NEW YORK STATE | Department of Environmental Conservation

Establishing a Value of Carbon

GUIDELINES FOR USE BY STATE AGENCIES

Kathy Hochul, Governor | Basil Seggos, Commissioner

Record of Revision

Revision Date	Description of Changes
June 2021	For consistency with IWG interim estimates released in February 2021, estimates of the values for carbon dioxide, methane, and nitrous oxide are revised to reflect the usage of the annual GDP Implicit Price Deflator values in the U.S. Bureau of Economic Analysis' (BEA) NIPA Table 1.1.9.
June 2021	For consistency with the IWG approach, the values for methane and nitrous oxide have been rounded to two significant figures and a recalculation of estimates using the PAGE model to exclude a small number of model runs in which a climate discontinuity is triggered in the marginal run but not the baseline run, leading to spuriously high values.
October 2021	Correction of a typo in the Executive Summary stating the central value for the value of nitrous oxide was $142,000 per ton was changed to $42,000 per ton.
May 2022	Added values for hydrofluorocarbons (HFCs), updated text to describe these values, and provide an example. Updated the description of federal policy regarding global versus domestic SCC.
August 2023	Added values for an additional HFC (HFC-236fa) and sulfur hexafluoride (SF6), updated text to describe these values, and provided both formats used by the federal government (Tables 1-11 in this document and Tables A1-A11 in the Appendix.

Contents

Executive Summary

The Climate Leadership and Community Protection Act directed 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. This guidance provides damages-based values as a tool to aid state agencies in the consideration of 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, nitrous oxide, and hydrofluorocarbons (HFCs). Resources for the Future, under contract to the New York State Energy Research and Development Authority (NYSERDA), provided the federal IWG values in 2020 dollars per metric ton of emissions (adjusted for inflation) along with estimates based on additional discount rates for carbon dioxide, methane and nitrous oxide. Estimates for sulfur hexafluoride and seven HFCs, HFC-32, HFC-125, HFC-134a, HFC-143a, HFC-152a, HFC-227ea, and HFC-236fa were developed by the Department using the federal IWG's methodology and are provided 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 $51-406 per ton, with a central value of $121 per ton; a 2020 value of methane of $1,500-6,400 per ton, with a central value of $2,700 per ton; a value of nitrous oxide of $18,000-130,000 per ton, with a central value of $42,000 per ton. Tables 1-11 below contain the values calculated for these gases reported in five-year increments through 2050. The full set of values for 2020-2050 emission years for each gas is provided in an Appendix to this document.

In September 2022, the USEPA proposed new social cost values for carbon dioxide, methane, and nitrous oxide based on updated modeling and a revised approach to discounting.[1] DEC considers EPA's proposal to be the best available information and the new approach to discounting addresses public concerns regarding intergenerational equity. DEC will consider adopting EPA's final values once they are issued as well as apply the updated methodology to additional GHGs.

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 directive, as added to the Environmental Conservation Law:

> *§ 75-0113. VALUE OF CARBON.*
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> *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*

[1] https://www.epa.gov/environmental-economics/scghg

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 "social cost of carbon."[2] 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 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, which are all 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.

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[2] 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.

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 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[3]; 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.[4]

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.[5]

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 of a specific greenhouse gas into the atmosphere in that year or, equivalently, the benefits of reducing emissions of that gas 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.[6]

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[3] 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
[4] Environmental Conservation Law § 75-0101(7).
[5] e.g., Kesicki, F and Strachan, N. 2011. Marginal abatement cost (MAC) curves: confronting theory and practice. Environmental Science and Policy 14:1195-1204
[6] National Academies. 2017. op cit.

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.

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.[7] 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

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[7] 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.

valuation in use in the U.S. is the federal government's "social cost of carbon" metric,[8] which 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 government later established social cost values for methane, nitrous oxide, and certain HFCs 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.[9] The U.S. Governmental Accountability Office reviewed the history and status of the federal IWG metrics and the prospects for future improvements.[10] A previous federal administration also appropriately suggested that the federal IWG metrics could be used to inform environmental reviews.[11] 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.[12]

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.

