Department of
Environmental
Conservation

Establishing a Value of Carbon

GUIDELINES FOR USE BY STATE AGENCIES

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Executive Summary

The Climate Leadership and Community Protection Act directs the Department of Environmental Conservation (the Department or DEC) to establish a value of carbon for use by State agencies. This guidance document provides a recommended procedure for using a damages-based value of carbon along with a general review of the marginal abatement cost approach. The current guidance is focused on the damages-based value as a tool to aid state agencies as they begin to regularly consider greenhouse gas emissions and climate change in their decision-making. In some decision-making contexts, particularly those that have a history of valuing carbon, such as the New York electric industry, alternative approaches may be more appropriate for both resource valuation and benefit-cost analyses.

This guidance document is designed to provide accessible and practical assistance to State agencies and authorities for applying a damages-based value of carbon where it is useful and appropriate. It is not the intention of the Department that this guidance be interpreted as establishing a requirement on any public or private entity.

Where appropriate, the Department is recommending the use of the federal U.S. Interagency Working Group's (federal IWG) damages-based value of carbon, also referred to as the social cost of carbon dioxide, methane, and nitrous oxide. Resources for the Future, under contract to the New York State Energy Research and Development Authority (NYSERDA), has provided the federal IWG values in 2020 dollars per metric ton of emissions (adjusted for inflation) along with estimates based on additional discount rates. Recommendations are also provided for assessing other greenhouse gases and public health impacts.

The Department specifically recommends that State entities provide an assessment using a central value that is estimated at the 2 percent discount rate as the primary value for decision-making, while also reporting the impacts at 1 and 3 percent to provide a comprehensive analysis. State agencies should look at the full range as a method that is consistent with the federal government's guidance for using a damages-based value of carbon. This range translates into a 2020 value of carbon dioxide of $53-421 per ton, with a central value of $125 per ton; a 2020 value of methane of $1,527-6,578 per ton, with a central value of $2,782 per ton; and a value of nitrous oxide of $19,084-140,766 per ton, with a central value of $44,727 per ton. The full set of values for 2020-2050 is provided in the separate Appendix tables.

Various jurisdictions have used the damages-based value of carbon as part of cost benefit analyses, rulemaking processes, environmental assessment, and for demonstrating the benefits

of climate change policies. These and other applications are reviewed along with simplified examples in this document. State agencies and authorities may apply this guidance in those contexts or identify additional applications for the Value of Carbon and develop additional guidance. DEC and NYSERDA staff are available to assist in addressing any technical or implementation questions related to this guidance or the Value of Carbon. Please contact the DEC Office of Climate Change at 518-402-8448 or climatechange@dec.ny.gov.

I. Purpose of this Guidance

The Climate Leadership and Community Protection Act, Chapter 106 of the Laws of 2019 (CLCPA) provides direction to all State entities regarding actions to address climate change. This guidance is intended to address the following CLCPA directive, as added to the Environmental Conservation Law:

> *§ 75-0113. VALUE OF CARBON.*
>
> *1. No later than one year after the effective date of this article, the Department, in consultation with the New York State Energy Research and Development Authority, shall establish a social cost of carbon for use by State agencies, expressed in terms of dollars per ton of carbon dioxide equivalent.*
>
> *2. The social cost of carbon shall serve as a monetary estimate of the value of not emitting a ton of greenhouse gas emissions. As determined by the Department, the social cost of carbon may be based on marginal greenhouse gas abatement costs or on the global economic, environmental, and social impacts of emitting a marginal ton of greenhouse gas emissions into the atmosphere, utilizing a range of appropriate discount rates, including a rate of zero.*
>
> *3. In developing the social cost of carbon, the Department shall consider prior or existing estimates of the social cost of carbon issued or adopted by the federal government, appropriate international bodies, or other appropriate and reputable scientific organizations.*

This guidance establishes a value of carbon based on an estimate of net damages incurred as a result of climate change, which also formed the basis of the U.S. federal government's

previously established "social cost of carbon."[1] This guidance also considers the types of State activities for which this approach may be best suited and discusses some key considerations.

State agencies may find the damages-based value of carbon provided in this guidance useful for describing the global value of policies, programs, or projects or for estimating global damages in an assessment of benefits and costs. However, other values of carbon may be established by the Department or other State entities for other purposes. In particular, the marginal abatement cost approach has been used in some instances, including by New York State in the electric power sector, to aid in planning to meet discrete greenhouse gas reduction goals.

The guidance is broken down into seven parts, including this Part that describes the purpose. Part II lists definitions for terms used throughout this guidance. Part III describes the "value of carbon" concept in a broad sense and explains the differences between the two approaches referred to in the CLCPA: (i) the damages approach used to establish the federal social cost of carbon and the primary focus of this guidance; and (ii) the marginal abatement cost approach. Part IV provides additional details on the damages approach, how it was calculated by the federal government, and how it may be updated. Part V explains when a damages-based value of carbon could be used by State entities and reviews the key considerations that would need to be addressed. Part VI describes how the damages approach may be applied to all of the greenhouse gases that are subject to the CLCPA, including the federal government's social cost of methane and the social cost of nitrous oxide, which are two special cases of the social cost of carbon. Part VII provides example scenarios in which the greenhouse gas emissions associated with a project and a policy are evaluated using the damages-based value of carbon. A separate Appendix document provides the estimates for the value of carbon that is described in this guidance.

This guidance establishes a value of carbon that can be used by State entities to aid decision-making and used as a tool for the State to demonstrate the global societal value of actions to reduce greenhouse gas emissions. The Department recommends that a value of carbon be used as part of a full and transparent assessment of environmental, economic, and social impacts, wherever appropriate. This guidance does not impose a compliance obligation or fee

[1] Interagency Working Group on Social Cost of Greenhouse Gases, United States Government. 2016. Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.

on any entity; the imposition of any such new compliance obligation or fee on any entity would require separate State action.

