More Residual Risks:

An Update on New York City Boilers

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This policy brief reviews and updates initial estimates of the tremendous health and environmental benefits that could be generated if New York City switched its buildings to cleaner heating fuels. In *Residual Risks: The Unseen Costs of Using Dirty Oil in New York City Boilers* (Policy Integrity Report No. 5, January 2010), the benefits of such a conversion were calculated to include hundreds of avoided mortalities, billions of dollars worth of measurable health benefits, and substantial additional health, environmental, and welfare effects.

Using different assumptions and newly available data, this update expands on those original findings, and now concludes that:

- Switching all residential and commercial boilers from dirty residual oil to natural gas would likely save 259 lives per year. Over a thirty-year period, in excess of $22 billion worth of health benefits could be generated.
- Switching to alternatives that are not quite as clean as natural gas, such as low-sulfur #4 oil or low-sulfur #2 oil, will save lives, but not as many.
- In particular, switching all residential and commercial boilers from dirty residual oil to low-sulfur #4 oil would likely save 84 lives per year, generating at least $7.2 billion in health benefits over a thirty-year period.
- Switching all residential and commercial boilers from dirty residual oil to natural gas would deliver up to $6 billion in climate benefits over a thirty-year period—as much as taking 441,000 cars off the road.
- The benefits of lowering the sulfur content of #4 oil should easily exceed the costs, by a margin of 2:1 or more. But switching to natural gas could save New Yorkers several billion dollars in financial costs, on top of the roughly $28 billion in health and environmental benefits.

Passing laws to lower the sulfur content of heating oil is an admirable goal that will deliver undeniably important health benefits to New York City. Any action on this crucial public health threat is overdue and welcome. But politicians, building owners, and individual citizens should all bear in mind that the cleanest, most efficient option remains natural gas. Low-sulfur fuels offer a significant improvement over the status quo, but ultimately they are a second-best policy choice.

Scope of Analysis

How far should governments go to restrict residual oils?

New York's Battle Against Soot

The air we breathe is filled with soot—the more common name for particulate matter or "PM." PM is a complex and diverse mixture of acids and chemicals emitted by smokestacks, fires, and vehicle tailpipes. The smallest particles, those with diameters of less than 2.5 micrometers (about 1/30 the diameter of a human hair), are called fine particulate matter, or $PM_{2.5}$. These fine particles are small enough that they can travel deep into human lungs or even slip directly into the bloodstream.

The cardiovascular and respiratory ailments experienced by people exposed to elevated soot concentrations are comparable to those expected for a non-smoker who lives with a smoker. The more costly health consequences include heart attacks, chronic bronchitis, childhood acute bronchitis, thousands of lost work days, and, ultimately, premature death.

Three years ago, Mayor Bloomberg's administration recognized that the soot emitted by burning dirty heating oil in residential and commercial building was a particularly dangerous but controllable form of pollution.[1] So-called "residual oils," also known as #6 or #4 oil, emit noticeably more fine particulate matter than the fuel known as #2 distillate oil; natural gas is considerably cleaner still. By switching from residual oil to cleaner fuel, many negative health effects can be avoided. A switch would also reduce the emission of other pollutants, like sulfur dioxide (a culprit behind acid rain) and carbon dioxide (a potent heat-trapping gas with climate implications).[2]

In recent months, both the New York State legislature and New York City government have actively explored lowering the sulfur content of either #4 or #2 oil, as a way to cut soot emissions.[3] Both fuel types already have some legal restrictions placed on their sulfur content,[4] but those levels could be tightened further. Given this new focus on low-sulfur fuel as an alternative to traditional residual oil, it is important to take a second look at the comparative health benefits of all available policy options. Additionally, as discussed below, it is now possible to recalibrate initial estimates using different assumptions and datasets.

This update confirms and expands on the original findings of *Residual Risks: The Unseen Costs of Using Dirty Oil in New York City Boilers*. Specifically, switching all residential and commercial boilers from residual oil to natural gas as quickly as possible would generate the greatest health and environmental benefits for New York City and its residents. Lowering the sulfur content of heating oil will achieve important public health gains compared to the status quo, but such action alone cannot fully address the premature mortalities and negative climate impacts caused by the combustion of dirty heating oil in New York City.

