

Climate Change Indicators Point to a Promising and Challenging Future

The beginning of any new year brings delight to the statistician who likes to compare data on a conveniently recognizable calendar year format. The year 2020 will be a year with much data to look at, given the onset of the coronavirus and all of its implications socially and economically, but here at Climate Change Business Journal we concern ourselves with a more narrow range of indicators to assess the health and future prospects of the climate change industry.

Whereas the second quarter is too soon for CCBJ to reach a final conclusion on 2020 performance in absolute terms of billions of dollar in revenues of the U.S. and global climate change industry, a sector that CCBJ defines in nine segments and 58 quantifiable subsegments, in this review we look at a relatively short list of indicators in market drivers and key subsegments.

Assessing market drivers and policy influencers, a snapshot of the latest temperature, weather and emissions data indicates that nothing has really changed to curtail the perilous path of anthropogenic climate change. The year 2020, like 2009 before, will be a mere blip on the upwards curve of global greenhouse gas emissions that is set to continue to a still undetermined peak – that most analysts set in the 2030s, although some speculate could conceivably have been 2019 – but CCBJ's more optimistic scenario has at 2024. (See perspective on other 'peaks' on page 12.)

A continued increase of greenhouse gas emissions into the atmosphere means extending the still aspirational goal of a peak of the concentration of CO₂ in the atmosphere. Extending the increasing con-

Climate Change Industry Indicators: 2020 Data & Outlook

Climate Change Business Journal® previews its annual analysis of the climate change industry with a dissection of preliminary 2020 data in key indicator areas of global temperatures, emissions and weather events, and in key industry segments wind, solar, energy storage, electric vehicle and carbon markets.

Executive contributors highlight business and thought leaders 1-10

MIT Climate and Sustainability Consortium Convenes Leaders from Multiple Sectors to Focus on Supply Chains 12

Moody's ESG Solutions Group Targets the Climate Risk Concerns of Banks, Insurers, Investors and Companies and Non-Energy Sectors Collaboration 14

GreenPrint Leads Consumer Product Companies Into Sustainability; Expands its Impact Collective to Support Initiatives 16

Zinc8 Energy Solutions Develops Storage Systems for Multiple Markets 19

Aspen Skiing Company Exhibits a Strong Commitment to Sustainability; Local Coal Methane to Power Project in Colorado a Success Story 20

Edison Energy Positions Innovation Expertise to Advise Clients on Sustainability; Hershey Sets 2030 Goals to Reduce Footprint and Address Climate Change 22

Author Ian Palmer Says the Shale Revolution Continues to Hold Back the Energy Transition in North America 25

Society for Risk Analysis Advocates Phased-In Reform of Insurance Premiums & Cost-Effective Loss Reduction to Balance Climate-Impacted Markets 27

Former Congressman Bob Inglis Sets a Path for 'Climate Conservatism'; Steve Melink & 'Fusion Capitalism: A Clean Energy Vision For Conservatives' 29

Volkswagen Places a Big Bet on Electric Vehicles 31

Solar Energy in California:The Good News and the Bad News 32

Feature on the Social Cost of Carbon: Biden Sets a Price of \$51 Triggering Opinions from Stern & Stiglitz, the Institute for Policy Integrity at NYU; American Petroleum Institute Declares a Position on a Price on Carbon 34

Guidehouse Adds 11th Financial Institution in HSBC to its Joint **Partnership for Carbon Accounting Financials** 41

Duke Energy Weighs Plans for the 2020s; Continues to Retire Coal Plants but Uncertain About Wind, Grid & EVs 43

General Motors Aims for Leadership in Decarbonization & EVs 44

DOE Experts Anticipate Sustained Wind Energy Cost Reductions, Technology Advancements, and Value Enhancements 46

centration of atmospheric carbon inevitably leads to more prolonged increases in global air and ocean temperature, and the annual lists of economically disruptive weather events. So clearly the climate indicators are still heading in the wrong direction – or in the right direction if the objective is to mobilize more urgent policy response from the global community of nations.

Assessing some key subsegments of the climate change industry, it is welcome news that capacity additions, as well as total electricity generation, set annual records in 2020 by some margin in both solar and wind, and that energy storage had a breakthrough year in 2020. Global new capacity additions increased 62% in energy storage, 53% in wind and 22% in solar in 2020; USA capacity additions increased 187% in energy

storage, 77% in wind and 39% in solar in 2020. (Conversely, global oil production decreased 6.4%, and global natural gas production dropped 3.6% in 2020.) Other segments saw global markets outpace the USA in 2020. The number of new electric vehicles sold globally in 2020 increased 39% in 2020 to 3.1 million units worldwide, while falling for the second consecutive year in the United States, in 2020 by 11% to just 292,000 EVs sold in the U.S., less than one-fourth of the sales in each of China and Europe.

