Low Sulfur Heating Oil in the Northeast States: An Overview of Benefits, Costs and Implementation Issues

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The Northeast states are considering adopting a regionally consistent low sulfur standard for heating oil to reduce air pollution from this source. This White Paper evaluates the benefits, costs and implementation issues associated with reducing sulfur in #2 distillate heating oil from its current average of 2,000 to 3,000 parts per million (ppm) to 500 ppm. The states' long-term goal is to bring the sulfur content of heating oil into line with the future highway and nonroad ultra-low sulfur diesel fuel requirement of 15 ppm.

Heating oil burners emit particulate matter (PM), oxides of nitrogen (NO_x), sulfur dioxide (SO_2), mercury (Hg), carbon dioxide (CO_2) and other pollutants. Collectively, these pollutants have direct health impacts, contribute to the formation of ozone and fine particulate matter, cause regional haze, contribute to acid deposition and nitrification of water bodies, add to the global mercury pool and contribute to the build up of greenhouse gasses in the atmosphere. The combustion of heating oil is a significant source of SO_2 emissions in the region – second only to electric power plants. The burning of heating oil also produces approximately 10 percent of total CO_2 emissions in the Northeast.

As shown in Table ES-1, reducing the sulfur content of heating oil from 2,500 ppm to 500 ppm lowers SO_2 emissions by 75 percent, PM emissions by 80 percent, NO_x emissions by 10 percent, and CO_2 emissions by 1 to 2 percent. Other benefits associated with lowering the sulfur content of heating oil include heating system efficiency improvements, the opportunity to develop and market advanced high efficiency boiler and furnace technologies, and harmonizing with European and Canadian fuel standards.

Table ES-1: Emission Benefits of Low Sulfur Heating Oil and Biodiesel Blends (% reduction compared to 2,500 ppm sulfur fuel)

Pollutant	Reduction with 500 ppm Sulfur Heating Oil	Reduction with 500 ppm Sulfur Heating Oil/Biodiesel Blend (80/20)
SO2	75 %	84 %
PM	80 %	>80 %[1]
NOx	10 %	20 %
Hg	n/a	20 %[2]
CO2	1 % - 2%	17-18 %

[1] Additional PM reductions are expected with biodiesel blends, but no known test data exists to substantiate this assumption.
[2] Value based on the assumption that biodiesel contains no mercury. No known test data exist to substantiate this assumption

These benefits can be achieved at an overall savings to heating oil marketers and consumers. The incremental cost of low sulfur (500 ppm) heating oil compared to the higher sulfur product varies over time, but historically has averaged about 1.5 cents per gallon. Lower sulfur heating oil is cleaner burning and emits less particulate matter which reduces the rate of fouling of heating equipment and can permit longer time intervals between vacuum cleanings, if existing service practices are converted from annual to “as needed” cleaning. The potential savings for oil heated homes due to reduced maintenance costs is on the order of hundreds of million of dollars a year on a national basis. The cleaning cost savings generated by using lower sulfur fuel oil is two to three times higher than the added fuel cost based on historic price differences between heating oil and highway diesel.

Biofuels, including soy-based biodiesel, contain negligible amounts of sulfur and nitrogen and can be blended with low sulfur heating oil to further reduce air emissions, improve the environmental attractiveness of home heating oil and extend supplies with renewable domestic feedstocks. Low sulfur (500 ppm) heating oil blended with a 20 percent soy-based biodiesel can reduce SO_2 emissions by 84 percent, PM emissions by greater than 80 percent, NO_x emissions by 20 percent, mercury emissions by 20 percent and carbon dioxide emissions by approximately 16 percent compared to 2,500 ppm sulfur heating oil.

The region’s heating oil comes from Gulf Coast refiners, Northeast refiners, and foreign sources. Imports provide about a 20 percent of demand on an annual average basis, but can rise significantly during periods of peak usage. The continued availability of adequate home heating oil through domestic sources and imports is an important consideration as states assess implementation issues associated with a low sulfur oil heating oil initiative. This White Paper discusses a variety of steps that should be taken to ensure that a low sulfur heating oil program in the Northeast would not adversely affect supply and cost during periods of peak demand. Potential solutions include: (1) increasing stocks of lower sulfur fuel oil; (2) increasing imports from countries with lower sulfur standards; (3) permitting seasonal averaging of sulfur levels; (4) blending of lower sulfur diesel with higher sulfur imports; and (5) introducing greater amounts of domestic biofuels into the market.

The analysis summarized in this White Paper supports the Northeast states’ conclusion that significant reductions in SO_2, NO_x, and PM emissions can be achieved by mandating lower sulfur heating oil. Importantly, these reductions can achieved with an expected cost savings to the consumer. Adding the public health and environmental benefits associated with lower sulfur fuel increases the favorable cost-benefit ratio of a regional 500 pm sulfur heating fuel program.

1. INTRODUCTION AND BACKGROUND

1.1. Introduction

The combustion of heating oil containing sulfur levels on the order of 2,500 parts per million (ppm) contributes to ambient concentrations of fine particles found in the Northeast. These particles have adverse health and environmental impacts. The Northeastern U.S. is one of the world's largest markets for heating oil. In the eight state NESCAUM region (CT, ME, MA, NH, HJ, NY, RI and VT), approximately 4 billion gallons of heating oil are burned annually in residential furnaces and approximately 1 billion gallons are burned in commercial furnaces. Heating oil represents 54 percent of total demand for #2 distillate oil in the Northeast, compared to 38 percent for highway diesel.

Due to the high level of sulfur currently found in heating oil, its combustion is a significant source of sulfur dioxide (SO_2) emissions in the region – second only to electric power plants. Regionally, the burning of high sulfur heating oil generates approximately 100,000 tons of SO_2 annually – an amount equivalent to the emissions from two average sized coal-burning power plants. Oil heating is also a source of particulate matter (PM), oxides of nitrogen (NO_x) and carbon monoxide (CO). While data are limited and uncertain, residential heating with fuel oil is estimated to produce almost 25 percent of mercury emissions in the six New England states. The burning of heating oil also produces approximately 10 percent of total CO_2 emissions in the region and is estimated to represent as much as 17 percent of Connecticut's CO_2 inventory.

To address this concern, the Northeast states are considering adopting regionally consistent standards to cap the sulfur content of heating oil at 500 parts per million, by no later than 2010. The states' long-term goal is to limit the sulfur content of heating oil to levels consistent with future ultra-low sulfur diesel standards for highway and nonroad fuels (15 ppm). However, more research and development is needed to prevent the undesired impacts on home heating equipment that have been experienced in Europe with ultra-low sulfur fuel including damage to oil burner air tubes in blue flame oil burners.

This analysis is intended to help states better understand the benefits and costs associated with the proposed regional low sulfur heating oil initiative. While this analysis is preliminary in nature, it provides state regulators with additional information as they consider appropriate next steps.

This White Paper includes six sections. Section 1 provides background information on the oil heat market, the environmental and public health impacts associated with emissions from this source, and a summary of the proposed Northeast low sulfur heating oil initiative. Section 2 summarizes the emission reduction potential of lowering the sulfur content of heating oil and evaluates the potential benefits of adding biodiesel to heating oil. Section 3 summarizes the findings of the cost-benefit analysis undertaken for low sulfur heating oil. Section 4 discusses other benefits of this proposed initiative. Section 5 provides a brief overview of supply and distribution issues for the Northeast heating oil market. Section 6 presents conclusions.

1.2. Background

Lowering the sulfur content in heating oil will significantly reduce the threats to public health and sensitive ecosystems posed by SO_2 emissions in the Northeast. Emissions of NO_x, which contribute to a number of public health and environmental problems in the Northeast, will also decrease with lower sulfur heating oil. The use of cleaner fuel has the potential to improve furnace efficiency by reducing fouling rates of boiler and furnace heat exchangers and other components. Further, the availability of low sulfur heating oil will enable the introduction of highly efficient condensing furnace technology. Both outcomes will lower emissions of CO_2 and other pollutants from this source sector by reducing fuel use.

The region's heating oil comes from Gulf Coast refiners, Northeast refiners, and foreign sources. Imports provide about a 20 percent of demand on an annual average basis, but can rise significantly during periods of peak usage. The ability to bring in offshore product is important to heating oil availability and price stability. European supplies range from 13 percent on an annual average to 23 percent during January and February, with Russia supplying as much as 18 percent of the region's total demand during peak periods, based on recent reports.

Oil heat industry representatives have expressed concern that offshore suppliers will not have sufficient low sulfur product available for the North American market in the near to mid-term which will undermine the delicate supply balance that now exists. Industry representatives suggest that it will take a broader international shift toward low sulfur heating oil to drive offshore refiners to invest in de-sulfurization technology for this portion of the product stream. Europe, a major market for heating oil, will require low sulfur (1000 ppm) product beginning in 2008 and Canada is committed to a similar requirement. To minimize supply concerns, the Northeast states are considering an annual averaging compliance program that would allow higher sulfur product into the market during peak demand periods, if necessary. Further, as discussed in this paper, the blending of biodiesel into heating oil provides an additional stream of clean and renewable domestic feedstock to increase the supply of fuel for space heating. However, biofuels supplies are currently rather limited.

1.3. Public Health and Environmental Impacts

The Northeast states are faced with developing state implementation plans (SIPs) to demonstrate compliance with the new 8-hour ozone and fine particulate matter national ambient air quality standards. The states must also submit plans that include strategies for protecting visibility in national parks and wilderness areas. After three decades of controlling air pollution, the challenges of achieving sufficient additional emission reductions to attain these new standards are substantial.

Heating oil burners emit significant levels of SO_X, NO_x, PM, and mercury. These burners also emit CO_2, a greenhouse gas that contributes to global warming. Collectively, these pollutants have direct health impacts, contribute to the formation of ozone and fine particulate matter, cause regional haze, contribute to acid deposition and nitrification of water bodies, add to the global mercury pool and contribute to the buildup of greenhouse gases in the atmosphere.