Regulating Residual Oil Will Save Lives

This policy brief starts by examining the comparative emissions for the new fuel options under discussion: low-sulfur #2 and low-sulfur #4.[5] Total particulate matter emissions are included since they are often considered by policymakers, but emissions of fine particulate matter ($PM_{2.5}$) are much more significant from a public health perspective. As evident from Table 1, lowering the sulfur content of heating oil does effectively reduce the overall emission of particulate matter; but the biggest payoff in terms of reducing fine particulate matter comes from switching residual oil customers over to natural gas.

Table 1. Comparison of Emissions for PM and $PM_{2.5}$ by Fuel Type[6]

Fuel	PM (lbs/million BTUs)	Percent Reduction	$PM_{2.5}$ (lbs/million BTUs)	Percent Reduction
#6 oil	0.0497	0.0%	0.0190	0.0%
#4 oil	0.0366	26.3%	0.0171	10.0%
#4, low-sulfur	0.0309	37.8%	0.0156	18.1%
#2 oil	0.0236	52.6%	0.0152	20.1%
#2, low-sulfur	0.0121	75.6%	0.0121	36.2%
Natural gas	0.00745	85.0%	0.00745	60.9%

Heating fuel is not the only source of particulate matter in New York City. Though it is a key local source, a majority of New York's soot actually comes from non-local sources, such as out-of-state power plants.[7] Determining how a switch to cleaner heating fuels would affect New Yorkers' health requires first calculating how much soot in New York City's air can be traced back specifically to residual oil. Then, by plugging in the emissions factors from Table 1, the decreased exposure levels for the population of New York City can be estimated. From decreased exposure levels, health benefits can be predicted in terms of fewer fatal heart attacks, fewer respiratory ailments, fewer work days lost, and so forth.

Various methodologies can be used to calculate the portion of ambient $PM_{2.5}$ attributable to heating oil emissions. Below, Table 2 presents three sets of estimates for the number of lives saved, based on three different methodologies. The first updates the original and novel methods used in *Residual Risks*.[8] That report developed an innovative approach, made possible by two special

characteristics of residual oil: first, its emissions are high in nickel, making residual oil easy to trace; and second, its use varies widely from winter to summer. Comparing heating season and non-heating season nickel concentrations, in conjunction with other factors, creates a picture of what New York City's air would be like if residual oil were phased out. This update adjusts that methodology with slightly less conservative assumptions, for example on the most likely energy content of #2 distillate oil.

The second methodology presented in Table 2 is a compilation of three independent "source apportionment" studies, each of which employed rigorous analysis of source emissions profiles and other data to estimate what portion of New York City soot is due to heating oil sources.[9] The third methodology utilizes newly available data from the New York City Community Air Survey, which monitored air quality and pollution concentration levels across the city.[10]

Each methodology has its own strengths and shortcomings,[11] but the three separate estimation techniques—using different monitoring data and methodologies—all generate roughly the same numbers for annual avoided mortalities. That consistency suggests that the estimated range of health benefits is accurate. Table 2 shows these estimates of the lives that could be saved each year by converting from residual oil to cleaner fuel types. 95% confidence intervals for the mortality estimates are presented in parentheses—a statistical tool that indicates the reliability and precision of the estimates.

Table 2. Annual Avoided Mortalities due to $PM_{2.5}$ Reductions, by Fuel Conversion and Methodology

	Annual Avoided Mortalities (95% CI)		
Scenario	*Residual Risks*, updated	Source Apportionment Compilation	NYCCAS
All residual oil converted to #4 fuel	26.7 (14-39)	34.8 (19-51)	36.3 (20-53)
All residual oil converted to low-sulfur #4 fuel	61.8 (33-90)	80.7 (43-118)	84.1 (45-123)
All residual oil converted to #2 fuel	62.8 (34-92)	82.1 (44-120)	85.5 (46-125)
All residual oil converted to low-sulfur #2 fuel[12]	113.3 (61-166)	147.9 (80-216)	154.2 (83-225)
All residual oil converted to natural gas	190.2 (102-278)	248.3 (134-363)	258.8 (139-378)