II. Definitions

Discount Rate – a reduction (or "discount") in value each year as a future cost or benefit is adjusted for comparison with a current cost or benefit[2]; a higher rate places a higher value on the present.

Greenhouse Gas – carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride (SF_6), and any other substance emitted into the air that may be reasonably anticipated to cause or contribute to anthropogenic climate change.[3]

Marginal Greenhouse Gas Abatement Cost – a monetary estimate of the cost, usually in dollars per ton of carbon dioxide, associated with the last unit (the marginal cost) of emission abatement for varying amounts of greenhouse gas emissions reduction.[4]

Social Cost (of Carbon) – an estimate, in dollars, of the present discounted value of the future damage caused by a metric ton increase in emissions into the atmosphere in that year or, equivalently, the benefits of reducing emissions by the same amount in that year. It is intended to provide a comprehensive measure of the net damages—that is, the monetized value of the net impacts—from global climate change that result from an additional ton of emissions.[5]

Value of Carbon – any representation of monetary cost applied to a unit of greenhouse gas emissions, expressed in terms of the net cost of societal damages (i.e., social cost of carbon), marginal greenhouse gas abatement cost, or using another approach.

[2] National Academies of Sciences, Engineering, and Medicine. 2017. Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide. Washington DC: The National Academies Press. doi: 10.17226/24651
[3] Environmental Conservation Law § 75-0101(7).
[4] e.g. Kesicki, F and Strachan, N. 2011. Marginal abatement cost (MAC) curves: confronting theory and practice. Environmental Science and Policy 14:1195-1204
[5] National Academies. 2017. op cit.

III. What is a Value of Carbon?

A value of carbon is a monetary representation of the impact of a marginal change in greenhouse gas emissions. This value is usually expressed in terms of dollars per ton of a specific gas, such as carbon dioxide. Placing a value on greenhouse emissions can be a useful tool for policymaking and for decisions regarding proposed projects, as it allows the costs associated with emissions, and the benefits of avoided emissions, to be compared to other monetary values.

The CLCPA directed the Department to consider two approaches for establishing a value of carbon.[6] The first approach is based on the monetary cost of damages that would result from an incremental increase in emissions as a result of climate change, commonly referred to as the social cost of carbon. The second approach, the marginal abatement cost, establishes a value of carbon with reference to a specific emissions reduction goal. In other words, what would be the cost to reduce, or *abate*, the last metric ton of emissions by the amount needed to meet a particular emissions target at least cost.

The Damages Approach and the Social Cost of Carbon

The damages approach provides a monetary estimate of the impacts on society from activities that are a source of greenhouse gas emissions. Greenhouse gas emissions are often described as a negative externality in the economy and as a market failure, as there are costs to society from such emissions that are not accounted for in market prices. A market may in turn allow greenhouse gas emissions to exceed socially optimal levels. A damages-based value of carbon puts the effects of climate change into economic terms to help decisionmakers understand the economic impacts of decisions that would increase or decrease emissions.

A damages-based value of carbon can be used on its own, such as an informational item, or compared to other monetary values in a cost-benefit analysis. The most common damage valuation in use in the U.S. is the federal government's "social cost of carbon" metric,[7] which

[6] There are additional ways to establish a monetary value for a ton of greenhouse gas emissions. For example, the Regional Greenhouse Gas Initiative, 6 NYCRR Part 242, establishes a market-based compliance cost on carbon dioxide emitted from certain power plants and the Public Service Commission Clean Energy Standard, Case 15-E-0302, sets Tier 1 compliance costs based on the results of competitive solicitations for renewable energy generation projects. These costs could also be incorporated into the development of a marginal abatement cost.
[7] Interagency Working Group op cit.

was first established in 2007 as an estimate of the global, net damages from an additional ton of carbon dioxide added to the atmosphere. The federal Interagency Working Group on the Social Cost of Greenhouse Gases (or "federal IWG") established this metric specifically for use in the cost-benefit analyses that are required as part of regulatory actions by the federal government. The federal IWG later established a social cost of methane and nitrous oxide for the same purposes. The Department has strongly supported the use of these metrics by federal agencies to more fully account for the benefits of reducing greenhouse gas emissions, particularly when measured as global damages.[8] Most recently, the U.S. Governmental Accountability Office reviewed the history and status of the federal IWG metrics and the prospects for future improvements.[9] The previous federal administration also appropriately suggested that the federal IWG metrics could be used to inform environmental reviews.[10] This could be federal environmental reviews conducted under the National Environmental Policy Act, or state reviews conducted under state law analogs, such as the New York State Environmental Quality Review Act. U.S. States have also used the federal IWG social cost of carbon as an informational item to accompany climate change planning documents.[11]

There is a large volume of literature describing the limitations of the federal social cost of carbon, which include the uncertainty inherent in predicting long-term economic, demographic, and climatic changes. Such limitations also include many of the issues that are common to environmental cost-benefit analyses, such as the difficulty in putting a monetary cost on non-monetary values, such as human health, and in selecting a discount rate. Approaches for addressing these issues are described later in this guidance.

The Marginal Abatement Cost Approach

An alternative approach to valuing carbon included in the CLCPA reflects the cost of a marginal reduction in emissions. Marginal abatement cost typically is derived from a "marginal abatement cost curve," which can be generated either by plotting abatement measures along an increasing

[8] See e.g., Comments of the New York State Department of Environmental Conservation. October 26, 2018. National Highway Traffic Safety Administration (NHTSA) Proposed Rule: The Safer Affordable Fuel-Efficient Vehicles Rule for Model Years 2021-2026 Passenger Cars and Light Trucks. NHTSA-2018-0067-11905.
[9] GAO. 2020. Identifying a Federal Entity to Address the National Academies' Recommendations Could Strengthen Regulatory Analysis. GAO-20-254
[10] Council on Environmental Quality. 2016. Final Guidance for Federal Departments and Agencies on Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in National Environmental Policy Act Reviews.
[11] See e.g., California Air Resources Board. 2017. Estimated Social Costs of Evaluated Measures. California's 2017 Climate Change Scoping Plan.

scale of cost per emission reduction or by using economic or energy models to evaluate the level of emissions reductions across an economy or a sector resulting from the imposition of a carbon price. The marginal abatement cost is the highest cost required to meet the emission reduction goal.

