ENVIRONMENTAL LAW & POLICY CENTER
Protecting the Midwest's Environment and Natural Heritage

September 14, 2021

Ms. Lisa Felice
Michigan Public Service Commission
7109 W. Saginaw Hwy.
P. O. Box 30221
Lansing, MI 48909

RE: MPSC Case No. U-20763

Dear Ms. Felice:

The following is attached for paperless electronic filing:

Direct Testimony and Exhibits ELP-1 through ELP-7 of Peter Erickson

Direct Testimony and Exhibits ELP-8 through ELP-10 of Peter Howard

Direct Testimony and Exhibits ELP-11 through ELP-16 of Jonathan Overpeck

Direct Testimony and Exhibits of ELP-17 through ELP-25 of Elizabeth Stanton

Proof of Service

Sincerely,

Margrethe K. Kearney

Margrethe Kearney
Environmental Law & Policy Center
mkearney@elpc.org

cc: Service List, Case No. U-20763

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STATE OF MICHIGAN
MICHIGAN PUBLIC SERVICE COMMISSION

In the matter of **ENBRIDGE ENERGY, LIMITED PARTNERSHIP** application for the Authority to Replace and Relocate the Segment of Line 5 Crossing the Straits of Mackinac into a Tunnel Beneath the Straits of Mackinac, if Approval is Required Pursuant to 1929 PA 16; MCL 483.1 et seq. and Rule 447 of the Michigan Public Service Commission's Rules of Practice and Procedure, R 792.10447, or the Grant of other Appropriate Relief	)))))))))))	Case No. U-20763

DIRECT TESTIMONY OF DR. PETER HOWARD

ON BEHALF OF

THE ENVIRONMENTAL LAW & POLICY CENTER AND THE MICHIGAN CLIMATE ACTION NETWORK

September 14, 2021

Q. Please state your name, business name and address.

A. My name is Dr. Peter Howard. I am the economics director at the Institute for Policy Integrity at the New York University School of Law.[1] Our offices are located at 139 MacDougal Street, Wilf Hall, 3rd Floor, New York, NY 10012. 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.

Q. What is the purpose of your testimony?

A. My testimony applies a widely-accepted economic methodology, known as the Social Cost of Greenhouse Gases, to monetize the incremental climate costs from the emissions from construction and operation of the proposed Line 5 project, as well as the lifecycle emissions from the oil and natural gas products that would be transported by that Proposed Project. Specifically, based on the best available quantitative data and conservative valuations, the Proposed Project will generate a present value of $41 billion (in 2020 USD) or more in net monetized climate costs from 2027 to 2070 as compared to the no-action alternative—in other words, the Proposed Project will generate average annual monetized climate costs of approximately $1 billion each year over this period, plus significant unmonetized climate effects and other unquantified pollution costs to human health and the environment. This $41 billion figure represents real-world, concrete climate damages to Michigan, the United States, and the world, in the form of energy system disruptions, human health effects from air quality impacts and extreme temperatures, water quality and water scarcity impacts, agricultural productivity losses, property damage, biodiversity losses, and costs to other

[1] No part of this testimony purports to present the views, if any, of New York University or its School of Law.

climate-vulnerable market sectors and natural resources[2] that matter to the people of Michigan. Translating these damages into dollar figures helps to contextualize how the pollution from the Proposed Project will concretely impair the air, water, natural resources, and public trust. These results further demonstrate the prudence of the no-action alternative by putting the Proposed Project's incremental climate costs into terms that can more readily be compared against the Proposed Project's alleged benefits and so reveal the Proposed Project to be, on net, detrimental to society.

Q. What is your educational background?

A. I hold a Ph.D. in Agricultural and Resource Economics from the University of California, Davis, where my research focused on climate change, environmental policy, and agricultural policy. I also hold a Bachelor of Arts from Bard College, where I majored in economics.

Q. Can you briefly describe your professional background?

A. After graduating with my Ph.D. in 2012, I started my academic career as an economic fellow at the Institute for Policy Integrity at New York University School of Law. During this time, my research focused primarily on the social cost of carbon. In 2015, I accepted my current position as the Economics Director at Policy Integrity, where the primary focus of my work remains on the social cost of carbon and related climate economic issues, though my work and expertise has expanded to include several related topics, including resource extraction. Over the last decade, my climate economics work has been published in various prestigious environmental economics, legal, and policy journals. My work has

[2] *See* Climate Impacts Reflected in the SCC Estimates, https://costofcarbon.org/scc-climate-impacts (last visited Aug. 26, 2021) (detailing which climate impacts are included or partially included in the current estimates of the social cost of greenhouse gases).

been cited by the federal government (e.g., the Interagency Working Group on the Social Cost of Greenhouse Gases, 2016; 2021) and researchers (National Academy of Sciences, 2017). My 2017 paper with Thomas Sterner on climate damages formed the basis of Nobel Prize recipient William Nordhaus's alternative damage function that he published in 2019. My Curriculum Vitae is attached as Exhibit ELP-8 (PH-1).

Q. Have you ever testified in front of the Michigan Public Service Commission?

A. No.

Q. Have you testified in other jurisdictions?

A. Yes. I have testified on the value of using the social cost of greenhouse gases before: the New Jersey legislature, the Colorado Air Quality Control Commission, the U.S. District Court for the District of Montana, the National Academies of Sciences Committee on Assessing Approaches to Updating the Social Cost of Carbon, the U.S. Office of Information and Regulatory Affairs, and the U.S. Interagency Working Group on the Social Cost of Greenhouse Gases.

Q. On whose behalf are you submitting this testimony?

A. I am submitting this testimony on behalf of the Environmental Law & Policy Center and the Michigan Climate Action Network.

Q. Are you sponsoring any exhibits?

A. Yes. I am sponsoring the following exhibits:

ELP-8 (PH-1) – Curriculum Vitae of Dr. Peter Howard.PDF

ELP-9 (PH-2) – SCC Calculations for Line 5

ELP-10 (PH-3) – Extrapolation Code

Q. Can you summarize your conclusions?

A. By applying a widely-accepted economic methodology, known as the Social Cost of Carbon, to monetize the relative climate benefits of a "no-action scenario" compared to the Proposed Project, based on the available data, it is very likely that the no-action scenario will generate tens, if not hundreds, of billions of dollars of net climate benefits. Our main net present estimate of $41 billion (2020 USD) as the Proposed Project's incremental climate costs from construction, operation, and lifecycle emissions from transported products, is certainly a conservative underestimate for several reasons. First, the available estimates of the social cost of carbon dioxide are conservative lower bounds because multiple highly significant climate damages—such as wildfires, flooding and mortality from inland extreme weather, groundwater overexploitation, habitat modifications, and invasive species—are not currently quantified, among other reasons.[3] Second, our $41 billion estimate applies a social cost of carbon dioxide calculated using a conservative discount rate of 3%, even though overwhelming evidence now supports decreasing the discount rate to 2% or lower, which would increase the social cost of carbon dioxide values substantially.[4] Third, the $41 billion figure reflects the net present value of the Proposed Project's climate impacts only through the year 2070, because the federal government's

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[3] *See* 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); *see also* Climate Impacts Reflected in the SCC Estimates, *supra* note 2 (listing omitted damage categories).

[4] *See* Peter Howard & Jason A. Schwartz, *About Time: Recalibrating the Discount Rate for the Social Cost of Greenhouse Gases* (Policy Integrity Report 2021), https://policyintegrity.org/files/publications/About_Time.pdf (summarizing the economics literature and arguments); *see also* Interagency Working Group on the Social Cost of Greenhouse Gases, Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide, Interim Estimates under Executive Order 13990 at 19-21 (2021), https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf [hereinafter 2021 TSD] (conceding the updated evidence); Council of Economic Advisers, *Discounting for Public Policy: Theory and Recent Evidence on the Merits of Updating the Discount Rate* (Issue Brief, Jan. 2017), https://obamawhitehouse.archives.gov/sites/default/files/page/files/201701_cea_discounting_issue_brief.pdf (arguing to lower the consumption-based discount rate to 2%).

estimates of the social cost of carbon currently end in 2070. But the Proposed Project could continue to have climate impacts through at least 2127, and additional values of the social cost of carbon can be extrapolated from 2071 through 2127. Accounting for the latter two adjustments (using a 2% discount rate and extrapolating damages through 2127) would likely increase the estimate of the Proposed Project's net monetized climate damages by approximately four-fold, up to roughly $160 billion. Even this figure could underestimate the Proposed Project's climate damage, because it omits key damage categories and may not fully account for the risk of catastrophic impacts.

Q. What is your understanding of the project for which Enbridge seeks approval?

A. Enbridge Energy is proposing to build a tunnel beneath the Straits of Mackinac to house a segment of its Line 5 oil and natural gas liquids pipeline (the "Proposed Project").

Q. Do you know whether Enbridge considered any alternatives?

A. Enbridge reports having examined two alternatives to its proposed tunnel: "(ii) a new pipe installed across the Straits using an open-cut method that includes secondary containment; or (iii) a new pipe installed below the Straits using the horizontal directional drilling (HDD) method." (Pastoor Direct at 15:.22-25).

Q. What would a no-action alternative entail?

A. A no-action alternative would entail allowing the existing pipeline to shut down, and not building a tunnel or installing any replacement pipelines. This would have the effect of decreasing the supply of oil and natural gas liquids. Basic economic principles of supply and demand dictate that with decreased supply, the quantity demanded will also drop in response to price signals. Decreased demand for oil and natural gas liquids will decrease the combustion of oil and natural gas liquids, which will decrease emissions of greenhouse gases and other harmful pollutants. The reductions in lifecycle emissions from the oil and gas products that the Proposed Project would otherwise transport, as well as avoided emissions from the construction and operation of any action alternative, can be monetized as the incremental benefits of selecting the no-action alternative (or, equivalently, as the incremental costs of selecting the Proposed Project). This testimony provides such a monetization of the greenhouse gas effects.

Q: Have you reviewed any analysis of the no-action alternative?

A: Yes, I have reviewed Peter A. Erickson's testimony.

Q: Do you rely on Mr. Erickson's calculations?

A: Yes. I rely on his finding of the Proposed Project's total greenhouse gas emissions from construction and operation, and the lifecycle emissions from the transported oil and gas products, as well as his calculation of the net greenhouse gas emissions compared to the no-action alternative. I use his calculations of quantified tons of greenhouse gas emissions to monetize the Proposed Project's climate costs.

Q. Why is monetization of environmental externalities important for evaluating how pollution from the Proposed Project impairs the air, water, natural resources, or public trust?

A. Monetization can help both decisionmakers and the public understand the nature of the Proposed Project's pollution and the impairment it causes. When environmental externalities are presented only qualitatively, decisionmakers and the public both will tend to overly discount the importance of the effects. In general, non-monetized effects are often irrationally treated as worthless.[5] This may be especially true if some effects (like capital

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

cost and operational costs) are monetized, while other effects (like climate and health benefits) are discussed only quantitatively or qualitatively.[6]

It also may be especially difficult for the public and decisionmakers to fully consider climate effects that are presented only quantitatively through estimates of emissions volumes. As the U.S. Environmental Protection Agency's website explains, "abstract measurements" of so many tons of greenhouse gases can be less useful for the public, unless "translat[ed] . . . into concrete terms you can understand."[7] In particular, it may be difficult for many members of the public—and even for some decisionmakers otherwise well-versed in climate change—to conceptualize how significant emissions of 27 million tons per year of greenhouse gases actually are, let alone what concrete impacts those emissions will have to the air, water, natural resources, human health, economy, and public trust. Comparisons of tons of greenhouse gases emitted by the Proposed Project to statewide, national, or global totals of annual emissions may misleadingly make such quantitative figures appear small.[8] But in fact, even a "small portion of a gargantuan source of . . . pollution" may still "constitute[] a gargantuan source of . . . pollution on its own terms."[9] Monetization makes that clear. Specifically, while 27 million tons per year may

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[6] A well-documented mental heuristic called "salience bias" causes people to irrationally focus more on salient figures and ignore less salient figures. Because people are very familiar with money, but do not often encounter in their everyday lives statistics on the metric tons of greenhouse gas emissions, people are more likely to focus on costs and benefits presented in monetary terms, and less likely to focus on climate costs presented only quantitatively or qualitatively.

[7] EPA, Greenhouse Gas Equivalencies Calculator, https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator (last updated Mar. 2021), *available at* https://perma.cc/UNX8-PQ3J.

[8] A well-documented mental heuristic called "probability neglect" causes people to irrationally reduce small probability risks entirely down to zero. Cass R. Sunstein, *Probability Neglect: Emotions, Worst Cases, and Law*, 112 Yale L61, 63, 72 (2002) (drawing from the work of recent Nobel laureate economist Richard Thaler). Another well-document mental heuristic called "scope neglect" suggests that abstract volume estimates will fail to give people the required informational context to understand climate risks. 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).

[9] Sw. Elec. Power Co. v. EPA, 920 F.3d 999, 1032 (5th Cir. 2019) (internal quotation marks omitted).

be hard to conceptualize, the monetized expected cost of the climate risks associated with those same emissions—about $1 billion per year according to the federal Interagency Working Group's central estimate of the social cost of carbon[10]—is a salient, relevant, and contextualized way of understanding the Proposed Project's pollution. (This type of calculation is explored in much greater detail later in this testimony.)

Moreover, monetization using the social cost of greenhouse gas methodology will help decisionmakers and the public understand the concrete impairment to air, water, natural resources, and the public trust caused by that pollution. Though the current best estimates of the social cost of greenhouse gases cannot yet capture all categories of climate damages, current estimates do at least partially reflect many key real-world impacts such as:[11]

- **energy system losses** and disruptions, including from temperature-related changes to the demand for cooling and heating;
- human health impacts, including cardiovascular and respiratory mortality from climate-induced **changes in air quality**, as well as from heat-related illnesses,

[10] *See infra* and attached exhibits for more details on this calculation. To briefly summarize, the quantified metric tons of incremental carbon dioxide-equivalent emissions from the Proposed Project as compared to the no-action alternative (from Peter A. Erickson's testimony) are monetized by the relevant central estimate of the social cost of carbon dioxide published in February 2021 by the federal Interagency Working Group (2021 TSD, *supra*), and then discounted back to present value at a 3% rate. This $1 billion per year figure reflects that the total net present value of the incremental climate effects from 2027-2070 is conservatively estimated at $41 billion, and $41 billion over 44 years is nearly $1 billion per year. The actual present value figure varies each year.

[11] These impacts are all included to some degree in at least one of the three integrated assessment models (IAMs) used by the Interagency Working Group (namely, the DICE, FUND, and PAGE models), though some impacts are modeled incompletely or not represented in all three models, and many other important damage categories are currently omitted from these IAMs. *Compare* Interagency Working Group on the Social Cost of Carbon, *Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis* at 6-8, 29-33 (2010), https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf [hereinafter IWG, *2010 TSD*]; *with* Peter Howard, *Omitted Damages: What's Missing from the Social Cost of Carbon* (Cost of Carbon Project Report, 2014), http://costofcarbon.org/files/Omitted_Damages_Whats_Missing_From_the_Social_Cost_of_Carbon.pdf.

changing disease vectors like malaria and dengue fever, and **water-borne diseases**;

- **water supply losses** and disruptions, including changes in fresh water availability from extreme weather events and infrastructure impacts;
- lost productivity and other impacts to **agriculture, forestry, and fisheries**, due to alterations in temperature, precipitation, CO_2 fertilization, and other climate effects;
- **property lost** or damaged by coastal flooding, storms, other extreme weather events, as well as the cost of protecting vulnerable property and the cost of resettlement following property losses;
- some **biodiversity losses** and ecosystem service impacts;
- some impacts to **outdoor recreation** and other non-market amenities; and
- some **catastrophic impacts**, including the triggering of climate tipping point events and damages at very high temperatures.

By translating tons of emissions into dollars of real-world climate damages, applying the social cost of greenhouse gas metrics will help decisionmakers and the public understand the nature of the impairment caused by the Proposed Project's greenhouse gas pollution.

Q. Why is monetization of environmental externalities important for evaluating whether the no-action scenario is a feasible and prudent alternative to the Proposed Project?

A. Monetization can help decisionmakers and the public weigh climate costs against other costs and benefits of various alternatives, and so determine the relative prudence of the no-action alternative as compared to the Proposed Project. In order to ensure that environmental effects will be treated on par with other costs and benefits, those environmental externalities should, whenever feasible, be monetized. When all costs and benefits are translated into the common metric of money, the tradeoffs inherent in policy choices become apparent, and decisionmakers can more readily and more transparently compare society's preferences for competing priorities. Specifically, the fact that the Proposed Project will inflict an additional $41 billion or more in climate damages as compared to the no-action alternative is clearly relevant in weighing the prudence of the no-action alternative.

Q. Why is monetization appropriate for greenhouse gas emissions in particular, including the greenhouse gas emissions from the Proposed Project?

A. Greenhouse gas emissions are particularly suitable candidates for monetization, and the emissions from the Proposed Project can be readily monetized.

First, greenhouse gases are global pollutants, such that any ton of carbon dioxide emissions causes the same environmental harms regardless of the source of the emission. It does not matter what type of project caused the emission or where the emission originated geographically: any ton of carbon dioxide will become well-mixed in the global atmosphere, cause the same kind of additional radiative forcing and other atmospheric interactions over its long lifespan, contribute the same incremental temperature increase and other impacts to climate and weather, and so cause the same additional impairment to air, water, natural resources, human health, and the economy. (The measurement of such impacts through the application of integrated assessment models is discussed more below.) For this reason, we can calculate with reasonable certainty the climate costs imposed by the emissions from the Proposed Project.

The second reason why greenhouse gas emissions are particularly suited for monetization is that a widely accepted monetization tool exists. The federal Interagency Working Group's estimates of the Social Costs of Greenhouse Gases have been thoroughly vetted by economists, scientists, and the courts; have been widely adopted by a growing list of other U.S. states; and are freely available and easy to apply. (The development, vetting, and use of these estimates is detailed more below.)

The global nature of the climate effects of greenhouse gases also creates a third reason why monetization of greenhouse gas emissions is particularly appropriate: reciprocity. By using the metrics in its decisionmaking proceedings, Michigan can help build a precedent for other states to follow. As Michigan helps encourage other jurisdictions to likewise weigh the social cost of greenhouse gases in their decisions, Michigan will benefit as other jurisdictions' emissions are reduced. Because greenhouse gases do not stay within geographic borders, but rather mix in the earth's atmosphere and affect climate worldwide, greenhouse gases emitted outside Michigan contribute directly to climate damages in Michigan (just as Michigan's emissions contribute directly to climate damages outside Michigan). Michigan stands to benefit greatly as other U.S. states apply a global social cost of greenhouse gas value to their energy policy decisions and so weigh the externalities of their emissions that will fall on Michigan. It is therefore rational for Michigan to use the social cost of greenhouse gases in its own decisionmaking, because it will encourage other states to follow suit.[12]

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[12] *See* Peter Howard & Jason Schwartz, *Think Global: International Reciprocity as Justification for a Global Social Cost of Carbon*, 42 Columb. J. Envtl. L. 203 (2017); Jason A. Schwartz, *Strategically Estimating Climate Pollution Costs in a Global Environment* n.34 (Policy Integrity Report, June 2021), https://policyintegrity.org/files/publications/Strategically_Estimating_Climate_Pollution_Costs_in_a_Global_Environment.pdf (making the case for state-level reciprocity).

Several U.S. states already apply the federal Interagency Working Group's methodology in their energy policy decisions, including Colorado, Nevada, Minnesota, California, Washington, and others. (See *infra* for more on how other states are valuing the social cost of greenhouse gases.) Michigan should join those states as a leader in climate policy by considering the social cost of greenhouse gases in its decisionmaking, and so encourage additional states to follow suit—which in turn will benefit Michigan.

Q. How are climate effects monetized using the social cost of greenhouse gas methodology?

A. Economists 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 emitted from any source anywhere in the world (such as from burning oil or operating tunnel-boring equipment) 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. The resulting monetary estimate of how each additional unit of greenhouse gases will impact our health, our economic activity, our quality of life, and our overall well-being is called the social cost of greenhouse gases.

Q. Is there a consensus among scientists, economists, and other experts on the best methodology for monetizing climate damages from greenhouse gas emissions?

