cases, not at all).[18]

In addition, the IWG SCC estimates are skewed downward because of the way the IAMs take into account the costs of adaptation. Each IAM treats adaptation differently: one model implicitly takes into account how adaptation may reduce climate damages; another takes into account some forms of adaptation, such as seawalls; the final model explicitly includes adaptation costs for all non-catastrophic impacts.[19] A number of scholars consider the IAMs too optimistic about the ability of adaptation to reduce climate damages.[20] Given these factors and the potentially condensed timeline to adapt to climate impacts, the SCC estimate may be biased downward even further.[21]

The tables below summarize the damages highlighted by the IPCC in AR5 compared to what is included in the IWG SCC estimates.

How We Should Proceed

These omitted factors in the IWG SCC should motivate policymakers to use the estimates that are most appropriate for their jurisdiction's circumstances, knowing that there is little chance that they are weighing the costs of climate change too heavily if they use a figure based on the IWG SCC.

Some decisionmakers have already taken actions that reflect the conservative nature of the IWG SCC. For example, states like Washington and California have begun to consider using higher values from the IWG's range of estimates.[22] Policies reflecting these choices will account for more severe expected climate damages, compared to the central SCC estimate.[23] Given that the IWG SCC should be considered a lower bound, many policymakers may push further in this direction when trying to account for the full effects of climate change.

Future improvements to the SCC calculation may provide a more appropriate range of estimates. In recent reports,[24] the National Academy of Sciences highlighted extensive damage literature currently ignored by IAMs. Economists and scientists need to work together to synthesize this literature and other findings into the IAMs to improve damage estimates, particularly by filling in missing gaps in the climate impact literature identified by the IPCC. Groups tasked with updating the SCC can use these reports as guidance. Some groups are doing just this, including Resources for the Future[25] and the Climate Impact Lab.[26] Finally, groups working on updating the SCC should continue to address new information as it becomes available, so that the SCC better represents the full extent of expected climate impacts.

143x

Table 1: How the IWG SCC Accounts for IPCC Climate Impact Drivers

Status	Climate-Related Drivers of Impacts
Excluded	Extreme temperature *The health impacts of extreme temperatures are the only impact considered by IAMs*
	Drying trend
	Extreme precipitation
	Snow cover
	Ocean acidification
Partially Included	Flooding *Coastal flooding is included and inland flooding is excluded*
	Storm surge *Partially included, but the models fail to account for the combined effect of sea level rise and increased intensity of coastal storms*
Included	Warming trend
	Precipitation
	Damaging cyclones
	Carbon dioxide concentration
	Sea level rise

144X

Table 2: IPCC Climate Impacts in the IWG SCC Estimates

Damage Type	Sector	Status	Impact
Economic	Agriculture	Included	Impacts on average crop yields due to average temperature increases and CO_2 fertilization effect *Models are more optimistic than current observations, potentially due to optimistic assumptions about CO_2 fertilization effect*
		Excluded	Increases in yield variability
		Excluded	Change in food quality, including nutrition content
		Excluded	Increased pest and disease damage
		Excluded	Flood and sea level impacts on food infrastructure and farmland
		Excluded	Food security
		Excluded	Food price stability and price spikes
	Forestry	Included	CO_2 fertilization
		Included	Shifting geographic range
		Excluded	Increased pest and disease damage
		Excluded	Increasing risk of wildfire
	Fresh water availability	Included	Changing precipitation
		Excluded	Melting snowpack
		Excluded	Changing water quality
		Excluded	Competing uses, including overexploitation of groundwater resources
		Excluded	Water security and water prices
		Partially Included	Water supply system losses and disruptions *While general infrastructure costs of coastal extreme events (flooding and storms) are included, inland extreme events are omitted. Also, IAMs exclude more long-term costs from these infrastructure losses, including human suffering.*
	Fisheries and aquatic tourism	Excluded	Shifted geographic ranges, seasonal activities, migration patterns, abundances, and species interactions
		Excluded	Reduced growth and survival of shellfish and other calcifiers
		Excluded	Coral bleaching
		Excluded	Decrease in catch potential at some latitudes

145X

Damage Type	Sector	Status	Impact
Economic *continued*	Energy	Partially Included	Energy system losses and disruptions *While general infrastructure costs of coastal extreme events (flooding and storms) are included, inland extreme events are omitted. Also, IAMs exclude more long-term costs from these infrastructure losses, including human suffering and increases in energy prices.*
	Property and infrastructure loss	Included	Coastal property losses due to storms, flooding, and sea level rise
		Excluded	Inland property loss due to extreme weather events, including flooding
		Excluded	Melting permafrost
		Excluded	Wildfires
	Declining economic growth	Excluded	Labor productivity
		Excluded	Prolonging and creating new types of poverty traps
		Excluded	Diverted R&D funds for adaptation research
		Excluded	Lost land, capital, and infrastructure
Non-market	Human health *Cardiovascular, respiratory disorders, diarrhea, and morbidity for some health impacts are included in FUND, and thus partially included in PAGE*	Included	Coastal mortality from flooding and storms
		Included	Spread in geographic range of vector-borne diseases *Significant diseases are included, though Lyme disease is excluded*
		Excluded	Wildfires
		Excluded	Mortality from inland extreme weather events
		Excluded	Food and water availability
		Partially Included	Heat related deaths
		Partially Included	Water-borne diseases
		Partially Included	Morbidity: non-fatal illness and injury
		Partially Included	Air quality *Air quality is included in DICE, though it does not account for changes due to pollen or wildfire*
	Terrestrial, freshwater, and marine ecosystems and wildlife	Included	Shifted geographic ranges, seasonal activities, migration patterns, abundances, and species interactions *The value of ecosystems and biodiversity are included in general terms, not specific to any one damage*
		Included	Extinction and biodiversity loss
		Excluded	Non-climate stressors: habitat modification, over-exploitation, pollution, and invasive species

146X

Damage Type	Sector	Status	Impact
Non-market *continued*	Terrestrial, freshwater, and marine ecosystems and wildlife *continued*	Excluded	Abrupt and irreversible regional-scale change in the composition, structure, and function of ecosystems *Environmental tipping points in non-climate systems are excluded*
		Excluded	Effects of ocean acidification on polar ecosystems and coral reefs *Ocean acidification is excluded*
		Partially Included	Loss of habitat to sea level rise *Wetland loss explicitly modeled in FUND, and thus partially in PAGE*
Social	Migration	Excluded	Increased displacement *FUND partially accounts for migration, but uses arbitrary measurements of resettlement and costs*
	Social and political instability	Excluded	Violence, civil war, and inter-group conflict
		Excluded	National Security
Non-climate stressors	Non-climate stressors	Excluded	Climate-related hazards exacerbate other stressors
	Multidimensional inequalities	Excluded	Inequalities, including income
	Violent conflict	Excluded	Violent conflict increases vulnerability
Tipping points	Climate tipping points *Known tipping points are modeled as a single event, instead of multiple events. Furthermore, fat tails, which capture unknown tipping points, are excluded*	Partially Included	Reduction in terrestrial carbon sink
		Partially Included	Boreal tipping point
		Partially Included	Amazon tipping point
		Partially Included	Other tipping points
	Ecosystem tipping points	Excluded	Abrupt and irreversible regional-scale change in the composition, structure, and function of ecosystems *Environmental tipping points in non-climate systems are excluded*

147X

Endnotes

1 Iliana Paul et al. INSTITUTE FOR POLICY INTEGRITY, THE SOCIAL COST OF GREENHOUSE GASES AND STATE POLICY (2017), *available at*: https://policyintegrity.org/publications/detail/social-cost-of-ghgs-and-state-policy. [Hereinafter Policy Integrity 2017].

2 Peter Howard, COST OF CARBON PROJECT. OMITTED DAMAGES: WHAT'S MISSING FROM THE SOCIAL COST OF CARBON (2014), *available at*: http://costofcarbon.org/reports/entry/omitted-damages-whats-missing-from-the-social-cost-of-carbon [hereinafter "OMITTED DAMAGES"]. "Playing Catch Up to the IPCC," CostOfCarbon.org (Apr. 22, 2014).

3 For 2020 emissions in 2018 dollars; INTERAGENCY WORKING GRP. ON SOC. COST OF GREENHOUSE GASES, TECHNICAL SUPPORT DOCUMENT: TECHNICAL UPDATE OF THE SOCIAL COST OF CARBON FOR REGULATORY IMPACT ANALYSIS UNDER EXECUTIVE ORDER 12,866, at 4 (2016) [hereinafter 2016 TSD] *available at* https://www.obamawhitehouse.gov/sites/default/files/omb/inforeg/scc_tsd_final_clean_8_26_16.pdf.

4 For more on why the IWG SCC should be considered a lower bound, see Richard L. Revesz et al., *Global Warming: Improve Economic Models of Climate Change*, 508 NATURE 173 (2014).

5 INTERAGENCY WORKING GRP. ON SOC. COST OF GREENHOUSE GASES, TECHNICAL SUPPORT DOCUMENT: TECHNICAL UPDATE OF THE SOCIAL COST OF CARBON FOR REGULATORY IMPACT ANALYSIS UNDER EXECUTIVE ORDER 12,866 (2010) [hereinafter 2010 TSD] at 5, *available at* https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf.

6 IPCC: *IPCC Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (2014) [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp. [Hereinafter AR5].