1.3.1. Particulate Matter

Both solid particles and condensable liquid droplets are generated from most combustion sources including heating oil burners. Most of the particulate matter emitted by combustion sources is classified as fine PM with diameters less than 2.5 microns ($PM_{2.5}$). Primary particulates include unburned carbonaceous materials (soot) that are directly emitted into the air. Secondary particulates, such as sulfates, are formed after sulfur dioxide is emitted into the air from combustion sources burning sulfur-containing fuels. Particulate matter less than 10 microns in size (PM_{10}) is linked to a number of adverse health outcomes including asthma, bronchitis, cardiac arrhythmia, and heart attacks (reference 9). Sulfates are also the primary cause of regional haze and acid deposition in the Northeast.

Direct PM emissions from residential and small commercial oil burners in the form of soot have decreased by approximately 95 percent over the past three decades (as will be discussed later in this section). Sulfates that condense in the outdoor air after being emitted by oil heating equipment are now the predominate form of PM associated with emissions from heating oil burners. Reducing the sulfur content of the fuel can lower sulfate emissions.

1.3.2. Oxides of Nitrogen

NO_x is emitted during all types of fuel combustion. Nitrogen dioxide (NO_2) and the secondary oxidants that are formed in the atmosphere contribute to numerous adverse health outcomes. NO_2 causes respiratory distress, respiratory infection, and irreversible lung damage. These are exacerbated by the secondary oxidants that are produced including ozone and fine particulate matter. In addition these oxidants contribute to the formation of acid rain and regional haze.

Efficiency advances in residential oil heat equipment have included the introduction of flame retention oil burners that produce higher flame temperatures and enhanced heat transfer rates. These improvements have helped decrease PM emissions, however, the resultant elevated flame temperatures contribute to increased rates of nitric oxide production by oil burners (thermal NO_x). On the positive side, the higher emission rates are offset by the improved efficiency and reduced fuel use. New oil burners are currently under development in the U.S. that lower nitrogen oxide emissions substantially. The use of lower sulfur home heating oil also lowers the emissions of nitrogen oxide by reducing the nitrogen content of the fuel that contributes to total NO_x emissions.

1.3.3. Sulfur Dioxide

SO_2 is a criteria air pollutant produced in significant quantities by residential and commercial oil heat burners. Elevated levels of SO_2 in the atmosphere can cause wheezing, breathing difficulty, and shortness of breath. Through its important role in fine particulate matter formation, SO_2 also contributes to cardiovascular disease, respiratory illness, and impaired lung function especially in individuals with pulmonary diseases including asthma. Sulfur dioxide also contributes to acid rain and related crop and vegetation damage. Sulfates are the primary cause of regional haze in the Eastern U.S.

Burning home heating oil with lower sulfur content directly reduces SO_2 emissions and its negative impact on health and the environment.

1.3.4. Mercury

Mercury is a potent neurotoxin, particularly damaging to the fetus and young child. Greater than 84,000 newborns in the Northeast are at risk for irreversible neurological deficits from exposure to mercury. Emerging data also suggest a link between mercury exposure and increased risk of adverse cardiovascular effects. The Northeast is implementing a Mercury Action Plan that has reduced total in-region emissions by greater than 55 percent over the past five years. Much of this reduction has come from emission controls put on municipal waste combustors and medical waste incinerators. With emissions from these major stationary sources better controlled, the combustion of fuel oil in residential and commercial burners is now considered a major source of mercury emissions in the region.

1.4. Proposed Northeast Low Sulfur Heating Oil Initiative

The Northeast states are considering adopting consistent low sulfur heating oil requirements as part of the larger plan to address the region's air pollution problems. The decision to pursue a consistent regional strategy is premised on the Northeast's common airshed and the regional nature of the heating oil supply network. In order to achieve reductions in SO_2 emissions from home oil burners, a regional low sulfur initiative is proposed for the states in the Northeast where oil is a predominant energy source. This initiative is summarized in a *DRAFT Memorandum of Understanding for Regional Fuel Sulfur Content Standards for Distillate Number 2 Heating Oil* dated February 4, 2005 (reference 7). The memorandum proposes a reduction in the sulfur content of distillate fuel oil used for space heating from the typical range of 2000 to 3000 part per million (ppm) down to 500 ppm, as now required for highway diesel fuel. The sulfur content of highway diesel will be lowered to 15 ppm beginning in 2006.

Homeowners and fuel oil service companies will benefit from reduced fouling of boiler and furnace heat transfer surfaces that permits extended intervals between vacuum cleanings. This has the potential to substantially lower annual service costs for oil heating equipment. Nationwide, this translates to potential cleaning cost savings on the order of $200 million to $300 million a year; with much of this benefit accruing in the Northeast. As discussed in more detail in Section 3, the added cost for the cleaner fuel is expected to be more than offset by the savings resulting from reduced maintenance and improved burner efficiency. The oil heat industry also benefits when the environmental impact of heating oil is reduced since it makes this product more competitive with natural gas as clean energy source for space heating.

As shown in Table 1-1 (reference 7), current sulfur requirements for home heating oil vary widely from state to state in the Northeast. The proposed limit on the sulfur content of distillate oil used for commercial and residential heating would establish a uniform standard across all states in the region at 500 parts per million.

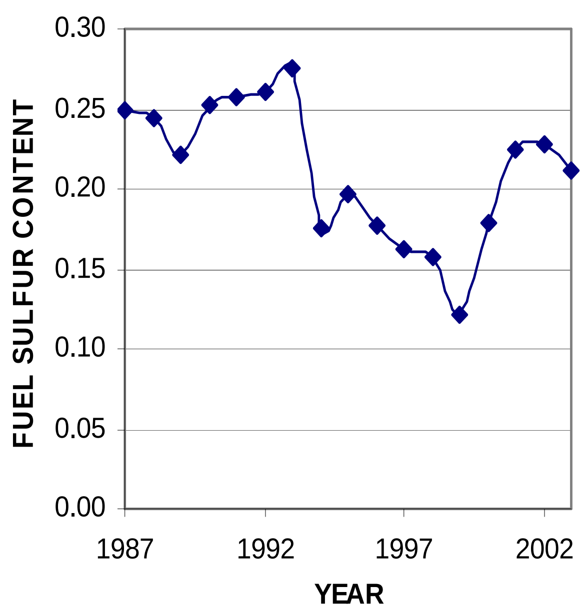
Table 1-1: State Sulfur Limits for Heating Oil

State	Sulfur Limit In percent	Sulfur Limit In parts per million
Connecticut	0.3	3000
Maine	0.3 to 0.5	3000 to 5000
Massachusetts	0.3	3000
New Hampshire	0.4	4000
New Jersey	0.2 to 0.3	2000 to 3000
New York Upstate	1.0 to 1.5	10,000 to 15,000
New York Downstate	0.2 to 0.37	2000 to 3700
Rhode Island	0.5	5000
Vermont	2.0	20,000

1.5. Current Fuel Sulfur Content of Heating Oil

According to sampling conducted over the past two decades, the average sulfur content of heating oil varies from year to year (see Figure 1-1). These data are reported in *Heating Oils, 2003* published by Northrop Grumman Mission Systems (reference 8). Historically, the sulfur content of home heating oil was in the range of 0.25 percent or 2500 ppm. After lower sulfur diesel (500 ppm) was introduced for highway use, the average sulfur content of home heating oil decreased.

Figure 1-1: #2 Fuel Oil Sulfur Content Percentage (REF: NGMS – 231)



From 1987 to 1993, the average sulfur content of heating oil remained at approximately 0.25 percent. Between 1993 and 1999, the percentage of sulfur decreased steadily within the 1200 to 2000 ppm range. For the period 1999 to 2002, the average sulfur content has increased, returning to historic levels. From 2002 to 2003 the average sulfur content was 0.22 percent. These results are based on relatively small sample sizes, however, and the actual average sulfur content of oil used in homes in the Northeast has not been accurately determined.

1.6. Fuel Sulfur Requirements in Other Countries

Lower sulfur heating oil is gaining acceptance around the world including in Canada and Europe. The sulfur content of distillate oil in EU countries will be limited to 0.1 percent or 1000 ppm by January 1, 2008, based on Directive 1999/32/ EC (reference 19). The average sulfur content of light heating oil in Canada from 1995 to 2001 was between 2000 ppm and 2700 ppm, with an average of 2010 ppm in 2001 (reference 19), which is similar to sulfur levels in the U.S. The Minister of Environment in Canada has indicated an intention to reduce sulfur levels in fuel oil to improve public health and the environment with the goal of matching the sulfur requirement set by the European Union (EU) for 2008.

A presentation by the Institute for Wirtschaftliche Oelheizung, dated September 17, 2003, listed the current fuel sulfur standards for Europe in percent: Austria 0.005 to 0.1; Belgium 0.2 or less; France 0.2 or less; Germany 0.005 to 0.2; Great Britain 0.2 or less; Italy 0.2 or less; Sweden 0.1 or less; Switzerland 0.2 or less (reference 20). This presentation also showed a decreasing trend in sulfur content with Switzerland moving toward 50 ppm to 500 ppm sulfur, and Scandinavia, Germany, Austria and Belgium moving toward 50 ppm sulfur fuel limits.