A. Yes. The methodology and estimates developed by the federal Interagency Working Group on the Social Cost of Greenhouse Gases, published most recently in February 2021, is widely considered to be the best available calculation of the social cost of greenhouse gases, even though it is also widely considered to be a conservative underestimate of true costs of climate change.[13]

In 2009, an Interagency Working Group assembled experts from a dozen federal agencies and White House offices to "estimate the monetized damages associated with an incremental increase in [greenhouse gas] emissions in a given year" based on "a defensible set of input assumptions that are grounded in the existing scientific and economic literature."[14] The estimates are based on the three most cited, most peer-reviewed models built to link physical impacts to the economic damages of each additional ton of greenhouse gas emissions. Those three leading integrated assessment models are DICE (by Nobel laureate William Nordhaus of Yale University), FUND (by Richard Tol and David Anthoff of Sussex University and University of California-Berkeley), and PAGE (by Chris Hope of Cambridge University). These models are able to estimate and monetize many[15] of the most important categories of climate damages, including, but not limited to: energy system losses and disruptions; air quality and water quality changes and associated impacts to human health; fresh water supply losses; impacts to forestry, fisheries, and agriculture; property damage; biodiversity losses and ecosystem service impacts; impacts to outdoor recreation and other non-market amenities; and catastrophic impacts.

The Working Group ran these models using inputs and reasonable assumptions drawn from the peer-reviewed literature, and the Working Group updated its estimates every few years—most recently in February 2021—to reflect the latest and best scientific

[13] *See* IWG, 2021 TSD, *supra* note 4, at 4 (admitting that its own estimates "likely underestimate societal damages from GHG emissions").

[14] IWG, 2010 TSD, *supra* note 11.

[15] *See supra* notes 2-3 & 11 and accompanying text for details on which categories are or are not currently included.

and economic data.[16] From early 2017 through January 2021, the Trump Administration disbanded the Working Group, and during that period some agencies developed much lower "interim" estimates of the social cost of greenhouse gases.[17] In 2020, a federal court found those "interim" estimates to be arbitrarily and illegally inconsistent with the best available science and economics;[18] a report by the U.S. Governmental Accountability Office (GAO) similarly concluded that those "interim" estimates had no process for ensuring consistency with the best available science and economics.[19] In 2021, the Biden Administration reconstituted the Working Group, which quickly readopted the prior values from 2016 (adjusting them for inflation into 2020$).[20] The Working Group expects to more thoroughly update the estimates by January 2022, and in particular has expressed a need to reexamine the selection of the discount rate.[21]

Q. What discount rates did the Working Group select, and what range of estimates has the Working Group issued?

A. For each greenhouse gas (i.e., carbon dioxide, methane, nitrous oxide), the Working Group has issued a "central estimate" of social costs per metric ton of emissions per year based on a 3% discount rate and taking the average from a probability distribution; a "high-impact estimate" based on the 95th percentile of that probability distribution calculated at a 3% discount rate; as well as additional estimates that explore the calculation's sensitivity to a

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[16] IWG, 2021 TSD, *supra* note 4.

[17] *See* Policy Integrity, *How the Trump Administration Is Obscuring the Costs of Climate Change* (2018), https://policyintegrity.org/files/publications/Obscuring_Costs_of_Climage_Change_Issue_Brief.pdf.

[18] California v. Bernhardt, 472 F.Supp.3d 573, 611-14 (N.D.Cal. 2020).

[19] GAO, GAO-20-254, *Social Cost of Carbon: Identifying a Federal Entity to address the National Academies' Recommendations Could Strengthen Regulatory Analysis* 29 (2020) (concluding that the "interim" estimates "may not be well positioned to ensure agencies' future regulatory analyses are using the best available science").

[20] IWG, 2021 TSD, *supra* note 4.

[21] *Id.*

lower (2.5%) or higher (5%) discount rate.[22] Discount rates are important because of the nature of greenhouse gases and climate change. Once emitted, greenhouse gases can linger in the atmosphere for centuries, building up the concentration of radiative-forcing pollution and affecting the climate in cumulative, non-linear ways.[23] The integrated assessment models project future climate damages over roughly a 300-year timescale. However, society tends to value economic effects today more than future effects.[24] A discount rate is used to take all the marginal climate damages that an additional ton of emissions emitted in the near future will inflict over the next 300 years, and translate those future damages back into present-day values.

Since its founding in 2009 through its most recent updated guidance, the Working Group has chosen a 3% discount rate for its central estimate based on available data and historical precedents on federal agencies' default choice of discount rates.

Q. Is the Working Group's choice of discount rates appropriate, and should other discount rates be considered?

A. Though the choice of a 3% central discount rate was appropriate as a conservative selection a decade ago, more recently updated market data on U.S. Treasury rates, consumer saving rates, and economic forecasts—as well as updated economic literature on uncertainty, correlations between climate damages and economic growth, preferences for inter-

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[22] *See generally* 2010 TSD, *supra* note 11. The 5% discount rate was selected as an "upper value" to reflect "possibility that climate damages are positively correlated with market returns," *id.* at 23, while the 2.5% rate was used to reflect the fact that "interest rates are highly uncertain over time," *id.*

[23] Carbon dioxide also has cumulative effects on ocean acidification, in addition to cumulative radiative-forcing.

[24] However, many experts on climate policy and economics believe that a non-zero rate of time preference is inappropriate in the context of long-term climate change, because society really does not or should not care less about the welfare of future generations. *See* Richard Revesz & Matthew Shahabian, *Climate Change and Future Generations*, 84 S. Cal. L. Rev. 1097 (2011).

generational equity, expert elicitations, and other technical concepts[25]—all point strongly in the direction of a lower discount rate being more appropriate. Based on such economic and ethical considerations, New York has already moved to estimates based on a 2% discount rate (calculated through a methodology otherwise based on and consistent with the Working Group's estimates), and Washington and Colorado have adopted the Working Group's estimates at 2.5%.[26] In February 2021, the Working Group expressed that a rate of 2.5% *or lower* may be appropriate, and the Working Group will revisit its choice of discount rates when it updates its values in January 2022.[27] For that reason, this testimony shows both the Working Group's estimates at the 3% and 2.5% discount rates, but cautions that even the 2.5% estimates are likely conservative underestimates because the most appropriate discount rate is likely at or below 2%.[28] To further address this potential source of underestimation, we also ran the analysis using New York State's valuations of the social cost of carbon dioxide at a 2% discount rate, though these estimates are available only through the year 2050.

Q. What are the values of the social cost of carbon dioxide over time?

A. The social cost of greenhouse gases increases over time, because an additional ton of emissions will inflict greater damages in the future as emissions accumulate in the atmosphere and climate and economic systems become increasingly stressed. The following table shows the Interagency Working Group's estimates for the social cost of

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[25] Howard & Schwartz, *About Time*, *supra* note 4.

[26] N.Y. Dep't of Envtl. Conserv., Establishing a Value of Carbon: Guidelines for Use by State Agencies 18 (2020; revised 2021), https://www.dec.ny.gov/docs/administration_pdf/vocguidrev.pdf; Wash. Dept. of Commerce, *Recommendation for Standardizing the Social Cost of Carbon When Used for Public Decision-Making Processes* (2014) http://www.commerce.wa.gov/wp-content/uploads/2015/11/Energy-EV-Planning-Social-Cost-of-Carbon-Sept-2014.pdf; Colo. H.B. 21-1238 (2021).

[27] 2021 TSD, *supra* note 4, at 21, 35.

[28] *See* Howard & Schwartz About Time, *supra* note 4.

carbon, by year of emissions, calculated at both the 3% and 2.5% discount rates, as well as corresponding social cost of carbon dioxide estimates calculated at the 2% rate by New York State in a manner consistent with the Working Group's method.

Importantly, the Working Group's central estimate omits key categories of climate damages—like many of the risks of catastrophic and irreversible consequences, including environmental and social "tipping points." The Working Group developed a set of high-impact estimates (calculated at the 95th-percentile of the probability distribution for the 3% discount rate estimates), which serve as a partial proxy for, among other things, omitted catastrophic damages, risk aversion, and other uncertainties.[29] Policy decisions should therefore be informed by the Working Group's full range of estimates, and the high-impact estimates are provided in the following table as well.

The Working Group's most recent set of estimates, published in February 2021, run through year 2050. Recently, in June 2021, the U.S. Environmental Protection Agency (EPA)—a key member of the Working Group—extended the Working Group's estimates from 2050 out through year 2070. New York's estimates are currently available only through year 2050.

[29] IWG, 2010 TSD, *supra* note 11, at 25, 30.

Table 1. Social Cost of Carbon Dioxide Estimates (in 2020$, per metric ton)[30]

Year	IWG/EPA's Central Estimates at a 3% Discount Rate	IWG/EPA's Estimates at a 2.5% Discount Rate	New York's Central Estimates at a 2.0% Discount Rate	IWG/EPA's High Impact Estimates (95th-percentile at a 3% discount rate)
2020	$51	$76	$121	$152
2025	$56	$83	$129	$169
2030	$62	$89	$137	$187
2035	$67	$96	$146	$206
2040	$73	$103	$154	$225
2045	$79	$110	$164	$242
2050	$85	$116	$172	$260
2060	$94	$128	*not available*	$276
2070	$108	$144	*not available*	$328

Q. Have the Working Group's estimates been reviewed by third parties?

A. Yes, the Working Group's estimates have been repeatedly endorsed by reviewers. In 2014, the U.S. Government Accountability Office reviewed the Working Group'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.[31] In 2016, the U.S. Court of Appeals for the Seventh Circuit held that estimates of the social cost of carbon used to date by agencies were reasonable.[32] In 2016 and 2017, the National Academies of Sciences issued two reports that, while recommending future improvements to the methodology,

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[30] The table shows rounded figures. Unrounded values are available at https://www.whitehouse.gov/wp-content/uploads/2021/02/tsd_2021_annual_unrounded.csv. *See* IWG, 2021 TSD, *supra* note 4; EPA, *Social Cost of Greenhouse Gases (SC-GHGs) Unrounded Annual Estimates through 2070*, June 2021 https://www.regulations.gov/document/EPA-HQ-OAR-2021-0208-0161; N.Y. Dep't of Envtl. Conserv., *supra* note 26.

[31] Gov't Accountability Office, *Regulatory Impact Analysis: Development of Social Cost of Carbon Estimates* 12-19 (2014).

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

supported the continued use of the existing Working Group estimates.[33] In 2020, the U.S. District Court for the Northern District of California held that by breaking from the Working Group's estimates, the Trump Administration had ignored the best available science and economics.[34] It is, therefore, unsurprising that scores of economists and climate policy experts have endorsed the Working Group's values as the best available estimates, even while stressing that the estimates are conservative underestimates.[35] The Working Group's estimates have been used in well over 100 federal regulatory proceedings, and counting, each subject to a thorough public comment period.[36]

Q. Do other states use the Working Group's estimates for the social cost of greenhouse gases?

A. A number of states have recognized the importance of considering the social cost of carbon estimates and have begun using the federal Interagency Working Group's estimates or methodology to measure the harms from carbon dioxide emissions in their proceedings. States that consider the damage of carbon dioxide emissions in various energy and climate policy proceedings include Colorado, Minnesota, Nevada, Virginia, Washington, California, Illinois, Maine, New Jersey, New Mexico, and New York.[37] Notably, all states that have to date incorporated or are considering incorporating the social cost of greenhouse

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[33] 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).

[34] California v. Bernhardt, 472 F.Supp.3d at 611-14.

[35] *See, e.g.*, Joseph E. Aldy et al., *Keep Climate Policy Focused on the Social Cost of Carbon*, 373 SCIENCE 950 (2021); 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).

[36] *See* Howard & Schwartz, *Think Global*, *supra* note 12, App. A (cataloguing uses in federal proceeding).

[37] *See* Cost of Carbon, States Using the SCC, https://costofcarbon.org/states.

gases into their electricity decisionmaking have relied at least in part—and, more often, exclusively—on the Interagency Working Group's numbers or methodology.

A few key examples are worth exploring in more detail. Several states have decided to focus on estimates that are greater than the Working Group's "central" estimates calculated at the 3% discount rate. As mentioned above, New York States has adapted the Working Group's methodology but applied a 2% discount rate, to be consistent with more recent economic data and also to help offset the fact that the social cost of greenhouse gases is underestimated because many significant categories of climate damages cannot currently be estimated due to data limitations.[38] Back in 2014, Washington decided to focus on the Working Group's estimates at the 2.5% discount rate for similar reasons, and to fulfill ethical obligations to future generations and maintain Washington's role as a leader on climate change.[39] Colorado also requires its gas and electricity utilities to focus on the 2.5% estimates.[40] Similarly, California's Public Utilities Commission requires consideration of the Working Group's high-impact estimates,[41] because many of the climate damage categories most relevant to the state's energy infrastructure and economy—such as wildfires, thermal efficiency decreases, and overheating of electricity system components—are not fully incorporated into the central estimates of the social cost of carbon.[42]

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[38] N.Y. Dep't of Envtl. Conserv., *supra* note 26, at 18-19.

[39] Wash. Dept. of Commerce, *supra* note 26, at 3-5.

[40] Colo. HB 21-1238, *supra* note 26.

[41] Before the Cal. PUC, 19-05-019, Decision Adopting Cost-Effectiveness Analysis Framework Policies for All Distributed Energy Resources at 42 (May 16, 2019), http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M293/K833/293833387.PDF.

[42] *See* Before the Cal. PUC, ALJ's Ruling Seeking Responses to Questions and Comment on Staff Amended Proposal on Societal Cost Test (Mar. 14, 2018), http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M212/K023/212023660.PDF.

Michigan should join these states as a climate leader by considering the Working Group's estimates—including high-impact estimates and estimates at lower discount rates—as it weighs the impairment caused by the Proposed Project's pollution and the comparative prudence of the no-action alternative. As the Governor recently recognized in an Executive Directive, "Michigan must be a leader in this fight."[43]

Q. Why is a global perspective necessary and appropriate when valuing the social cost of greenhouse gas emissions?

A. Several reasons explain why a full accounting of climate costs requires a global estimate of the social cost of greenhouse gases. First, the principles of reciprocity discussed above dictate the need for a global perspective. Michigan cannot solve climate change on its own, and Michigan benefits tremendously when other states and other countries reduce their greenhouse gas emissions. In prioritizing the actions that Michigan should take to contribute to the global efforts to combat climate change, Michigan should think about the climate damages it inflicts on the rest of the world, just as Michigan would want the rest of the world to think about the damages their actions cause to Michigan's air, water, natural resources, and public trust. As Michigan recognized when joining the U.S. Climate Alliance:

> Smart, coordinated state action can ensure that the United States continues to contribute to the global effort to address climate change.…Alliance members are committed to supporting the international agreement, and are pursuing climate action to make progress toward its goals. It is time for Michigan to join the effort.[44]

To encourage other jurisdictions to continue to take account of the externalities of their emissions impose on Michigan, Michigan must likewise take account of the

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[43] Gov. Gretchen Whitmer, Executive Directive 2020-10: Building a Carbon-Neutral Michigan (Sept. 23, 2020).

[44] Gov. Gretchen Whitmer, Executive Directive 2019-12: Responding to Climate Change (Feb. 4, 2019).

externalities of its emissions that fall outside state borders. The fragile tit-for-tat dynamic could fall apart in the face of too many jurisdictions turning a blind eye to their global externalities and considering only local effects. For example, soon after the Trump administration reversed course and developed its own, flawed, domestic-only "interim" values of the social cost of greenhouse gases, the country of Mexico also moved toward considering only domestic climate impacts in its regulatory analyses.[45] To secure the reciprocal level of efficient action of greenhouse gas emissions, Michigan should follow the lead of Colorado, Minnesota, Nevada, and other states, and use a global number.

Second, climate damages do not respect political borders. The people of Michigan have financial and personal interests in businesses and property located outside Michigan that may be affected by climate change. Michigan's businesses depend on non-local economies to buy their exports, sell imports, and fill their supply chains. If rising temperatures and rising seas cause climate refugees or infectious disease vectors to migrate toward or within the United States, Michigan will feel the impacts along with the rest of the country. Michigan's economy, public health, and security are all linked to globally interconnected systems. Because climate damages occurring outside Michigan borders can spill over and affect the people of Michigan, a global perspective on the social cost of greenhouse gases is required.[46] In fact, a federal judge recently found it was arbitrary and illegal to focus on climate effects occurring only within strict geographic borders given that effects occurring beyond those borders will spill back and inflict local economic, health, and security damages.[47]

[45] *See* Schwartz, *Strategically Estimating Climate Pollution Costs in a Global Environment*, *supra* note 12, at n.38.

[46] *See id;* Howard & Schwartz, *Think Global*, *supra* note 12.

[47] California v. Bernhardt, 472 F.Supp.3d at 611-14.

Finally, no existing methodology can calculate accurately a domestic-only estimate. The models simply were not designed to produce such estimates: for example, the models do not account for any inter-regional spillover effects. Any approximate and speculative estimate based on factors like percentage of global GDP, or share of global coastline or landmass, will be inherently misleading, as they ignore inter-regional spillover effects and extraterritorial interests of citizens.[48] While many scientists can and do describe the impact of climate change on natural resources in Michigan,[49] and there is no question that specific natural resources in Michigan will be impacted in individual ways, there is no Michigan-only estimate of the social cost of greenhouse gases; only global estimates.[50]

Every state that has begun to incorporate the social cost of greenhouse gases is using a global damage estimate. Attempting to apply a Michigan-specific estimate would be akin to a homeowner throwing trash in her neighbor's yard without considering the odors and pests that will spill back to her own property, or how the neighbor might retaliate in kind.

Q. What quantitative figures do you use to monetize the climate damages from the Proposed Project's emissions?

A. We take as given Peter A. Erickson's quantitative estimates of the metric tons of carbon dioxide-equivalent[51] emissions that the Proposed Project's construction and operation will

[48] *See* Schwartz, *Strategically Estimating Climate Pollution Costs in a Global Environment*, *supra* note 12, at 29 (explaining, for example, that the coastline-based scaling would absurdly suggest that landlocked or non-coastal states have a zero valuation of the social cost of greenhouse gases).

[49] *See, e.g.,* Direct Testimony of Dr. Overpeck.

[50] *See e.g.,* Joint Comments to U.S. Forest Service on Use of Social Cost of Carbon in Colorado Roadless Rule, at 11-14 (Jan. 15, 2016), *available at* http://policyintegrity.org/documents/Forest_Service_SDEIS_comments.pdf (explaining, for example, that there is no national-, Colorado-, or forest-only estimate of the social cost of carbon).

[51] Erickson presents his quantitative figures in carbon dioxide-equivalent totals, using a relative global warming potential for methane as 29.8 over a 100-year timeframe. Considering the nearer-term relative potency of methane, however, puts methane's relative global warming potential much higher, at 82.5 over a 20-year timeframe. *See* IPCC, AR6: Chapter 7, at 7-125 (2021). Ultimately, because of different lifespans and other atmospheric interactions, it is

generate, and the lifecycle emissions from the oil and gas products transported by the Proposed Project relative to emissions under the no-action scenario. As Erickson's testimony explains, his figures could under- or over-estimate some emissions, and overall Erickson's testimony states that its results may be conservative.

Q. How did you monetize the climate costs from construction of the Proposed Project, and what assumptions did you make about the Proposed Project's construction timeline?

A. Because the social cost of carbon dioxide increases over time, we must place Erickson's quantitative estimates into specific calendar years. To do this, we assume that it could take about another six years from 2021 for the Proposed Project to clear the remaining environmental reviews and other procedures before construction could begin in 2027.[52] Then based on Enbridge's estimate of a two-year construction period,[53] we assume construction will be completed from 2027-2028, and we assume that Erickson's calculation of 87,000 metric tons of carbon dioxide-equivalent emissions from construction would be split equally between 2027 and 2028 (i.e., 43,500 metric tons per year). We then multiplied these annual construction emissions by the corresponding year's estimates of the social cost of carbon dioxide, considering the four sets of values defined above (3%, 2.5%, 2%, and high-impact). We then discounted these future damage estimates back to their present-

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somewhat more accurate to directly estimate the social cost of methane rather than to convert tons of methane into carbon dioxide-equivalents using relative global warming potentials. The Working Group has developed estimates for the social cost of methane, which range from about 29-37 times greater than the social cost of carbon estimate for the corresponding year. IWG, 2021 TSD, *supra* note 4, at 5. However, given the tons of methane at stake here compared to the tons of carbon dioxide, using the social cost of methane would not be significantly different from using the global warming potential-adjusted figures here.

[52] *See* U.S. Council on Environmental Quality, *Environmental Impact Statement Timelines (2010-2018)* at 8 (2020), https://ceq.doe.gov/docs/nepa-practice/CEQ_EIS_Timeline_Report_2020-6-12.pdf (noting that U.S. Army Corps of Engineers-approved projects take about 6 years to complete environmental review).