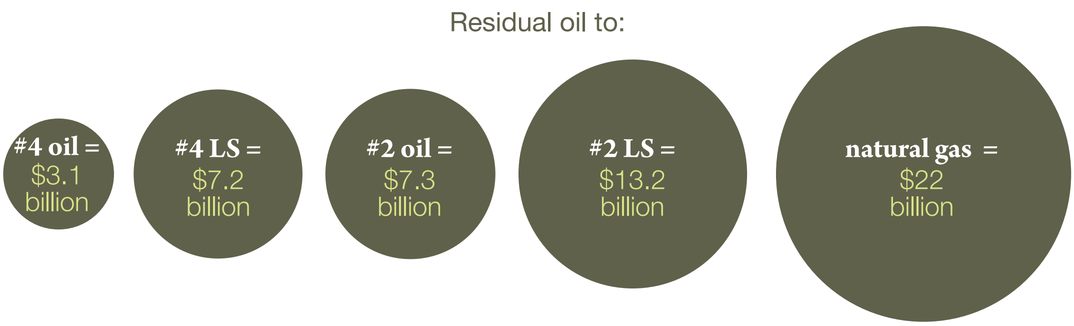
As evident from these calculations, a full conversion from traditional residual oil to low-sulfur #4 oil could be an important step in delivering health benefits. But switching to natural gas will likely save three times as many lives per year. If all residential and commercial boilers were converted from residual oil to low-sulfur #4 starting in 2012, by the year 2040, approximately 2,439 lives would be saved. Over that same time period, a full conversion to natural gas would have saved about 7,505 lives.

Improving Community Health Delivers Significant Monetized Benefits

Saving lives, preventing illness, and generally improving public health delivers significant, quantifiable benefits that can be assigned a monetary value. Not only can the cost of illness be calculated—in terms of medical resources used, lost productivity (such as lost wages) during illness, and so forth—but individuals and society as a whole have a "willingness to pay" to avoid negative health outcomes. Government agencies routinely calculate and apply such monetary values when deciding whether to regulate a dangerous substance, to determine if the health benefits justify the economic costs of regulation.

Using conservative estimates for the monetized value of health outcomes, along with a conservative 7% discount rate, the net present value of health benefits generated from 2012 through 2040 can be calculated.[13] For a full conversion from residual oil to low-sulfur #4 oil, at least $7.2 billion worth of health benefits will be generated over that period. For a full conversion to natural gas, in excess of $22 billion worth of health benefits would be generated over the same time.

Figure 1. Cumulative Monetary Health Benefits due to $PM_{2.5}$ Reductions, from 2012 through 2040



This update has focused on premature mortalities. But fine particulate matter has many other negative and costly health impacts: non-fatal heart attacks, chronic bronchitis, childhood acute bronchitis, asthma, pneumonia, hospital admissions, and lost work days. Moreover, these estimates do not take into account the potential effects of particle composition on increased mortality. Residual oil emissions contain especially high nickel and vanadium concentrations, which may present additional hazards to human health. The potential role of such particle composition effects was discussed in greater detail in *Residual Risks*, but the issue needs further study. It is safe to say, however, that the health benefits calculated here are low estimates for the total health and economic value from switching New York City over to cleaner heating fuels.