Whereas the damages approach is intended to establish a value of carbon for all sectors, marginal abatement costs are typically estimated with regard to sector-specific technologies, markets, and emission reduction goals. That is, the marginal abatement approach requires an analysis of the relevant economic sector or sectors and policy options of interest for the relevant timeframe, which could result in multiple values of carbon that differ between economic sectors or policies. In New York State today, the electric power sector is best positioned to apply marginal abatement approaches, due to available cost information and its longer history of effective emissions reductions policies. In its recent review of the federal IWG social cost of carbon, the U.S. Government Accountability Office referred to the marginal abatement cost as a type of "target-consistent approach" to valuing emissions, which reflects the fact that this approach establishes a value that depends in part on the relevant emission reduction target.[12]

Many public and private entities have used marginal abatement cost curves to aid decision making. The federal government, for example, has used marginal abatement curves to describe policy options for reducing non-CO_2 gases.[13] Most notably, the marginal abatement cost approach has been used by some jurisdictions to guide climate change planning at the national level.[14] As in the case of the damages approach, the underlying assumptions can be highly uncertain. For example, marginal abatement costs are sensitive to rates of technological improvements and the costs of and potential for abatement, changes that may not be easily predicted. However, policymakers may regularly update and refine their estimate of marginal abatement costs to address these changes. In this way, the marginal abatement approach can be used along with other metrics in an adaptive planning process and adjusted as needed on a regular basis, for example as new and lower-cost technologies are made available.

General Recommendations for Establishing a Value of Carbon

For the purposes of this guidance, the Department is establishing a value of carbon for state agencies based on the damages approach. The rationale for utilizing a damages approach is

[12] GAO 2020 op cit.
[13] Most recently in Environmental Protection Agency. 2019. Global Non-CO_2 Greenhouse Gas Emission Projections and Mitigation Potential: 2015-2050.
[14] See examples for France and the United Kingdom described in GAO 2020 op cit.

three-fold. First, the damages approach provides a set of values that can be used by any State entity in a wide variety of contexts to describe the value of any emission reduction, without additional analysis. Secondly, the damages approach is already in use by the State's counterparts in the federal government for similar types of decisions, such as in the development of regulations and the assessment of environmental impacts. Finally, the Department is not seeking to establish an economic cost, compliance cost, or fee on any entity through this guidance, which would require specific, targeted analyses of the relevant sectors. Instead, the purpose of this guidance is to provide information that can be readily applied by State entities when estimating the greenhouse gas reduction value of their actions.

With regard to the use of other approaches to the value of carbon, including the marginal abatement cost approach, the Department may provide additional guidance at a later date. In the interim, the Department provides the following general recommendations for applying any value of carbon:

- In applying a value of carbon, the Department recommends that the full scope of the emission sources that are subject to the CLCPA be considered whenever possible. For example, the CLCPA includes emissions outside of the state associated with imported fossil fuels and electricity.[15]
- Although the value of carbon is most frequently applied only to carbon dioxide, all relevant greenhouse gases should be assessed. No policy intended to reduce one greenhouse gas should unintentionally increase emissions of other greenhouse gases or result in the "leakage" of emission sources into other jurisdictions, if avoidable.
- The value of carbon should be considered as part of a full assessment of the impacts described within the CLCPA, including to disadvantaged communities, as well as to public health and the environment, per the State Environmental Quality Review Act.[16]
- Careful consideration should be applied when combining different values of carbon and applying the net total to the same marginal ton of emissions as they may represent contradictory or redundant valuations, such as a global damages estimate versus a market-based allowance price. If multiple approaches are used within a decision or planning context, the results should be treated as distinct pieces of information.

[15] ECL § 75-00101(13)
[16] See ECL Article 8, 6 NYCRR Part 617.

IV. Establishing a Damages-Based Value of Carbon

The values derived from the damages approach can be used to help understand the economic impacts of policies or projects that would result in a change in emissions. Policies or projects that would result in increased emissions would have economic costs, while policies or projects that reduce emissions result in economic benefits. When compared against other costs, such as the capital costs associated with a project, the damages-based value of carbon can help determine if a project or policy provides a net benefit or a net cost to the State.

There is extensive literature available that describes the damages-based approach, its uses, and key considerations. Informative documents include the federal IWG technical support document,[17] the National Academies of Science 2016[18] and 2017[19] reviews and recommendations for future improvements, and the 2020 review provided by the U.S. Government Accountability Office.[20] In addition, work is ongoing from organizations such as Resources for the Future, the Climate Impact Lab, and New York University's Institute for Policy Integrity, among others.

At a high-level, the damages approach uses Integrated Assessment Models (IAMs) to translate a marginal increase in emissions into a change in atmospheric greenhouse gas concentrations, a resulting change in the global climate, and then subsequent economic impacts. Some of the considerations when applying the damages approach include the selection of IAM, the geographic scope and timeframe, and the discount rate applied to the model output to describe costs in a common present value.

At this time, the Department recommends that State entities apply the methods that the U.S. federal IWG used to establish a social cost of carbon, social cost of methane, and social cost of nitrous oxide for use by federal agencies.[21] Resources for the Future, under contract to NYSERDA, has provided the federal IWG values in 2020 dollars per metric ton of emissions (adjusted for inflation) along with estimates based on additional discount rates. The background

[17] IWG op cit.
[18] National Academies of Sciences, Engineering, and Medicine. 2016. Assessment of Approaches to Updating the Social Cost of Carbon: Phase 1 Report on a Near Term Update. Committee on Assessing Approaches to Updating the Social Cost of Carbon, Board on Environmental Change and Society. Washington, DC: The National Academies Press. doi:10.17226/21898
[19] National Academies of Sciences, Engineering, and Medicine. 2017. Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide. Washington DC: The National Academies Press. doi: 10.17226/24651
[20] GAO 2020 op cit.
[21] IWG op cit.

information below provides additional information on how the federal government addressed certain key considerations. Further guidance is provided later in this document as to how State entities may approach these considerations in their own processes and how a comparable metric may be established for the other greenhouse gases that are listed in the CLCPA.