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[8] Interagency Working Group op cit.

[9] 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.

[10] GAO. 2020. Identifying a Federal Entity to Address the National Academies' Recommendations Could Strengthen Regulatory Analysis. GAO-20-254

[11] 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.

[12] See e.g., California Air Resources Board. 2017. Estimated Social Costs of Evaluated Measures. California's 2017 Climate Change Scoping Plan.

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 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 for 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.[13]

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.[14] Most notably, the marginal abatement cost approach has been used by some jurisdictions to guide climate change planning at the national level.[15] 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

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

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 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.[16]
- 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.[17]

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

- 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.

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,[18][19] the National Academies of Science 2016[20] and 2017[21] reviews and recommendations for future improvements, the 2020 review provided by the U.S. Government Accountability Office.[22] and the 2021 Regulatory Impact Analysis for phasing down HFCs by the U.S. Environmental Protection Agency.[23] 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

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[18] IWG op cit.

[19] IWG. 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990

[20] 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

[21] 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

[22] GAO 2020 op cit.

[23] U.S. Environmental Protection Agency. 2021. Regulatory Impact Analysis for Phasing Down Production and Consumption of Hydrofluorocarbons (HFCs). Establishing the Allowance Allocation and Trading Program under the American Innovation and Manufacturing Act. EPA-HQ-OAR-2021-0044-0227.

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 the social costs of greenhouse gases for use by federal agencies.[24] For this guidance, DEC developed estimates of the social costs of carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, and seven hydrofluorocarbons (HFCs) using federal IWG methods, in 2020 dollars per metric ton of emissions (adjusted for inflation) along with estimates based on additional discount rates. DEC worked in conjunction with Resources for the Future, under contract to NYSERDA, and the U.S. EPA. The information below explains 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[25] 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[26]), PAGE (Policy Analysis of the Greenhouse Effect[27]), and FUND (Climate Framework for Uncertainty, Negotiation, and Distribution[28]). 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

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[24] IWG op cit.

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

[26] 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.

[27] 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.

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

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.[29] A previous federal administration applied a domestic rather than global scope, or damages that occurred in the United States alone. Under the CLCPA, New York State is required to consider global damages.[30] Furthermore, the global cost is the most appropriate value to use due to the global nature of climate change and the economy. 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 as projections extend 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.[31] The federal IWG's

[29] Presidential Executive Order 13783 disbanded the IWG in 2017.
[30] ECL § 75-0113(2).
[31] 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.

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 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[32] and in particular when addressing the impacts of climate change.[33] 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.

Value of Carbon Estimates

The following tables provide the U.S. Social Cost of Greenhouse Gases values adjusted for New York State as described in this document. These values are provided in the format used by the federal government or rounded to two significant figures. The raw values are also available in a separate Appendix.

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[32] 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

[33] 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.

Table 1: *Social cost of carbon dioxide (CO_2), 2020-2050 (in 2020 dollars per metric ton CO_2)*

Year	Recommended Discount Rates 3%	2%	1%	0%
2020	53	130	420	2,200
2025	59	130	430	2,200
2030	64	140	450	2,200
2035	70	150	460	2,100
2040	76	160	470	2,100
2045	81	170	480	2,100
2050	88	180	490	2,000

Table 2: *Social cost of methane (CH_4), 2020-2050 (in 2020 dollars per metric ton CH_4)*

Year	Recommended Discount Rates 3%	2%	1%	0%
2020	1,500	2,800	6,600	24,000
2025	1,800	3,100	7,100	25,000
2030	2,000	3,500	7,600	25,000
2035	2,300	3,800	8,100	26,000
2040	2,500	4,200	8,700	26,000
2045	2,900	4,600	9,200	27,000
2050	3,200	5,000	9,700	27,000

Table 3: *Social cost of nitrous oxide (N_2O), 2020-2050 (in 2020 dollars per metric ton N_2O)*

