Contribution of Home Heating Oil to SO_2 Emission Inventory by State

	Annual	Heating Season
Maine	15%	23%
New Hampshire	7%	12%
Vermont	19%	28%
Massachusetts	13%	21%
Connecticut	36%	49%
Rhode Island	34%	46%
New York	8%	13%
New Jersey	7%	11%
Pennsylvania	2%	3%
Delaware	1%	2%
Maryland	1%	2%
District of Columbia	9%	14%
NESCAUM	10%	16%
MANE-VU	5%	8%

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.

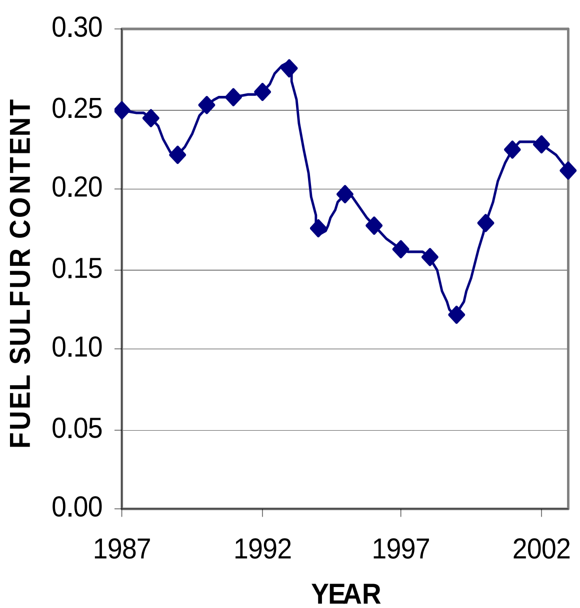
Table 1-1: State Sulfur Limits for Heating Oil

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.

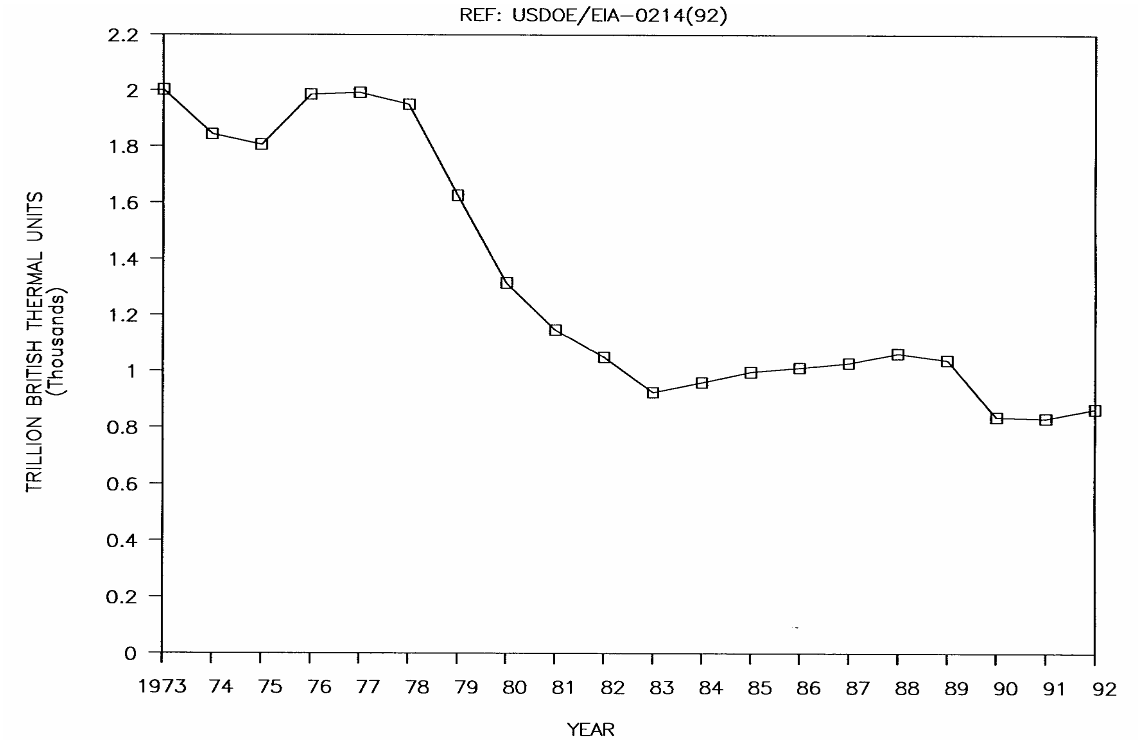
Switzerland has an allowable limit for sulfur content of 0.2 percent, but taxes fuel oil higher than 0.1 percent. Reportedly, most of the fuel sold had sulfur content of 0.1 percent or lower. There are low sulfur fuels with 0.03 to 0.05 percent sulfur on the market in Europe and its use is reported to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

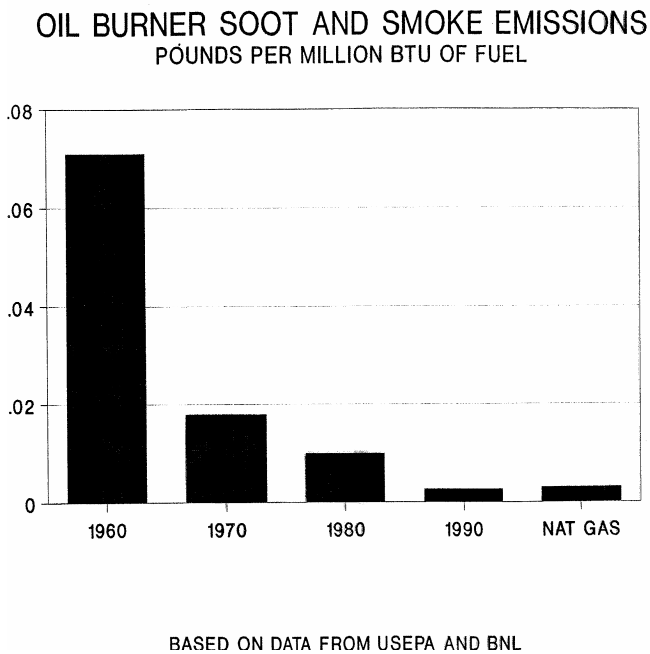


In addition to energy conservation programs, the historical reduction in fuel oil use has been spurred by the development and use of new higher efficiency oil heating equipment. The flame retention oil burner, which increases fuel efficiency by about 15 percent, was developed through industry-sponsored 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

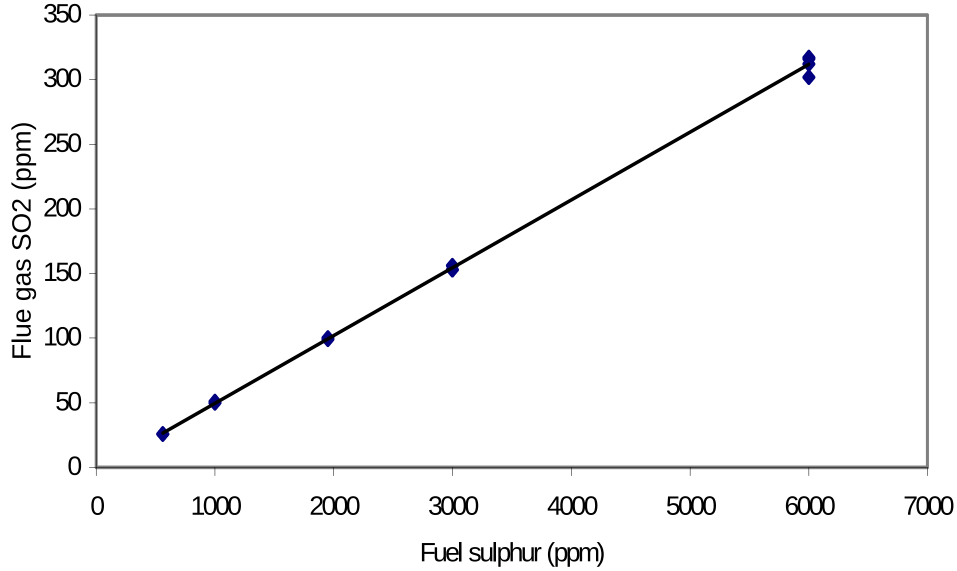
Pollutant	Emission Rate In lbs/MMBTU
PM Total	0.012
PM Condensable	0.0094
PM Filterable	0.0030
CO	0.036
TOC / VOC (non methane)	0.0051
NOx	0.13
SOx 0.05%	0.05
SOx 0.25%	0.26

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

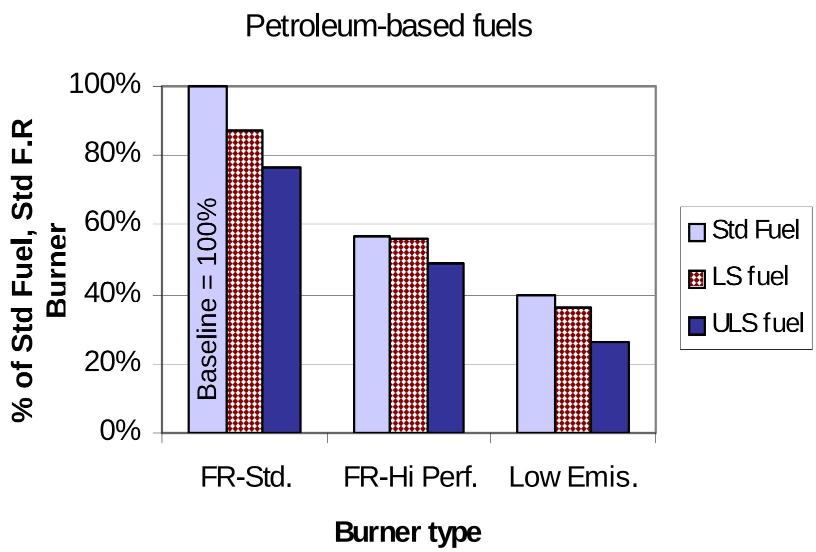


2.1.2. Nitrogen Oxide Reductions:

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.

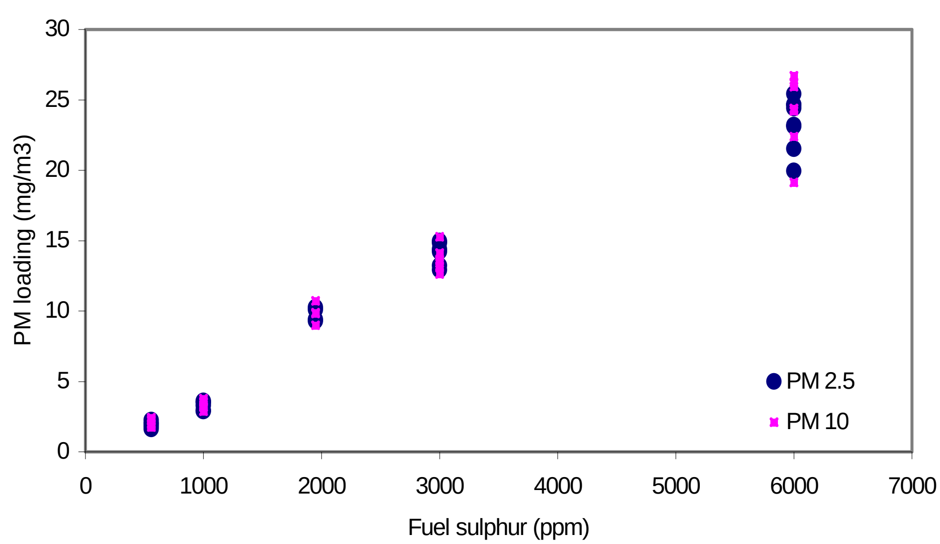
Figure 2-2: Nitrogen Oxide Emission Reductions with Lower Sulfur Heating Oil



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).

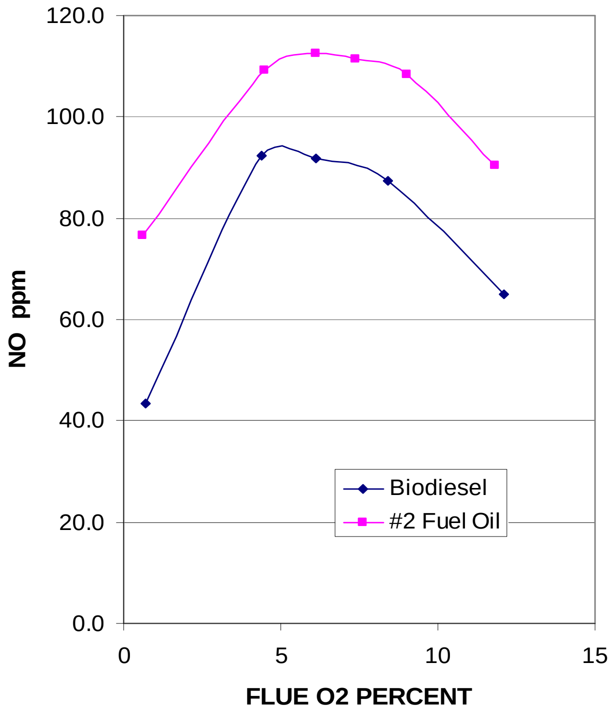
2.2.1. Sulfur Dioxide Reductions

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.

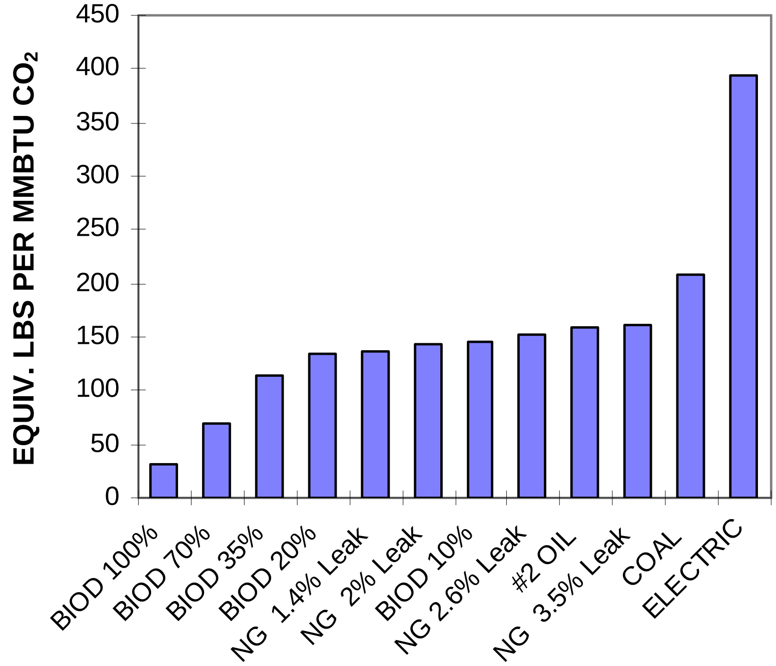
2.2.5. Greenhouse Gas Emission Reductions:

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.

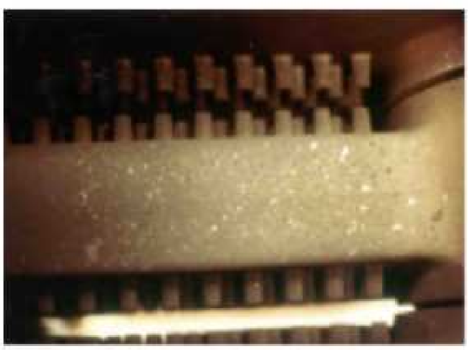
One important factor in comparing the climate impacts of natural gas and heating oil is methane leakage that occurs during natural gas transmission and distribution given the higher global warming potential of methane compared to carbon dioxide. Because biofuel are renewables, when blended with home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

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

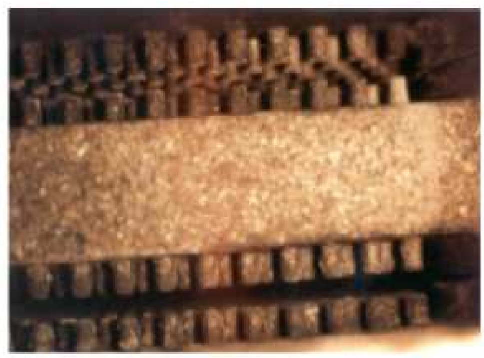
Lower sulfur heating oil is cleaner burning and emits less particulate matter which reduces the rate of fouling of heating equipment and permits longer time intervals between vacuum cleanings. The potential costs savings for oil heated homes due to reduced maintenance is on the order of hundreds of million 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.

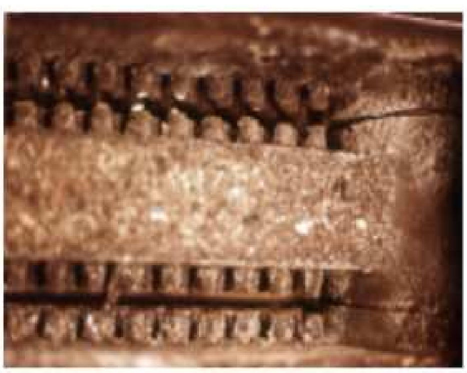
Figure 3-1: Boiler Fouling for Varying Fuel Oil Sulfur Contents



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

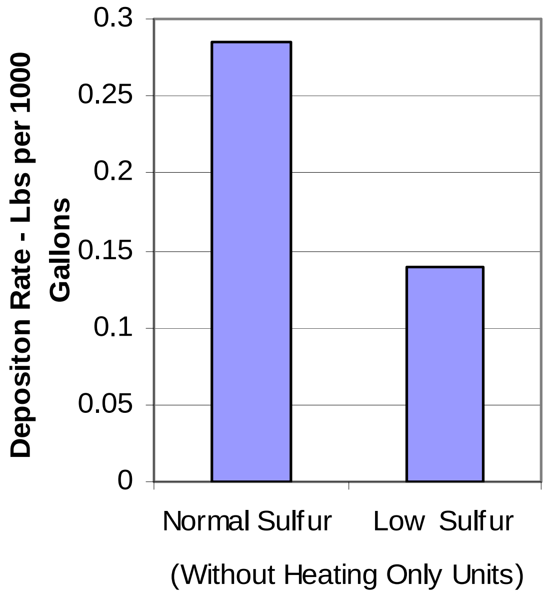
No . 2 heating fuel, 1.08% Sulfur by weight

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.