7 See Policy Integrity 2017, *supra* note 1. (The IWG produced four different SCC estimates by using different discount rates. According to the IWG's 2010 Technical Support Document, the 3-percent discount rate estimate is considered the central estimate because it uses the central (i.e., middle) discount rate and is based on an average or mean, rather than worse-than-expected, climate outcome.); *See also supra* notes 3 and 5.

8 Jane A. Leggett. "Federal Citations to the Social Cost of Greenhouse Gases." CONGRESSIONAL RESEARCH SERVICE (Mar. 21, 2017).

9 See AR5, *supra* note 8, at Topic 1: Observed Changes and their Causes.

10 See AR5, *supra* note 8, at Topic 2: Future Climate Changes, Risk and Impacts.

11 IPCC. IPCC *Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* (2018) [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland, 32 pp.

12 Leggett 2016, *supra* note 7.

13 DICE2013-R and FUND 3.9 have since become available.

14 Omitted Damages, *supra* note 2.

15 Omitted Damages, *supra* note 2, at 16; *see also* Yohe, G. W., & Tirpak, D. (2008). A research agenda to improve economic estimates of the benefits of climate change policies. Integrated Assessment, 8(1).

16 Revesz et al. 2014, *supra* note 4.

17 Omitted Damages, *supra* note 2.

18 Omitted Damages, *supra* note 2, at 17.

19 For a more detailed explanation, see Omitted Damages, *supra* note 2, at 42-43."

20 See Omitted Damages, *supra* note 2, at 43.

21 Omitted Damages, *supra* note 2.

22 Washington uses the 2.5% discount rate and California is exploring the use of the high impact estimate, which is taken from the 95th percentile of the central range. See CostofCarbon.org for more details on state use of the SCC.

23 Policy Integrity 2017, *supra* note 1.

24 Nat'l Acad. Sci., Engineering & Med., *Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide* 3 (2017), https://www.nap.edu/read/24651/chapter/1; Nat'l Acad. Sci., Engineering & Med., *Assessment of Approaches to Updating the Social Cost of Carbon: Phase 1 Report on a Near-Term Update* 1–2 (2016); https://www.nap.edu/read/21898/chapter/1.

25 See http://www.rff.org/research/collection/rffs-social-cost-carbon-initiative.

26 http://www.impactlab.org/research-area/social-cost/.

148x

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How the Trump Administration Is Obscuring the Costs of Climate Change

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When federal and state policymakers account for the impacts of climate change, they regularly use an indispensable tool called the Social Cost of Carbon (SCC). **The SCC puts a dollar value on the most significant, quantifiable damages caused by each additional ton of carbon dioxide emitted.** Related estimates, such as the Social Cost of Methane (SCM), quantify damages from other greenhouse gases.

In 2016, the federal government released the most recent estimate of the SCC, finding that each ton of carbon dioxide causes at least $51 in quantifiable damages to the economy, with this number rising over time.[1] For methane, it found a staggering $1470 in quantifiable damages for each ton emitted.[2] **Those damages include lost agricultural productivity, lost property value, extreme weather damages, some increases in disease, and decreased fresh water availability, among others.**[3] But these estimates are conservative because they do not include many other significant damages from climate change that are currently difficult to quantify, such as spikes in food prices, impacts from increased wildfires, and national security effects.[4]

The SCC was developed in 2009 and last updated in 2016 by an Interagency Working Group made up of experts from 12 federal agencies. The Interagency Working Group used the best available economic models, and inputs and assumptions drawn from peer-reviewed scientific and economic literature, to produce highly rigorous estimates of climate damages.[5]

149x

Photo © U.S. Air Force photo/Staff Sgt. James L. Harper Jr.

Because the SCC provides a dollar estimate of the cost of carbon emissions, it allows decisionmakers to transparently and efficiently weigh the costs and benefits of policies under consideration.[6] But now, turning its back on years of work, **the Trump administration has disbanded the Interagency Working Group,[7] and the Environmental Protection Agency has produced a new "interim" estimate claiming that each ton of carbon dioxide causes as little as $1 in climate damages.[8]** Similarly, for the Social Cost of Methane, federal agencies have issued an estimate of only $58 per ton, down from the previous estimate of $1,470.[9] **This "interim" estimate relies on faulty economics. It is unreliable and should not be used.**

The "interim" estimate ignores the interconnected, global nature of our climate-vulnerable economy, and it obscures the devastating effects that climate change will have on younger and future generations. Through these two major manipulations of the SCC—a spurious "domestic-only" calculation and an overblown 7% discount rate—the administration obscures roughly 98% of expected climate damages. These manipulations are inconsistent with sound economic principles and the consensus views of scientific and economic experts.[10]

Federal law requires government agencies to monetize the costs of climate change when they calculate the benefits of a regulation or project,[11] and the administration has been proposing rollbacks of environmental rules and related actions using this problematic SCC estimate as justification. Many state policymakers also use the SCC, and this flawed "interim" estimate has created confusion about the proper value. The Interagency Working Group's value remains the best available estimate.

What's wrong with considering only the domestic effects of climate change?

The Interagency Working Group appropriately took a global perspective on climate damages. But the "interim" estimate instead relies on so-called "domestic-only" effects of climate change. **The Trump administration's calculation completely disregards how climate damages in foreign countries will spill back into the U.S. economy through globally interconnected trade, health, and national security.** This estimate also ignores that the United States cannot solve climate change on its own. Because greenhouse gases emitted anywhere affect the global climate, no one state's or country's reductions can address the harms of carbon emissions unless they also spur reciprocal actions by other governments.

Taking more ambitious action on climate change in the United States will cause other countries to do the same, which directly benefits the United States—as each ton of greenhouse gases emitted abroad affects the global climate and so affects Americans. The Trump administration's approach also ignores the extraterritorial interests of U.S. citizens: investing in foreign businesses, owning foreign property, enjoying the environment abroad, and altruistically caring about the welfare of foreign citizens.[12]

Limiting the SCC estimate to so-called "domestic-only" effects is as irrational as a homeowner dumping trash in her neighbor's yard without considering whether that might attract pests and generate odors on her own property, affect her property value, or provoke her neighbor to retaliate in kind. The Interagency Working Group's global estimate reasonably took these spillover and reciprocity effects into account, and the use of this estimate was upheld in a major federal court decision in 2016.[13] The "interim" estimate, by contrast, ignores these effects.

150 X

Even if a "domestic-only" approach were appropriate, existing economic models cannot accurately calculate a domestic-only estimate. The National Academies of Sciences,[14] the Office of Management and Budget,[15] and the economists[16] who built the models underlying the SCC all agree that existing methodologies cannot accurately calculate a domestic-only estimate, because existing methods are unable to estimate spillover effects of foreign climate damages into the United States without drawing on the global estimate.

What's wrong with using a 7% discount rate to determine how we value avoiding future climate damages?

The Trump administration has also manipulated the SCC by using a higher discount rate than is reasonable, devaluing the importance of damages that will affect children and future generations. Most people value having a dollar tomorrow less than a dollar today, and discount rates reflect how people trade off present and future costs and benefits. A higher discount rate, for example, reflects a sense that an individual person is willing to pay relatively less today to prevent future harms to herself.

In the context of climate damages stretching out over many decades, the discount rate determines how much value is given to the welfare of future generations. Higher discount rates falsely imply that people today are willing to pay little to nothing to prevent potentially catastrophic climate damages that will occur in the future. The Interagency Working Group rejected the 7% discount rate as inappropriately high for climate damages spanning several generations and instead used a 3% discount rate to calculate its central SCC estimates.[17] A growing consensus of economists now thinks that the discount rate for intergenerational impacts should be even lower (around 2%) or decline over time and eventually approach 0%.[18] Ignoring that growing consensus, the Trump administration has instead done the opposite and trumpeted the $1 "interim" estimate, which is based on a 7% discount rate.[19]

Including a 7% discount rate in the analysis has no purpose aside from obscuring the full costs of climate change. Though White House guidance on cost-benefit analysis does recommend that generic regulatory analyses should use 7% and 3% rates as default values to assess costs and benefits stretching two or three decades into the future, that guidance also explains that different regulatory contexts call for different methodological choices and that all assumptions must be sound and defensible.[20] **In the context of intergenerational climate damages occurring over three centuries or more, the National Academies of Sciences,[21] the Office of Management and Budget,[22] and many prominent economists,[23] including the independent economists who built the models underlying the SCC,[24] all agree that a discount rate based on the rate of return on private investment (such as the 7% rate) is not sound or defensible.** And the Interagency Working Group reasonably refused to include it in its estimates of future climate damages.

Want to know more about the Social Cost of Carbon?

Manipulating the Social Cost of Carbon is a key strategy used to downplay the impacts of climate change. Policymakers should avoid such manipulations and use accurate, scientifically justified estimates of climate impacts to shape their decisionmaking. The Interagency Working Group's 2016 estimates for the SCC remain the best available values for climate damages.

For more background and technical information on the Social Cost of Carbon and its use in federal and state policy, read our primers on the topic:

Social Costs of Greenhouse Gases – Issue Brief

The Social Cost of Greenhouse Gases and State Policy

151x

Endnotes

1 *See* Interagency Working Group, Technical Update of the Social Cost of Carbon 4 (2016), https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc_tsd_final_clean_8_26_16.pdf (the central estimate for year 2020 emissions, adjusted for inflation using the CPI calculator, is $51 per ton of carbon in current 2018$).