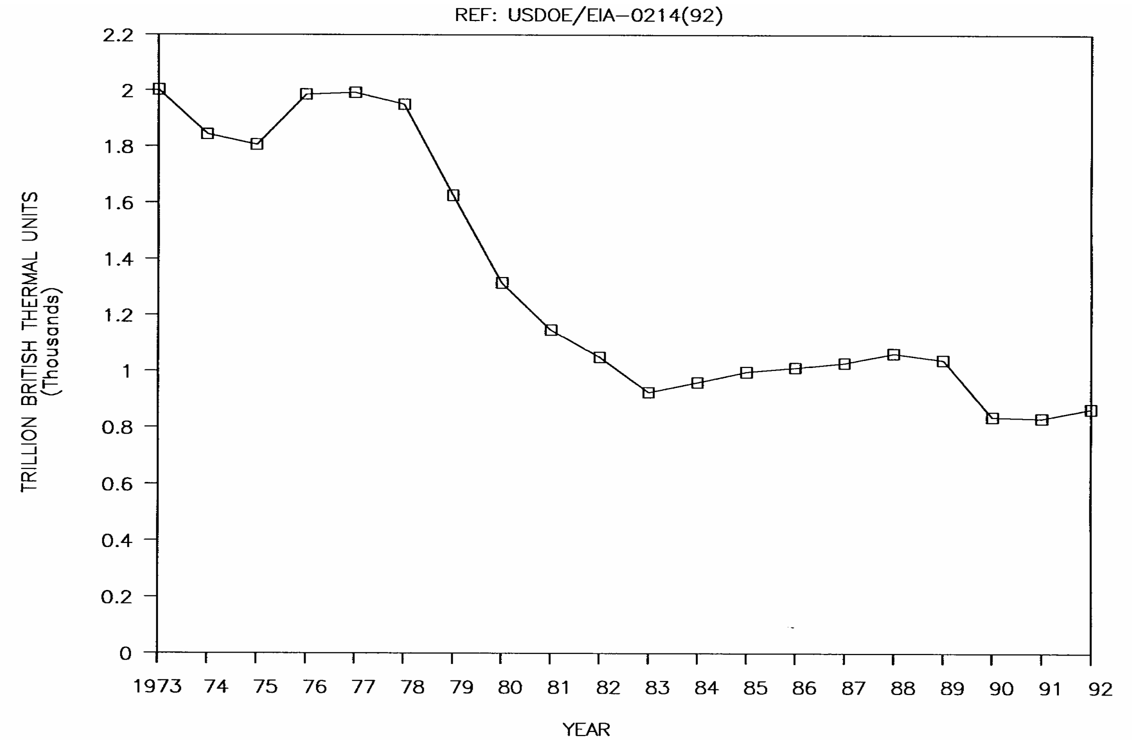
Switzerland has an allowable limit for sulfur content of 0.2 percent, but taxes fuel oil higher than 0.1 percent. Reportedly, most of the fuel sold had sulfur content of 0.1 percent or lower. There are low sulfur fuels with 0.03 to 0.05 percent sulfur on the market in Europe and its use is reported to represent up to 20 percent of the fuel sold in Germany.

1.7. Past Advances in Oil Heat Emissions Performance

Important advances have occurred over the past three decades that have helped to reduce air emissions from residential oil heating equipment through the efforts of oil heat marketers and equipment manufacturers. These include voluntary energy conservation initiatives that have lowered fuel use and technology advances that have substantially lowered the emission rate for particulate matter from oil burners.

Prior to 1973 and the first substantial oil price increases, oil heated homes typically consumed 1400 gallons of fuel annually. Efforts by the oil heat research program at Brookhaven National Laboratory and the oil heat equipment manufacturers resulted in the development of more efficient equipment that contributed to a decrease in oil consumption by the average house to less than 900 gallons a year. The plot that follows, based on data published by the Energy Information Administration (U.S. Department of Energy), shows a 40 percent reduction in fuel use from the mid 1970s to the present time. Between 1977 and 1992 residential annual fuel oil use decreased from 1,994 to 865 trillion BTU. The number of oil heated homes fell by about 25 percent, and energy efficiency improvement is credited with lowering fuel use by approximately 40 percent (references 1,2). The annual residential consumption of distillate fuel oil averaged 861 trillion BTU from 1995 through 1999.

Figure 1-2: U.S. Annual Residential Fuel Oil Use

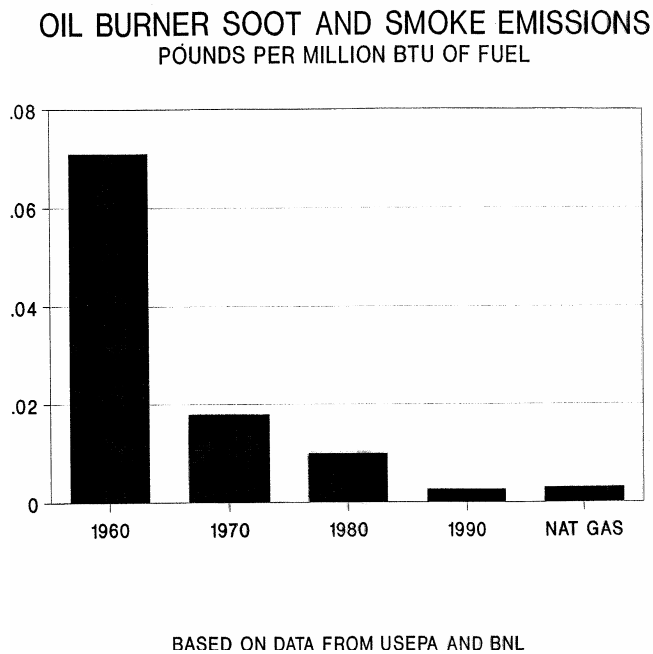


In addition to energy conservation programs, the historical reduction in fuel oil use has been spurred by the development and use of new higher efficiency oil heating equipment. The flame retention oil burner, which increases fuel efficiency by about 15 percent, was developed through industry-sponsored research and development efforts and began to dominate the market in the late 1970s (reference 3). The efficiency of new oil-powered boilers and furnaces also increased substantially from the late-1970s to the present with average annual fuel utilization efficiencies rising from less than 70 percent (estimated) to more than 85 percent.

The increases in oil burner, boiler, and furnace efficiencies directly contributed to the 40 percent reduction in average annual fuel consumption. Annual emissions of air pollutants including PM, SO_x, NO_x, and CO_2 have also decreased by 40 percent as a direct result of the reduction in annual fuel consumption in homes. In fact, calculations indicate that from 1977 to 1992, greenhouse gases from oil heat were lowered by 470 million tons (reference 1).

Particulate matter emissions from oil burners have been lowered by more than 95 percent over the past three decades as a result of the development and deployment of the flame retention oil burner. In addition to increasing efficiency and lowering fuel use, the rate of PM emissions is much lower with the flame retention design. The plot that follows shows the reduction in the rate of PM emissions by oil burners over the past 30 years (reference 4).

Figure 1-3: Reductions in Oil Burner PM Emissions



The rate of filterable particulate emissions decreased by a factor of 20 from the 1960s to the 1990s as oil burner design evolved and fuel-air mixing improved as a result of increased air supply pressure. Enhanced fuel-air mixing produces more complete combustion and lowers PM (smoke and soot) emissions. These substantial reductions in PM emissions from residential oil burners were recognized by the U.S. Environmental Protection Agency in the mid 1990s when the standard emissions factor for oil burners was lowered by a factor of seven to 0.003 pounds of PM per million BTU of fuel burned during cyclic operation (references 4, 5). Properly adjusted oil burners now produce particulate mater emissions that are similar to natural gas burners.

While the oil heat industry has compiled an impressive record of energy conservation and lowered air emissions over the past several decades, the high sulfur content of the fuel used for space heating continues to represent a significant source of SO_2. These emissions can be lowered dramatically through the introduction of lower sulfur heating oil as will be discussed in the next section.

Given the nature of this source (i.e., millions of individual units), there are fewer options for reducing air pollution from residential and commercial heating units than large industrial source. Since traditional regulatory measures, such as the addition of emission control technology to existing facilities, are not practical for this sector, the use of cleaner fuel represents the best near-term option for controlling emissions from oil burners.

2. EMISSION REDUCTION POTENTIALS OF LOW SULFUR HEATING OIL AND BIOFUELS

This section summarizes the emission reduction potential associated with the use of lower sulfur home heating oil for SO_2, NO_x, PM and CO_2. Additionally, the potential environmental benefits that could be achieved by blending biofuels into low sulfur heating oil are discussed.

2.1. Low Sulfur (500 ppm) Home Heating Oil

As described earlier, the introduction of lower sulfur heating oil can reduce emissions of several key air pollutants. Table 2-1 shows typical emission rates for residential oil burners using fuel with sulfur contents of 500 and 2500 parts per million, based on emission factors published by the U.S. Environmental Protection Agency (references 1,5).

Table 2-1: Air Emission Rates for Home Oil Burners

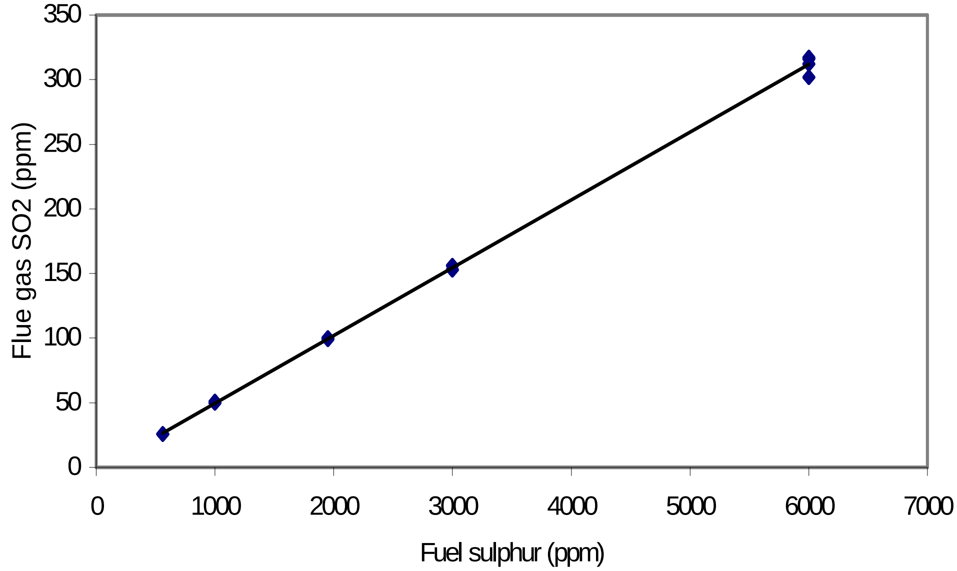
Pollutant	Emission Rate In lbs/MMBTU
PM Total	0.012
PM Condensable	0.0094
PM Filterable	0.0030
CO	0.036
TOC / VOC (non methane)	0.0051
NOx	0.13
SOx 0.05%	0.05
SOx 0.25%	0.26

Reference: *Oil Burner Emissions: AP-42 Sept 98 (Jan 2004)*

2.1.1. Sulfur Dioxide Emissions

The SO_2 emission rate for home heating oil with 0.25 percent (2500 ppm) sulfur is 0.26 pounds per Million BTU of fuel burned. Using oil containing 0.05 percent sulfur (500 ppm) lowers the sulfur oxide emissions to 0.05 pounds per million BTU. Figure 1-1 indicates that typical sulfur contents of distillate fuel oil are currently in the 0.22 percent range. The graph in Figure 2-1 shows the change in SO_2 emissions as the sulfur content of heating oil changes (reference 10). SO_2 emissions from home oil burners are directly related to the sulfur content of the fuel. Reducing the sulfur content of heating oil from an average of 0.20 percent to 0.05 percent lowers the rate of sulfur oxide emissions by 75 percent. If the fuel sulfur content is lowered by 80 percent, the sulfur dioxide emissions decrease by 80 percent.