[53] Enbridge, *Line 5 Straits of Mackinac Crossing* at 2, https://www.enbridge.com/~/media/Enb/Documents/Factsheets/FS_Line5_Straits_tunnel_project.pdf?la=en.

day value in the current year of 2021 using the discount rate that corresponds to the underlying rate used to calculate the relevant social cost of carbon values (i.e., a 2.5% discount rate is used when applying the social cost of carbon values calculated at a 2.5% rate).

Q. How did you monetize the climate costs from operation of the Proposed Project, including costs for emissions occurring after the year 2070?

A. Following Erickson's calculations, we assume that the Proposed Project's annual operating emissions are 520 metric tons of carbon dioxide-equivalents, and that the Proposed Project's lifespan was 99 years. Therefore, if we assume construction will end in 2028 and operations will begin in 2029, operations will continue through to at least 2127.

Neither the social cost of carbon dioxide estimates published by the federal government or those issued by New York are available through 2127. The federal Interagency Working Group's latest estimates run through 2050, though EPA has extended this analysis through to 2070. New York's estimates run through 2050.

However, estimates of the social cost of carbon dioxide grow at relatively stable rates over time. As such, we can extend the Working Group/EPA's estimates beyond 2070 to 2127 using linear extrapolation. We select linear extrapolation over other alternatives (such as polynomial and box-cox transformation) as these more flexible alternative functions are essentially linear for the average social cost of carbon estimates corresponding to the 3% and 2.5% discount rates, avoids overfitting the model based on its simplicity, and produces a lower-bound approximation. The projected, extrapolated values through 2127 are available in Exhibit PH-2 and the extrapolation code is available in Exhibit PH-3.

Given the different timeframes during which different estimates of the social cost of carbon dioxide are available, we have made calculations based on three separate time periods. Our central estimates are calculated for emissions occurring over the time period 2027-2070, using EPA's estimates of the social cost of carbon. However, we also calculate from 2027-2050, to limit the estimate to the Working Group's set of values. And we also calculate from 2027-2127, applying our extrapolation of social cost of carbon dioxide figures into the future.

Q: What is your estimate of the climate costs from the construction and operation of the Proposed Project?

A: From 2027 to 2070, the climate costs of the Proposed Project's emissions from the construction and operation of the pipeline equals $5.0 million dollars when applying the social cost of carbon values calculated at the 3% discount rate. 84% of these effects stem from the pipeline's construction. Using the 2.5% discount rate and the high-impact SCC estimate increases the joint GHG cost of construction and operation up to $7.6 million and $15.2 million, respectively. A longer timeline to 2127 slightly increases the GHG cost estimates, as does using a lower discount rate of 2%. Considering these issues jointly could increase these cost estimates to approximately $13 million. See the attached spreadsheet (Exhibit PH-2) for a more complete breakdown of climate costs associated with various emissions sources. However, as explained above, the per-ton monetized damages from carbon dioxide does not change depending on the source of emissions. From an economic perspective, it does not matter whether a ton of carbon dioxide is emitted by construction, operation, or downstream combustion of transported products—all those emissions will cause climate damages. Basic economic principles of supply and demand indicate that construction and operation of the Proposed Project will increase the net supply and demand of oil and gas products, and so increase net lifecycle emissions from the production, transport, and combustion of those oil and gas products. All those emissions can and should be monetized as well.

Q. Mr. Erickson also estimated incremental greenhouse gas emissions resulting from the transport of oil and NGL through the Proposed Project, as compared to a no-action alternative. How did you monetize the net climate costs from the products delivered by the Proposed Project, as compared to emissions under the no-action alternative?

A. Following Erickson's testimony, we assumed a net increase of 27 million metric tons of greenhouse gas emissions (CO2e) annually from the fuel transported by the pipeline, as compared to emissions under the no-action alternative. As explained above for operational emissions, we assumed that the lifespan of the pipeline will be at least 99 years, such that the pipeline will begin transporting oil and gas in 2029, and run through at least 2127. Given those assumptions, the monetization of lifecycle emissions from the transported products is then identical to above.

Q. What are the total monetized climate costs of the Proposed Project's emissions from construction and operation and the lifecycle emissions from additional oil and gas products transported by the Proposed Project?

A. As explained above, we use the federal Interagency Working Group's estimates of the social cost of carbon calculated at a 3% discount rate, and extended by EPA through year 2070, for our main, conservative estimate. But we also test our calculation's sensitivity to using other social cost of carbon figures (specifically, estimates at the 2.5% and 2% discount rates, and the Working Group's high-impact estimates), as well as over different time periods (through 2050, or through 2127). In all cases, we discount future effects back to present value as of 2021. For undiscounted totals, estimates additional discount rates (0%, 1%, and 5%), and breakdowns of estimates by construction source or lifecycle stage, please see Exhibit PH-2.

Table 3. Total Value of the Proposed Project's Net Monetized Climate Costs (Present Value in 2021; in 2020$)

Time Period	Estimate of the Social Cost of Carbon Dioxide			
	IWG/EPA's Central 3% Estimates	IWG/EPA's 2.5% Estimates	New York's Central 2% Estimates	IWG/EPA's High Impact Estimates
2027-2050	$24.95 billion	$38.45 billion	$63.24 billion (154% higher than the 3% estimate)	$76.24 billion
2027-2070	**$41.02 billion**	$64.95 billion	*not directly available; an assumed 154% increase would total $104.00 billion*	$124.38 billion
2027-2127	$63.38 billion	$106.84 billion	*not directly available; an assumed 154% increase would total $160.68 billion*	$191.45 billion

Q. Is your monetization of the environmental costs of the Proposed Project a conservative estimate?

A. Yes, our estimate of $41 billion in net present value climate costs from the Proposed Project's emissions from 2027 through 2070, calculated using the 3% social cost of carbon figures, is a very conservative for several reasons.[54]

[54] Again, this analysis takes as given the quantified totals from Erickson's testimony. The monetized totals presented here may be under- or over-estimates to the extent those quantified totals are under- or over-estimates.

First, the pipeline is expected to have at least a 99-year lifespan, implying an end date of 2127, not 2070. Extrapolating and applying the 3% social cost of carbon estimates through 2127 would increase the net present value from $41 billion to $63 billion.

Second, as discussed above, considerable recent evidence strongly points to a discount rate below 3%, of 2% or lower. If the Working Group's 2.5% estimates are applied over the 2027-2070 period rather than the 3% figures, the net present value of climate costs would increase to almost $65 billion. Similarly, over the shorter 2027-2050 time period, moving from the 3% estimates to New York's estimates of the social cost of carbon at a 2% discount rate would increase the net present value of the project's climate costs by 154% (from $25 billion to $63 billion). If that same relative percentage increase holds true over the longer analysis period of 2027-2127, then we can predict that applying 2% social cost of carbon figures over the 2027-2127 period instead of the 3% figures would increase the net present total value to over $160 billion.[55] Even this may be a low estimate, as some recent evidence supports a discount rate below 2%.

Third, the methodology for calculating the social cost of greenhouse gases currently excludes many significant health, environmental, and welfare impacts due to data limitations, such as:

- Wildfires, including acreage burned, health impacts from smoke, property losses, and deaths;
- Agricultural impacts, including food price spikes and changes from heat and precipitation extremes;

[55] That is, a 154% increase of $63.38 billion = 63.38 billion * (1+1.54) = 160.65 billion.

- Death, injuries, and illnesses from omitted natural disasters and interruptions in the supply of water, food, sanitation, and shelter;
- Impacts on labor productivity from extreme heat and weather;
- Catastrophic impacts and tipping points, including rapid sea level rise and damages at very high temperatures;
- Ocean acidification and extreme weather effects on fisheries and coral reefs;
- Biodiversity and habitat loss, and species extinction;
- Changes in land and ocean transportation;
- National security impacts from regional conflict, including from refugee migration stemming from extreme weather and from food, water, and land scarcity;
- And many more categories.[56]

Consequently, while the Working Group's estimates remain among the best available for government decisionmakers to use, they are widely acknowledged to be underestimates, perhaps severely so.[57] To proxy for these omitted impacts, the Working Group has recommended considering its high-impact estimates. Over the 2027-2127

[56] Howard, *Omitted Damages*, *supra* note 11. For more on wildfires specifically, see Peter H. Howard, *Flammable Planet: Wildfires and the Social Cost of Carbon* (Policy Integrity/Cost of Carbon Report, 2014), https://costofcarbon.org/files/Flammable_Planet__Wildfires_and_Social_Cost_of_Carbon.pdf. For other lists of actual climate effects, including air quality mortality, extreme temperature mortality, lost labor productivity, harmful algal blooms, spread of West Nile virus, damage to roads and other infrastructure, effects on urban drainage, damage to coastal property, electricity demand and supply effects, water supply and quality effects, inland flooding, lost winter recreation, effects on agriculture and fish, lost ecosystem services from coral reefs, and wildfires, *see* EPA, *Multi-Model Framework for Quantitative Sectoral Impacts Analysis: A Technical Report for the Fourth National Climate Assessment* (2017); U.S. Global Change Research Program, *Climate Science Special Report: Fourth National Climate Assessment* (2017); EPA, *Climate Change in the United States: Benefits of Global Action* (2015); Union of Concerned Scientists, *Underwater: Rising Seas, Chronic Floods, and the Implications for U.S. Coastal Real Estate* (2018).

[57] *See* Revesz et al., *Global Warming: Improve Economic Models of Climate Change*, *supra* note 4.

timeframe, applying the high-impact estimates would calculate total net present climate damages as $194 billion. Note that this estimate would be even higher if the 95th percentile of the probability distribution associated with a 2% discount rate were taken, instead of the 95th percentile for the 3% rate's distribution that the Working Group used.

Finally, these estimates cover climate only damages from greenhouse gas emissions. But the construction and operation of the Proposed Project, as well as the production and combustion of products delivered by the Proposed Project, will emit a variety of other harmful air emissions and also have other impacts to water and natural resources. Some of those additional environmental impacts could be monetized with additional data collection and analysis; others cannot currently be quantified or monetized but may still be highly significant and should be considered. Their omission from this analysis further confirms that the estimate of $41 billion in damages is a conservative underestimate of the Proposed Project's environmental externalities.

Q. Does this conclude your testimony?

A. Yes.

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Institute for Policy Integrity, New York University School of Law
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Regulation's proposed surface water regulations; estimate the economic cost of fumigant and emulsifiable concentrate regulations in Fresno County, California; estimate the economic cost to California agriculture of the non-registration of methyl iodide; estimate the economic cost of fumigant regulations in Ventura County, California; estimate the economic cost to California agriculture of California Department of Pesticide Regulation's VOC regulations
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Supervisor: Kris Feder

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WORKING PAPERS

Between Two Worlds: Methodological and Subjective Differences in Climate Impact Meta-Analyses
Peter Howard and Thomas Sterner

Option value and the social cost of carbon: What are we waiting for?
Peter Howard, Alexander Golub, and Oleg Lugovoy

The Relative Price of Agriculture: The Effect of Food Security on the Social Cost of Carbon
Peter Howard and Thomas Sterner

Optimal Preservation of Private Open Space within a Municipality under Irreversibility and Uncertainty
Peter Howard

Measuring the Welfare Loss to Landowners of Future Geographic Shifts in the Suitable Habitat for Vegetation Due to Climate Change
Peter Howard

PRESENTATIONS AND POSTERS

Between Two Worlds:: Methodological and Subjective Differences in Climate Impact Meta-Analyses
Peter Howard and Thomas Sterner, 2020 AERE Summer Conference

Option value and the social cost of carbon: What are we waiting for?
Peter Howard, Alexander Golub, and Oleg Lugovoy, 2020 AERE Summer Conference

Between Two Worlds:: Methodological and Subjective Differences in Climate Impact Meta-Analyses
Peter Howard and Thomas Sterner, 13th Annual Meeting of EfD- in Colombia

Option value and the social cost of carbon: What are we waiting for?
Peter Howard, Alexander Golub, and Oleg Lugovoy, 2019 SISC Annual Conference

Two Heads are Better than One: Using Economic Consensus to Address Positive and Normative Uncertainties in Climate-Economic Models
Peter Howard and Derek Sylvan, 2018 at 2018 World Congress of Environmental and Resource Economists

Wisdom of the Experts: Using Economic Consensus to Address Positive and Normative Uncertainties in Climate-Economic Models
Peter Howard and Derek Sylvan, 2018 at Environmental Defense Fund

The Wisdom of the Economic Crowd: Calibrating Integrate Assessment Models Using Consensus
Peter Howard and Derek Sylvan, 2016 AAEA Annual Meeting

Few and Not So Far Between: A Meta-analysis of Climate Damage Estimates
Peter Howard and Derek Sylvan, 2016 AAEA Annual Meeting

Few and Not So Far Between: A Meta-analysis of Climate Damage Estimates
Peter Howard and Derek Sylvan, 2016 EAERE Annual Meeting

Comments on the 2017-2022 Outer Continual Shelf (OCS) Oil and Gas Leasing Program
Peter Howard, Invited speaker to BOEM's Energy Supply/Demand Modeling, Market Substitutions, and Implications of Downstream GHGs/Climate Policy Change. June 2016.

The Economic Climate: Establishing Expert Consensus on the Economics of Climate Change
Peter Howard, Invited speaker to Bard College's Environmental and Urban Studies Colloquium

The Economic Climate: Establishing Expert Consensus on the Economics of Climate Change
Peter Howard and Derek Sylvan, 2015 AAEA Annual Meeting

Estimating the Option Value of Offshore Drilling in United States' OCS Regions
Peter Howard, 2015 Society for BCA Conference

The Social Cost of Carbon: How the Federal Government Values Carbon Dioxide Emissions
Peter Howard, 2015 Climate Leadership Conference sponsored by the Environmental Protection Agency

What's the Cost of Climate Change? How to Improve the Social Cost of Carbon
Peter Howard, Invited Speaker to Bard College

Raising the Temperature on Food Prices: Climate Change, Food Security, and the Social Cost of Carbon
Peter Howard and Thomas Sterner, 2014 AAEA Annual Meeting

Loaded DICE: Refining the Meta-analysis Approach to Calibrating Climate Damage Functions
Peter Howard and Thomas Sterner, 2014 AAEA Annual Meeting

The Relative Price of Agriculture: the Effect of Food Security on the Social Cost of Carbon
Peter Howard and Thomas Sterner, 2013 AAEA & CAES Joint Annual Meeting

The Relative Price of Agriculture: the Effect of Food Security on the Social Cost of Carbon
Peter Howard and Thomas Sterner, 2013 AERE Summer Conference

The Relative Price of Agriculture: the Effect of Food Security on the Social Cost of Carbon
Peter Howard, 2013 Society for BCA Conference

Climate Change, Vegetation, and Welfare: Estimating the Welfare Loss to Landowners of Marginal Shifts in Blue Oak Habitat
Peter Howard, 2012 AAEA Annual Meeting

Are Pesticide Buffers Expensive? Using Positive Mathematical Programming to Estimate the Cost of Proposed Pesticide Buffers in California

Peter Howard, Rachael Goodhue, Pierre Mérel. 2012 AAEA Annual Meeting

Optimal Preservation of Agricultural and Environmental Land within a Municipality Under Irreversibility and Uncertainty
Peter Howard, 2011 AAEA & NAREA Joint Annual Meeting

Measuring the Welfare Loss to Landowners of Future Geographic Shifts in the Suitable Habitat for Vegetation Due to Climate Change
Peter Howard, 2011 AERE Summer Conference

Optimal Preservation of Oak Woodlands within a Municipality
Peter Howard, 12th Occasional California Workshop on Environmental and Resource Economics (2010)

Optimal Preservation of Oak Woodlands within a Municipality
Peter Howard, 2010 Belpasso International Summer School on Environmental and Resource Economics, Sicily

Optimal Preservation of Oak Woodlands within a California Municipality
Peter Howard, 2010 Giannini ARE Student Conference

Optimal Preservation of Oak Woodlands within a California Municipality
Peter Howard, 2010 UCD Brown Bag Presentation

Should More California Oak Habitat Be Protected Because of Global Warming?
Peter Howard, 2009 AAEA & ACCI Joint Annual Meeting

The Economic Effects of Regulations to Reduce VOC Emissions from Pesticides: The Case of Fumigants
Peter Howard, 40th California Nematology Workshop (2008)

EXPERT TESTIMONY

Presentation of "Meta-Regression of Global Climate Damages" to the Interagency Working Group on the Social Cost of Greenhouse Gases
Peter H Howard and Thomas Sterner, August 2021

Report on Colorado's Zero Emission Vehicle Program Submitted to the Colorado Air Quality Control Commission
Peter H Howard and Jason A Schwartz, October 2018

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Peter Howard, April 2019

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Peter H Howard and Jason A Schwartz, October 2018

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Peter Howard, May 2018

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Peter Howard, 2017

Meeting with the Office of Information and Regulatory Affairs
Peter Howard, 2016

Presentation of Policy Integrity's "Comments on the 2017-2022 Outer Continental Shelf (OCS) Oil and Gas Leasing Program" to BOEM during a conversation about Energy Supply/Demand Modeling, Market Substitutions, and Related Implications of Downstream GHGs/Climate Policy Change
Peter Howard, July 2016

BLOG

How Much Higher? The Growing Consensus on the Federal SCC Estimate
Peter Howard, September 2014, Cost of Carbon Pollution Project
Available at http://costofcarbon.org/blog/entry/how-much-higher-the-growing-consensus-on-the-federal-scc-estimate.

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Is the rift between Nordhaus and Stern evaporating with rising temperatures?
Peter Howard and Charles Komanoff, August 2014, Carbon Tax Center
Available at http://www.carbontax.org/blogarchives/2014/08/21/is-the-rift-between-nordhaus-and-stern-evaporating-with-rising-temperatures/.

Playing Catch Up to the IPCC
Peter Howard, April 2014, Cost of Carbon Pollution Project
Available at http://costofcarbon.org/blog/entry/playing-catch-up-to-the-ipcc.