The U.S. Interagency Working Group on the Social Cost of Carbon

The federal IWG[22] applied the damages approach in order to establish social cost of carbon values that would be used by federal agencies in cost-benefit analyses. The federal IWG's approach to four key considerations is described below: model selection, geographic scope, timeframe, and the discount rate.

Model Selection: The federal IWG utilized the outputs of three IAMs: DICE (Dynamic Integrated Climate and Economy[23]), PAGE (Policy Analysis of the Greenhouse Effect[24]), and FUND (Climate Framework for Uncertainty, Negotiation, and Distribution[25]). These models translate: (1) marginal emissions into atmospheric greenhouse gas concentrations, (2) greenhouse gas concentrations into changes in temperature, and finally (3) changes in temperature into various economic damages. By incorporating the outputs of multiple models, the federal IWG was able to consider changes in net agricultural productivity, property damages from increased flood risk, human health, energy systems costs, and other aspects of the economy, in order to provide a comprehensive estimate of impacts from climate change.

Geographic Scope: The initial work of the federal IWG considered the global impacts of climate change, and this is the approach utilized by the Department in this guidance.[26] Under the current administration federal agencies subsequently have relied on a set of interim estimates based on the IWG approach but using a domestic scope, which inappropriately considers the damages occurring only within the United States. Under the CLCPA, New York State is required to consider global damages.[27] In addition to being a CLCPA requirement, the global cost is the most appropriate value to use due to the global nature of climate change and the economy.

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[22] Initially the Interagency Working Group on the Social Cost of Carbon, later renamed the Interagency Working Group on the Social Cost of Greenhouse Gases

[23] e.g., Nordhaus, W.D.. 2017 Evolution of assessments of the economics of global warming: Changes in the DICE model, 1992-2017.National Bureau of Economic Research. Working Paper 23319.

[24] e.g., Hope, C. 2006. The marginal impact of CO2 from PAGE 2002. Integrated Assessment Journal. 6:9-56; Dietz S., Hope C., Patmore N. 2007. Some economics of 'dangerous' climate change: Reflections on the Stern Review. Global Environmental Change. 17:311-325.

[25] e.g., Anthoff D., Tol R.S. 2011. The uncertainty about the social cost of carbon: A decomposition analysis using FUND. Climatic Change. 117.

[26] Presidential Executive Order 13783 disbanded the IWG in 2017.

[27] ECL § 75-0113(2).

Greenhouse gas emissions have an effect on climatic changes worldwide, regardless of where the source of emissions is located. Emissions in New York State will cause damages outside the State and emissions from other jurisdictions will impact the damages experienced in New York State.

Timeframe: The federal IWG estimates damages through 2300 to represent long-term damages, but there is substantial uncertainty when forecasting future damages. Some portion of carbon dioxide emissions will persist in the atmosphere for more than a century. As such, the resulting damages must be modeled over that entire period. However, climate change affects every aspect of the environment and the uncertainty in predicting those effects will increase the further into the future. Furthermore, each greenhouse gas has a different atmospheric lifespan, and some are much shorter or much longer in duration than carbon dioxide. Methane, due to its role as an ozone precursor, is also associated with both climate impacts and impacts to public health that may occur over different timeframes.

Discount Rate: Discounting is a common and useful aspect of economic analyses that allows for the balancing of present versus future value and it has been widely discussed in the literature, particularly in its application to the federal social cost of carbon. However, the selection of the discount rate has a large effect on the estimate of the value of carbon, and there is no consensus or uniform scientific basis for the selection of a discount rate. The federal IWG compared a descriptive approach to establishing public preferences, based on observations of consumer behavior for example, to a normative approach, based on a consideration of the social or ethical implications of discounting damages to future generations.[28] The federal IWG's approach to discounting was primarily based on observations of consumer behavior, as measured through market rates of return. It applied a social discount rate, which reflects the rate at which society as a whole is willing to trade off a value received at one point in time (e.g., today) with a value received at another point in time (e.g., the future).

The federal IWG utilized real discount rates of 2.5, 3, and 5 percent per year in order to reflect a range of decision contexts, and as a reflection of reasonable judgments under both the descriptive and normative approaches described above. The federal IWG's central value applies a 3 percent discount rate that is consistent with the economics literature and in the federal government's Circular A-4 guidance for the consumption rate of interest. The 3 percent discount

[28] As reviewed in the National Academies reports op cit. e.g., IWG. 2010. "F. Discount Rate". Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866. Page 18.

rate is also roughly equal to calculations of the after-tax riskless interest rate. The 5 percent discount rate was intended as an upper value that represents the possibility that climate damages are positively correlated with market returns. This higher rate may also be justified by the high interest rates that consumers use to smooth consumption across time periods. The lower 2.5 percent discount rate was intended to address the concern that interest rates have a high degree of uncertainty over time. Additionally, if climate investments are negatively correlated with the overall market rate of return, then a lower discount rate is more justified. Subsequent analyses suggested that the values adopted by the federal IWG are relatively high, and that lower values would be more appropriate for the consumption rate of discount in general[29] and in particular when addressing the impacts of climate change.[30] The purpose of the discount rate when applied to actions by public entities should be, in part, to reflect public preferences as to costs as well as to public safety, welfare, and environmental protection. As such, the Department has considered additional, lower discount rates as well, as discussed further below in Part V.

V. Guidelines for Applying a Damages-Based Value of Carbon

When do these guidelines apply?