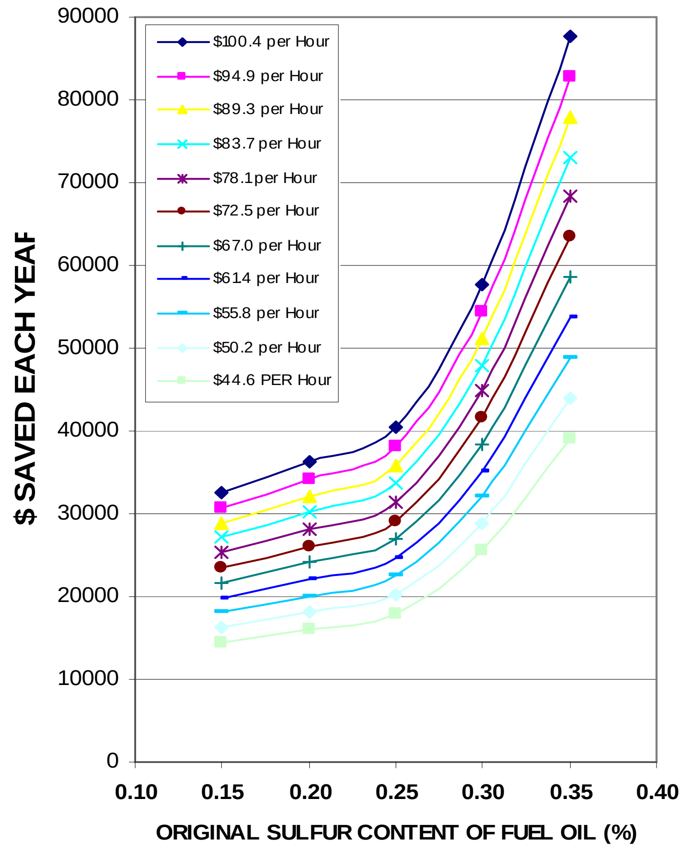
Figure 3-2: Measured Boiler Deposits – Normal and Low Sulfur Fuel Oil



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.

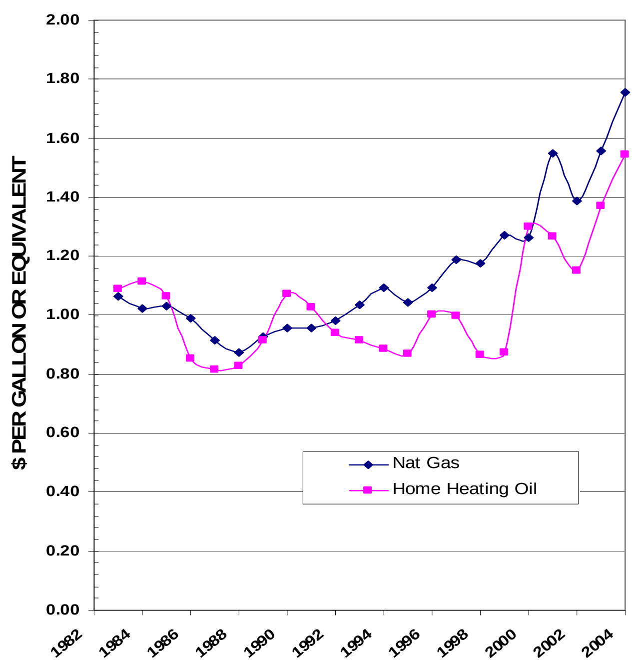
3.2. Added Cost for Lower Sulfur Heating Oil and Historic Fuel Prices

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.

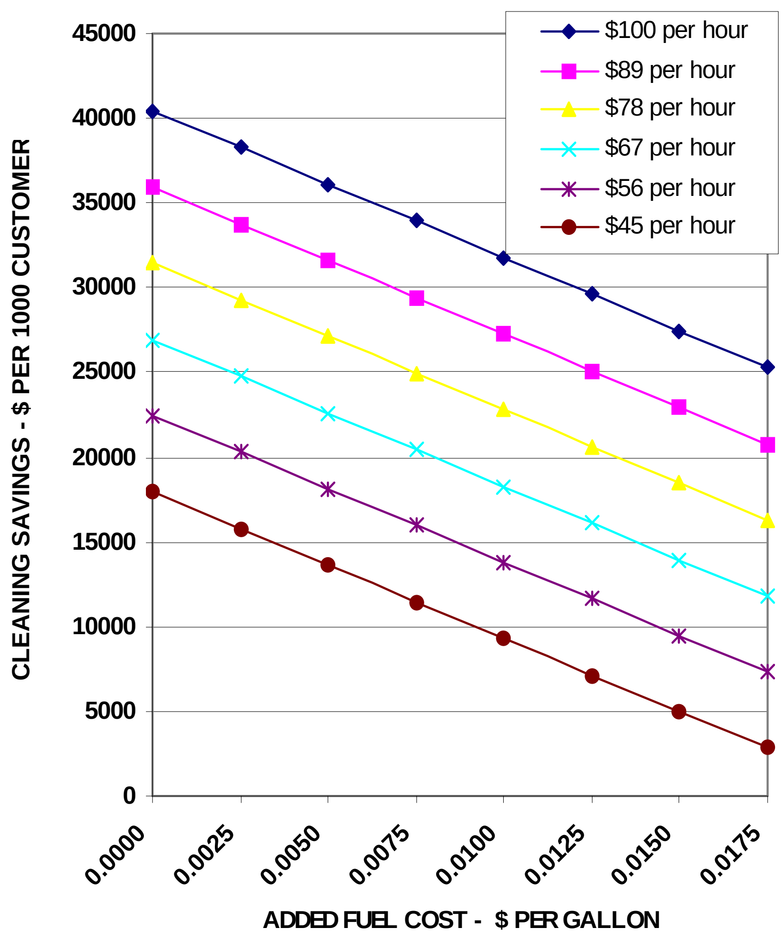
The added cost of low sulfur heating oil is on the order of 1.6 cents per gallon; representing approximately 1 percent of the average oil price. The incremental cost of low sulfur heating oil is much smaller than historical oil price fluctuations. Therefore, the added cost for lower sulfur heating oil 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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Low Sulfur Distillate and Residual Oil Strategy

MARAMA Workshop on
Energy & Air Quality Issues
September 23, 2008

Arthur Marin
NESCAUM

Regional Initiative for Low Sulfur Distillate/Residual Oil

- MANE-VU States have agreed to pursue low sulfur standards for distillate & residual fuel oil to reduce regional haze & particulate matter
- Strategy is among the most significant SO2 control options available in the region
- May end up being only regional haze emission control strategy to emerge out of the RPO planning processes

Rationale & Challenges of Low Sulfur Distillate Oil Strategy

- Distillate combustion is major source of SO2
- Fuel de-sulfurization is proven emission control strategy
- Implementation challenges are economic rather than technical
- 3 primary issues must be addressed:
  - Supply
  - Cost
  - Political viability

Goals of Presentation

- Review importance of fuel oil combustion as source of SO_2 emissions & the emission benefits of lowering fuel sulfur content
- Discuss supply issues
- Look at cost impacts of strategy
- Tee-up discussion of strategy for moving this program forward
- Focus is primarily on #2 distillate oil

Proposed Sulfur Requirements in MANE-VU Region

Geographic Region	500 ppm #2 Distillate	15 ppm #2 Distillate	0.25% (wt) #4 Oil	**0.3-0.5%** #6 Oil
Inner Zone (DE, NJ, NY, PA)	no later than 2012	2016	no later than 2012	no later than 2012
Outer Zone (all other states)	no later than 2014	2018 "depending on availability"	no later than 2018	no later than 2018

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Largest Sources of SO_2 Emission in the MANE-VU Region

Source Category	Emissions (tpy)	% of Regional Total
EGUs	1,628,333	71%
ICI Boilers	156,333	7%
Residential/Commercial Oil Heat Burners & Furnaces	153,225	7%

Largest Sources of SO_2 Emission in the NESCAUM Region

Source Category	Emissions (tpy)	% of Regional Total
EGUs	433,754	53%
Residential/Commercial Oil Heat Burners & Furnaces	120,508	15%
ICI Boilers	58,683	7%

Estimated Emission Benefits of 500 ppm Sulfur Heating Oil

(% reduction compared to 2,500 ppm sulfur fuel)

•Pollutant	500 ppm	15 ppm
SO_2	75 %	93%
PM	80 %	?
NOx[1]	10 %	?
Hg	?	?
CO_2	1%-2%%	1%-2%

Annual Emission Benefits in the MANE-VU Region of 500 ppm Sulfur Limit

2009	SO2	NOx	PM
Emissions 2,500 ppm fuel	176,742 tons	65,087 tons	6,541 tons
Projected Reductions 500 ppm	132,557 tons	6,509 tons	5,211 tons
Remaining Emissions	44,185 tons	58,578 tons	1,303 tons

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Annual SO2 Emission Benefits in the MANE-VU Region in 2018

2018	15 ppm #2 (from 2000+ ppm baseline)	5,000 ppm #4 & #6 (from 10,000 ppm baseline)	Total Reductions from Low Sulfur Oil Strategy
Emission Reductions	167,000 tons	19,000 tons	186,000 tons

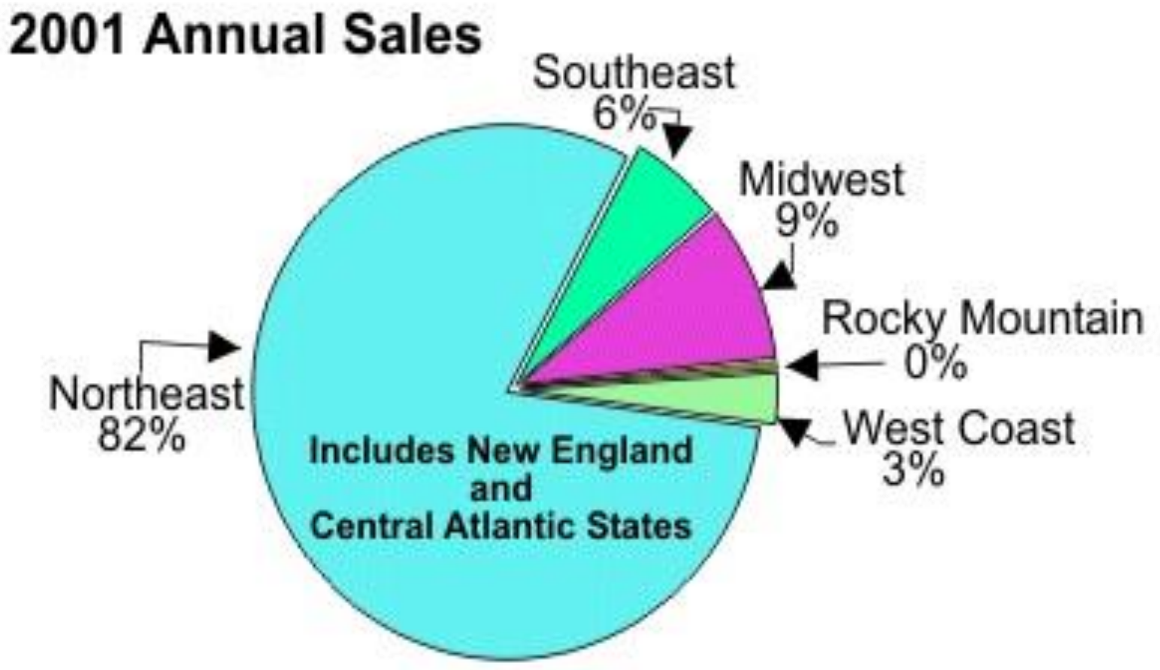
Supply Issues

- Dramatic changes in fuel composition are occurring on global scale due to sulfur regulation
- Heating oil is seasonal product with demand tied to vagaries of weather
- Offshore markets & reserves provide a “safety valve” for Northeast market during peak demand
- Response of offshore refiners to U.S. low sulfur regulations is uncertain in near-term

Heating Oil Market in the Region

- Collectively the Northeast/Mid-Atlantic States constitute one of the world's largest markets for heating oil
- In NESCAUM states, 55% of total distillate demand is for heating oil (42% residential/13% commercial)
- This compares to 38% for highway diesel

Regional Sale of Heating Oil



Source: EIA *Fuel Oil and Kerosene Sales, 2001.*
Note: Due to rounding, Rocky Mountain region appears as zero percent. Gulf Coast Sales too small to display.

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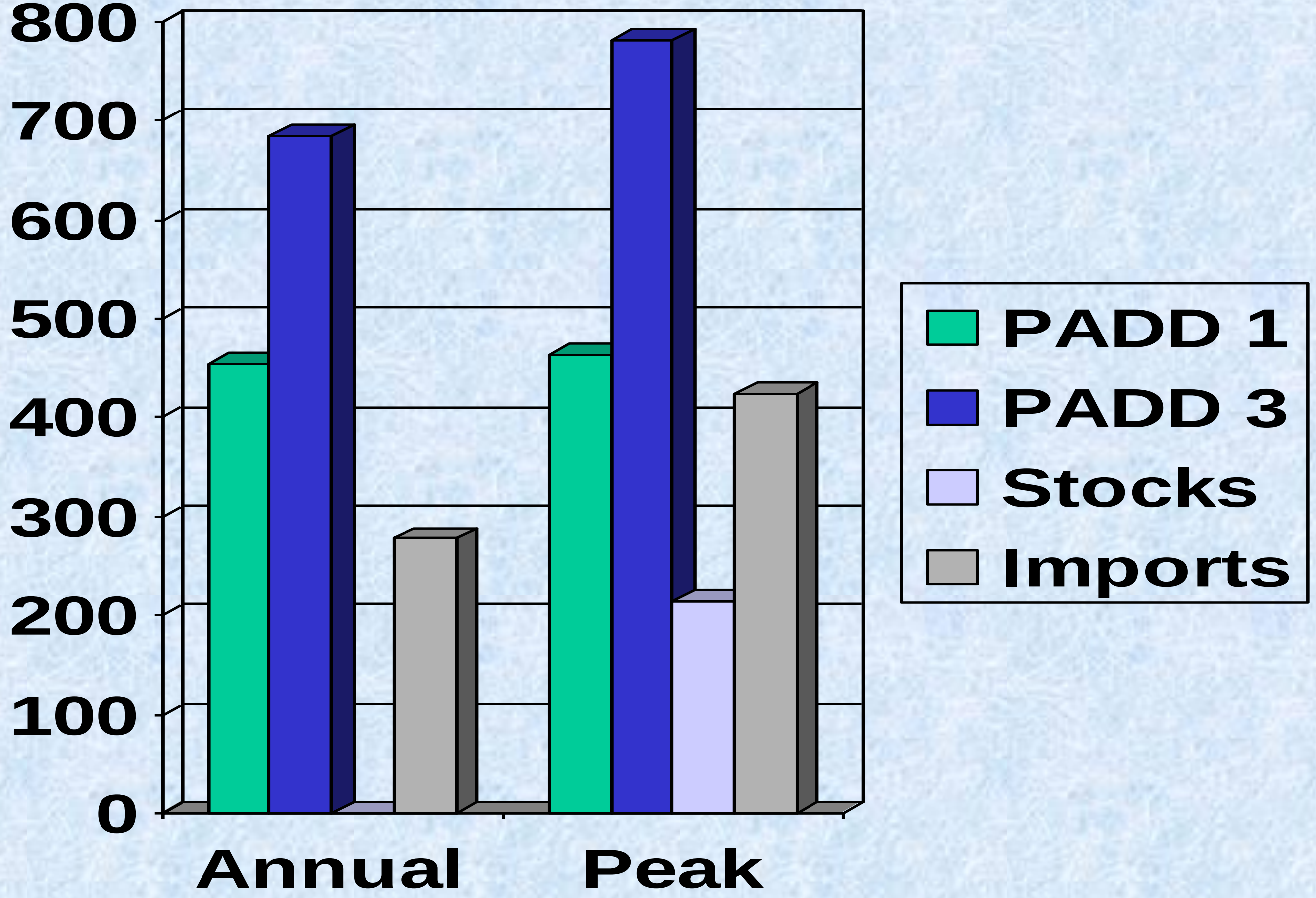
Sources of Northeast Distillate

(avg. 2001-04 in TBD)



Federal Diesel Sulfur Standards

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Who	Covered Fuel	2006	2007	2008	2009	2010	2011	2012	2013	2014
	Highway Diesel		80% 15 ppm / 20% 500 ppm			15	15	15	15	15
Large Refiner & Importer	Nonroad (NR)		500	500	500	15	15	15	15	15
Large Refiner & Importer	Loco/Marine (LM)		500	500	500	500	500	15	15	15
	NRLM w/Credits		HS	HS	HS	500	500	500	500	15
Small Refiner	NRLM		HS	HS	HS	500	500	500	500	15
Transmix & In-use	NR		HS	HS	HS	500	500	500	500	15
Transmix & In-use	LM		HS	HS	HS	500	500	500	500	500

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Meeting the Supply Demands of Mane-VU Low Sulfur Regulations

- In the past refiners, wholesalers and retailers have questioned their ability to meet the supply demands of this strategy
- However, a recent study conducted for the National Oilheat Research Alliance (NORA) suggests that supplies of low and ultra-low sulfur distillate should be available to meet the demands of the M-V program in the general timeframes laid out by the states

Supply & Demand

"With the rapid changes required through 2012, the low sulfur market will be strained and undergo a transition throughout the period. Any additional shift to <15 ppm for the Northeast market will further tighten and constrain supply. In the 2010 to 2012 period, most of the market will be moving from 500 ppm to <15 ppm. Adding a requirement for additional shift from 2000 or higher to <15 ppm will be more difficult and have a far greater marginal impact on the market"

Supply & Demand

"Shifting the heating oil to 500 ppm in 2012, would be more reasonable but would still add to what will likely be a constrained market. The 500 ppm standard may provide some positive synergies with other markets shifting from 500 ppm to <15 ppm"

Supply & Demand

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"By 2018, with the entire Northeast heating oil market at <15 ppm, the ultra low sulfur market will be about 94 percent of the market. Most supply sources will be marketing all or predominately ultra low sulfur distillate. The on-road and non-road diesel conversions to <15 ppm were complete more than 5 years earlier. Supplying the additional <15ppm product would not place significant strain on the market, assuming adequate notice was provided to suppliers"