2 The current central estimate of the social cost of methane for year 2020 emissions is around $1470 per ton in 2018$. *See* IWG, Addendum: Application of the Methodology to Estimate the Social Cost of Methane and the Social Cost of Nitrous Oxide 7 (2016), https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/august_2016_sc_ch4_sc_n2o_addendum_final_8_26_16.pdf (the central estimate for year 2020 emissions, adjusted for inflation using the CPI calculator, is $1470 per ton of methane in current 2018$).

3 Iliana Paul, Peter Howard & Jason A. Schwartz, The Social Cost of Greenhouse Gases and State Policy: A Frequently Asked Questions Guide 3, *available at* http://policyintegrity.org/files/publications/SCC_State_Guidance.pdf [hereinafter "Social Cost of GHG FAQ"].

4 *See* EPA Factsheet, Social Cost of Carbon (2016), https://perma.cc/K42M-UTHN. *See also* Peter Howard, Omitted Damages: What's Missing from the Social Cost of Carbon (2014), *available at* http://policyintegrity.org/files/publications/Omitted_Damages_Whats_Missing_From_the_Social_Cost_of_Carbon.pdf.

5 *See* Richard L. Revesz, Michael Greenstone et al., *Best Cost Estimate of Greenhouse Gases*, 357 Science 655 (2017); Richard L. Revesz et al., *Global Warming: Improve Economic Models of Climate Change*, 508 Nature 173 (2014) (co-authored with Nobel Laureate Kenneth Arrow, among others).

6 *See generally* Institute for Policy Integrity, Social Costs of Greenhouse Gases (2017), *available at* http://policyintegrity.org/files/publications/Social_Cost_of_Greenhouse_Gases_Factsheet.pdf.

7 Exec. Order. No. 13,783 § 5(b), 82 Fed. Reg. 16,093 (Mar. 31, 2017).

8 An SCC estimate of $1 per ton is the lower of two estimates provided by the Environmental Protection Agency in its proposed repeal of the Clean Power Plan, for year 2020 emissions. *See* EPA, Regulatory Impact Analysis for the Review of the Clean Power Plan: Proposal 44 (2017), *available at* https://www.epa.gov/sites/production/files/2017-10/documents/ria_proposed-cpp-repeal_2017-10.pdf.

9 *See* Bureau of Land Mgmt., Regulatory Impact Analysis for the Proposed Rule to Suspend or Delay Certain Requirements of the 2016 Waste Prevention Rule 26 (2017), *available at* https://www.regulations.gov/document?D=BLM-2017-0002-0002 (estimating the social cost of methane in 2020 at as little as $58 per ton in 2018$, down from $1470); and EPA, Memorandum on Estimated Cost Savings and Forgone Benefits Associated with the Proposed Rule, "Oil and Natural Gas: Emission Standards for New, Reconstructed, and Modified Sources: Stay of Certain Requirement" 9 (Oct. 17, 2017), *available at* https://www.epa.gov/sites/production/files/2017-11/documents/oilgas_memo_proposed-stay_2017-10.pdf (similar social cost of methane estimates).

10 *See* Peter Howard & Derek Sylvan, Expert Consensus on the Economics of Climate Change (2015), *available at* http://policyintegrity.org/files/publications/ExpertConsensusReport.pdf.

11 *E.g.*, Ctr. for Biological Diversity v. Nat'l Highway Traffic Safety Admin., 538 F.3d 1172, 1202 (9th Cir. 2008); Mont. Envtl. Info. Ctr. v. Office of Surface Mining, 274 F. Supp. 3d 1074, 1094–98 (D. Mont. 2017) (holding it was arbitrary for the agency to quantify benefits of a mining permit while failing to use the Social Cost of Carbon to quantify costs). Note that, despite these legal requirements, more often than not, the Trump administration has refused to use the Social Cost of Greenhouse Gas metrics in its environmental impact analyses.

12 *See generally* Peter Howard & Jason Schwartz, *Think Global: International Reciprocity as Justification for a Global Social Cost of Carbon*, 42 Columbia J. Envtl. L. 203 (2017).

13 Zero Zone v. Dept. of Energy, 832 F.3d 654, 679 (7th Cir. 2016) (finding that the agency "acted reasonably" in using global estimates of the Social Cost of Carbon).

14 National Academies of Sciences, Engineering and Medicine, Valuing Climate Damages: Updating Estimates of the Social Cost of Carbon Dioxide 9 (2017).

15 Interagency Working Group on Social Cost of Carbon, Response to Comments: Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12,866 at 36 (2015), *available at* https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc-response-to-comments-final-july-2015.pdf [hereinafter "IWG Response to Comments"].

16 William Nordhaus, the developer of the DICE model, cautioned that "regional damage estimates are both incomplete and poorly understood." William D. Nordhaus, *Revisiting the Social Cost of Carbon*, 114 PNAS 1518, 1522 (2017).

152X

[17] *See* IWG Response to Comments, *supra* note 15, at 36. As the Interagency Working Group's central estimate, a 3-percent discount rate was consistently used by federal government agencies between 2010 and 2016. State governments also use the 3-percent discount rate, with some using even lower discount rates. *See* Social Cost of GHG FAQ, *supra* note 3, at 9–12 for examples.

[18] Social Cost of GHG FAQ, *supra* note 3, at 19.

[19] *See* citations accompanying notes 8-9, *supra*.

[20] *See* Office of Management & Budget, *Circular A-4* at 33–34, 35–36 (Sept. 17, 2003), *available at* https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/circulars/A4/a-4.pdf.

[21] *See* National Academies of Sciences, *supra* note 14, at 19 and 180-181.

[22] *See* IWG Response to Comments, *supra* note 15, at 36 ("[T]he use of 7 percent is not considered appropriate for intergenerational discounting. There is wide support for this view in the academic literature . . . .").

[23] *See* Revesz & Greenstone et al., *supra* note 5; Council of Econ. Advisers, Discounting for Public Policy: Theory and Recent Evidence on the Merits of Updating the Discount Rate 1–3 (CEA Issue Brief, 2017), *available at* https://obamawhitehouse.archives.gov/sites/default/files/page/files/201701_cea_discounting_issue_brief.pdf; Howard & Sylvan, *supra* note 10, at 20–21; Kenneth J. Arrow et al., *Is There a Role for Benefit-Cost Analysis in Environmental, Health, and Safety Regulation?*, 272 Science 221 (1996) (explaining that a consumption-based discount rate is appropriate in intergenerational contexts, such as climate change); Richard G. Newell, *Unpacking the Administration's Revised Social Cost of Carbon*, Resources for the Future Blog (Oct. 10, 2017), *available at* http://www.rff.org/blog/2017/unpacking-administration-s-revised-social-cost-carbon (explaining that a consumption-based discount rate is appropriate for climate change).

[24] The three integrated assessment models used by the Interagency Working Group—DICE, FUND, and PAGE—all use consumption discount rates; a capital discount rate (like 7%) is thus inconsistent with the underlying models.

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153x

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Testimony of Peter Howard, Ph.D., Economics Director, and Denise Grab, Western Regional Director, Institute for Policy Integrity, New York University School of Law[1]

Before the New Jersey Legislature
Senate Environment and Energy Committee
Assembly Environment and Solid Waste Committee

April 25, 2019

Thank you for inviting us to testify before these Joint Committees. Peter Howard, Ph.D., is the Economics Director at the Institute for Policy Integrity whose fields of expertise includes climate economics. He received his Ph.D. in Agricultural and Resource Economics from University of California–Davis. He has published in academic journals on the social cost of greenhouse gases, including in *Science*, *Nature*, *Environmental and Resource Economics*, *Harvard Environmental Law Review*, and the *Columbia Journal of Environmental Law*. His work has been cited by many prominent organizations, including the 2016 Interagency Working Group on the Social Cost of Greenhouse Gases and the National Academy of Sciences' Committee on the Social Cost of Carbon. Denise Grab is the Western Regional Director at the Institute for Policy Integrity, where she has written academic articles and reports and has advised regulators in multiple states on the use of the social cost of greenhouse gases in policy. She received a J.D. from Yale Law School and a Master of Environmental Management degree from the Yale School of Forestry and Environmental Studies.

The Institute for Policy Integrity at New York University School of Law ("Policy Integrity") is a nonpartisan think tank dedicated to improving the quality of government decisionmaking through advocacy and scholarship in the fields of administrative law, economics, and public policy. Policy Integrity has particular expertise in the application of the social cost of greenhouse gases to state and federal decisionmaking, having written dozens of academic articles and reports and commented in hundreds of regulatory proceedings on the topic.

We applaud the New Jersey legislature's recognition of the importance of considering the costs of greenhouse gas emissions, both by holding this hearing and enacting legislation like

[1] No part of this document purports to present New York University School of Law's views, if any.

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154✓

Senate Bill 2313 in the 2018 legislative session.[2] We encourage the legislature to extend application of the social cost of greenhouse gases into other types of proceedings.

This testimony will address: (1) why consideration of the social cost of greenhouse gases in state decisionmaking is important; (2) different ways in which states can and have applied a social cost of greenhouse gases; and (3) approaches to calculating the social cost of greenhouse gases.

I. Importance of Considering the Social Cost of Greenhouse Gases in State Policy

Climate change is already causing quantifiable and monetizable damages, such as increased extreme storm activity and coastal destruction. In both the near future and over the long term, unabated climate change will cause significant impacts to both market and nonmarket sectors, including agriculture, forestry, water, energy use, sea-level rise, human health, and ecosystem services.