Figure 2-1: Relationship of Fuel Sulfur Content to SO_2 Emissions

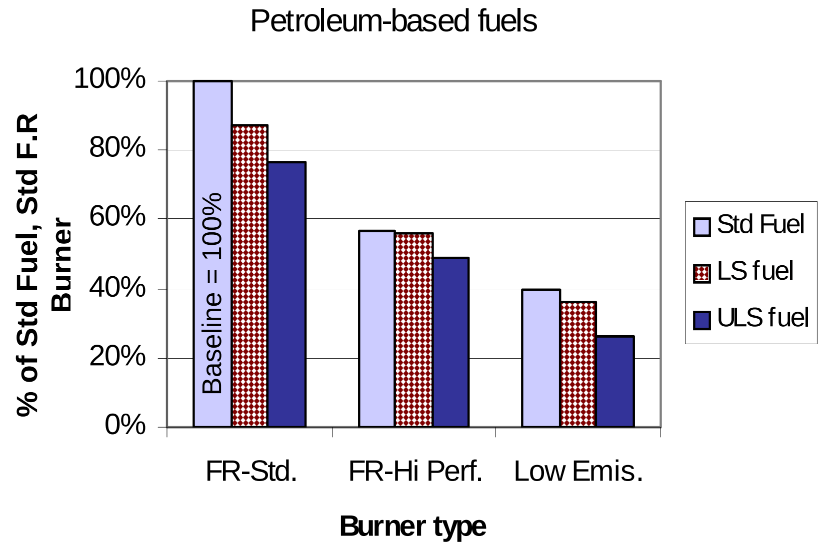


2.1.2. Nitrogen Oxide Reductions:

Figure 2-2 shows measured reductions in NO_x emissions associated with using lower sulfur heating oil for several oil burner types (reference 11). The chart shows the measured reduction in nitrogen oxide emissions for three oil burner designs and three fuel sulfur contents. "FR-Std" refers to a standard flame retention oil burner, "FR-Hi Perf" is a new high performance flame retention oil burner, and "LowEmis" refers to a new generation of low NO_x oil burners. The three test fuels were: standard fuel oil (nominally 2100 ppm S), low sulfur fuel at 250 ppm (LS), and an ultra low sulfur fuel oil (ULS) at 91 ppm. For each burner type, as the fuel sulfur content decreased, the NO_x emission rate also dropped. The standard flame retention oil burner produced 10 percent lower NOx emissions when the 500 ppm sulfur fuel was used in place of normal sulfur (2000 ppm) fuel. These tests clearly demonstrate that NO_x emissions from residential heating systems decrease when low sulfur heating oil is burned. Further, these test data point to the additional NO_x reductions that could be realized by reducing heating sulfur below 500 ppm.

For a standard flame retention oil burner, the most common burner type now used in homes, the lower sulfur heating reduced NO_x emissions by about 12 percent. However, the test fuel contained 250 ppm of sulfur, so the expected NO_x reduction for a 500 ppm fuel would be slightly less. The expected reduction in nitrogen oxide emissions from conventional flame retention oil burners is in the range of 10 percent when conventional heating oil (>2000 ppm sulfur) is replaced with 500 ppm sulfur oil. These reductions can be achieved by changing only the fuel properties, without any burner modifications.

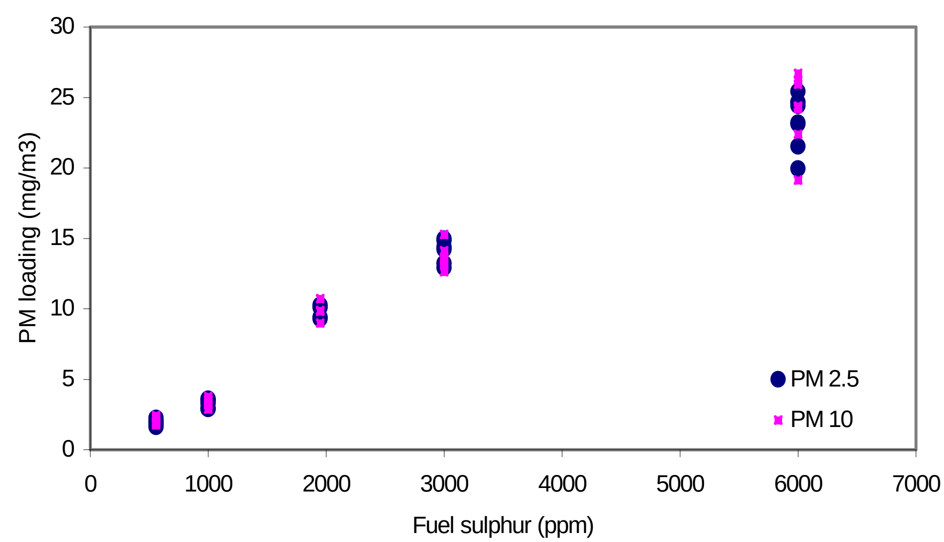
Figure 2-2: Nitrogen Oxide Emission Reductions with Lower Sulfur Heating Oil



2.1.3. Particulate Matter (PM) Reductions:

Figure 2-3 relates PM emissions (filterable and condensable) from home oil burners to fuel sulfur content (reference 10). The x-axis shows the fuel sulfur content of heating oil in parts per million and the y-axis shows the total loading in milligrams per cubic meter of exhaust for both PM_{10} and $PM_{2.5}$. There is a linear relationship between total PM loading and fuel sulfur content: as the sulfur content of fuel decreases, the PM loading decreases proportionally. These data indicate that lowering the sulfur content of the fuel from 2500 ppm to 500 ppm reduces total PM emissions by a factor of five, and lowering the sulfur content from 2000 ppm to 500 ppm reduces PM emissions by a factor of four. PM emissions from oil burners using low sulfur heating oil approach the particulate emissions of natural gas burners which are widely recognized as one of the cleanest combustion sources.

Figure 2-3: Effect of fuel sulfur on $PM_{2.5}$ and PM_{10} emissions



2.2. Low Sulfur (500 ppm) Heating Oil Blended with Biofuels

Low sulfur heating oil can be blended with biofuels to further reduce air emissions, improve the environmental attractiveness of home heating oil and extend supplies with domestic feedstocks. Biofuels, including soy-based biodiesel, contain negligible amounts of sulfur and nitrogen and can further lower SO_2 and NO_x emissions from oilheat burners. In addition, smoke and soot emissions from biofuel blends are less than for petroleum-based distillate oil. Biodiesel is not known to contain mercury. Greenhouse gas emissions are also lowered as the feedstocks for biofuels are re-grown and sequester carbon from the air.

Lower sulfur heating oil blended with biofuels represents a premium fuel with excellent combustion characteristics and lower air emission rates than conventional petroleum-based distillate heating oil. In fact, low sulfur (500 ppm) heating oil combined with a 20 percent soy-based biodiesel has comparable environmental characteristics to natural gas (reference 12).

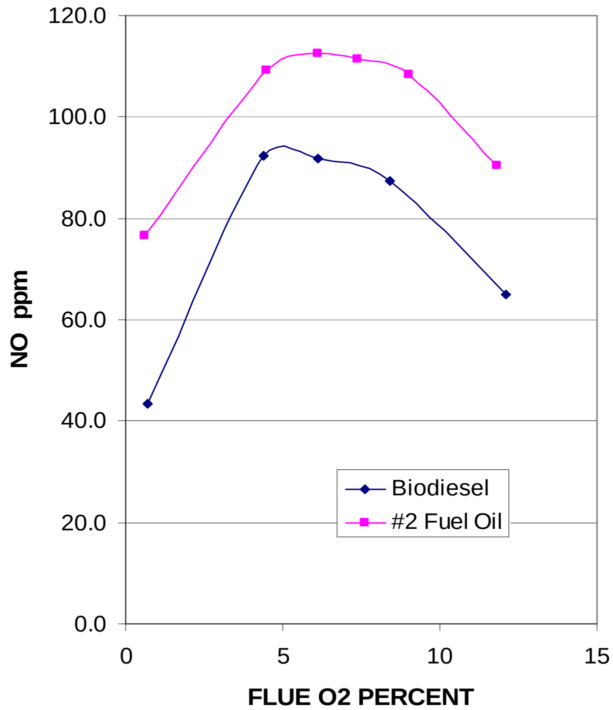
2.2.1. Sulfur Dioxide Reductions

Tests of sulfur dioxide emissions with a blend of 80 percent heating oil containing 500 ppm sulfur and 20 percent soy-based biodiesel were conducted for the Massachusetts Oilheat Council at the New England Fuel Institute in 2003 (reference 13). Because the sulfur content of biofuels is near zero, adding 20 percent biodiesel lowers the fuel sulfur content of the final blend. The measured reduction in SO_2 emissions was 84 percent compared to the normal sulfur distillate fuel used for these tests. Compared to a 2000 ppm base fuel, an 80 percent reduction in SO_2 emissions is expected for a blend of 80 percent low sulfur (500 ppm) distillate fuel and 20 percent biofuel. This is greater than the 75 percent reduction expected when 500 ppm sulfur fuel oil replaces 2000 ppm sulfur fuel.