TEACHING

- Adjunct Assistant Professor of Public Service, Wagner Graduate School of Public Service, Environmental Economics: developed and taught course
- Advised on projects at Policy Integrity's Regulatory Policy Clinic (worked with New York University Law Students)
- Guest lecture at University of Cape Town
- Guest lecture for Katrina Wyman, New York University School of Law (Multiple times)
- Guest lecture for Rickey Revesz and Nathaniel Keohane, New York University School of Law
- Guest lecture for Principles of Macroeconomics at the University of North Carolina Asheville (UNCA)
- Guest lecture at Bard College (Multiple times)
- Supervised undergraduate summer interns
- Teaching Assistant in graduate school for undergraduate economics course
- Taught 7th Grade

GRANTS, FELLOWSHIPS, AND HONORS

- Gamma Sigma Delta - The Honors Society of Agriculture 2010-Present
- Giannini Foundation Mini-grant with Richard Howitt 2009-2010
- Non-Resident Tuition Fellowship 2005-2006

AWARDS

- UCD & Humanities Graduate Research Award 2010-11
- Jastro-Shields Graduate Research Scholarship Award 2010-2011
- UCD & Humanities Graduate Research Award 2009-2010
- Jastro-Shields Graduate Research Scholarship Award 2009-2010

PROFESSIONAL MEMBERSHIPS

- Agricultural and Applied Economics Association
- Former Board Member of the Henry George School

COMPUTER PROGRAMS

- Programming: Julia, MATLAB, and GAMS
- Statistics: Stata
- Spatial: ArcGIS
- Microsoft office: Word, Excel, Access, PowerPoint
- Other word processing: Latex

PEER REIVEW

- Ecological Economics
- Nature Climate Change
- Nature Communications
- Nature Sustainability

SELECTED MEDIA COVERAGE

- **3 in 4 economists agree: something needs to be done about climate change, and fast: A recent survey found growing concern among economists.** Available at https://thehill.com/changing-america/sustainability/climate-change/545865-three-in-four-economists-agree-something-needs
- **Economists weigh in on the merits of net-zero climate goals: survey.** Available at https://www.reuters.com/article/us-climate-change-economists-idUSKBN2BM0A1
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- **'Social Cost Of Carbon' Too Low, Report** Says. Available http://www.huffingtonpost.com/2014/03/13/social-cost-carbon_n_4953638.html

Data Sources

Data	Source	Note
SCC to 2070	UNITED STATES ENVIRONMENTAL PROTECTION AGENCY's Office of Air and Radiation. (2021, June 9). Social Cost of Greenhouse Gases (SC-GHGs) unrounded	The original document says 2018 USD, though checking this document against IWG (2021), we find that this is an error. The numbers are already in 2020 USD so no adjustment is required.
SCC to 2050 for 0% to 2% discount rates	https://www.dec.ny.gov/docs/administration_pdf/vocapprev.pdf	
SCC to 2050 for 2.5% to 5% discount rates	IWG (2021)	
CPI	U.S. Bureau of Economic Analysis (BEA) NIPA Table 1.1.9" available at https://apps.bea.gov/iTable/iTable.cfm?reqid=19&step=3&isuri=1&nipa_table_list=13 (Last Revised on: August 26, 2021 - Next Release Date September 30, 2021 and	
GHG Emissions	Pete Erickson's Testimony	
Breakdown	Pete Erickson's Testimony	Have to do break down by upstream, midstream, and downstream by present value. Then breakdown upstream by Table 1 in Pete Erickson's testimony
Construction time		2 year construction
EIS time	https://ceq.doe.gov/docs/nepa-practice/CEQ_EIS_Timeline_Report_2020-6-12.pdf	Average 6 years EIS review by United States Army Corps of Engineers (USACE)

Table 1.1.9. Implicit Price Deflators for Gross Domestic Product
[Index numbers, 2012=100]
Bureau of Economic Analysis
Last Revised on: August 26, 2021 - Next Release Date September 30, 2021

Line		2007	2008	2009	2010	2011	2012
1	Gross domestic product	92.642	94.419	95.024	96.166	98.164	100
27	Gross national product	92.64	94.421	95.018	96.162	98.165	100

2013	2014	2015	2016	2017	2018	2019	2020			
101.751	103.654	104.691	105.74	107.747	110.321	112.294	113.648	1.030157	1.0302	1.0302
101.747	103.652	104.681	105.727	107.734	110.314	112.283	113.636	1.030114	1.0301	1.0301

SCC to 2070 (2020 USD)

Year	5% Average	3% Average	2.5% Average	3% & 95th Percentile
2020	$14.48	$51.08	$76.42	$151.61
2021	$14.96	$52.15	$77.73	$155.12
2022	$15.45	$53.22	$79.03	$158.63
2023	$15.94	$54.29	$80.34	$162.14
2024	$16.43	$55.36	$81.64	$165.65
2025	$16.92	$56.42	$82.95	$169.16
2026	$17.41	$57.49	$84.26	$172.67
2027	$17.90	$58.56	$85.56	$176.18
2028	$18.39	$59.63	$86.87	$179.69
2029	$18.87	$60.70	$88.17	$183.20
2030	$19.36	$61.76	$89.48	$186.71
2031	$19.95	$62.91	$90.84	$190.54
2032	$20.53	$64.05	$92.21	$194.36
2033	$21.11	$65.20	$93.57	$198.18
2034	$21.70	$66.34	$94.93	$202.01
2035	$22.28	$67.48	$96.30	$205.83
2036	$22.86	$68.63	$97.66	$209.65
2037	$23.45	$69.77	$99.02	$213.48
2038	$24.03	$70.92	$100.39	$217.30
2039	$24.61	$72.06	$101.75	$221.12
2040	$25.20	$73.20	$103.11	$224.95
2041	$25.84	$74.35	$104.45	$228.45
2042	$26.49	$75.50	$105.78	$231.95
2043	$27.14	$76.64	$107.12	$235.45
2044	$27.78	$77.79	$108.46	$238.95
2045	$28.43	$78.93	$109.79	$242.45
2046	$29.08	$80.08	$111.13	$245.95
2047	$29.72	$81.22	$112.46	$249.45
2048	$30.37	$82.37	$113.80	$252.95
2049	$31.01	$83.52	$115.14	$256.45
2050	$31.66	$84.66	$116.47	$259.94
2051	$32.54	$85.19	$118.11	$260.82
2052	$33.13	$86.13	$119.20	$261.70
2053	$33.71	$87.06	$120.29	$262.58
2054	$34.30	$88.00	$121.38	$263.46
2055	$34.89	$88.94	$122.47	$266.07
2056	$35.49	$89.91	$123.59	$268.11
2057	$36.10	$90.87	$124.71	$270.14
2058	$36.70	$91.84	$125.83	$272.18
2059	$37.30	$92.80	$126.95	$274.21
2060	$37.91	$93.77	$128.06	$276.25
2061	$39.07	$95.17	$129.60	$281.25
2062	$40.24	$96.57	$131.13	$286.25
2063	$41.41	$97.97	$132.67	$291.25
2064	$42.57	$99.37	$134.20	$296.25

SCC to 2070 (2020 USD)

2065	$43.74	$100.77	$135.74	$301.25
2066	$44.92	$102.20	$137.30	$306.51
2067	$46.11	$103.62	$138.86	$311.78
2068	$47.29	$105.05	$140.42	$317.04
2069	$48.47	$106.47	$141.98	$322.31
2070	$49.65	$107.90	$143.54	$327.57

Specification	Linear				Polynomial				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(1)
	5%	3%	2.50%	3%	5%	3%	2.50%	3%	5%
	Average	Average	Average	95th	Average	Average	Average	95th	Average
VARIABLES	SCC_5	SCC_3	SCC_2	SCC_3_95	SCC_5	SCC_3	SCC_2	SCC_3_95	SCC_5
t	0.667***	1.106***	1.320***	3.283***	0.250***	1.106***	1.320***	1.220***	0.196
	(0.012)	(0.006)	(0.004)	(0.044)	(0.047)	(0.006)	(0.004)	(0.384)	(0)
t2					0.026***			0.258***	
					(0.004)			(0.030)	
t3					-0.001***			-0.009***	
					(0.000)			(0.001)	
t4					0.000***			0.000***	
					(0.000)			(0.000)	
Constant	11.979***	49.788***	75.142***	151.841***	14.482***	49.788***	75.142***	152.764***	15.41
	(0.354)	(0.171)	(0.130)	(1.322)	(0.179)	(0.171)	(0.130)	(1.471)	(0)
lambda	0	0	0	0	0	0	0	0	1.385***
									(0.0362)
Observations	51	51	51	51	51	51	51	51	51
R2	0.985	0.999	0.999	0.991	1	0.999	0.999	0.999	0.985
Adjusted R-squared	0.984	0.999	0.999	0.991	0.999	0.999	0.999	0.999	0.984
Likelihood	-82.61	-45.45	-31.63	-149.7	5.989	-45.45	-31.63	-101.3	-82.61
F-statistic	3158	37320	91410	5507	24282	37320	91410	8686	3158
Prob>F	0	0	0	0	0	0	0	0	0

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Linear		
(2)	(3)	(4)
3%	2.50%	3%
Average	Average	95th
SCC_3	SCC_2	SCC_3_95
1.047	1.354	4.519
(0)	(0)	(0)
51.16	76.32	150.2
(0)	(0)	(0)
1.018***	0.992***	0.897***
(0.0160)	(0.0101)	(0.0366)
51	51	51
0.999	0.999	0.991
0.999	0.999	0.991
-45.45	-31.63	-149.7
37320	91410	5507
0	0	0

0.667	1.106	1.32	3.283	0.249685	1.106	1.32	1.22
				0.025602			0.2576528
				-0.0008			-0.009166
				9.22E-06			0.0000977
11.979	49.788	75.142	151.841	14.482	49.788	75.142	152.764
0	0	0	0	0	0	0	0

0.196	1.047	1.354	4.519

15.41	51.16	76.32	150.2
1.385	1.018	0.992	0.897

Project SCC to 2128 (2020 USD)

Year	Time	5% Average	3% Average	2.5% Average
			Linear Model	
2020	1	$12.65	$50.89	$76.46
2021	2	$13.31	$52.00	$77.78
2022	3	$13.98	$53.11	$79.10
2023	4	$14.65	$54.21	$80.42
2024	5	$15.31	$55.32	$81.74
2025	6	$15.98	$56.42	$83.06
2026	7	$16.65	$57.53	$84.38
2027	8	$17.32	$58.64	$85.70
2028	9	$17.98	$59.74	$87.02
2029	10	$18.65	$60.85	$88.34
2030	11	$19.32	$61.95	$89.66
2031	12	$19.98	$63.06	$90.98
2032	13	$20.65	$64.17	$92.30
2033	14	$21.32	$65.27	$93.62
2034	15	$21.98	$66.38	$94.94
2035	16	$22.65	$67.48	$96.26
2036	17	$23.32	$68.59	$97.58
2037	18	$23.99	$69.70	$98.90
2038	19	$24.65	$70.80	$100.22
2039	20	$25.32	$71.91	$101.54
2040	21	$25.99	$73.01	$102.86
2041	22	$26.65	$74.12	$104.18
2042	23	$27.32	$75.23	$105.50
2043	24	$27.99	$76.33	$106.82
2044	25	$28.65	$77.44	$108.14
2045	26	$29.32	$78.54	$109.46
2046	27	$29.99	$79.65	$110.78
2047	28	$30.66	$80.76	$112.10
2048	29	$31.32	$81.86	$113.42
2049	30	$31.99	$82.97	$114.74
2050	31	$32.66	$84.07	$116.06
2051	32	$33.32	$85.18	$117.38
2052	33	$33.99	$86.29	$118.70
2053	34	$34.66	$87.39	$120.02
2054	35	$35.32	$88.50	$121.34
2055	36	$35.99	$89.60	$122.66
2056	37	$36.66	$90.71	$123.98
2057	38	$37.33	$91.82	$125.30
2058	39	$37.99	$92.92	$126.62
2059	40	$38.66	$94.03	$127.94
2060	41	$39.33	$95.13	$129.26
2061	42	$39.99	$96.24	$130.58
2062	43	$40.66	$97.35	$131.90
2063	44	$41.33	$98.45	$133.22
2064	45	$41.99	$99.56	$134.54

2065	46	$42.66	$100.66	$135.86
2066	47	$43.33	$101.77	$137.18
2067	48	$44.00	$102.88	$138.50
2068	49	$44.66	$103.98	$139.82
2069	50	$45.33	$105.09	$141.14
2070	51	$46.00	$106.19	$142.46
2071	52	$46.66	$107.30	$143.78
2072	53	$47.33	$108.41	$145.10
2073	54	$48.00	$109.51	$146.42
2074	55	$48.66	$110.62	$147.74
2075	56	$49.33	$111.72	$149.06
2076	57	$50.00	$112.83	$150.38
2077	58	$50.67	$113.94	$151.70
2078	59	$51.33	$115.04	$153.02
2079	60	$52.00	$116.15	$154.34
2080	61	$52.67	$117.25	$155.66
2081	62	$53.33	$118.36	$156.98
2082	63	$54.00	$119.47	$158.30
2083	64	$54.67	$120.57	$159.62
2084	65	$55.33	$121.68	$160.94
2085	66	$56.00	$122.78	$162.26
2086	67	$56.67	$123.89	$163.58
2087	68	$57.34	$125.00	$164.90
2088	69	$58.00	$126.10	$166.22
2089	70	$58.67	$127.21	$167.54
2090	71	$59.34	$128.31	$168.86
2091	72	$60.00	$129.42	$170.18
2092	73	$60.67	$130.53	$171.50
2093	74	$61.34	$131.63	$172.82
2094	75	$62.00	$132.74	$174.14
2095	76	$62.67	$133.84	$175.46
2096	77	$63.34	$134.95	$176.78
2097	78	$64.01	$136.06	$178.10
2098	79	$64.67	$137.16	$179.42
2099	80	$65.34	$138.27	$180.74
2100	81	$66.01	$139.37	$182.06
2101	82	$66.67	$140.48	$183.38
2102	83	$67.34	$141.59	$184.70
2103	84	$68.01	$142.69	$186.02
2104	85	$68.67	$143.80	$187.34
2105	86	$69.34	$144.90	$188.66
2106	87	$70.01	$146.01	$189.98
2107	88	$70.68	$147.12	$191.30
2108	89	$71.34	$148.22	$192.62
2109	90	$72.01	$149.33	$193.94
2110	91	$72.68	$150.43	$195.26
2111	92	$73.34	$151.54	$196.58

Project SCC to 2128 (2020 USD)

2112	93	$74.01	$152.65	$197.90
2113	94	$74.68	$153.75	$199.22
2114	95	$75.34	$154.86	$200.54
2115	96	$76.01	$155.96	$201.86
2116	97	$76.68	$157.07	$203.18
2117	98	$77.35	$158.18	$204.50
2118	99	$78.01	$159.28	$205.82
2119	100	$78.68	$160.39	$207.14
2120	101	$79.35	$161.49	$208.46
2121	102	$80.01	$162.60	$209.78
2122	103	$80.68	$163.71	$211.10
2123	104	$81.35	$164.81	$212.42
2124	105	$82.01	$165.92	$213.74
2125	106	$82.68	$167.02	$215.06
2126	107	$83.35	$168.13	$216.38
2127	108	$84.02	$169.24	$217.70
2128	109	$84.68	$170.34	$219.02

99

		Polynomial Model	
3% & 95th Percentile	**5% Average**	**3% Average**	**2.5% Average**
$155.12	$14.76	$50.89	$76.46
$158.41	$15.08	$52.00	$77.78
$161.69	$15.44	$53.11	$79.10
$164.97	$15.84	$54.21	$80.42
$168.26	$16.28	$55.32	$81.74
$171.54	$16.74	$56.42	$83.06
$174.82	$17.23	$57.53	$84.38
$178.11	$17.75	$58.64	$85.70
$181.39	$18.28	$59.74	$87.02
$184.67	$18.83	$60.85	$88.34
$187.95	$19.40	$61.95	$89.66
$191.24	$19.97	$63.06	$90.98
$194.52	$20.56	$64.17	$92.30
$197.80	$21.15	$65.27	$93.62
$201.09	$21.75	$66.38	$94.94
$204.37	$22.35	$67.48	$96.26
$207.65	$22.96	$68.59	$97.58
$210.94	$23.57	$69.70	$98.90
$214.22	$24.18	$70.80	$100.22
$217.50	$24.78	$71.91	$101.54
$220.78	$25.39	$73.01	$102.86
$224.07	$26.00	$74.12	$104.18
$227.35	$26.60	$75.23	$105.50
$230.63	$27.21	$76.33	$106.82
$233.92	$27.81	$77.44	$108.14
$237.20	$28.42	$78.54	$109.46
$240.48	$29.02	$79.65	$110.78
$243.77	$29.63	$80.76	$112.10
$247.05	$30.24	$81.86	$113.42
$250.33	$30.86	$82.97	$114.74
$253.61	$31.48	$84.07	$116.06
$256.90	$32.11	$85.18	$117.38
$260.18	$32.75	$86.29	$118.70
$263.46	$33.41	$87.39	$120.02
$266.75	$34.08	$88.50	$121.34
$270.03	$34.77	$89.60	$122.66
$273.31	$35.48	$90.71	$123.98
$276.60	$36.21	$91.82	$125.30
$279.88	$36.98	$92.92	$126.62
$283.16	$37.77	$94.03	$127.94
$286.44	$38.60	$95.13	$129.26
$289.73	$39.48	$96.24	$130.58
$293.01	$40.39	$97.35	$131.90
$296.29	$41.36	$98.45	$133.22
$299.58	$42.38	$99.56	$134.54

$302.86	$43.46	$100.66	$135.86
$306.14	$44.60	$101.77	$137.18
$309.43	$45.81	$102.88	$138.50
$312.71	$47.10	$103.98	$139.82
$315.99	$48.47	$105.09	$141.14
$319.27	$49.93	$106.19	$142.46
$322.56	$51.48	$107.30	$143.78
$325.84	$53.13	$108.41	$145.10
$329.12	$54.89	$109.51	$146.42
$332.41	$56.76	$110.62	$147.74
$335.69	$58.76	$111.72	$149.06
$338.97	$60.88	$112.83	$150.38
$342.26	$63.14	$113.94	$151.70
$345.54	$65.55	$115.04	$153.02
$348.82	$68.11	$116.15	$154.34
$352.10	$70.83	$117.25	$155.66
$355.39	$73.71	$118.36	$156.98
$358.67	$76.78	$119.47	$158.30
$361.95	$80.04	$120.57	$159.62
$365.24	$83.49	$121.68	$160.94
$368.52	$87.15	$122.78	$162.26
$371.80	$91.02	$123.89	$163.58
$375.09	$95.12	$125.00	$164.90
$378.37	$99.46	$126.10	$166.22
$381.65	$104.04	$127.21	$167.54
$384.93	$108.88	$128.31	$168.86
$388.22	$113.99	$129.42	$170.18
$391.50	$119.37	$130.53	$171.50
$394.78	$125.05	$131.63	$172.82
$398.07	$131.03	$132.74	$174.14
$401.35	$137.32	$133.84	$175.46
$404.63	$143.93	$134.95	$176.78
$407.92	$150.88	$136.06	$178.10
$411.20	$158.19	$137.16	$179.42
$414.48	$165.85	$138.27	$180.74
$417.76	$173.89	$139.37	$182.06
$421.05	$182.32	$140.48	$183.38
$424.33	$191.14	$141.59	$184.70
$427.61	$200.39	$142.69	$186.02
$430.90	$210.06	$143.80	$187.34
$434.18	$220.17	$144.90	$188.66
$437.46	$230.74	$146.01	$189.98
$440.75	$241.78	$147.12	$191.30
$444.03	$253.30	$148.22	$192.62
$447.31	$265.33	$149.33	$193.94
$450.59	$277.87	$150.43	$195.26
$453.88	$290.94	$151.54	$196.58

$457.16	$304.55	$152.65	$197.90
$460.44	$318.73	$153.75	$199.22
$463.73	$333.48	$154.86	$200.54
$467.01	$348.83	$155.96	$201.86
$470.29	$364.78	$157.07	$203.18
$473.58	$381.36	$158.18	$204.50
$476.86	$398.59	$159.28	$205.82
$480.14	$416.47	$160.39	$207.14
$483.42	$435.04	$161.49	$208.46
$486.71	$454.29	$162.60	$209.78
$489.99	$474.26	$163.71	$211.10
$493.27	$494.96	$164.81	$212.42
$496.56	$516.40	$165.92	$213.74
$499.84	$538.62	$167.02	$215.06
$503.12	$561.61	$168.13	$216.38
$506.41	$585.41	$169.24	$217.70
$509.69	$610.04	$170.34	$219.02

Project SCC to 2128 (2020 USD)

		Box-Cox	
3% & 95th Percentile	**5% Average**	**3% Average**	**2.5% Average**
$154.23	$15.61	$52.21	$77.67
$156.16	$15.92	$53.28	$79.01
$158.50	$16.31	$54.36	$80.35
$161.20	$16.75	$55.45	$81.68
$164.22	$17.23	$56.55	$83.00
$167.51	$17.75	$57.65	$84.33
$171.02	$18.31	$58.75	$85.65
$174.72	$18.90	$59.86	$86.97
$178.57	$19.52	$60.96	$88.29
$182.54	$20.17	$62.07	$89.61
$186.59	$20.84	$63.18	$90.93
$190.69	$21.53	$64.30	$92.25
$194.82	$22.25	$65.41	$93.56
$198.95	$22.99	$66.53	$94.88
$203.05	$23.75	$67.65	$96.19
$207.10	$24.53	$68.77	$97.51
$211.09	$25.33	$69.89	$98.82
$215.01	$26.15	$71.01	$100.13
$218.82	$26.98	$72.14	$101.45
$222.53	$27.83	$73.26	$102.76
$226.13	$28.70	$74.39	$104.07
$229.60	$29.58	$75.51	$105.38
$232.94	$30.48	$76.64	$106.69
$236.16	$31.40	$77.77	$108.00
$239.25	$32.33	$78.90	$109.31
$242.21	$33.27	$80.03	$110.62
$245.05	$34.23	$81.16	$111.93
$247.77	$35.21	$82.29	$113.23
$250.39	$36.19	$83.42	$114.54
$252.91	$37.19	$84.55	$115.85
$255.36	$38.20	$85.69	$117.16
$257.74	$39.23	$86.82	$118.46
$260.08	$40.26	$87.96	$119.77
$262.40	$41.31	$89.09	$121.08
$264.72	$42.37	$90.23	$122.38
$267.07	$43.45	$91.36	$123.69
$269.47	$44.53	$92.50	$124.99
$271.95	$45.63	$93.64	$126.30
$274.56	$46.73	$94.78	$127.60
$277.32	$47.85	$95.92	$128.91
$280.27	$48.98	$97.05	$130.21
$283.45	$50.12	$98.19	$131.51
$286.90	$51.27	$99.33	$132.82
$290.68	$52.43	$100.48	$134.12
$294.82	$53.60	$101.62	$135.42