Cost of Compliance

- Over a ten year period (1993-2003), the incremental cost between 2500 ppm and 500 ppm distillate averaged 1.5 cents per gallon
- Over past several years this delta has been higher, due in part to rapid changes in the oil industry as result of environmental regulations
- In the past year the gap has begun to close
- As market moves toward nearly all ULSD, the incremental cost of high, low and ultra-low product should normalize

Cost of Compliance

NORA study estimates:

- 6.3 to 6.8 cents/gal incremental production cost for 500 ppm vs. 2500 ppm sulfur distillate, including capital costs
- Cost will increase to as high as 8.9 cents/gal for 15 ppm
- However, where refiners have de-sulfurization capabilities, incremental cost of producing ultra low sulfur distillate will be less than 5 cents/gal

Cost vs. Price

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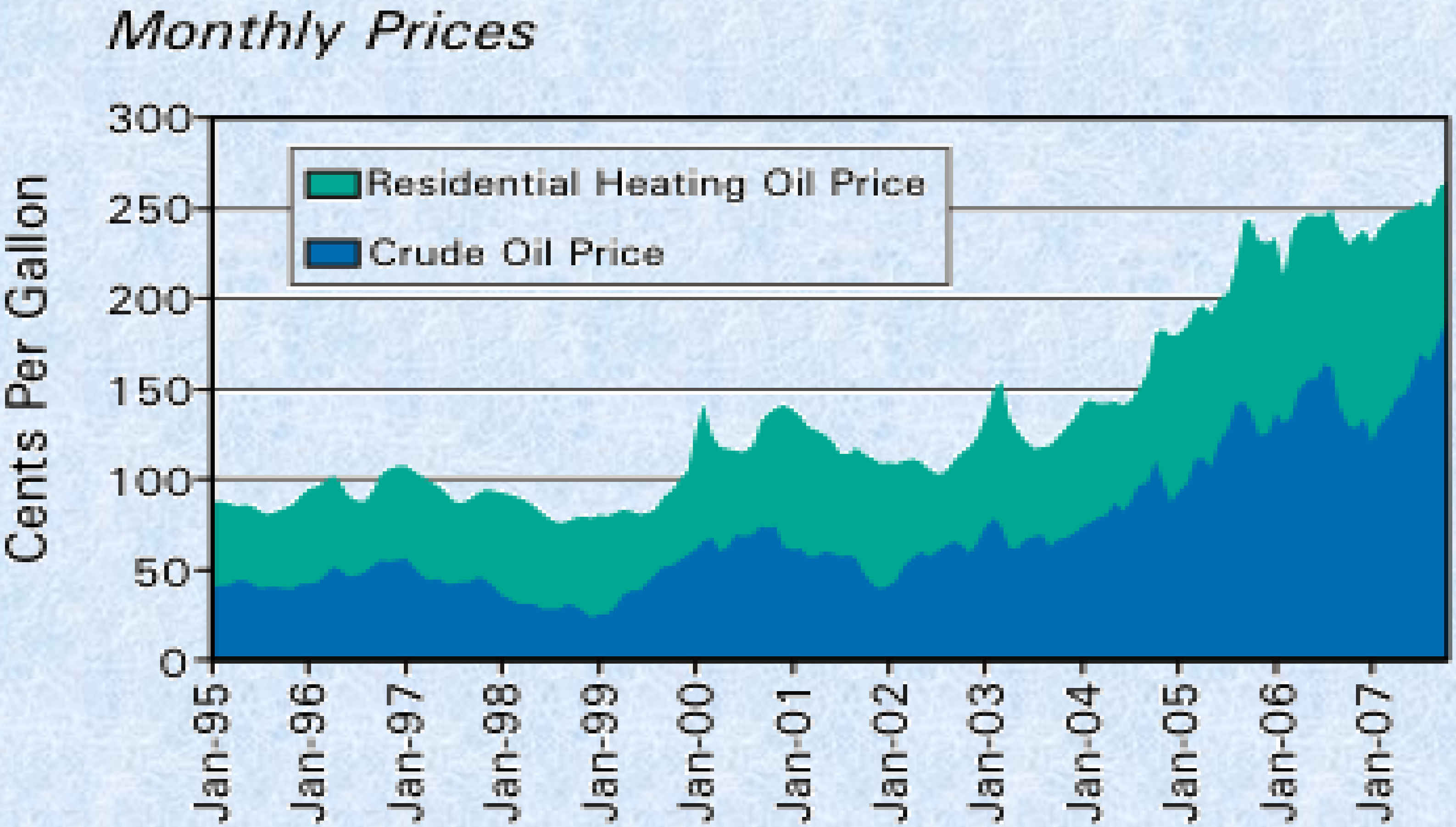
- Forces other than production costs will also play role in determining the price differential that consumers will pay for cleaner heating oil
- Relative cost of diesel fuel compared to gasoline this past year is good example
- Similarly, heating oil prices didn't always track well with crude oil prices
- It is difficult to predict actual price impact of low sulfur regs and of course this is what consumers & politicians want to know

Historical Price



Source: EIA, Petroleum Marketing Monthly, January 1995-present

Heating Price on NY Spot Market $/gallon

1-2-04	$1.01
1-2-05	$1.17
1-2-06	$1.77
1-2-07	$1.66
1-2-08	$2.73
7-14-08	$4.03

Comparative Price $/gal on NY Spot Market

	9/10/08	9/10/07
#2 Fuel Oil	$2.87	$2.21
500ppm Diesel	$2.94	$2.27
15ppm Diesel	$2.97	$2.33

Consumer Benefits of Low Sulfur Heating Oil

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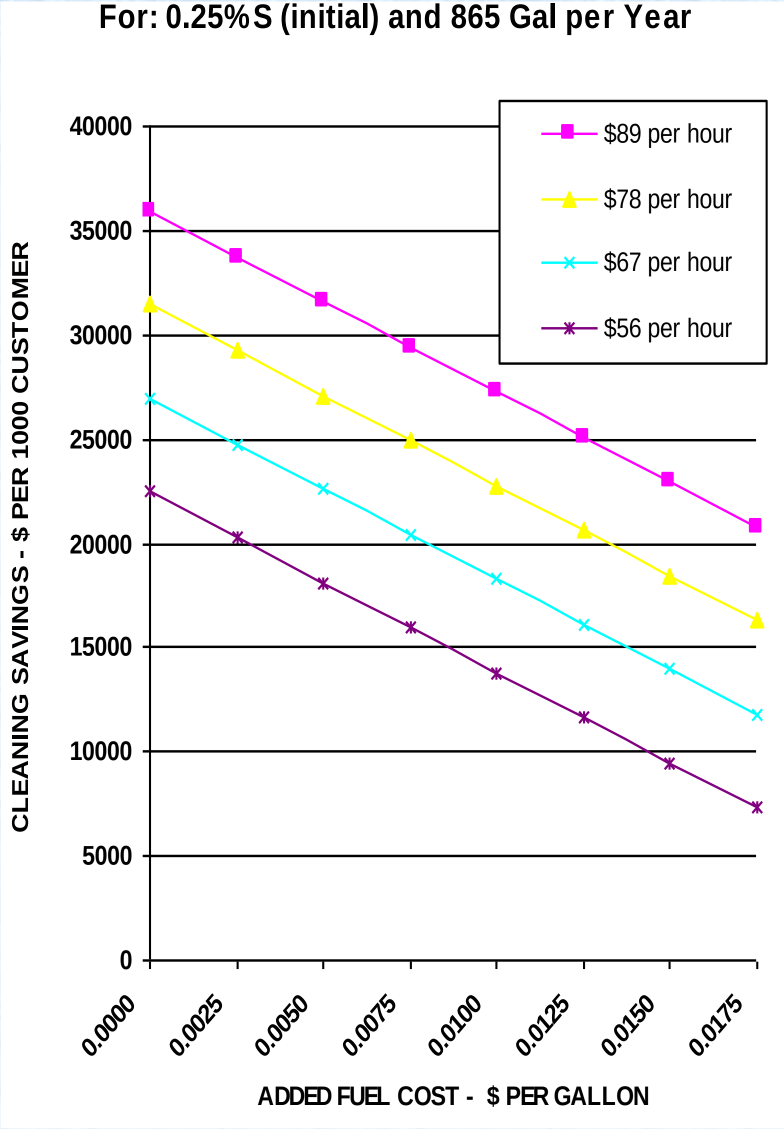
- Sulfur reductions can save consumer money
- Low sulfur heating oil reduces rate of fouling of heating equipment & therefore reduces maintenance
- Cleaner furnaces/boilers burn less fuel
- Table shows net cost savings per 1,000 households at various cost points



Politics of Adopting Low Sulfur Heating Standards

- Cost increment of cleaner fuel is tiny compared to other economic factors that have already increased price by 3x to 4x since states began to consider this strategy in 2004
- However, in light of the tremendous increase in heating oil prices over the past couple of seasons, heating costs are "prime time" political issue today
- States are concerned about their ability to get regulations through in this political climate without buy-in of industry & strong support from environmental community

Regional Initiative for Low Sulfur Distillate/Residual Oil

- States will need to clearly articulate both the environmental/public health & supply/cost impacts of this strategy
- Successful adoption and implementation of low sulfur strategy will likely hinge on states, industry, consumer groups & environmental community providing a unified message to Governors & state legislatures about the program's merit & viability

Oilheat Industry Perspective

- Oilheat dealers are generally supportive of lowering sulfur as means of “greening” their image relative to natural gas competitors
- In recent hearings in NYC, wholesalers & retailers voiced support for M-V approach & timeline
- Timing & avoiding patchwork of different requirements are key to this support
- Rapidly rising oil heat costs may temper industry support

Potential Next Steps

- Hold small meetings with:
  1. wholesalers
  2. retailers
  3. refiners
- Hold more public workshop/conference with above groups, energy officials, equipment manufacturers, consumer groups

Other Heating Oil Issues

- Biofuels
- Mercury in heating oil
- Low carbon fuel standard

Adding Biodiesel to Low Sulfur Heating Oil

- Biofuels can be blended with low sulfur diesel to further reduce emissions and extend heating oil supplies with domestic feedstocks
- Biofuels, including soy-based biodiesel, contain negligible amounts of sulfur and nitrogen and no mercury
- Biofuels can be produced locally from variety of materials

Benefits of Adding Biodiesel to Low Sulfur Heating Oil

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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)
SO_2	75%	84 %
PM	80	>80 %[1]
NO_x [1]	10	20 %
Hg	n/a	20 %[2]
CO_2	1-2%	17-18 %[3]

- 1 Additional PM reductions are expected, but no known test data exists to substantiate this assumption.
- 2 Value based on the assumption that biodiesel contains no mercury.
- 3 Does not include lifecycle emissions

Mercury Content of Heating Oil

- AP-42 emission factor suggests fairly high mercury content in heating oil
- Neither states, nor industry have been comfortable with this factor
- Northeast states raised this with EPA, but they never followed up
- NESCAUM secured funding from NYSERDA to conduct sampling of #2 & #6 oil to quantify Hg and metal content
- Major suppliers are providing samples

Hg Emission Factors

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	#2 Fuel Oil	#6 Fuel Oil
Study Report to Congress-1997	0.96 lbs./10^6 Gallons	1.1 lbs./10^6 Gallons
AP-42 1995 / EPCRA 2000	0.42 lbs./10^6 Gallons	0.113 lbs./10^6 Gallons
L&E Report 1997	0.86 lbs./10^6 Gallons	0.071 lbs./10^6 Gallons
EPCRA 1999	3.34 lbs./10^6 Gallons	0.04 lbs./10^6 Gallons
NHDES 2003	0.013 lbs./10^6 Gallons	0.415 lbs./10^6 Gallons
NESCAUM Preliminary Results	0.02 lbs./10^6 Gallons	**Not yet available**

Next Steps for Hg Study

- Study will be complete in 2009
- Assuming final results remain consistent with early sampling, Northeast states and heating oil industry intend to present results to EPA
- Goal is to convince EPA to modify the AP-42 emission factor as appropriate

Low Carbon Fuel Standard

- States in the region are exploring the viability of a low carbon fuel standard as a GHG reduction strategy
- Whereas CA is expected to include only transportation fuels, Northeast is considering including space heating fuels
- One of the options that is being evaluated is fuel switching from high carbon distillate oil to potentially lower carbon (on lifecycle basis) solid and gaseous fuels (wood, natural gas & propane)

2005 NESCAUM Evaluation for MANE-VU
using 2002 Data

Emissions (TPY)

State_FIPS	State	SO2 emissions					SO2 emissions from Residential/Commercial Distillate Oil Combustion (exclude engines)		
		Point	Area	OnRoad	NonRoad	Total	Area	Point	Area+Point
09	Connecticut	15,988.0	12,418.4	1,666.9	2,087.4	32,160.7	12,077.9	62.1	12,140.0
10	Delaware	73,743.9	1,588.4	583.9	3,983.3	79,899.5	1,209.6	20.3	1,229.9
11	District of Columbia	962.6	1,336.5	271.1	375.4	2,945.6	1,196.8	213.2	1,410.0
23	Maine	23,711.2	13,148.8	1,803.9	916.8	39,580.8	11,351.0	119.4	11,470.4
24	Maryland	290,926.7	12,393.2	4,057.6	7,941.6	315,319.1	6,028.4	31.6	6,060.0
25	Massachusetts	101,049.4	54,923.3	4,398.8	3,791.2	164,162.7	49,384.9	1,374.7	50,759.6
33	New Hampshire	46,559.7	7,071.8	776.9	891.0	55,299.4	5,649.3	18.1	5,667.5
34	New Jersey	61,217.2	10,743.6	3,648.6	15,686.0	91,295.5	8,401.3	46.9	8,448.2
36	New York	294,728.6	130,409.4	10,639.5	12,919.7	448,697.3	52,321.1	64.1	52,385.2
42	Pennsylvania	995,174.7	63,679.2	10,924.1	7,915.0	1,077,693.0	23,766.0	280.8	24,046.8
44	Rhode Island	2,666.4	4,556.9	425.3	377.2	8,025.8	4,533.1	197.5	4,730.6
50	Vermont	905.1	4,087.4	893.8	372.1	6,258.4	1,210.2	4.3	1,214.6
NESCAUM Total		546,825.7	237,359.7	24,253.8	37,041.3	845,480.5	144,929.0	1,887.1	146,816.1
MANE-VU - NESCAUM Total		1,360,808.0	78,997.3	15,836.6	20,215.3	1,475,857.2	32,200.7	546.0	32,746.7
MANE-VU Total		1,907,633.7	316,357.0	40,090.5	57,256.6	2,321,337.8	177,129.7	2,433.1	179,562.8

2005 NESCAUM Evaluation for MANE-VU
using 2002 Data

Emissions % fraction

State_FIPS	State	SO2 emissions					SO2 emissions from Residential/Commercial Distillate Oil Combustion (exclude engines)		
		Point	Area	OnRoad	NonRoad	Total	Area	Point	Area+Point
09	Connecticut	49.7%	38.6%	5.2%	6.5%	100.0%	37.6%	0.2%	37.7%
10	Delaware	92.3%	2.0%	0.7%	5.0%	100.0%	1.5%	0.0%	1.5%
11	District of Columbia	32.7%	45.4%	9.2%	12.7%	100.0%	40.6%	7.2%	47.9%
23	Maine	59.9%	33.2%	4.6%	2.3%	100.0%	28.7%	0.3%	29.0%
24	Maryland	92.3%	3.9%	1.3%	2.5%	100.0%	1.9%	0.0%	1.9%
25	Massachusetts	61.6%	33.5%	2.7%	2.3%	100.0%	30.1%	0.8%	30.9%
33	New Hampshire	84.2%	12.8%	1.4%	1.6%	100.0%	10.2%	0.0%	10.2%
34	New Jersey	67.1%	11.8%	4.0%	17.2%	100.0%	9.2%	0.1%	9.3%
36	New York	65.7%	29.1%	2.4%	2.9%	100.0%	11.7%	0.0%	11.7%
42	Pennsylvania	92.3%	5.9%	1.0%	0.7%	100.0%	2.2%	0.0%	2.2%
44	Rhode Island	33.2%	56.8%	5.3%	4.7%	100.0%	56.5%	2.5%	58.9%
50	Vermont	14.5%	65.3%	14.3%	5.9%	100.0%	19.3%	0.1%	19.4%
NESCAUM Total		64.7%	28.1%	2.9%	4.4%	100.0%	17.1%	0.2%	17.4%
MANE-VU - NESCAUM		92.2%	5.4%	1.1%	1.4%	100.0%	2.2%	0.0%	2.2%
MANE-VU Total		82.2%	13.6%	1.7%	2.5%	100.0%	7.6%	0.1%	7.7%

2002 MANE-VU Emissions Inventory Summary for SO2 Emissions – MANE-VU States

Source Category	SCC	Source Type	ANNUAL	
			Emissions (tons/year)	Percent of Total
External Combustion Boilers-Electric Generation	1010	Point	1,628,333	70
Residential/Commercial Distillate Oil Combustion	2103004xxx, 2104004xxx, 2199004xxx, 103005xx, 10500205	Point + Area	179,563	8
External Combustion Boilers-Industrial	1020	Point	156,333	7
Stationary Source Fuel Combustion-Industrial	2102	Area	66,138	3
Industrial Processes-Mineral Products	305	Point	47,759	2
Top Categories			2,078,126	90
Total SO2 Emissions			**2,321,338**	**100**

Northeast Heating Oil Assessment

Report Presented to:

National Oilheat Research Alliance

Submitted by:

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NORTHEAST HEATING OIL ASSESSMENT

I. Executive Summary

A. Background and Objectives

There have been a number of initiatives aimed at reducing the sulfur content of heating oil in the U.S. Northeast market. The Mid-Atlantic/Northeast Visibility Union (Mane-VU) has developed a position calling for 500 ppm sulfur for the inner zone states by 2012, reducing to 15 ppm by 2016. For the outer zone states, the position calls for 500 ppm in 2014 and 15 ppm in 2018.

The lower sulfur requirements have the potential to reduce supply availability, alter traditional supply sources, tighten low sulfur markets and place pressure on low sulfur product pricing.

