The bottom of the barrel

HOW THE DIRTIEST HEATING OIL POLLUTES OUR AIR AND HARMS OUR HEALTH

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EDF ENVIRONMENTAL DEFENSE FUND
Finding the ways that work

URBAN GREEN U.S. GREEN BUILDING COUNCIL NEW YORK

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Our mission
Environmental Defense Fund is dedicated to protecting the environmental rights of all people, including the right to clean air, clean water, healthy food and flourishing ecosystems. Guided by science, we work to create practical solutions that win lasting political, economic and social support because they are nonpartisan, cost-effective and fair.

The complete report is available at www.edf.org/dirtybuildings.

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Executive summary[1]

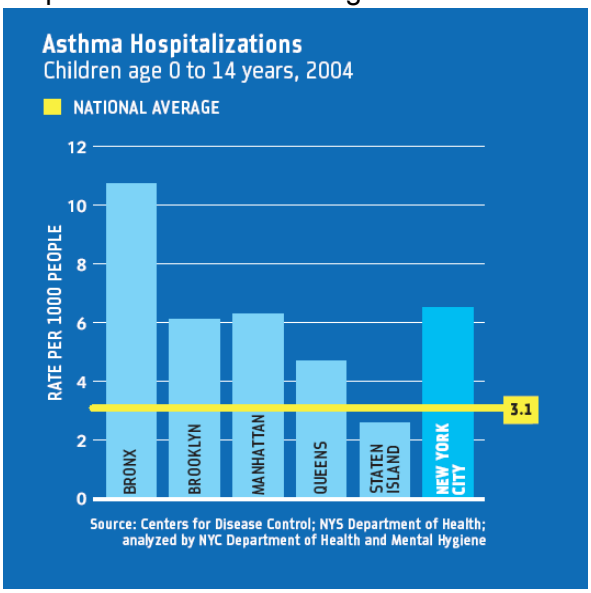
The problem


San Remo building spewing out black smoke from burning No. 6 oil (unrefined sludge)

New York City's air fails to meet health-based National Ambient Air Quality Standards (NAAQS) for soot and ozone.[2] Not surprisingly, the American Lung Association's (ALA) 2009 State of the Air report gives New York City a failing grade in terms of air quality.[3] The ALA report cites new research showing that ozone and fine particle pollution ($PM_{2.5}$) are extremely dangerous to public health. Soot and ozone pollution is unhealthy, takes the lives of infants and alters the lungs of children. The risks of air pollution are greater than we once thought.[4]

Still, black smoke pouring out of large New York City buildings is a common sight. These buildings' heating systems spew toxic soot, heavy metals (nickel) and other pollutants into the air because they are burning unrefined sludge (referred to as residual fuel or No. 4 or 6 oil).[5] Close to 9,000[6] large residential, commercial and institutional buildings currently burn this type of fuel, which contributes considerably to the city's air pollution and impacts public health.[7] For example, a new study shows that nickel-laden soot pollution is associated with respiratory symptoms in young children.[8] These sludge-burning buildings – which represent 1 percent of the city's buildings – contribute 86 percent[9] of the city's heating oil soot pollution which is more soot pollution than comes from the city's cars and trucks. Overall, residential, commercial and institutional heating systems release 50% more soot (PM)[10] and 17 times more sulfur dioxides (SO_2) than cars and trucks on New York City's roads.[11,12]

Figure 1: NYC asthma hospitalization rates compared to national average



Federal, state and local governments have enacted measures to reduce emissions from the on-road and off-road sectors. This is because of widespread awareness that $PM_{2.5}$ emissions have been linked to aggravated asthma, cancer, lung and heart disease and premature death; and, that New York City has twice the national asthma hospitalization rate among children 0–14 years. Air pollution exacts a high price for New Yorker's health and taxpayers' money. For example, in 2000, New York City

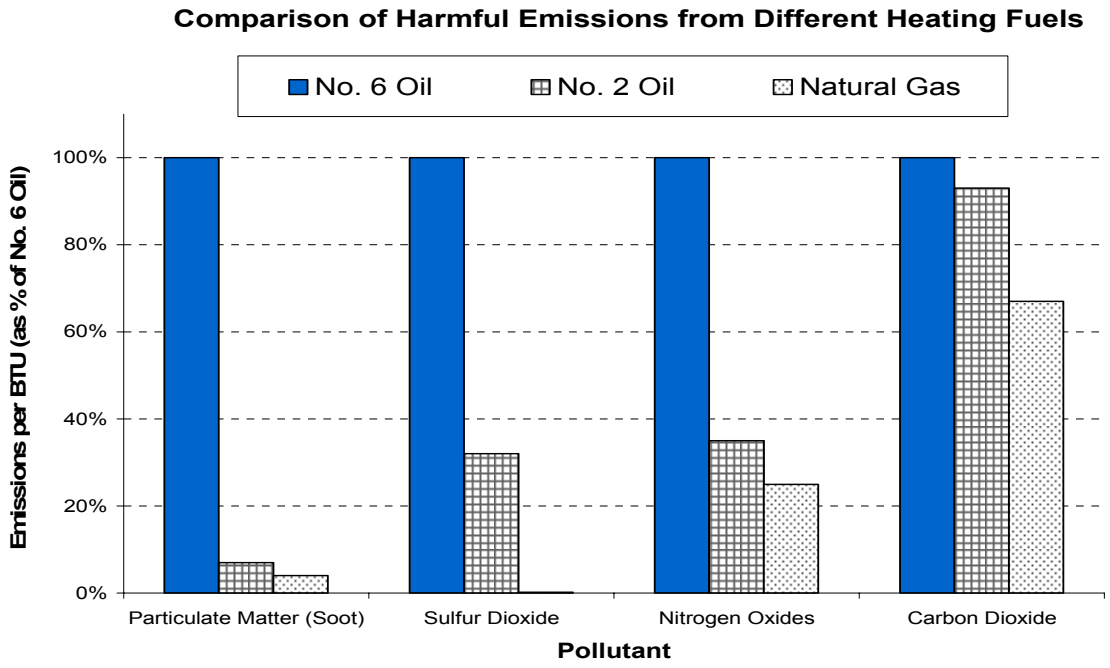
asthma hospitalizations alone cost government and individuals more than $240 million a year.[13] Medicaid and Medicare paid about 72% of these costs.