2.2.2. Nitrogen Oxide Reductions:

Nitrogen Oxide emissions are significantly lower for the 20 percent biofuel blend in 500 ppm fuel oil compared to the reductions achieved with lower sulfur fuel alone. In fact, typical measured NO_x reductions for the biofuel blend were double those for the 500 ppm sulfur heating oil. In one case, for a boiler with an atypically high combustion chamber temperature, the NO_x levels did not decrease for the biofuel/low sulfur blend. The figure below shows the results of a typical test.

Figure 2-4: Nitric Oxide Emissions for Low Sulfur / Biofuel Blend



Note: *NO ppm (at 3% excess air) versus FLUE O_2 %; Unit 13, 0.75 gph*

Figure 2-4 shows measured flue gas emissions of Nitric Oxide (NO) as the burner excess air is varied and the flue gas oxygen content increases. These data are corrected to 3 percent excess air. The biofuel/low sulfur oil blend emits much less NO than conventional higher sulfur home heating oil. These preliminary tests suggest that about one-half of the reduction is produced by the lower sulfur fuel oil and the other half is produced by the biofuel. The lower sulfur fuel oil and biofuel blends can substantially reduce NO_x emissions without requiring burner or boiler modifications.

2.2.3. Particulate Matter Reductions:

Lower sulfur content in heating oil reduces PM emissions and biofuels can lower these emissions even further. Combustion test results showed that biofuel blends lower smoke emissions. In one test program, a burner was adjusted for zero smoke using the blend of biofuel and low sulfur oil. When the conventional (higher sulfur) home heating oil was used at the some burner air setting, the smoke level increased from zero to a number 3 on the Bacharach (ASTM 2156) scale. While these tests cannot measure actual PM loading, it is clear that the biofuel blend lowers smoke and soot emissions.

2.2.4. Mercury Reductions

While there is a paucity of data, it is expected that adding biodiesel to heating oil will reduce Hg emissions by an amount equivalent to the blend percentage. Soy-based biofuel is not known to contain mercury and therefore will dilute the mercury concentration of the final fuel when blended with petroleum-based heating oil. Additional testing is needed to more accurately quantify the emission coming from residential and commercial oil heating and to verify the relationship between the addition of biodiesel and changes in mercury emissions from the combustion of the blended fuel. Further, the relationship between the sulfur and mercury content of distillate is not well understood. The Northeast states will begin a testing program in 2006 to measure both the sulfur and mercury content of heating oil and highway diesel in an effort to better quantify mercury content and the potential relationship between sulfur and mercury concentrations in distillate.

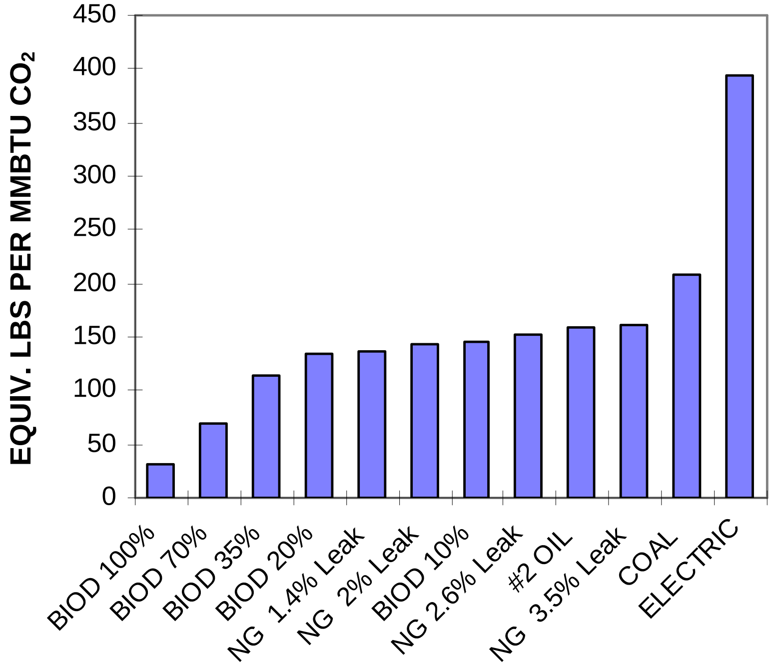
2.2.5. Greenhouse Gas Emission Reductions:

An additional benefit of biodiesel blends is that the biofuel component is re-grown which removes carbon dioxide from the atmosphere. While some energy is required to re-grow and process the soy-based biodiesel, research indicates a net reduction in greenhouse gases of 80 percent for soy-based biofuels. This means that a 20 percent soy biodiesel blend will lower carbon dioxide emissions by approximately 16 percent.

The chart in Figure 2-5 shows the net global warming impact potentials for a range of fuels including fuel oil with varying percentages of soy biodiesel. Values are in pounds per million BTU of fuel burned, and are based on emission factors published by the U.S. Environmental Protection Agency (reference 5).

"Biod 100%" is heating oil consisting of 100 percent soy-based biodiesel fuel. The next three values shown are biodiesel fuels at 70 percent, 35 percent, and 20 percent respectively. "NG 1.4% Leak" is for natural gas including a gas leakage rate during transmission and distribution of 1.4 percent of throughput, and an average methane-to-CO_2 global warming ratio of 30. "NG 2% Leak" is for natural gas including a gas leakage rate of 2.0 percent of throughput. "Biod 10%" is heating oil consisting of 10 percent biodiesel fuel. "NG 2.6% Leak" is for natural gas including a gas leakage rate of 2.6 percent. "Number 2 oil" shows emissions for standard distillate heating oil used in homes. Coal emissions are higher because of the higher carbon-to-hydrogen ratio. Electric energy has the highest greenhouse gas emissions based on U.S. Department of Energy Publications showing total CO_2 emissions and total energy generated.

Figure 2-5: Global Warming Potentials of Various Energy Sources



Note: *Equivalent CO_2 Emissions Pounds Per Million BTU for Oil and Natural Gas (Ref: USEPA AP-42)*

The lowest global warming potentials for all fuels are the biodiesel-heating oil blends. The 100 percent biodiesel blend (B100) produces the lowest global warming potential. The B20 blend is lower than all other sources including natural gas. For the 10 percent biodiesel in petroleum-based heating oil, the total global warming potential is lower than for natural gas within the range of expected gas leakage rates.

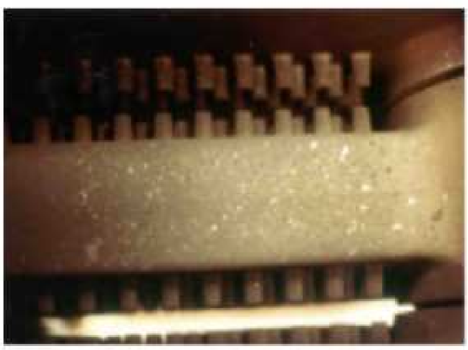
One important factor in comparing the climate impacts of natural gas and heating oil is methane leakage that occurs during natural gas transmission and distribution given the higher global warming potential of methane compared to carbon dioxide. Because biofuel are renewables, when blended with home heating oil, they reduce the global warming potential below that of natural gas.

3. COST-BENEFIT ANALYSES OF LOW SULFUR HOME HEATING OIL

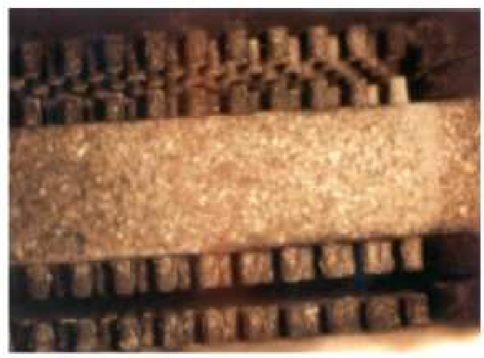
Lower sulfur heating oil is cleaner burning and emits less particulate matter which reduces the rate of fouling of heating equipment and permits longer time intervals between vacuum cleanings. The potential costs savings for oil heated homes due to reduced maintenance is on the order of hundreds of million of dollars a year, most of which accrues in the Northeast and Mid-Atlantic states where oil is a dominant fuel for space heating. The added cost for the lower sulfur fuel is expected to be less than the savings produced by cleaner operation.

Figure 3-1 shows the impact of various fuel oil sulfur contents on the rate of fouling depositions inside a residential cast iron boiler based on research conducted by Brookhaven National Laboratory. These photos clearly show that more boiler fouling occurs as the sulfur content of the fuel increases. The reduced rate of deposits with lower sulfur fuel oil lowers cleaning costs.