Clearing the Air

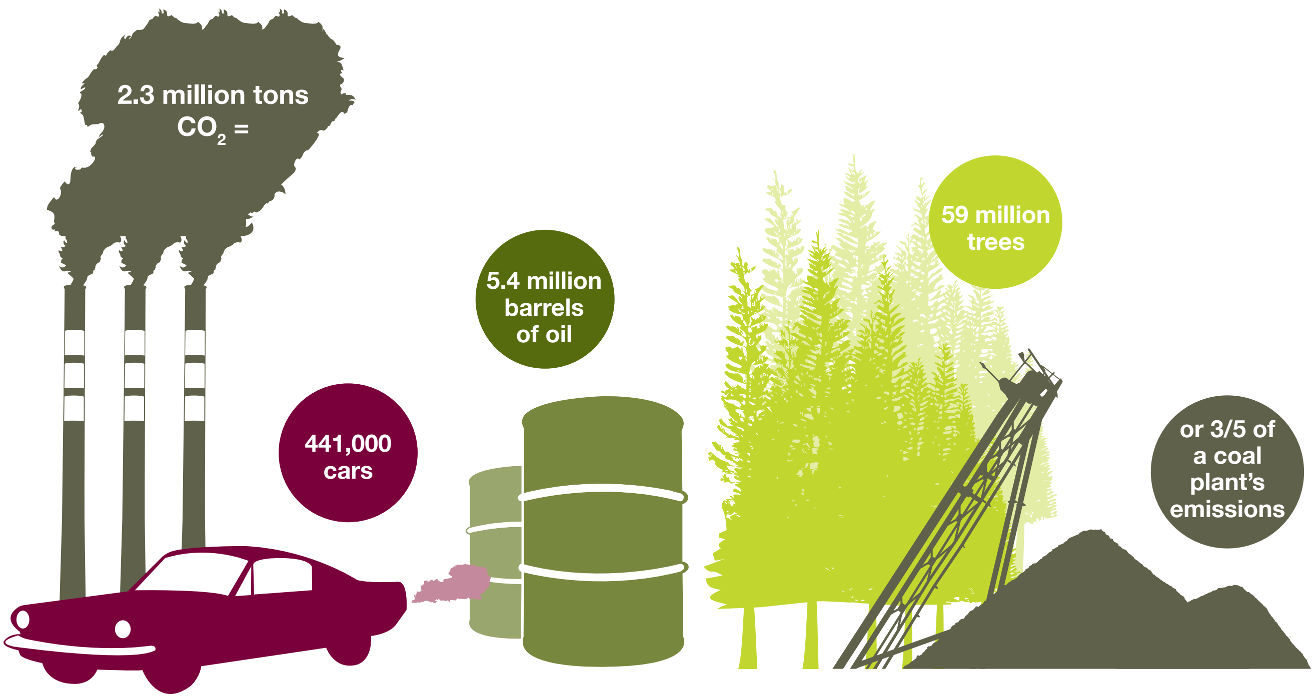
Updated climate estimates show bigger benefits

Regulating Residual Oil Benefits the Environment

In addition to its high soot levels, residual oil also emits more carbon dioxide—the greenhouse gas most responsible for global climate change—than cleaner fuels like natural gas. New data allows more precise calculation of the climate benefits generated by a full conversion from residual oil to natural gas in New York City boilers. In particular, the mayor's office has provided unofficial estimates of how much residual oil is burned in New York City's residential and commercial boilers ever year.[14]

When combined with the carbon dioxide emissions factors for various fuel types,[15] this data suggests that switching all residual oil to natural gas would save about 2,309,000 metric tons of carbon dioxide each year: the same as taking 441,000 cars off the road; or saving 5.4 million barrels of oil; or planting 59 million new trees; or eliminating three-fifths of the emissions from a typical coal-fired power plant.[16] Low-sulfur fuels may have some climate benefits compared to traditional residual oils, but not nearly on the scale of converting to natural gas.

Figure 2. Equivalent Climate Benefits of Phasing Out Residual Oil in New York Ciy



Environmental Benefits Carry Real Economic Value

Cutting carbon dioxide will mitigate the speed and severity of the myriad impacts of climate change on the environment, the economy, public health, and national security. Such benefits can be approximated by the "social cost of carbon" (SCC), which assigns a specific monetary value to the marginal impact over time of an additional ton of carbon dioxide emissions. SCC estimates take into consideration such factors as net agricultural productivity loss, human health effects, property damage from sea level rise, and changes in ecosystem services.

While all current SCC estimates involve a great deal of uncertainty and incompleteness that likely results in significant underestimation, federal agencies have recently settled on a relatively consistent and updated range of SCC figures.[17] Despite the high potential for underestimation, these figures provide a good starting point for analyzing the benefits of reducing greenhouse gas emissions.

In the year 2012, a full conversion from residual oil to natural gas would deliver about $50 million worth of climate benefits according to the federal government's central SCC estimate, but possibly as much as $150 million using the upper SCC estimate. However, SCC values grow every year, because future emissions are expected to produce larger climate-related damage as the earth's physical and economic systems become more stressed. Therefore, calculated through the year 2040, the climate benefits of switching from residual oil to natural gas could total over $6 billion.[18]

The Economic Case for Action

Updated cost-benefit comparisons
justify restricting residual oils

Low-Sulfur Fuels Help, But Natural Gas Is More Cost-Benefit Justified

The mayor's office has been developing a detailed cost-estimation model, which has been informally reviewed by representatives from industry and the advocacy community.[19] Unofficial results from the model suggest that the long-term capital and operating costs of converting residual oil to low-sulfur #4 in the year 2012 through 2040 could be a few billion dollars. But compared to the $7.2 billion in calculated health benefits, including 2,439 lives saved, along with additional, valuable health and environmental effects, the benefits of that switch should easily exceed the costs, by a factor of at least 2:1.