Climate Change Industry Indicators 2019-2020

Solar PV Capacity (MW)	2019	2020	2020 Growth
Global Capacity Additions	115,000	140,000	22%
USA Capacity Additions	13,500	18,800	39%
% USA	12%	13%	
Wind Power Capacity (MW)	2019	2020	2020 Growth
Global Capacity Additions	60,877	93,000	53%
USA Capacity Additions	9,143	16,205	77%
% USA	15%	17%	
CO2 Emissions (bil tons)	2019	2020	2020 Growth
Global CO2 Emissions	35.94	33.64	-6.4%
USA CO2 Emissions	5.25	4.57	-12.9%
% USA	15%	14%	
Energy storage (in GWh)	2019	2020	2020 Growth
Global Capacity Additions	5.6	9.0	62%
USA Capacity Additions	1.2	3.5	187%
% USA	22%	39%	
New Electric Vehicles Sold	2019	2020	2020 Growth
Global New EVs Sold	2,230	3,100	39%
USA New EVs Sold	331	296	-11%
% USA	15%	10%	
Carbon Market (in \$bil)	2019	2020	2020 Growth
Global Carbon Market	227	272	20%
USA Carbon Market	24	28	16%
% USA/NA	11%	10%	

Source: CCBJ derived from IEA Photovoltaic Power Systems Programme; Global Wind Energy Council; International Energy Agency; Wood Mackenzie, Canalis; Platts Analytics, Refinitiv and others.

CLIMATE CHANGE BUSINESS JOURNAL®

ISSN 1940-8781

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Climate Change Business Journal® newsletter is published in quarterly feature editions and special supplements by Environmental Business International Inc., 4452 Park Blvd., Suite 306, San Diego, CA 92116. 619-295-7685 or email info@ebionline.org

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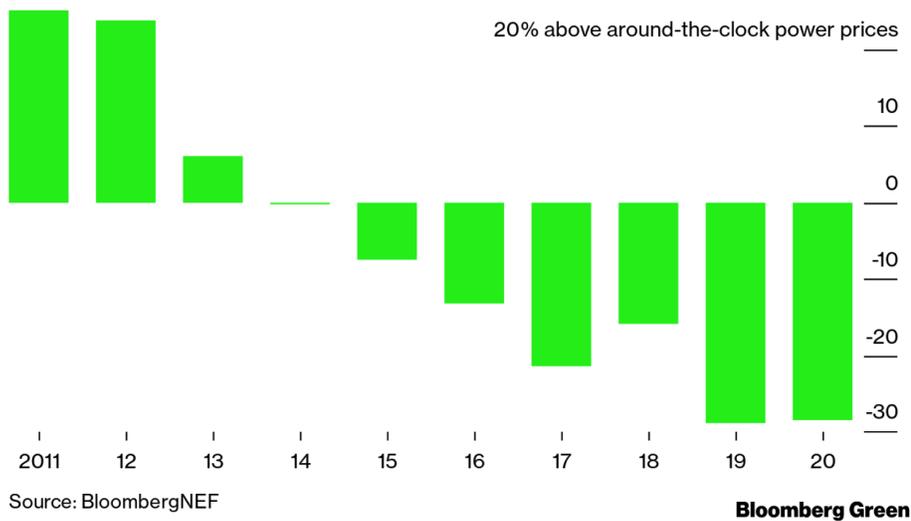
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Sunrise, Sunset

California solar power realized price compared to around-the-clock price



That was good for the early solar plants. However as solar generation increased and net demand fell further and further, fewer other power generators were needed to meet that net demand during solar hours. Those generators were lower-cost, with the result being that solar's realized price—what it earns during generating hours—has fallen steadily. Last year it was barely \$20 per megawatt-hour, down from \$50/MWh in 2014.

There's another wrinkle to this realized price phenomenon. Solar's challenge is not just that its realized price has fallen; it's also that the realized price is now a substantial haircut to the "around the clock" power prices that plants with 24-hour operations see. In 2011, when a small volume of solar captured high daytime prices, solar generators saw a significant premium to the around-the clock price. Today, a large volume of solar has depressed daytime prices, and solar generators now see a noticeable discount to the around-the-clock price.