The objective of this project and report is to assist the National Oilheat Research Alliance (NORA) and its membership in assessing the outlook for low sulfur heating oil supplies and the impact of low sulfur requirements in the U.S. Northeast on supply. The analysis provides a forecast of global and regional distillate and heating oil supply and demand by sulfur grade, including volume/timing for implementation of scheduled and anticipated low sulfur diesel and other distillate low sulfur programs. The analysis then identifies and quantifies capability of regional low sulfur distillate supply sources and specifically those supplying Northeast Oilheat markets. An assessment is provided of the impact of additional low sulfur requirements on supply.

B. Summary of Results

Global Distillate Markets and Trends

- Middle distillate will be the highest growth product globally. The shift to distillate will place pressure on refining supply and yield capability and market price differentials.
- North American distillate will grow at 1.6 percent annually, driven primarily by growth in on-road diesel.
- Europe, already experiencing a product mix imbalance, will continue to shift to diesel. Europe will look to outside sources for incremental diesel supply.
- Asia Pacific (primarily India) will be a source on near term (2012) supply for the Atlantic Basin. Longer term, the Middle East will be an incremental supply source for the Atlantic Basin.
- With global lower sulfur requirements focused primarily on on-road diesel (particularly in the near term), on-road diesel growth will increase pressure on low sulfur markets and refining production capability.

Northeast Heating oil Market

- About 40 percent of Northeast distillate and 36 percent of heating oil is supplied by U.S. East Coast refineries. Gulf Coast refineries provide an additional 33 percent of total distillate and 38 percent of the heating oil supply. The Virgin Islands and Eastern Canadian refineries make up a little over 15 percent of Northeast heating oil supply.
- Venezuela and Russia account for 10 percent of Northeast heating oil supply. They represent a major incremental supply source and most of the product originating from international market sources.

Distillate Quality Requirements

- There will be a major shift to ultra low sulfur distillate in the Atlantic Basin region by 2012. About 76 percent of distillate will be 50 ppm sulfur or less by 2012 versus 48 percent in 2006. The share of 500 ppm distillate will decline from 14 percent to 4 percent over this period.
- The shift to lower sulfur will continue through 2018, but at a slower pace. By 2018, 86 percent of Atlantic Basin distillate will have to be 50 ppm or less.

Distillate/Low Sulfur Production Capability

- Tightening global refining capacity and favorable refining economics have stimulated investment in refining capacity worldwide. Investments scheduled or anticipated in the Atlantic Basin will add distillate production capability to meet most of incremental distillate volume for 2012 and 2018. Additional expansion in India and the Middle East will provide sources of incremental product.
- Capacity additions identified and projected will fall short of ultra low sulfur distillate requirements. Additional refining investments and capacity revamps are likely, but low sulfur production capability will be tight at least through 2012. Beyond 2012 the pace of low sulfur requirements will slow and additional time is available for new long term projects to develop.

Assessment of Impact of Additional Northeast Low Sulfur Requirements

- Despite the expansion of potential supply sources, the 2006 to 2012 shift in market to ultra low sulfur is large and will occur over a short and limited time period, particularly coming on the heels of the initial on-road diesel requirement initiated in 2006.
- With the rapid changes required through 2012, the low sulfur market will be strained and undergo a transition throughout the period. Any additional shift to <15 ppm for the Northeast market will further tighten and constrain supply. In the 2010 to 2012 period, most of the market will be moving from 500 ppm to <15 ppm. Adding a requirement for additional shift from 2000 or higher to <15 ppm will be more difficult and have a far greater marginal impact on the market. Given the timing for other diesel product transition to ultra low sulfur (some starting in 2010), planning is well along and may be difficult to alter.
- Shifting the heating oil to 500 ppm in 2012, would be more reasonable but would still add to what will likely be a constrained market. The 500 ppm standard may provide some positive synergies with other markets shifting from 500 ppm to <15 ppm. Suppliers could

optimize on which supply sources provided the most feasible and economic source of the ultra low sulfur product and which to target for 500 ppm. A 500 ppm standard may also be better suited in suppliers ultra low sulfur planning.

- Venezuela will have no low or ultra low sulfur requirements in place by 2012 and will not likely have capability to supply any low sulfur product. It is doubtful that Venezuela will be capable of supplying <15 ppm or 500 ppm product in 2012.
- Russia has limited capability to supply <15 ppm and will internally be transitioning to the ultra low sulfur product. Russia will have insufficient supply for its own market. Given its internal demand and shortfall in supply capability, Russia will not be capable of supplying <15 ppm and will be very limited in its ability to supply any 500 ppm product.
- There will be a need for a large amount of capacity to reduce 500 ppm diesel to <15 ppm by 2012, above that announced, identified or assumed available through capacity creep. The increased refining capability will fall short of ultra low sulfur production capability. A requirement for <15 ppm in the Northeast will further constrain the system. On the other hand, the increased distillate production capability will likely provide some opportunity for incremental supply of 500 ppm product. Given the overall low sulfur constraints, an additional 500 ppm requirement will have an impact in the constrained market, but some product could likely be produced with minimal impact.
- There will be some additional opportunity for low sulfur supply from India in 2012. The product may replace some of that lost from Russia and Venezuela if heating oil sulfur is reduced.
- By 2018, with the entire Northeast heating oil market at <15 ppm, the ultra low sulfur market will be about 94 percent of the market. Most supply sources will be marketing all or predominately ultra low sulfur distillate. The on-road and non-road diesel conversions to <15 ppm were complete more than 5 years earlier. Supplying the additional <15ppm product would not place significant strain on the market, assuming adequate notice was provided to suppliers.
- By 2018, Russia is expected to have completed its transition to ultra low sulfur. By then most product will be ultra low sulfur. Some supply will likely be available for the Northeast market, but less than current. There will still be some pressure for converting non-road and heating oil to lower sulfur. Europe, will increasingly be relying on imports, and will compete for incremental ultra low sulfur product.
- Venezuela will move slowly on sulfur reduction and is projected to be at 500 ppm for on-road diesel by 2018. It is questionable that Venezuela will be capable of supplying <15 ppm product in 2018. A limited supply of 500 ppm may be available.
- For 2018, refinery expansions will cover much of the required ultra low sulfur needs. Given the time for transition, an ultra low sulfur requirement for Northeast heating oil will not have adverse market impacts. A key to the 2018 balance is the Eastern Canadian refinery status.
- By 2018, supplies available from India will decline, but the Middle East will significantly increase supply potential. Europe will compete for an additional <15 ppm product when it becomes available.

Distillate Cost and Price Implications

- The cost of producing 500 ppm versus high sulfur distillate is estimated at 6.3 to 6.8 cents per gallon, including capital cost. The costs will increase to as high as 8.9 cents per gallon for <15 ppm sulfur. Where refiners have existing desulfurization facilities which can be revamped for lower sulfur operation, incremental costs for producing ultra low can be as much as 4 cents per gallon lower.

- Price differentials will continue to reflect a minimum premium of at least capital and operating costs. As long as ultra low sulfur programs are expanding and capital investment is required, the markets will justify full capital charge premiums. Markets are projected to be relatively tight through 2012, and therefore volatility in premiums (and high premiums) should be seen, particularly as new requirements are implemented.
- Longer term, as more refinery and desulfurization capacity comes on and the pace of low sulfur implementation slows, the premiums will be less volatile and at times may fall a little below full capital charge. Refinery E&C and equipment costs should ease after 2012 to 2014, easing premiums slightly.

II. Study Overview and Approach

A. Overview

The objective of the Northeast Heating Oil Assessment is to provide an assessment of the outlook for low sulfur heating oil supply and the impact of low sulfur requirements in the U.S. Northeast on supply potential. Historically, global distillate markets consisted of low sulfur on-road diesel (~500 ppm sulfur), high sulfur non-road diesel and heating oil. The on-road market represented less than 60 percent of the pool and low sulfur diesel was required primarily in major industrialized countries.

Some non-road diesel and heating oils were subjected to modest sulfur restrictions, which could be met with minimal refinery treatment. Essentially, most of the international global distillate pool was suitable for the U.S. Northeast heating oil market.

More recently, the on-road diesel pool has increased faster than other distillate. Sulfur requirements have become more stringent, low sulfur requirements are expanding to other on-road diesel markets and low sulfur requirements are also expanding to non-road diesel and heating oil applications.

As more stringent sulfur requirements are expanded throughout international distillate markets, the lower sulfur markets will initially have more limited supply sources, and will be dependent on refining investment in facilities to produce a lower sulfur pool. In the longer term, lower sulfur product will represent a greater market share, refining will adjust to those market needs and lower sulfur distillate will become more readily available.

This assessment examines factors that will impact future supply of low sulfur distillates and in particular supplies in markets which will impact the Northeast heating oil market.

The study identifies trends in distillate sulfur requirements, refining investment and shifting low sulfur supply and demand.

B. Approach

The Northeast Heating Oil Assessment first quantifies trends in global distillate market, including trends in supply, demand and global product trade. The review then focuses on the Northeast market and identifies demand and trends in sources of supply and quality. Section III of the report summarizes global refined product and distillate supply demand and net imports for 2006, 2012 and 2018.

Section IV focuses on the North American distillate market and diesel and heating oil in the Northeast. The Northeast market is characterized in terms of sulfur content and supply sources. A base projection of future supply and sulfur content is developed assuming current Northeast heating oil sulfur requirements.

The characterizations in Sections III and IV identify trends in market supply sources and potential incremental supply sources. For the Northeast market, the assessment quantifies the relative contribution of supply sources for diesel and heating oil by sulfur content. These trends will impact potential supply of low sulfur distillates and availability of supply for the Northeast heating oil market.

The assessment then identifies diesel and heating oil sulfur programs and requirements through 2018, including sulfur initiatives underway and projections of likely future developments. Based on these quality trends and the demand projections, projections of regional/country demand by sulfur content are developed. Section V provides a projection of regional and country distillate demand by sulfur content for 2012 and 2018. The projections assess the size of future low and high sulfur markets in Eastern North America and regional/countries which impact Northeast distillate supply.

In Section VI changes in supply capability for distillate and low sulfur distillate are examined for 2012 and 2018. Expansion projects including scheduled and anticipated refinery projects are projected for 2012 and 2018. An assessment is made of the additional distillate and low sulfur distillate available from expanded refinery capacity.

Section VII then provides a qualitative assessment of the impact of incremental low sulfur heating oil demand in the Northeast on supply. Trends in market penetration of low sulfur diesel and heating oil and the timing of low sulfur initiatives are examined to provide an indication of the portion of diesel and heating oil supply shifting to low sulfur. As the share of low and ultra low sulfur diesel and heating oil increases, the sources of supply for low sulfur are expanded and refining capacity will be reconfigured for greater low sulfur production capability.

The assessment also looks at timing of low sulfur requirements, anticipated low sulfur production capability and traditional sources of supply to the Northeast heating oil market. The potential availability of additional 500 ppm or <15 ppm heating oil for the Northeast market is addressed based on the projected market environment, refining capability and status of traditional supply sources.

The assessment in Section VII first focuses on the Northeast market and then on the overall Atlantic Basin system which will impact this market.

Finally, low sulfur distillate production costs and market pricing trends are examined in Section VIII.

C. Regional Definitions

Section III provides global supply with regional breakdowns as defined below. The global regions have been defined to reflect major refining and demand centers and consistency with Hart Energy Consulting's internal data base. The North American region is further divided into refining and demand sub regions also defined below. In subsequent sections, an Atlantic Basin region is defined reflecting areas with greatest potential impact on the Northeast heating oil market. The regions reported are defined below.

Global

North America – includes United States, Canada and Puerto Rico/Virgin Islands.

Latin America – Mexico, Central America, Non-U.S. Caribbean and South America

Europe – European Union and other non-EU countries of Western and Eastern Europe, excluding CIS countries.

CIS – Russia and other Commonwealth Independent State countries.

Asia Pacific – Australasian region, Southeast Asia and Asian continent.

Middle East – Persian Gulf and other Middle East regions excluding Afghanistan and Pakistan.

Africa – African continent.

North America

East North America – U.S. PADD 1, Eastern Canada and Puerto Rico Virgin Islands. This region operates an an integrated refined products supply system.

Mid Continent – U.S. PADDs 2 and 4 and Western Canada

Gulf Coast – U.S. PADD 3

West Coast – U.S. PADD 5.

Atlantic Basin

East North America – As defined above.

Gulf Coast – As defined above, a major supplier to East North America and the Northeast market.

Mid Continent – As defined above. While not closely linked to the Eastern North American market, also draws from Gulf Coast for a large portion of supply.

Latin America – Major Latin American countries integrated with North American supply and or undergoing changes in diesel and heating oil quality requirements. Includes Argentina, Brazil, Mexico, Venezuela and Columbia.

Europe – As defined above

CIS – As defined above

Northeast Market

Northeast Market – New England states and New York, New Jersey, Pennsylvania, and Delaware.
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III. Global/Regional Refined Product and Distillate Supply/Demand

A. Refined Product Supply and Demand Trends

Tables III.1 through III.3 summarize global and regional refined product supply and demand for 2006, 2012 and 2018. For each region the tables show refined product production, demand and net product imports. The tables summarize overall trends in production sources (refining) and trade flow.

Globally, middle distillate will be the highest growth product. Middle distillate will increase 2.1 percent per year versus 1.5 percent for gasoline and 1.6 percent for all other products. Approximately 34 percent of incremental refined product demand will be middle distillate. Currently, middle distillate accounts for only 28 percent of demand. The shift to distillates will place increasing pressure on refining distillate supply and yield capability and market price differentials.

North American demand will grow by approximately 1 percent annually. Refined product growth will be met largely by increased output from indigenous refining. The growth in imports shown will consist primarily of LPG.

European growth in demand will be low, less than 0.6 percent annually. More significant is the anticipated shift in product demand from gasoline to distillate. Gasoline demand will decline by 1.2 percent per year while distillate grows by 1.1 percent. The distillate growth will be driven by increased dieselization of the automotive fleet. Europe will continue to experience a surplus of gasoline and will need to increase distillate imports to meet demand.

Latin America product demand will increase by nearly 2 percent annually. Indigenous refining will supply most incremental product.

Elsewhere, Asia Pacific will account for the largest portion of global growth in refined product demand. Product demand in the region will rise by about 2.7 percent annually and will account for 48 percent of global growth in demand.

Longer term, the Middle East will be the marginal supplier of refined product demand. Middle East producers plan large expansions of merchant refining capacity for the export market. Initially (through 2012), most capacity expansion in the Middle East will be required to serve local demand which is anticipated to grow by over 3 percent annually. Product exports are projected to remain relatively stable through 2012. Between 2012 and 2018, Middle East refined product exports will escalate by nearly 1.2 million barrels per day. Distillate exports will increase by 870 thousand barrels per day. The Asia pacific and European markets will be the primary markets for long term Middle East exports.

Through 2012, most global refining expansion will occur in the Asia Pacific region (primarily India and China). Net product imports to the region will decline between 2006 and 2012. Most significant is the Reliance refining project scheduled to begin start up at the end of this year. Longer term product growth in the region will absorb output from the initial wave of refining expansion and product imports are projected to eventually grow.

Table III.1: Global/Regional Refined Product Supply and Demand: 2006 (thousand barrels per day)

North America	Production	Net Imports	Demand
Gasoline	9350	720	10070
Jet Fuel/Kerosene	1710	120	1830
Middle Distillate	4790	-40	4750
Residual Fuel	880	-10	870
LPG/Naphtha/Other	5110	220	5330
Total	**21840**	**1010**	**22850**

Europe	Production	Net Imports	Demand
Gasoline	3540	-810	2730
Jet Fuel/Kerosene	1010	330	1340
Middle Distillate	5900	670	6570
Residual Fuel	2050	-60	1990
LPG/Naphtha/Other	4200	280	4480
Total	**16700**	**410**	**17110**

Latin America	Production	Net Imports	Demand
Gasoline	1990	-70	1920
Jet Fuel/Kerosene	360	-60	300
Middle Distillate	1890	140	2030
Residual Fuel	1120	-200	920
LPG/Naphtha/Other	1870	30	1900
Total	**7230**	**-160**	**7070**

CIS	Production	Net Imports	Demand
Gasoline	1100	-180	920
Jet Fuel/Kerosene	280	-10	270
Middle Distillate	1510	-670	840
Residual Fuel	990	-490	500
LPG/Naphtha/Other	1190	-70	1120
Total	**5070**	**-1420**	**3650**

Asia Pacific	Production	Net Imports	Demand
Gasoline	4150	-50	4100
Jet Fuel/Kerosene	2350	-80	2270
Middle Distillate	6970	50	7020
Residual Fuel	2970	920	3890
LPG/Naphtha/Other	6500	1500	8000
Total	**22940**	**2340**	**25280**

Middle East	Production	Net Imports	Demand
Gasoline	1050	210	1260
Jet Fuel/Kerosene	750	-320	430
Middle Distillate	1910	-330	1580
Residual Fuel	1450	-80	1370
LPG/Naphtha/Other	3110	-1700	1410
Total	**8270**	**-2220**	**6050**

Africa	Production	Net Imports	Demand
Gasoline	510	180	690
Jet Fuel/Kerosene	260	20	280
Middle Distillate	860	180	1040
Residual Fuel	530	-80	450
LPG/Naphtha/Other	1060	-260	800
Total	**3220**	**40**	**3260**

Total World	Production	Net Imports	Demand
Gasoline	21690	0	21690
Jet Fuel/Kerosene	6720	0	6720
Middle Distillate	23830	0	23830
Residual Fuel	9990	0	9990
LPG/Naphtha/Other	23040	0	23040
Total	**85270**	**0**	**85270**

Table III.2: Global/Regional Refined Product Supply and Demand: 2012
(thousand barrels per day)

North America	Production	Net Imports	Demand
Gasoline	9920	710	10630
Jet Fuel/Kerosene	1830	110	1940
Middle Distillate	5290	-40	5250
Residual Fuel	940	0	940
LPG/Naphtha/Other	5390	340	5730
Total	**23370**	**1120**	**24490**

Europe	Production	Net Imports	Demand
Gasoline	3260	-770	2490
Jet Fuel/Kerosene	1220	330	1550
Middle Distillate	6360	740	7100
Residual Fuel	1830	-60	1770
LPG/Naphtha/Other	4550	300	4850
Total	**17220**	**540**	**17760**