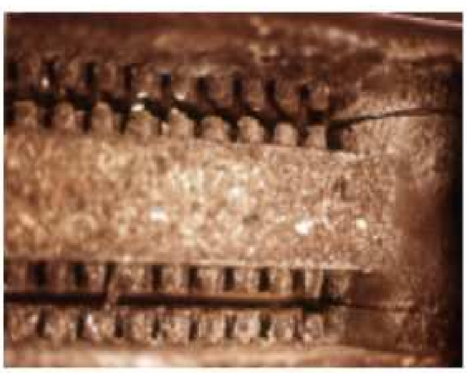
Figure 3-1: Boiler Fouling for Varying Fuel Oil Sulfur Contents



No 2 heating fuel, 0.04% Sulfur by weight



No. 2 heating fuel, 0.18% Sulfur by weight



No 2 heating fuel, 0.34% Sulfur by weight

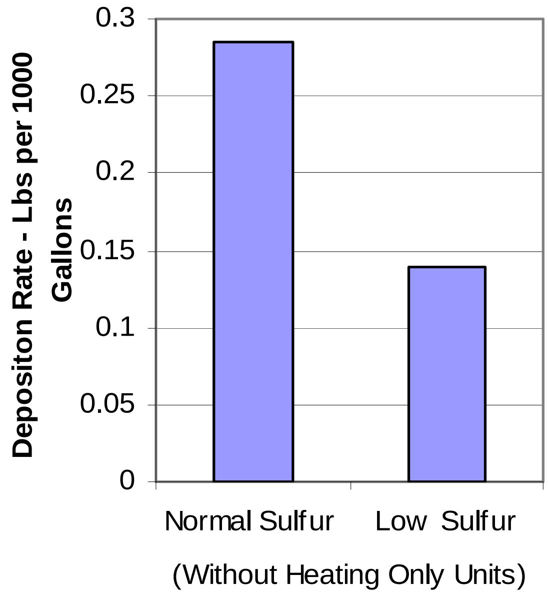
No. 2 heating fuel, 1.08% Sulfur by weight

The lower sulfur fuel produces minimal boiler deposits as shown in the upper left photograph for the 0.04 percent sulfur fuel (reference 10).

3.1. Reduced Maintenance Costs

Figure 3-2 summarizes the results of a comprehensive field study of the impacts of low sulfur fuel oil (0.05 percent) funded by the New York State Energy Research and Development Authority (NYSERDA). See Reference 10 for details of this multi-year study. Boiler deposits were collected and analyzed for houses burning normal sulfur and low sulfur heating oil. The results showed a significant reduction in boiler deposits for the low sulfur houses, consistent with the laboratory tests conducted by Brookhaven National Laboratory and in Canada on boiler deposition rates.

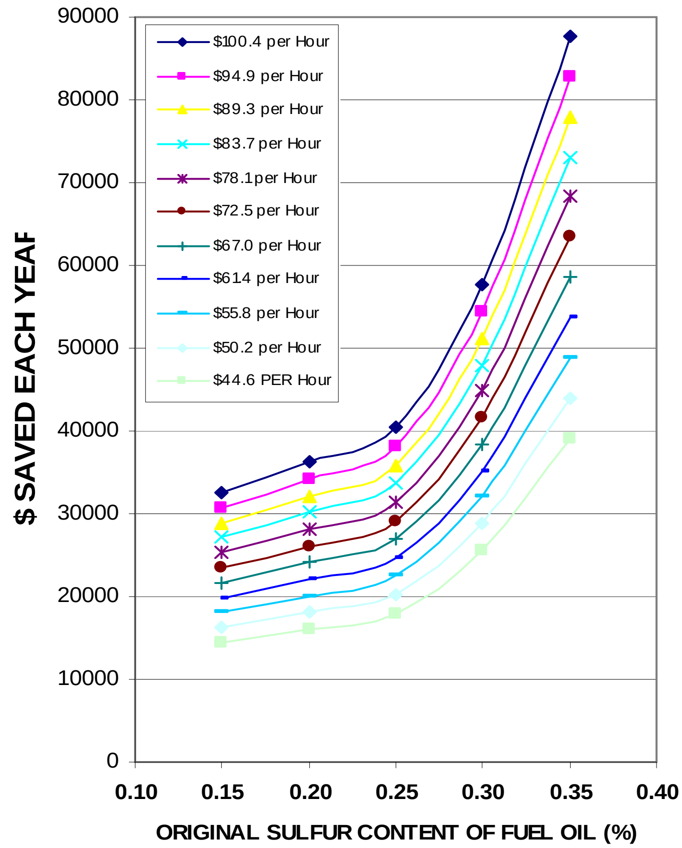
Figure 3-2: Measured Boiler Deposits – Normal and Low Sulfur Fuel Oil



Boiler deposits were reduced by a factor of two by lowering the fuel sulfur content from 0.14 percent to 0.05 percent for the houses in the study. Larger reductions in boiler depositions are produced when the initial sulfur content is higher. These reduced deposits translate into much lower costs for vacuum cleaning by extending the service interval. When the existing heating oil sulfur content is 2000 to 2500 ppm and 500 ppm sulfur fuel is substituted, the service interval can be extended by a factor of three or more (e.g., cleaning at three year intervals rather than annually). This produces substantial savings in service costs for oil-heated homes.

The reduced boiler and furnace fouling rates achieved by using lower sulfur fuel oil translate directly into lower vacuum-cleaning costs for fuel oil companies and homeowners. The chart that follows summarizes expected savings for a range of hourly service rates and for varying initial fuel oil sulfur percentages (reference 10).

Figure 3-3: Vacuum Cost Savings per 1000 Houses



Note: *The cost savings in dollars per year, by using 0.05% Sulfur Fuel Oil per 1,000 customers*

For example, at a median hourly service cost of $72.50 and an initial fuel sulfur content of 0.25 percent (2500 ppm), the expected reduction in vacuum cleaning costs is $29,000 a year per 1000 houses. If the hourly service rates are higher, the annual savings are also higher. The service rates shown here are for illustrative purposes, actual costs may be higher than the maximum values or lower than the minimum values shown on the graph.

The potential vacuum-cleaning cost savings for the U.S., for a starting fuel sulfur content of 0.20 percent, ranges from approximately $200 million a year to $390 million a year for service costs of $50 to $100 per hour. Therefore, if all oil heated homes switched to 500 ppm sulfur heating oil, more than $200 million a year could be saved, which would significantly lower the overall operating costs of fuel oil marketers (reference 10). Given the dominant share of the U.S. heating oil market represented by the Northeast states, a large percentage of the projected national benefits would accrue in the region.

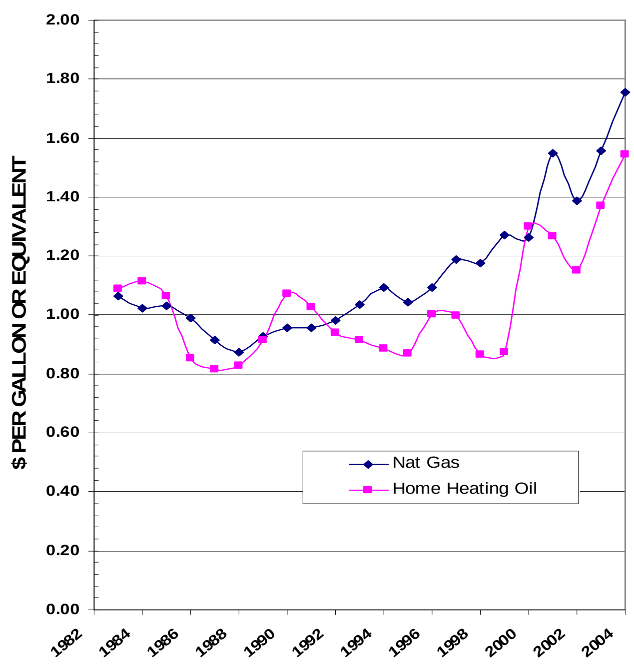
3.2. Added Cost for Lower Sulfur Heating Oil and Historic Fuel Prices

The incremental cost of low sulfur (500 ppm) home heating oil compared to the higher sulfur product varies over time. Fuel oil prices reported in the *Weekly Petroleum Status Report* published by the U.S. Department of Energy (reference 15) were used to compare New York Harbor spot market prices of # 2 heating oil and # 2 diesel (low sulfur). From January 2003 through March 2004, the price of the low sulfur diesel ranged from $ 0.0022 per gallon to $ 0.0378 per gallon higher than the price of the higher sulfur heating oil. The average price increment for the lower sulfur product was 1.6 cents per gallon for the 15 month period examined.

Data collected by the Oilheat Manufacturers Association, which tracks fuel oil and natural gas prices, shows that the retail price of home heating oil has cycled up and down over the past twenty years (reference 16). Figure 3-4 shows dollar per gallon equivalent prices for heating oil and natural gas between 1982 and 2004.

Figure 3-4: Home Heating Oil and Nat Gas Prices

(CT, ME, MA, NH, RI, VT, DE, MD, NJ, NY, PA, DC, VA)



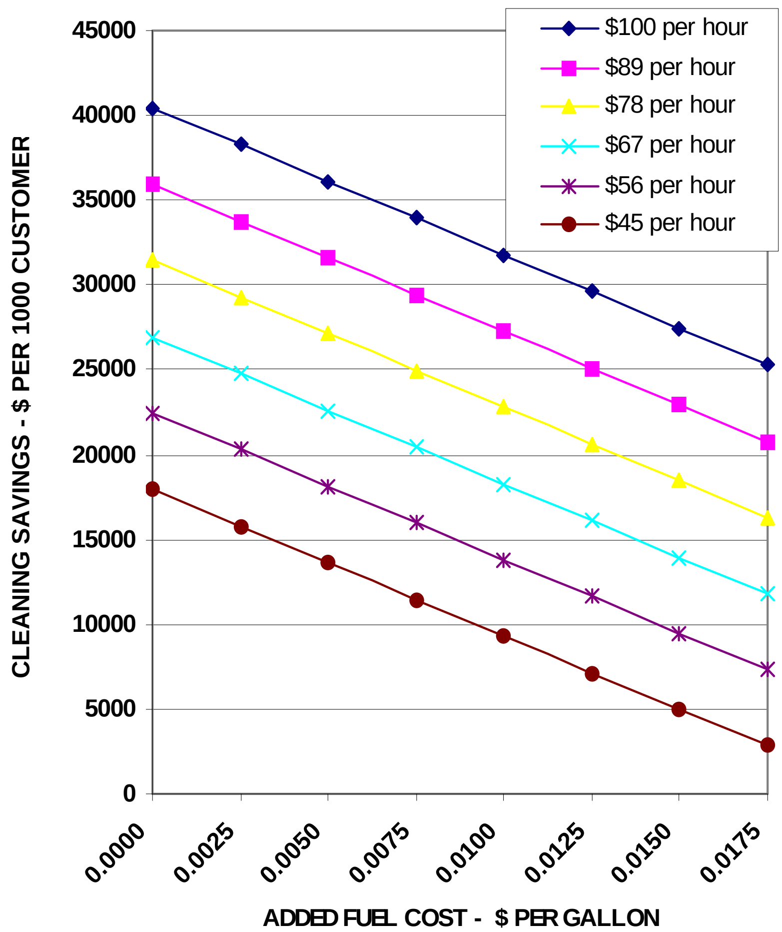
Residential oil prices have increased and decreased over this period. From 1984 to 1988 oil prices fell about 27 percent, and then increased from 1984 to 1991 by about the same amount. This represents a cyclical change of more than 25 percent. From 2001 to 2002 average oil prices increased by more than 50 percent, and then decreased for the next two years.

