Caiazza Personal Comment on the Scoping Plan Social Cost of Carbon Benefit Calculation

Summary
This comment addresses two issues with the Draft Scoping Plan Social Cost of Carbon Benefit calculations. I explain that the methodology is flawed and that I cannot reproduce the values in the Scoping Plan. This is important because the only way that the Scoping Plan can claim that the "cost of inaction exceeds the cost of action by more than $90 billion" is by using a defective approach.

The societal cost of carbon reduction methodology is flawed. The Climate Act Scoping Plan manipulates the GHG emissions, the GHG emissions accounting, and calculation of social cost of carbon benefits to inflate these benefits to claim that there are net benefits. In order to maximize the benefits from emission reductions the Scoping Plan uses non-conventional assumptions to contrive increased emission estimates that are 1.9 times higher in 1990 and 2.3 times higher in 2019 than conventional, or UNFCCC, format for emissions accounting used by other jurisdictions. New York's Value of Carbon guidance chooses a lower discount rate that places lower value on immediate benefits relative to higher delayed benefits received in the future. The combined effect of the higher emissions and lower discount rate means that New York's societal benefits of GHG emission reductions are 4.5 times higher for 1990 emissions and 5.4 times higher for 2019 emissions than other jurisdictions. Most importantly, it is inappropriate to claim the benefits of an annual reduction of a ton of greenhouse gas over any lifetime or to compare it with avoided emissions. The Value of Carbon guidance incorrectly calculates benefits by applying the value of an emission reduction multiple times. Using that trick and the other manipulations results in New York societal benefits more than 21 times higher than benefits using everybody else's methodology. When just the over-counting error is corrected, the total societal benefits range between negative $74.5 billion and negative $49.5 billion.

The Scoping Plan claims that 2020-2050 societal benefits are greater than societal costs by between $90 and $120 billion. The largest proposed benefits come from avoided GHG emission impacts on climate change due to GHG emission reductions. Appendix G – Integration Analysis Technical Supplement Section I – Page 63: states: "Reducing GHG emissions in line with Climate Act emissions limits avoids economic impacts of damages caused by climate change equaling approximately $235 to $250 billion." I am unable to reproduce those numbers as shown in these comments.

Inventory Games
One way to increase Scoping Plan benefits is to increase the emissions inventory thereby creating more "value" when they are reduced. New York's GHG emission inventory does two things that increase emissions relative to all other jurisdictions: it includes upstream emissions and it changes the global warming potential time period. Obviously if upstream emissions are included then the total increases. At the same time however, it makes the NY inventory incompatible with everybody else's inventory. Global warming potential (GWP) weighs the radiative forcing of a gas against that of carbon dioxide over a specified time frame so that it is possible to compare the effects of different gases. Almost all jurisdictions use a 100-year GWP time horizon but the Climate Act mandates the use of the 20-year GWP.

The DEC inventory report does not break out the effects of these metrics on emissions so that the New York inventory can be compared to the inventories developed by other jurisdictions. However, some insight on the effect of upstream emissions is provided in the recently released New York State Oil and Gas Methane Emissions Inventory: 2018-2020 Update that includes a couple of tables describing emissions that are a component of the DEC inventory. One update in this report is a revision to use more recent Intergovernmental Panel on Climate Change emission factors from report AR5 rather than AR4. Table 18 in the report compares AR4 and AR5 GWP100 and GWP20 values. Using the GWP20 instead of GWP100 increases methane emissions by a factor of 3.

Table 18. Comparison of AR4 and AR5 GWP_{100} and GWP_{20} Values Applied to the 2018, 2019 and 2020 Emissions from the Oil and Natural Gas Sector ($MTCO_2e$)

	AR4 GWP_{100}	AR4 GWP_{20}	AR5 GWP_{100}	AR5 GWP_{20}
CH_4 GWP (CO_2e)	**25**	**72**	**28**	**84**
2018 Oil and Gas CH_4 ($MMTCO_2e$)	3,744,730	10,784,823	4,194,098	12,582,293
2019 Oil and Gas CH_4 ($MMTCO_2e$)	3,753,499	10,810,076	4,203,919	12,611,756
2020 Oil and Gas CH_4 ($MMTCO_2e$)	3,708,353	10,680,057	4,153,356	12,460,067

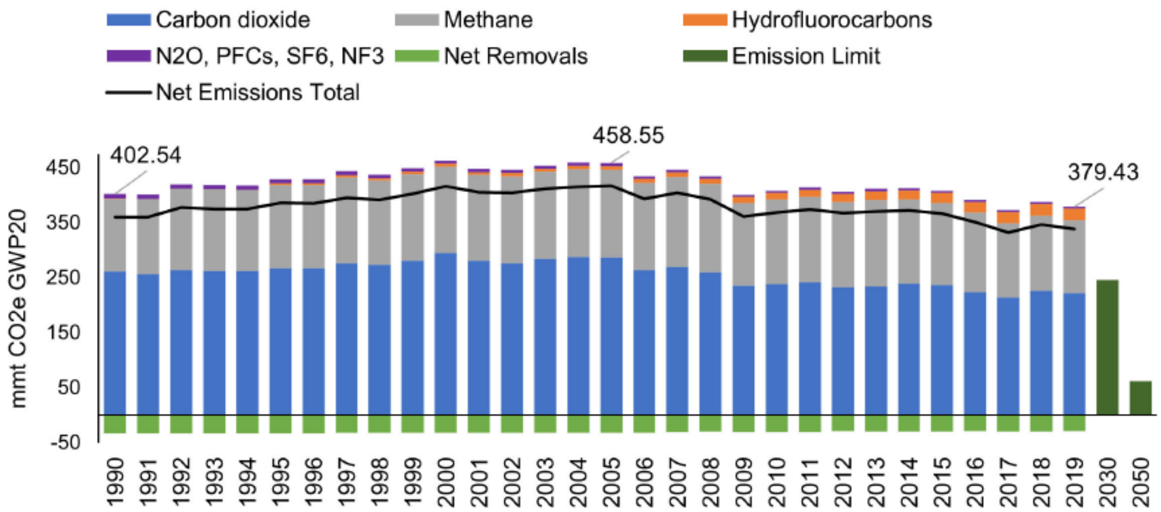
Tables 11 through 13 in the methane inventory update list emissions by source category from 1990 to 2020. I summed the emissions to get totals for representative years for upstream, midstream and downstream emissions. It appears that the DEC inventory adds on the order of 10% for upstream emissions.