Latin America	Production	Net Imports	Demand
Gasoline	2360	-40	2320
Jet Fuel/Kerosene	410	-60	350
Middle Distillate	2160	150	2310
Residual Fuel	1050	-200	850
LPG/Naphtha/Other	2110	-30	2080
Total	**8090**	**-180**	**7910**

CIS	Production	Net Imports	Demand
Gasoline	1140	-150	990
Jet Fuel/Kerosene	330	-10	320
Middle Distillate	1660	-680	980
Residual Fuel	940	-490	450
LPG/Naphtha/Other	1340	-120	1220
Total	**5410**	**-1450**	**3960**

Asia Pacific	Production	Net Imports	Demand
Gasoline	5070	-80	4990
Jet Fuel/Kerosene	2700	-80	2620
Middle Distillate	8520	-130	8390
Residual Fuel	3230	920	4150
LPG/Naphtha/Other	8400	1630	10030
Total	**27920**	**2260**	**30180**

Middle East	Production	Net Imports	Demand
Gasoline	1520	140	1660
Jet Fuel/Kerosene	780	-310	470
Middle Distillate	2130	-220	1910
Residual Fuel	1920	-90	1830
LPG/Naphtha/Other	3720	-1800	1920
Total	**10070**	**-2280**	**7790**

Africa	Production	Net Imports	Demand
Gasoline	570	190	760
Jet Fuel/Kerosene	280	20	300
Middle Distillate	1090	180	1270
Residual Fuel	550	-80	470
LPG/Naphtha/Other	1050	-320	730
Total	**3540**	**-10**	**3530**

Total World	Production	Net Imports	Demand
Gasoline	23840	0	23840
Jet Fuel/Kerosene	7550	0	7550
Middle Distillate	27210	0	27210
Residual Fuel	10460	0	10460
LPG/Naphtha/Other	26560	0	26560
Total	**95620**	**0**	**95620**

Table III.3: Global/Regional Refined Product Supply and Demand: 2018 (thousand barrels per day)

North America	Production	Net Imports	Demand
Gasoline	10400	650	11050
Jet Fuel/Kerosene	1960	100	2060
Middle Distillate	5750	-20	5730
Residual Fuel	940	0	940
LPG/Naphtha/Other	5480	480	5960
Total	**24530**	**1210**	**25740**

Europe	Production	Net Imports	Demand
Gasoline	3080	-710	2370
Jet Fuel/Kerosene	1470	330	1800
Middle Distillate	6600	890	7490
Residual Fuel	1730	-60	1670
LPG/Naphtha/Other	4670	330	5000
Total	**17550**	**780**	**18330**

Latin America	Production	Net Imports	Demand
Gasoline	2730	-20	2710
Jet Fuel/Kerosene	480	-50	430
Middle Distillate	2480	170	2650
Residual Fuel	950	-200	750
LPG/Naphtha/Other	2370	-60	2310
Total	**9010**	**-160**	**8850**

CIS	Production	Net Imports	Demand
Gasoline	1110	-110	1000
Jet Fuel/Kerosene	360	-10	350
Middle Distillate	1790	-680	1110
Residual Fuel	920	-480	440
LPG/Naphtha/Other	1480	-180	1300
Total	**5660**	**-1460**	**4200**

Asia Pacific	Production	Net Imports	Demand
Gasoline	5940	10	5950
Jet Fuel/Kerosene	2930	-50	2880
Middle Distillate	9250	560	9810
Residual Fuel	3290	910	4200
LPG/Naphtha/Other	9970	1730	11700
Total	**31380**	**3160**	**34540**

Middle East	Production	Net Imports	Demand
Gasoline	2110	0	2110
Jet Fuel/Kerosene	850	-340	510
Middle Distillate	3300	-1090	2210
Residual Fuel	1920	-90	1830
LPG/Naphtha/Other	4230	-1920	2310
Total	**12410**	**-3440**	**8970**

Africa	Production	Net Imports	Demand
Gasoline	700	180	880
Jet Fuel/Kerosene	310	20	330
Middle Distillate	1350	170	1520
Residual Fuel	570	-80	490
LPG/Naphtha/Other	1220	-380	840
Total	**4150**	**-90**	**4060**

Total World	Production	Net Imports	Demand
Gasoline	26070	0	26070
Jet Fuel/Kerosene	8360	0	8360
Middle Distillate	30520	0	30520
Residual Fuel	10320	0	10320
LPG/Naphtha/Other	29420	0	29420
Total	**104690**	**0**	**104690**

B. Distillate Product Supply and Demand Trends

Tables III.4 through III.6 summarize global/regional middle distillate supply and demand for 2006, 2012 and 2018. The tables show production, demand and net imports as in the previous tables and provide a breakdown of the distillate pool into on-road diesel, other transport diesel, other non-road diesel (industrial, agriculture, etc), and heating oil. Additionally, the projections identify major trends in production sources and trade flow.

Globally, growth in distillate demand will be driven by on-road diesel. On-road diesel will increase 2.4 percent per year versus 1.6 percent for other distillates. With global lower sulfur requirements focused primarily on on-road diesel (particularly in the near term), on-road diesel growth will build pressure on low sulfur markets and refining production capability.

North American distillate is projected to grow at 1.6 percent annually, driven primarily by growth in on-road diesel (over 2 percent annual growth). Non-road diesel plus heating oil will grow by only 0.7 percent. Little change is anticipated in trade flow.

Latin American distillate will rise by 2.2 percent annually. Local refining will fall short of this growth and Latin America, currently a major heating oil supplier to the U.S., will become increasingly tight on supply and will as a region increase net imports.

As noted previously, Europe will experience a strong shift toward diesel and will increase reliance on imported supplies. Europe will look to supply sources outside the Atlantic Basin.

The CIS (primarily Russia), another major source of U.S. heating oil supply, will experience 2.3 percent growth in middle distillate. Local production increases are anticipated to cover the increased demand.

Distillate demand in the high growth Middle East and Asia Pacific regions will grow by 2.8 percent annually. By 2012, the scheduled refinery expansions in Asia Pacific will provide more than required distillate volume and exports volumes will rise. The Middle East will initially reduce exports, but as major refinery expansion projects are completed post 2012, distillate exports will increase significantly, i.e., to over 1 million barrels per day. The Middle East will be the long term marginal global supplier for distillates.

Asia Pacific (primarily India) will be a source on near term (2012) supply for the Atlantic Basin. Longer term, the Middle East will be an incremental supply source for the Atlantic Basin.

Table III.4: Global/Regional Middle Distillate Supply and Demand: 2006 (thousand barrels per day)

North America	Production	Net Imports	Demand
On-road Diesel	2990	0	2990
Other Transport	410	-10	400
Other Diesel	770	-70	700
Heating Oil	620	40	660
Total	**4790**	**-40**	**4750**

Europe	Production	Net Imports	Demand
On-road Diesel	3640	370	4010
Other Transport	320	40	360
Other Diesel	690	130	820
Heating Oil	1250	130	1380
Total	**5900**	**670**	**6570**

Latin America	Production	Net Imports	Demand
On-road Diesel	1190	130	1320
Other Transport	90	10	100
Other Diesel	520	30	550
Heating Oil	90	-30	60
Total	**1890**	**140**	**2030**

CIS	Production	Net Imports	Demand
On-road Diesel	700	-380	320
Other Transport	140	-40	100
Other Diesel	420	-110	310
Heating Oil	250	-140	110
Total	**1510**	**-670**	**840**

Asia Pacific	Production	Net Imports	Demand
On-road Diesel	3260	40	3300
Other Transport	740	0	740
Other Diesel	1850	10	1860
Heating Oil	1120	0	1120
Total	**6970**	**50**	**7020**

Middle East	Production	Net Imports	Demand
On-road Diesel	1090	-270	820
Other Transport	10	0	10
Other Diesel	380	-30	350
Heating Oil	430	-30	400
Total	**1910**	**-330**	**1580**

Africa	Production	Net Imports	Demand
On-road Diesel	410	110	520
Other Transport	50	0	50
Other Diesel	250	40	290
Heating Oil	150	30	180
Total	**860**	**180**	**1040**

Total World	Production	Net Imports	Demand
On-road Diesel	13280	0	13280
Other Transport	1760	0	1760
Other Diesel	4880	0	4880
Heating Oil	3910	0	3910
Total	**23830**	**0**	**23830**

Table III.5: Global/Regional Middle Distillate Supply and Demand: 2012 (thousand barrels per day)

North America	Production	Net Imports	Demand
On-road Diesel	3410	0	3410
Other Transport	450	-10	440
Other Diesel	810	-70	740
Heating Oil	620	40	660
Total	**5290**	**-40**	**5250**

Europe	Production	Net Imports	Demand
On-road Diesel	4180	440	4620
Other Transport	340	40	380
Other Diesel	610	120	730
Heating Oil	1230	140	1370
Total	**6360**	**740**	**7100**

Latin America	Production	Net Imports	Demand
On-road Diesel	1380	140	1520
Other Transport	100	10	110
Other Diesel	580	30	610
Heating Oil	100	-30	70
Total	**2160**	**150**	**2310**

CIS	Production	Net Imports	Demand
On-road Diesel	760	-390	370
Other Transport	150	-40	110
Other Diesel	490	-110	380
Heating Oil	260	-140	120
Total	**1660**	**-680**	**980**

Asia Pacific	Production	Net Imports	Demand
On-road Diesel	4130	-120	4010
Other Transport	920	0	920
Other Diesel	2160	0	2160
Heating Oil	1310	-10	1300
Total	**8520**	**-130**	**8390**

Middle East	Production	Net Imports	Demand
On-road Diesel	1190	-180	1010
Other Transport	20	0	20
Other Diesel	420	-10	410
Heating Oil	500	-30	470
Total	**2130**	**-220**	**1910**

Africa	Production	Net Imports	Demand
On-road Diesel	540	110	650
Other Transport	50	0	50
Other Diesel	310	40	350
Heating Oil	190	30	220
Total	**1090**	**180**	**1270**

Total World	Production	Net Imports	Demand
On-road Diesel	15590	0	15590
Other Transport	2030	0	2030
Other Diesel	5380	0	5380
Heating Oil	4210	0	4210
Total	**27210**	**0**	**27210**

Table III.6: Global/Regional Middle Distillate Supply and Demand: 2018
(thousand barrels per day)

North America	Production	Net Imports	Demand
On-road Diesel	3810	0	3810
Other Transport	470	-10	460
Other Diesel	830	-40	790
Heating Oil	640	30	670
Total	**5750**	**-20**	**5730**

Europe	Production	Net Imports	Demand
On-road Diesel	4390	590	4980
Other Transport	370	40	410
Other Diesel	600	110	710
Heating Oil	1240	150	1390
Total	**6600**	**890**	**7490**

Latin America	Production	Net Imports	Demand
On-road Diesel	1590	160	1750
Other Transport	110	10	120
Other Diesel	680	20	700
Heating Oil	100	-20	80
Total	**2480**	**170**	**2650**

CIS	Production	Net Imports	Demand
On-road Diesel	820	-390	430
Other Transport	160	-40	120
Other Diesel	560	-130	430
Heating Oil	250	-120	130
Total	**1790**	**-680**	**1110**

Asia Pacific	Production	Net Imports	Demand
On-road Diesel	4370	420	4790
Other Transport	1100	0	1100
Other Diesel	2350	100	2450
Heating Oil	1430	40	1470
Total	**9250**	**560**	**9810**

Middle East	Production	Net Imports	Demand
On-road Diesel	2100	-890	1210
Other Transport	20	0	20
Other Diesel	560	-100	460
Heating Oil	620	-100	520
Total	**3300**	**-1090**	**2210**

Africa	Production	Net Imports	Demand
On-road Diesel	680	110	790
Other Transport	60	0	60
Other Diesel	380	40	420
Heating Oil	230	20	250
Total	**1350**	**170**	**1520**

Total World	Production	Net Imports	Demand
On-road Diesel	17760	0	17760
Other Transport	2290	0	2290
Other Diesel	5960	0	5960
Heating Oil	4510	0	4510
Total	**30520**	**0**	**30520**

IV. Northeast Heating Oil Market

A. North American Product Supply and Demand Trends

Tables IV.1 through IV.3 summarize North American refined product supply and demand for 2006, 2012 and 2018. The tables show production, demand and net imports as well as transfers between regions. For distillate, a breakdown is provided for on-road diesel, other transport diesel, other non-road diesel and heating oil.

Overall, North America is a net exporter of distillate, with exports from the Gulf Coast to Central and South America offsetting imports into the East Coast.

The Gulf Coast is the primary incremental distillate supplier for both the Mid Continent and East Coast. The Gulf accounts for 20 percent of Mid Continent supply and 40 percent of East Coast supply. Imports account for an additional 6 percent of East Coast supply.

In the future the Gulf Coast will increase its share of both Mid Continent and East Coast distillate supply. Two major refinery capacity expansions are currently underway in the Gulf, and will be fully on stream prior to 2012. These expansions will provide a major portion of growth in U.S refined product demand. Both projects are designed for high diesel yield to serve this growing market. As indicated in Tables IV.1 and IV.2, Gulf Coast distillate production is projected to increase by about 360 thousand barrels per day between 2006 and 2012. About 90 thousand barrels per day will supply the East Coast market and 150 thousand barrels will supply the Mid Continent markets.

From 2012 to 2018, a major portion of Mid Continent supply will come from refinery expansions associated with increasing capability to process Canadian Oil Sands crude. For the East Coast market the projections in Table IV.3 assume a major expansion of Eastern Canadian refinery capacity. A couple of projects have been proposed, but a new refinery project by Irving Oil is furthest along in the planning process. The project is expected to emphasize low sulfur diesel/distillate production. A majority of the increased East Coast demand from 2012 to 2018 is projected to originate from East Coast refineries.

Table IV.1: North American Supply and Demand: 2006
(thousand barrels per day)

Region	Production	Imports	Regional Transfers	Total Supply
East North America				
Gasoline	1480	690	1470	3640
Jet Fuel/Kerosene	190	60	480	730
Middle Distillate	840	100	630	1570
On-road Diesel	*450*	*10*	*440*	*900*
Other Transport	*50*	*10*	*30*	*90*
Other Diesel	*50*	*10*	*40*	*100*
Heating Oil	*290*	*70*	*120*	*480*
Residual Fuel	320	90	90	500
Mid Continent				
Gasoline	2640	0	780	3420
Jet Fuel/Kerosene	330	0	130	460
Middle Distillate	1450	0	360	1810
On-road Diesel	*900*	*0*	*320*	*1220*
Other Transport	*130*	*0*	*10*	*140*
Other Diesel	*310*	*0*	*20*	*330*
Heating Oil	*110*	*0*	*10*	*120*
Residual Fuel	120	0	-30	90
Gulf Coast				
Gasoline	3720	-20	-2320	1380
Jet Fuel/Kerosene	780	-10	-620	150
Middle Distillate	1930	-130	-1010	790
On-road Diesel	*1290*	*-20*	*-780*	*490*
Other Transport	*170*	*-20*	*-40*	*110*
Other Diesel	*300*	*-70*	*-60*	*170*
Heating Oil	*170*	*-20*	*-130*	*20*
Residual Fuel	290	-100	-70	120
Western North America				
Gasoline	1510	50	70	1630
Jet Fuel/Kerosene	410	70	10	490
Middle Distillate	570	-10	20	580
On-road Diesel	*350*	*10*	*20*	*380*
Other Transport	*60*	*0*	*0*	*60*
Other Diesel	*110*	*-10*	*0*	*100*
Heating Oil	*50*	*-10*	*0*	*40*
Residual Fuel	150	0	10	160
Total North America				
Gasoline	9350	720	0	10070
Jet Fuel/Kerosene	1710	120	0	1830
Middle Distillate	4790	-40	0	4750
On-road Diesel	*2990*	*0*	*0*	*2990*
Other Transport	*410*	*-10*	*0*	*400*
Other Diesel	*770*	*-70*	*0*	*700*
Heating Oil	*620*	*40*	*0*	*660*
Residual Fuel	880	-10	0	870

Table IV.2: North American Supply and Demand: 2012 (thousand barrels per day)

Region	Production	Imports	Regional Transfers	Total Supply
East North America				
Gasoline	1530	680	1640	3850
Jet Fuel/Kerosene	200	50	520	770
Middle Distillate	880	110	720	1710
On-road Diesel	*470*	*20*	*540*	*1030*
Other Transport	*60*	*10*	*30*	*100*
Other Diesel	*50*	*10*	*40*	*100*
Heating Oil	*300*	*70*	*110*	*480*
Residual Fuel	340	90	110	540
Mid Continent				
Gasoline	2800	0	800	3600
Jet Fuel/Kerosene	360	0	130	490
Middle Distillate	1480	0	510	1990
On-road Diesel	*940*	*0*	*430*	*1370*
Other Transport	*130*	*0*	*20*	*150*
Other Diesel	*300*	*0*	*50*	*350*
Heating Oil	*110*	*0*	*10*	*120*
Residual Fuel	120	0	-30	90
Gulf Coast				
Gasoline	3990	-20	-2510	1460
Jet Fuel/Kerosene	830	-10	-660	160
Middle Distillate	2290	-140	-1260	890
On-road Diesel	*1600*	*-30*	*-1000*	*570*
Other Transport	*190*	*-20*	*-50*	*120*
Other Diesel	*340*	*-70*	*-90*	*180*
Heating Oil	*160*	*-20*	*-120*	*20*
Residual Fuel	320	-90	-90	140
Western North America				
Gasoline	1600	50	70	1720
Jet Fuel/Kerosene	440	70	10	520
Middle Distillate	640	-10	30	660
On-road Diesel	*400*	*10*	*30*	*440*
Other Transport	*70*	*0*	*0*	*70*
Other Diesel	*120*	*-10*	*0*	*110*
Heating Oil	*50*	*-10*	*0*	*40*
Residual Fuel	160	0	10	170
Total North America				
Gasoline	9920	710	0	10630
Jet Fuel/Kerosene	1830	110	0	1940
Middle Distillate	5290	-40	0	5250
On-road Diesel	*3410*	*0*	*0*	*3410*
Other Transport	*450*	*-10*	*0*	*440*
Other Diesel	*810*	*-70*	*0*	*740*
Heating Oil	*620*	*40*	*0*	*660*
Residual Fuel	940	0	0	940