In addition, the soot pollution spewed out in disproportionate amounts by buildings burning No. 4 or No. 6 oil not only contributes to unhealthy air but also to climate change. Recent studies have shown that soot pollution (black carbon) is the second-largest contributor (after CO_2) to climate change. So reducing soot pollution will also have an immediate impact on mitigating climate change.[14]

The heating oil sector has been entirely ignored by the federal government and largely remains neglected by the state government, which has not yet acted on various proposals to make its sulfur caps protective enough for public health.[15,16] Nevertheless, the city has left this air pollution problem unaddressed. Air pollutants from No. 4 and 6 heating oil boilers are uncontrolled, contribute to unhealthy air quality and are a quality of life issue when New Yorkers open their windows to let in "fresh" breezes.

Switching from No. 6 oil to No. 2 heating oil reduces PM emissions by about 95%, SO_2 by about 68% and nitrogen oxides (NOx) by about 65%. Switching from No. 6 oil to natural gas reduces PM emissions by about 96%, SO_2 by over 99% and NOx by about 75%. In terms of global warming pollution, switching from No. 6 oil to No. 2 heating oil reduces heat-trapping CO_2 emissions by about 7%, and natural gas reduces CO_2 emissions by about 30% compared to No. 6 oil.[17] Switching to No. 2 heating oil or natural gas will also eliminate harmful nickel emissions as No. 4 and 6 oil spew out high levels of toxic nickel. Not surprisingly, New York City's nickel levels are on average nine times higher than average nickel levels in other U.S. cities. Nickel is a metal that when airborne has been linked to cardiovascular disease and premature death.[18]

Figure 2: This Figure depicts the dramatic difference in pollutants generated by No. 6 oil compared to No. 2 heating oil or natural gas. No. 4 oil is typically a 50/50 mix of No. 6 oil and No. 2 heating oil.



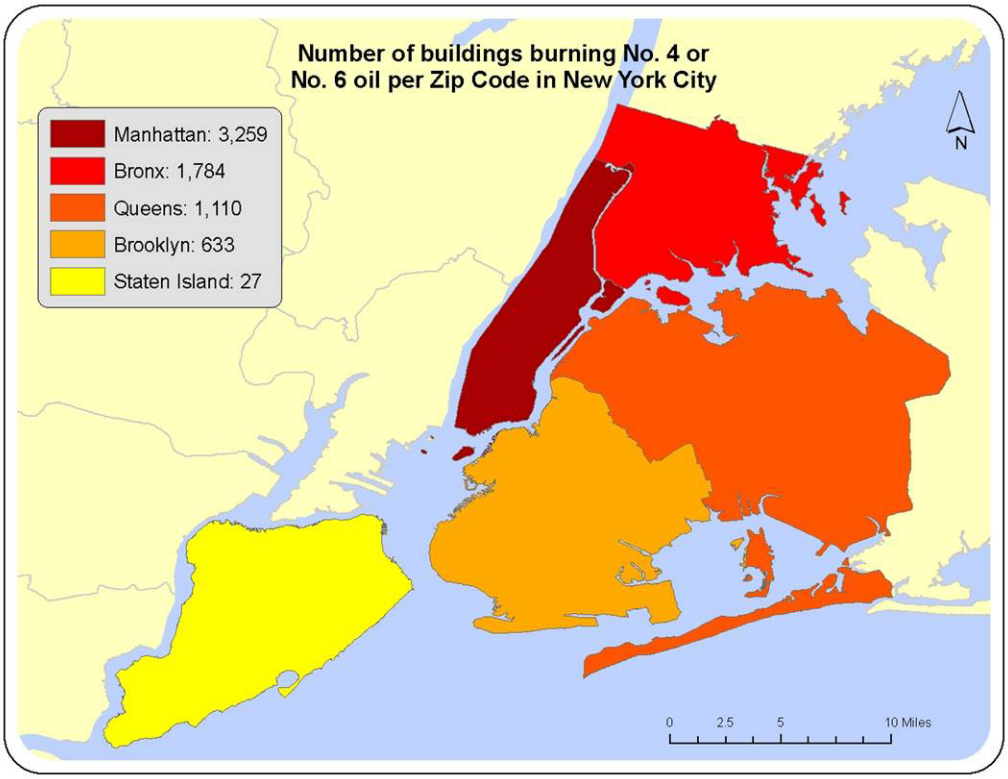
The problem is so urgent that it requires a clear phase-out schedule to ensure that these buildings are no longer allowed to burn No. 4 or 6 oil. The following steps should be taken by promulgating a new Dept. of Environmental Protection rule: a) new real estate developments as well as buildings currently burning No. 2 heating oil should be denied permits for No. 4 or No. 6 oil, b) develop a phase-out system for existing boilers/burners that burn dirty fuels with a variance procedure for low income buildings to give them enough time to switch to natural gas, and 3) devise ways to help New Yorkers transition to cleaner, greener fuels.

In addition, to facilitate the needed conversions, the city should work with the New York State Energy Research and Development Authority (NYSERDA) to develop conversion incentives especially for low income buildings presently burning No. 4 or 6 oils. The city should also coordinate with Con Edison and National Grid to establish the needed natural gas infrastructure.

