

## Chapter 1 *Why worry about boiler emissions?*

The burning of fossil fuels is the most significant source of man-made air pollution. While most people realize that automobiles and electricity production contribute to poor air quality in our cities, they may not recognize how much of the pollution in the air we breathe comes from the boilers used to heat our homes, apartments and office buildings. Residential, commercial and institutional heating systems release 50% more fine

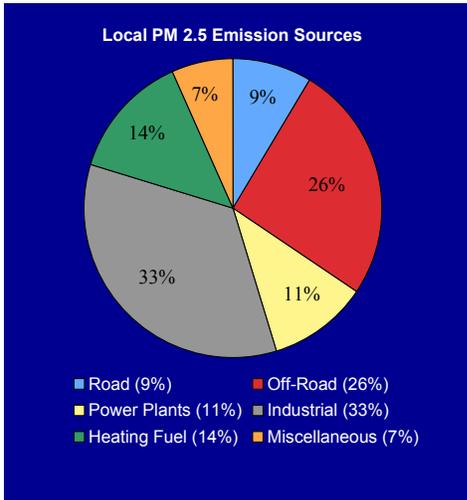


Figure 1: Data based on 2005 EPA National Emissions Inventory and Synapse Energy Economics, Inc. Report "Quantifying and Controlling Fine Particulate Matter in NYC", August 28, 2007.

particulate matter (PM<sub>2.5</sub>) and 17 times more SO<sub>2</sub> than cars and trucks<sup>1</sup> on New York City's roads.<sup>2</sup> See Figure 1. The 9,000 sludge-burning buildings in the city – which represent 1 percent of the city's buildings – contribute 87 percent<sup>3</sup> of the city's heating oil soot pollution.

According to the U.S. Environmental Protection Agency (EPA), in 2002 residential, commercial and institutional heating systems in New York City alone released more than 30,000 tons of nitrogen oxides (NO<sub>x</sub>), over 17,000 tons of sulfur dioxide (SO<sub>2</sub>) and over 1,100 tons of soot or fine particulate matter (PM<sub>2.5</sub>) into the atmosphere. every year.<sup>4</sup> Compared to on-road motor vehicles, residential and commercial boilers emit fifty percent more PM<sub>2.5</sub> and seventeen times more SO<sub>2</sub> every year.

These emissions contribute to poor air quality in New York City and other large metropolitan areas.

### ***National Ambient Air Quality Standards***

National Ambient Air Quality Standards (NAAQS) are set by EPA and are used to define acceptable threshold levels of certain "criteria" pollutants in the air we breathe. If there is too much of one or more pollutant, the air is considered unhealthy because the pollutants can contribute to respiratory and other health problems. Many areas of the United States have air quality that does not meet the NAAQS and have received "nonattainment" designations for specific pollutants. One of several ozone and PM nonattainment areas in the United States is the New York-Northern New Jersey-Long Island-Connecticut Nonattainment Area (NY-NJ-LI-CT NAA), which includes New York City.



Black smoke coming out of chimney in NYC, Upper East Side..

The pollutants created by residential and commercial heating systems that contribute to New York City's violation of air quality standards include NO<sub>x</sub>, volatile organic compounds (VOCs) and particulate matter less than 2.5 microns in size (PM<sub>2.5</sub>). Emissions of SO<sub>2</sub> are also important because they contribute to the formation of acid rain, which damages forests and water quality throughout the Northeast.

## **Health effects of poor air quality**

### **Ozone**

Nitrogen oxides (NO<sub>x</sub>) are formed by the combination of nitrogen and oxygen during high temperature combustion processes such as the operation of a residential or commercial boiler.<sup>5</sup>

In the atmosphere, NO<sub>x</sub> combine with VOCs to form ground-level ozone (smog) in the presence of sunlight. Ozone is an irritant that can cause breathing problems for people with respiratory diseases.

NO<sub>x</sub> also form solid nitrate particles (secondary particulate matter) as they undergo various chemical reactions in the atmosphere.