Year	Recommended Discount Rates 3%	2%	1%	0%
2020	19,000	45,000	140,000	680,000
2025	22,000	48,000	150,000	690,000
2030	24,000	52,000	150,000	690,000
2035	27,000	56,000	160,000	700,000
2040	29,000	60,000	170,000	700,000
2045	32,000	64,000	170,000	710,000
2050	34,000	68,000	180,000	710,000

Table 4: *Social cost of HFC-125, 2020-2050 (in 2020 dollars per metric ton HFC-125)*

Year	Recommended Discount Rates 3%	2%	1%	0%
2020	210,000	410,000	1,000,000	4,000,000
2025	243,248	460,000	1,100,000	4,100,000
2030	276,673	510,000	1,200,000	4,200,000
2035	312,777	560,000	1,300,000	4,300,000
2040	351,877	620,000	1,400,000	4,400,000
2045	391,086	670,000	1,500,000	4,500,000
2050	432,231	730,000	1,500,000	4,600,000

Table 5: *Social cost of HFC-134a, 2020-2050 (in 2020 dollars per metric ton HFC-134a)*

Year	Recommended Discount Rates 3%	2%	1%	0%
2020	88,000	160,000	380,000	1,400,000
2025	100,000	180,000	420,000	1,500,000
2030	120,000	200,000	450,000	1,500,000
2035	140,000	230,000	490,000	1,600,000
2040	150,000	250,000	530,000	1,600,000
2045	170,000	280,000	560,000	1,700,000
2050	190,000	300,000	600,000	1,700,000

Table 6: *Social cost of HFC-143a, 2020-2050 (in 2020 dollars per metric ton HFC-143a)*

Year	Recommended Discount Rates 3%	2%	1%	0%
2020	270,000	560,000	1,500,000	6,300,000
2025	310,000	620,000	1,600,000	6,500,000
2030	340,000	680,000	1,700,000	6,600,000
2035	380,000	740,000	1,800,000	6,800,000
2040	430,000	810,000	1,900,000	6,900,000
2045	470,000	870,000	2,000,000	7,000,000
2050	520,000	940,000	2,100,000	7,100,000

Table 7: *Social cost of HFC-32, 2020-2050 (in 2020 dollars per metric ton HFC-32)*

Year	Recommended Discount Rates 3%	2%	1%	0%
2020	39,000	68,000	160,000	600,000
2025	46,000	78,000	170,000	620,000
2030	53,000	89,000	190,000	640,000
2035	62,000	100,000	210,000	660,000
2040	71,000	110,000	230,000	690,000
2045	82,000	130,000	250,000	710,000
2050	93,000	140,000	260,000	730,000

Table 8: *Social cost of HFC-152a, 2020-2050 (in 2020 dollars per metric ton HFC-152a)*

Year	Recommended Discount Rates 3%	2%	1%	0%
2020	5,300	9,500	22,000	86,000
2025	6,400	11,000	25,000	89,000
2030	7,400	12,000	27,000	92,000
2035	8,700	14,000	29,000	95,000
2040	10,000	16,000	32,000	98,000
2045	12,000	18,000	35,000	100,000
2050	13,000	20,000	38,000	110,000

Table 9: *Social cost of HFC-227ea, 2020-2050 (in 2020 dollars per metric ton HFC-227ea)*

Year	Recommended Discount Rates			
	3%	2%	1%	0%
2020	190,000	380,000	990,000	3,800,000
2025	220,000	430,000	1,100,000	3,900,000
2030	250,000	470,000	1,100,000	4,000,000
2035	280,000	520,000	1,200,000	4,100,000
2040	320,000	570,000	1,300,000	4,200,000
2045	350,000	620,000	1,400,000	4,300,000
2050	390,000	670,000	1,400,000	4,400,000

Table 10: *Social cost of HFC-236fa, 2020-2050 (in 2020 dollars per metric ton HFC-236fa)*