Locations of NYC buildings that burn dirty fuel

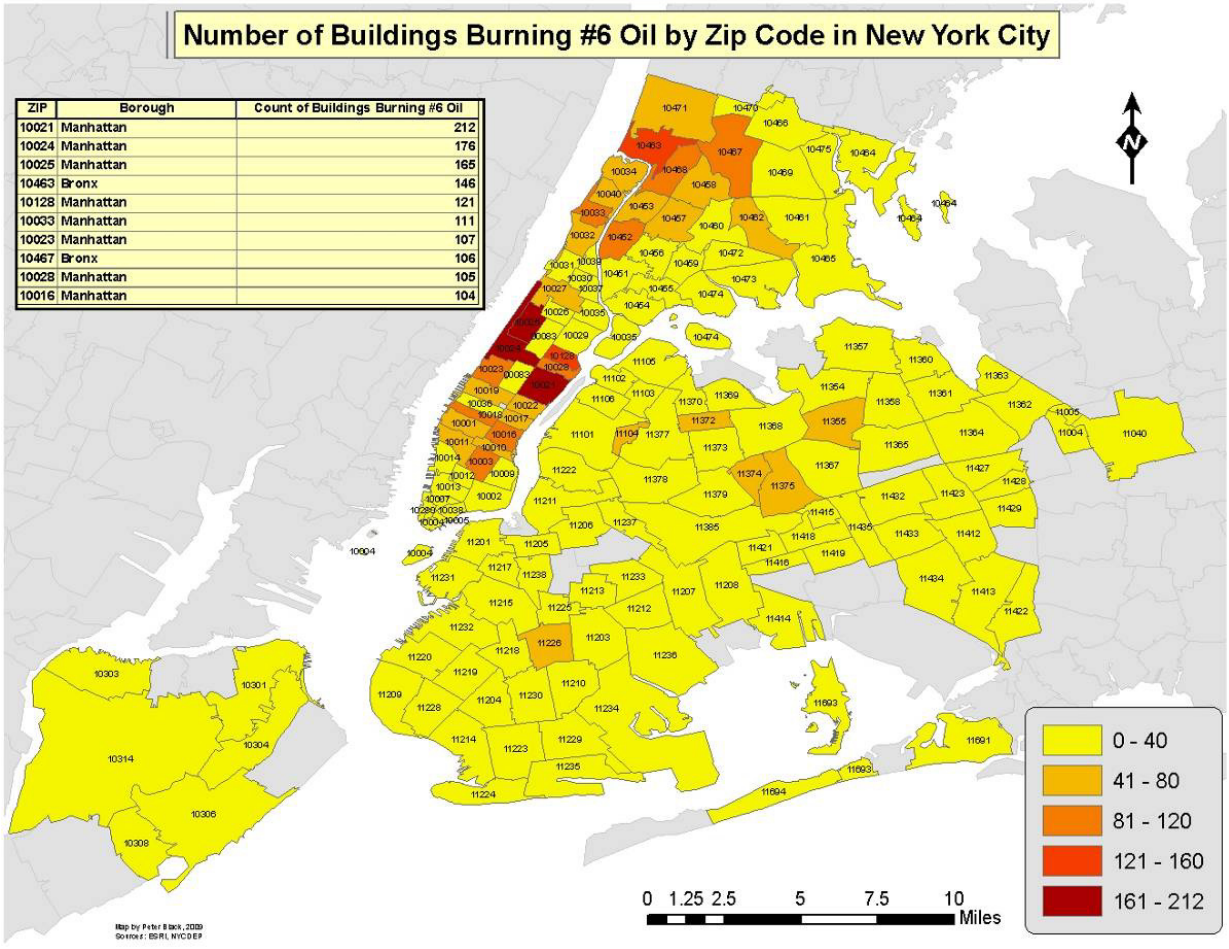
As figure 3 below depicts, almost half of the approx. 6,800 large buildings with active permits burning No. 4 or No. 6 oil are located in Manhattan.[19]

Figure 3: Distribution of the approximately 7,000 buildings burning No. 4 or 6 oil with active permits (an additional 2,000 buildings have permits "under review" meaning buildings trying to renew their permits or buildings that previously didn't burn No. 4 or 6 oil applying for a permit to burn No. 4 or 6 oil.



Citywide, about 5,500 large boilers burn approximately 227 million gallons of No. 6 oil annually.[20] An additional 3,500 large boilers burn about 84 million gallons of only slightly cleaner No. 4 oil.[21] In comparison, about 700 million gallons of much cleaner No. 2 heating oil are burned annually in New York City.[22] This shows that about 27% of the total heating oil burned in New York City is dirty oil (No. 4 and 6 oil) and about 73% of heating oil burned is No. 2 heating oil.[23] Close to 9,000 buildings burn No. 4 or 6 oil while more than 25,000 large and midsize buildings burn No. 2 heating oil.[24] Thousands of smaller, two-family and single-family homes also burn No. 2 heating oil.[25] As a result, one percent of buildings, of the city's 900,000 buildings, are responsible for 86%[26] of the heating oil soot pollution and airborne nickel levels that are nine times higher than average levels of other U.S. cities levels.[27]

Figure 4: Top ten zip codes with most buildings burning No. 6 oil

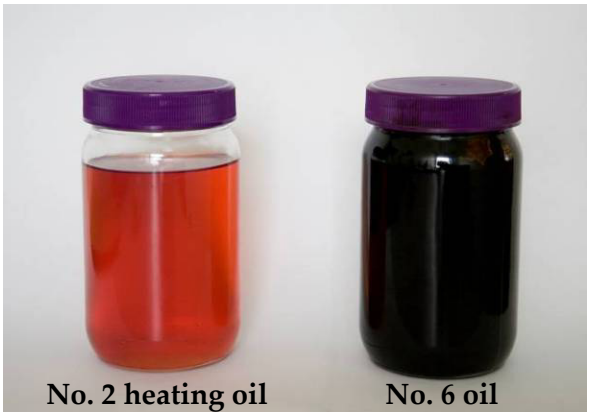


New York State relies heavily on dirty No. 4 and 6 oil for heating

The combustion of No. 4 and 6 oil in boilers is much more prevalent in New York State (most of it is burned in New York City) than in other states. In 2007, in New York State

350 million gallons of No. 6 oil were burned for heating purposes of which 227 million were burned in New York City. In comparison, these states[28] burned the following amounts of No. 6 oil for heating purposes in 2007:

- Massachusetts: 33 million gallons;
- New Hampshire: 17 million gallons;
- Maine: 16 million gallons;
- Pennsylvania: 15 million gallons
- New Jersey: 9 million gallons;
- Connecticut: 7 million gallons;
- Vermont: 3 million gallons;
- Michigan: zero gallons;
- Illinois: zero gallons;
- Colorado: zero gallons.[29]



The solutions

The good news is that pollution from residual oil can be cut by about over 93% by switching to No. 2 heating oil or natural gas. Also, implementing best maintenance practices and efficiency measures help buildings save money and pay for themselves.

The city needs to pursue a two-track strategy to achieve maximum air quality and public health benefits.

First, the city should put an immediate moratorium on new No. 4 and 6 permits for buildings that are currently burning No. 2 heating oil or newly constructed buildings that wish to use No. 4 or No. 6 oil.

Second, the Environmental Defense Fund urges the city to promulgate a new rule that will fully phase out renewal permits for No. 4 and 6 boilers by 2020. Every three years, buildings have to get their boiler permits renewed by the DEP, offering an opportunity to the city to get these buildings switched over to cleaner heating fuels over a timeframe of about six years for buildings that are not low income buildings[30] and give low income buildings until 2020 to switch to cleaner fuel. See Policy Recommendations for more details.

The city should work with the natural gas providers to speed up natural gas infrastructure for city-managed financial assistance buildings and low income buildings (natural gas prices are predicted to be cheaper than No. 6 oil) and/or help these buildings with efficiency measures.