This realized price trend is a problem in search of a solution. One certainly exists already: utility-scale energy storage in the form of large batteries that can store bulk power during solar hours and discharge it again when demand peaks in the evening. California has already studied the notion in depth, and there are plenty of commercial developers already pursuing utility-scale solar and storage projects.

Another solution is something that Bullard and Bloomberg NEF has written about before in the case of even more solar-rich South Australia: Creating new sources of demand. Abundant, inexpensive, zero-carbon electrons are in search of companies and business models to use them. In Australia, California and soon many more regions. Applications could include electrolyzing hydrogen, performing energy-intensive computation in large data centers, charging electric vehicles, or—just as importantly—other electricity-intensive processes and businesses that do not yet exist. ⚙️

The Importance of Setting the Social Cost of Carbon

In one of his first acts in office, on January 20, President Biden issued an executive order establishing an Interagency Working Group on the Social Cost of Greenhouse Gases (referred to as the social cost of carbon or SCC). The group's task is to devise a better estimate for the dollar cost of each ton emitted into the atmosphere. The number, referred to as the social cost of carbon (SCC), gives policymakers and government agencies a basis for evaluating the benefits of public projects and regulations designed to curb CO₂ emissions—or of any project or regulation that might indirectly affect emissions.

If the working group settles on a low number, many projects and regulations won't go ahead because their price tags will exceed the estimated climate benefits. In addition to its use as a shadow price in government cost-benefit analysis, SCCs can be used as internal prices by private firms and, where possible, as a carbon tax. So, it is vital to get the number right—and by right, economists Nicholas Stern and Joseph Stiglitz mean higher than it has been in the past. Stern and Stiglitz' February 2021 paper: *The Social Cost of Carbon, Risk, Distribution, Market Failures: An Alternative Approach*, claims that existing methodologies are flawed and that the "costs of climate action are overestimated and the benefits underestimated", and provides an alternative methodology to calculate the SCC.

The Interagency Working Group in the Obama Administration, focusing on a 3% discount rate, suggested a SCC for 2030 of around \$50/ton, while the Stern-Stiglitz Commission in 2017 reached a consensus that a price of around \$100 would be required to achieve the Paris goals. Stern and Stiglitz argue that the problem was the Obama administration's use of integrated assessment models, which integrate economics and environmental sciences to

calculate the course of the economy and climate over the next century or more. Integrating economics and the environment makes sense, but varying models have generated widely varying ranges of estimates that are highly sensitive to particular assumptions.

A prominent result from one popular version of these models is that we should accept global warming of 3.5°C relative to pre-industrial levels. This is far higher than the 1.5–2°C limit that the international community adopted in the 2015 Paris Agreement. The Intergovernmental Panel on Climate Change has emphasized that the risks associated with global warming of 2°C are much greater than at 1.5°C. Integrated assessment models don't adequately recognize the potential role of innovation and increasing returns to scale in climate action.

Another problem with the Obama methodology say Stern and Stiglitz is that it disadvantaged future generations. Much of the benefit of curbing emissions now lies in avoiding the risk of dangerous climate change decades in the future. Formally, the Obama-era methodology addressed this issue by making assumptions about discounting, showing how much less a dollar will be worth next year (and the year after) compared to today. The Obama administration used an annual discount rate of 3%, implying that to save \$1 in 50 years, we would be willing to spend 22 cents today; to save \$1 in 100 years, we would be willing to spend five cents. There is no ethical justification for giving so little weight to future generations' welfare. But there is not even an economic rationale once we take risk into account.

We pay insurance premiums today to avoid losses tomorrow—in other words, to mitigate risk. We typically pay \$1.20 to get back \$1 next year on average, because the insurance company delivers the money when we need it—like after a car accident or a house fire. With spending that lowers future risks, the appropriate discount

rate is low or can be negative, as in this example, when the potential effects could involve immense destruction. Spending money today on climate action is like buying an insurance policy, because it reduces the risk of future climate disasters. So, risk translates into a lower discount rate and a higher carbon price.

Now that the Biden administration has committed itself to the international goal of limiting global warming to 1.5–2°C, it should embrace a second, more reliable way to calculate the SCC. It is simply the price at which we will be able to reduce emissions enough to prevent the world from heating up dangerously.