More impressively, the same model predicts that the long-term capital and operating costs of converting to natural gas through the year 2040 could be negative, thanks to the lower projected price of natural gas versus residual oil. In other words, the city and its residents could *save several billion dollars* by switching to a cleaner fuel. Those financial savings come on top of the $22 billion in calculated health benefits, including 7,505 lives saved, and $6 billion in climate benefits expected from such a switch.

While a switch to low-sulfur fuels is clearly cost-benefit justified, it will not deliver the same cost-savings and dramatic health benefits as natural gas.

New York Should Take Swift Action

Several thousand lives could be saved, a significant number of heart attacks and childhood bronchitis cases could be avoided, and considerable climate benefits could be achieved if New York City switched from residual oil to cleaner fuels. Lowering the sulfur content of heating oil will achieve important public health gains compared to the status quo, but such action alone cannot fully address the premature mortalities and negative climate impacts caused by the combustion of dirty heating oil in New York City. Instead, switching all residential and commercial boilers from residual oil to natural gas as quickly as possible would generate the greatest health and environmental benefits for New York City and its residents.

In either case, given the number of lives affected and the low cost of switching to cleaner fuels, this update confirms that taking swift action to wean New York City off dirty heating oil is both urgently needed and economically justified.

Notes

[1] *See* City of New York, PlaNYC: A Greener, Greater New York 127 (2007).

[2] See Kevin R. Cromar & Jason A Schwartz, *Residual Risk: The Unseen Costs of Using Dirty Oil in New York City Boilers* (Policy Integrity Report No. 5, January 2010) for more background on residual oil and the health and environmental effects of fine particulate matter.

[3] *See, e.g.*, New York City Council Int. No. 194 § 10 (2010) (proposed by council members Gennaro et al.) (lowering the sulfur content of #4 heating oil); New York State S. 1145-A (2009) (proposing to lower the sulfur content of #2 heating oil).

[4] For example, a New York City law dating from 1971, which was subsequently incorporated into state regulations, restricts the sulfur content of heating oil. *See* N.Y. Comp. Codes R. & Regs. tit. 6 § 225-1.2 (d) (1985).

[5] *See* U.S. Envtl. Prot. Agency, No. AP-42-ED-5, Compilation of Air Pollutant Emission Factors: Vol. 1—Stationary Point and Area Sources (1995). Primary PM and $PM_{2.5}$ emission factors for fuel oil combustion are derived from *id.*, tlbs. 1.3-1, 1.3-2, and 1.3-7. Emission factors for #4 (and low-sulfur #4) are calculated as the average of #6 and #2 (and low-sulfur #2) emission factors. Calculations assume 150,000 BTUs per gallon and 140,000 BTUs per gallon for #6 and #2, respectively. Sulfur content for #6 is 3000 ppm, or 0.3% by weight. Unlike #6, direct calculation of emission factors for #2 based on sulfur content is not available. However, the "residential furnace" emission factor in Table 1.3-1 provides a reasonable estimate of the filterable portion of low-sulfur #2, based on the anticipated decrease in primary emissions as a result reducing sulfur content by nearly 2000 ppm, or 0.2% by weight. Therefore, the calculated primary emission factors for low-sulfur #4 and low-sulfur #2 are representative of a sulfur content of approximately 1500 ppm and <100 ppm, respectively.

[6] *See id.*

[7] *See* PlaNYC, *supra* note 1, at 120.

[8] The monitoring data comes from R.E. Peltier & M. Lippmann, *Residual Oil Combustion: Distributions of Airborne Nickel and Vanadium within New York City*, J Expo. Sci. Envtl. Epidemiol. (2009). The portion of the nickel and fine particulate matter attributable to commercial, institutional, and residential residual heating oil combustion was determined by seasonal differencing, as outlined in *Residual Risks*, *supra* note 2. The main strength of this approach is the monitoring locations which, while few in number, were operated for many weeks in both the heating and non-heating seasons, providing detailed information on the ambient pollution attributable to heating season residual oil combustion. However, this approach does not account for summertime residual oil emissions from commercial, institutional, and residential sources; and it has poor spatial resolution results in underestimate of fine particulate matter from residual oil combustion, especially in New York and Queens counties.