$299.37	$54.78	$102.76	$136.73
$304.39	$55.97	$103.90	$138.03
$309.94	$57.17	$105.04	$139.33
$316.05	$58.38	$106.19	$140.63
$322.81	$59.60	$107.33	$141.93
$330.26	$60.83	$108.47	$143.24
$338.47	$62.07	$109.62	$144.54
$347.51	$63.31	$110.76	$145.84
$357.44	$64.57	$111.91	$147.14
$368.34	$65.84	$113.05	$148.44
$380.27	$67.11	$114.20	$149.74
$393.32	$68.39	$115.34	$151.04
$407.55	$69.69	$116.49	$152.34
$423.06	$70.99	$117.64	$153.64
$439.91	$72.29	$118.78	$154.94
$458.21	$73.61	$119.93	$156.24
$478.03	$74.94	$121.08	$157.54
$499.46	$76.27	$122.23	$158.84
$522.59	$77.61	$123.38	$160.14
$547.52	$78.96	$124.53	$161.44
$574.35	$80.32	$125.67	$162.74
$603.17	$81.69	$126.82	$164.04
$634.08	$83.06	$127.97	$165.34
$667.19	$84.44	$129.12	$166.63
$702.60	$85.83	$130.27	$167.93
$740.43	$87.23	$131.43	$169.23
$780.77	$88.64	$132.58	$170.53
$823.75	$90.05	$133.73	$171.83
$869.48	$91.47	$134.88	$173.12
$918.07	$92.89	$136.03	$174.42
$969.65	$94.33	$137.18	$175.72
$1,024.34	$95.77	$138.34	$177.02
$1,082.25	$97.22	$139.49	$178.31
$1,143.53	$98.68	$140.64	$179.61
$1,208.30	$100.14	$141.79	$180.91
$1,276.68	$101.61	$142.95	$182.21
$1,348.82	$103.09	$144.10	$183.50
$1,424.84	$104.57	$145.26	$184.80
$1,504.90	$106.06	$146.41	$186.10
$1,589.12	$107.56	$147.56	$187.39
$1,677.66	$109.07	$148.72	$188.69
$1,770.65	$110.58	$149.87	$189.98
$1,868.24	$112.10	$151.03	$191.28
$1,970.59	$113.62	$152.18	$192.58
$2,077.85	$115.15	$153.34	$193.87
$2,190.17	$116.69	$154.50	$195.17
$2,307.72	$118.24	$155.65	$196.46

Project SCC to 2128 (2020 USD)

$2,430.64	$119.79	$156.81	$197.76
$2,559.10	$121.34	$157.96	$199.05
$2,693.26	$122.91	$159.12	$200.35
$2,833.30	$124.48	$160.28	$201.64
$2,979.38	$126.06	$161.44	$202.94
$3,131.67	$127.64	$162.59	$204.23
$3,290.35	$129.23	$163.75	$205.53
$3,455.59	$130.82	$164.91	$206.82
$3,627.57	$132.42	$166.07	$208.12
$3,806.47	$134.03	$167.23	$209.41
$3,992.48	$135.65	$168.38	$210.71
$4,185.77	$137.27	$169.54	$212.00
$4,386.54	$138.89	$170.70	$213.29
$4,594.98	$140.52	$171.86	$214.59
$4,811.27	$142.16	$173.02	$215.88
$5,035.62	$143.80	$174.18	$217.18
$5,268.22	$145.45	$175.34	$218.47

Linear is an underestimate

3% & 95th Percentile

$154.72	-12.6%	-0.4%	0.1%	2.3%	1.9%	-0.4%
$158.62	-11.0%	-0.3%	0.1%	2.1%	0.8%	-0.3%
$162.31	-9.5%	-0.2%	0.1%	1.9%	-0.1%	-0.2%
$165.87	-8.1%	-0.1%	0.1%	1.7%	-0.6%	-0.1%
$169.34	-6.8%	-0.1%	0.1%	1.6%	-0.9%	-0.1%
$172.74	-5.5%	0.0%	0.1%	1.4%	-1.1%	0.0%
$176.09	-4.4%	0.1%	0.1%	1.2%	-1.0%	0.1%
$179.38	-3.3%	0.1%	0.2%	1.1%	-0.8%	0.1%
$182.63	-2.2%	0.2%	0.2%	0.9%	-0.6%	0.2%
$185.85	-1.2%	0.3%	0.2%	0.8%	-0.2%	0.3%
$189.03	-0.2%	0.3%	0.2%	0.7%	0.2%	0.3%
$192.18	0.2%	0.2%	0.2%	0.4%	0.1%	0.2%
$195.31	0.6%	0.2%	0.1%	0.1%	0.1%	0.2%
$198.41	1.0%	0.1%	0.1%	-0.2%	0.2%	0.1%
$201.49	1.3%	0.1%	0.0%	-0.5%	0.2%	0.1%
$204.54	1.7%	0.0%	0.0%	-0.7%	0.3%	0.0%
$207.58	2.0%	-0.1%	-0.1%	-1.0%	0.4%	-0.1%
$210.60	2.3%	-0.1%	-0.1%	-1.2%	0.5%	-0.1%
$213.60	2.6%	-0.2%	-0.2%	-1.4%	0.6%	-0.2%
$216.58	2.9%	-0.2%	-0.2%	-1.6%	0.7%	-0.2%
$219.55	3.1%	-0.3%	-0.2%	-1.9%	0.8%	-0.3%
$222.51	3.1%	-0.3%	-0.3%	-1.9%	0.6%	-0.3%
$225.45	3.1%	-0.4%	-0.3%	-2.0%	0.4%	-0.4%
$228.38	3.1%	-0.4%	-0.3%	-2.0%	0.3%	-0.4%
$231.30	3.1%	-0.4%	-0.3%	-2.1%	0.1%	-0.4%
$234.20	3.1%	-0.5%	-0.3%	-2.2%	0.0%	-0.5%
$237.09	3.1%	-0.5%	-0.3%	-2.2%	-0.2%	-0.5%
$239.97	3.1%	-0.6%	-0.3%	-2.3%	-0.3%	-0.6%
$242.84	3.1%	-0.6%	-0.3%	-2.3%	-0.4%	-0.6%
$245.70	3.1%	-0.7%	-0.3%	-2.4%	-0.5%	-0.7%
$248.55	3.1%	-0.7%	-0.4%	-2.4%	-0.6%	-0.7%
$251.40	2.4%	0.0%	-0.6%	-1.5%	-1.3%	0.0%
$254.23	2.6%	0.2%	-0.4%	-0.6%	-1.1%	0.2%
$257.05	2.8%	0.4%	-0.2%	0.3%	-0.9%	0.4%
$259.87	3.0%	0.6%	0.0%	1.2%	-0.7%	0.6%
$262.67	3.2%	0.7%	0.2%	1.5%	-0.4%	0.7%
$265.47	3.3%	0.9%	0.3%	1.9%	0.0%	0.9%
$268.26	3.4%	1.0%	0.5%	2.4%	0.3%	1.0%
$271.04	3.5%	1.2%	0.6%	2.8%	0.8%	1.2%
$273.82	3.6%	1.3%	0.8%	3.3%	1.3%	1.3%
$276.59	3.7%	1.5%	0.9%	3.7%	1.8%	1.5%
$279.35	2.4%	1.1%	0.8%	3.0%	1.0%	1.1%
$282.11	1.0%	0.8%	0.6%	2.4%	0.4%	0.8%
$284.85	-0.2%	0.5%	0.4%	1.7%	-0.1%	0.5%
$287.60	-1.4%	0.2%	0.3%	1.1%	-0.5%	0.2%

Project SCC to 2128 (2020 USD)

$290.33	-2.5%	-0.1%	0.1%	0.5%	-0.6%	-0.1%
$293.06	-3.6%	-0.4%	-0.1%	-0.1%	-0.7%	-0.4%
$295.78	-4.6%	-0.7%	-0.3%	-0.8%	-0.6%	-0.7%
$298.50	-5.6%	-1.0%	-0.4%	-1.4%	-0.4%	-1.0%
$301.21	-6.5%	-1.3%	-0.6%	-2.0%	0.0%	-1.3%
$303.92	-7.4%	-1.6%	-0.8%	-2.5%	0.6%	-1.6%
$306.62						
$309.32						
$312.01						
$314.69						
$317.37						
$320.05						
$322.72						
$325.38						
$328.05						
$330.70						
$333.35						
$336.00						
$338.65						
$341.28						
$343.92						
$346.55						
$349.18						
$351.80						
$354.42						
$357.03						
$359.64						
$362.25						
$364.86						
$367.46						
$370.05						
$372.65						
$375.24						
$377.82						
$380.40						
$382.98						
$385.56						
$388.13						
$390.70						
$393.27						
$395.83						
$398.39						
$400.95						
$403.51						
$406.06						
$408.61						
$411.15						

$413.69
$416.23
$418.77
$421.31
$423.84
$426.37
$428.89
$431.42
$433.94
$436.46
$438.97
$441.49
$444.00
$446.51
$449.01
$451.52
$454.02

0.1%	1.7%	7.8%	2.2%	1.6%	2.1%
0.1%	0.7%	6.4%	2.2%	1.7%	2.3%
0.1%	-0.1%	5.5%	2.2%	1.7%	2.3%
0.1%	-0.6%	5.1%	2.1%	1.7%	2.3%
0.1%	-0.9%	4.9%	2.2%	1.7%	2.2%
0.1%	-1.0%	4.9%	2.2%	1.7%	2.1%
0.1%	-1.0%	5.2%	2.2%	1.7%	2.0%
0.2%	-0.8%	5.6%	2.2%	1.6%	1.8%
0.2%	-0.6%	6.2%	2.2%	1.6%	1.6%
0.2%	-0.4%	6.8%	2.3%	1.6%	1.4%
0.2%	-0.1%	7.6%	2.3%	1.6%	1.2%
0.2%	0.1%	8.0%	2.2%	1.5%	0.9%
0.1%	0.2%	8.4%	2.1%	1.5%	0.5%
0.1%	0.4%	8.9%	2.0%	1.4%	0.1%
0.0%	0.5%	9.5%	2.0%	1.3%	-0.3%
0.0%	0.6%	10.1%	1.9%	1.3%	-0.6%
-0.1%	0.7%	10.8%	1.8%	1.2%	-1.0%
-0.1%	0.7%	11.5%	1.8%	1.1%	-1.3%
-0.2%	0.7%	12.3%	1.7%	1.1%	-1.7%
-0.2%	0.6%	13.1%	1.7%	1.0%	-2.1%
-0.2%	0.5%	13.9%	1.6%	0.9%	-2.4%
-0.3%	0.5%	14.5%	1.6%	0.9%	-2.6%
-0.3%	0.4%	15.1%	1.5%	0.9%	-2.8%
-0.3%	0.3%	15.7%	1.5%	0.8%	-3.0%
-0.3%	0.1%	16.4%	1.4%	0.8%	-3.2%
-0.3%	-0.1%	17.0%	1.4%	0.8%	-3.4%
-0.3%	-0.4%	17.7%	1.3%	0.7%	-3.6%
-0.3%	-0.7%	18.5%	1.3%	0.7%	-3.8%
-0.3%	-1.0%	19.2%	1.3%	0.7%	-4.0%
-0.3%	-1.4%	19.9%	1.2%	0.6%	-4.2%
-0.4%	-1.8%	20.7%	1.2%	0.6%	-4.4%
-0.6%	-1.2%	20.5%	1.9%	0.3%	-3.6%
-0.4%	-0.6%	21.5%	2.1%	0.5%	-2.9%
-0.2%	-0.1%	22.5%	2.3%	0.7%	-2.1%
0.0%	0.5%	23.5%	2.5%	0.8%	-1.4%
0.2%	0.4%	24.5%	2.7%	1.0%	-1.3%
0.3%	0.5%	25.5%	2.9%	1.1%	-1.0%
0.5%	0.7%	26.4%	3.0%	1.3%	-0.7%
0.6%	0.9%	27.3%	3.2%	1.4%	-0.4%
0.8%	1.1%	28.3%	3.4%	1.5%	-0.1%
0.9%	1.5%	29.2%	3.5%	1.7%	0.1%
0.8%	0.8%	28.3%	3.2%	1.5%	-0.7%
0.6%	0.2%	27.4%	2.9%	1.3%	-1.4%
0.4%	-0.2%	26.6%	2.6%	1.1%	-2.2%
0.3%	-0.5%	25.9%	2.3%	0.9%	-2.9%

Project SCC to 2128 (2020 USD)

0.1%	-0.6%	25.2%	2.0%	0.7%	-3.6%
-0.1%	-0.7%	24.6%	1.7%	0.5%	-4.4%
-0.3%	-0.6%	24.0%	1.4%	0.3%	-5.1%
-0.4%	-0.3%	23.5%	1.1%	0.2%	-5.8%
-0.6%	0.2%	23.0%	0.8%	0.0%	-6.5%
-0.8%	0.8%	22.5%	0.5%	-0.2%	-7.2%

SCC to 2070 (2020 USD) rounded

Year	5% Average	3% Average	2.5% Average	3% & 95th Percentile
2020	14	51	76	152
2021	15	52	78	155
2022	15	53	79	159
2023	16	54	80	162
2024	16	55	82	166
2025	17	56	83	169
2026	17	57	84	173
2027	18	59	86	176
2028	18	60	87	180
2029	19	61	88	183
2030	19	62	89	187
2031	20	63	91	191
2032	21	64	92	194
2033	21	65	94	198
2034	22	66	95	202
2035	22	67	96	206
2036	23	69	98	210
2037	23	70	99	213
2038	24	71	100	217
2039	25	72	102	221
2040	25	73	103	225
2041	26	74	104	228
2042	26	75	106	232
2043	27	77	107	235
2044	28	78	108	239
2045	28	79	110	242
2046	29	80	111	246
2047	30	81	112	249
2048	30	82	114	253
2049	31	84	115	256
2050	32	85	116	260
2051	33	85	118	261
2052	33	86	119	262
2053	34	87	120	263
2054	34	88	121	263
2055	35	89	122	266
2056	35	90	124	268
2057	36	91	125	270
2058	37	92	126	272
2059	37	93	127	274
2060	38	94	128	276
2061	39	95	130	281
2062	40	97	131	286
2063	41	98	133	291
2064	43	99	134	296

SCC to 2070 (2020 USD) rounded

2065	44	101	136	301
2066	45	102	137	307
2067	46	104	139	312
2068	47	105	140	317
2069	48	106	142	322
2070	50	108	144	328

SCC to 2050 (2020 USD) rounded

	New York Calculation (Consistent with IWG)				IWG (2021)		
Year	3% Average	2% Average (Central NY Rate)	1% Average	0% Average	5% Average	3% Average	2.5% Average
2020	51	121	406	2,130	14	51	76
2021	52	123	409	2125	15	52	78
2022	53	124	411	2119	15	53	79
2023	54	126	414	2114	16	54	80
2024	55	128	416	2108	16	55	82
2025	56	129	418	2103	17	56	83
2026	57	131	421	2098	17	57	84
2027	59	132	423	2093	18	59	86
2028	60	134	426	2088	18	60	87
2029	61	136	428	2083	19	61	88
2030	62	137	430	2077	19	62	89
2031	63	139	433	2072	20	63	91
2032	64	141	435	2067	21	64	92
2033	65	142	437	2061	21	65	94
2034	66	144	440	2056	22	66	95
2035	67	146	442	2050	22	67	96
2036	69	147	444	2045	23	69	98
2037	70	149	446	2040	23	70	99
2038	71	151	449	2035	24	71	100
2039	72	152	451	2030	25	72	102
2040	73	154	453	2024	25	73	103
2041	74	156	456	2020	26	74	104
2042	75	158	459	2015	26	75	106
2043	77	160	461	2011	27	77	107
2044	78	162	464	2006	28	78	108
2045	79	164	467	2002	28	79	110
2046	80	166	469	1995	29	80	111
2047	81	167	471	1989	30	81	112
2048	82	169	472	1983	30	82	114
2049	84	170	474	1976	31	84	115
2050	85	172	476	1970	32	85	116

3% & 95th Percentile	Check		Check 2		
152	0.0%	0.0%	0.0%	0.0%	0.0%
155	0.0%	0.0%	0.0%	0.0%	0.0%
159	0.0%	0.0%	0.0%	0.0%	0.0%
162	0.0%	0.0%	0.0%	0.0%	0.0%
166	0.0%	0.0%	0.0%	0.0%	0.0%
169	0.0%	0.0%	0.0%	0.0%	0.0%
173	0.0%	0.0%	0.0%	0.0%	0.0%
176	0.0%	0.0%	0.0%	0.0%	0.0%
180	0.0%	0.0%	0.0%	0.0%	0.0%
183	0.0%	0.0%	0.0%	0.0%	0.0%
187	0.0%	0.0%	0.0%	0.0%	0.0%
191	0.0%	0.0%	0.0%	0.0%	0.0%
194	0.0%	0.0%	0.0%	0.0%	0.0%
198	0.0%	0.0%	0.0%	0.0%	0.0%
202	0.0%	0.0%	0.0%	0.0%	0.0%
206	0.0%	0.0%	0.0%	0.0%	0.0%
210	0.0%	0.0%	0.0%	0.0%	0.0%
213	0.0%	0.0%	0.0%	0.0%	0.0%
217	0.0%	0.0%	0.0%	0.0%	0.0%
221	0.0%	0.0%	0.0%	0.0%	0.0%
225	0.0%	0.0%	0.0%	0.0%	0.0%
228	0.0%	0.0%	0.0%	0.0%	0.0%
232	0.0%	0.0%	0.0%	0.0%	0.0%
235	0.0%	0.0%	0.0%	0.0%	0.0%
239	0.0%	0.0%	0.0%	0.0%	0.0%
242	0.0%	0.0%	0.0%	0.0%	0.0%
246	0.0%	0.0%	0.0%	0.0%	0.0%
249	0.0%	0.0%	0.0%	0.0%	0.0%
253	0.0%	0.0%	0.0%	0.0%	0.0%
256	0.0%	0.0%	0.0%	0.0%	0.0%
260	0.0%	0.0%	0.0%	0.0%	0.0%

GHG (metric tons of CO2e)

Year	Net GHG Emissions (metric tons of CO2e)
2020	0
2021	0
2022	0
2023	0
2024	0
2025	0
2026	0
2027	43,500
2028	43,500
2029	27,000,520
2030	27,000,520
2031	27,000,520
2032	27,000,520
2033	27,000,520
2034	27,000,520
2035	27,000,520
2036	27,000,520
2037	27,000,520
2038	27,000,520
2039	27,000,520
2040	27,000,520
2041	27,000,520
2042	27,000,520
2043	27,000,520
2044	27,000,520
2045	27,000,520
2046	27,000,520
2047	27,000,520
2048	27,000,520
2049	27,000,520
2050	27,000,520
2051	27,000,520
2052	27,000,520
2053	27,000,520
2054	27,000,520
2055	27,000,520
2056	27,000,520
2057	27,000,520
2058	27,000,520
2059	27,000,520
2060	27,000,520
2061	27,000,520
2062	27,000,520
2063	27,000,520
2064	27,000,520
2065	27,000,520

GHG (metric tons of CO2e)

2066	27,000,520
2067	27,000,520
2068	27,000,520
2069	27,000,520
2070	27,000,520
2071	27,000,520
2072	27,000,520
2073	27,000,520
2074	27,000,520
2075	27,000,520
2076	27,000,520
2077	27,000,520
2078	27,000,520
2079	27,000,520
2080	27,000,520
2081	27,000,520
2082	27,000,520
2083	27,000,520
2084	27,000,520
2085	27,000,520
2086	27,000,520
2087	27,000,520
2088	27,000,520
2089	27,000,520
2090	27,000,520
2091	27,000,520
2092	27,000,520
2093	27,000,520
2094	27,000,520
2095	27,000,520
2096	27,000,520
2097	27,000,520
2098	27,000,520
2099	27,000,520
2100	27,000,520
2101	27,000,520
2102	27,000,520
2103	27,000,520
2104	27,000,520
2105	27,000,520
2106	27,000,520
2107	27,000,520
2108	27,000,520
2109	27,000,520
2110	27,000,520
2111	27,000,520
2112	27,000,520

GHG (metric tons of CO2e)

2113	27,000,520		
2114	27,000,520		
2115	27,000,520		
2116	27,000,520		
2117	27,000,520		
2118	27,000,520		
2119	27,000,520		
2120	27,000,520		
2121	27,000,520		
2122	27,000,520		
2123	27,000,520		
2124	27,000,520		
2125	27,000,520		
2126	27,000,520		
2127	27,000,520		
2128	27,000,520	Count	100
	2,700,139,000		