Tables 11-13. CH4 Emissions by Source Category in NYS from 1990 to 2020 (MTCO2e; AR5 GWP20)

	1990	2016	2017	2018	2019	2020
Total Upstream	1,784,833	1,441,972	1,280,681	1,171,232	1,311,098	1,228,290
Total Midstream	5,255,044	6,079,968	6,071,633	6,057,280	6,059,781	6,066,603
Total Downstream	8,442,135	5,712,298	5,567,443	5,353,779	5,240,878	5,165,175
State Total	15,482,012	13,234,238	12,919,757	12,582,291	12,611,757	12,460,068

According to the DEC GHG report: “Total statewide gross emissions in 2019 were 6% below 1990 and 17% below 2005 levels, when assessed using CLCPA accounting”. Figure ES.1 in the DEC GHG inventory shows the annual statewide emissions from 1990 to 2019. It is disappointing DEC did not provide the actual numbers used to generate this graphic. The only numbers provided are the 1990 baseline value of 402.54, the maximum in 2005 of 458.55 and the 2019 value of 379.43. All these values are in million metric tons of carbon dioxide equivalent in terms of GWP20. The only reference to values comparable to other inventories states “As a point of comparison, when applying the conventional, or UNFCCC, format for governmental accounting, emissions declined 21% percent from 1990 to 2019, or from a net emission rate of 210.43mmt to 165.46 mmt CO2e GWP100”.

Figure ES.1: NYS Statewide Greenhouse Gas Emissions by Gas, 1990-2019 (mmt CO_2e GWP20)



Avoided Cost of GHG Emissions Benefits

The largest benefit for the Climate Act is claimed for avoided societal costs from GHG emissions. For the three mitigation scenarios in the Scoping Plan these benefits range from $235 billion to $250 billion. Because this concept is complex, these comments detail how the societal benefits are estimated and how the Scoping Plan calculated these estimates.

The Social Cost of Carbon (SCC) or Value of Carbon is a measure of the avoided costs from global warming impacts out to 2300 enabled by reducing a ton of today's emissions. This is a complicated concept and I don't think my explanations have successfully described it well. Fortunately, I believe that Bjorn Lomborg does a very good job explaining it. I highly recommend his 2020 book *False Alarm - How Climate Change Panic Costs Us Trillions, Hurts the Poor, and Fails to Fix the Planet* (Basic Books, New York, NY ISBN 978-1-5416-4746-6, 305pp.). The following is an excerpt from his chapter What is Global Warming Going to Cost Us?

> We need to have a clear idea about what global warming will cost the world. so that we can make sure that we respond commensurately. If it's a vast cost, it makes sense to throw everything we can at reducing it. If it's smaller, we need to make sure that the cure isn't worse than the disease.
>
> Professor William Nordhaus of Yale University was the first (and so far, only) climate economist to be awarded the Nobel Prize in economics in 2018. He wrote one of the first ever papers on the costs of climate change in 1991 and has spent much of his career studying the issue. His studies have helped to inspire what is now a vast body of research.
>
> How do economists like Professor Nordhaus go about estimating the costs of future climate change impacts? They collate all the scientific evidence from a wide range of areas, to estimate the most important and expensive impacts from climate change, including those on agriculture, energy, and forestry, as well as sea-level rises. They input this economic information into

computer models; the models are then used to estimate the cost of climate change at different levels of carbon dioxide emissions, temperature, economic development, and adaptation. These models have been tested and peer reviewed over decades to hone their cost estimates.

Many of the models also include the impacts of climate change on water resources, storms, biodiversity, cardiovascular and respiratory diseases, vector-borne diseases (like malaria), diarrhea, and migration. Some even try to include potential catastrophic costs such as those resulting from the Greenland ice sheet melting rapidly. All of which is to say that while any model of the future will be imperfect, these models are very comprehensive.

When we look at the full range of studies addressing this issue, what we find is that the cost of climate change is significant but moderate, in terms of overall global GDP.

Figure 5.1 shows all the relevant climate damage estimates from the latest UN Climate Panel report, updated with the latest studies. On the horizontal axis, we can see a range of temperature increases. Down the vertical axis, we see the impact put into monetary terms: the net effect of all impacts from global warming translated into percentage of global GDP. The impact is typically negative, meaning that global warming will overall be a cost or a problem.