New Jersey is also already experiencing these damages. Average annual temperature has already risen 2.2°C in New Jersey since 1900, along with the frequency and intensity of heavy rainfall, and these increases will continue at a higher rate than other U.S. regions. Because of rising sea levels and more extreme precipitation events, New Jersey will also experience damages from loss of wetlands, beach erosion, saltwater intrusion, flooding risk, and coastal home and infrastructure destruction. New Jersey will also experience a myriad of other impacts, including impacts to health from higher temperatures driving heat-related deaths, increased ozone formation, and expanded seasons and geographic extents of vector borne diseases; and ocean acidification and higher ocean temperatures negatively impacting fisheries.[3]

The social cost of greenhouse gas metrics—such as the Social Cost of Carbon and Social Cost of Methane—translate into dollars the amount of damage that will be caused by each ton of emissions of that pollutant.[4] Monetizing the impacts of emissions changes can help agencies and the public compare these emissions costs against other costs and benefits. Without such values, decisionmakers and the public are faced with imperfect information. When impacts are translated into the common metric of money, decisionmakers can more easily compare society's preferences for competing priorities, and the public can more readily understand the consequences of a regulatory choice.

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[2] *See* N.J. STAT. ANN. § 48:3-87.3 (b)(8) (determining that the "social cost of carbon, as calculated by the U.S. Interagency Working Group on the Social Cost of Carbon in its August 2016 Technical Update, is an accepted measure of the cost of carbon emissions").

[3] *See* U.S. GLOBAL CLIMATE RESEARCH PROGRAM, CLIMATE SCIENCE SPECIAL REPORT 10, 195, 218, 352 (2017), *available at* https://science2017.globalchange.gov/downloads/CSSR2017_FullReport.pdf; U.S. EPA, WHAT CLIMATE CHANGE MEANS FOR NEW JERSEY (2016), https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-nj.pdf; N.J. Dep't of Envtl. Prot., NEW JERSEY CLIMATE DATA, https://www.nj.gov/dep/climatechange/data.html (last visited Apr. 24, 2019).

[4] Each ton of methane and nitrous oxide warms the climate substantially more than each ton of carbon dioxide. In addition, the pollutants persist in the atmosphere for different lengths of time, resulting in different social cost metrics for each.

If an analysis discusses the externalities of emissions only qualitatively, decisionmakers and the public will both tend to minimize the significance of the effects. In general, non-monetized effects are often irrationally treated as worthless.[5] This may be especially true when some effects (like compliance costs and fuel savings) are monetized, while other effects (like climate and health benefits) are discussed only quantitatively or qualitatively.

It also may be especially difficult for the public and decisionmakers to give appropriate consideration to climate effects that are only presented through estimates of emissions volumes.[6] After all, New Jersey's 101 million metric tons of greenhouse gases (measured in carbon dioxide equivalent) emitted per year[7] may seem like a small fraction of global emissions,[8] and reducing that figure down to, for example, 99 million metric tons per year may seem like an insignificant difference. Specifically, while decisionmakers and the public certainly can tell that 99 million metric tons per year of carbon dioxide is less than 101 million metric tons, without any context it may be difficult to weigh the climate consequences of that 2-million-ton reduction.[9] Yet the monetized expected benefits of avoiding the climate damages from those 2 million metric tons of carbon dioxide—about $100 million per year[10]—is less easily overlooked. Monetization makes clear the significance of the emissions reduction.

Such context would be helpful to New Jersey agencies in analyzing their regulatory choices as well as in explaining the climate benefits of the decision to New Jersey citizens. New Jersey should monetize environmental and health benefits, as it is useful to decisionmakers and the public.

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[5] Richard L. Revesz, *Quantifying Regulatory Benefits*, 102 CAL. L. REV. 1424, 1434-35, 1442 (2014).

[6] As the U.S. Environmental Protection Agency's website explains, "abstract measurements" of so many tons of greenhouse gases can be rather inscrutable for the public, unless "translat[ed] . . . into concrete terms you can understand." EPA, GREENHOUSE GAS EQUIVALENCIES CALCULATOR, https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator (last updated Sept. 2017).

[7] N.J. Dep't of Envtl. Prot., NEW JERSEY CLIMATE DATA, https://www.nj.gov/dep/climatechange/data.html (last visited Apr. 24, 2019).

[8] Ctr. for Climate Change & Energy Solutions, GLOBAL EMISSIONS, https://www.c2es.org/content/ international-emissions/ (last visited Jan. 31, 2018) (estimating global carbon dioxide emissions as approaching 35 billion metric tons per year by 2020).

[9] *See* Cass R. Sunstein, *Probability Neglect: Emotions, Worst Cases, and Law*, 112 YALE L.J. 61, 63, 72 (2002); Daniel Kahneman et al., *Economic Preferences or Attitude Expressions? An Analysis of Dollar Responses to Public Issues*, 19 J. RISK & UNCERTAINTY 203, 212-213 (1999) (describing mental heuristics called "probability neglect" and "scope neglect" that can cause people to underestimate climate risks).

[10] The Interagency Working Group's central estimate of the social cost of carbon for year 2020 emissions is $42 in 2007$. INTERAGENCY WORKING GRP. ON SOCIAL COST OF GREENHOUSE GASES, TECHNICAL SUPPORT DOCUMENT: TECHNICAL UPDATE OF THE SOCIAL COST OF CARBON FOR REGULATORY IMPACT ANALYSIS UNDER EXECUTIVE ORDER 12,866, at 4 (2016), *available at* https://www.obamawhitehouse.gov/sites/default/files/omb/inforeg/scc_tsd_final_clean_8_26_16.pdf [hereinafter IWG 2016]. Using the CPI Inflation Calculator, that equals about $50 in 2017$. A reduction of 2 million metric tons per year multiplied by $50/ton equals $100 million (undiscounted). As the social cost of carbon increases over time, the benefit of an annual reduction of 2 million tons per will increase, as well.

II. How States Can Incorporate a Social Cost of Greenhouse Gases into Decisionmaking

States can use a social cost of greenhouse gases in a wide variety of energy and environmental decisionmaking. Our report, *The Social Cost of Greenhouse Gases and State Policy: A Frequently Asked Questions Guide*, is attached as an exhibit to this testimony, and provides additional detail on how states can use the social cost of greenhouse gases in policymaking.[11] Our *Cost of Carbon Pollution* website, https://costofcarbon.org, includes an updated list of ways in which state agencies are currently using the social cost of greenhouse gases. We summarize our analysis and highlight particular examples here.

- Rulemakings that address greenhouse gas emissions directly

States can use the social cost of greenhouse gases to value the benefits and costs of proposed regulatory actions that would change the quantity of greenhouse gas emissions. Such analysis can be used in formal cost-benefit analyses or informally to evaluate options throughout the regulatory process.[12] The social cost of greenhouse gases can be used to set the stringency of a greenhouse-gas reduction target or to evaluate different proposed regulatory alternatives to determine which is most beneficial to the public.

New Jersey's agencies could use the social costs of greenhouse gases in many types of proceedings. For example, agencies could use the Social Cost of Carbon to set the stringency of an emissions reduction target for the electricity, transportation, industrial, or agricultural sector. Agencies could use the Social Cost of Methane to assess the impacts of a regulation to require the recapture of fugitive methane emissions at landfills.

Other leading state agencies have already begun applying the social cost of greenhouse gas emissions in rulemakings. For example, the California Air Resources Board applies the Social Cost of Carbon in its 2030 Climate Scoping Plan to evaluate the proposed alternative reduction approaches.[13] CalRecycle (a state agency) has used the Social Cost of Methane values to assess its regulation to reduce of methane emissions from landfills,[14] and the California Air Resources Board and the California Public Utilities Commission have discussed the potential for using the Social Cost of Methane in rulemakings involving

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[11] ILIANA PAUL, ET AL., THE SOCIAL COST OF GREENHOUSE GASES AND STATE POLICY: A FREQUENTLY ASKED QUESTIONS GUIDE (2017), available at https://policyintegrity.org/files/publications/SCC_State_Guidance.pdf. For New Jersey-specific analysis, see Zach Froio et al., *At What Co$t?: Incorporating the Social Cost of Carbon into State-Level Policies in New Jersey* (2018).

[12] Note that cost-benefit analysis is most useful when applied consistently across different policies. To the extent that resource capacity limits agencies' ability to do so, *see id.* at 17, 34–36, New Jersey might consider expanding that capacity.

[13] *See* CALIFORNIA AIR RESOURCES BOARD, CALIFORNIA'S 2017 CLIMATE CHANGE SCOPING PLAN 39–46 (2017), *available at* https://www.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf. Note that AB 197 instructs the agency to "consider the social costs of the emissions of greenhouse gases" when developing rules, regulations, and plans to achieve greenhouse gas emissions reductions.

[14] CALRECYCLE, PROPOSED REGULATION FOR SHORT-LIVED CLIMATE POLLUTANTS: ORGANIC WASTE METHANE EMISSIONS, STANDARDIZED REGULATORY IMPACT ASSESSMENT 37-38 (2019), *available at* https://www.calrecycle.ca.gov/docs/cr/laws/rulemaking/slcp/impactassessment.pdf.

emissions standards for crude oil and natural gas facilities and methane leakage from natural gas pipeline facilities.[15]

- Electricity ratemaking and regulation

State electricity regulators can use the social cost of greenhouse gases to account for the climate effects associated with different types of proposed generation resources. So far, ten states, including New Jersey, have begun using monetary estimates of climate damages in electricity proceedings. These state regulators have used the social cost of greenhouse gases in three main ways: utility resource planning, compensation for low- or zero-emissions resources, and cost-benefit analysis frameworks. As a state with a deregulated electricity market, the first category (utility resource planning) does not apply to New Jersey.