Third, as detailed below, privately-owned buildings can switch to a cleaner fuel (like natural gas or No. 2 heating oil) and implement a wide range of good maintenance and efficiency measures that can yield some cost-effective fuel use reductions from almost any current system.

By switching from dirty residual fuel to No. 2 heating oil or natural gas, building managers can reduce boiler emissions substantially and lower their maintenance and operational costs. Similarly, regular boiler maintenance, fine-tuning of the heating system, pipe and boiler insulation and implementing efficiency upgrades on existing boilers will decrease fuel use and save money.

For example, the reduction in annual PM emissions from switching from No. 6 oil to natural gas in just one 200-unit apartment building would be the equivalent of taking more than 45 delivery trucks off the road .[31,32] Thus, the air quality and public health benefits of such reductions in pollution cannot be taken lightly.

About 420 public schools, a few hospitals and some other city-owned buildings burn No. 4 or 6 oil. No New York City Housing Authority (NYCHA) buildings are burning No. 4 or 6 oil, but a few buildings that are managed by the New York City Department of Housing and Preservation and Development (HPD) are burning the dirty fuel. Thirty Mitchell-Lama buildings citywide are also burning No. 4 or 6 oil.[33] Many of these buildings are being switched over already. EDF urges the city to devise a phase-out schedule for its remaining buildings to convert to cleaner fuels.

What can I do?

Contact your building's management and check on the interactive map at www.edf.org/dirtybuildings if your building is burning No. 4 or 6 oil. The map is also a useful tool to determine which neighboring buildings are burning dirty fuel and might be interested in splitting the costs of bringing the gas line to the buildings.[34] The New York City Department of Buildings' web site has an updated database with the type of fuel a building is burning—go to http://www.nyc.gov/html/dob/html/home/home.shtml and enter the address on the right side under BIS database, then click on "DEP Boiler Information."[35] If your building is burning No. 4 or No. 6 oil, we recommend that you provide the building's management or board of managers with the "Building owner/managing agent letter" and the "FAQ" sheet that can be found on www.edf.org/dirtybuildings which will show them how the building can switch to cleaner No. 2 heating oil or natural gas. You should also encourage your building management to do an energy audit and look into various efficiency measures presented in the chart at the end of this summary

NYC heating fuels in terms of air pollution	
No. 6 Residual Oil	Dirtiest
No. 4 Heavy-Distillate Oil (mixture of No. 2 and No. 6 oil)	Slightly cleaner than No. 6 oil
No. 2 Distillate Oil (No. 2 Heating Oil)	Cleaner than No. 4 or 6
Natural Gas	Cleanest

(or in chapters 5 and 6 of the online report). Cleaner fuels and a more efficient heating system can save buildings money and clear the air.

If your building is burning No. 4 or 6 oil, the different options for switching to a cleaner fuel are listed below. Ideally, these should be combined with regular heating system maintenance and efficiency measures to reduce fuel consumption and save money.

1. Switch to No. 2 heating oil. This switch could happen within months. Later, natural gas could be added to go to dual fuel as discussed next.
2. Switch to dual fuel, with natural gas as your primary fuel and No. 2 heating oil as a backup fuel. With dual fuel, the cheaper, "interruptible" gas rate applies. Contact your utility company regarding switching to natural gas.[36]
3. Switch to natural gas only. With natural gas only, the "firm" (higher) gas rate applies.
4. Install a co-generation system that runs on natural gas and produces both heat and electricity for the building.

Costs and benefits of switching fuels

The cost/benefits and impacts will vary according to the measures chosen. Depending on the existing burner/boiler and depending on the fuel a building switches to, conversion costs for a building with a dual fuel burner already in place on average range between $2,000 and $50,000.[37] We recommend that building owners check with their heating system contractor on the exact costs. If your heating system contractor also sells No. 4 or 6 oil to your building, we recommend going to a different heating system contractor for advice. If a building has a burner/boiler that is more than 30 years old, the building owners should look into investing in a more efficient burner/boiler. See also chapter 4 online for conversion cost estimates and Appendix A for conversion cost case studies.

The Energy Information Administration (EIA) projects that for at least the next ten years natural gas prices will be lower than prices for No. 2, 4 and 6 oils. No. 2 heating oil prices will be about 30% higher than No. 6 oil. See figure 5 below for price predictions. Calculating the cost of switching from No. 4 or 6 oil to No. 2 oil is simple. Calculating the switch to natural gas is slightly more complicated because oil prices are by the gallon while natural gas prices are calculated in therms.

Figure 5: Comparison of heating fuels price projections (Average 2010–2020) by EIA

Fuel	Energy content	Price	
		per gallon	per million Btu
No. 2 fuel oil	140,000 Btu/gal	$2.87	$20.49
No. 4 fuel oil	145,000 Btu/gal	$2.57	$17.82
No. 6 fuel oil	150,000 Btu/gal	$2.27	$15.14
Natural gas (firm rate)	1,028 Btu/scf	NA	$10.73
Interruptible natural gas	1,028 Btu/scf	NA	$8.26

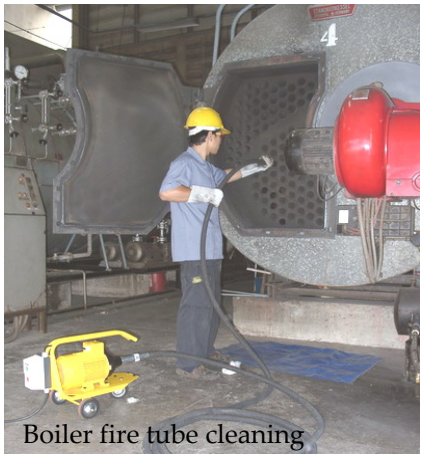
No price projections exist for interruptible natural gas rates.
Interruptible natural gas rate provided by National Grid – New York City, September 2008

No. 6 oil is about 10-30% less expensive than No. 2 heating oil, but the increased fuel costs can be mitigated or eliminated with smart management of the system to win efficiency gains (see chapter 5 online and the end of this executive summary). The price predictions show that the costs of switching from No. 6 oil to natural gas can be recouped quickly if a dual fuel burner is already in place—usually within 1–3 years (see case studies in Appendix A of the online report). This report shows how building owners can evaluate the options available to them to be part of the solution for healthy air and climate change.

The following is an example for a building that burns 50,000 gallons of No. 6 oil per year and the owner wants to switch to dual fuel natural gas/No. 2 heating oil. In June 2009, Con Edison quoted about $84,750 for natural gas heating per year with an interruptible rate.[38] In comparison, the owner would pay between $85,649 and $113,500 for No. 6 oil (price range due to different prices for No. 6 oil depending on June 2009 prices or the $2.27/gallon as per EIA's long-term predictions, see figure 5 above).