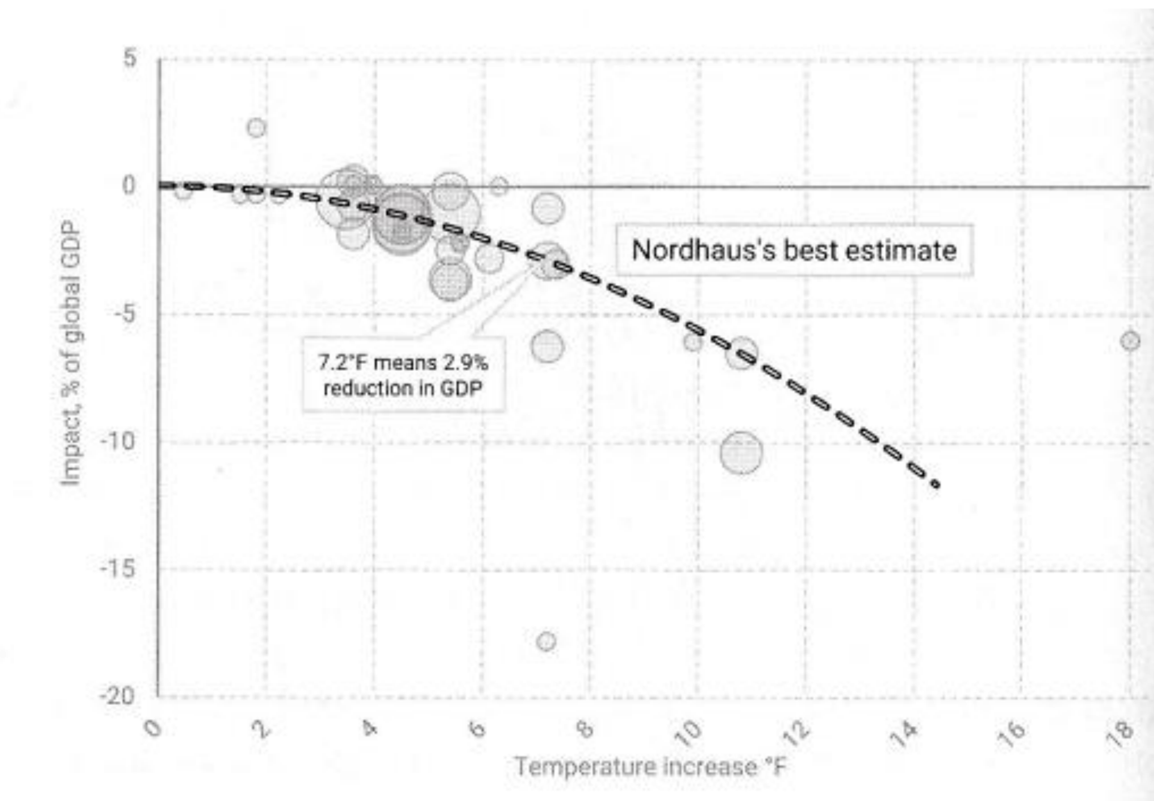


FIGURE 5.1 Impact of temperature rise. Total impact as percentage of global GDP of a given temperature rise, based on thirty-nine published estimates in the literature. Larger circles are better studies. This is an update of the UN's overview (IPCC 2014a,690, SM10-4) Size of circles shows the weight of the individual studies (larger circles for latest estimates, using independent and appropriate methods; smaller circles for earlier estimates, secondhand studies, or less appropriate methods). The black dashed line is Nordhaus's best estimate, based on median quadratic weighted regression.

Right now, the planet has experienced a bit less than 2°F global temperature increase since the industrial revolution. This graph shows us that it is not yet clear whether the net global impact from a 2°F change is positive or negative; there are three studies that show a slight negative impact, and one showing a rather large benefit. As the temperature increase grows larger, the impact becomes ever more negative. The dashed line going through the data is Nordhaus's best estimate of the reduction in global GDP for any given temperature rise.

We should focus on the temperature rise of just above 7°F, because that is likely to be what we will see at the end of the century, without any additional climate policies beyond those to which governments have already committed. At 7.2°F in 2100, climate change would cause negative impacts equivalent to a 2.9 percent loss to global GDP.

Remember, of course, that the world will be getting much richer over die course of the century. And that will still be true with climate change -we will still be much richer, but slightly less so than we would have been without global warming.

In summary, models are used to project the benefits of reducing GHG emissions on future global warming impacts including those on agriculture, energy, and forestry, as well as sea-level rises, water resources, storms, biodiversity, cardiovascular and respiratory diseases, and vector-borne diseases (like malaria), and diarrhea. Richard Tol describes the value of greenhouse gas emission reductions thusly: "In sum, the causal chain from carbon dioxide emission to social cost of carbon is long, complex and contingent on human decisions that are at least partly unrelated to climate policy. The social cost of carbon is, at least in part, also the social cost of underinvestment in infectious disease, the social cost of institutional failure in coastal countries, and so on."

Social Cost of Carbon Caveats

There are some important caveats in this approach. For example, Lomborg does not mention the fact that the models estimate those impacts out to the year 2300 and that the largest impacts are predicted to occur at the end of the modeling period. All of these economic models simplify the relationship between emissions and potential global warming impacts and they all presume a high sensitivity to those impacts from greenhouse gases which is entirely consistent with the Climate Act's presumed impacts. However, the high climate sensitivity to GHG gases is a modeling artifact not observed in nature. Finally, keep in mind that there is no attempt to consider advantages of greenhouse gases, much less balance them in their projected benefit costs.

Advocates for the Climate Act often say we need to act on climate change for our children and grandchildren. However, if a generation is 25 years long, then the avoided cost of carbon societal benefit is applied to 11 generations out to 2300. One of the points that Lomborg makes in *False Alarm* is that the costs of global warming will only reach 2.6% of GDP by 2100 but that global GDP will be so much higher at that time that this number is insignificant.

New Yorkers also need to be aware that benefits mostly accrue to those jurisdictions outside of New York. To this point they are more vulnerable because there is under-investment in resilient agriculture, energy, and forestry; their society is not rich enough to address sea-level rises like Holland has done for centuries; adaptation for water resources, storms, and biodiversity is not a priority because of poverty;

and where underfunding for cardiovascular and respiratory diseases, vector-borne diseases (like malaria), and diarrhea makes the impacts of those diseases worse than in New York.

Importantly, if total global greenhouse gas emissions continue to rise as developing countries improve their resiliency to weather events and health care system using fossil fuels then there will not be any actual societal benefits from New York's emission reductions. The benefits argument devolves into claiming that the value of New York's avoided greenhouse gas emissions reductions is that impacts would have been even worse without them. New York's share of global GHG emissions is 0.45% in 2016, the last year when state-wide emissions consistent with the methodology used elsewhere are available, so they can only claim only less than half a percent worse because that is New York's share of total emissions today. Furthermore, global emissions have increased by more than half a percent annually which is more than New York's total share of global emissions since 1995, so whatever New York does to reduce emissions will be supplanted by global emissions increases in a year.