Table IV.3: North American Supply and Demand: 2018
(thousand barrels per day)

Region	Production	Imports	Regional Transfers	Total Supply
East North America				
Gasoline	1680	620	1700	4000
Jet Fuel/Kerosene	250	50	520	820
Middle Distillate	990	110	750	1850
On-road Diesel	*580*	*30*	*540*	*1150*
Other Transport	*60*	*10*	*30*	*100*
Other Diesel	*50*	*10*	*50*	*110*
Heating Oil	*300*	*60*	*130*	*490*
Residual Fuel	340	90	110	540
Mid Continent				
Gasoline	2930	0	800	3730
Jet Fuel/Kerosene	390	0	130	520
Middle Distillate	1630	0	550	2180
On-road Diesel	*1070*	*0*	*460*	*1530*
Other Transport	*140*	*0*	*20*	*160*
Other Diesel	*310*	*0*	*60*	*370*
Heating Oil	*110*	*0*	*10*	*120*
Residual Fuel	120	0	-30	90
Gulf Coast				
Gasoline	4120	-20	-2580	1520
Jet Fuel/Kerosene	850	-10	-670	170
Middle Distillate	2460	-140	-1340	980
On-road Diesel	*1720*	*-40*	*-1040*	*640*
Other Transport	*180*	*0*	*-50*	*130*
Other Diesel	*380*	*-80*	*-110*	*190*
Heating Oil	*180*	*-20*	*-140*	*20*
Residual Fuel	320	-90	-90	140
Western North America				
Gasoline	1670	50	80	1800
Jet Fuel/Kerosene	470	60	20	550
Middle Distillate	690	-10	40	720
On-road Diesel	*440*	*10*	*40*	*490*
Other Transport	*70*	*0*	*0*	*70*
Other Diesel	*130*	*-10*	*0*	*120*
Heating Oil	*50*	*-10*	*0*	*40*
Residual Fuel	160	0	10	170
Total North America				
Gasoline	10400	650	0	11050
Jet Fuel/Kerosene	1960	100	0	2060
Middle Distillate	5770	-40	0	5730
On-road Diesel	*3810*	*0*	*0*	*3810*
Other Transport	*450*	*10*	*0*	*460*
Other Diesel	*870*	*-80*	*0*	*790*
Heating Oil	*640*	*30*	*0*	*670*
Residual Fuel	940	0	0	940

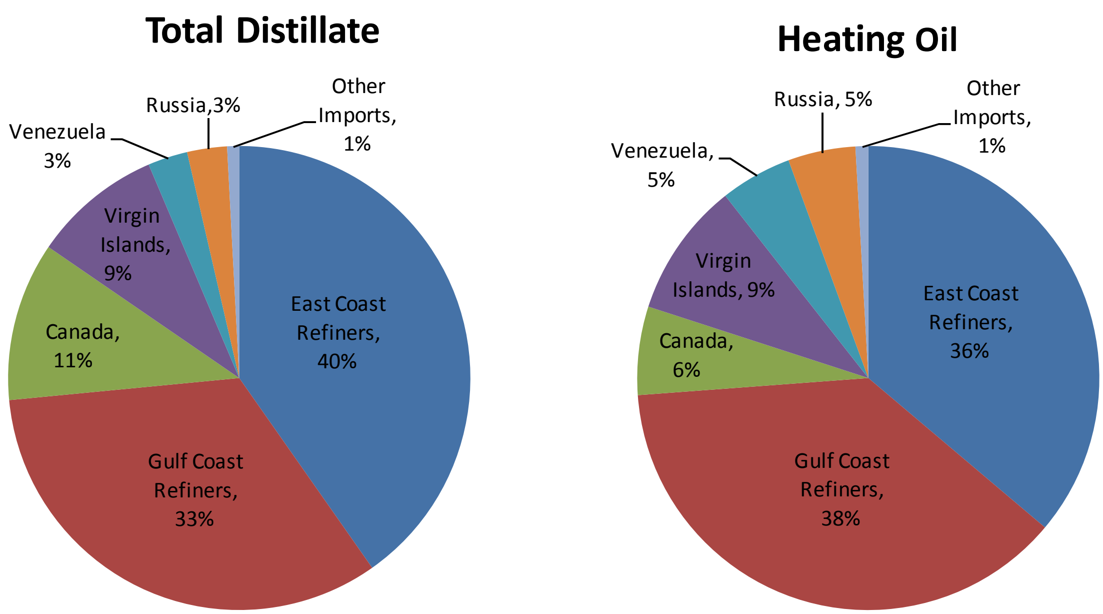
B. U.S. Northeast Distillate Supply

Table IV.4 provides an estimate of current distillate supply for the U.S. Northeast. The table shows source of supply by product sulfur category with a breakdown of on-road diesel, non-road transport diesel, other non-road diesel and heating oil. Figure IV.1 shows the breakdown of total distillate and heating oil by supply source.

About 40 percent of Northeast distillate and 36 percent of heating oil is supplied by U.S. East Coast refineries. Gulf Coast refineries provide an additional 33 percent of total distillate and 38 percent of the heating oil supply. The Virgin Islands and Eastern Canadian refineries make up a little over 15 percent of Northeast heating oil supply.

Venezuela and Russia account for nearly 10 percent of Northeast heating oil. They represent a major incremental supply source and most of the supply originated from international market sources. The remainder of imports account for less than 1 percent of supply. They consist of product from Europe and Asia Pacific. Imports from Europe have been declining as their demand has shifted from gasoline to diesel.

Figure IV.1: U.S. Northeast Distillate Supply by Source



Source: Energy Information Administration and Hart Energy Consulting

Table IV.4: U.S. Northeast Current Distillate Supply (thousand barrels per day)

On Road Diesel	<15	15-500	500+	Total
East Coast Refiners	123	14	0	137
Gulf Coast Refiners	70	11	0	81
Canada	55	1	0	56
Virgin Islands	25	2	0	27
Venezuela	0	0	0	0
Russia	0	0	0	0
Other Imports	2	1	0	3
Total	275	29	0	304
Other Transport Diesel	**<15**	**15-500**	**500+**	**Total**
East Coast Refiners	0	0	10	10
Gulf Coast Refiners	0	0	11	11
Canada	0	0	1	1
Virgin Islands	0	0	2	2
Venezuela	0	0	1	1
Russia	0	0	1	1
Other Imports	0	0	0	0
Total	0	0	26	26
Other Diesel	**<15**	**15-500**	**500+**	**Total**
East Coast Refiners	0	0	20	20
Gulf Coast Refiners	0	0	19	19
Canada	0	0	2	2
Virgin Islands	0	0	4	4
Venezuela	0	0	2	2
Russia	0	0	3	3
Other Imports	0	0	0	0
Total	0	0	50	50
Heating Oil	**<15**	**15-500**	**500+**	**Total**
East Coast Refiners	0	0	123	123
Gulf Coast Refiners	0	0	128	128
Canada	0	0	21	21
Virgin Islands	0	0	32	32
Venezuela	0	0	17	17
Russia	0	0	16	16
Other Imports	0	0	3	3
Total	0	0	340	340
Total Northeast Supply	**<15**	**15-500**	**500+**	**Total**
East Coast Refiners	123	14	153	290
Gulf Coast Refiners	70	11	158	239
Canada	55	1	24	80
Virgin Islands	25	2	38	65
Venezuela	0	0	20	20
Russia	0	0	20	20
Other Imports	2	1	3	6
Total	275	29	416	720

V. Distillate Quality Requirements

A. Market Overview

Distillate sulfur requirements, and in particular diesel sulfur requirements are being driven to lower throughout all areas of the world. This is particularly the case for the North American and other Atlantic Basin areas/countries closely linked to the North American market.

Table V.1 summarizes regional distillate demand by sulfur content for Eastern North America and other key areas/countries in the Atlantic Basin supply system.

Table V.1: Global/Regional Refined Product Supply and Demand: 2018 (thousand barrels per day)

Current	<15	15-50	50-500	500+	Total
Eastern North America	2220	0	1420	620	4260
Europe	1090	3010	0	2570	6670
CIS	0	60	20	780	860
Latin America	20	0	390	1100	1510
Total	3330	3070	1830	5070	13300
% of Pool	25.0%	23.1%	13.8%	38.1%	

2012	<15	15-50	50-500	500+	Total
Eastern North America	3760	0	190	640	4590
Europe	5730	280	0	1090	7100
CIS	50	270	260	400	980
Latin America	270	600	60	790	1720
Total	9810	1150	510	2920	14390
% of Pool	68.2%	8.0%	3.5%	20.3%	

2018	<15	15-50	50-500	500+	Total
Eastern North America	4360	0	0	650	5010
Europe	6100	1390	0	0	7490
CIS	650	0	150	300	1100
Latin America	310	750	230	670	1960
Total	11420	2140	380	1620	15560
% of Pool	73.4%	13.8%	2.4%	10.4%	

There will be a major shift to ultra low sulfur distillate (less than 15 ppm) by 2012. The shift reflects additional ultra low sulfur on-road diesel programs and inclusion of non-road diesel in the ultra low sulfur requirements. Some of the shift represents reductions from 50 ppm to <15 ppm. A large shift (18 percent) is also projected from distillate 500 ppm and higher. By 2012 over 75 percent of the distillate pool will be 50 ppm or less.

From 2012 to 2018, the pool sulfur requirements are projected to be more stable. The ultra low sulfur share is projected to increase by only about 5 percent and the 15 to 50 ppm pool will also increase by 5 percent. The portion of the pool above 500 ppm is projected to decline by 10 percent.

An increasing share of the Atlantic Basin product will move to low and ultra low sulfur as lower sulfur requirements are expanded to the entire diesel pool. There are initiatives underway or being debated to reduce sulfur content of heating oil as well, in the U.S. and Europe. Europe is projected to require 50 ppm but not until after 2012. Outside of this and the initiatives under consideration for the Northeast market (Main-VU), heating oil sulfur reduction programs involve more modest reduction of sulfur, i.e., 1000 ppm or higher.

Individual country/region distillate sulfur initiatives are discussed in the following subsections.

B. North American Distillate Quality Requirements

United States

U.S. is currently phasing in its ultra low sulfur on-road diesel program which currently requires that 80 percent of on-road diesel be 15 ppm sulfur or less. The remaining 20 percent must be less than 500 ppm. In 2010, the phase in will be complete and all on-road diesel must meet the 15 ppm standard.

For non-road diesel, a 500 ppm standard was implemented in 2007. In 2010, this will be reduced to 15 ppm for non-road diesel, excluding locomotive and marine services. The locomotive and marine standard will be reduced to 15 ppm in June of 2012.

Federal regulations specify ASTM D396 for heating oils which includes a maximum sulfur of 5000 ppm. Many states have adopted their own heating oil sulfur requirements including: Connecticut (3000 ppm), Maine (3000 ppm in some regions), Massachusetts (3000 ppm), New Hampshire (4000 pm), New Jersey (2000 to 3000 ppm region dependent), New York (2000 to 3000 ppm region dependent).

Canada

Canada adopted ultra low sulfur on-road diesel limits similar to the U.S., but without the phase in. All Canadian on-road diesel must meet the 15 ppm sulfur standard.

Canada also adopted a 500 ppm standard for non-road diesel, going down to 15 ppm in 2010. There are some regional exemptions from the 15 ppm standard in 2010, but by 2012 all non-road diesel will require 15 ppm.

There are no regulated national standards for heating oil. However, there is a voluntary standard for light fuel oil set by the Canadian General Standards Board and several provincial governments have developed and implemented regulations for sulfur content in fuel oils. Federal voluntary and provincial regulations limit sulfur to 5000 ppm.

C. European Distillate Quality Requirements

Low sulfur diesel fuel quality for the EU Member States is regulated by Directive 98/70/EC, amended by Directive 2003/17/EC. The Directive requires that on-road diesel sulfur be limited to 50 ppm and a diesel fuel with a maximum sulfur content of 10 ppm must also be marketed.

Some member countries have implemented tax policies to encourage early implementation of the 10 ppm standard and have already converted their entire on-road diesel market to the lower standard. Denmark, Finland, Germany, Netherlands and Sweden are already at 10 ppm.

Many of the non-EU European countries are progressing toward EU standards or have already reached the 50 ppm level as part of their plans to join the EU.

The EU on-road diesel program is in the progress of developing a final mandate for 10 ppm in all on-road diesel by January 2009. The official process has stalled, waiting for incorporation of biofuel initiatives, and has not received final approval. However, it is likely to be in effect by 2009, and certainly before 2012.

Non-road distillates, including heating oil, were limited to 2000 ppm until January of this year. The limit has since lowered to 1000 ppm.

In 2007, the EU issued proposals calling for alignment of non-road diesel (for non-road mobile machinery and agriculture) sulfur with on-road specification by 2009. Again the proposal has not received final approval but is expected to be in effect by 2012, and likely by 2010.

The EU has additionally proposed to reduce inland marine diesel to 10 ppm in a two step program; to 300 ppm in 2009 and 10 ppm in 2011.

EU heating oil sulfur limits are currently at 1000 ppm. Proposals have been raised before the EU Parliament for 50 ppm heating oil, but the initiative is not likely to go further until after full implementation of the non-road diesel. The 50 ppm heating oil requirement is not expected by 2012, but is very likely to be in place a few years after, certainly by 2018. However, some countries have or are in the process of developing more stringent requirements. Germany has introduced tax incentives to encourage introduction of 50 ppm heating oil.

D. Russia and CIS Distillate Quality Requirements

Despite significant changes in the region since 1991, fuel quality legislation in the CIS lags many years behind the European Union. In the case of Russia, which has been in the forefront of CIS fuel quality, the time difference between EU and Russian quality initiatives is about 10 years. The gap is narrowing but the region still faces a long process to achieve EU standards.

In addition to the lag in fuel quality developments, there is a lack of adequate fuel quality monitoring which reduces incentives for further progress.

In July of 2006, the Russian Government implemented standards for new diesel vehicles specifying three grades with sulfur ranges between 350 ppm and 10 ppm. Less than 15 percent of the market is below 500 ppm.

A considerable portion of available 50 ppm and 10 ppm diesel fuel is for supply along international transport corridors to allow for EU freight carriers.

Russia is aiming to align its diesel fuel specifications with the European Standards; however, this will not take place prior to 2010. Russia plans to introduce 50 ppm sulfur in January 2010 and Euro 5 equivalent fuel quality (10 ppm) in 2014.

Of the remaining CIS countries, only Belarus is expected to introduce lower sulfur consistent with the Russian schedule. In fact, as a result of refinery projects, Belarus will comply with 10 ppm diesel by 2012.

Little progress is anticipated for the remaining CIS countries through 2012. Diesel sulfur levels will be reduced, but will remain well above 500 ppm. Eventually these States will follow Russia and/or EU standards and by 2018 diesel sulfur is predicted to comply with 50 ppm.

Heating oil sulfur requirements are expected to continue to lag EU implementation throughout the CIS region, and are not anticipated to reach lower than 1000 ppm by 2018.

E. Latin American Distillate Quality Requirements

Argentina

Current regulations limit on-road diesel to 1500 ppm for urban use and 2500 ppm for the remainder of the country. All other distillates follow the same standards.

There are currently no initiatives underway to lessen on-road or other distillate sulfur.

Based on other fuel initiatives in Argentina and those in neighboring Brazil, Argentina is projected to eventually develop lower standards. No new requirements are probable by 2012, but all distillate is estimated to be limited to 500 ppm by 2018.

Brazil

Current standards specify two grades of diesel: urban diesel (~20 percent of the market) with a maximum sulfur content of 500 ppm, and interior (rest of country) diesel with a maximum sulfur of 2000 ppm. Beginning in 2009, all on-road diesel will be decreased to 50 ppm.

Other distillates are currently limited to a maximum sulfur of 10,000 ppm. There are no initiatives to further regulate other diesel and no changes are anticipated by 2012. Based on other initiatives, some sulfur reduction is expected by 2018, but not to levels below 2000 ppm.

Mexico

Mexican on-road diesel specifications will be harmonized with the U.S. but the implementation will be extended. Currently, 15 ppm is required in Northwest Mexico only, and the remainder of the country is limited to 500 ppm. Mexico City, Guadalajara and Monterrey will be reduced to 15 ppm in 2009 and the rest of the country in 2010.

There are currently no restrictions for non-road diesel or heating oil and none are anticipated by 2012. Some sulfur improvement is expected by 2018, but not lower than 2000 to 5000 ppm.

Venezuela

Venezuela has a 5000 ppm single specification on-road and non-road (excluding industrial and marine) diesel. The specifications for marine diesel and industrial diesel are 15,000 ppm and 10,000 ppm, respectively.

There are currently no initiatives to reduce diesel sulfur and no changes are anticipated by 2012. On-road diesel is projected to be reduced to 500 ppm by 2018. Other distillate sulfur limits are also expected to be lowered, but not below 5000 ppm.

Colombia

Colombia recently reduced on-road diesel sulfur to 500 ppm. The Colombian government has proposed to reduce this to 50 ppm in 2013.

There are no restrictions on other distillates and none are anticipated by 2012. Some restrictions are expected by 2018, but not below 2000 ppm.

F. Other Global Distillate Quality Requirements

The Middle East and Asia Pacific regions are expanding refining and will become incremental supply sources to the Atlantic Basin region. These regions are also implementing low sulfur programs which will have some (shorter term) impact on their ability to supply low sulfur diesel exports.

In Asia, Hong Kong, South Korea, Taiwan, and Singapore are currently at 50 ppm diesel and Japan at 10 ppm. By 2012, 77 percent of the region's diesel (37 percent of total distillate) will be 50 ppm or below, and up from 35 percent (16 percent distillate) currently. There is less focus on heating oils which will not be widely controlled.

Currently, no low sulfur diesel requirements are in the Middle East. By 2012, Jordan, Kuwait, Qatar and Saudi Arabian cities will implement 50 ppm sulfur. Bahrain and the remainder of Saudi Arabia will implement 500 ppm diesel. By 2018, all of Saudi Arabia will be 10 ppm diesel and Iran will be 500 ppm. In 2018, 41 percent of diesel will be 50 ppm or below. Heating oil low sulfur requirements are not anticipated by 2018, and 22 percent of the total distillate pool will be 50 ppm sulfur or lower.