### **Particulate matter (soot)**

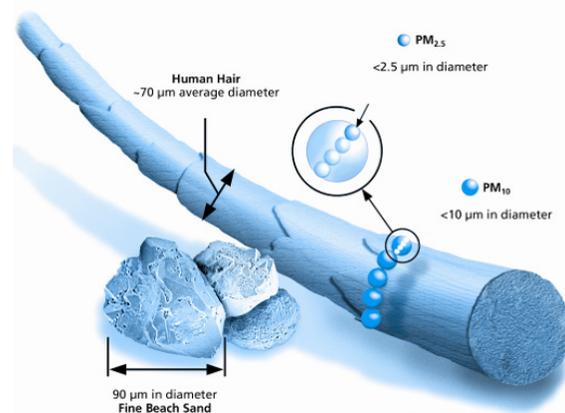
Particulate matter (PM) or soot formed by combustion of fossil fuels is a complex mixture of elemental carbon (EC), unburned or partly combusted fuel such as organic carbon (OC), sulfate from fuel sulfur and lubricant products (i.e., ash and additives). PM emissions are of substantial concern because they contribute to poor visibility and negatively impact human health.

The particulate matter of greatest concern is fine and ultrafine particles with diameters of 2.5 microns or less. This portion of PM is referred to as PM<sub>2.5</sub>. In comparison, a human hair has a diameter of approximately 70 microns—25 times greater than the diameter of a PM<sub>2.5</sub> particle.

When inhaled, these particles are small enough to get past the body's defenses and embed deep within the lungs. The smallest of these particles can also enter the bloodstream directly through the lungs. Human exposure to PM<sub>2.5</sub> can be short term (a few hours to several days), long term (from one to many years), or both.

Short-term exposure is most harmful for people with existing heart and respiratory problems, including asthma. Short-term exposure to elevated PM levels can aggravate existing lung disease, trigger asthma attacks, coughing and acute bronchitis, increase the

### **Diesel particulate matter—size compared to human hair and beach sand**



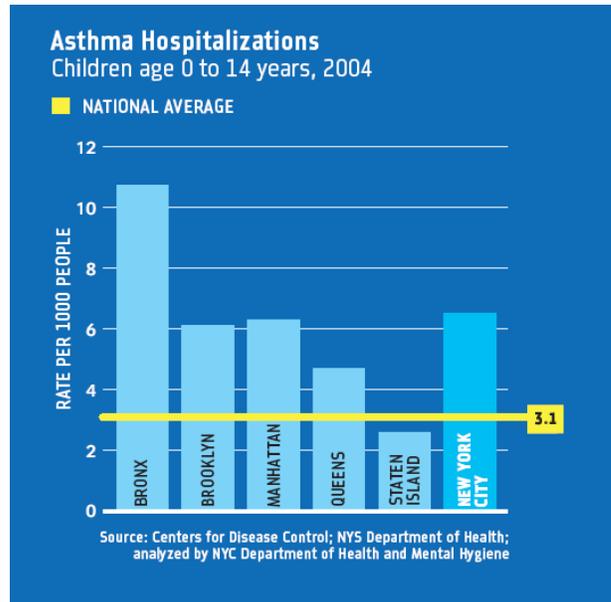
Source: US EPA Office of Research & Development

severity of asthma attacks and may increase susceptibility to respiratory infections. Short-term PM exposure has also been linked to heart attacks and arrhythmias in people with existing heart disease.