New York Avoided Cost of Carbon Estimates

In order to claim that the Climate Act emission reductions provide societal benefits the Social Cost of Carbon (SCC) or Value of Carbon is used. The metric is a measure of the avoided costs from global warming impacts out to 2300 caused by reducing a ton of GHG emissions. In order to calculate the benefit, the New York values of carbon are multiplied by the number of tons of carbon reduced. I believe that the societal benefit for Climate Act reductions should use one and only one of the three values in Figure ES.1. Using the maximum rather than the baseline makes sense if you want to get credit for New York's biggest impacts and using the most recent value could be argued as appropriate because it represents the actual value of the Climate Act itself. As shown below I cannot reproduce the numbers in the Draft Scoping Plan.

The following table lists the societal benefits for the three different discount rates listed in New York's Value of Carbon guidance. Note that New York's emissions estimates using upstream emissions and unconventional assumptions increase emission estimates to 1.9 times higher in 1990 and 2.3 times higher in 2019 than emissions accounting used by other jurisdictions. The state recommends using the 2% discount rate which gives societal benefits ranging between $46.7 billion and $56.4 billion using the 2021 values depending on which historical emission value is used. However, consider that most other jurisdictions, including the Federal government are using conventional, or UNFCCC, format for governmental accounting and the 3% discount rate. That drops the social benefits to $8.6 for 2019 emissions to $10.9 billion for 2019 emissions. In 1990 New York's emissions accounting increases the benefits to $20.9 billion and for 2019 emissions the accounting increases the benefits to $19.7 billion.

The discount rate value is a measure of trading off the welfare of the present generation for the benefit of future generations. This is entirely a value judgement and the Climate Act chooses a lower discount rate that places lower value on immediate benefits relative to higher delayed benefits received in the future. The combined effect of the higher emissions and lower discount rate means that New York's societal benefits of GHG emission reductions are 4.5 times higher for 1990 emissions and 5.4 times higher for 2019 emissions than other jurisdictions.

Societal Benefits of New York GHG Emission Reductions and Scooping Plan Scenarios

	Year	NYS GHG Emissions mmT CO2e	Recommended Range of Discount Rates			Societal Benefit of Climate Act ($millions)		
			3%	2%	1%	3%	2%	1%
Climate Act	**1990**	402.54	$ 52	$ 123	$ 409	$ 20,932	$ 49,512	$ 164,639
	2005	458.55	$ 52	$ 123	$ 409	$ 23,845	$ 56,402	$ 187,547
	2019	379.43	$ 52	$ 123	$ 409	$ 19,730	$ 46,670	$ 155,187
Everybody Else	**1990**	210.43	$ 52			$ 10,942		
	2019	165.46	$ 52			$ 8,604		

	Scenario	Scenario Description	Societal Benefit of Climate Act		
Scoping Plan	2	Strategic Use of Low Carbon Fuels		$ 235,000	
	3	Accelerated Transition Away from Combustion		$ 240,000	
	4	Beyond 85% Reductions		$ 250,000	

New York's Flawed Avoided Cost of Carbon Benefits Methodology

Despite all these machinations the societal benefits in the Scoping Plan are not large enough to claim positive net benefits. The Scoping Plan relies on flawed DEC Value of Avoided Carbon Guidance. The Guidance includes a recommendation how to estimate emission reduction benefits for a plan or goal. I believe that the guidance approach is wrong because it applies the social cost multiple times for each ton reduced. It is inappropriate to claim the benefits of an annual reduction of a ton of greenhouse gas over any lifetime or to compare it with avoided emissions. The social cost calculation that is the basis of the Scoping Plan carbon valuation sums projects benefits for every year for some unspecified lifetime subsequent to the year the reductions. As shown above, the value of carbon for an emission reduction is based on all the damages that occur from the year that ton of carbon is reduced out to 2300. Clearly, using cumulative values for this parameter is incorrect because it counts those values over and over. I contacted social cost of carbon expert Dr. Richard Tol about my interpretation of the use of lifetime savings and he confirmed that "The SCC should not be compared to life-time savings or life-time costs (unless the project life is one year)".

The State has contrived higher estimates for societal greenhouse gas emission benefits to the point where their valuation is around five times higher than other jurisdictions using conventional methodology. This manipulation was not sufficient to "prove" that societal benefits were greater than the costs for the Scoping Plan mitigation scenarios so the Scoping Plan Integration Analysis relied on state guidance that mistakenly over counts the benefits. That gamesmanship results in New York societal benefits more than 21 times higher than benefits using everybody else's methodology.

Calculation Methodology Questions

In Appendix G – Integration Analysis Technical Supplement, Section I – Page 63 the Scoping Plan states: "Reducing GHG emissions in line with Climate Act emissions limits avoids economic impacts of damages caused by climate change equaling approximately $235 to $250 billion." I have been unable to reproduce those numbers. My question is how were the $235 to $250 billion social cost of carbon benefit estimates calculated?

New York's Value of Carbon guidance states that:

> 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.

I have some questions how this guidance was applied:

- What year did the Integration Analysis start calculating the benefit?
- How many years did the Integration Analysis calculate the cumulative benefits?
- Did all the Integration Analysis calculation use just the equivalent CO2 mass or the component Part 496 GHG gases?

Calculation of the avoided economic impacts of damages caused by climate change

The calculation should multiply the emissions reduced times the social cost of GHG value to get the avoided economic impacts of damages caused by climate change. The Social Cost Benefits of GHG Reductions Alternate Methodologies table at the end of this document lists emissions and social cost values from the Integration Analysis and calculates the avoided economic damages. The spreadsheet with the calculations is included in the comment submittal.

I used data from two Integration Analysis sources in the Social Cost Benefits of GHG Reductions spreadsheet:

- Integration Analysis Technical Supplement, Section I, Annex 2: Key Drivers and Outputs, IPAT tab
    - Gross GHG emissions for the reference case and Scenarios 2-4 are listed and I used those numbers as the starting point for the emissions reductions.
- Integration Analysis Technical Supplement, Section I, Annex 2: Input Assumptions, Social Cost of GHG tab
    - Social Cost of GHG Pollutant Mitigation by 2% Discount Rate, Adjusted for New York State (2020$ per metric ton of pollutant) lists the social cost values I used.