Period	From 2020 to 2070				
Source	EPA Numbers Consistent with IWG				EPA N
Year	5% Average	3% Average	2.5% Average	3% & 95th Percentile	5% Average
2020	$0	$0	$0	$0	$0
2021	$0	$0	$0	$0	$0
2022	$0	$0	$0	$0	$0
2023	$0	$0	$0	$0	$0
2024	$0	$0	$0	$0	$0
2025	$0	$0	$0	$0	$0
2026	$0	$0	$0	$0	$0
2027	$778,510	$2,547,345	$3,721,975	$7,663,856	$778,510
2028	$799,771	$2,593,811	$3,778,786	$7,816,559	$799,771
2029	$509,615,105	$1,638,824,912	$2,380,761,131	$4,946,530,365	$509,615,105
2030	$522,811,339	$1,667,667,137	$2,416,023,540	$5,041,312,990	$522,811,339
2031	$538,567,762	$1,698,556,002	$2,452,831,999	$5,144,552,178	$538,567,762
2032	$554,323,916	$1,729,445,137	$2,489,640,458	$5,247,794,067	$554,323,916
2033	$570,080,069	$1,760,334,272	$2,526,448,917	$5,351,033,255	$570,080,069
2034	$585,836,223	$1,791,223,407	$2,563,257,375	$5,454,272,443	$585,836,223
2035	$601,592,376	$1,822,112,542	$2,600,065,564	$5,557,514,332	$601,592,376
2036	$617,348,529	$1,853,001,407	$2,636,874,023	$5,660,753,520	$617,348,529
2037	$633,104,953	$1,883,890,542	$2,673,682,482	$5,763,992,708	$633,104,953
2038	$648,861,106	$1,914,779,677	$2,710,490,401	$5,867,234,596	$648,861,106
2039	$664,617,260	$1,945,668,811	$2,747,300,210	$5,970,473,785	$664,617,260
2040	$680,373,413	$1,976,557,946	$2,784,107,319	$6,073,715,673	$680,373,413
2041	$697,820,609	$2,007,494,332	$2,820,174,613	$6,168,206,693	$697,820,609
2042	$715,268,075	$2,038,430,988	$2,856,241,908	$6,262,700,413	$715,268,075
2043	$732,715,271	$2,069,367,374	$2,892,306,503	$6,357,194,132	$732,715,271
2044	$750,162,737	$2,100,304,030	$2,928,373,797	$6,451,687,852	$750,162,737
2045	$767,609,933	$2,131,240,685	$2,964,441,092	$6,546,181,572	$767,609,933
2046	$785,057,399	$2,162,177,071	$3,000,508,386	$6,640,675,292	$785,057,399
2047	$802,504,595	$2,193,113,727	$3,036,575,681	$6,735,169,012	$802,504,595
2048	$819,951,791	$2,224,050,383	$3,072,640,276	$6,829,662,732	$819,951,791
2049	$837,399,257	$2,254,986,769	$3,108,707,570	$6,924,156,452	$837,399,257
2050	$854,846,453	$2,285,923,424	$3,144,774,865	$7,018,647,471	$854,846,453
2051	$878,600,701	$2,300,103,827	$3,188,947,716	$7,042,351,228	$878,600,701
2052	$894,460,806	$2,325,440,845	$3,218,378,282	$7,066,052,284	$894,460,806
2053	$910,320,912	$2,350,777,863	$3,247,806,149	$7,089,753,341	$910,320,912
2054	$926,181,017	$2,376,114,881	$3,277,236,716	$7,113,454,397	$926,181,017
2055	$942,041,123	$2,401,451,629	$3,306,667,283	$7,184,128,258	$942,041,123
2056	$958,338,097	$2,427,503,081	$3,336,894,365	$7,239,071,616	$958,338,097
2057	$974,635,340	$2,453,554,263	$3,367,124,147	$7,294,012,275	$974,635,340
2058	$990,932,314	$2,479,605,444	$3,397,353,929	$7,348,952,933	$990,932,314

2059	$1,007,229,558	$2,505,656,896	$3,427,581,011	$7,403,896,291	$1,007,229,558
2060	$1,023,526,532	$2,531,708,078	$3,457,810,794	$7,458,836,949	$1,023,526,532
2061	$1,055,028,579	$2,569,545,257	$3,499,251,192	$7,593,839,549	$1,055,028,579
2062	$1,086,530,355	$2,607,382,435	$3,540,688,890	$7,728,842,149	$1,086,530,355
2063	$1,118,032,402	$2,645,219,884	$3,582,129,288	$7,863,844,749	$1,118,032,402
2064	$1,149,534,179	$2,683,057,063	$3,623,566,986	$7,998,847,349	$1,149,534,179
2065	$1,181,036,225	$2,720,893,701	$3,665,007,384	$8,133,847,249	$1,181,036,225
2066	$1,212,970,010	$2,759,382,943	$3,707,152,496	$8,275,996,887	$1,212,970,010
2067	$1,244,903,795	$2,797,874,884	$3,749,297,607	$8,418,146,524	$1,244,903,795
2068	$1,276,837,580	$2,836,364,125	$3,791,442,719	$8,560,296,162	$1,276,837,580
2069	$1,308,771,365	$2,874,853,366	$3,833,587,831	$8,702,445,799	$1,308,771,365
2070	$1,340,705,150	$2,913,342,608	$3,875,732,942	$8,844,595,437	$1,340,705,150
2071	-	-	-	-	$1,259,925,265
2072	-	-	-	-	$1,277,934,612
2073	-	-	-	-	$1,295,943,958
2074	-	-	-	-	$1,313,953,305
2075	-	-	-	-	$1,331,962,652
2076	-	-	-	-	$1,349,971,999
2077	-	-	-	-	$1,367,981,346
2078	-	-	-	-	$1,385,990,693
2079	-	-	-	-	$1,404,000,039
2080	-	-	-	-	$1,422,009,386
2081	-	-	-	-	$1,440,018,733
2082	-	-	-	-	$1,458,028,080
2083	-	-	-	-	$1,476,037,427
2084	-	-	-	-	$1,494,046,774
2085	-	-	-	-	$1,512,056,121
2086	-	-	-	-	$1,530,065,467
2087	-	-	-	-	$1,548,074,814
2088	-	-	-	-	$1,566,084,161
2089	-	-	-	-	$1,584,093,508
2090	-	-	-	-	$1,602,102,855
2091	-	-	-	-	$1,620,112,202
2092	-	-	-	-	$1,638,121,548
2093	-	-	-	-	$1,656,130,895
2094	-	-	-	-	$1,674,140,242
2095	-	-	-	-	$1,692,149,589
2096	-	-	-	-	$1,710,158,936
2097	-	-	-	-	$1,728,168,283
2098	-	-	-	-	$1,746,177,629
2099	-	-	-	-	$1,764,186,976
2100	-	-	-	-	$1,782,196,323
2101	-	-	-	-	$1,800,205,670
2102	-	-	-	-	$1,818,215,017
2103	-	-	-	-	$1,836,224,364
2104	-	-	-	-	$1,854,233,710
2105	-	-	-	-	$1,872,243,057

2106	-	-	-	-	$1,890,252,404
2107	-	-	-	-	$1,908,261,751
2108	-	-	-	-	$1,926,271,098
2109	-	-	-	-	$1,944,280,445
2110	-	-	-	-	$1,962,289,792
2111	-	-	-	-	$1,980,299,138
2112	-	-	-	-	$1,998,308,485
2113	-	-	-	-	$2,016,317,832
2114	-	-	-	-	$2,034,327,179
2115	-	-	-	-	$2,052,336,526
2116	-	-	-	-	$2,070,345,873
2117	-	-	-	-	$2,088,355,219
2118	-	-	-	-	$2,106,364,566
2119	-	-	-	-	$2,124,373,913
2120	-	-	-	-	$2,142,383,260
2121	-	-	-	-	$2,160,392,607
2122	-	-	-	-	$2,178,401,954
2123	-	-	-	-	$2,196,411,300
2124	-	-	-	-	$2,214,420,647
2125	-	-	-	-	$2,232,429,994
2126	-	-	-	-	$2,250,439,341
2127	-	-	-	-	$2,268,448,688

$2,152,593,746
$2,254,975,801

Value in Period t (2020 USD)

From 2020 to 2127					
lumbers Linearly Projected Beyond 2070			IWG (2021) with Rounding to nearest		
3% Average	**2.5% Average**	**3% & 95th Percentile**	5% Average	3% Average	2.5% Average
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$2,547,345	$3,721,975	$7,663,856	$783,000	$2,566,500	$3,741,000
$2,593,811	$3,778,786	$7,816,559	$783,000	$2,610,000	$3,784,500
$1,638,824,912	$2,380,761,131	$4,946,530,365	$513,009,880	$1,647,031,720	$2,376,045,760
$1,667,667,137	$2,416,023,540	$5,041,312,990	$513,009,880	$1,674,032,240	$2,403,046,280
$1,698,556,002	$2,452,831,999	$5,144,552,178	$540,010,400	$1,701,032,760	$2,457,047,320
$1,729,445,137	$2,489,640,458	$5,247,794,067	$567,010,920	$1,728,033,280	$2,484,047,840
$1,760,334,272	$2,526,448,917	$5,351,033,255	$567,010,920	$1,755,033,800	$2,538,048,880
$1,791,223,407	$2,563,257,375	$5,454,272,443	$594,011,440	$1,782,034,320	$2,565,049,400
$1,822,112,542	$2,600,065,564	$5,557,514,332	$594,011,440	$1,809,034,840	$2,592,049,920
$1,853,001,407	$2,636,874,023	$5,660,753,520	$621,011,960	$1,863,035,880	$2,646,050,960
$1,883,890,542	$2,673,682,482	$5,763,992,708	$621,011,960	$1,890,036,400	$2,673,051,480
$1,914,779,677	$2,710,490,401	$5,867,234,596	$648,012,480	$1,917,036,920	$2,700,052,000
$1,945,668,811	$2,747,300,210	$5,970,473,785	$675,013,000	$1,944,037,440	$2,754,053,040
$1,976,557,946	$2,784,107,319	$6,073,715,673	$675,013,000	$1,971,037,960	$2,781,053,560
$2,007,494,332	$2,820,174,613	$6,168,206,693	$702,013,520	$1,998,038,480	$2,808,054,080
$2,038,430,988	$2,856,241,908	$6,262,700,413	$702,013,520	$2,025,039,000	$2,862,055,120
$2,069,367,374	$2,892,306,503	$6,357,194,132	$729,014,040	$2,079,040,040	$2,889,055,640
$2,100,304,030	$2,928,373,797	$6,451,687,852	$756,014,560	$2,106,040,560	$2,916,056,160
$2,131,240,685	$2,964,441,092	$6,546,181,572	$756,014,560	$2,133,041,080	$2,970,057,200
$2,162,177,071	$3,000,508,386	$6,640,675,292	$783,015,080	$2,160,041,600	$2,997,057,720
$2,193,113,727	$3,036,575,681	$6,735,169,012	$810,015,600	$2,187,042,120	$3,024,058,240
$2,224,050,383	$3,072,640,276	$6,829,662,732	$810,015,600	$2,214,042,640	$3,078,059,280
$2,254,986,769	$3,108,707,570	$6,924,156,452	$837,016,120	$2,268,043,680	$3,105,059,800
$2,285,923,424	$3,144,774,865	$7,018,647,471	$864,016,640	$2,295,044,200	$3,132,060,320
$2,300,103,827	$3,188,947,716	$7,042,351,228	-	-	-
$2,325,440,845	$3,218,378,282	$7,066,052,284	-	-	-
$2,350,777,863	$3,247,806,149	$7,089,753,341	-	-	-
$2,376,114,881	$3,277,236,716	$7,113,454,397	-	-	-
$2,401,451,629	$3,306,667,283	$7,184,128,258	-	-	-
$2,427,503,081	$3,336,894,365	$7,239,071,616	-	-	-
$2,453,554,263	$3,367,124,147	$7,294,012,275	-	-	-
$2,479,605,444	$3,397,353,929	$7,348,952,933	-	-	-

Value in Period t (2020 USD)

$2,505,656,896	$3,427,581,011	$7,403,896,291	-	-	-
$2,531,708,078	$3,457,810,794	$7,458,836,949	-	-	-
$2,569,545,257	$3,499,251,192	$7,593,839,549	-	-	-
$2,607,382,435	$3,540,688,890	$7,728,842,149	-	-	-
$2,645,219,884	$3,582,129,288	$7,863,844,749	-	-	-
$2,683,057,063	$3,623,566,986	$7,998,847,349	-	-	-
$2,720,893,701	$3,665,007,384	$8,133,847,249	-	-	-
$2,759,382,943	$3,707,152,496	$8,275,996,887	-	-	-
$2,797,874,884	$3,749,297,607	$8,418,146,524	-	-	-
$2,836,364,125	$3,791,442,719	$8,560,296,162	-	-	-
$2,874,853,366	$3,833,587,831	$8,702,445,799	-	-	-
$2,913,342,608	$3,875,732,942	$8,844,595,437	-	-	-
$2,897,155,796	$3,882,188,767	$8,709,206,730	-	-	-
$2,927,018,371	$3,917,829,453	$8,797,849,437	-	-	-
$2,956,880,946	$3,953,470,139	$8,886,492,144	-	-	-
$2,986,743,521	$3,989,110,826	$8,975,134,851	-	-	-
$3,016,606,096	$4,024,751,512	$9,063,777,558	-	-	-
$3,046,468,672	$4,060,392,199	$9,152,420,265	-	-	-
$3,076,331,247	$4,096,032,885	$9,241,062,973	-	-	-
$3,106,193,822	$4,131,673,571	$9,329,705,680	-	-	-
$3,136,056,397	$4,167,314,258	$9,418,348,387	-	-	-
$3,165,918,972	$4,202,954,944	$9,506,991,094	-	-	-
$3,195,781,547	$4,238,595,631	$9,595,633,801	-	-	-
$3,225,644,122	$4,274,236,317	$9,684,276,508	-	-	-
$3,255,506,697	$4,309,877,003	$9,772,919,216	-	-	-
$3,285,369,273	$4,345,517,690	$9,861,561,923	-	-	-
$3,315,231,848	$4,381,158,376	$9,950,204,630	-	-	-
$3,345,094,423	$4,416,799,063	$10,038,847,337	-	-	-
$3,374,956,998	$4,452,439,749	$10,127,490,044	-	-	-
$3,404,819,573	$4,488,080,435	$10,216,132,751	-	-	-
$3,434,682,148	$4,523,721,122	$10,304,775,459	-	-	-
$3,464,544,723	$4,559,361,808	$10,393,418,166	-	-	-
$3,494,407,298	$4,595,002,495	$10,482,060,873	-	-	-
$3,524,269,874	$4,630,643,181	$10,570,703,580	-	-	-
$3,554,132,449	$4,666,283,867	$10,659,346,287	-	-	-
$3,583,995,024	$4,701,924,554	$10,747,988,994	-	-	-
$3,613,857,599	$4,737,565,240	$10,836,631,701	-	-	-
$3,643,720,174	$4,773,205,927	$10,925,274,409	-	-	-
$3,673,582,749	$4,808,846,613	$11,013,917,116	-	-	-
$3,703,445,324	$4,844,487,299	$11,102,559,823	-	-	-
$3,733,307,899	$4,880,127,986	$11,191,202,530	-	-	-
$3,763,170,474	$4,915,768,672	$11,279,845,237	-	-	-
$3,793,033,050	$4,951,409,359	$11,368,487,944	-	-	-
$3,822,895,625	$4,987,050,045	$11,457,130,652	-	-	-
$3,852,758,200	$5,022,690,731	$11,545,773,359	-	-	-
$3,882,620,775	$5,058,331,418	$11,634,416,066	-	-	-
$3,912,483,350	$5,093,972,104	$11,723,058,773	-	-	-

Value in Period t (2020 USD)

$3,942,345,925	$5,129,612,791	$11,811,701,480	-	-	-
$3,972,208,500	$5,165,253,477	$11,900,344,187	-	-	-
$4,002,071,075	$5,200,894,163	$11,988,986,895	-	-	-
$4,031,933,651	$5,236,534,850	$12,077,629,602	-	-	-
$4,061,796,226	$5,272,175,536	$12,166,272,309	-	-	-
$4,091,658,801	$5,307,816,223	$12,254,915,016	-	-	-
$4,121,521,376	$5,343,456,909	$12,343,557,723	-	-	-
$4,151,383,951	$5,379,097,595	$12,432,200,430	-	-	-
$4,181,246,526	$5,414,738,282	$12,520,843,138	-	-	-
$4,211,109,101	$5,450,378,968	$12,609,485,845	-	-	-
$4,240,971,676	$5,486,019,655	$12,698,128,552	-	-	-
$4,270,834,252	$5,521,660,341	$12,786,771,259	-	-	-
$4,300,696,827	$5,557,301,027	$12,875,413,966	-	-	-
$4,330,559,402	$5,592,941,714	$12,964,056,673	-	-	-
$4,360,421,977	$5,628,582,400	$13,052,699,380	-	-	-
$4,390,284,552	$5,664,223,087	$13,141,342,088	-	-	-
$4,420,147,127	$5,699,863,773	$13,229,984,795	-	-	-
$4,450,009,702	$5,735,504,459	$13,318,627,502	-	-	-
$4,479,872,277	$5,771,145,146	$13,407,270,209	-	-	-
$4,509,734,852	$5,806,785,832	$13,495,912,916	-	-	-
$4,539,597,428	$5,842,426,519	$13,584,555,623	-	-	-
$4,569,460,003	$5,878,067,205	$13,673,198,331	-	-	-

Value in Period t (2020 USD)

From 2020 to 2050				
dollar	New York Calculation (Consistent with IWG)			
3% & 95th Percentile	2% Average (Central NY Rate)	1% Average	0% Average	

3% & 95th Percentile	2% Average (Central NY Rate)	1% Average	0% Average
$0	$0	$0	$0
$0	$0	$0	$0
$0	$0	$0	$0
$0	$0	$0	$0
$0	$0	$0	$0
$0	$0	$0	$0
$0	$0	$0	$0
$7,656,000	$5,742,000	$18,400,500	$91,045,500
$7,830,000	$5,829,000	$18,531,000	$90,828,000
$4,941,095,160	$3,672,070,720	$11,556,222,560	$56,242,083,160
$5,049,097,240	$3,699,071,240	$11,610,223,600	$56,080,080,040
$5,157,099,320	$3,753,072,280	$11,691,225,160	$55,945,077,440
$5,238,100,880	$3,807,073,320	$11,745,226,200	$55,810,074,840
$5,346,102,960	$3,834,073,840	$11,799,227,240	$55,648,071,720
$5,454,105,040	$3,888,074,880	$11,880,228,800	$55,513,069,120
$5,562,107,120	$3,942,075,920	$11,934,229,840	$55,351,066,000
$5,670,109,200	$3,969,076,440	$11,988,230,880	$55,216,063,400
$5,751,110,760	$4,023,077,480	$12,042,231,920	$55,081,060,800
$5,859,112,840	$4,077,078,520	$12,123,233,480	$54,946,058,200
$5,967,114,920	$4,104,079,040	$12,177,234,520	$54,811,055,600
$6,075,117,000	$4,158,080,080	$12,231,235,560	$54,649,052,480
$6,156,118,560	$4,212,081,120	$12,312,237,120	$54,541,050,400
$6,264,120,640	$4,266,082,160	$12,393,238,680	$54,406,047,800
$6,345,122,200	$4,320,083,200	$12,447,239,720	$54,298,045,720
$6,453,124,280	$4,374,084,240	$12,528,241,280	$54,163,043,120
$6,534,125,840	$4,428,085,280	$12,609,242,840	$54,055,041,040
$6,642,127,920	$4,482,086,320	$12,663,243,880	$53,866,037,400
$6,723,129,480	$4,509,086,840	$12,717,244,920	$53,704,034,280
$6,831,131,560	$4,563,087,880	$12,744,245,440	$53,542,031,160
$6,912,133,120	$4,590,088,400	$12,798,246,480	$53,353,027,520
$7,020,135,200	$4,644,089,440	$12,852,247,520	$53,191,024,400
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Value in Period t (2020 USD)

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Value in Period t (2020 USD)