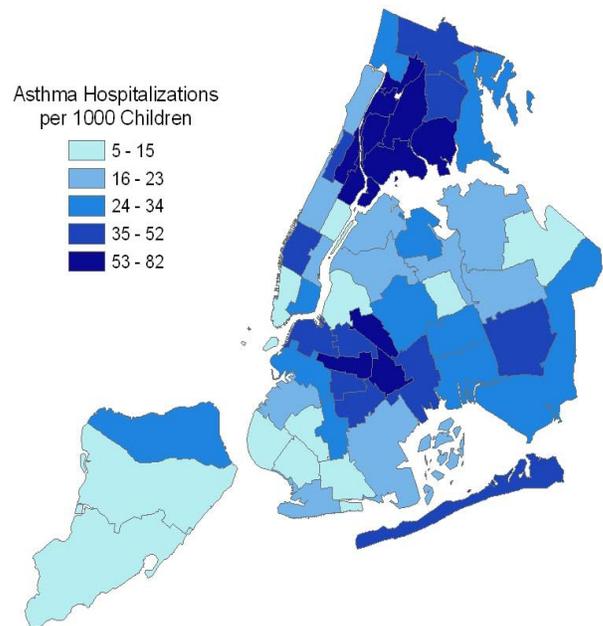
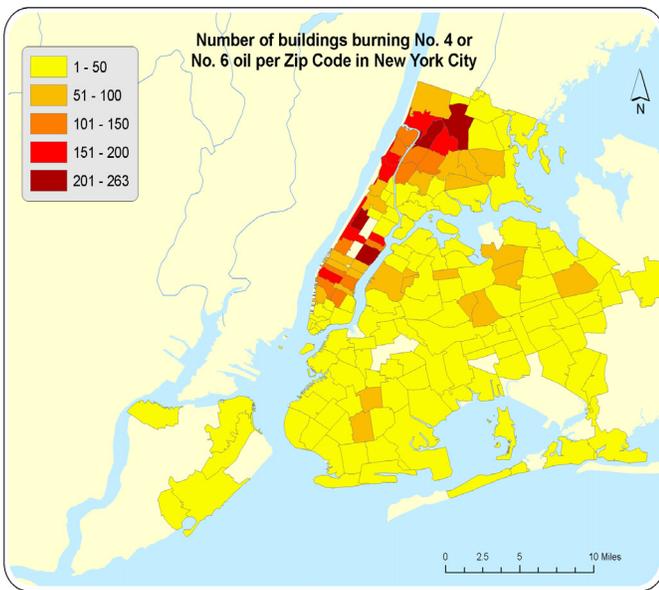
Long-term exposure to PM has been associated with reduced lung function, the development of chronic bronchitis, cardiovascular diseases<sup>6</sup> and even premature death. Many studies show that when particle levels are high, older adults are more likely to be hospitalized and die, often of aggravated heart or lung disease.

New York City has twice the national asthma hospitalization rate among children age 0-14 years. Over 300,000 New York City children have been diagnosed with asthma. This comes at a high cost as asthma hospitalizations cost over \$240 million a year. The maps below show how some of the neighborhoods with the highest asthma hospitalization rates also have many buildings burning the dirtiest heating oil (No. 4 or 6 oil) which exacerbates air quality in these neighborhoods.

Figure 2: NYC asthma hospitalization rates compared to national average



Figures 3 & 4: Concentration of buildings burning No. 4 and 6 oil by ZIP codes and asthma hospitalizations per 1000 children by neighborhoods