The added cost of low sulfur heating oil is on the order of 1.6 cents per gallon; representing approximately 1 percent of the average oil price. The incremental cost of low sulfur heating oil is much smaller than historical oil price fluctuations. Therefore, the added cost for lower sulfur heating oil is expected to have a minimal overall economic impact on home heating oil consumers.

3.3. Net Cost Savings with Lower Sulfur Fuel Oil

The chart in Figure 3-5 presents the net cost savings of lower sulfur heating oil including the effect of added fuel costs (reference 10). The net savings are shown for a range of added fuel costs and for various hourly service rates. For an added cost of low sulfur home heating oil of 1.5 cents per gallon, and for an hourly service rate of $78 per hour, the net cost savings by reduced vacuum cleaning intervals is $18,000 or about $18 per customer. This chart can be used to estimate the net savings associated with the use of lower sulfur home heating oil for a range of fuel and maintenance costs.

Figure 3-5: Net Cost savings per 1,000 Houses Using Low Sulfur Oil
For: 0.25%S (initial) and 865 Gal per Year



The cleaning cost savings generated by using lower sulfur fuel oil are greater than the added cost of the fuel. The NYSERDA study indicates that the expected savings in vacuum cleaning costs is approximately two to three times higher than the added fuel cost for service rates of $75 to $100 per hour. Other reductions in service costs, in addition to the vacuum cleaning cost savings, were also observed during NYSERDA's multi-year field demonstration of low sulfur home heating oil (reference 10). This further improves the benefit to cost ratio for lower sulfur fuel oil.

3.4. Environmental and Health Benefits

In addition to the cost savings that would accrue to oil heat marketers and consumers due to reduced maintenance, substantial public health and environmental benefits would be realized through the introduction of low sulfur heating oil. According to the NYSERDA study referenced earlier, the potential reductions in SO_2 emissions by using 500 ppm sulfur oil to replace 2000 ppm sulfur is approximately 60,000 tons per year nationwide. These emission reductions occur primarily in the Northeast where a majority of the home heating oil is consumed. In New York State alone, the projected SO_2 reductions associated with the shift to low sulfur home heating oil is about 13,000 tons per year (reference 10).

In summary, this section suggests that lower sulfur fuel oil and lower sulfur/biofuel blends can provide important public health and environmental benefits in a very cost-effective manner. In fact, the cost savings due to reduced need for heating system cleaning and maintenance alone more than offset the incremental cost of the lower sulfur fuel. When the public health and environmental benefits are added to the equation, a 500 ppm sulfur heating oil program represents one of the most cost-effective air pollution control strategies available to the Northeast states. The next section discusses other benefits associated with the introduction of lower sulfur heating oil.

4. OTHER BENEFITS OF LOW SULFUR HEATING OIL

Additional benefits derived from the use of heating oil with lower sulfur content include efficiency improvements, the opportunity to develop and market advanced boiler and furnace technologies, and harmonizing with European and Canadian fuel standards.

4.1. Improved Efficiency

Lower sulfur fuel oil produces less fouling of the heat transfer surfaces inside boilers and furnaces as discussed earlier. This helps improve the long-term efficiency of the boiler or furnace by maintaining high heat transfer rates from the hot flame gases to the boiler water or furnace warm air. Research conducted by Brookhaven National Laboratory indicates that the drop in heating equipment efficiency is on the order of one or two percent each year, with higher decreases in some cases. After the heating unit is cleaned, the thermal efficiency returns to the higher levels. Therefore, using lower sulfur home heating oil can improve the efficiency of oil heating equipment on the order of one to two percent.

The added benefits of improved efficiency are two-fold. First, heating costs are reduced, as less fuel is required to supply the required heating demand. Second, the emissions of all pollutants are reduced, as less fuel is consumed by more efficient boilers and furnaces. On an individual basis this is a small increment. However, when applied to the more than 10 million home heating systems in the U.S., the reductions in fuel use and air emissions are meaningful.

4.2. Opportunity to Utilize Advanced Equipment

Part of the energy loss from heating equipment is in the form of water vapor in the exhaust gases. Each pound of water vapor removes 970 BTUs, which represents about 6.5 percent of the energy content of the fuel oil. Brookhaven National Laboratory conducted research in the 1980’s on developing “condensing” furnaces and boilers that operate at very low exhaust temperatures that permit some of the water vapor heat loss to be recovered. One problem with heating oil is that the fuel sulfur content increases the acidity of the condensed water vapor. This requires measures to protect the heat transfer surfaces from acid attack and damage. Recently, the National Oilheat Research Alliance funded the development of oil-powered condensing heating equipment and the availability of lower sulfur heating oil will support expanded use of this new technology.

The use of lower (500 ppm) and eventually ultra low sulfur (15 ppm) heating oil offers the opportunity to improve boiler and furnace designs to include flue gas condensation and increase efficiencies into the mid to upper 90 percent range. This is comparable to the highest efficiencies now available from natural gas-powered equipment.

Historically, condensing oil furnaces have been available. However, design and maintenance problems associated with the use of higher sulfur heating oil limited widespread use of condensing oil equipment. The availability of lower sulfur oil can lower equipment and service costs and permit expanded use of higher efficiency warm air oil furnaces and hot water boilers. This is an important option for oil heat consumers as both oil and natural gas prices continue to rise. Higher efficiency equipment can help assure that oil heat remains an economically viable option for residential consumers to maintain a mix of fuels needed for energy diversity. The use of this higher efficiency equipment will reduce the emissions of all air pollutants, including CO_2, as less fuel is needed to produce the same heat output. Market demand for condensing furnaces is likely to increase as prices for heating oil rise.

4.3. Harmonizing with Worldwide Standards

Clearly, the trend in Europe, Canada and elsewhere is toward lower sulfur heating oil. Home heating oil sulfur contents are being lowered to 0.1 percent or 1000 ppm in the near-term with a target of 500 ppm to 50 ppm in many European countries and other nations around the world as reviewed earlier. The U.S. can keep pace with these changes and encourage fuel refiners and suppliers toward lower sulfur products by joining with other nations in requiring lower sulfur oil. Joining forces with other major fuel users around the world will help to move sulfur standards to lower levels so that the many benefits of the lower sulfur product that are summarized in this report can be realized as soon as possible. Reducing the number of products transported and stored around the world by harmonizing sulfur limits is the most expeditious way to achieve the goal of lower sulfur fuel oil.

5. OVERVIEW OF SUPPLY AND DISTRIBUTION OF HEATING OIL IN THE NORTHEAST

The continued availability of adequate supplies of heating oil from domestic sources and imports is an important consideration in assessing the costs and benefits of establishing low sulfur standards. This section presents a brief overview of some key issues and potential strategies that will enable the use of lower sulfur home heating oil in the U.S. in the near-term without significant supply disruptions or price spikes.

In April 2005, total petroleum use in the U.S. was 20.4 million barrels per day (MMBPD) of which 13.2 MMBPD was from imports (reference 21). Imports accounted for approximately 65 percent or almost two-thirds of the total petroleum products in the U.S. supplied for domestic uses. In contrast, the percentage of distillate fuel imported into the U.S. is much smaller. Table 5-1 is based on data related to distillate fuel oil supply from reference 21.

Table 5-1: US Distillate Fuel Oil Supply (Thousand Barrels per Day)

Year	Refiner Output	Imports	% Imports
2002	3,592	267	7.4
2003	3,707	333	9.0
2004	3,819	320	8.4
2005	3,627	384	10.5 (Jan to April 2005)

Distillate fuel use in the U.S. is less than 20 percent of total petroleum use. The percentage of distillate fuel oil imported to U.S. from 2002 to 2005 ranged from 7.4 to 10.5 percent. This does not include exports of distillate fuel oil that ranged from 87 to 112 thousand barrels per day, or changes in stocks. The percentage of imported fuel is considerably higher in the Northeast where the majority of the nation's heating oil is consumed, especially during periods of peak demand.

Nationally, residential distillate fuel oil consumption is only a small percentage of total U.S. distillate use, ranging from 10.7 to 11.4 percent of the total from 1999 to 2003 (reference 22). Residential consumption represents less than two percent of total U.S. petroleum use. Highway diesel fuel consumption is five times higher than that of residential distillate, ranging from 55.5 to 58 percent of total U.S. distillate demand for the same time period. However, the situation in the Northeast is dramatically different where heating oil represents 54 percent of total demand for #2 distillate oil, compared to 38 percent for highway diesel.

Distillate fuel oil is brought into the Northeast from a combination of sources that include a pipeline that runs from the Gulf States to New Jersey, refineries in New Jersey and Pennsylvania, imported fuel from Canada by trucks, and from other countries by tanker. Distillate imports come from three main sources: Canada, the Virgin Islands, and Venezuela with a combine volume of 196 thousand barrels per day for the peak year from 2000 to 2003. These three countries provide about two-thirds of total distillate imports to the Northeast on an annual average basis (reference 23).