Year	Recommended Discount Rates			
	3%	2%	1%	0%
2020	640,000	1,600,000	5,700,000	27,000,000
2025	710,000	1,700,000	6,000,000	28,000,000
2030	790,000	1,900,000	6,200,000	28,000,000
2035	870,000	2,000,000	6,500,000	28,000,000
2040	960,000	2,200,000	6,800,000	28,000,000
2045	1,100,000	2,300,000	7,000,000	28,000,000
2050	1,200,000	2,500,000	7,300,000	28,000,000

Table 11: *Social cost of sulfur hexafluoride (SF6), 2020-2050 (in 2020 dollars per metric ton SF6)*

Year	Discount Rate			
	3%	2%	1%	0%
2020	1,700,000	4,500,000	18,000,000	110,000,000
2025	1,800,000	4,800,000	19,000,000	110,000,000
2030	2,000,000	5,200,000	20,000,000	120,000,000
2035	2,300,000	5,600,000	21,000,000	120,000,000
2040	2,500,000	6,100,000	22,000,000	120,000,000
2045	2,700,000	6,500,000	23,000,000	130,000,000
2050	3,000,000	6,900,000	24,000,000	130,000,000

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:

- 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.

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 other major greenhouse gases,[34] 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 12). 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.[35] A review of all available data and methods for estimating greenhouse gas emissions would be beyond the scope of this

[34] See definition of greenhouse gas in ECL 75-0101 which includes additional substances
[35] 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

document. However, State entities can consult with the Department and NYSERDA to locate additional resources, as needed.

Table 12: 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) and Hydrofluoroolefins (HFOs)	Substitutes for Ozone-Depleting Substances; Refrigeration, Heating and Cooling, Manufacturing
Perfluorocarbons (PFCs)	Manufacturing
Sulfur hexafluoride	Electricity transmission and distribution, Manufacturing
Nitrogen trifluoride	Manufacturing, Research

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.

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[36] 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

[36] National Academies op cit.

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 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.[37] 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

[37] ECL § 75-0113(2).

climate change. If a damages-based value of carbon is used within the context of the CLCPA, 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.[38]

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.[39] 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

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[38] Drupp M.A. et al. 2018. Discounting disentangled. American Economic Journal: Economic Policy. 10:109-134

[39] National Academies of Science 2017 op cit.

costs using multiple rates.[40] An additional benefit of considering multiple rates is that the impact 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 emission reduction requirements cover seven types of greenhouse gases that are commonly included in international climate policy: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons (HFCs), perfluorocarbons, and sulfur hexafluoride, and nitrogen trifluoride.[41] 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 these gases, as well as synthetic gases of emerging importance like hydrofluoroolefins (HFOs), 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 conflicts and potential tradeoffs.

Establishing a value of carbon for different greenhouse gases is complicated by two factors: (i) each gas affects climate change differently; and (ii) some gases are associated with additional impacts unrelated to climate change (e.g., local human health impacts). All of the greenhouse gases included in the CLCPA are well-mixed gases that contribute to atmospheric warming. However, methane and most HFCs have shorter atmospheric lifetimes than carbon dioxide, sulfur hexafluoride, or nitrous oxide. As such, the long-term damages associated with the climate impacts of these different greenhouse gases should be expected to vary. Besides impacts caused by climate change, carbon dioxide and methane emissions may also be associated with other impacts, such as changes in agricultural productivity or local impacts on air quality and human health.

Recommended Approach

The federal IWG models and parameters have been used to develop social cost estimates for carbon dioxide, methane, nitrous oxide, and the most important HFC compounds. These values are available in the social cost tables in the Appendix to this guidance. The same methods can

[40] See examples in the Federal register, such as NHTSA-2014-0132
[41] 6 NYCRR Part 496 per ECL § 75-0101(7).

be applied to other well-mixed GHGs including the synthetic greenhouse gases sulfur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). This guidance may be updated as evaluations of the social costs of these and other greenhouse gases are completed. Work is also underway to understand the social costs of the hydrofluoroolefins (HFOs) that are potential replacements for HFCs in some applications.