Both tabs are included in the spreadsheet and the SCC calculation tab calculates the avoided damages estimates.

In my analysis I assumed that the appropriate emissions reductions to use were the difference between the reference case and Scenarios 2-4. Those represent the emission reduction due to the Climate Act itself. For example, in the Social Cost Benefits of GHG Reductions table:

- In 2021 the Integration Analysis predicts that Gross GHG annual emission reductions will be 2.272 million metric tons (MMT) greater than the reference case reductions for Scenario 2, 2.301 MMT for Scenario 3 and 2.303 MMT for Scenario 4.

- In 2021 the NY value of carbon is $123 so the avoided economic impacts of damages caused by climate change is that value multiplied by the emission reductions or $279 million for Scenario 2, $283 million for Scenario 3 and $283 million for Scenario 4.

The appropriate avoided economic impacts of damages caused by climate change equals the sum of the annual values: $35.916 billion for Scenario 2, $35.796 billion for Scenario 3 and $39.115 billion for Scenario 4. All are far below the Scoping Plan estimate of "approximately $235 to $250 billion".

In addition, as documented above I disagree with the New York's Value of Carbon guidance that cumulatively calculates those values instead of summing the annual values. Even though I disagree with the guidance it is still important to be able to reproduce the Scoping Plan estimates. I tried to reproduce the cumulative accounting for four different periods: 5 years, 10 years, 15 years, and over the entire period 2021 to 2050.

- If the annual benefits are incorrectly accumulated over five years, then the total avoided economic impacts of damages caused by climate change range between $177.074 billion and $191.381 billion for the three scenarios.
- If the annual benefits are incorrectly accumulated over ten years, then the total avoided economic impacts of damages caused by climate change range between $342.407 billion and $365.549 billion for the three scenarios.
- If the annual benefits are incorrectly accumulated over fifteen years, then the total avoided economic impacts of damages caused by climate change range between $477.835 billion and $505.976 billion for the three scenarios.
- If the annual benefits are incorrectly accumulated over the period 2021 to 2050, then the total avoided economic impacts of damages caused by climate change range between $634.72 billion and $672.443 billion for the three scenarios.

In my analysis the range of estimates falls outside the Scoping Plan $235 to $250 billion values as shown below.

Summary of Alternate Value of Carbon Guidance Social Cost Benefits of GHG Reductions 2020 to 2050

	Scenario 2	Scenario 3	Scenario 4
Social Cost Benefits of GHG Reductions - No Accumulated Values	$ 35,916	$ 35,796	$ 39,115
Social Cost Benefits of GHG Reductions - 5-yr accumulation	$ 177,074	$ 176,662	$ 191,381
Social Cost Benefits of GHG Reductions - 10-yr accumulation	$ 343,131	$ 342,407	$ 365,549
Social Cost Benefits of GHG Reductions -15-yr accumulation	$ 480,197	$ 477,835	$ 505,976
Social Cost Benefits of GHG Reductions -Accumulate Entire Period	$ 639,537	$ 634,720	$ 672,443

Conclusion

The avoided economic impacts of damages caused by climate change provide the largest societal benefits for GHG emission reductions in the Scoping Plan. The Scoping Plan does not clearly explain that the Integration Analysis values used for this calculation trade off the welfare of the present generation for the benefit of 11 future generations by its unique choice of the discount value and that those benefits mostly accrue to jurisdictions outside of New York. The Scoping Plan has also contrived to manipulate these "benefits" by using unconventional emissions and accounting techniques.

Despite all this suspect benefit manipulation the benefits do not out-weigh the costs. In order to increase the societal benefits, the Scoping Plan artificially increases the benefits by counting them multiple times. In the Societal Benefits of New York GHG Emission Reductions and Scoping Plan Scenarios table the maximum societal benefit of the Climate Act is calculated by multiplying the baseline 1990, maximum 2005, and the most recent 2019 emissions by the 2021 NY value of carbon ($127 per ton). The societal benefit of the Climate Act section of the table shows that the maximum benefits if all the emissions were eliminated in 2021 range from $46.670 and $56.402 billion. Those values represent the benefits of reducing those GHG emissions on future global warming impacts including those on agriculture, energy, and forestry, as well as sea-level rises, water resources, storms, biodiversity, cardiovascular and respiratory diseases, and vector-borne diseases (like malaria), and diarrhea calculated out to 2300. It is obviously incorrect to claim that the 2021 reduction benefits could also be counted in 2022 and other years over some arbitrary lifetime. Using the lifetime approach someone who lost 10 pounds five years ago and kept it off can claim that they lost 50 pounds. When just this over-counting error is corrected, the total societal benefits range between negative $74.5 billion and negative $49.5 billion.

Finally, I have questions about the methodology. The Integration Analysis resources do not include explicit spreadsheet documentation for the Scoping Plan value of carbon estimates that address my specific questions. Using the available information, I am unable to reproduce Integration Analysis numbers. The Climate Action Council and the Scoping Plan should provide spreadsheet documentation for all the numbers in the Scoping Plan. Many of the figures in the document are supported by this type of information but a surprising number do not.

I am submitting this comment on the calculation of Greenhouse Gas (GHG) emission reduction benefits for avoiding future global warming impacts because I have the background and experience to know that this law is ill-conceived and a danger to the health and welfare of the citizens of New York. I have written extensively on implementation of the Climate Act because I believe the ambitions for a zero-emissions economy outstrip available technology such that it will adversely affect reliability and affordability, risk safety, affect lifestyles, will have worse impacts on the environment than the purported effects of climate change in New York, and cannot measurably affect global warming when implemented. The opinions expressed in this post do not reflect the position of any of my previous employers or any other company I have been associated with, these comments are mine alone.