As described in chapter 4 of the online report, No. 2 heating oil and natural gas will also lead to lower maintenance and operational costs than No. 4 or 6 oil. Quantifying these lower costs is difficult, however, because they depend on the age and condition of the existing boiler (see Appendix A online for more detailed case studies). See also chapters 4 and 5 of the online report for proper maintenance practices to get heating systems running as efficiently as possible and reduce fuel use.

Proper maintenance and efficiency measures help reduce heating fuel expenses


Boiler fire tube cleaning

About 40% of the energy used to heat and cool homes is wasted.[39] Chapter 5 of the online report gives recommendations of proper system maintenance and efficiency measures.[40] As a first step, we recommend that building owners conduct a combustion efficiency test right away to ensure that the heating system is well tuned.[41] In addition, steam and hot water pipes and the boiler should be insulated wherever they are accessible without opening up walls. Regular maintenance and fine-tuning of the burner and boiler to run at maximum efficiency, in combination with proper insulation, can save thousands of dollars in reduced heating fuel use at very low cost.

As a second step, we recommend that building owners hire a specialist (for example, one recommended by NYSERDA—see Appendix E or www.getenergysmart.org/Resources/FindPartnerDetails.aspx?co=62) to perform a building energy audit to identify efficiency opportunities.[42] The chart that follows summarizes ways to reduce heating fuel consumption.[43]

Summary of heating system efficiency measures	
Efficiency Measure	**Approximate Fuel Savings ***
Keep heating and hot water systems well maintained with regular boiler tube cleanings and yearly combustion efficiency tests. Adjust air/fuel ratio for increased efficiency. Maintain well-functioning steam traps, air valves and shutoff valves on all radiators.	20% or more
Three low cost items (around $100 each) that will help save fuel and give heating system operators daily important information as to heating system efficiency are: • Permanent stack thermometer • Makeup water meter • Domestic hot water temperature sensor	Varies
Install thermostatic radiator valves or radiator shutoff valves (low-cost investment and increased resident comfort).	3-20%
Install an energy or building management system (EMS/BMS) that takes indoor air temperature into account for heating control.	15-25%
Use an EMS/BMS and zoning system (creating different heating zones in a building).	20% or more
Install a programmable thermostat (in smaller buildings).	15%
Control pump-recirculating domestic hot water with an aquastat (senses and controls water temperature, just like a thermostat does air).	Varies
Put in wall and pipe insulation (whenever pipes are accessible).	20%
Require residents to use properly sized radiators to avoid underheating or overheating. Also require all radiators to be accessible for maintenance purposes.	Varies
Weather-strip and caulk windows and doors.	Varies
Replace single-glazed windows with double-glazed windows and low-emissivity coatings and argon gas fill.	Varies

* The savings indicated are for each measure in isolation. Installing any one measure (e.g. TRVs) lower the potential savings of others (e.g. EMS).

Policy recommendations


Building spewing out black soot from burning No. 6 oil

A new EPA study shows that the greatest health benefits (in terms of health cost savings) are achieved by reducing direct $PM_{2.5}$ emissions, such as No. 4 and 6 oil emissions.[44] To protect the health of New Yorkers and get closer to meeting federal health-based air quality standards[45], Environmental Defense Fund is urging the city to promulgate a new rule that regulates the transition to cleaner fuels in two ways. First, the use of No. 4 and 6 oil must be phased out by 2020; just as the federal government and local policies have introduced cleaner fuels into the truck, bus and construction fleets—it is time to do the same for buildings.

99 percent of New York City buildings – including single family homes -- are already using cleaner fuels (No. 2 heating oil, natural gas or ConEdison steam). Unfortunately, close to 9,000 buildings – which is 1 percent of the city's buildings -- are still allowed to burn highly polluting No. 4 and 6 oil which comes at a high cost for the air we all breathe. It is time to require that all buildings burn cleaner fuels. Given that No. 2 heating oil is readily available and given that most buildings are already burning No. 2 heating oil, the city should cease to renew boiler permits for non low-income buildings. A staggered phase-out should be implemented. EDF recommends the following phase-out schedule based on boiler age and type of burner:

- Buildings with dual fuel burners (these type of burners can readily burn cleaner fuels) already in place would need to switch fuel upon DEP boiler permit renewal (between 2010 and 2013)

- Buildings with boilers from 1980 to 2010 that burn No. 6 oil would need to switch fuel by 2014 and if they burn No. 4 oil by 2015.

- Buildings with boilers from 1979 or older that burn No. 6 oil would need to switch by 2015 and if they burn No. 4 oil by 2016.

In addition, the DEP should have discretion to allow variances until 2020 for low income buildings (term still needs to be defined for a heating oil rule).

All these steps are needed to help the city get closer to meeting federal health-based air quality standards (called National Ambient Air Quality Standards); and, to get the city closer to the goal of PlaNYC, a comprehensive sustainability plan for the city's future, which is to make New York City have the cleanest air of any big city in America.

To increase efficiency and reduce fuel costs, a DEP rule should also require annual boiler cleanings, an annual combustion efficiency test (see Chapter 5 of this report), boiler and pipe insulation and annual tuning of the burner/boiler. Multifamily residential buildings with 5 or more units, commercial and institutional buildings that operate their own boilers should be required to install a permanent stack thermometer, a makeup water meter (boiler) and a domestic hot water temperature sensor. The superintendent or the person in charge of the heating system, should be required to keep a daily log with these temperature measurements. These measurements will give the superintendent and DEP/DOB inspectors an indication on how efficiently the heating system is running and where efficiency could be increased. All these simple maintenance measures cost little and will save buildings money by reducing fuel use.

Often buildings heat the domestic hot water above 120 deg F. which is wasteful and dangerous. A DEP rule should further require that buildings do not heat the hot water above 120 deg. F.

EDF recommends that the city also takes the following steps:

- The city should issue an annual progress report listing the buildings that have switched to cleaner fuels.
- The City should work with Con Edison and National Grid to project the increase in demand for natural gas this program will produce, at the level of distribution nodes and pipes; and, work with them to ensure that delivery capacity is made available.
- In addition to the steps above, the city should work with the City Council to enact a law that requires commercial and residential landlords, co-op and condominium boards, and building owners to equip all the residents' radiators with functioning shutoff valves or thermostatic radiator valves and working steam traps. These are low-cost investments with big payoffs and increase residents' comfort.