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 each GHG following the guidelines provided in Part VI. Each of these estimates represents a gas-specific, but comparable, assessment of the value of a marginal ton of these greenhouse gases in terms of global damages related to climate change.

In September 2021, the EPA released the "Regulatory Impact Analysis for Phasing Down Production and Consumption of Hydrofluorocarbons (HFCs)" that includes estimates of the social costs of different HFCs.[42] In 2022, the Department developed social cost estimates using the lower range of discount values (0, 1, 2, and 3%) for six main HFCs by using the Mimi framework[43] developed by Resources for the Future's Social Cost of Carbon Initiative and applying EPA's methodology for HFCs. These values may vary slightly from those in the EPA's Regulatory Impact Analysis due to independent model runs. These values are provided in the updated appendix of this guidance document.

In 2023, this approach was also applied to sulfur hexafluoride (SF6) and HFC-236fa. However, these gases are much longer-lived than the other HFCs previously analyzed with this method; HFC-236fa has an atmospheric lifetime of 213 years and SF_6 of 1,000 years. The models used by the IWG to estimate the social cost of a greenhouse gas emission do not capture the impact of the marginal damages that occur after the year 2300. As such, only a portion of the damages caused by these long-lived pollutants can be estimated using this approach. For example, a pulse emission of SF_6 that occurred in 2020 will maintain a tail of elevated concentration that extends far into the future such that 75% of the emission pulse (in ppb-years) will occur after the year 2300 and only 25% can be captured during the period that is assessed by the IWG's models (2020-2300). An artifact of terminating the damages assessment in year 2300 is that emissions that occur in later years have slightly lower social costs than emissions in earlier years because the damages have a shorter amount of time to accrue. DEC addressed this

[42] HFC-23, HFC-32, HFC-125, HFC-134a, HFC-143a, HFC-152a, HFC-227ea, HFC-236fa, HFC-245fa, and HFC-43-10mee. EPA (2021) op. cit.
[43] https://www.mimiframework.org

issue by adding the appropriate number of additional years' worth of marginal damages to the social costs of emissions that occur after 2020.

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[44]) provided an estimation of damages from multiple pollutants based on one of the damage models used by the federal IWG. This includes values for 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 13). The GWP weighs the radiative forcing of a gas against that of carbon dioxide over a specified time frame.[45] 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.[46] 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.[47] Thus, simply adjusting the

[44] Shindell, D.T. 2015. The social cost of atmospheric release. Climatic Change 130:313-326.
[45] 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.
[46] As discussed by Working Groups 1 and 3 in the Fifth Assessment Report
[47] 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's social cost of CO_2 values by the relative GWP of a given greenhouse gas in order to determine the social cost 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.[48] 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 types of gases listed in the CLCPA, HFCs and perfluorocarbons (PFCs), represent multiple separate gases that would impose different impacts. Table 13 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[49] 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.

[48] e.g., Marten et al. 2015 and National Academies 2017 op cit.
[49] e.g., the 20-year GWP of CFC-12 is 11,400 and HCFC-22 is 5690, which are two commonly used substances.

Table 13. Example Global Warming Potential Values

		IPCC AR5		IPCC AR6	
Greenhouse gas	Lifespan (years)	100-YEAR GWP	20-YEAR GWP	100-YEAR GWP	20 YEAR GWP
Carbon dioxide (CO_2)	~100[50]	1	1	1	1
Methane (CH_4)	11.8	28	84	27.9	81.2
Nitrous oxide (N_2O)	109	265	264	273	273
Hydrofluorocarbons (HFCs)					
HFC-134A	14.0	1300	3710	1530	4140
HFC-125	30	3170	6090	3740	6740
HFC-32	5.4	677	2430	771	2690
HFC-143A	51	4800	6940	5810	7840
Perfluorocarbons (PFCs)					
PFC-14	50,000	6630	4880	7380	5300
PFC-116	10,000	11100	8210	12400	8940
PFC-218	2,600	8900	6640	9290	6770
PFC-318	3,200	9540	7110	10200	7400
Sulfur hexafluoride (SF_6)	3,200	23500	17500	24300	18200

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's estimates of the social cost of carbon dioxide include some consideration of the effect that elevated carbon dioxide has on agricultural production as this is a specific feature of the FUND model. However, the federal IWG's estimates for methane do 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.[51]

[50] 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.
[51] 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. The Department 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 and the social costs of HFCs provided in this document (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 based on new peer-reviewed models.