An important consideration regarding a requirement for lower sulfur heating oil is the availability of lower sulfur distillate fuel imports during times of peak fuel consumption, in January and February when the outdoor temperature is the coldest. A presentation by Allegro Energy Consulting on August 23, 2004 (reference 23) compared the annual percentage of imported distillate fuel oil (high sulfur) in the Northeast to the percentage of total demand met by domestic refiners. Table 5-2 summarizes this information.

Table 5-2: Source of Annual Distillate Fuel Oil Supplies on the East Coast (%)

Year	East Coast Refineries	Golf Coast Receipts	Imports
2000	39%	36%	**24%**
2001	33%	38%	**29%**
2002	37%	37%	**26%**
2003	34%	37%	**29%**

The annual percentage of high sulfur distillate oil imports used for heating ranged from 24 to 29 percent from 2000 to 2003. This is higher than the national average for all distillate fuel oil that ranged from 7.4 to 10.5 percent. The percentage of imports to the East Coast during the first quarter of the years 2000 to 2003 when the peak demand occurs are shown in Table 5-3 (Reference 23).

Table 5-3: Peak Distillate Fuel Oil Imports (%)

Year	To East Coast
2000	30%
2001	41%
2002	24%
2003	39%

These data indicate a significant year-to-year fluctuation in wintertime demand met by imports. In 2002, imports accounted for 24 percent of peak quarter demand, which is similar to the average annual East Coast values. By contrast, 41 percent of peak demand was met by imports in 2001. The peak volume of imported distillate fuel oil to the East Coast, approximately 400 thousand BPD, occurred during the first quarter of 2001. It is important to note that distillate stocks were not available to meet the peak demand in 2001, as it was in subsequent years, which caused imports to increase.

The Allegro presentation indicates that about two-thirds of distillate imports to the Northeast during the peak year come from Canada, the Virgin Islands, and Venezuela that supply 74, 71, and 51 thousand BPD of distillate fuel, respectively. The next largest suppliers of imported fuel have been: Europe at 31 TBPD; Russia at 28 TBPD; Africa at 14 TBPD; and Asia, South America, Caribbean, Middle East, and Mexico for a total of 27 TBPD. Concern has been expressed regarding the ability of offshore marketers to supply lower sulfur distillates fuel as needed to meet peak demand in the near-term. Russia and Africa are two historic suppliers that are not expected to lower sulfur content of their distillate fuels in the near-term. However, together, they supplied only about 14 percent of imports during the peak year examined. It seems likely that other suppliers will be able to make up the difference. However, during episodic cold spells, the demand for imports can be significantly higher than the first quarter averages discussed above.

Based on the concern expressed by industry representatives about potential near-term adverse supply impacts associated with a low sulfur heating oil requirement, the Northeast states are assessing potential strategies for ensuring needed supplies during peak heating demand periods. These include: (1) increasing pre-season stocks of lower sulfur fuel oil; (2) increasing imports from countries with lower sulfur standards; (3) permitting seasonal averaging of sulfur levels; (4) blending of lower sulfur distillate with higher sulfur imports; and (5) introducing greater amounts of domestic biofuels into the market over time.

The Irving presentation (reference 24) indicates that during peak heating demand, in the 2001 to 2004 period, heating oil stocks helped supply the needed fuel. Fuel stocks supplied approximately 200 thousand BPD for that time period. This limited the amount of imports during periods of peak demand between 2002 and 2004. The exception was in 2001, when adequate distillate stocks were not available, and the peak demand for imports increased to about 400 thousand BPD. Therefore, building adequate stocks of distillate fuel at the start of the heating season is an important mechanism for lowering reliance on imports.

Some sources of imported distillate oil may not be able to supply the lower sulfur fuel oil in the near-term, but other sources are expected to have low sulfur product available. For example, European countries are leading the way with 0.1percent sulfur oil required in 2008. Canada plans to meet the EU target, and other nations are also expected to meet the lower sulfur mandates. Small increases in imports from some of the larger suppliers who will produce reduced sulfur fuel can compensate for the countries that lag in sulfur reduction.

Seasonal averaging would diminish supply constraints by allowing providers to bring in “non-specification” fuel during periods of peak demand as long as the higher sulfur gallons are offset by lower sulfur fuel over the course of the heating season. The objective is to have an average seasonal or yearly fuel delivery that meets the new sulfur limit. This provision permits flexibility when fuel supplies are tight and fuel marketers must rely more on imports to meet the heating demand.

Fuel blending is another approach for meeting lower fuel sulfur standards. The ultra-low sulfur (ULS) or 15 ppm standard for highway use is approaching and diesel fuel with very low sulfur content will be widely available. If this lower sulfur product is added to a higher sulfur stock, the average sulfur content drops rapidly. For example, a blend of 80 percent fuel with 500 ppm sulfur and 20 percent 15 ppm fuel produces an average sulfur content of 403 ppm. This fuel blending method can be used to comply with lower sulfur standards for heating oil. It is important to remember that in the U.S., diesel production and fuel use is approximately five times higher than home heating oil use. Therefore, if all home heating oil was blended with 20 percent ULS diesel, it would require only about 4 percent of the diesel supply. In reality, much less than 4 percent of the ULS diesel supply would be needed, given the other compliance methods available.

The supply of imported fuel oil is strongly dependent on the fuel price differential. Historically, the volume of net imports increases as the price of heating oil increases on spot markets. After October 1989, the heating oil spot market price increased by 5 to 10 cents per gallon and the volume of imports doubled from less than 250 to 500 thousand BPD. A similar increase in imports occurred after October 2002. Even increases of 5 cents per gallon have historically produced substantial increases in the rate of distillate fuel imports. Higher fuel oil prices for the lower sulfur product must be minimized so that the balance between oil, natural gas and other energy sources is not disrupted. The strong relationship between distillate import rates and changes in fuel prices suggests that imports could help offset temporary fuel shortages during times of peak demand.

Many environmental, public health, and equipment service cost benefits are produced by using lower sulfur home heating oil. The use of lower sulfur distillate heating oil is gaining acceptance, with Europe, Canada and other nations leading the way, much as the U.S. led the way for lower sulfur diesel fuel. An immediate question is how much can the sulfur limits be lowered without disturbing normal fuel supplies around the world. The good news is that distillate heating oil in the U.S. represents a much smaller fraction of the barrel than diesel fuel use whose sulfur content has already been reduced to 500 ppm and is slated to go to 15 ppm beginning in 2006. The challenge is to develop a plan for implementing lower sulfur heating oil standards that will minimize supply problems in the Northeast especially during times of peak heating demand in January and February.

6. CONCLUSIONS

The Northeast states are in the process of developing long-term strategies to meet national ambient air quality standards and visibility goals and regional targets for mercury and greenhouse gas reductions. As part of the planning effort, a wide range of pollution control strategies are being evaluated. Residential and commercial space heating with fuel oil has been identified as an important source of emissions. Given the relative lack of regulation of this sector, the implementation of lower sulfur fuel standards appears to represent a cost-effective emission reduction option.

The emissions from residential and commercial oil heating contribute to ozone and particulate matter formation, mercury deposition and the build up of greenhouse gasses in the atmosphere. Given the impracticality of applying source-by-source emission control technology, the best option for reducing emissions from fuel oil heaters is the introduction of cleaner-burning fuel.

SO_2 emission reductions of 75 percent can be achieved by lowering the sulfur content of heating oil from current levels to 500 ppm. A ten percent reduction in NO_x emissions from this source sector can also be achieved. The benefits of this approach are realized immediately upon introduction of the cleaner fuel and therefore can help states meet specific near to mid-term emission reduction targets.

The Northeast states are also evaluating the merits of blending biofuels with lower sulfur heating oil to improve the emission characteristics and open up the market for domestically produced clean-burning renewable fuels. Blending twenty percent biodiesel with 80 percent 500 ppm sulfur #2 distillate further lowers SO_2 and PM emissions compared to 500 ppm sulfur heating oil and doubles the NO_x benefits. The addition of twenty percent soy-based biodiesel also lowers greenhouse gas emissions by almost twenty percent and through dilution, reduces average mercury concentrations in the emission stream.

The significant emission reductions associated with the introduction of lower sulfur heating oil standards can be achieved in a cost-effective manner. The incremental cost of 500 ppm highway diesel fuel has averaged 1.5 cents per gallon more than heating oil over the past decade. Further, the use of lower sulfur heating oil reduces the fouling of heating oil equipment and consequently extends maintenance intervals. Assuming that maintenance is needed only every third year, rather than annually, the cleaning cost savings are projected to be two to three times greater than the added fuel cost. With the recent increase in fuel oil cost, the 1.5 cent per gallon increment is a smaller percentage of total heating oil cost.

The volatile nature of heating supply and demand presents unique challenges to the fuel oil industry. The success of a low sulfur fuel oil program is predicated on meeting these challenges. The Northeast states are assessing a variety of business strategies and regulatory approaches that could be used to minimize any potential adverse supply and price impacts that could result from a regional 500 ppm sulfur standard for heating oil. Suppliers can increase pre-season reserves and look to increase imports from offshore refiners producing low sulfur product. Blending domestically produced biodiesel into heating oil offers opportunity to reduce imports, stabilize supplies and minimize supply-related price spikes. Air quality regulators are also considering permitting seasonal averaging of sulfur content which would allow higher sulfur imports to be brought to the Northeast market during periods of peak demand. Over the course of the year, the higher sulfur fuel would have to be offset by heating oil with a sulfur content below the standard.

The analysis summarized in this White Paper supports the Northeast states conclusion that significant reductions in SO_2, NO_x, PM and CO_2 emissions can be achieved by mandating lower sulfur heating oil. Importantly, these reductions can achieved at an overall savings to the consumer. Adding the public health and environmental benefits of a lower sulfur fuel further substantiate the favorable cost-benefit ratio of a regional 500 ppm sulfur heating fuel program.

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