[9] The compilation was made from three separate source apportionment studies of New York City: R. Lall, *A Source Apportionment and Time-Series Health Analysis of Fine Particle Air Pollution in New York City* (NYU School of Medicine, Ph.D. thesis, 2008); K. Ito, N. Xue & G. Thurston, *Spatial Variation of $PM_{2.5}$ Chemical Species and Source-Apportioned Mass Concentrations in New York City*, 28 Atmoshperic Environment 5269–5282 (2004); Y. Qin, E. Kim & P. Hopke, *The Concentrations and Sources of PM2.5 in Metropolitan New York City*, 40 Atmospheric Environment S312-S332 (2006). Monitoring data was from the EPA's Speciation Trends Network and was adjusted for a decrease in nickel concentrations observed over the past eight years. The portion of fine particulate matter attributable to commercial, institutional, and residential residual heating oil combustion was determined from the U.S. EPA 2005 National Emissions Inventory for New York, Bronx, and Queens Counties. Kings County health benefits were included from *Residual Risks*. Compiling three separate source apportionment studies strengthens the confidence in exposure estimate. But using the National Emissions Inventory to determine source proportions may not fully represent the pollutant contributions from area sources such as building emissions.

[10] Monitoring data was obtained from the New York City Community Air Study, as presented by the City of New York during a March 3, 2010 stakeholder meeting on heating oil. The calculated, heating season NYCCAS nickel concentrations were approximately 20% and 70% higher than the monitored concentrations from the Peltier and Lippmann study for Bronx and New York Counties, respectively, *see supra* note 8. The discrepancy in monitored values is likely due to the increased number of monitoring sites in the areas with the highest nickel concentrations

in the NYCCAS study. The concentrations were nearly identical for Queens and Kings Counties in the two studies. While the monitored values were the same in Queens County, the increased number of monitors in the NYCCAS study resulted in higher estimates of county-wide fine particle concentrations than was possible in *Residual Risks* using the Peltier and Lippmann data. The methodology used in calculating health benefits is described in *Residual Risks*, *supra* note 2. The large number of monitoring locations provided improves spatial resolution of ambient nickel concentrations, especially in New York and Queens Counties. But this methodology does not account for non-heating season residual oil emissions from commercial, industrial, and residential buildings.

11 *See supra* notes 8-10.

12 Estimates only represent the health benefits of converting current residual oil use to low-sulfur #2. Additional health benefits would occur due to conversion of current #2 fuel customers to low-sulfur #2.

13 The U.S. EPA recommends a central "value of statistical life" estimate of $7.0 million (2006$). Nat'l Ctr. for Evntl. Econ., U.S. Envtl. Prot. Agency, Guidelines for Preparing Economic Analysis 7-6 (Sept. 12, 2008) (unpublished external review draft). Though several biases and potentials for underestimation are built in to the EPA's methodology for calculating the VSL, *see* Richard L. Revesz & Michael A. Livermore, Retaking Rationality (2008), that value is used in this update. An inflation rate was calculated from Bureau of Labor Statistics data, but is conservative because inflation has been unusually flat since 2008. A 7% discount rate was chosen to be consistent with cost estimates presented *infra*.

14 Data presented by the City of New York during a March 3, 2010 stakeholder meeting on heating oil. When estimated BTUs are combined for sole #6/#4 boilers and for primary #6/#4 boilers, approximately 70 trillion BTUs worth of #6 oil and approximately 25 trillion BTUs worth of #4 oil is combusted in New York City annually.

15 Data for carbon dioxide emission factors comes from Energy Info. Admin., U.S. Dept. of Energy, Fuel Emission Factors, http://www.eia.doe.gov/oiaf/1605/excel/Fuel%20Emission%20Factors.xls (last visited Jan. 19, 2010).

16 *See* EPA, Greenhouse Gas Equivalencies Calculator, http://www.epa.gov/rdee/energy-resources/calculator.html (last visited May 20, 2010).

17 *See* Interagency Working Group on the Social Cost of Carbon, Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (2010) (listing $21 as the central estimate for 2010, and $64 as the upper estimate).

18 Based on approximately a 2% growth rate in the SCC, as recommended by *id.* No discount rate is applied to climate benefits. For the economic, legal, and ethical reasons not to discount in the climate context, see Revesz & Livermore, *supra* note 13.

19 Model presented by the City of New York during a March 3, 2010 stakeholder meeting on heating oil.

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