The purpose of this guidance is to aid State entities in decision making by establishing a monetary value of greenhouse gas emission reductions or increases that reflects global societal impacts. This guidance does not itself establish a price or fee on emissions, and the value of carbon presented here is not the only value that may be used by the State. Alternative methods for establishing a value of carbon may be used by State entities, including the Department, as needed to achieve the goals and requirements of the CLCPA as well as other State goals, such as to protect public safety, welfare, and the environment.

The damages approach to establishing a value of carbon may be best suited to the following types of actions:

[29] Council of Economic Advisers. 2017. Discounting for public policy: Theory and recent evidence on the merits of updating the discount rate. Issue brief. Washington, DC. https://obamawhitehouse.archives.gov/sites/default/files/page/files/201701_cea_discounting_issue_brief.pdf

[30] e.g., van den Bergh, J.C.J.M., Botzen, W.J.W. 2015. Monetary valuation of the social cost of CO_2 emissions: A critical survey. Ecological Economics. 114:33-46.

- Cost-Benefit Analysis, such as may be used to evaluate alternatives as a part of rulemakings or environmental assessments
- Describing the societal benefits of strategic plans, programs, or policies that will reduce greenhouse gas emissions
- Evaluating other types of decisions, such as those regarding State procurements, contracts, grants, or permitting

Recommended Procedure

The Department recommends that State entities apply the methods adopted by the federal IWG when utilizing a damages-based approach to valuing greenhouse gas emissions, along with the recommended steps below.

1. Estimate the emissions for all relevant greenhouse gases.[31]

Almost all of the literature regarding the value of carbon is focused on carbon dioxide, which is the greenhouse gas that has had the greatest impact on global climate change. However, the scope of the CLCPA encompasses carbon dioxide and five other major greenhouse gases, other substances that affect climate change, the co-pollutants that are typically associated with greenhouse gas emission sources, as well as the "leakage" of greenhouse gases in other jurisdictions. This guidance is intended to aid in the use of a value of carbon using the damages approach. State entities may require additional assessments when evaluating actions to meet the requirements of the CLCPA.

A first step in determining the impacts of a given decision will be to determine which of the major greenhouse gases are likely to be associated or affected by the project, policy, or program in question and then to estimate the emissions of those gases for each year (Table 1). This may already be determined as part of other requirements, e.g., for permits or environmental assessments, or may be informed by other available guidance.[32] A review of all available data and methods for estimating greenhouse gas emissions would be beyond the scope of this document. However, State entities can consult with the Department and NYSERDA to locate additional resources, as needed.

[31] See definition of greenhouse gas in ECL 75-0101 which includes additional substances
[32] New York State Department of Environmental Conservation. 2009. DEC Policy: Assessing Energy Use and Greenhouse Gas Emissions in Environmental Impact Statements. https://dec.ny.gov/regulations

Table 1: Examples of Greenhouse Gas Emission Sources

Greenhouse gas	Examples of primary sources
Carbon dioxide	Fossil fuels, Land management
Methane	Fossil fuels, Land management, Waste, Livestock
Nitrous oxide	Fossil fuels, Soil management, Wastewater
Hydrofluorocarbons (hfcs)	Substitutes for Ozone-Depleting Substances; Refrigeration, Heating and Cooling, Manufacturing
Perfluorocarbons (pfcs)	Manufacturing
Sulfur hexafluoride	Electricity transmission and distribution, Manufacturing

2. Consider the fullest geographic scope of damages.

The CLCPA directs the Department to establish a value of carbon that considers global damages, which would best protect the public and the environment. As such, the Department recommends that the State use the global estimation of damages established by the federal IWG, as updated through the work of NYSERDA and its consultant Resources for the Future, as opposed to the U.S. domestic damages estimation that is currently used by federal agencies.

3. Apply the most up-to-date, peer-reviewed information available.

The federal IWG social cost of carbon was established using the best available models and information available at the time, but regular updates will be needed to improve the estimation of global damages and to integrate up-to-date information on atmospheric greenhouse gas concentrations along with economic, demographic and other parameters. The National Academies of Science laid out an approach for updating and improving the federal IWG's values[33] and multiple research teams are actively working to address these recommendations and to make additional improvements to the relevant science. The Department recommends that State entities stay apprised of new updates and apply the most up-to-date values available. To support this objective, the Department will synthesize and provide updated values as appropriate, including through updates to the Appendix document.

4. Apply an appropriate discount rate.

Importantly, because the damages-based value of carbon described here is not intended to levy an actual cost or fee on any entity, the selection of discount rate should not be interpreted as having an actual, direct cost to the public. Since the damages-based value of carbon is used primarily for societal decision making, the correct discount rate to use in its calculation is a

[33] National Academies op cit.

social discount rate, which reflects the rate at which society as a whole is willing to trade off a value received today with a value received in the future. As has been the case with the use of the social cost of carbon by federal agencies, the range of discount rates can be used to describe the potential impacts of global climate change and to compare this alongside other economic and environmental costs and benefits.

The CLCPA requires the Department to consider "a range of appropriate discount rates, including a rate of zero" when establishing a value of carbon.[34] Based on an assessment of the literature and consultation with State partners and stakeholders, the Department recommends that State entities present the damages-based value of carbon using estimates calculated at a range of discount rates from 1 to 3 percent, with a central value that is estimated at the 2 percent discount rate, as discussed further below. Resources for the Future, under contract to NYSERDA, provided New York State with values in 2020 dollars per metric ton of emissions for the federal IWG social cost of carbon, methane, and nitrous oxide at discount rates of 0, 1, 2, and 3 percent (see Appendix document). The 0 percent discount rate is provided to give full consideration of a range of rates as required by the CLCPA, but the Department is not recommending its usage by state agencies. These estimates were calculated using the same peer-reviewed models that were used by the federal IWG.