Sincerely,

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Social Cost Benefits of GHG Reductions

Gross GHG Emissions from IPAT tab																																		
Scenario	Units	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Reference	MMT CO2e	384.180	383.517	382.238	378.626	377.302	373.107	368.944	366.525	359.913	353.014	347.017	340.325	332.672	329.248	326.006	322.967	319.984	317.293	316.064	314.685	313.428	312.300	311.368	310.682	309.975	309.624	309.493	309.330	309.035	308.875	308.714	308.770	308.796
Scenario 2	MMT CO2e	384.180	383.639	381.616	375.732	370.007	360.953	347.263	334.343	319.845	302.717	285.730	267.152	245.287	231.761	219.237	206.192	193.409	179.060	165.180	152.381	140.792	128.555	115.767	108.005	99.892	92.971	86.639	79.394	75.323	71.950	68.050	65.124	60.449
Scenario 3	MMT CO2e	384.180	383.504	381.485	375.572	370.868	362.702	349.779	337.578	323.978	301.472	280.386	264.503	245.126	232.616	220.890	208.433	196.070	181.988	168.011	154.857	142.795	130.085	116.746	108.680	100.341	93.403	87.128	79.914	75.877	72.497	68.630	65.832	61.312
Scenario 4	MMT CO2e	384.180	383.637	381.614	375.699	370.267	361.532	348.071	335.351	321.191	298.341	276.994	260.273	240.150	227.012	214.761	201.882	189.199	174.891	161.079	148.145	136.343	123.912	110.935	100.647	90.797	82.298	74.435	67.351	60.921	55.165	49.741	44.473	39.967

Social Cost of GHG Pollutant Mitigation by 2% Discount Rate, Adjusted for New York State (2020$ per metric ton of CO2e)

$ 121	$ 123	$ 124	$ 126	$ 128	$ 129	$ 131	$ 132	$ 134	$ 136	$ 137	$ 139	$ 141	$ 142	$ 144	$ 146	$ 147	$ 149	$ 151	$ 152	$ 154	$ 156	$ 158	$ 160	$ 162	$ 164	$ 166	$ 167	$ 169	$ 170	$ 172

Scenario Reductions Relative to the Reference Case

Gross GHG Annual Reductions		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	
Scenario 2	MMT CO2e	-2.272	-4.401	-4.860	-9.527	-10.501	-7.885	-10.230	-10.989	-11.887	-14.212	-10.102	-9.282	-10.005	-9.800	-11.659	-12.651	-11.419	-10.333	-11.108	-11.857	-7.076	-7.406	-6.570	-6.201	-7.083	-3.776	-3.213	-3.740	-2.981	-4.702	-247.725
Scenario 3	MMT CO2e	-2.301	-3.379	-3.972	-8.760	-9.782	-6.987	-15.608	-15.089	-9.191	-11.723	-9.086	-8.484	-9.418	-9.379	-11.392	-12.748	-11.775	-10.804	-11.582	-12.407	-7.380	-7.632	-6.587	-6.145	-7.050	-3.742	-3.220	-3.707	-2.853	-4.547	-246.731
Scenario 4	MMT CO2e	-2.303	-4.107	-4.541	-9.298	-10.301	-7.547	-15.952	-15.350	-10.029	-12.470	-9.714	-9.009	-9.840	-9.700	-11.616	-12.584	-11.554	-10.545	-11.303	-12.045	-9.602	-9.142	-8.148	-7.732	-6.921	-6.135	-5.596	-5.264	-5.324	-4.533	-268.205

Social Cost Benefits of GHG Reductions		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	
Scenario 2	Million 2020$	$ 279	$ 546	$ 612	$ 1,219	$ 1,355	$ 1,033	$ 1,350	$ 1,473	$ 1,617	$ 1,947	$ 1,404	$ 1,309	$ 1,421	$ 1,411	$ 1,702	$ 1,860	$ 1,701	$ 1,560	$ 1,688	$ 1,826	$ 1,104	$ 1,170	$ 1,051	$ 1,005	$ 1,162	$ 627	$ 537	$ 632	$ 507	$ 809	$ 35,916
Scenario 3	Million 2020$	$ 283	$ 419	$ 500	$ 1,121	$ 1,262	$ 915	$ 2,060	$ 2,022	$ 1,250	$ 1,606	$ 1,263	$ 1,196	$ 1,337	$ 1,351	$ 1,663	$ 1,874	$ 1,754	$ 1,631	$ 1,761	$ 1,911	$ 1,151	$ 1,206	$ 1,054	$ 995	$ 1,156	$ 621	$ 538	$ 626	$ 485	$ 782	$ 35,796
Scenario 4	Million 2020$	$ 283	$ 509	$ 572	$ 1,190	$ 1,329	$ 989	$ 2,106	$ 2,057	$ 1,364	$ 1,708	$ 1,350	$ 1,270	$ 1,397	$ 1,397	$ 1,696	$ 1,850	$ 1,722	$ 1,592	$ 1,718	$ 1,855	$ 1,498	$ 1,444	$ 1,304	$ 1,253	$ 1,135	$ 1,018	$ 934	$ 890	$ 905	$ 780	$ 39,115

Cumulative Value of Carbon Guidance Social Cost Benefits of GHG Reductions 2020 to 2050

Scenario 2	Million 2020$	$ 279	$ 827	$ 1,453	$ 2,696	$ 4,071	$ 5,167	$ 6,557	$ 8,129	$ 9,867	$ 11,887	$ 13,464	$ 14,967	$ 16,494	$ 18,137	$ 20,091	$ 22,089	$ 24,091	$ 25,974	$ 27,835	$ 30,027	$ 31,521	$ 33,095	$ 34,565	$ 36,001	$ 37,608	$ 38,693	$39,463	$40,567	$41,314	$42,609	$ 639,537
Scenario 3	Million 2020$	$ 283	$ 704	$ 1,216	$ 2,357	$ 3,637	$ 4,609	$ 6,704	$ 8,828	$ 10,209	$ 11,891	$ 13,327	$ 14,715	$ 16,157	$ 17,735	$ 19,645	$ 21,653	$ 23,702	$ 25,652	$ 27,582	$ 29,856	$ 31,395	$ 33,003	$ 34,475	$ 35,901	$ 37,501	$ 38,579	$39,349	$40,447	$41,171	$42,438	$ 634,720
Scenario 4	Million 2020$	$ 283	$ 795	$ 1,380	$ 2,592	$ 3,941	$ 4,991	$ 7,134	$ 9,299	$ 10,802	$ 12,590	$ 14,124	$ 15,598	$ 17,105	$ 18,743	$ 20,699	$ 22,691	$ 24,721	$ 26,645	$ 28,540	$ 30,771	$ 32,668	$ 34,531	$ 36,272	$ 37,978	$ 39,582	$ 41,083	$42,265	$43,661	$44,824	$46,131	$ 672,443