This is the price that will encourage low-carbon investments and innovations provided by the climate change industry, and help to make cities less congested and polluted. Many other complementary policies will be necessary, including government investments and regulations. As the international carbon-pricing commission co-chaired by Stern and Stiglitz emphasized in its 2017 report, the more successful these policies are in curbing CO₂ emissions, the lower the carbon price could be in the future. But the likely SCC would be closer to \$100 per ton by 2030 than the \$50 per ton estimated by the Obama administration. An SCC at the upper end of the \$50–100 range suggested in 2017 is entirely appropriate, given that the Paris Agreement's targets have rightly become more ambitious—a 1.5°C limit on warming and net-zero emissions by 2050.

Stern and Stiglitz assert that too many experts have not sufficiently accounted for the scale of climate risks, the well-being of future generations, and the opportunities for climate action given the right incentives. The Biden administration must put a high enough price on carbon to encourage the scale and urgency of action needed to meet the commitments it has made to Americans and the rest of the world. Stern and Stiglitz and others agree that the future of the planet depends on it. ⚙

The Institute for Policy Integrity Advocates Broader Acceptance and Use of the Social Cost of Carbon

The Institute for Policy Integrity is a non-partisan think tank dedicated to improving the quality of government decisionmaking through advocacy and scholarship in the fields of administrative law, economics, and public policy.

Richard L. Revesz, who directs the Institute for Policy Integrity, is AnBryce Professor of Law and Dean Emeritus at New York University School of Law. He is one of the nation's leading voices in the fields of environmental and regulatory law and policy.

CCBJ: We agree that the restoration of the social cost of carbon metric at \$51 a ton is not that a monumental achievement, but it should have significant influence on policies expected to roll out in the short-term and over the next 4 years. Do you agree that SCC will be an influential pillar of policymaking, and what policies do you expect out of the Biden administration that will start building a foundation for a larger and broader application of social cost of carbon into environmental, climate and economic policy?

Revesz: President Biden's Executive Order on Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis asks the Interagency Working Group to make recommendations by September 1, 2021 "regarding areas of decision-making, budgeting, and procurement" where the social cost of carbon should be applied.

This process provides a good opportunity to clarify that, because the social cost of carbon is simply a measure of damages from greenhouse gas emissions, it is relevant to decisions in all these areas.

The most recent paper by Stern and oth-

ers implies the social cost of carbon should more accurately be in excess of \$100 a ton.

CCBJ: How important do you feel it is that we have more consensus on this amount or that we can acknowledge it higher than a floor established for consideration of certain policy measures?

Revesz: The Biden administration has indicated that it will determine a final value of the social cost of carbon by January 2022. One likely change will be to lower the current 3% discount rate on which the social cost of carbon is based.

At a rate of 2%, which New York currently uses and which has the support of prominent economists, the value would increase to around \$125—a figure similar to the one favored in the Stern and Stiglitz paper.

CCBJ: What is your opinion on the concept of a retroactive carbon tax in the same edition as a mechanism to fund climate resilience and adaptation?

Revesz: 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 to society. 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 is a powerful tool that can streamline decisionmaking and underpin economically efficient policies. Many decisionmakers, including policymakers in several U.S. states, are now using the SCC to craft smarter energy and climate policies that benefit society. ✨

The SCC is a powerful tool that can streamline decisionmaking and underpin economically efficient policies.

Improve the Social Cost of Carbon, Do Not Replace It

by Justin Gundlach and Peter Howard.

Justin Gundlach is a Senior Attorney at the Institute for Policy Integrity at New York University School of Law. Peter Howard is the Economics Director of the Institute for Policy Integrity at New York University School of Law.

Every ton of planet-warming carbon dioxide emitted from a smokestack or a tailpipe contributes to climate change, imposing costs on us all. But how much cost exactly? Currently, the federal government puts that cost at \$51 per ton using a metric called the social cost of carbon, or SCC for short. Federal agencies use this metric when they analyze the consequences of actions that cause greenhouse gas emissions to rise or fall. In fact, agencies are required to analyze the SCC by executive orders that have been in effect for 40 years, under administrations led by both Republican and Democratic leadership.

Weighing the costs and benefits of a proposed regulation is an obligation recognized by the U.S. Supreme Court. It was a federal appellate court specifically insisting that agencies must quantify climate costs and benefits that led the Obama Administration to develop a method “to quantify avoided climate change damages” from reducing carbon emissions. The Administration’s resulting SCC estimates have since been upheld in court and praised as scientifically sound by independent experts.