Fundamentally, the Department is recommending State agencies consider a lower range of discount rates than recommended by the federal IWG. The federal IWG's central discount rate of 3 percent should be considered as a maximum discount rate. A rate of 2 percent should be used as the central value and a rate of 1 percent should be considered as the lower bound to ensure that State agencies are properly informed in their decision-making.

The Department recommends the use of a central discount rate to establish a central value of the potential impacts from the marginal increase in emissions. This central rate should be used as the primary value for decision-making purposes. Using a discount rate of no more than 2 percent to establish a central value is recommended for three reasons.

First, although higher discount rates may be appropriate for guiding the long-term investment of private funds, they are less appropriate for decisions regarding public safety and welfare, particularly when considering the scope and scale of the impacts to the public from global climate change. If a damages-based value of carbon is used within the context of the CLCPA,

[34] ECL § 75-0113(2).

then a lower range of discount rates is needed compared to those used by the federal government.

Second, multiple lines of research have concluded that the discount rates used by the federal IWG underestimate the value of avoided damages from greenhouse gas emissions. Experts now generally consider a range of 1-3 percent to be more acceptable.[35]

A lower discount rate may help address the underestimation of the potential damages from climate change. One of the fundamental critiques of the IAMs is that they do not properly account for the possibility of large-scale singular events or irreversible climatic tipping points, many of which are difficult to monetize. Ideally, this source of uncertainty would be addressed within the damage models rather than in the application of a discount rate. However, until this aspect of the modeling can be resolved, it is fair to assume that potential damages have been underestimated and using a lower discount rate can accommodate for this shortcoming in the existing models.

Finally, the Department is not recommending that a discount rate of zero be applied to the damages-based estimate that is provided here. Consistent with the requirements of the CLCPA a rate of zero is among the range of discount rates considered as part of developing this guidance document. A discount rate of zero treats present value and future value equally and assumes that the public has no preference regarding value over time periods or based on the relative wealth of a society, which may not be valid. As reviewed by the National Academies of Science, additional approaches to discounting may be taken up by the federal government that address the uncertainty and risks associated with discounting and climate change damages.[36] These approaches require further development and review before the Department can provide guidance for their usage. Additional approaches such as declining discount rates and providing estimates at the 95th percentile of the central value could also be considered by the Department in the future as more review and refinement of the estimates occur.

Until such time, it is more appropriate to report a range of values, including estimates at a low discount rate of 1 percent, as this recognizes that the public may have differing preferences and acknowledges that there is no one correct value. Federal agencies similarly report the social costs using multiple rates.[37] An additional benefit of considering multiple rates is that the impact

[35] Drupp M.A. et al. 2018. Discounting disentangled. American Economic Journal: Economic Policy. 10:109-134
[36] National Academies of Science 2017 op cit.
[37] See examples in the Federal register, such as NHTSA-2014-0132

of the discount rate is made apparent and a wider range of potential benefits may be considered.

VI. Guidelines for Assessing Multiple Greenhouse Gases

The CLCPA references six greenhouse gases that are commonly included in international climate policy: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons (HFCs), perfluorocarbons, and sulfur hexafluoride.[38] The federal IWG provided an estimation of the damages from the first three gases, as these represent the majority of global emissions and are associated with the economic activities of primary interest, namely fossil fuel combustion. However, all of the gases are relevant to planning and State decision-making under the CLCPA. In some cases, policies and projects that would reduce the emissions of one gas may lead to increases in other emissions. These types of interactions should be anticipated and, where possible, assessed using a comparable level of assessment. The damages-based approach may assist State entities in evaluating conflict and potential tradeoffs.

Establishing a value of carbon for each of the six greenhouse gases is complicated by two factors: (i) each gas affects climate change differently; and (ii) some gases impose additional impacts unrelated to climate change. All of the greenhouse gases included in the CLCPA are well-mixed gases that contribute in a similar way to climate change. However, methane and most HFCs are shorter-lived than carbon dioxide and the remaining gases are much longer-lived. As such, their impacts in terms of long-term damages should be expected to vary. Carbon dioxide and methane also impose other impacts, such as on agricultural productivity and public health, in addition to impacts caused by climate change.

Recommended Approach

Currently, there is no published analysis that applies the same models and parameters used by the federal IWG to all six of the greenhouse gases. State entities will need to take a different approach until this information is available.

Establish a value for each greenhouse gas using best available information.

The Department recommends that, where appropriate, State entities use the updated estimates of the federal IWG social costs of carbon dioxide, methane, and nitrous oxide following the guidelines provided in Part VI. Each of these estimates represents a gas-specific, but

[38] ECL § 75-0101(7).

comparable, assessment of the value of a marginal ton of these greenhouse gases in terms of global damages related to climate change.

For the remaining greenhouse gases, the Department considers the peer-reviewed scientific literature to be the best source of information for supplementing the federal IWG values. In some cases, there may be an estimation of damages for specific gases that may be useful even if the underlying methods are not identical to that used by the federal IWG. For example, Shindell et al. (2015[39]) provided an estimation of damages from multiple pollutants based on one of the damage models used by the federal IWG. This includes a value for the most common HFC, or HFC-134a, as well as pollutants that were not named in the CLCPA that may be of interest, such as black carbon. When work on these additional gases is comparable to the work of the federal IWG, the Department may supplement this guidance with additional information that will help State entities apply new research.