Cumulative Value of Carbon Guidance Social Cost Benefits of GHG Reductions 2020 to 2050 5-Year Cumulative Benefit Period

Scenario 2	Million 2020$	$ 279	$ 827	$ 1,453	$ 2,696	$ 4,071	$ 4,870	$ 5,676	$ 6,584	$ 7,003	$ 7,563	$ 7,981	$ 7,963	$ 7,879	$ 7,690	$ 7,424	$ 7,849	$ 8,275	$ 8,435	$ 8,690	$ 8,835	$ 8,080	$ 7,549	$ 7,043	$ 6,336	$ 5,631	$ 5,152	$ 4,483	$ 4,058	$ 3,535	$ 3,167	$ 177,074
Scenario 3	Million 2020$	$ 283	$ 704	$ 1,216	$ 2,357	$ 3,637	$ 4,307	$ 5,954	$ 7,534	$ 7,705	$ 8,028	$ 8,437	$ 7,554	$ 6,802	$ 6,925	$ 6,973	$ 7,559	$ 8,152	$ 8,471	$ 8,862	$ 9,135	$ 8,416	$ 7,869	$ 7,294	$ 6,504	$ 5,706	$ 5,172	$ 4,466	$ 4,033	$ 3,497	$ 3,108	$ 176,662
Scenario 4	Million 2020$	$ 283	$ 795	$ 1,380	$ 2,592	$ 3,941	$ 4,689	$ 6,288	$ 7,832	$ 8,048	$ 8,405	$ 8,829	$ 7,977	$ 7,251	$ 7,306	$ 7,282	$ 7,754	$ 8,239	$ 8,456	$ 8,756	$ 8,937	$ 8,588	$ 8,317	$ 8,039	$ 7,561	$ 6,813	$ 6,321	$ 5,767	$ 5,348	$ 4,971	$ 4,618	$ 191,381

Cumulative Value of Carbon Guidance Social Cost Benefits of GHG Reductions 2020 to 2050 10-Year Cumulative Benefit Period

Scenario 2	Million 2020$	$ 279	$ 827	$ 1,453	$ 2,696	$ 4,071	$ 5,167	$ 6,557	$ 8,129	$ 9,867	$ 11,887	$ 13,149	$ 14,026	$ 14,856	$ 15,105	$ 15,483	$ 16,290	$ 16,689	$ 16,814	$ 16,807	$ 16,665	$ 16,410	$ 16,324	$ 15,981	$ 15,597	$ 15,039	$ 13,749	$12,462	$11,497	$10,183	$ 9,072	$ 343,131
Scenario 3	Million 2020$	$ 283	$ 704	$ 1,216	$ 2,357	$ 3,637	$ 4,609	$ 6,704	$ 8,828	$ 10,209	$ 11,891	$ 13,007	$ 13,914	$ 14,786	$ 15,084	$ 15,528	$ 16,481	$ 16,135	$ 15,704	$ 16,172	$ 16,490	$ 16,438	$ 16,514	$ 16,270	$ 15,949	$ 15,434	$ 14,127	$12,784	$11,737	$10,323	$ 9,092	$ 342,407
Scenario 4	Million 2020$	$ 283	$ 795	$ 1,380	$ 2,592	$ 3,941	$ 4,991	$ 7,134	$ 9,299	$ 10,802	$ 12,590	$ 13,804	$ 14,694	$ 15,550	$ 15,827	$ 16,239	$ 17,091	$ 16,668	$ 16,166	$ 16,467	$ 16,618	$ 16,817	$ 17,053	$ 16,999	$ 16,892	$ 16,331	$ 15,459	$14,557	$13,839	$12,905	$11,764	$ 365,549

Cumulative Value of Carbon Guidance Social Cost Benefits of GHG Reductions 2020 to 2050 15-Year Cumulative Benefit Period

Scenario 2	Million 2020$	$ 279	$ 827	$ 1,453	$ 2,696	$ 4,071	$ 5,167	$ 6,557	$ 8,129	$ 9,867	$ 11,887	$ 13,464	$ 14,967	$ 16,494	$ 18,137	$ 20,091	$ 21,755	$ 23,096	$ 24,233	$ 24,634	$ 25,167	$ 25,367	$ 25,246	$ 24,859	$ 24,248	$ 23,378	$ 22,613	$21,736	$20,937	$19,902	$18,940	$ 480,197
Scenario 3	Million 2020$	$ 283	$ 704	$ 1,216	$ 2,357	$ 3,637	$ 4,609	$ 6,704	$ 8,828	$ 10,209	$ 11,891	$ 13,327	$ 14,715	$ 16,157	$ 17,735	$ 19,645	$ 21,315	$ 22,856	$ 24,194	$ 24,784	$ 25,514	$ 25,907	$ 24,978	$ 23,934	$ 23,740	$ 23,267	$ 22,663	$21,921	$21,218	$20,234	$19,295	$ 477,835
Scenario 4	Million 2020$	$ 283	$ 795	$ 1,380	$ 2,592	$ 3,941	$ 4,991	$ 7,134	$ 9,299	$ 10,802	$ 12,590	$ 14,124	$ 15,598	$ 17,105	$ 18,743	$ 20,699	$ 22,352	$ 23,766	$ 24,992	$ 25,462	$ 26,066	$ 26,725	$ 25,992	$ 25,168	$ 25,111	$ 24,511	$ 24,216	$23,792	$23,303	$22,697	$21,746	$ 505,976