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) compared to a no action scenario. 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 $123 per metric ton. The value of the reductions in 2021 are equal to $123 times 5,000 metric tons, or $615,000; in 2022 $124 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 $13.1-$108.5 million or $31.7 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 CO_2 Emission Reduction (Kt)	Total CO_2 Emission Reduction (Kt)	Annual Benefits ($K) [Total CO_2 Emission Reduction * Value]		
			3%	2%	1%
2021	5	5	260	615	2,045
2022	5	10	530	1,240	4,110
2023	5	15	810	1,890	6,210
2024	5	20	1,100	2,560	8,320
2025	5	25	1,400	3,225	10,450
2026	5	30	1,710	3,930	12,630
2027	5	35	2,065	4,620	14,805
2028	5	40	2,400	5,360	17,040
2029	5	45	2,745	6,120	19,260
2030	5	50	3,100	6,850	21,500
10-Year Cumulative Value			16,120	36,410	116,370
Net Present Value			13,094	31,689	108,536

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 million to $9.5 million. The net present value ranges from $1.8 million to $9.2 million with a central value of $3.6 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 million.

Cumulative And Net Costs and Benefits from Methane Reductions
(Totals May Not Sum Due to Independent Rounding.)

Year	Total CH_4 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	150			280			640		
2022	200	320			560			1,300		
2023	300	480			870			1,980		
2024	400	680			1,160			2,680		
2025	500	850			1,500			3,400		
Cumulative Benefit		2,480			4,370			10,000		
Cumulative Cost		-500			-500			-500		
Cumulative Net Value		1,980			3,870			9,500		
Net Present Value		1,766			3,591			9,155		

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.[52] A lifecycle value would be appropriate as the CLCPA directs agencies to reduce emissions associated with imported fossil fuels and electricity.

[52] 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 $1,988 to $15,420. 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 CO_2 Reductions *(Totals may not sum due to independent rounding.)*				
Year	Annual CO_2 Emission Reduction (mt)	Annual Benefits ($) [$CO_2$ Emission Reduction * Value]		
		3%	2%	1%
2020	7.5	383	908	3,045
2021	7.5	390	923	3,068
2022	7.5	398	930	3,083
2023	7.5	405	945	3,105
2024	7.5	413	960	3,120
5-Year Cumulative Value		1,988	4,665	15,420
Net Present Value		1,873	4,483	15,116

Comparing alternative technologies

This example applies the value of carbon for HFCs, which are used as refrigerants in many types of equipment. In this case, there are multiple alternative types of heat pump systems and refrigerants. This example illustrates the different social costs when choosing between alternative refrigerants. This example does not compare heat pumps to other types of appliances that they may replace (i.e., fossil fuel boilers or furnaces, air conditioning). Such a comparison would also consider emissions from the combustion of fossil fuels and from the electricity used to power a heat pump or air conditioning equipment.

The building manager for a 5-floor multifamily residential building with 40 apartments solicited bids for retrofitting the building with heat pumps. They received 4 bids for systems that each have an average lifetime of 16 years. The building's efficiency manager uses the following information about each system to calculate and compare the social costs of the hydrofluorocarbon (HFC) and hydrofluoroolefin (HFO) refrigerants emitted by each proposed system. These costs represent the economic damages caused by leakage of each of these greenhouse gases into the atmosphere over the heat pump lifetime. The building manager ranks highest the bid that has the lowest net present value of these cumulative costs (see table below). Each bid is described in detail in the text below. Note: The Appendix provides the costs per ton for each HFC, which have been converted to a cost per kg for this example. For the non-HFC alternative, HFO-1234ze(e), the value of CO_2 is used as a placeholder (see Bid #4). Information on charge size, leak rates, and end-of-life leakage are from NYSERDA (2021).[53]