In early 2021, the Biden Administration called for a review and possible updating of the SCC to ensure that it reflects the latest science. But some observers, including two prominent economists, Nicholas Stern of the **London School of Economics** and Political Science and Joseph E. Stiglitz of **Columbia University**, argue that the SCC is too flawed for use in policymaking. Stern and Stiglitz contend that the SCC’s discount rates—the rate at which society is willing to trade off current

for future consumption—are too high, fail to reflect climatic tipping points and “unknown unknowns,” and assume away market imperfections and inequality.

Although the Biden Administration has pointed to these and other technical issues as components of the SCC that need attention and improvement, Stern and Stiglitz think these issues justify casting the metric aside altogether. Stern, the lead author of the *Stern Review on the Economics of Climate Change*, has played a significant role in global climate policy. Stiglitz won the Nobel Prize for his research on the role that information—including incomplete information—plays in economic decisions.

Rather than rely on the SCC to estimate the damage caused by each unit of carbon dioxide emissions, Stern and Stiglitz propose abandoning a damage-based estimate altogether and taking a fundamentally different approach: estimating how much society must spend to avoid emitting each ton of the carbon dioxide to ensure that global temperature increases do not exceed two degrees Celsius. We think Stern and Stiglitz’s estimate is worth developing to indicate whether the SCC is compatible with reaching a two degrees Celsius goal, but not to supplant the SCC. Replacing the SCC as they suggest would create problems for U.S. climate policy.

To begin, their estimate, known as a marginal abatement cost, is incompatible with the legal requirement that federal agencies must assess the costs and benefits of their regulatory measures. Because it does not assess the emissions-related damages imposed or avoided by a proposed regulation, it cannot support an agency’s crucial determination of whether a regulatory measure gives rise to positive net benefits for society as a whole.

Instead, Stern and Stiglitz assume a target with a scientific basis but not a legal one—at least not one based on current law. Although keeping global warming to two degrees Celsius is surely a worthy goal, the

U.S. Congress has not adopted this standard into law yet. Without a binding statutory emissions target, regulatory agencies must rely on the standard requirement that their regulations should yield more benefits to society than costs—an analysis aligned with the need for an estimate of the SCC. By jettisoning the SCC and failing to compare carbon emission costs to benefits, as Stern and Stiglitz suggest, agencies might neglect that key question and invite legal challenges.

One of the arguments that Stern and Stiglitz raise against the SCC is that it yields a value that is too low, compared to their marginal abatement cost value of about \$100 per ton. But this criticism appears misplaced. The update ordered by the Biden Administration, slated for completion in January 2022, will include a reexamination of the SCC's range of discount rates and is widely expected to result in a value that exceeds \$100 per ton—simply because the current SCC discount rate is considered too high. In 2020 New York State adopted an SCC of \$125, based on discount rates.

None of this is to deny that Stern and Stiglitz's criticisms of the SCC should be taken seriously. But the Biden Administration seems to be doing just that by calling for an intensive review to incorporate recommendations from the **National Academy of Science** and recent scientific and economic research. Indeed, recent research suggests that a two degrees Celsius target may be too conservative, and thus using cost-benefit analysis could justify bolder climate action.

This prospect should not be surprising, given that an updated SCC promises a damage-based cost of carbon higher than Stern and Stiglitz's \$100 marginal abatement cost estimate—as evidenced by New York's recent evaluation. The Biden Administration is charting a prudent path, one that involves improving, rather than abandoning, a viable and legally necessary foundation for climate policy. ⚙️

What is the Social Cost of Carbon?

The U.S. federal government's **Interagency Working Group on the Social Cost of Greenhouse Gases** (IWG), which operated from 2009–2017 and was reconvened in 2021, is the best source for Social Cost of Carbon (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 being assessed. The table below is from the Interagency Working Group's 2021 Technical Support Document and shows the SCC estimates, in 2020 dollars, at five-year intervals. In previous IWG technical support documents, these figures are given in 2007 dollars, but the values included in the most recent technical support document are inflated to current (2020) dollars.

Social Cost of CO2 (in 2020 dollars per metric ton of CO2)

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	\$51	\$76	\$152
2025	\$17	\$56	\$83	\$169
2030	\$19	\$62	\$89	\$187
2035	\$22	\$67	\$96	\$206
2040	\$25	\$73	\$103	\$225
2045	\$28	\$79	\$110	\$242
2050	\$31	\$85	\$116	\$260

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 more detail in the full report.