Calculations Not Relative to the Reference Casa

Gross GHG Annual Reductions		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	
Reference	MMT CO2e	-3.612	-1.325	-4.194	-4.164	-2.418	-6.613	-6.899	-5.997	-6.691	-7.653	-3.424	-3.242	-3.039	-2.983	-2.691	-1.228	-1.380	-1.257	-1.128	-0.932	-0.686	-0.707	-0.351	-0.131	-0.163	-0.295	-0.160	-0.160	0.055	0.027	-73.442
Scenario 2	MMT CO2e	-5.884	-5.725	-9.054	-13.690	-12.920	-14.498	-17.128	-16.987	-18.578	-21.865	-13.527	-12.524	-13.044	-12.783	-14.350	-13.879	-12.799	-11.590	-12.236	-12.789	-7.762	-8.113	-6.921	-6.332	-7.246	-4.071	-3.373	-3.900	-2.926	-4.675	-321.167
Scenario 3	MMT CO2e	-5.912	-4.704	-8.166	-12.923	-12.201	-13.600	-22.506	-21.086	-15.883	-19.376	-12.510	-11.726	-12.458	-12.363	-14.083	-13.977	-13.154	-12.062	-12.710	-13.339	-8.066	-8.339	-6.938	-6.276	-7.213	-4.038	-3.380	-3.867	-2.798	-4.520	-320.172
Scenario 4	MMT CO2e	-5.915	-5.432	-8.735	-13.461	-12.720	-14.160	-22.850	-21.347	-16.720	-20.123	-13.138	-12.251	-12.879	-12.683	-14.307	-13.812	-12.934	-11.802	-12.431	-12.977	-10.288	-9.850	-8.499	-7.863	-7.084	-6.431	-5.756	-5.424	-5.268	-4.506	-341.647

Social Cost Benefits of GHG Reductions		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	
Reference	Million 2020$	$ 444	$ 164	$ 529	$ 533	$ 312	$ 866	$ 911	$ 804	$ 910	$ 1,048	$ 476	$ 457	$ 432	$ 430	$ 393	$ 181	$ 206	$ 190	$ 171	$ 143	$ 107	$ 112	$ 56	$ 21	$ 27	$ 49	$ 27	$ 27	$ (9)	$ (5)	$ 10,011
Scenario 2	Million 2020$	$ 724	$ 710	$ 1,141	$ 1,752	$ 1,667	$ 1,899	$ 2,261	$ 2,276	$ 2,527	$ 2,995	$ 1,880	$ 1,766	$ 1,852	$ 1,841	$ 2,095	$ 2,040	$ 1,907	$ 1,750	$ 1,860	$ 1,969	$ 1,211	$ 1,282	$ 1,107	$ 1,026	$ 1,188	$ 676	$ 563	$ 659	$ 497	$ 804	$ 45,927
Scenario 3	Million 2020$	$ 727	$ 583	$ 1,029	$ 1,654	$ 1,574	$ 1,782	$ 2,971	$ 2,826	$ 2,160	$ 2,655	$ 1,739	$ 1,653	$ 1,769	$ 1,780	$ 2,056	$ 2,055	$ 1,960	$ 1,821	$ 1,932	$ 2,054	$ 1,258	$ 1,318	$ 1,110	$ 1,017	$ 1,183	$ 670	$ 564	$ 653	$ 476	$ 777	$ 45,806
Scenario 4	Million 2020$	$ 728	$ 674	$ 1,101	$ 1,723	$ 1,641	$ 1,855	$ 3,016	$ 2,861	$ 2,274	$ 2,757	$ 1,826	$ 1,727	$ 1,829	$ 1,826	$ 2,089	$ 2,030	$ 1,927	$ 1,782	$ 1,890	$ 1,998	$ 1,605	$ 1,556	$ 1,360	$ 1,274	$ 1,162	$ 1,067	$ 961	$ 917	$ 896	$ 775	$ 49,126

Cumulative Value of Carbon Guidance Social Cost Benefits of GHG Reductions

Reference	Million 2020$	$ 444	$ 612	$ 1,150	$ 1,702	$ 2,027	$ 2,925	$ 3,858	$ 4,720	$ 5,700	$ 6,791	$ 7,366	$ 7,929	$ 8,416	$ 8,965	$ 9,482	$ 9,728	$ 10,065	$ 10,390	$ 10,631	$ 10,914	$ 11,163	$ 11,418	$ 11,618	$ 11,785	$ 11,957	$ 12,152	$12,252	$12,425	$12,490	$12,632	$ 243,704
Scenario 2	Million 2020$	$ 724	$ 1,440	$ 2,604	$ 4,397	$ 6,098	$ 8,092	$ 10,415	$ 12,849	$ 15,567	$ 18,677	$ 20,830	$ 22,895	$ 24,910	$ 27,102	$ 29,573	$ 31,816	$ 34,156	$ 36,364	$ 38,465	$ 40,941	$ 42,683	$ 44,512	$ 46,183	$ 47,786	$ 49,564	$ 50,845	$51,714	$52,993	$53,804	$55,241	$ 883,241
Scenario 3	Million 2020$	$ 727	$ 1,316	$ 2,367	$ 4,058	$ 5,664	$ 7,533	$ 10,562	$ 13,547	$ 15,910	$ 18,681	$ 20,693	$ 22,644	$ 24,573	$ 26,700	$ 29,127	$ 31,381	$ 33,768	$ 36,042	$ 38,213	$ 40,770	$ 42,557	$ 44,421	$ 46,093	$ 47,686	$ 49,458	$ 50,731	$51,601	$52,872	$53,661	$55,070	$ 878,424
Scenario 4	Million 2020$	$ 728	$ 1,407	$ 2,530	$ 4,294	$ 5,968	$ 7,915	$ 10,992	$ 14,019	$ 16,502	$ 19,381	$ 21,490	$ 23,526	$ 25,522	$ 27,708	$ 30,181	$ 32,419	$ 34,787	$ 37,036	$ 39,171	$ 41,684	$ 43,831	$ 45,949	$ 47,891	$ 49,763	$ 51,539	$ 53,235	$54,517	$56,086	$57,314	$58,763	$ 916,147