  
  Steam trap on steel radiator

  For example, for steam systems, which are used mostly in large commercial and residential buildings, well-maintained steam traps can reduce fuel consumption by 10–20%. Also, residents should always be able to turn off their radiators so that they do not have to open windows to regulate indoor temperature.

Incentives

- The city should work with NYSERDA to create incentives for buildings (especially low income buildings) that wish to switch to No. 2 heating oil or natural gas sooner than required under a future city rule phasing out No. 4 and 6 oil.[46]
- The city should work with Con Edison and National Grid to develop incentives for buildings in close proximity to switch to natural gas as a group, with the utility companies paying to bring the gas lines to the buildings.[47] Ideally, low income buildings would receive natural gas infrastructure first.

Conclusion

Because of the significant pollution and public health impacts created by the combustion of dirty, toxic residual fuel in New York City boilers, it is imperative that the city take action now towards a full phase-out by 2020 to address this unregulated sector. At the same time that these buildings will be required to switch to cleaner fuels, the city should use this opportunity to reach out to building owners about the many opportunities they have to reduce fuel costs with proper maintenance and system upgrades that are cost-effective, save fuel and decrease pollution. Best maintenance practices and efficiency measures could also be required by rule. Black smoke and inefficient heating systems should be a thing of the past.

[1] For the full report go to: www.edf.org/dirtybuildings.
[2] See EPA web site for detailed information. Online resource is available at: http://www.epa.gov/oar/oaqps/greenbk/ .
[3] See http://www.stateoftheair.org/ .
[4] See http://www.stateoftheair.org/2009/health-risks/overview.html and also see *Residual Risks, The Unseen Costs of Using Dirty Oil in New York City Boilers*, a 2010 report by the New York Law School Institute for Policy Integrity, online resource at: http://www.policyintegrity.org/documents/ResidualRisks.pdf
[5] Residual fuel is also referred to as bunker fuel when it is burned in ships.
[6] According to the NYC Dept. of Environmental Protection database, about 6,813 buildings currently have active permits to burn either No. 4 or No. 6 oil, about an additional 2,000 buildings have No. 4 and 6 boiler permits "under review". Under review means that these are either buildings that previously burned No. 4 or 6 oil and are now applying for a renewal of the boiler permit. Under review can also stand for buildings that are brand new and are applying to burn No. 4 or 6 oil or buildings that are currently burning No. 2 heating oil but wish to switch to No. 4 or 6 oil. For the full database of buildings burning No. 4 or 6 oil including their addresses go to www.edf.org/dirtybuildings.
[7] Typically, only large buildings burn dirty heating oil (No. 4 or 6 oil) because of the increased maintenance involved. A "large" residential building would typically have at least 40 units.
[8] Researchers at the Columbia Center for Children's Environmental Health (CCCEH) have released a new paper that finds that exposure shortly after birth to ambient metals (i.e. nickel) from residual fuel oil combustion and particles (soot pollution) from diesel emissions are associated with respiratory symptoms in young children living in urban areas. December 2009 issue of the *American Journal of Respiratory and Critical Care Medicine*. http://www.ccceh.org/pdf-papers/Patel2009.pdf.
[9] There are approx. 900,000 buildings in New York City, including single family homes. 9,000 buildings is 1 percent of this but these 9,000 buildings are large buildings so 27% of the heating oil burned in NYC is dirty heating oil (No. 4 or 6 oil) that contributes 86% of the heating oil soot pollution because No. 6 oil is about 15 times more polluting in terms of soot pollution than No. 2 oil. 269 million gallons of No. 6 oil and 742 million gallons of No. 2 heating oil are burned in NYC. Each gallon of No. 6 burned creates 15 times more soot (PM) pollution than No. 2 heating oil according to the EPA emission standards. Total residual fuel numbers include No. 4 oil by allocating 50% to No. 2 oil and 50% to No. 6 oil. Specifically, of the 84 million gallons of No. 4 oil burned, we allocated 42 million gallons to No. 6 oil and 42 million gallons to No. 2 heating oil. The emissions factors shown in this report show that No. 2 oil produces 0.18 g/gal PM and No. 6 oil produces 2.71g/gal PM.

So: #6 PM = 227 mmgal x 15.29 = 3470.83 pollution units
4 PM = 84 mmgal x 10.6 = 890.4 pollution units
#2 PM = 700 mmgal x 1 = 700 pollution units
TOTAL PM 5061.23 pollution units
#6 and #4 oil PM pollution = 4361.23 ÷ 5061.23 = 86% of total PM from burning heating oil.

[10] This report will refer to total PM which includes PM_{10}, $PM_{2.5}$, ultrafine PM, and nano-sized PM.
[11] According to EPA's emission model MOBILE6.2, there are 1.13 million gasoline-powered vehicles in New York City and more than 108,000 diesel-powered vehicles.

[12] In New York City, residential, commercial and institutional heating systems release more than 30,000 tons of nitrogen oxides (NO_x), more than 17,000 tons of sulfur dioxide (SO_2) and more than 1,100 tons of soot or particulate matter every year. Over 750 tons/year of particulate matter come from buildings burning No. 4 or 6 oil. Data are from the EPA 2005 National Emissions Inventory. (NOx is a precursor to ozone.)

[13] The $242 million in asthma hospitalization costs in New York City are split up among the following payers: 49% by Medicaid, 23% by Medicare, 9% self-pay and 19% by others. See Asthma Facts, 2nd Ed. NYC Dept. of Health, 2003, p. 13. Online resource is available at http://www.nyc.gov/html/doh/downloads/pdf/asthma/facts.pdf .

[14] Jacobson, Mark Z., "Testimony for Hearing on Black Carbon and Global Warming," U.S. House of Representatives, Committee on Oversight and Government Reform, October 18, 2007;
Bond, Tami C. and Haolin Sun, "Can Reducing Black Carbon Emissions Counteract Global Warming?" *Environ. Sci. Technol*. (2005), 39, 5921-5926.

[15] In 1985, the State Dept. of Environmental Conservation incorporated New York City's and other local standards in its regulation and adapted a default regulation of a 20,000 ppm cap for heating oil which has not changed since then. In comparison, New York City's regulation has capped sulfur levels at 3,000ppm for No. 6 oil and 2,000ppm for No. 2 heating oil.