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Period	From 2020 to 2070			
Source	EPA Numbers Consistent with IWG			
Year	5% Average	3% Average	2.5% Average	3% & 95th Percentile
2020	$0	$0	$0	$0
2021	$0	$0	$0	$0
2022	$0	$0	$0	$0
2023	$0	$0	$0	$0
2024	$0	$0	$0	$0
2025	$0	$0	$0	$0
2026	$0	$0	$0	$0
2027	$580,936	$2,133,361	$3,209,447	$6,418,359
2028	$568,382	$2,109,006	$3,178,961	$6,355,577
2029	$344,927,562	$1,293,703,519	$1,954,001,534	$3,904,836,748
2030	$337,008,850	$1,278,127,998	$1,934,578,571	$3,863,746,629
2031	$330,633,887	$1,263,885,185	$1,916,148,437	$3,828,029,971
2032	$324,101,713	$1,249,387,964	$1,897,466,484	$3,791,118,089
2033	$317,441,914	$1,234,663,041	$1,878,555,960	$3,753,107,063
2034	$310,681,457	$1,219,735,979	$1,859,439,128	$3,714,094,129
2035	$303,845,030	$1,204,631,046	$1,840,137,111	$3,674,171,681
2036	$296,955,198	$1,189,371,091	$1,820,670,691	$3,633,422,278
2037	$290,032,674	$1,173,978,303	$1,801,059,184	$3,591,929,694
2038	$283,095,951	$1,158,473,194	$1,781,320,894	$3,549,773,422
2039	$276,162,199	$1,142,875,368	$1,761,475,237	$3,507,024,106
2040	$269,246,863	$1,127,203,378	$1,741,536,293	$3,463,755,179
2041	$263,001,249	$1,111,500,938	$1,721,070,620	$3,415,186,493
2042	$256,740,014	$1,095,757,102	$1,700,567,261	$3,366,510,072
2043	$250,478,621	$1,079,987,314	$1,680,038,659	$3,317,771,944
2044	$244,231,462	$1,064,206,721	$1,659,501,343	$3,269,016,998
2045	$238,011,208	$1,048,429,193	$1,638,966,419	$3,220,287,560
2046	$231,829,626	$1,032,667,811	$1,618,445,987	$3,171,623,503
2047	$225,696,982	$1,016,935,272	$1,597,951,558	$3,123,062,359
2048	$219,622,709	$1,001,243,142	$1,577,492,682	$3,074,639,416
2049	$213,615,222	$985,602,295	$1,557,082,558	$3,026,387,820
2050	$207,681,801	$970,023,290	$1,536,729,624	$2,978,337,523
2051	$203,288,389	$947,612,322	$1,520,307,497	$2,901,355,462
2052	$197,102,914	$930,146,445	$1,496,915,419	$2,826,330,081
2053	$191,045,560	$912,894,103	$1,473,758,786	$2,753,213,785
2054	$185,118,152	$895,857,676	$1,450,842,449	$2,681,959,013
2055	$179,322,049	$879,039,121	$1,428,167,267	$2,629,713,508
2056	$173,737,387	$862,694,293	$1,406,070,737	$2,572,645,868
2057	$168,278,018	$846,555,777	$1,384,203,602	$2,516,670,743
2058	$162,944,582	$830,625,514	$1,362,566,708	$2,461,773,837
2059	$157,737,552	$814,905,152	$1,341,160,776	$2,407,940,703

2060	$152,656,901	$799,395,803	$1,319,989,496	$2,355,154,216
2061	$149,862,254	$787,711,676	$1,303,228,304	$2,327,943,461
2062	$146,987,567	$776,030,021	$1,286,498,509	$2,300,319,837
2063	$144,046,871	$764,360,685	$1,269,810,489	$2,272,330,477
2064	$141,052,903	$752,712,706	$1,253,170,267	$2,244,020,119
2065	$138,017,469	$741,094,667	$1,236,587,285	$2,215,430,474
2066	$134,999,328	$729,687,428	$1,220,299,712	$2,188,493,227
2067	$131,955,663	$718,316,683	$1,204,071,028	$2,161,245,710
2068	$128,895,751	$706,988,619	$1,187,908,051	$2,133,728,849
2069	$125,828,039	$695,711,068	$1,171,817,229	$2,105,981,449
2070	$122,760,210	$684,490,697	$1,155,804,657	$2,078,040,282
2071	-	-	-	-
2072	-	-	-	-
2073	-	-	-	-
2074	-	-	-	-
2075	-	-	-	-
2076	-	-	-	-
2077	-	-	-	-
2078	-	-	-	-
2079	-	-	-	-
2080	-	-	-	-
2081	-	-	-	-
2082	-	-	-	-
2083	-	-	-	-
2084	-	-	-	-
2085	-	-	-	-
2086	-	-	-	-
2087	-	-	-	-
2088	-	-	-	-
2089	-	-	-	-
2090	-	-	-	-
2091	-	-	-	-
2092	-	-	-	-
2093	-	-	-	-
2094	-	-	-	-
2095	-	-	-	-
2096	-	-	-	-
2097	-	-	-	-
2098	-	-	-	-
2099	-	-	-	-
2100	-	-	-	-
2101	-	-	-	-
2102	-	-	-	-
2103	-	-	-	-
2104	-	-	-	-
2105	-	-	-	-
2106	-	-	-	-

2107	-	-	-	-
2108	-	-	-	-
2109	-	-	-	-
2110	-	-	-	-
2111	-	-	-	-
2112	-	-	-	-
2113	-	-	-	-
2114	-	-	-	-
2115	-	-	-	-
2116	-	-	-	-
2117	-	-	-	-
2118	-	-	-	-
2119	-	-	-	-
2120	-	-	-	-
2121	-	-	-	-
2122	-	-	-	-
2123	-	-	-	-
2124	-	-	-	-
2125	-	-	-	-
2126	-	-	-	-
2127	-	-	-	-
Total for Period of Analysis				
2021 to 2070	$9,171,829,071	$41,023,461,968	$64,953,802,912	$124,384,897,714
2021 to 2127				
2021 to 2050				
Total (Billions of 2020 USD)				
For relevant period of analysis	9.17	41.02	64.95	124.38

		0.95		3.032042927
		$932,351,408		
		$976,648,086		
		104.00		

From 2020 to 2127					
EPA Numbers Linearly Projected Beyond 2070				IWG (2021) with Rou	
5% Average	**3% Average**	**2.5% Average**	**3% & 95th Percentile**	5% Average	3% Average
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0
$580,936	$2,133,361	$3,209,447	$6,418,359	$584,287	$2,149,403
$568,382	$2,109,006	$3,178,961	$6,355,577	$556,463	$2,122,169
$344,927,562	$1,293,703,519	$1,954,001,534	$3,904,836,748	$347,225,280	$1,300,182,049
$337,008,850	$1,278,127,998	$1,934,578,571	$3,863,746,629	$330,690,743	$1,283,006,319
$330,633,887	$1,263,885,185	$1,916,148,437	$3,828,029,971	$331,519,542	$1,265,728,126
$324,101,713	$1,249,387,964	$1,897,466,484	$3,791,118,089	$331,519,542	$1,248,368,008
$317,441,914	$1,234,663,041	$1,878,555,960	$3,753,107,063	$315,732,897	$1,230,945,396
$310,681,457	$1,219,735,979	$1,859,439,128	$3,714,094,129	$315,016,949	$1,213,478,658
$303,845,030	$1,204,631,046	$1,840,137,111	$3,674,171,681	$300,016,142	$1,195,985,144
$296,955,198	$1,189,371,091	$1,820,670,691	$3,633,422,278	$298,717,371	$1,195,811,838
$290,032,674	$1,173,978,303	$1,801,059,184	$3,591,929,694	$284,492,734	$1,177,808,198
$283,095,951	$1,158,473,194	$1,781,320,894	$3,549,773,422	$282,725,699	$1,159,838,864
$276,162,199	$1,142,875,368	$1,761,475,237	$3,507,024,106	$280,481,844	$1,141,917,109
$269,246,863	$1,127,203,378	$1,741,536,293	$3,463,755,179	$267,125,566	$1,124,055,407
$263,001,249	$1,111,500,938	$1,721,070,620	$3,415,186,493	$264,581,513	$1,106,265,462
$256,740,014	$1,095,757,102	$1,700,567,261	$3,366,510,072	$251,982,393	$1,088,558,248
$250,478,621	$1,079,987,314	$1,680,038,659	$3,317,771,944	$249,213,356	$1,085,035,406
$244,231,462	$1,064,206,721	$1,659,501,343	$3,269,016,998	$246,136,648	$1,067,113,374
$238,011,208	$1,048,429,193	$1,638,966,419	$3,220,287,560	$234,415,855	$1,049,314,868
$231,829,626	$1,032,667,811	$1,618,445,987	$3,171,623,503	$231,226,523	$1,031,647,898
$225,696,982	$1,016,935,272	$1,597,951,558	$3,123,062,359	$227,809,383	$1,014,119,900
$219,622,709	$1,001,243,142	$1,577,492,682	$3,074,639,416	$216,961,317	$996,737,766
$213,615,222	$985,602,295	$1,557,082,558	$3,026,387,820	$213,517,486	$991,309,168
$207,681,801	$970,023,290	$1,536,729,624	$2,978,337,523	$209,909,664	$973,893,658
$203,288,389	$947,612,322	$1,520,307,497	$2,901,355,462	-	-
$197,102,914	$930,146,445	$1,496,915,419	$2,826,330,081	-	-
$191,045,560	$912,894,103	$1,473,758,786	$2,753,213,785	-	-
$185,118,152	$895,857,676	$1,450,842,449	$2,681,959,013	-	-
$179,322,049	$879,039,121	$1,428,167,267	$2,629,713,508	-	-
$173,737,387	$862,694,293	$1,406,070,737	$2,572,645,868	-	-
$168,278,018	$846,555,777	$1,384,203,602	$2,516,670,743	-	-
$162,944,582	$830,625,514	$1,362,566,708	$2,461,773,837	-	-
$157,737,552	$814,905,152	$1,341,160,776	$2,407,940,703	-	-

PV in 2021 (2020 USD)

$152,656,901	$799,395,803	$1,319,989,496	$2,355,154,216	-	-
$149,862,254	$787,711,676	$1,303,228,304	$2,327,943,461	-	-
$146,987,567	$776,030,021	$1,286,498,509	$2,300,319,837	-	-
$144,046,871	$764,360,685	$1,269,810,489	$2,272,330,477	-	-
$141,052,903	$752,712,706	$1,253,170,267	$2,244,020,119	-	-
$138,017,469	$741,094,667	$1,236,587,285	$2,215,430,474	-	-
$134,999,328	$729,687,428	$1,220,299,712	$2,188,493,227	-	-
$131,955,663	$718,316,683	$1,204,071,028	$2,161,245,710	-	-
$128,895,751	$706,988,619	$1,187,908,051	$2,133,728,849	-	-
$125,828,039	$695,711,068	$1,171,817,229	$2,105,981,449	-	-
$122,760,210	$684,490,697	$1,155,804,657	$2,078,040,282	-	-
$109,870,179	$660,861,748	$1,129,492,572	$1,986,631,714	-	-
$106,133,963	$648,226,809	$1,112,060,441	$1,948,399,751	-	-
$102,504,438	$635,767,252	$1,094,806,740	$1,910,709,560	-	-
$98,979,916	$623,483,581	$1,077,733,137	$1,873,562,017	-	-
$95,558,626	$611,376,118	$1,060,841,109	$1,836,957,483	-	-
$92,238,729	$599,445,021	$1,044,131,957	$1,800,895,842	-	-
$89,018,327	$587,690,287	$1,027,606,808	$1,765,376,521	-	-
$85,895,471	$576,111,764	$1,011,266,626	$1,730,398,521	-	-
$82,868,175	$564,709,159	$995,112,219	$1,695,960,442	-	-
$79,934,418	$553,482,046	$979,144,246	$1,662,060,504	-	-
$77,092,157	$542,429,877	$963,363,222	$1,628,696,576	-	-
$74,339,330	$531,551,985	$947,769,527	$1,595,866,191	-	-
$71,673,866	$520,847,593	$932,363,411	$1,563,566,573	-	-
$69,093,685	$510,315,823	$917,144,999	$1,531,794,655	-	-
$66,596,709	$499,955,701	$902,114,301	$1,500,547,098	-	-
$64,180,866	$489,766,161	$887,271,213	$1,469,820,310	-	-
$61,844,090	$479,746,056	$872,615,525	$1,439,610,463	-	-
$59,584,330	$469,894,160	$858,146,925	$1,409,913,511	-	-
$57,399,549	$460,209,175	$843,865,005	$1,380,725,205	-	-
$55,287,730	$450,689,736	$829,769,266	$1,352,041,108	-	-
$53,246,879	$441,334,415	$815,859,123	$1,323,856,610	-	-
$51,275,026	$432,141,727	$802,133,906	$1,296,166,941	-	-
$49,370,227	$423,110,136	$788,592,871	$1,268,967,188	-	-
$47,530,568	$414,238,056	$775,235,198	$1,242,252,300	-	-
$45,754,164	$405,523,856	$762,059,997	$1,216,017,109	-	-
$44,039,162	$396,965,866	$749,066,314	$1,190,256,333	-	-
$42,383,742	$388,562,379	$736,253,131	$1,164,964,594	-	-
$40,786,120	$380,311,655	$723,619,375	$1,140,136,422	-	-
$39,244,544	$372,211,924	$711,163,914	$1,115,766,270	-	-
$37,757,299	$364,261,390	$698,885,567	$1,091,848,519	-	-
$36,322,706	$356,458,233	$686,783,103	$1,068,377,490	-	-
$34,939,124	$348,800,613	$674,855,248	$1,045,347,451	-	-
$33,604,948	$341,286,671	$663,100,683	$1,022,752,624	-	-
$32,318,608	$333,914,535	$651,518,051	$1,000,587,194	-	-
$31,078,576	$326,682,317	$640,105,958	$978,845,316	-	-
$29,883,357	$319,588,122	$628,862,974	$957,521,121	-	-

PV in 2021 (2020 USD)

$28,731,495	$312,630,044	$617,787,640	$936,608,722	-	-
$27,621,572	$305,806,173	$606,878,465	$916,102,221	-	-
$26,552,205	$299,114,594	$596,133,933	$895,995,714	-	-
$25,522,048	$292,553,389	$585,552,503	$876,283,298	-	-
$24,529,793	$286,120,640	$575,132,609	$856,959,071	-	-
$23,574,165	$279,814,431	$564,872,667	$838,017,145	-	-
$22,653,926	$273,632,847	$554,771,073	$819,451,643	-	-
$21,767,873	$267,573,979	$544,826,206	$801,256,706	-	-
$20,914,836	$261,635,922	$535,036,430	$783,426,497	-	-
$20,093,681	$255,816,778	$525,400,095	$765,955,206	-	-
$19,303,304	$250,114,659	$515,915,541	$748,837,051	-	-
$18,542,638	$244,527,683	$506,581,096	$732,066,283	-	-
$17,810,645	$239,053,980	$497,395,080	$715,637,187	-	-
$17,106,319	$233,691,693	$488,355,805	$699,544,087	-	-
$16,428,684	$228,438,973	$479,461,578	$683,781,348	-	-
$15,776,796	$223,293,988	$470,710,701	$668,343,379	-	-
$15,149,739	$218,254,918	$462,101,472	$653,224,632	-	-
$14,546,628	$213,319,957	$453,632,187	$638,419,609	-	-
$13,966,602	$208,487,316	$445,301,141	$623,922,860	-	-
$13,408,831	$203,755,222	$437,106,629	$609,728,987	-	-
$12,872,511	$199,121,916	$429,046,947	$595,832,646	-	-

$11,838,332,964	$63,382,173,014	$106,840,517,376	$191,451,489,531	$6,032,159,194	$24,945,392,436

11.84	63.38	106.84	191.45	6.03	24.95

160.6764852

PV in 2021 (2020 USD)

From 2020 to 2050				
nding to nearest dollar		New York Calculation (Consistent with IWG)		
2.5% Average	3% & 95th Percentile	2% Average (Central NY Rate)	1% Average	0% Average
$0	$0	$0	$0	$0
$0	$0	$0	$0	$0
$0	$0	$0	$0	$0
$0	$0	$0	$0	$0
$0	$0	$0	$0	$0
$0	$0	$0	$0	$0
$0	$0	$0	$0	$0
$3,225,853	$6,411,779	$5,098,732	$17,334,103	$91,045,500
$3,183,768	$6,366,507	$5,074,495	$17,284,198	$90,828,000
$1,950,131,410	$3,900,546,147	$3,134,077,002	$10,671,977,649	$56,242,083,160
$1,924,187,311	$3,869,712,608	$3,095,217,339	$10,615,689,806	$56,080,080,040
$1,919,441,439	$3,837,366,223	$3,078,826,464	$10,583,913,622	$55,945,077,440
$1,893,204,100	$3,784,115,525	$3,061,888,358	$10,527,524,811	$55,810,074,840
$1,887,181,181	$3,749,649,054	$3,023,141,058	$10,471,215,073	$55,648,071,720
$1,860,739,099	$3,713,980,135	$3,005,608,342	$10,438,712,717	$55,513,069,120
$1,834,464,221	$3,677,208,055	$2,987,600,885	$10,382,338,031	$55,351,066,000
$1,827,007,050	$3,639,427,333	$2,949,082,259	$10,326,056,373	$55,216,063,400
$1,800,634,125	$3,583,902,089	$2,930,593,949	$10,269,871,426	$55,081,060,800
$1,774,460,828	$3,544,859,626	$2,911,696,843	$10,236,585,424	$54,946,058,200
$1,765,804,922	$3,505,051,127	$2,873,509,415	$10,180,378,898	$54,811,055,600
$1,739,626,083	$3,464,554,336	$2,854,234,068	$10,124,281,883	$54,649,052,480
$1,713,673,811	$3,408,493,587	$2,834,609,846	$10,090,425,849	$54,541,050,400
$1,704,028,367	$3,367,273,514	$2,814,657,842	$10,056,247,752	$54,406,047,800
$1,678,150,348	$3,311,471,693	$2,794,398,453	$10,000,065,174	$54,298,045,720
$1,652,520,972	$3,269,744,824	$2,773,851,405	$9,965,486,653	$54,163,043,120
$1,642,071,426	$3,214,356,938	$2,753,035,769	$9,930,612,553	$54,055,041,040
$1,616,584,730	$3,172,317,286	$2,731,969,976	$9,874,397,964	$53,866,037,400
$1,591,364,445	$3,117,479,692	$2,694,536,889	$9,818,323,040	$53,704,034,280
$1,580,274,798	$3,075,300,667	$2,673,339,992	$9,741,751,224	$53,542,031,160
$1,555,255,471	$3,021,132,702	$2,636,429,972	$9,686,168,150	$53,353,027,520
$1,530,516,518	$2,978,968,835	$2,615,143,917	$9,630,730,750	$53,191,024,400
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-

PV in 2021 (2020 USD)

-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
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-	-	-	-	-
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PV in 2021 (2020 USD)

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-	-	-	-	-
-	-	-	-	-
$38,447,732,277	$76,219,690,282	$63,237,623,272	$223,657,373,123	$1,204,594,069,140
38.45	76.22	63.24	223.66	1204.59

154%
64%

Breakdown (2020 USD)

Type of emissions	Source of emissions	Emissions (metric tons CO2e)[1]	Method notes and assumptions
Upstream (Tunnel Construction)	Equipment: tunnel boring machine and related tunneling equipment (TBM, using electricity)	56,000	64%
	Equipment: other (electricity)	2,300	3%
	Equipment: other vehicles (diesel)	5,100	6%
	Materials: concrete for tunnel liner and roadway	19,000	22%
	Materials: steel for pipeline	3,300	4%
	Land-clearing	570	1%
	Estimated total construction emissions	87,000	100%
Midstream and Upstream	Tunnel operation	520	0.0%
	Liquids (crude oil and NGL) handled (combustion)	27000000	100.0%
	Estimated total midstream and upstream	27000520	100.0%

Tunnel and construction

From 2020 to 2070				From 20	
EPA Numbers Consistent with IWG				EPA Numbers Linearly	
5% Average	3% Average	2.5% Average	3% & 95th Percentile	5% Average	3% Average
$739,791	$2,730,719	$4,112,079	$8,222,304	$739,791	$2,730,719
$30,384	$112,155	$168,889	$337,702	$30,384	$112,155
$67,374	$248,690	$374,493	$748,817	$67,374	$248,690
$251,001	$926,494	$1,395,170	$2,789,710	$251,001	$926,494
$43,595	$160,917	$242,319	$484,529	$43,595	$160,917
$7,530	$27,795	$41,855	$83,691	$7,530	$27,795
$1,149,318	$4,242,367	$6,388,408	$12,773,936	$1,149,318	$4,242,367
$176,617	$789,985	$1,250,815	$2,395,269	$227,971	$1,220,588
$9,170,503,135	$41,018,429,616	$64,946,163,689	$124,369,728,509	$11,836,955,675	$63,376,710,058
$9,170,679,753	$41,019,219,601	$64,947,414,504	$124,372,123,778	$11,837,183,646	$63,377,930,647