With respect to the second category, resource compensation programs, state utility regulators use these programs to compensate low-carbon generators for their emissions reduction benefits. These programs go by different names for different types of generation resources and in different states: for example, zero emission credit (ZEC) programs that compensate nuclear generators, and value of distributed energy resources (VDER) proceedings that compensate distributed energy resources (DERs). These programs share the common thread of paying money to electricity sources that reduce carbon dioxide pollution based on the value of the emissions they reduce.

New Jersey has begun developing a zero emission credit (ZEC) program that compensates nuclear generators for their emission reduction benefits.[16] In enacting that program, the legislature recognized that the "social cost of carbon, as calculated by the U.S. Interagency Working Group on the Social Cost of Carbon in its August 2016 Technical Update, is an accepted measure of the cost of carbon emissions."[17] Nonetheless, New Jersey designed its ZEC program "such that its costs are guaranteed to be significantly less than the social cost of carbon emissions avoided by the continued operation of selected nuclear power plants."[18] In order to fairly compensate all clean energy resources for their emissions reduction benefits, New Jersey should extend the ZEC compensation program to all non-emitting generation resources. The state could also increase the value of its credit to account for the

[15] *See* CALIFORNIA AIR RESOURCES BOARD, FINAL STATEMENT OF REASONS FOR THE REGULATION FOR GREENHOUSE GAS EMISSION STANDARDS FOR CRUDE OIL AND NATURAL GAS FACILITIES 110 (2017), *available at* https://www.arb.ca.gov/regact/2016/oilandgas2016/ogfsor.pdf; Cal. Pub. Util. Comm'n, Proposed Decision Approving Natural Gas Leak Abatement Program Consistent with Senate Bill 1371, Rulemaking No. 15-01-008 at 135 (May 17, 2017) (noting that incorporation of the social cost of methane is a "long term objective" in the proceeding), *available at* http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M186/K437/186437714.PDF.

[16] *See* N.J. STAT. ANN. §§ 48:3-87.3 to 48:3-87.7.

[17] *See* N.J. Stat. Ann. §§ 48:3-87.3 (b)(8).

[18] *See id.*

full social cost of carbon (adjusted downward by the Regional Greenhouse Gas Initiative ("RGGI") allowance price).[19]

The third type of proceeding where states have valued climate damages is in developing cost-benefit tests, which have then been used to decide which distributed energy resources to permit utilities to develop.[20] In the past, these cost-benefit analysis frameworks had focused primarily on direct expenditures by the utilities and ratepayers, without considering broader costs to the public. Recently, utilities commissions have begun adopting societal cost test frameworks that consider effects on the public, including climate damages as reflected by the Social Cost of Carbon.[21]

As a neighboring deregulated state, New York offers a good model for how New Jersey might apply the social cost of greenhouse gases in its electricity proceedings. New York has begun using the Social Cost of Carbon to value climate damages in three different proceedings: (1) benefit-cost analysis for distributed energy resources under the state's Reforming the Energy Vision proceeding;[22] (2) resource compensation paid to nuclear generators via the Zero-Emissions Credit Program;[23] and (3) resource compensation paid to distributed energy resources to reflect the environmental value they provide to the grid as part of the Valuing Distributed Energy Resources program.[24]

For more detail on how states can apply a social cost of greenhouse gases in electricity proceedings, see our report, *Opportunities for Valuing Climate Impacts in U.S. State Electricity Policy*,[25] attached as an exhibit.

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[19] The most recent RGGI auction priced an allowance at about $5 per ton of carbon dioxide, while the Social Cost of Carbon is about $50 per ton. See Reg'l Greenhouse Gas Initiative, ALLOWANCE PRICES AND VOLUMES, https://www.rggi.org/auctions/auction-results/prices-volumes (last visited Apr. 24, 2019).

[20] *See* Denise A. Grab, *Balancing on the Grid Edge: Regulating for Economic Efficiency in the Wake of* FERC v. EPSA, 40 HARV. ENVTL. L. REV. F. 32, 35–37 (2016).

[21] *See, e.g.*, Cal. Pub. Util. Comm'n, Order Instituting Rulemaking to Create a Consistent Regulatory Framework for the Guidance, Planning, and Evaluation of Integrated Distributed Energy Resources, Rulemaking 14-10-003, Proposed Decision Adopting Cost-Effectiveness Analysis Framework Policies for All Distributed Energy Resources (Mar. 25, 2019), http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M274/K960/274960797.PDF.; N.Y. Pub. Serv. Comm'n, Order Establishing the Benefit Cost Analysis Framework, Case 14-M-0101 (Jan. 21, 2016) http://documents.dps.ny.gov/public/Common/ViewDoc.aspx? DocRef Id=%7bF8C835E1-EDB5-47FF-BD78-73EB5B3B177A%7d.

[22] *Id.*

[23] N.Y. Pub. Serv. Comm'n, Order Adopting a Clean Energy Standard 134, Case 15-E-0302 (Aug. 1, 2016), http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRef Id={44C5D5B8-14C3-4F32-8399-F5487D6D8FE8}. Unlike New Jersey, New York has directly based its Zero Emissions Credit value on the Social Cost of Carbon. New York's program was recently upheld by the U.S. Court of Appeals for the Second Circuit, based in part on the fact that the credit value is tied to the Interagency Working Group's estimates of the social cost of carbon. Coalition for Competitive Elec. v. Zibelman, 906 F.3d 41, 51 (2d Cir. 2018), *cert. denied* (Apr. 15, 2019).

[24] N.Y. Pub. Serv. Comm'n, Order on Net Energy Metering Transition, Phase One of Value of Distributed Energy Resources, and Related Matters 15–16, Case 15-E-0751 (Mar. 9, 2017), http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRef Id={5B69628E-2928-44A9-B83E-65CEA7326428}.

[25] DENISE A. GRAB ET AL., OPPORTUNITIES FOR VALUING CLIMATE IMPACTS IN U.S. STATE ELECTRICITY POLICY (2019), *available at* https://policyintegrity.org/files/publications/Pricing_Climate_Impacts.pdf.

- <u>Environmental Impact Statements and Permitting</u>

Another type of proceeding in which the social cost of greenhouse gases can help improve decisionmaking is evaluating environmental impact statements in conjunction with permitting for a proposed construction project. Application of the social cost of greenhouse gases can help New Jersey's Department of Environmental Protection to better understand the full scope of the impact of the proposed project.[26] Using the social cost of greenhouse gases is especially important when the environmental impact statement monetizes some impacts, such as projected revenue from the project, but not the greenhouse gas impacts.

The project reviewers can tailor the analysis to the particular type of project involved. For instance, the analysis for an intrastate gas pipeline could use the social cost of methane to assess the impact of potential leakage, while the analysis for a new highway project could use the social cost of carbon to assess the impact of emissions from additional vehicle miles traveled. For guidance on applying the social cost of greenhouse gases in an environmental impact statement in the analogous context of federal National Environmental Policy Act review, see Policy Integrity's report *Pipeline Approvals and Greenhouse Gas Emissions*.[27]

Other states have already begun incorporating the social cost of carbon into their assessments of proposed state projects. For example, the California Department of Transportation uses the social cost of carbon in its lifecycle and benefit-cost analyses for proposed highway and transit projects.[28]

- <u>State agency procurement</u>

State entities can use the social cost of greenhouse gases to evaluate purchasing options for state procurement. In deciding, for example, whether to renovate state buildings to be more energy efficient or whether to buy more low- or zero-emission state vehicles, agencies could include the social cost of greenhouse gases in the financial analysis of which options to select.

As an example, Washington State has developed guidance on using the social cost of greenhouse gases to evaluate energy efficiency and transportation options for state procurement. With Executive Order 14-04, Governor Inslee directed the state Department of Commerce to develop "a new statewide program to significantly improve the energy performance of both our public and private buildings," which, among other measures, would "[e]nsure that the cost-benefit tests for energy-efficiency improvements include full

[26] Froio et al., *supra* note 11, at 28–30.
[27] Jayni Hein, Jason Schwartz, & Avi Zevin, *Pipeline Approvals and Greenhouse Gas Emissions* (2019), *available at* https://policyintegrity.org/files/publications/Pipeline_Approvals_and_GHG_Emissions.pdf; *see also, e.g.*, Inst. for Policy Integrity, Comments on Arctic Coastal Plain Draft EIS to U.S. Bureau of Land Management (Mar. 13, 2019) (describing how the social cost of carbon should be used in an environmental impact statement for a proposed oil and gas leasing plan), *available at* https://policyintegrity.org/documents/Arctic_Coastal_Plain_DEIS_Comments_2019.3.13-final.pdf.
[28] *See* Cal. Dep't of Transp., CALIFORNIA LIFE-CYCLE BENEFIT/COST ANALYSIS MODEL VOL. 4 at II-64 (2017), http://www.dot.ca.gov/hq/tpp/offices/eab/benefit_files/Cal-BCTechSupplementVol4v3.pdf; Cal. Senate Office of Research, *Social Cost of Carbon: Federal and California Activity*, POLICY MATTERS 6 (2018), https://sor.senate.ca.gov/sites/sor.senate.ca.gov/files/Policy%20Matters%20SCC%20Final.pdf.