[16] DEC Regulations Subpart 225-1. It is worth mentioning that the Mid-Atlantic/Northeast Visibility Union (MANE-VU) has formed a regional coalition of state governments from Maine to Maryland and the oil industry to improve air quality and visibility in the region. MANE-VU's plan is to lower the sulfur content of heating oil to 500 ppm by 2012 and 15 ppm by 2016 for No. 2 oil, and 2500-5000 ppm for No. 4 and No. 6 oil by 2012. Thus, this regional strategy does not improve upon the existing limits in New York City (3000 ppm) for No. 4 and 6 oil. Another major effort of MANE-VU is to improve heating system efficiency. Go to www.nescaum.org for more information.

[17] See http://www.epa.gov/ttn/chief/ap42/index.html for EPA emission's factors AP-42 for No. 2, 4 and 6 oil as well as natural gas. See also the table on page 35 of the report: AP-42 shows that PM emissions from burning No. 6 oil are 22.59 g/mmBtu, while they are only 1.32 g/mmBtu from burning #2 oil, which is a 94% reduction.

The PM numbers in this report only include the "filterable" portion of PM, not the "condensable" portion. Condensable PM is virtually all VOCs (which can condense to a liquid droplet in the atmosphere) not solid carbon. EPA's AP-42 emission factors have two different values for the emissions factor for No. 2 oil, one for "residential" boilers and one for "commercial" boilers. The value for commercial boilers is significantly higher, based on an assumption of using "older" burner technology as well as higher fuel sulfur levels. We chose to use the value for residential boilers for three reasons: 1. Number 2 oil in NYC has low sulfur content by law; 2. while the boilers in question (those currently burning No. 6 oil) are relatively large compared to the boiler in a typical 2 – 10 family "residential" building they are pretty small in comparison to true "commercial" boilers and are therefore more like residential boilers; and, 3. any new conversion to the use of No. 2 oil would use burners with "new" as opposed to old technology. MJ Bradley had a lengthy discussions with NYCDEP about these assumptions, and the NYCDEP agreed with these assumptions and emissions factors.

As to CO2 emission rates, online resource is available at
http://www.eia.doe.gov/oiaf/1605/excel/Fuel%20Emission%20Factors.xls.
The following are CO2 emission rates for the different fuels:

Natural Gas: 117.6 lb/mmBtu

#2 Oil: 159.3 lb/mmBtu
#6 Oil; 166.7 lb/mmBtu

Compared to No. 2 heating oil, natural gas results in a 26% reduction in CO2. Compared to No. 6 oil, natural gas results in a 29% reduction in CO2. Efficiency gains also result in a one-for-one reduction in CO2 (i.e .,10% reduction in fuel use [mmBTU] results in a 10% reduction in CO2 emissions, all else being equal).

[18] A 2006 study found that nickel is particularly toxic and harmful to the cardiovascular system. Nickel emissions occur when No. 4 and 6 oil are burned and as a result, New York City has by far, the highest airborne nickel levels of any city in the country. On average, New York City's nickel concentrations are about 9 times higher compared to other U.S. cities. See Lippmann et al., Environmental Health Perspectives, Vol. 114, Number 11, November 2006. See also *Fresh Air Maybe Hazardous To Yur Health And In NYC, it may be downright deadly, warns Dr. Morton Lippmann*, published in NYU Physician Summer 2008. Online resource at: http://communications.med.nyu.edu/publications/nyu-physician/summer-2008

[19] Source: New York City Department of Environmental Protection. See chart below:

#2 Oil	Floor Area	
	ft²	
Boro	Non-Residential	Residential
Manhattan	76,869,742	183,433,783
Bronx	39,748,838	70,733,394
Brooklyn	66,444,967	201,810,036
Queens	85,309,338	117,397,931
Staten Island	12,672,854	8,228,263
Total	281,045,739	581,603,407

#4 Oil	Floor Area	
	ft²	
Boro	Non-Residential	Residential
Manhattan	37,090,951	65,489,989
Bronx	5,068,627	54,715,863
Brooklyn	14,561,875	15,084,597
Queens	13,999,112	29,055,404
Staten Island	791,123	1,425,279
Total	71,511,688	165,771,132

#6 Oil	Floor Area	
	ft²	
Boro	Non-Residential	Residential
Manhattan	107,877,191	255,934,426
Bronx	9,048,370	111,726,558
Brooklyn	7,272,890	50,718,753
Queens	12,757,833	80,727,649
Staten Island	1,506,762	3,345,791
Total	138,463,046	502,453,177

DEP chart of number of buildings burning No. 2, 4 or 6 oil (DEP does not regulate one- or two-family homes or boilers less than 350,000 Btu/hr, so these buildings are not represented in this chart. One- or two-family homes typically burn No. 2 heating oil or natural gas).

	# of units using #4 oil		# of units using #6 oil		# of units using #2 oil	
	Non-Residential	Residential	Non-Residential	Residential	Non-Residential	Residential

Manhattan	382	1,240	505	2,044	1,665	6,822
Bronx	63	1,148	51	1,227	815	2,645
Brooklyn	105	302	48	425	1,265	7,427
Queens	104	352	49	714	1,385	3,302
Staten Island	7	8	5	16	147	100
Total	661	3,050	658	4,426	5,277	20,296

[20] To access an interactive map of all the buildings burning No. 4 or 6 oil go to: www.edf.org/dirtybuildings. The NYC Department of Buildings has the most up to date database on the buildings' boilers and what fuel they are burning. Go to: http://www.nyc.gov/html/dob/html/home/home.shtml and enter the building address you want to check.

[21] New York City Department of Environmental Protection, Boiler Inventory database. Energy Policy Research Foundation, Inc., "Costs and Supply Risks to Prohibition On the Use of No. 4 and No. 6 Oil in New York City," preliminary report, February 12, 2009, and EPA AP-42 (5th ed.) chapter 1. Some buildings have more than one boiler. The DEP database shows close to 9,000 buildings with active permits burning No. 4 or 6 oil. See www.edf.org/dirtybuildings for a full list.

[22] Information provided by the heating oil industry. EDF could not find any other source specifying the amount of No. 2 heating oil burned in NYC annually.

[23] Numbers include No. 4 oil by allocating 50% to No. 2 oil and 50% to No. 6 oil. Specifically, of the 84 million gallons of No. 4 oil burned, we allocated 42 million gallons to No. 6 oil and 42 million gallons to No. 2 heating oil.

[24] These numbers are based on the New York City Dept. of Environmental Protection (DEP) boiler database. The DEP only regulates boilers that are 350,000 Btu/hr or larger.