The method that has been widely discussed in the literature is to adjust the federal IWG values using carbon dioxide-equivalence, as determined by the Intergovernmental Panel on Climate Change (IPCC)'s Global Warming Potential metric (or GWP; Table 2). The GWP weighs the radiative forcing of a gas against that of carbon dioxide over a specified time frame.[40] The GWP metric is a useful heuristic for policymakers as it provides a simplified framework for emissions accounting. However, as the IPCC has discussed, the GWP is not a full representation of the physical properties of each gas or its potential impacts, and it is a relative value that is heavily influenced by the IPCC's estimation of current concentrations of carbon dioxide.[41] Additionally, the underlying approach for modeling climate change is fundamentally different from the IAMs used to estimate global damages. There would have to be a number of assumptions made to equate the underlying concept of relative radiative forcing with the approach to modeling economic damages, including that temperature change and economic damages are simultaneous, that all of the underlying modeling is comparable and considers the same time intervals, and that there would be no additional discounting applied.[42] Thus, simply adjusting the

[39] Shindell, D.T. 2015. The social cost of atmospheric release. Climatic Change 130:313-326.
[40] Commonly 100-years, but the CLCPA defines carbon dioxide-equivalence in terms of 20-years. ECL § 75-0101(2). As the IPCC has stated, the choice of time horizon is subjective. Like the discount rate, the difference reflects a preference for weighing near-term versus long-term impacts.
[41] As discussed by Working Groups 1 and 3 in the Fifth Assessment Report
[42] Marten, A.L. et al. 2015. Incremental CH_4 and N_2O mitigation benefits consistent with the U.S. government's SC-CO_2 estimates. Climate Policy 15: 272-298.

federal IWG values for CO_2 by the relative GWP of a given greenhouse gas in order to determine the value of that gas is not necessarily appropriate.

Although there is broad consensus that using the GWP is not appropriate for this purpose, using the approach is still recommended by some authors as an alternative to omitting an assessment of these gases altogether, or essentially treating these gases as if they have no impact or a value of zero.[43] The Department recommends that every effort be made to assess the damages of each gas and that peer-reviewed research on damages be applied whenever possible (see above). State entities and partners should also undertake additional analyses of any additional gases that may be associated with policies of interest to ensure that actions to reduce one gas do not inadvertently increase other gases with the unintended outcome of undermining the ability of the policy to achieve the requirements of the CLCPA. When including damage estimates for other gases, agencies should indicate how the value was determined, either through application of the GWP metric or by referencing the relevant publication, and consideration should be made as to whether the analysis is likely to have over or under-estimated actual damages.

It is also important to note that two of the gases listed in the CLCPA, HFCs and perfluorocarbons (PFCs), represent multiple separate gases that would impose different impacts. Table 2 provides information for some gases, but the most recent IPCC Assessment Report should be consulted with regards to the full suite of greenhouse gases. There are greenhouse gases that may be relevant to State entities that are not named in the CLCPA. For example, HFCs were introduced to replace ozone-depleting substances, which are greenhouse gases[44] that are subject to a separate international phase-down. These gases may continue to be used until the available supply is diminished. State entities may wish to assess the benefits of further, more accelerated reductions and would be able to demonstrate these benefits using the damages approach.

[43] e.g., Marten et al 2015 and National Academies 2017 op cit.
[44] e.g., the 20-year GWP of CFC-12 is 10,800 and HCFC-22 is 5280, which are two commonly used substances.

Table 2: Physical Properties of Example Greenhouse Gases (IPCC Fifth Assessment Report)			
Greenhouse gas	Lifespan (years)	100-YEAR GWP	20-YEAR GWP
Carbon dioxide (CO_2)	~100[45]	1	1
Methane (CH_4)	12.4	28	84
Nitrous oxide (N_2O)	121	265	264
Hydrofluorocarbons (HFCs)			
HFC-134A	13.4	1300	3710
HFC-125	28.2	3170	6090
HFC-32	5.2	677	2430
HFC-143A	47.1	4800	6940
Perfluorocarbons (PFCs)			
PFC-14	50,000	6630	4880
PFC-116	10,000	11100	8210
PFC-218	2,600	8900	6640
PFC-318	3,200	9540	7110
Sulfur hexafluoride (SF_6)	3,200	23500	17500

Seek comparable, damages-based values for additional impacts.

Carbon dioxide and methane impose other damages in addition to those damages caused by climate change. For example, the federal IWG estimate of the social cost of carbon dioxide includes some consideration of the effect that elevated carbon dioxide has on agricultural systems through fertilization as this is a specific feature of the FUND model. However, the federal IWG estimation for methane does not include other known damages, particularly the role that methane plays as a precursor to ozone formation, which has direct impacts on human health. As in the case of the additional effects of carbon dioxide, it is possible to estimate additional damages from methane so they can be more easily integrated into cost benefit analyses or in the description of the benefits of emission reduction policies. The Department recommends consideration of such estimates if available in the peer-reviewed literature.[46]

[45] Some portion of emitted CO_2 is taken up by the biosphere and some portion will persist in the atmosphere for the full lifespan of the gas.
[46] Shindell, D.T., Fuglestevedt, Collins, W.J. 2017. The social cost of methane: theory and applications. Faraday Discussions. 200:429.

VII. Example Applications

The following hypothetical examples are provided to illustrate how State entities could use a damages-based value of carbon in different decision contexts. These examples are intentionally over-simplified and are intended to illustrate the utility of the value of carbon at a high-level. Real world examples can also be found in the record of federal decisions, such as by searching for the "social cost of carbon" in the Federal Register. DEC also seeks public input on other applications of the value of carbon by state entities.

Each of the examples below uses the updated social costs of carbon dioxide, methane, and nitrous oxide as provided by NYSERDA and Resources for the Future (see separate Appendix). These are provided in 2020 dollars. Agencies can update these values with inflation as needed. However, these values will remain static otherwise until the Department provides an update, e.g., based on new peer-reviewed modeling.

Estimating the emission reduction benefits of a plan or goal.

An agency has developed a strategic plan with the goal of reducing carbon dioxide emissions 50% over ten years from current levels, or 50,000 metric tons over 10 years. In order to determine the benefits to society in terms of avoided damages, the agency will need to determine the annual level of emission reductions (or emissions avoided). If split evenly across all 10 years, the annual reduction is 5,000 metric tons per year (see table).