160x

accounting for the external costs of greenhouse gas emissions."[29] The order also instructed "[t]he Department of Commerce, in collaboration with the Departments of Enterprise Services and Ecology" to "evaluate incentives and life-cycle costs for the purchase of electric vehicles and other clean-fuel cars" and to "move forward with state procurement of these vehicles where the life-cycle costs and benefits are comparable, including consideration of the benefits of emission reductions."[30] The state Department of Commerce developed guidance to implement the governor's executive order, "recommend[ing] that all Washington State agencies use the most recent estimates produced by the federal interagency working group for the SCC," specifically the estimates using the 2.5% discount rate.[31]

- Setting carbon emissions caps or taxes

Environmental regulators or the legislature could also use the social cost of greenhouse gases to set a carbon emission cap or tax. New Jersey plans to rejoin the Regional Greenhouse Gas Initiative ("RGGI"), which will add an allowance price to electricity transactions in the state of about $5 per ton of carbon dioxide (in the most recent auction),[32] which is substantially lower than the Social Cost of Carbon (currently about $50). Optimally, the price of a carbon allowance or tax should be as high as the social cost of greenhouse gases, in order to make sure that the harms from emissions are fully internalized in the market. Therefore, a state-level effort to price carbon for electricity transactions should take into account the Social Cost of Carbon minus the RGGI price of carbon. No such modification would be necessary for putting a price on emissions from small generators, transportation, or other sectors that are not covered by RGGI.

III. Approaches for Calculating the Social Cost of Greenhouse Gases

Economists can estimate and monetize climate damages by linking together global climate models with global economic models, producing what are called integrated assessment models. These integrated assessment models can take a single additional unit of greenhouse gas emissions (whether emitted from driving a car or burning coal at a power plant) and calculate the change in atmospheric greenhouse concentrations, translate that change in concentration into a change in temperature, and model how that temperature change and associated weather changes will cause economic damages to agriculture, forestry, fisheries, energy, buildings and infrastructure, water, ecosystems, and human health. The resulting monetary estimate of how each additional unit of greenhouse gases will impact our health,

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[29] Exec. Order 14-04, Washington Carbon Pollution Reduction and Clean Energy Action 6 (Apr. 29, 2014), *available at* https://www.governor.wa.gov/sites/default/files/exe_order/eo_14-04.pdf.
[30] *Id.* at 7. *See also* WASH. ADMIN. CODE §§ 194-29-020 & 194-29-070 (requiring consideration of "the social cost of carbon emissions" in a lifecycle cost analysis to determine the extent to which a local government must meet its goal under REV. CODE WASH. § 43.19.648 of transitioning 100% of its vehicle fleet to electric or biofuel vehicles).
[31] Wash. Dep't of Commerce, THE SOCIAL COST OF CARBON 2–3 (2014), http://www.commerce.wa.gov/wp-content/uploads/2015/11/Energy-EV-Planning-Social-Cost-of-Carbon-Sept-2014.pdf.
[32] Reg'l Greenhouse Gas Initiative, ALLOWANCE PRICES AND VOLUMES, https://www.rggi.org/auctions/auction-results/prices-volumes (last visited Apr. 24, 2019).

our economic activity, our quality of life, and our overall well-being is called the social cost of greenhouse gases.

In 2009, a federal Interagency Working Group (IWG) was convened to develop consistent estimates of the social cost of greenhouse gases for agencies to use in their analyses, based on "a defensible set of input assumptions that are grounded in the existing scientific and economic literature."[33] Using the three leading IAMs—DICE, FUND, and PAGE—combined with other reasonable assumptions and the best available data transparently drawn from the peer-reviewed literature, the IWG began first estimating the social cost of carbon dioxide.[34] By 2016, the IWG added separate estimates for the social cost of methane and the social cost of nitrous oxide as well, since different greenhouse gases have different climate impacts based on their individual capacity to absorb the sun's energy and their lifespans in the earth's atmosphere.[35]

For each greenhouse gas, the IWG issued a central estimate of social costs per metric ton of emissions per year based on a 3% discount rate, as well as additional estimates that explore the calculation's sensitivity to a lower (2.5%) or higher (5%) discount rate.[36] Discount rates determine how future costs and benefits are weighed compared to present-day costs and benefits. Because of the long lifespan of greenhouse gases and the long-term or irreversible consequences of climate change, the effects of today's greenhouse emissions will stretch out over the next several centuries. Recognizing the importance of selecting a discount rate that reflected the economic consensus and was grounded in the literature, the IWG chose a 3% rate (based on the average rate of return on Treasury notes) to drive its central estimate of the social cost of greenhouse gas. The IWG specifically rejected any discount rate higher than 5% as "not considered appropriate,"[37] and three recent, independent surveys indicate a strong consensus among economists and climate experts for using a discount rate below 3% for climate analyses, with little to no support for a rate above 5%.[38]

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[33] INTERAGENCY WORKING GRP. ON SOCIAL COST OF GREENHOUSE GASES, TECHNICAL SUPPORT DOCUMENT: TECHNICAL SUPPORT DOCUMENT: SOCIAL COST OF CARBON FOR REGULATORY IMPACT ANALYSIS UNDER EXECUTIVE ORDER 12,866 (2010), *available at* https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/foragencies/Social-Cost-of-Carbon-for-RIA.pdf [hereinafter IWG 2010].

[34] *See id.*

[35] INTERAGENCY WORKING GRP. ON SOCIAL COST OF GREENHOUSE GASES, APPLICATION OF THE METHODOLOGY TO ESTIMATE THE SOCIAL COST OF METHANE AND THE SOCIAL COST OF NITROUS OXIDE (2016), *available at* https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/august_2016_sc_ch4_sc_n2o_addendum_final_8_26_16.pdf.

[36] *See generally* IWG 2010, *supra* note 33. A fourth estimate, based on the 95th percentile value of the distribution of estimates at a 3% discount rate, is also included, as a proxy for omitted catastrophic damages, risk aversion, and other uncertainties.

[37] INTERAGENCY WORKING GRP. ON SOCIAL COST OF GREENHOUSE GASES, RESPONSE TO COMMENTS 36 (2015), *available at* https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc-response-to-comments-final-july-2015.pdf.

[38] Moritz Drupp et al., *Discounting Disentangled: An Expert Survey on the Determinants of the Long-Term Social Discount Rate* (Ctr. for Climate Change Econ & Pol'y, Working Paper No. 195, 2015); PETER HOWARD & DEREK SYLVAN, EXPERT CONSENSUS ON THE ECONOMICS OF CLIMATE CHANGE (2015), available at https://policyintegrity.org/files/publications/ExpertConsensusReport.pdf; Council of Econ. Advisers, DISCOUNTING FOR PUBLIC POLICY: THEORY AND RECENT EVIDENCE ON THE MERITS OF UPDATING THE DISCOUNT RATE

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Importantly, even the central estimate omits key categories of climate damages—like the risk of catastrophic, irreversible consequences—and so should be treated as a conservative underestimate of total climate damages from combustion. For more details on what impacts are included and excluded from the IWG estimates, see Policy Integrity's issue brief *A Lower Bound: Why the Social Cost of Carbon Does Not Capture Critical Climate Damages and What That Means for Policymakers*[39] and report *Omitted Damages: What's Missing from the Social Cost of Carbon*.[40]

The Interagency Working Group on the Social Cost of Greenhouse Gases included, along with its range of three estimates across different discount rates, a fourth estimate. That fourth and highest estimate, calculated as the 95th percentile of the distribution of damages estimates at a 3% discount rate, was intended to serve as an imperfect proxy for, among other things, omitted catastrophic damages.[41] In any given year, this high 95th percentile estimate is about three times the central estimate of the social cost of greenhouse gases.[42] Like the other estimates, this estimate increases over time because each additional ton of emissions will become much more damaging as GHG emissions accumulate in the atmosphere.

The IWG's estimates have been repeatedly endorsed by reviewers. In 2014, the U.S. Government Accountability Office reviewed the IWG's methodology and concluded that it had followed a "consensus-based" approach, relied on peer-reviewed academic literature, disclosed relevant limitations, and adequately planned to incorporate new information via public comments and updated research.[43] In 2016, the U.S. Court of Appeals for the Seventh Circuit held that it was reasonable for agencies to use the IWG's estimates.[44] In 2016 and 2017, the National Academies of Sciences issued two reports that, while recommending future improvements to the methodology, supported the continued use of the existing IWG

(2017), https://obamawhitehouse.archives.gov/sites/default/files/page/files/201701_cea_discounting_issue_brief.pdf.

[39] Inst. for Policy Integrity, A LOWER BOUND: WHY THE SOCIAL COST OF CARBON DOES NOT CAPTURE CRITICAL CLIMATE DAMAGES AND WHAT THAT MEANS FOR POLICYMAKERS (2019), https://policyintegrity.org/files/publications/Lower_Bound_Issue_Brief.pdf.

[40] PETER HOWARD, OMITTED DAMAGES: WHAT'S MISSING FROM THE SOCIAL COST OF CARBON (2014), *available at* https://costofcarbon.org/files/Omitted_Damages_Whats_Missing_From_the_Social_Cost_of_Carbon.pdf.

[41] IWG 2010 TSD, *supra* note 33.