Biden's Path Forward on the Social Cost of Carbon

The Biden administration on Feb. 26 2021 took a significant step toward meeting the goals of its day-one executive order on tackling climate change with a simple numerical update. The administration determined an interim value for the social cost of carbon (SCC), as well as corresponding values for the social costs of nitrous oxide and methane. These estimates of the damage caused by the emission of a ton of the respective greenhouse gases play

a key role in the evaluation of government actions affecting climate change.

The Biden administration has reverted to an Obama-era method for calculating the social cost of greenhouse gases, which will be key in evaluating government actions affecting climate change. NYU Law Professor Richard L. Revesz has examined the change thoroughly, and says some related actions, including updating the discount rate used to evaluate future consequences, need to happen in the coming months to make the SCC more universally accepted and broadly applicable.

The Interagency Working Group on the Social Cost of Greenhouse Gases that conducted this review restored and adjusted for inflation the values in effect at the end of the Obama administration, which measured global impacts and had been upheld in court. It abandoned the Trump administration's approach of considering what it called "domestic only" impacts, which a court struck down as "arbitrary and capricious," finding it "riddled with errors," in part because, despite the label, it ignored many adverse consequences accruing to the U.S.

Biden's move is significant, raising the SCC by an order of magnitude, from \$1-\$7 to \$51, but there is even more important work still to come. A more thorough review is likely to further increase the value of the SCC, and other moves could strengthen the legal footing for its use in numerous contexts.

The executive order calls on the interagency working group to determine a final SCC by January 2022, in light of developments in the scientific literature. The newly restored SCC value is widely regarded to be a lower bound of the true damage of emissions, in part because quantification techniques have improved since the estimation made under the Obama administration and, therefore, more of the myriad adverse consequences of climate change can now be included in the SCC.

Updating the Discount Rate

But perhaps the largest increase will come from updating the discount rate used to evaluate future consequences. For example, if the SCC were computed using a discount rate of 2%, which the state of New York now uses in its own SCC calculation, instead of the 3% rate used during the Obama administration, the value would be 2.5 times higher. The 3% rate is prescribed in OMB Circular A-4, a 2003 document that provides cost-benefit-analysis guidance to agencies.

But that rate was set to match the long-term interest rates on government bonds at the time. These interest rates are now far lower, and the Council of Economic Advisers and prominent economists have recommended lowering the corresponding discount rate as well.

Moreover, over the last decade, a robust academic literature has explained why discount rates should be particularly low when the consequences of governmental action will occur in the distant future, as is true for many impacts of climate change.

Presidential Memo and Revisions to OMB Circular

The work of determining an appropriate discount rate for the SCC should proceed alongside a broader inquiry, launched by another day-one action of the Biden administration: the presidential memorandum on modernizing regulatory review. The memo calls for revisions to the Office of Management and Budget's Circular A-4 "to ensure that the review process promotes policies that reflect new developments in scientific and economic understanding."

A general update of discount rates should be a top focus of these modernization efforts. The memo does not specify a deadline for completing the broader update of the OMB's circular. Nonetheless, it would be highly desirable for this work to be completed at the same time as the SCC update. Otherwise, the processes could result in an inconsistency, in which long-term climate impacts are evaluated using a different discount rate than other long-term impacts. Such an inconsistency, if not properly explained, could be highlighted in court challenges to climate-related actions.

Some institutional creativity will be necessary to accomplish these updates simultaneously, as the interagency working group will be handling SCC tasks while the director of the OMB will oversee the broader modernization effort. The execu-

tive order also asks the interagency working group to "provide recommendations to the President, by no later than September 1, 2021, regarding areas of decision-making, budgeting, and procurement" where the SCC should be applied.

A Broader Scope for SCC Use

Opponents of climate action, including the Trump administration, have argued that these values are relevant only for regulations, and should not be used for the evaluation of projects, such as pipeline approvals under the National Gas Act, or in environmental impact statements prepared under the National Environmental Policy Act.

Some courts have adopted this narrow view of the SCC's scope, limiting its use to regulatory contexts, though others have insisted that the SCC be used to evaluate non-regulatory actions as well. A reason for this confusion may be that the narrow title of the Obama administration's SCC documents was "Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866."

In its upcoming report, the interagency working group can easily put this issue to rest because the SCC is simply a measure of damages from greenhouse gas emissions. It is equally relevant for estimating regulatory consequences, infrastructure approvals, and government procurement decisions.

The Biden administration eliminated some of the underbrush of bad analysis left over from the Trump administration. In the coming months, efforts to address climate change could be boosted further as the SCC is updated to reflect the best available science, and it is used in all relevant contexts that affect emissions. ⚙️

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