Comparative Costs of Refrigerant Leakage Value of HFC Emissions at the Central 2% Discount Rate	
	Net Present Value ($)
Bid #1 Multisplits with R-410a	-47,382
Bid #2 VRF with R-410a	-60,468
Bid #3 Multisplits with R-32	-7598
Bid #4 Multisplits with R-1234ze*	-18

Bid #1 includes 40 individual multisplit heat pumps that contain R-410a refrigerant, with one rooftop condenser and two heads per apartment. Each heat pump contains (2.69 kg) of R-410a refrigerant, which is 50% HFC-32 and 50% HFC-125. The average refrigerant leakage from each heat pump is 6.3% of the initial charge per year (0.17 kg/year) and the end-of-life loss rate is assumed to be 80% of the charge remaining (2.02 kg). The net present value of the damages accrued from HFC leakage during the lifetime of the 40 heat pumps ranges from negative $23,685 at a 3% discount rate to negative $120,934 at a 1% discount rate, and negative $47,382 at the 2% or central discount rate. The social cost of the HFC leakage for each year is presented in the table below.

[53] NYSERDA. 2021. "Hydrofluorocarbon Emissions Inventory and Mitigation Potential in New York State," Report Number 21-28. Prepared by Guidehouse, Inc. Albany, NY, USA: New York State Energy Research and Development Authority. https://www.nyserda.ny.gov/publications.

Annual and Cumulative Value of HFC Refrigerant Leakage **Bid #1: Multisplit heat pumps with R-410a**				
Year	Annual R-410a Leakage (kg) for 40 units	Annual Costs ($) for 40 units [Total Cost HFC-32 and HFC-125]		
		3%	2%	1%
2022	6.8	886	1704	4310
2023	6.8	926	1744	4310
2024	6.8	964	1785	4310
2025	6.8	971	1826	4310
2026	6.8	1008	1866	4344
2027	6.8	1049	1907	4344
2028	6.8	1052	1948	4683
2029	6.8	1093	1989	4717
2030	6.8	1130	2033	4717
2031	6.8	1137	2073	4717
2032	6.8	1178	2114	4751
2033	6.8	1215	2158	4751
2034	6.8	1256	2199	5124
2035	6.8	1262	2240	5124
2036	6.8	1303	2274	5124
2037	87.6	17333	30201	66530
16-Year Cumulative Cost		33761	60060	136164
Net Present Value		-23685	-47382	-120934

Bid #2 includes 5 large VRF (variable refrigerant flow) systems that contain R-410a refrigerant, with one unit installed per floor. Each VRF unit is charged with 27.22 kg of R-410a. The systems have an average annual leakage of 10% of the initial charge per year (2.72 kg/year) and an end-of-life loss of 20% of the remaining charge (4.90 kg). The VRF systems leak more R-410a refrigerant over their lifetime than the multisplit heat pumps proposed in the first bid. The net present value of the damages accrued from HFC leakage during the heat pumps' lifetime ranges from negative $30,533 at a 3% discount rate to negative $153,409 at a 1% discount rate, and negative $60,468 at the central 2% discount rate. The social cost of the HFC leakage for each year is presented in the table below.

Annual and Cumulative Value of HFC Refrigerant Leakage Bid #2: VRF heat pumps with R-410a				
Year	Annual R-410a Leakage (kg) for 5 units	Annual Costs ($) for 5 units [Total Cost HFC-32 and HFC-125]		
		3%	2%	1%
2022	13.6	1776	3416	8641
2023	13.6	1857	3497	8641
2024	13.6	1932	3579	8641
2025	13.6	1946	3660	8641
2026	13.6	2021	3742	8709
2027	13.6	2102	3824	8709
2028	13.6	2109	3905	9389
2029	13.6	2191	3987	9457
2030	13.6	2266	4076	9457
2031	13.6	2279	4157	9457
2032	13.6	2361	4239	9525
2033	13.6	2436	4327	9525
2034	13.6	2517	4409	10274
2035	13.6	2531	4491	10274
2036	13.6	2613	4559	10274
2037	38.1	7544	13145	28957
16-Year Cumulative Cost		40482	73012	168573
Net Present Value		-30533	-60468	-153409