VI. Assessment of Distillate/Low Sulfur Capability

A. Atlantic Basin

Largely as a response to tightening global refinery capacity and favorable refining economics, there is a substantial amount of refinery expansion activity throughout the world. The projects have been initiated fairly recently so most expansion will occur around 2010. Until then, global refining capacity, and refined product supply, will remain firm.

Many of the new projects will emphasize diesel production, consistent with demand trends. Additionally, there is significant project activity in the area of increased ultra low sulfur diesel supply.

Refinery expansion projects in the Atlantic Basin supply region have been identified and the volume of distillate and low sulfur distillate expected to be available from the expansions have been estimated. In addition to the major announced/identified projects, the industry has over the years increased capacity and output through miscellaneous process improvement/optimization projects or "capacity creep" projects. The latter are not typically part of project announcements or construction reports and the future impact of these on production capability is subject to some uncertainty.

In terms of distillate output, additional production capability has come on-stream and is likely to add to future distillate production capability due to yield shifts from gasoline to distillate. Estimates of the impact of yield shifts on distillate production are included in capacity creep.

Table VI.1 provides a projection of incremental distillate and low sulfur distillate production from capacity expansions in the Atlantic Basin Supply Region through 2018. Incremental production is shown as announced or identified projects and that associated with capacity creep. Some of the high sulfur volume is shown as negative. This reflects projects which will upgrade high sulfur to low sulfur product.

Table VI.1: Atlantic Basin Region Incremental Distillate Expansion (thousand barrels per day)

2007-2012	Total Distillate	<15 ppm	15-50 ppm	High Sulfur
Announced/Identified Projects	930 - 1020	1550 - 1640	140 - 150	(730 - 760)
Projected Capacity Creep	230 - 460	210 - 560	20 - 30	0 - 10
Total	1160 - 1480	1750 - 2200	160 - 180	(720 - 750)

2012-2018	Total Distillate	<15 ppm	15-50 ppm	High Sulfur
Announced/Identified Projects	390 - 460	470 - 490	0	(20 - 30)
Projected Capacity Creep	200 - 400	180 - 360	20 - 30	0 - 10
Total	590 - 860	600 - 850	20 - 30	(0 - 20)

Through 2012, the incremental distillate production is projected to be more than adequate to meet incremental demand in the region. However, projected incremental low sulfur production capability is less than half the projected requirement to meet low sulfur diesel demand.

The lower than required projection for low sulfur capacity does not necessarily suggest a product shortfall, but rather a need for additional capability beyond that identified or anticipated to result from traditional capacity creep. Many of these incremental low sulfur projects will involve revamp of existing capacity and/or additional capacity creep projects. However, the projected balance does suggest that refiners will be pressed to add capacity and their low sulfur capacity balance should remain tight.

From 2012 to 2018 the projected incremental distillate production represents about 50 to 75 percent of the growth in demand. The upper range of incremental production estimates from current to 2018 meets projected increases in demand. An additional 15 percent of this may be supplied as product from capacity expansion projects in the Middle East (Section III supply-demand).

The incremental low sulfur projects for 2012 to 2018 also represent 50 to 70 percent of requirements. The incremental low sulfur production is short by about 500 thousand barrels per day versus over 2 million barrels per day for the 2006 to 2012 period. Considering the longer lead time as well, the low sulfur market will be less constrained over the longer term.

Regional capacity expansion discussions are provided below.

B. East North America

There are a number of major U.S. refinery expansion projects that will add significantly to distillate and low sulfur diesel supply in the near term. Two projects, Marathon in Louisiana and Motiva in Texas, represent the largest refinery projects in the U.S. since the 1970's. Both of these projects will deviate from the traditional U.S. refinery configuration and are being designed to emphasize low sulfur distillate production.

In addition to specific projects announced or identified, noted previously, capacity increases for distillate (includes yield shifts) have recently averaged about 2.5 percent annually. This includes a few major heavy oil expansions which added to distillate production and would likely be covered in the category of identified/announced projects. The capacity creep is also likely to be lower because announced expansions are adequate to cover product needs. Furthermore, the major announced projects are oriented toward diesel, reducing need to shift gasoline to diesel yield in other refineries. Capacity creep is projected to add about 3 to 6 percent to total distillate production in each of the two time periods.

Capacity projects beyond 2012 are less defined. Most significant are a number of Mid Continent projects designed to accommodate Canadian oil sands crude and proposals for new refineries in Eastern Canada. The Mid Continent projects are primarily focused on conversion to handle more difficult feed. They will not involve major expansions of refined product output, but some increased production capability is expected.

There are a number of new refinery projects under consideration for Eastern Canada. It is unlikely that more than one of these projects will eventually go forth. A new 300 thousand barrel per day refinery project proposed by Irving Oil in St. John is furthest along and will most likely develop into a final project. Like the Marathon and Motiva projects, the refinery will be designed to emphasize low sulfur distillate production. Irving Oil is looking to supply incremental gasoline and low sulfur distillate demand for the North American East Coast and to supply incremental low sulfur distillate to Europe.

Table VI.2 provides a summary projection of incremental distillate and low sulfur distillate production from capacity expansions in Eastern North America through 2018. The projections include an assumed 3 to 6 percent capacity creep in each period. The negative high sulfur volume indicates projects treating high sulfur material for production of ultra low sulfur diesel.

The table shows the relative contribution of the two large U.S. refinery projects and the proposed East Canada refinery.

Table VI.2: East North America Incremental Distillate Expansion (thousand barrels per day)

2007-2012	Total Distillate	<15 ppm	High Sulfur
Marathon/Motiva Projects	180 - 200	180 - 190	0 - 10
Other Announced/Identified Projects	170 - 190	250 - 270	(70 - 90)
Projected Capacity Creep	140 - 280	140 - 280	0
Total	490 - 670	550 - 730	(70 - 80)

2012-2018	Total Distillate	<15 ppm	High Sulfur
East Canada Refinery	100 - 120	100 - 120	0
Other Announced/Identified Projects	70 - 80	100 - 110	(20 - 40)
Projected Capacity Creep	140 - 280	140 - 280	0
Total	310 - 470	340 - 510	(20 - 30)

The incremental product available through 2012 will cover anticipated increased demand for Eastern North America. Projected additional low sulfur volumes will cover only about 35 to 45 percent of incremental ultra low sulfur. However, about 80 percent of the incremental low sulfur will be the result of 500 ppm non-road reduced to <15 ppm. Most of these requirements will likely be met through revamp of existing capacity. In some cases, this involves a simple catalyst change to reduce sulfur from 500 to 15 ppm.

For 2012 to 2018, the projected incremental distillate production again is adequate to cover demand increases. Low sulfur incremental production is short of requirements but by only 90 to 160 thousand barrels per day. The low sulfur capability and supply balance are projected to improve from 2012 to 2018.

C. Europe

No major refining projects are identified for Europe, but numerous smaller diesel projects are underway. These projects involve hydrocracking and desulfurization focused on increased production of ultra low sulfur diesel. The projects will increase output of diesel without increasing surplus gasoline and residual fuel.

Table VI.3 provides a summary projection of incremental distillate and low sulfur distillate production from capacity expansions in Europe through 2018. Historic capacity creep has been about half that of North America, largely because overall product demand growth has been flat and there are growing surpluses of gasoline and heavy fuel oil. Past capacity creep has primarily reflected gasoline to distillate yield shifts which will be more difficult to achieve in the future. The projections include an assumed 1 to 2 percent capacity creep in each period.

Table VI.3: Europe Incremental Distillate Expansion (thousand barrels per day)

2007-2012	Total Distillate	<15 ppm	High Sulfur
Announced/Identified Projects	320 - 340	630 - 650	(300 - 310)
Projected Capacity Creep	60 - 120	60 - 120	0
Total	380 - 460	690 - 770	(300 - 310)

2012-2018	Total Distillate	<15 ppm	High Sulfur
Announced/Identified Projects	150 - 170	150 - 170	0
Projected Capacity Creep	30 - 60	30 - 60	0
Total	180 - 230	180 - 230	0

The projected European incremental supply through 2012 is close to demand requirements. The incremental low sulfur supply represents only 35 to 40 percent of incremental demand requirements. Up to 15 percent of that may be supplied via imports from Asia Pacific (primarily India, see Section III).

From 2012 to 2018 incremental supply is short relative to growth in demand by 200 thousand barrels per day. The global supply demand projections in Section III suggest that most of this will be supplied by Middle East imports. Low sulfur volume is also estimated to be far short of demand due to the anticipated reduction in heating oil sulfur.

D. CIS

Only one major refining project is identified for the CIS region. This consists of a major refinery expansion, Tatneft (140 thousand barrels per day), scheduled for completion in 2012 to 2015. Most of the other refinery projects in the area are focused on modernization and increasing low sulfur gasoline and diesel capability.

Table VI.4 provides a summary projection of incremental distillate and low sulfur distillate production from capacity expansions in CIS through 2018. Historic capacity creep has been low because many of the refineries are older inefficient facilities in need of modernization. Until recently, Russia has focused their investment in production rather than refining. The projections include an assumed 1 to 2 percent capacity creep in each period.

Table VI.4: CIS Incremental Distillate Expansion (thousand barrels per day)

2007-2012	Total Distillate	<15 ppm	High Sulfur
Announced/Identified Projects	50-60	220-240	(170-180)
Projected Capacity Creep	10-30	10-20	0-10
Total	60-90	230-260	(170-180)

2012-2018	Total Distillate	<15 ppm	High Sulfur
Announced/Identified Projects	50-60	50-60	0
Projected Capacity Creep	10-30	10-20	0-10
Total	130-200	130-200	0

Expansions through 2012 closely balance demand requirements for both distillate and low sulfur diesel. The low sulfur demand assumes that by 2012 Russia is still in transition to ultra low sulfur diesel. No additional low sulfur supply is likely to be available for export.

E. Latin America

There are a lot of capacity expansions underway in Latin America, particularly in Brazil and Mexico. Brazil is in the development stage for a new 200 thousand barrel per day refinery that will emphasize distillate production. There are also a number of heavy fuel conversion projects (which will result is additional distillate) and major diesel desulfurization projects throughout the country. Mexico is planning a number of revamp projects to reduce diesel sulfur from 500 ppm to 15 ppm.

Table VI.5 provides a summary projection of incremental distillate and low sulfur distillate production from capacity expansions in Latin America through 2018. Like the CIS, historic capacity creep is low because many of the refineries are older inefficient facilities in need of modernization. Most incremental needs are being met by major revamp projects such as those in Brazil and Mexico. The projections include an assumed 1 to 2 percent capacity creep in each period.

Table VI.5: Latin America Incremental Distillate Expansion (thousand barrels per day)

2007-2012	Total Distillate	<15 ppm	15-50 ppm	High Sulfur
Announced/Identified Projects	210 - 230	270 - 290	140 - 150	(190 - 200)
Projected Capacity Creep	20 - 30	0	20 - 30	0
Total	230 - 260	270 - 290	160 - 180	(190 - 200)

2012-2018	Total Distillate	<15 ppm	15-50 ppm	High Sulfur
Announced/Identified Projects	20 - 30	20 - 30	0	0
Projected Capacity Creep	20 - 30	0	20 - 30	0
Total	40 - 60	20 - 30	20 - 30	0

Projected incremental distillate production through 2012 is adequate to meet growth in demand. Low sulfur capability increases will only satisfy about half the requirement. For the period 2012 to 2018 total product and low sulfur product is short of the incremental demand requirements. Despite a significant increase in low sulfur distillate production capability from 2006 to 2018, additional capacity will be needed and capacity is likely to be tight.

F. Other Global Regions

There are currently a number of major expansion projects in China and India that will add significantly to distillate and low sulfur diesel supply by 2012. Those scheduled in China will be required to meet growing demand in that country. India expansions will allow for incremental distillate exports, particularly form the Reliance Refinery starting up the end of 2008.

Much of the export capability will be for low and ultra low sulfur distillate. Some volume will serve Asian and African markets, but product will also be available for the European and other Atlantic Basin markets.

Longer term beyond 2012, Asia Pacific demand growth is estimated to exceed Asian refining expansion and more of India’s product will serve the Asia Pacific market.

There are also a number of major expansion projects underway in the Middle East. The initial projects to be completed by 2012 will largely serve the indigenous market. For projects coming on beyond 2012, the majority of the capacity expansion will serve global export markets including Europe and the Atlantic Basin market. Around 800 thousand barrels per day of distillate will be available to the export market, over half of which will be low sulfur.

VII. Impact of Additional Northeast Low Sulfur Requirements

The assessment of the impact of additional Northeast heating oil low sulfur requirements first focuses on trends and capabilities of the Eastern North American market. Refineries in the U.S. East and Gulf coasts supply about 74 percent of the Northeast heating oil market. Canadian and Virgin Island refineries which are tied closely to the U.S. northeast market supply an additional 15 percent. Venezuela and Russia account for most of the remaining supply.

The assessment first considers low sulfur distillate trends in the Eastern North America market and how additional low sulfur requirements can impact these requirements. Traditional sources of supply are also examined and their likely disposition under a low sulfur scenario. Finally, supply capability and the potential for additional low sulfur supplies are examined.

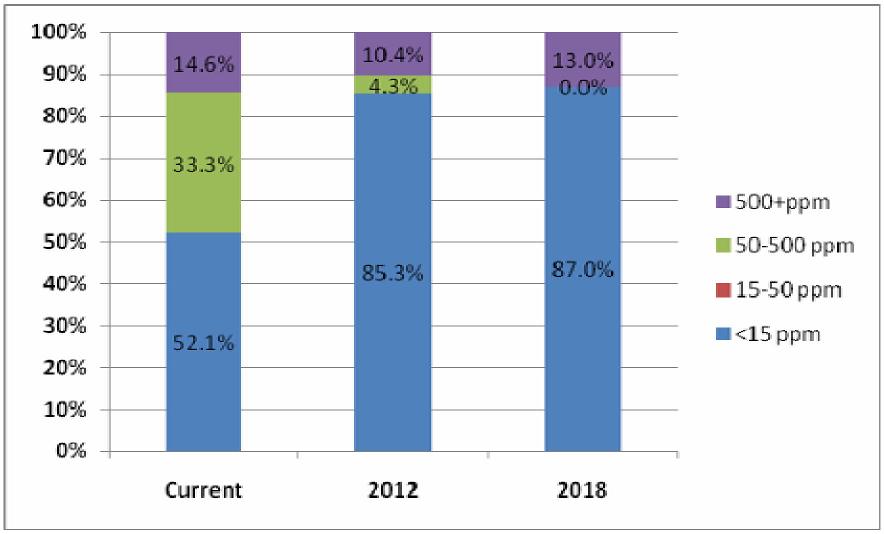
A broader assessment is then made considering all supply and demand sources in the Atlantic Basin supply region.

A. Northeast Assessment

Distillate Market Trends

Figure VII.1 shows the trends in the Eastern North America distillate market sulfur grade distribution. In the current market, 52 percent of product is required to be <15 ppm. Another 33 percent is limited to 500 ppm and the remainder is above 500 ppm, typically 2000 ppm or higher. By 2012, the ultra low sulfur portion increases to 85 percent, and only 10 percent is still above 500 ppm.

Figure VII.1: East North America Distillate Market by Sulfur



With 85 percent of the market at ultra low sulfur, there will be a wide range of indigenous sources for low sulfur product. Sources of supply are greatly expanded should the inner zone of the Northeast adopt these standards.

Refineries in the region are expected to adjust capability to meet this sulfur demand slate. The relatively high low sulfur market share would suggest that suppliers could accommodate some additional low sulfur demand in 2012.

Despite the expansion of potential supply sources, the 2006 to 2012 shift in market to ultra low sulfur is large. The shift will occur over a short and limited time period, particularly coming on the heels of the initial on-road diesel requirement initiated in 2006. The requirement gradually increases over the period as a greater portion of the non-road diesel is incorporated in the ultra low sulfur standards. By 2012, the transition remains underway (rail road and marine standards become effective midyear.)

With the rapid changes required through 2012, the low sulfur market will be strained and undergoing transition throughout the period. Any additional shift to <15 ppm for the Northeast market will further tighten and constrain supply. In the 2010 to 2012 period, most of the market will be moving from 500 ppm to <15 ppm. Adding a requirement for additional shift from 2000 or higher to <15 ppm will be more difficult and have a far greater marginal impact on the market. A 2012 requirement for <15 ppm product in the inner zone states will increase the ultra low sulfur market share to about 86 percent. Given the timing for other diesel product transition to ultra low sulfur (some starting in 2010) planning is well along and may be difficult to alter.

Shifting the heating oil to 500 ppm in 2012, would be more reasonable but would still add to what may likely be a constrained market. The 500 ppm standard would provide some positive synergies with other markets shifting from 500 ppm to <15 ppm. Suppliers could optimize on which supply sources provided the most feasible and economic source of the ultra low sulfur product and which to target for 500 ppm. A 500 ppm standard may also be better suited in suppliers ultra low sulfur planning.

By 2018, the ultra low sulfur market share increases by only another 5 percent. With the entire Northeast heating oil market at <15 ppm, the ultra low sulfur market would be about 94 percent of the market. Most supply sources will be marketing all or predominately ultra low sulfur distillate. The on-road and non-road diesel conversions to <15 ppm were completed more than 5 years earlier. Supplying the additional <15ppm product would not place significant strain on the market, assuming adequate notice was provided to suppliers.

Supply Sources

The Northeast market relies on Russia and Venezuela for about 10 percent of supply. Russia has limited capability to supply <15 ppm and will internally be transitioning to the ultra low sulfur product. Russia will have insufficient supply for its own market. (The quality distribution for CIS in Section V assumes an ultra low sulfur requirement is in place in 2012 but Russian refineries will not be capable of meeting it country wide.) Given its internal demand and shortfall in supply capability, Russia will not be capable of supplying <15 ppm and will be very limited in its ability to supply any 500 ppm product.

Venezuela will have no low or ultra low sulfur requirements in place by 2012 and is not likely to have capability to supply any low sulfur product. It is questionable that Venezuela will be capable of supplying <15 ppm or 500 ppm product in 2012.