[42] IWG 2016, *supra* note 10. For example, for year 2020 emissions, the central estimate of the social cost of carbon (in 2007$) is $42, while the 95th percentile estimate is $123. Similarly, for year 2020 emissions, the central estimate of the social cost of methane (in 2007$) is $1200, while the 95th percentile estimate is $3200. For nitrous oxide, the social cost for year 2020 emissions increases from $15,000 at the central estimate to $39,000 at the 95th percentile value.

[43] GOV'T ACCOUNTABILITY OFFICE, REGULATORY IMPACT ANALYSIS: DEVELOPMENT OF SOCIAL COST OF CARBON ESTIMATES 12–19 (2014), *available at* https://www.gao.gov/assets/670/665016.pdf.

[44] Zero Zone, Inc. v. Dep't of Energy, 832 F.3d 654, 679 (7th Cir. 2016).

estimates.[45] It is, therefore, unsurprising that scores of economists and climate policy experts have endorsed the IWG's values as the best available estimates.[46]

In March 2017, President Trump's Executive Order 13,783 disbanded the IWG.[47] Since then, in an attempt to justify the repeals of beneficial rules, some federal agencies have relied on faulty economic theory to propose "interim" estimates of the social cost of greenhouse gases that drop the social cost of carbon from $50 per ton in year 2020 down to as little as $1 per ton, and drop the social cost of methane from $1420 per ton in year 2020 down to $58.[48] These "interim" estimates from the Trump administration rely on two manipulations of the social cost of greenhouse gases: a spurious "domestic-only" calculation and an inappropriately high 7% discount rate, which experts agree are inconsistent with accepted science and economics.[49]

For more detail on why the Trump administration's "interim" estimates are based on faulty science and economics, and should not be used by New Jersey, see Policy Integrity's Issue Brief, *How the Trump Administration is Obscuring the Costs of Climate Change*.[50]

Recognizing that the IWG's 2016 estimates remain the best available estimates of the social cost of carbon, a growing list of states have continued to adopt these estimates, even after the IWG was disbanded. The states that have continued to incorporate the IWG's estimates or methodologies into their own decisionmaking include California, Colorado, Illinois, Maine, Maryland, Minnesota, Nevada, New York, and Washington state.[51]

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[45] NAT'L ACAD. SCI., ENG. & MEDICINE, VALUING CLIMATE DAMAGES: UPDATING ESTIMATES OF THE SOCIAL COST OF CARBON DIOXIDE 3 (2017); NAT'L ACAD. SCI., ENG. & MEDICINE, ASSESSMENT OF APPROACHES TO UPDATING THE SOCIAL COST OF CARBON: PHASE 1 REPORT ON A NEAR-TERM UPDATE 1 (2016).

[46] *See, e.g.*, Richard Revesz et al., *Best Cost Estimate of Greenhouse Gases*, 357 SCIENCE 655 (2017); Michael Greenstone et al., *Developing a Social Cost of Carbon for U.S. Regulatory Analysis: A Methodology and Interpretation*, 7 REV. ENVTL. ECON. & POL'Y 23, 42 (2013); Richard L. Revesz et al., *Global Warming: Improve Economic Models of Climate Change*, 508 NATURE 173 (2014) (co-authored with Nobel Laureate Kenneth Arrow, among others); Richard G. Newell et al., *Carbon Market Lessons and Global Policy Outlook*, 343 SCIENCE 1316 (2014); Bonnie L. Keeler et al., *The Social Costs of Nitrogen*, 2 SCIENCE ADVANCES e1600219 (2016).

[47] Exec. Order. No. 13,783 § 5(b), 82 Fed. Reg. 16,093 (Mar. 28, 2017). The Order instructed agencies to use the "best" estimates of the social cost of greenhouse gases. In fact, the IWG estimates remain the best estimates available.

[48] BUREAU OF LAND MGMT., REGULATORY IMPACT ANALYSIS FOR THE PROPOSED RULE TO RESCIND OR REVISE CERTAIN REQUIREMENTS OF THE 2016 WASTE PREVENTION RULE 71 (2018). Meanwhile, some other agencies continued to use the IWG's 2016 estimates after the Executive Order was issued. In fact, as recently as August 2017, BLM's sister agency in the Department of the Interior (the Bureau of Ocean Energy Management) continued to use the IWG's 2016 numbers.

[49] *See* NAT'L ACAD. OF SCI., VALUING CLIMATE DAMAGES: UPDATING ESTIMATION OF THE SOCIAL COST OF CARBON DIOXIDE (2017); Richard G. Newell, UNPACKING THE ADMINISTRATION'S REVISED SOCIAL COST OF CARBON (Oct. 10, 2017), http://www.rff.org/blog/2017/unpacking-administration-s-revised-social-cost-carbon; Inst. for Policy Integrity, HOW THE TRUMP ADMINISTRATION IS OBSCURING THE COSTS OF CLIMATE CHANGE (2018), http://policyintegrity.org/files/publications/Obscuring_Costs_of_Climage_Change_Issue_Brief.pdf.

[50] Inst. for Policy Integrity, HOW THE TRUMP ADMINISTRATION IS OBSCURING THE COSTS OF CLIMATE CHANGE (2018), http://policyintegrity.org/files/publications/Obscuring_Costs_of_Climage_Change_Issue_Brief.pdf.

[51] DENISE GRAB ET AL., OPPORTUNITIES FOR PRICING CLIMATE IMPACTS IN U.S. STATE ELECTRICITY POLICY 19–20 (2019), *available at* https://policyintegrity.org/files/publications/Pricing_Climate_Impacts.pdf.

While the IWG recommends considering all four social cost of carbon estimates to capture uncertainty, several states selected *one* preferred estimate. Most have applied the central discount rate of 3%. Meanwhile, Washington State's Department of Ecology selected a 2.5% rate to align with the Office of Financial Management's real discount rate, reflect anticipated future increases in the best available estimates, incorporate intergenerational discount rates, reduce the risk of underestimating the social cost of carbon, and take leadership on climate issues.[52] California's Public Utilities Commission has proposed to use both the average value and the 95th percentile estimate for a 3% discount rate to account for omitted impacts like catastrophic damages and wildfires.[53] Best economic practices give some leeway to policymakers to select within or below the range of discount rates included in the IWG analysis.

As discussed, the IWG's 2016 estimates for the social cost of greenhouse gases are currently the best available estimates. At least 10 states have applied these values, and it would be appropriate for New Jersey to do so, as well. One particularly notable reason to apply the IWG's estimates at the present time is that the state would be able to draw on the tremendous analytical efforts of that group, including the involvement of twelve federal agencies and review by the National Academy of Sciences (including fourteen academics at the top of their fields).

Note, however, that the social cost of greenhouse gases is an active area of research. Based in part on recommendations from the National Academy of Sciences, there are three ongoing efforts to develop the next generation of integrated assessment models: (1) Resources for the Future, (2) David Anthoff's decentralized FUND model, and (3) the Climate Impact Lab. These groups may issue updated estimates of the social cost of greenhouse gases in the coming years. As the science and economics evolves, New Jersey's agencies should seek input from academic experts in deciding how to update the state's application of the social cost of greenhouse gases. New Jersey's universities have a wealth of academic expertise on the topic.[54]

The continuing research to update the estimates should not stop New Jersey from applying the social cost of greenhouse gases now. New Jersey should adopt estimates that are consistent with the best available science and economics: at present, the 2016 IWG

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[52] Wash. Dep't of Ecology, PRELIMINARY COST-BENEFIT AND LEAST-BURDENSOME ALTERNATIVE ANALYSIS: CHAPTER 173-442 WAC CLEAN AIR RULE & CHAPTER 173-441 WAC REPORTING OF EMISSIONS OF GREENHOUSE GASES 38 (2016), at 38, https://fortress.wa.gov/ecy/publications/documents/1602008.pdf.

[53] Cal. Pub. Util. Comm'n, Order Instituting Rulemaking to Create a Consistent Regulatory Framework for the Guidance, Planning, and Evaluation of Integrated Distributed Energy Resources 36–40, Rulemaking 14-10-003, Proposed Decision Adopting Cost-Effectiveness Analysis Framework Policies for All Distributed Energy Resources (Mar. 25, 2019), *available at* http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M274/K960/274960797.PDF.

[54] Notably, Rutgers University is home to one of the world's leading experts on the social cost of greenhouse gases: Dr. Robert Kopp, Professor of Earth and Planetary Sciences and Director of the Institute of Earth, Ocean, and Atmospheric Sciences at Rutgers University, is a leading member of the Climate Impact Lab team, a Scientific Advisory Board Member for Resources for the Future's social cost of carbon project, a former member of the National Academy of Sciences' committee assessing the social cost of carbon; and a former member of the 2010 Interagency Working Group on the Social Cost of Carbon.

estimates. When updated estimates are released in the future, New Jersey's agencies should draw on the knowledge of academic experts to review and assess the new estimates before adoption.

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We thank you again for inviting us to testify today, and we would be happy to answer any questions you may have.

166x

Atlantic City Electric Testimony to the New Jersey Assembly Environment and the Senate Environment and Energy Committees

April 25, 2019

Chairwoman Pinkin, Chairman Smith and members of the Assembly and Senate Environment Committees. I am Robert Revelle, New Jersey Government Affairs Director for Atlantic City Electric Company, an Exelon Company. Thank you for the opportunity to submit testimony for the record. As a member of the Exelon family of utilities, ACE provides for the transmission and distribution of electric energy to approximately 556,000 residential, commercial, and industrial customers in the eight southernmost counties in New Jersey. The ACE service area spreads over approximately 2,700 square miles and includes both rural and shore communities, Atlantic City and its casinos and diverse areas in between.