$1,325,936	$5,032,352	$7,639,223	$15,169,205	$1,377,289	$5,462,956
	0.843018811				

20 to 2127		From 2020 to 20			
' Projected Beyond 2070		IWG (2021) with Rounding to nearest dollar			
2.5% Average	**3% & 95th Percentile**	5% Average	3% Average	2.5% Average	3% & 95th Percentile
$4,112,079	$8,222,304	$734,276	$2,749,518	$4,125,733	$8,225,104
$168,889	$337,702	$30,158	$112,927	$169,450	$337,817
$374,493	$748,817	$66,872	$250,403	$375,736	$749,072
$1,395,170	$2,789,710	$249,129	$932,872	$1,399,802	$2,790,660
$242,319	$484,529	$43,270	$162,025	$243,124	$484,694
$41,855	$83,691	$7,474	$27,986	$41,994	$83,720
$6,388,408	$12,773,936	$1,140,750	$4,271,572	$6,409,621	$12,778,286
$2,057,507	$3,686,897	$116,151	$480,338	$740,337	$1,467,660
$106,832,071,461	$191,435,028,698	$6,030,902,293	$24,940,640,526	$38,440,582,319	$76,205,444,336
$106,834,128,967	$191,438,715,594	$6,031,018,443	$24,941,120,864	$38,441,322,656	$76,206,911,996
$8,445,915	$16,460,833	$1,256,901	$4,751,910	$7,149,958	$14,245,946

)50		
New York Calculation (Consistent with IWG)		
2% Average (Central NY Rate)	1% Average	0% Average
$6,548,284	$22,283,045	$117,068,000
$268,947	$915,196	$4,808,150
$596,362	$2,029,349	$10,661,550
$2,221,739	$7,560,319	$39,719,500
$385,881	$1,313,108	$6,898,650
$66,652	$226,810	$1,191,585
$10,173,227	$34,618,302	$181,873,500
$1,217,690	$4,306,726	$23,195,640
$63,226,232,355	$223,618,448,096	$1,204,389,000,000
$63,227,450,045	$223,622,754,821	$1,204,412,195,640

Source of construc tion-	Emissions (metric tons CO2e)[1]

$11,390,917 $38,925,027 $205,069,140

$13,095,380.87

Method notes and assumpti

Breakdown (%)

Type of emissions	Source of emissions	Emissions (metric tons CO2e)[1]	Method notes and assumptions	From 20	
				EPA Numbers Co	
				5% Average	**3% Average**
Upstream (Tunnel Construction)	Equipment: tunnel boring machine and related tunneling equipment (TBM, using electricity)	56,000	64%	0.00807%	0.00666%
	Equipment: other (electricity)	2,300	3%	0.00033%	0.00027%
	Equipment: other vehicles (diesel)	5,100	6%	0.00073%	0.00061%
	Materials: concrete for tunnel liner and roadway	19,000	22%	0.00274%	0.00226%
	Materials: steel for pipeline	3,300	4%	0.00048%	0.00039%
	Land-clearing	570	1%	0.00008%	0.00007%
	Estimated total construction emissions	87,000	100%	0.01253%	0.01034%
Midstream and Upstream	Tunnel operation	520	0.0%	0.00193%	0.00193%
	Liquids (crude oil and NGL) handled (combustion)	27000000	100.0%	99.99%	99.99%
	Estimated total midstream and upstream	27000520	100.0%	99.99%	99.99%

Breakdown (%)

20 to 2070		From 2020 to 2127					
onsistent with IWG		EPA Numbers Linearly Projected Beyond 2070				IWG (2021) with Rou	
2.5% Average	**3% & 95th Percentile**	**5% Average**	**3% Average**	**2.5% Average**	**3% & 95th Percentile**	5% Average	3% Average
0.00633%	0.00661%	0.00625%	0.00431%	0.00385%	0.00429%	0.01217%	0.01102%
0.00026%	0.00027%	0.00026%	0.00018%	0.00016%	0.00018%	0.00050%	0.00045%
0.00058%	0.00060%	0.00057%	0.00039%	0.00035%	0.00039%	0.00111%	0.00100%
0.00215%	0.00224%	0.00212%	0.00146%	0.00131%	0.00146%	0.00413%	0.00374%
0.00037%	0.00039%	0.00037%	0.00025%	0.00023%	0.00025%	0.00072%	0.00065%
0.00006%	0.00007%	0.00006%	0.00004%	0.00004%	0.00004%	0.00012%	0.00011%
0.00984%	0.01027%	0.00971%	0.00669%	0.00598%	0.00667%	0.01891%	0.01712%
0.00193%	0.00193%	0.00193%	0.00193%	0.00193%	0.00193%	0.00193%	0.00193%
99.99%	99.99%	99.99%	99.99%	99.99%	99.99%	99.98%	99.98%
99.99%	99.99%	99.99%	99.99%	99.99%	99.99%	99.98%	99.98%

Breakdown (%)

From 2020 to 2050				
nding to nearest dollar		New York Calculation (Consistent with IWG)		
2.5% Average	3% & 95th Percentile	2% Average (Central NY Rate)	1% Average	0% Average
0.01073%	0.01079%	0.01036%	0.00996%	0.00972%
0.00044%	0.00044%	0.00043%	0.00041%	0.00040%
0.00098%	0.00098%	0.00094%	0.00091%	0.00089%
0.00364%	0.00366%	0.00351%	0.00338%	0.00330%
0.00063%	0.00064%	0.00061%	0.00059%	0.00057%
0.00011%	0.00011%	0.00011%	0.00010%	0.00010%
0.01667%	0.01677%	0.01609%	0.01548%	0.01510%
0.00193%	0.00193%	0.00193%	0.00193%	0.00193%
99.98%	99.98%	99.98%	99.98%	99.98%
99.98%	99.98%	99.98%	99.98%	99.98%

Source of construc tion-	Emissions (metric tons CO2e)[1]	Method notes and assumpti

Table 1

Year	Estimates at a 3% Discount Rate	Estimates at a 2.5% Discount Rate	Estimates at a 2.0% Discount Rate	High-Impact Estimates (95th-percentile at a 3% discount rate)
2020	$51	$76	$121	$152
2025	$56	$83	$129	$169
2030	$62	$89	$137	$187
2035	$67	$96	$146	$206
2040	$73	$103	$154	$225
2045	$79	$110	$164	$242
2050	$85	$116	$172	$260

```
clear
cd "C:\Users\Peter\Documents\NYU\Testimony\Michigan\Calculation\Stata"
import excel "C:\Users\Peter\Documents\NYU\Testimony\Michigan\Calculation\Line 5 Data_090221b.xlsx", sheet("SCC to 2070 (2020 USD)") firstrow
rename Average SCC_5
rename C SCC_3
rename D SCC_2
rename E SCC_3_95

*********************************************************************************************************
*********************************************************************************************************
***********************************************3% Average************************************************
*********************************************************************************************************
*********************************************************************************************************

*********************************************************************************************************
***********************************************Regression************************************************
*********************************************************************************************************

*Linear
gen t=Year-2019
reg SCC_3 t
outreg2 using Table_extra_3,  addstat("Liklihood", e(ll), "F-statistic", e(F), "Prob>F", e(p), "R2", e(r2)) dec(3) adjr2 excel replace
predict pred_linear
gen e2_linear=(pred_linear-SCC_3)^2
*Polynomial Approximation
gen t2=t^2
reg SCC_3 t t2
gen t3=t^3
reg SCC_3 t t2 t3
gen t4=t^4
reg SCC_3 t t2 t3 t4
outreg2 using Table_extra_3,  addstat("Liklihood", e(ll), "F-statistic", e(F), "Prob>F", e(p), "R2", e(r2)) dec(3) adjr2 excel
predict pred_poly
gen e2_poly=(pred_poly-SCC_3)^2
gen t5=t^5
reg SCC_3 t t2 t3 t4 t5
*Box Cox
boxcox SCC_3 t, model(rhsonly)
outreg2 using Table_extra_3,  addstat("Liklihood", e(ll)) dec(3) excel
predict pred_box
gen e2_box=(pred_box-SCC_3)^2


*********************************************************************************************************
***********************************************Fit*******************************************************
*********************************************************************************************************

******************************************In-Sample Fit**************************************************
preserve
collapse (sum) e2_linear e2_poly e2_box
sum e2*
restore

*Polynomial's second coefficient becomes insignificant when added, so actually appropropriate polynomial is linear*
```

```
*Polynomial outperforms other models in minimizing sum of squared-error, log-likelihood, and adjusted R-squared*
*Box-cox outpreforms linear, though box-cox is essentially linear


******************************************Out-of-Sample Fit**********************************************
*Linear
reg SCC_3 t if Year<=2050
predict pred_linear_out
gen e2_linear_out=(pred_linear_out-SCC_3)^2
*Polynomial Approximation
reg SCC_3 t t2 if Year<=2050
reg SCC_3 t t2 t3 if Year<=2050
predict pred_poly_out
gen e2_poly_out=(pred_poly_out-SCC_3)^2
reg SCC_3 t t2 t3 t4 if Year<=2050
*Box Cox
boxcox SCC_3 t if Year<=2050, model(rhsonly)
predict pred_box_out
gen e2_box_out=(pred_box_out-SCC_3)^2

*Fit
preserve
drop if Year<=2050
collapse (sum) e2_linear_out e2_poly_out e2_box_out
sum e2*
restore

*Linear outperforms other models in minimizing sum of squared error, though box-cox and polynomial are close
*Poly-nomial outperforms box-cox in minimizing sum of squared-error*

drop pred_* e2_*

*********************************************************************************************************
*********************************************************************************************************
***********************************************5%Average**************************************************
*********************************************************************************************************
*********************************************************************************************************

*********************************************************************************************************
***********************************************Regression************************************************
*********************************************************************************************************

*Linear
reg SCC_5 t
outreg2 using Table_extra_5,  addstat("Liklihood", e(ll), "F-statistic", e(F), "Prob>F", e(p), "R2", e(r2)) dec(3) adjr2 excel replace
predict pred_linear
gen e2_linear=(pred_linear-SCC_5)^2
*Polynomial Approximation
reg SCC_5 t t2
reg SCC_5 t t2 t3
reg SCC_5 t t2 t3 t4
outreg2 using Table_extra_5,  addstat("Liklihood", e(ll), "F-statistic", e(F), "Prob>F", e(p), "R2", e(r2)) dec(3) adjr2 excel
predict pred_poly
gen e2_poly=(pred_poly-SCC_5)^2
reg SCC_5 t t2 t3 t4 t5
*Box Cox
boxcox SCC_5 t, model(rhsonly)
```

```
outreg2 using Table_extra_5,  addstat("Liklihood", e(ll)) dec(3) excel
predict pred_box
gen e2_box=(pred_box-SCC_5)^2


*********************************************************************************************************
***********************************************Fit*******************************************************
*********************************************************************************************************

******************************************In-Sample Fit**************************************************
preserve
collapse (sum) e2_linear e2_poly e2_box
sum e2*
restore

*Polynomial outperforms other models in minimizing sum of squared-error, log-likelihood, and adjusted R-squared*
*Box-cox outpreforms linear

******************************************Out-of-Sample Fit**********************************************
*Linear
reg SCC_5 t if Year<=2050
predict pred_linear_out
gen e2_linear_out=(pred_linear_out-SCC_5)^2
*Polynomial Approximation
reg SCC_5 t t2 if Year<=2050
reg SCC_5 t t2 t3 if Year<=2050
predict pred_poly_out
gen e2_poly_out=(pred_poly_out-SCC_5)^2
reg SCC_5 t t2 t3 t4 if Year<=2050
*Box Cox
boxcox SCC_5 t if Year<=2050, model(rhsonly)
predict pred_box_out
gen e2_box_out=(pred_box_out-SCC_5)^2

*Fit
preserve
drop if Year<=2050
collapse (sum) e2_linear_out e2_poly_out e2_box_out
sum e2*
restore

*Poly-nomial outperforms linear and box-cox in minimizing sum of squared-error*
*Box-cox outpreforms linaer

drop pred_* e2_*

*********************************************************************************************************
*********************************************************************************************************
***********************************************2% Average************************************************
*********************************************************************************************************
*********************************************************************************************************

*********************************************************************************************************
***********************************************Regression************************************************
*********************************************************************************************************

```

```
*Linear
reg SCC_2 t
outreg2 using Table_extra_2,  addstat("Liklihood", e(ll), "F-statistic", e(F), "Prob>F", e(p), "R2", e(r2)) dec(3) adjr2 excel replace
predict pred_linear
gen e2_linear=(pred_linear-SCC_2)^2
*Polynomial Approximation
reg SCC_2 t t2
reg SCC_2 t t2 t3
reg SCC_2 t t2 t3 t4
outreg2 using Table_extra_2,  addstat("Liklihood", e(ll), "F-statistic", e(F), "Prob>F", e(p), "R2", e(r2)) dec(3) adjr2 excel
predict pred_poly
gen e2_poly=(pred_poly-SCC_2)^2
reg SCC_2 t t2 t3 t4 t5
*Box Cox
boxcox SCC_2 t, model(rhsonly)
outreg2 using Table_extra_2,  addstat("Liklihood", e(ll)) dec(3) excel
predict pred_box
gen e2_box=(pred_box-SCC_2)^2


*********************************************************************************************************
***********************************************Fit*******************************************************
*********************************************************************************************************

******************************************In-Sample Fit**************************************************
preserve
collapse (sum) e2_linear e2_poly e2_box
sum e2*
restore

*Polynomial's second coefficient becomes insignificant when added, so actually appropropriate polynomial is linear*
*Polynomial outperforms other models in minimizing sum of squared-error, log-likelihood, and adjusted R-squared*
*Box-cox outpreforms linear, though box-cox is essentially linear

******************************************Out-of-Sample Fit**********************************************
*Linear
reg SCC_2 t if Year<=2050
predict pred_linear_out
gen e2_linear_out=(pred_linear_out-SCC_2)^2
*Polynomial Approximation
reg SCC_2 t t2 if Year<=2050
reg SCC_2 t t2 t3 if Year<=2050
predict pred_poly_out
gen e2_poly_out=(pred_poly_out-SCC_2)^2
reg SCC_2 t t2 t3 t4 if Year<=2050
*Box Cox
boxcox SCC_2 t if Year<=2050, model(rhsonly)
predict pred_box_out
gen e2_box_out=(pred_box_out-SCC_2)^2

*Fit
preserve
drop if Year<=2050
collapse (sum) e2_linear_out e2_poly_out e2_box_out
sum e2*
restore

*Linear outperforms other models in minimizing sum of squared error, though linear and polynomial are close
*Poly-nomial outperforms box-cox in minimizing sum of squared-error*

```

```
drop pred_* e2_*


**********************************************************************************************************
**********************************************************************************************************
***********************************************3% 95th************************************************
**********************************************************************************************************
**********************************************************************************************************

**********************************************************************************************************
***********************************************Regression*************************************************
**********************************************************************************************************

*Linear
reg SCC_3_95 t
outreg2 using Table_extra_3_95,  addstat("Liklihood", e(ll), "F-statistic", e(F), "Prob>F", e(p), "R2", e(r2)) dec(3) adjr2 excel replace
predict pred_linear
gen e2_linear=(pred_linear-SCC_3_95)^2
*Polynomial Approximation
reg SCC_3_95 t t2
reg SCC_3_95 t t2 t3
reg SCC_3_95 t t2 t3 t4
outreg2 using Table_extra_3_95,  addstat("Liklihood", e(ll), "F-statistic", e(F), "Prob>F", e(p), "R2", e(r2)) dec(3) adjr2 excel
predict pred_poly
gen e2_poly=(pred_poly-SCC_3_95)^2
reg SCC_3_95 t t2 t3 t4 t5
*Box Cox
boxcox SCC_3_95 t, model(rhsonly)
outreg2 using Table_extra_3_95,  addstat("Liklihood", e(ll)) dec(3) excel
predict pred_box
gen e2_box=(pred_box-SCC_3_95)^2


**********************************************************************************************************
***********************************************Fit********************************************************
**********************************************************************************************************

******************************************In-Sample Fit**************************************************
preserve
collapse (sum) e2_linear e2_poly e2_box
sum e2*
restore

*Polynomial outperforms other models in minimizing sum of squared-error, log-likelihood, and adjusted R-squared*
*Box-cox outpreforms linear

******************************************Out-of-Sample Fit**********************************************
*Linear
reg SCC_3_95 t if Year<=2050
predict pred_linear_out
gen e2_linear_out=(pred_linear_out-SCC_3_95)^2
*Polynomial Approximation
reg SCC_3_95 t t2 if Year<=2050
reg SCC_3_95 t t2 t3 if Year<=2050
```

```
predict pred_poly_out
gen e2_poly_out=(pred_poly_out-SCC_3_95)^2
reg SCC_3_95 t t2 t3 t4 if Year<=2050
*Box Cox
boxcox SCC_3_95 t if Year<=2050, model(rhsonly)
predict pred_box_out
gen e2_box_out=(pred_box_out-SCC_3_95)^2

*Fit
preserve
drop if Year<=2050
collapse (sum) e2_linear_out e2_poly_out e2_box_out
sum e2*
restore

*Poly-nomial outperforms box-cox and linear
*Linear outperforms box-cox

drop pred_* e2_*

*I am going to select Linear function*
*Polynomial overfits model for high temperatures, while linear seems to produce a lower bound approximation
*Like polynomial, boxcox transformation seems to do poorly on the non-linear SCC paths

**********************************Linear****************************************************************************************
reg SCC_5 t
outreg2 using Table_Linear_Extrapolation,  addstat("Liklihood", e(ll), "F-statistic", e(F), "Prob>F", e(p), "R2", e(r2)) dec(3) adjr2 excel replace
reg SCC_3 t
outreg2 using Table_Linear_Extrapolation,  addstat("Liklihood", e(ll), "F-statistic", e(F), "Prob>F", e(p), "R2", e(r2)) dec(3) adjr2 excel
reg SCC_2 t
outreg2 using Table_Linear_Extrapolation,  addstat("Liklihood", e(ll), "F-statistic", e(F), "Prob>F", e(p), "R2", e(r2)) dec(3) adjr2 excel
reg SCC_3_95 t
outreg2 using Table_Linear_Extrapolation,  addstat("Liklihood", e(ll), "F-statistic", e(F), "Prob>F", e(p), "R2", e(r2)) dec(3) adjr2 excel

**********************************Polynomial********************************************************************************************
reg SCC_5 t t2 t3 t4
outreg2 using Table_Poly_Extrapolation,  addstat("Liklihood", e(ll), "F-statistic", e(F), "Prob>F", e(p), "R2", e(r2)) dec(3) adjr2 excel replace
reg SCC_3 t
outreg2 using Table_Poly_Extrapolation,  addstat("Liklihood", e(ll), "F-statistic", e(F), "Prob>F", e(p), "R2", e(r2)) dec(3) adjr2 excel
reg SCC_2 t
outreg2 using Table_Poly_Extrapolation,  addstat("Liklihood", e(ll), "F-statistic", e(F), "Prob>F", e(p), "R2", e(r2)) dec(3) adjr2 excel
reg SCC_3_95 t t2 t3 t4
outreg2 using Table_Poly_Extrapolation,  addstat("Liklihood", e(ll), "F-statistic", e(F), "Prob>F", e(p), "R2", e(r2)) dec(3) adjr2 excel

**********************************Box-Cox*****************************************************************************************
boxcox SCC_5 t, model(rhsonly)
outreg2 using Table_box_Extrapolation,  excel replace
boxcox SCC_3 t, model(rhsonly)
outreg2 using Table_box_Extrapolation,  excel
boxcox SCC_2 t, model(rhsonly)
outreg2 using Table_box_Extrapolation,  excel
boxcox SCC_3_95 t, model(rhsonly)
outreg2 using Table_box_Extrapolation,  excel
```

STATE OF MICHIGAN
MICHIGAN PUBLIC SERVICE COMMISSION

In the matter of **Enbridge Energy, Limited Partnership's** declaratory request that it has the requisite authority needed from the Commission for the proposed Line 5 pipeline Project.	)))))	Case No. U-20763

PROOF OF SERVICE

I hereby certify that a true copy of the foregoing **Direct Testimony and Exhibits of Peter Erickson, Direct Testimony and Exhibits of Peter Howard, Direct Testimony and Exhibits of Elizabeth Stanton, and Direct Testimony and Exhibits of Jonathan Overpeck** were served by electronic mail upon the following Parties of Record, this 14th day of September, 2021.

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