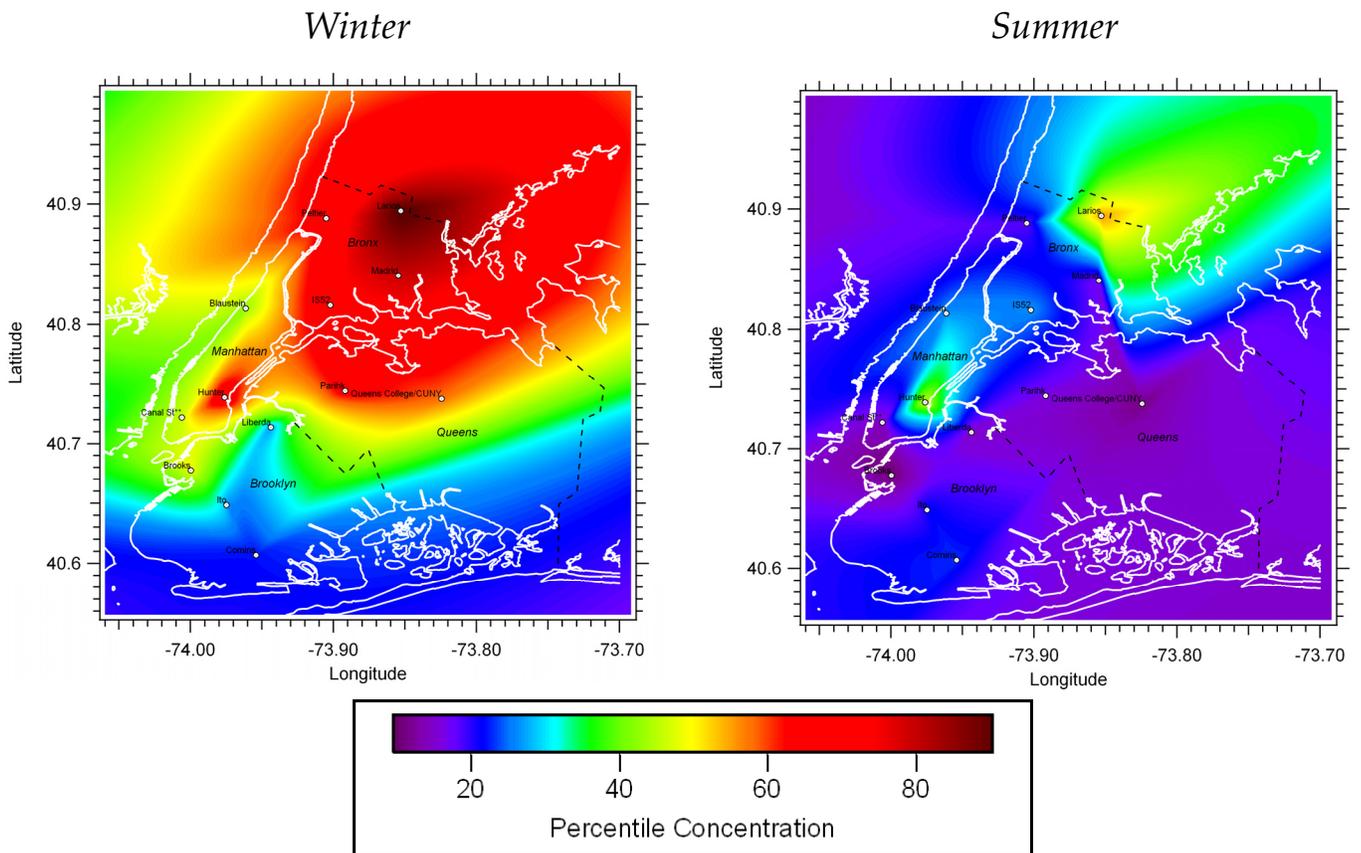


*Nickel Concentration in Air Correlate with Heating Season*

New York City’s commercial, institutional and residential heating systems that burn dirty heating oils (No. 4 or 6 oil) also spew out heavy metals such as nickel into the air. 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.<sup>7</sup> The two charts show how nickel levels in the air correlate with the heating season.<sup>8</sup>

A new study shows that nickel laden soot pollution is associated with respiratory symptoms in young children.<sup>9</sup> According to the EPA, respiratory effects have been reported in humans from inhalation exposure to nickel. Human and animal studies have reported an increased risk of lung and nasal cancers from exposure to nickel refinery dusts and nickel subsulfide. Animal studies of soluble nickel compounds (i.e., nickel carbonyl) have reported lung tumors. EPA has classified nickel refinery dust and nickel subsulfide as Group A, human carcinogens, and nickel carbonyl as a Group B2, probable human carcinogen.<sup>10</sup>

The charts below show the air nickel concentration (in red) in the winter and summer.



## References

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<sup>1</sup> According to EPA's emission model MOBILE6.2 there are 1.13 million gasoline powered vehicles in NYC and more than 108,000 diesel powered vehicles.

<sup>2</sup> Data from EPA 2005 National Emissions Inventory.

<sup>3</sup> 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 87% of the heating oil soot pollution because No. 6 oil is 18.8 times more polluting 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 18.8 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 3.39 g/gal PM. No. 6 oil produces 18.8 times as much PM per gallon than No. 2 oil.

So: #6 PM = 268 mmgal × 18.8 = 5057.2 pollution units

#2 PM = 742 mmgal × 1 = 742.0 pollution units

TOTAL PM 5799.2

#6 = 5057.2 ÷ 5799.2 = 87% of total PM from burning fuel oil.

<sup>4</sup> Data from EPA 2005 National Emissions Inventory.

<sup>5</sup> Most of the nitrogen and oxygen comes from the air, but both fuel-bound nitrogen and oxygen from oxygenated fuels can contribute to NOx formation.

<sup>6</sup> American Heart Association, American Heart Association Scientific Statement, "Air Pollution is Serious Cardiovascular Risk," June 1, 2004.

<sup>7</sup> 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 Your 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>

<sup>8</sup> Source: Morton Lippmann, PhD and Richard E. Peltier, PhD, Seasonal and Spatial Distributions of Nickel in New York City Ambient Air, ISES-ISEE 2008 Joint Annual Conference, Pasadena, CA (adopted from paper in press in *J. Expos. Sci & Environ. Epidemiol.*)

<sup>9</sup> 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>.

<sup>10</sup> See EPA webpage at: <http://www.atsdr.cdc.gov/toxprofiles/phs15.html#bookmark05>