Exelon and ACE are committed to "powering a cleaner and brighter future for our customers and communities." This statement truly serves as the foundation for ACE's testimony. It is a dynamic time in the energy industry, and New Jersey is at the forefront. A transformation toward a clean energy future is underway and New Jersey is leading this effort. This Committee and the legislature have rightly recognized the important need to take bold action to combat climate change and ensure the state is making investments today to meet the advancing climate challenge. With the enactment of A-3723 in 2018 and the commitment to rejoin the Regional Greenhouse Gas Initiative, New Jersey established itself as a leader in driving the clean energy economy, both across the region and throughout the country. ACE is committed to making the necessary investments to enable this future and deliver on its promise to provide safe, reliable, affordable and sustainable energy to all our customers.

We believe that ACE and the other New Jersey utilities play a critical role in helping the state achieve its 2050 greenhouse gas reduction targets and prepare for a world impacted by climate change, including in the areas of: 1) transportation electrification; 2) energy efficiency; and 3) infrastructure investment both to enable the deployment of and integrate clean energy technologies, such as community solar, energy storage and offshore wind, and to harden and further automate the grid to improve resilience in order to withstand the impacts of a changing climate.

Transportation Electrification – In order to meet the climate challenge, not only will New Jersey need to achieve the goal established by Governor Murphy of 100% clean electricity, but it will also require significant reductions in the greenhouse gas footprint of the state's transportation sector. Analyses have shown that using clean electricity to fuel transportation is cost-effective and provides multiple benefits, from improved public health to opportunities for economic growth and investment.

Accelerating the move toward electrifying the transportation system and expanding the electric vehicle (EV) market requires accelerating investments in charging infrastructure throughout the state. Doing so will encourage EV adoption across all strata of New Jersey residents and businesses. Electric utilities connect all people in their service areas, whether rich or poor, rural or urban. Electrification of transportation is one way all communities in New Jersey, including disadvantaged communities that bear a disproportionate burden as it relates to localized air pollution, can benefit from existing and future efforts to clean the electricity grid and use that clean electricity in more end use applications, including transportation. The combination of reducing emissions from power plants concurrent with reducing tailpipe emissions will result in both climate and public health benefits and help New Jersey to aggressively address the climate threat.

As cleaner electricity powers more of our energy needs, we all benefit from the climate and air quality improvements. We believe ACE is well-positioned to help insure EV participation meets the needs of diverse and low-and moderate-income customers and its benefits reach all communities, simply due to the attributes or our service territory and reach.

The widespread electrification of the transportation sector can help ensure that all customers share in the benefits of easier and more accessible EV charging, less vehicle noise, more electric transportation options, and downward pressure on utility rates due to increased electric throughput from more EV charging.

In Atlantic City Electric's February 2018 Electric Vehicle filing with the BPU, we outlined key areas to help ensure success in the EV market.

1. **Manage the Charging Load** – ACE is continuing to make significant investments in our infrastructure to ensure power reliability and power stability on the grid when Electric Vehicles are being charged. Managing this charging load is a key responsibility for utilities.

2. **Enhance Charging Infrastructure** – In order to realize the full economic and environmental benefit of transportation electrification, customers must have access to electricity as a transportation fuel at home, and on the road. This is true for both

168x

cars as well as public transit. ACE can help build out a foundational system of charging infrastructure that supports the needs of our customers and municipalities, while also supporting a reliable, consistent and positive customer experience. ACE can integrate transportation load on the grid in a manner that benefits both the energy grid and the customers who rely on it. And ACE is well-suited to help manage the transition to electric transportation in an efficient and cost-effective manner. Electric company investments in charging infrastructure can and should take many forms such as installing, owning and operating the charging equipment and can be accomplished in partnership with other market participants and new market entrants.

3. **Innovative Rate Options** – Customers want savings on their fuel bill but also want choice, options and flexibility on how to achieve those savings. Ideally, many customers will want to charge during off-peak hours after they get home from work. Through our innovative rate options, ACE can incent customers to charge at a time which is convenient for them and will maximize their overall fuel savings. Some customers may want a whole house rate (including the charger) or an EV only rate. The key here is let the customer choose what works best for them.

Electric company participation in the development and deployment of transportation electrification charging infrastructure supports New Jersey's clean energy and transportation goals, expands customer choice, and helps ensure the availability of needed EV charging infrastructure to support the growing number of EVs on the roads in New Jersey. Competitive, government, and utility programs can and must work in concert to build out the transportation electrification sector towards a more sustainable future.

Energy Efficiency – Atlantic City Electric has launched an Energy Efficiency and Demand Response pilot program with outreach to limited-income customers in targeted zip codes; it is also available to any customer living in single or multi-family homes. *Quick Home Energy Check Up* offers customers an energy assessment plus practical recommendations for energy saving improvements. This program is coupled with *Home Energy Reports*, giving customers timely feedback to reinforce behavioral changes resulting in real customer savings. The *Energy Wise Rewards ™* and *Comfort Partners* programs offer customers programmable thermostats and other weather assistance programs to reach our energy efficiency goals. Energy Efficiency is the most cost-effective means by which customers can reduce usage and lower their energy costs, as well as achieve greenhouse gas reductions.

Advanced Metering Infrastructure (AMI) is an important component in realizing the full potential of energy efficiency programs. ACE considers AMI an important cornerstone technology to support clean energy goals in New Jersey. Studies show that Maryland attributes 40% of the energy savings to smart meters which give customers real-time information to help them make smarter energy choices. In January 2019, Atlantic City Electric filed an AMI feasibility study and business case with the BPU to demonstrate the projected benefits and costs associated with deploying the infrastructure for our customers across south Jersey. Installation of AMI would provide additional benefits in support of New Jersey's Clean Energy Initiative and establish the connection necessary to support new technologies that will transform the future of energy service for our customers. We look forward to seeing smart meters approved for installation in New Jersey.

Infrastructure Investments – Scientists are predicting that the impacts of climate change in New Jersey will include more extremes in temperatures, including increased numbers of high degree cooling-days, as well as changes in precipitation and weather patterns that will lead to the increased frequency and severity of storms, including damaging winds and flooding in the coastal regions. Superstorm Sandy was a stark example of the impacts extreme weather and climate change can have on our communities. ACE, as a company and as part of the broader utility industry, has analyzed our systems and studied how we can make our infrastructure more reliable and more resilient in the face of climate change and other threats. Continued prudent investment in the electric grid is needed to meet customer expectations and protect critical infrastructure.

Atlantic City Electric is aggressively moving forward with its previously approved PowerAhead program and was recently authorized to make investments under its Infrastructure Investment Program. PowerAhead and the IIP are focused on accelerating capital investments in projects that enhance resiliency reliability and increase the overall integrity of the system. Both are positive steps to increasing the overall resilience and reliability of the grid, as well as enabling the clean energy future, but more is needed.

Accelerating and expanding these infrastructure investments will become increasingly important as we move to a world where the electricity system will be supporting more-and-more of the economy, including transportation and the increased electrification of buildings and homes. Investing in resiliency, hardening the electric grid and related assets, strategically deploying energy storage, and increasing automation of the electric system is key to maintaining the reliability our customers want and deserve, both today and into the future.

These investments can also allow us to enable more-and-more climate-friendly and innovative technologies to be integrated into the grid. Increasing amounts of distributed solar, off-shore wind, smart appliance and electric vehicles and transit, will require that utilities both increase the capacity of the underlying electric distribution system, as well as its automation and ability to handle two-way power flows, seamlessly and efficiently. For example, ACE has the highest concentration in the state of distributed solar facilities, with more than 30,000 facilities connected. In some areas, ACE is limited in the amount of new solar it can connect to its system, due to the need to upgrade capacity on select distribution feeders. As the electric grid continues to evolve to the platform that enables this new, clean energy future, we must be enabled through the regulatory process to make the necessary and timely investments to keep pace with the policies and goals established by the state, as well as the increasing needs and demands of our customers and communities.

We thank Governor Murphy and the Legislature for strong leadership on climate change and we will continue to be a partner in New Jersey's efforts in moving forward to reduce greenhouse gas emissions and improving grid resiliency.

Respectfully Submitted,

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ADDITIONAL APPENDIX MATERIALS
SUBMITTED TO THE

SENATE ENVIRONMENT AND ENERGY COMMITTEE
and
ASSEMBLY ENVIRONMENT AND SOLID WASTE COMMITTEE

for the

April 25, 2019 Meeting

Submitted by Peter Howard Ph.D, Economics Director, Institute for Policy Integrity, New York University School of Law; and **Denise A. Grab, Esq.,** Western Regional Director, Institute for Policy Integrity, and Adjunct Professor, New York University School of Law:

Iliana Paul, Peter Howard, Ph.D., Jason A. Schwartz, "The Social Cost of Greenhouse Gases and State Policy: A Frequently Asked Question Guide," Institute for Policy Integrity, October 2017, ©2017 Institute for Policy Integrity.

Denise A. Grab, Iliana Paul, Kate Fritz, "Opportunities for Valuing Climate Impacts in the U.S. State Electricity Policy," Institute for Policy Integrity, April 2019, ©2019 Institute for Policy Integrity.