Greenhouse gas	Emissions in 2020 (kt)	Reduction 2030	Annual Emission Reductions 2020-2030 (kt)
Carbon dioxide	100	50%	5

The net present value of the plan is equal to the cumulative benefit of the emission reductions that happened each year (adjusted for the discount rate). In other words, the value of carbon is applied to each year, based on the reduction from the no action case, 100,000 tons in this case. The Appendix provides the value of carbon for each year. For example, the social cost of carbon dioxide in 2021 at a 2% discount rate is $127 per metric ton. The value of the reductions in 2021 are equal to $127 times 5,000 metric tons, or $635,000; in 2022 $129 times 10,000 tons, etc. This calculation would be carried out for each year and for each discount rate of interest. The results for all three recommended discount rates are provided below.

Based on this assessment, the net present value of the plan by the end of 2030 ranges from $13.5-$112.4 million or $32.8 million using the central discount rate of 2%. It may be that

actions to reduce carbon dioxide will affect the emissions of other greenhouse gases as well. The net present value of those impacts may be estimated and combined with the net present value of the avoided carbon dioxide.

ANNUAL AND CUMULATIVE VALUE OF CO_2 REDUCTIONS (TOTALS MAY NOT SUM DUE TO INDEPENDENT ROUNDING.)					
YEAR	ANNUAL CO2 EMISSION REDUCTION (KT)	TOTAL CO2 EMISSION REDUCTION (KT)	ANNUAL BENEFITS ($K) [TOTAL CO2 EMISSION REDUCTION * VALUE]		
			3%	2%	1%
2020	-	-	-	-	-
2021	5	5	265	635	2,115
2022	5	10	550	1,290	4,260
2023	5	15	840	1,950	6,420
2024	5	20	1,140	2,640	8,620
2025	5	25	1,475	3,350	10,825
2026	5	30	1,800	4,050	13,080
2027	5	35	2,135	4,795	15,330
2028	5	40	2,480	5,560	17,640
2029	5	45	2,790	6,345	19,935
2030	5	50	3,200	7,100	22,300
10-Year Cumulative Value			16,675	37,715	120,525
Net Present Value			13,550	32,823	112,411

Net costs and benefits in an environmental assessment or rulemaking.

An agency is tasked with assessing the net costs of a project or policy and a no-action alternative. A separate assessment has determined that the other monetary costs, which may include the costs of compliance with the policy or the capital costs of the project, will be $100,000 per year for 5 years and that the end result will be a reduction of methane of 500 metric tons.

Greenhouse gas	Emission Reduction 2020-2025 (mt)	Reduction per year (mt)	Total Cost ($K)	Cost per year ($K)
Methane	500	100	500	100

As in the example above, the benefits in terms of avoided damages from climate change can be estimated by multiplying the emission reduction in each year by the relevant value (i.e., the federal IWG social cost of methane). As discussed in the guidance, methane emissions are also

associated with damages related to public health that are not included in the federal IWG value for methane, but these could be included in the overall net cost. The example table below includes a placeholder for additional health-related damages. If the health-related damages are omitted the net benefit of the action (or benefits minus costs) ranges from $2.1 million to $9.9 million. The net present value ranges from $1.9 million to $9.5 million with a central value of $3.7 million. The net value of the no-action alternative may be considered to be the inverse of the cumulative benefit, or a cumulative *cost* to society of up to $10.4 million.

CUMULATIVE AND NET COSTS AND BENEFITS FROM METHANE REDUCTIONS (TOTALS MAY NOT SUM DUE TO INDEPENDENT ROUNDING.)										
YEAR	**TOTAL CH4 EMISSION REDUCTION (MT)**	**ANNUAL BENEFITS ($K) 3%**			**ANNUAL BENEFITS ($K) 2%**			**ANNUAL BENEFITS ($K) 1%**		
		CLIMATE	**HEALTH**	**TOTAL**	**CLIMATE**	**HEALTH**	**TOTAL**	**CLIMATE**	**HEALTH**	**TOTAL**
2021	100	153			285			660		
2022	200	331			583			1,355		
2023	300	496			894			2,062		
2024	400	712			1,219			2,788		
2025	500	891			1,041			3,534		
Cumulative Benefit		2,583			4,537			10,406		
Cumulative Cost		-500			-500			-500		
Cumulative Net Benefit		2,083			4,037			9,906		
Net Present Value		1,857			3,746			9,546		

Describing the benefits of a procurement plan.

An agency plans to replace three fleet vehicles with new, zero-emission electric vehicles and would like to describe the societal benefits of this plan. The agency has estimated that the lifecycle carbon dioxide emissions associated with the new vehicles are up to 80% lower than its current sedans, when powered by the electricity grid in upstate New York.[47] A lifecycle value would be appropriate as the CLCPA directs agencies to reduce emissions associated with imported fossil fuels and electricity.

[47] Example comparing a Chevrolet Bolt with a Chevrolet Cruze from: Nigro N., Walsh A. 2017. EV Smart Fleets. Electric Vehicle Procurements for Public Fleets. Atlas Policy. https://atlaspolicy.com

Greenhouse gas	Annual Emission Reduction Per Vehicle (mt)	Annual Emission Reduction All Vehicles (mt)
Carbon dioxide	2.5	7.5

By applying the value of carbon provided in the Appendix tables, the agency can estimate the total annual benefit of the new vehicles, plus the total value over 5 years or longer. In this example, the full 7.5 tons of reductions are realized in the first year and repeated in each subsequent year. The estimated benefit of the new vehicles in the first five years range from $2,000 to $16,000. Fossil fuels and electricity generation are also associated with methane and nitrous oxide emissions, the value of which could be estimated as well.

Annual and 5-Year Cumulative Value of CO2 Reductions
(Totals may not sum due to independent rounding.)

Year	Annual CO2 Emission Reduction (mt)	Annual Benefits ($) [CO2 Emission Reduction * Value]		
		3%	2%	1%
2020	7.5	398	938	3,158
2021	7.5	398	953	3,173
2022	7.5	413	968	3,195
2023	7.5	420	975	3,210
2024	7.5	428	990	3,233
5-Year Cumulative Value		2,055	4,823	15,968
Net Present Value		1,936	4,635	15,653