Bid #3 includes 40 individual multisplit heat pumps that contain R-32, with one rooftop condenser and two heads per apartment. Each heat pump contains (1.91 kg) of R-32 refrigerant (100% HFC-32), which is pitched to the manager as ‘eco-friendly refrigerant’ and requires less charge than the R-410a multisplit system. The average refrigerant leakage from each heat pump is 3.15% of the initial charge per year (0.06 kg/year) and the end-of-life loss rate is assumed to be 80% of the charge remaining (1.48 kg) (NYSERDA 2021). For this bid, the net present value of the damages accrued from HFC-32 leakage during the heat pumps’ lifetime ranges from negative $4,009 at a 3% discount rate to negative $17,831 at a 1% discount rate, and negative $7,598 at the central 2% discount rate. The social cost of the HFC leakage for each year is presented in the table below.

Annual and Cumulative Value of HFC Refrigerant Leakage Bid #3: Multisplit heat pumps with R-32				
Year	Annual R-32 Leakage (kg) for 40 units	Annual Costs ($) for 40 units [Total Cost HFC-32]		
		3%	2%	1%
2022	2.4	99	173	410
2023	2.4	104	178	410
2024	2.4	106	183	410
2025	2.4	111	188	410
2026	2.4	113	193	434
2027	2.4	118	198	434
2028	2.4	120	202	434
2029	2.4	125	207	458
2030	2.4	128	214	458
2031	2.4	133	219	458
2032	2.4	137	224	482
2033	2.4	140	231	482
2034	2.4	145	236	506
2035	2.4	149	241	506
2036	2.4	154	241	506
2037	61.6	4070	6784	13568
16-Year Cumulative Cost		5952	9914	20362
Net Present Value		-4009	-7598	-17831

Bid #4 includes 40 individual multisplit heat pumps that contain R-1234ze, with one rooftop condenser and two heads per apartment. Each heat pump contains (3.23 kg) of R-1234ze refrigerant (HFO-1234ze(E)). The average refrigerant leakage from each heat pump is 3.15% of the initial charge per year (0.10 kg/year) and the end-of-life loss rate is assumed to be 80% of the charge remaining (2.50 kg) (NYSERDA 2021). The social costs of HFO-1234ze(E) have not been assessed yet, so the manager substitutes the social cost of CO_2 for HFO-1234ze(E), knowing that the GWP of HFO-1234ze(E) is similar to that of CO_2. The net present value of the damages accrued from HFO-1234ze(E) leakage ranges from negative $7 at the 3% discount rate to negative $64 at the 1% discount rate, with a value of negative $18 at the 2% central discount rate.

Annual and Cumulative Value of HFC Refrigerant Leakage Bid #4: Multisplit heat pumps with R-1234ze				
Year	Annual R-1234ze Leakage (kg) for 40 units	Annual Costs ($) for 40 units [Total Cost HFO-1234ze(e)*]		
		3%	2%	1%
2022	4	0.22	0.50	1.67
2023	4	0.22	0.51	1.69
2024	4	0.22	0.52	1.69
2025	4	0.23	0.53	1.70
2026	4	0.23	0.53	1.71
2027	4	0.24	0.54	1.72
2028	4	0.24	0.55	1.73
2029	4	0.25	0.55	1.74
2030	4	0.25	0.56	1.75
2031	4	0.26	0.57	1.76
2032	4	0.26	0.57	1.77
2033	4	0.26	0.58	1.78
2034	4	0.27	0.59	1.79
2035	4	0.27	0.59	1.80
2036	4	0.28	0.60	1.81
2037	104.4	7.30	15.53	46.49
16-Year Cumulative Cost		11	24	73
Net Present Value		-7	-18	-64