[25] There are approximately 900,000 buildings in New York City. (see http://www.nyc.gov/html/dob/html/news/commissioner_faia.shtml) These smaller buildings have smaller boilers that are not regulated by the DEP. See note above.

[26] See calculation in Endnote No. 9.

[27] See NYU Physician Summer 2008: *Fresh Air May Be Hazardous To Your Health,* by Dr. Morton Lippmann. Online resource available at: http://webdoc.nyumc.org/nyumc/files/communications/u2/summer2008_Cover.pdf

[28] For a complete list of all states go to http://tonto.eia.doe.gov/dnav/pet/pet_cons_821rsd_dcu_SVT_a.htm and check for category "commercial" which represents the residual oil used for heating purposes.

[29] The states listed have significantly lower total usage of residual fuel compared to New York State. For detailed numbers see http://tonto.eia.doe.gov/dnav/pet/pet_cons_821rsd_dcu_SVT_a.htm

[30] The requirements that need to be met to qualify as a low income buildings under a DEP rule still need to be worked out but could be similar to the requirements under the federal weatherization assistance program (WAP) managed by the U.S. Dept. of Energy, see http://www.dhcr.state.ny.us/programs/weatherizationassistance/index.htm).

[31] By switching from No. 6 oil to natural gas, annual heating-related PM, NO_x and SO_2 emissions from a 200-unit apartment building could be reduced by 205 pounds, 1,482 pounds and 1,692 pounds, respectively.

[32] Based on the average U.S. Class 6 truck, which travels 12,800 miles per year (USDOE) and emits 0.22 g/mi PM (USEPA, calendar year 2007 fleet average).

[33] Created in 1955, the Mitchell-Lama program provides affordable rental and cooperative housing to moderate- and middle-income families. See http://www.nyc.gov/html/hpd/html/apartment/mitchell-lama.shtml.

[34] Check with your utility company to find out if they pay to bring the gas line or if your building has to pay for the gas line in case the building wants to get the interruptible gas rate (cheapest rate). Sometimes buildings need to pay for the gas line themselves if they opt for the interruptible gas rate which means that it is beneficial to split the costs with neighboring buildings that also want to switch to natural gas. Sometimes the utility company will pay to bring the gas lines to the buildings and still lets them use the interruptible gas rate if enough buildings switch at the same time. It's best to discuss this with the utility company (National Grid for Staten Island, Brooklyn and southern part of Queens. Con Edison for northern part of Queens, Manhattan and the Bronx).

[35] When you enter your building's address you will see information about the building, ECB violations, etc. To the right of the ECB box you will see a series of links. The bottom link is for DEP boiler database. Click on DEP boiler database to see what fuel a building is burning. When EDF tested the database, there was no boiler information for some of the addresses. If this is the case, check the list on our web site at www.edf.org/dirtybuildings, or ask your managing agent.

[36] For Consolidated Edison contact (for buildings in Manhattan, part of Queens), go to www.coned.com/naturalgas or call 1-800-643-1289; National Grid contact (for buildings in Queens, Brooklyn, Staten Island), go to http://www2.nationalgridus.com/myngrid/, or call 1-877-MyNGrid (877-696-4743).

[37] Summary of potential conversion costs:

Conversions incur no incremental costs if the conversion happens at end of the useful life of the boiler/burner (25-35 yrs. for boilers (up to 60 if maintained and overhauled) and 20 years for burners);

- $15,000-30,000 (2 men, 3 days) for basic conversion from No. 6 oil to No. 2 heating oil
    - $5,000-10,000 to remove preheater and electric heater, repipe;
    - $5,000-10,000 to clean tank, steam lines;
    - $5,000-10,000 for burner "setup" to burn with proper air mix (improves efficiency by 15-20%, from 65-70% burn to 85% burn);
    - Burners less than 20 years old can be adjusted to burn all fuels; specs for dual fuel burners are somewhat different; the cost is $4,000;
- $40,000-60,000 for complete burner replacement, including electrical and filings
- Extras
    - $1,000-2,000 for low NOx burner (not available for No. 6 oil);
    - $6,000 for optional closed-loop oxygen system; boosts efficiency 2-10%;
    - $50,000 for economizer (heat exchanger in flue); boosts efficiency 5%, but these are bulky and unwieldy and are vulnerable to sulfur;
- Tank removal costs can be significant but may be inevitable under LUST regulations.

[38] Con Edison quoted an "interruptible" price of $1.13/therm of natural gas. One gallon of No. 6 oil contains about 150,000 Btu of energy, while one therm of natural gas contains 100,000 Btu. Therefore, the calculation is as follows: (150,000÷100,000) X 50,000 = 75,000 therms/year of natural gas needed. Multiply this by $1.13/therm as quoted by Con Edison for a total of about $84,750.

[39] See http://www.cecenter.org/?page_id=27 for more information.

[40] Go to www.edf.org/dirtybuildings.

[41] In a combustion efficiency (CE) test the heating system contactor measures how much fuel gets turned into usable heat, which shows whether the boiler and burner are running as efficiently as possible. The following gets performed in a CE test:

- stack temperature test
- measure percentage of CO_2 in exhaust
- draft test
- smoke test
- measure percentage of CO if natural gas is burned.

Information provided by Fred Goldner of EMRA; see www.emra.com.

[42] For more details about efficiency measures to reduce a building's electricity consumption, please refer to chapter 6 online.

[43] The potential fuel savings shown in the chart apply only if each measure is the only one undertaken. For example, if an EMS has been installed, TRVs will help with individual comfort issues, but building-wide savings will be smaller than shown here.

[44] *The influence of location, source, and emission type in estimates of human health benefits of reducing a ton of air pollution* by Neal Fann, Charles M. Fulcher and Bryan J. Hubbell, June 9, 2009. U.S. EPA, Office of Air Quality Planning and Standards. See http://www.springerlink.com/content/1381522137744641

[45] See EPA wegpage: http://www.epa.gov/pmdesignations/2006standards/final/region2.htm

[46] See NYSERDA webpage: www.getenergysmart.com.

[47] One inquiry with Con Edison for a building on the Upper West Side has shown that it would cost Con Edison about $250,000 to bring a natural gas line to one building. Con Edison pays for the gas line if the building only burns natural gas and pays the firm gas rate. However, the building owner has the option of paying for the line and instead choosing the cheaper interruptible gas rate. Lastly, the building owner can try to convince nearby buildings to switch to dual fuel natural gas/No. 2 heating oil, in which case Con Edison pays for the line and lets all the buildings in that area go on dual fuel with the cheaper interruptible gas rate.