By 2018, Russia is expected to have completed its transition to ultra low sulfur. By then most product will be ultra low sulfur. Some supply will likely be available but possibly less than current. There will still be some pressure for converting non-road and heating oil to lower sulfur and Europe, which will increasingly be relying on imports, will compete for incremental ultra low sulfur product.

Venezuela will move slowly on sulfur reduction and is projected to be at 500 ppm for on-road diesel by 2018. It is unlikely that Venezuela will be capable of supplying <15 ppm product in 2018. Some, but limited supply of 500 ppm may be available.

Refining Supply Capability

Capacity expansions scheduled to come on stream by 2012 will add considerable product to the market and eliminate some of the tightness in recent refined product markets. Potential distillate supply additions will exceed incremental demand requirements.

For the ultra low sulfur market, the supply capability will remain tight. As noted in Section VI, There will be a need for a large amount of capacity to reduce 500 ppm diesel to <15 ppm by 2012, above that announced, identified or assumed available through capacity creep. The increased refining capability will fall short of ultra low sulfur production capability. A requirement for <15 ppm in the Northeast will further constrain the system. On the other hand, the increased distillate production capability will likely provide some opportunity for incremental supply of 500 ppm product. Given the overall low sulfur constraints, an additional 500 ppm requirement will have an impact on the constrained market, but some product could likely be produced with minimal impact.

By 2018, refinery capacity additions again are adequate to meet demand increases. For 2018, expansions will cover much of the required ultra low sulfur needs. Given the time for transition, an ultra low sulfur requirement for Northeast heating oil will not have adverse market impacts. A key to the 2018 balance is the Eastern Canadian refinery status.

B. Atlantic Basin Assessment

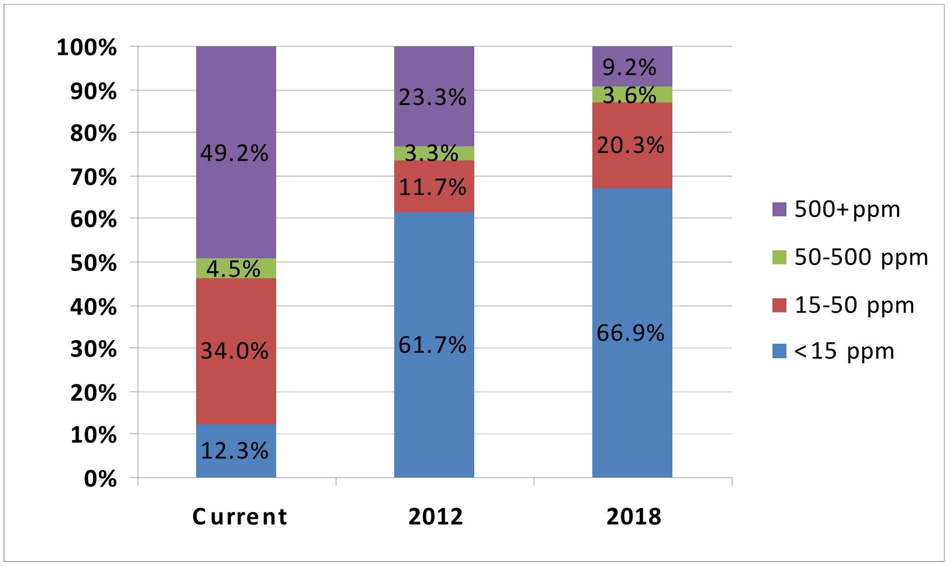
Distillate Market Trends

Figure VII.2 shows the trends in the Atlantic Basin region distillate market sulfur grade distribution. In the current market, 58 percent of product is required to be <50 ppm. Another 14 percent is limited to 500 ppm and the remainder is above 500 ppm, typically 1000 ppm or higher. By 2012, the ultra low sulfur portion increases to 70 percent, and 20 percent is still above 500 ppm.

The low sulfur market share expands rapidly from current to 2012, but a little less so than Eastern North America. There is also a portion of the ultra low sulfur market (16 percent of the low sulfur pool) that is at 50 ppm sulfur.

Despite the expansion of potential supply sources, the 2006 to 2012 shift in market to ultra low sulfur is large. The shift will occur over a short and limited time period, particularly coming on the heels of the initial on-road diesel requirement initiated in 2005. A significant portion of the expanded production is still at 50 ppm. Supply sources for the region will not be able to accommodate additional >15 ppm product for the U.S. Northeast heating oil market.

Figure VII.2: Atlantic Basin (ex North America) Distillate Market by Sulfur



In 2012 there will be a small and declining market for 500 ppm product. There may be greater potential for incremental 500 ppm product versus >15 ppm from Atlantic Basin sources, but incremental supply is likely to be very limited.

By 2018, the ultra low sulfur market share increases to 87 percent. Most supply sources will be marketing predominately ultra low sulfur distillate. Major shifts to ultra low sulfur (European heating oil and Russian diesel) will have been completed about 4 years earlier. Supplies will be tight in the region, but potential availability of < 15 ppm product will be significantly improved over 2012.

Supply Sources

The Atlantic Basin region outside Eastern North America is a net importer of distillate, with Eastern North America (high sulfur exports from the Gulf Coast) and the Middle East being primary supply sources. As noted above, the CIS (Russia) and Latin America (Venezuela) also supply exports to Eastern North America.

Through 2012, net import reliance will increase with marginal supplies coming from Asia Pacific (India). Russian plus Venezuelan exports to the U.S. are likely to decline slightly. The region will not have the capability to supply low sulfur heating oil to the Northeast.

Through 2018, reliance on imports will increase further largely driven by European requirements. Additional low sulfur supplies for the Northeast market will not be available from other Atlantic Basin sources.

Refining Supply Capability

Capacity expansions scheduled to come on stream by 2012 will add considerable product to the market. Potential distillate supply additions could come close to incremental demand requirements.

Capacity expansions for low sulfur diesel production by 2012 are well below requirements. Additional projects are likely to develop, but capacity will be tight. Atlantic Basin refining capacity is not likely to be capable of supplying additional <15 ppm sulfur diesel for the Northeast market. Unlike the situation in East North America where much of the ultra low sulfur incremental requirements will involve conversion of 500 ppm diesel to <15 ppm, the majority of the ultra low sulfur volume will require treating higher sulfur distillates, with less opportunity for simple catalyst changes and refinery revamps. In this case there is also not likely to be opportunity for increased supplies of 500 ppm diesel for the Northeast.

From 2012 to 2018, refinery capacity additions will fall short of demand requirements. As noted above, a portion of the supply is projected to be supplied by Middle East exports. Anticipated capacity for low sulfur production is also well below incremental needs. The region will not be a source of incremental low sulfur Northeast heating oil.

C. Other Supply

As noted in Section VI, India will be a potential source of incremental supply in 2012 for either <15 ppm of 500 ppm product. The Northeast market will compete with Europe for product. By 2018 supplies available from India will decline, but the Middle East will significantly increase supply potential.

VIII. Low Sulfur Distillate Cost and Price Implications

A. Desulfurization Cost

Production of low sulfur diesel involves desulfurization of some or all of the refinery components blended into the low sulfur product. The marginal cost of production of the low sulfur diesel equals the desulfurization operating costs (fuel, hydrogen, catalysts, etc), the opportunity cost resulting from small yield shifts from diesel to LPG and the capital charge for desulfurization capacity.

As low sulfur targets are reduced, a greater portion of the refinery blend streams requires desulfurization and the severity of desulfurization must be increased. For example, in the production of 2000 to 3000 ppm U.S. high sulfur diesel and heating oil, approximately 40 to 50 percent of the blend components are desulfurized. For 500 ppm fuel, 80 to 85 percent of the blend streams are desulfurized and for <15 ppm diesel, all the components must be desulfurized. All else being the same, the low sulfur production costs would increase for lower sulfur product according to the portion desulfurized.

Lower sulfur requirements generally also require more severe operation to lower the sulfur content of the desulfurized blend component. Lower sulfur product is achieved through a combination of higher temperature (via fuel), greater hydrogen use, greater catalyst use, larger yield penalties, higher pressures, and larger equipment (higher capital costs). The cost of higher sulfur operations over a range of sulfur targets is not linear. As sulfur is reduced, the marginal cost of removal per unit of sulfur increases. The cost of producing 60 ppm sulfur versus 100 ppm is significantly lower than the cost of a 10 ppm target versus 50 ppm.

Note that a large portion of the operating costs is directly related to energy cost (fuel, hydrogen and yield) and therefore will increase with increasing crude cost.

Desulfurization operating and capital costs are also dependent on the refinery streams being desulfurized. Very high sulfur cracked streams are more difficult and costly to desulfurize to a given target than virgin (typical diesel) feeds. Many of the more difficult to treat refinery streams have historically been blended to heating oil and other higher sulfur products. Therefore, as heating oil and other higher sulfur diesels are added to the low sulfur pool, the desulfurization step can be more difficult and costly.

Capital costs of ultra low sulfur desulfurization will also be influenced by the type of refinery processes, and in particular distillate desulfurization is available. In certain cases ultra low sulfur desulfurization can be achieved by modifying existing equipment (additional reactors, catalyst, hydrogen systems, etc). The cost of a revamp can be significantly lower than new capacity. For the first phase of U.S. diesel regulations, EPA estimated that about 80 percent of desulfurization would involve revamps and the capital costs for the revamps would be about 50 percent of the cost of a new unit.

Table VIII.1 provides estimates of the cost of low sulfur distillates of varying sulfur levels. The wide range of costs reflects the possible use of the revamp option for ultra low sulfur production. For the 50 ppm and <15 ppm figures, the low end of the range represents the desulfurization cost for revamping an existing desulfurization unit for more severe operation (not included for 500 ppm).

Table VIII.1: Cost of Low Sulfur Distillate (cents per gallon)

	500 ppm	50 ppm	<15 ppm
Capital Charge	2.2 - 2.8	1.3 - 3.0	1.5 - 3.2
Operating Cost	3.2 - 4.0	2.5 - 4.6	3.1 - 5.7
Total	5.4 - 6.8	3.8 - 7.6	4.6 - 8.9

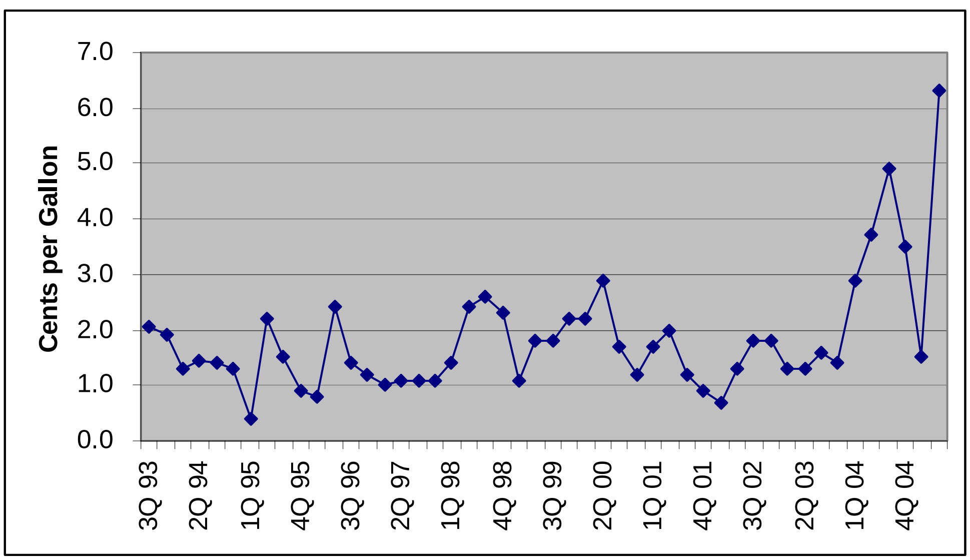
The costs in Table VIII.1 are impacted by crude/energy costs and high engineering and construction costs experienced in the current market.

B. Low Sulfur Price Implications

The market price of low versus higher sulfur distillates is a function of the production cost differential and market supply and demand. With surplus desulfurization capacity available, the market differential will tend to reflect the marginal operation cost differential. With a shortage or tightness in desulfurization capacity, the market will reflect a premium equal at least to the operating costs plus capital charge. The premium can be greater in a tighter market. In the longer term with a gradual growth in desulfurization capacity, the long term differential should approach operating and capital costs.

Figure VIII 1 shows historic price differentials for high sulfur distillate versus 500 ppm low sulfur diesel from 1993 through early 2005. Earlier data are not available from the data source, but at initial implementation of the 500 ppm standard in 1992, differentials were higher. Other variations over time reflected market conditions and less capacity tightness or concerns.

Figure VIII.1: NYH LS Diesel-No2 Distillate Price Differential



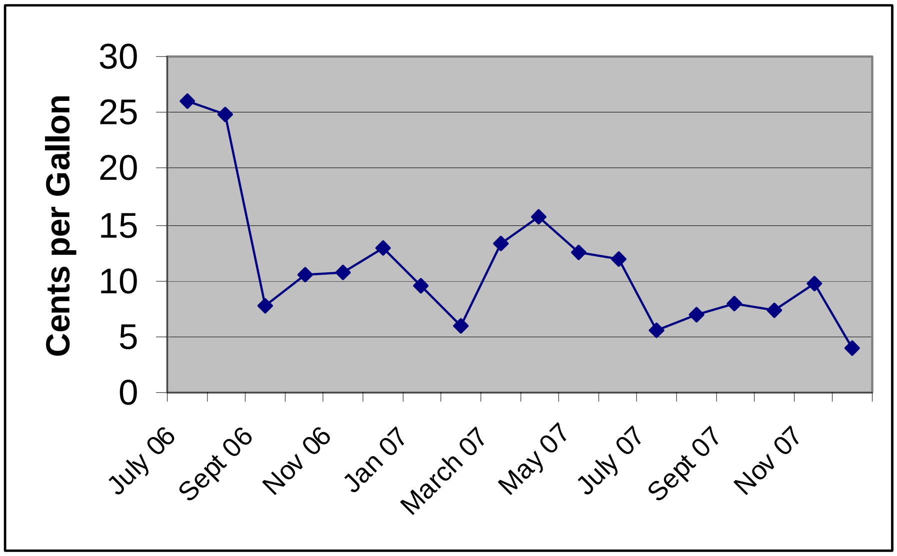
Source: Platts Oilgram Price Report

Prior to 2005, the differentials ranged from less than 1 cent per gallon to 3 cents per gallon. Given crude price (~$18-35/barrel) and lower construction cost during this period, the desulfurization cost was less than half that in Table VIII.1 or about 2.5 to 3.5 cents per gallon. Differentials were above operating cost but for most of the period below full capital cost.

The rise in differentials in early 2005 reflects increasing crude price (~$50/barrel) and some tightness in the market.

Figure VIII.2 provides price differentials for U.S. high sulfur distillate versus ultra low sulfur diesel. During initial implementation of ultra low sulfur diesel, the differentials reflected high premiums, above capital charge premiums. The premiums have since declined closer to operating plus capital charge.

Figure VIII.1: NYH ULS Diesel-No.2 Distillate Price Differential



Source: Platts Oilgram Price Report

Price differentials will continue to reflect a minimum premium of at least capital and operating costs. As long as ultra low sulfur programs are expanding and capital investment is required, the markets will justify full capital charge premiums. Markets are projected to be relatively tight through 2012, and therefore volatility in premiums (and high premiums) should be seen, particularly as new requirements are implemented.

Refinery E&C and capital costs are currently very high, which will also be reflected in premiums.

Longer term, as more refinery and desulfurization capacity comes on and the pace of low sulfur implementation slows, the premiums will be less volatile and at times may fall a little below full capital charge. Refinery E&C and equipment costs should ease some after 2012 to 2014, easing premiums slightly.

PO Overview

Status of Data 11/21/2017 05:02:00 Last Refreshed 11/21/2017 13:31:18

Filter Information

Query and Input Restrictions

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Vendor number	Empty Selection	Item Category	]Text[

Conditions and Exceptions

Filter

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Small Business Res	
Transaction Type	
Validity per. start	
Validity period end	
Vendor	
Key Figures	,IR Qty,IR Value

Table

Material		Business area		Plant		IR Qty	IR Value
144133	**FUEL OIL,HEATING,GRD,2,TANK WAGON**	**11**	**Corrections**	**1142**	**CORR SCI Camp Hill**	5,000.0 GAL	$ 8,628.50
				1161	**CORR SCI Rockview**	4,013.4 GAL	$ 7,286.73
				Resul		**9,013.4 GAL**	**$ 15,915.23**
		Result				**9,013.4 GAL**	**$ 15,915.23**
144134	**FUEL OIL,HEATING,GRD,2,TRUCK TRANSPORT**	**11**	**Corrections**	**1146**	**CORR SCI Dallas**	7,500.0 GAL	$ 12,556.50
				1148	**CORR SCI Graterford**	1,026,331.0 GAL	$ 1,728,613.70
				1152	**CORR SCI Huntingdon**	132,500.0 GAL	$ 211,763.13
				1160	**CORR SCI Retreat**	45,000.0 GAL	$ 72,956.25
				Resul		**1,211,331.0 GAL**	**$ 2,025,889.58**
		21	**Human Services**	**2103**	**DHS Allentown State Hospital**	185,412.0 GAL	$ 313,866.19
				2115	**DHS Hamburg Center**	363,105.0 GAL	$ 576,523.66
				2119	**DHS White Haven Center**	247,514.0 GAL	$ 385,424.56
				Resul		**796,031.0 GAL**	**$ 1,275,814.41**
		78	**Transportation**	**7828**	**PENNDOT Franklin**	7,500.0 GAL	$ 12,095.25
				7829	**PENNDOT Fulton**	5,000.0 GAL	$ 8,242.00
				7834	**PENNDOT Juniata**	5,000.0 GAL	$ 8,202.50
				Resul		**17,500.0 GAL**	**$ 28,539.75**
		Result				**2,024,862.0 GAL**	**$ 3,330,243.74**
326401	**HEATING OIL W/ADDITIVE**	**11**	**Corrections**	**1147**	**CORR SCI Frackville**	32,501.0 GAL	$ 52,058.02
				Resul		**32,501.0 GAL**	**$ 52,058.02**
		Result				**32,501.0 GAL**	**$ 52,058.02**
338133	**HEATING OIL W/ADDITIVE,TW**	**11**	**Corrections**	**1161**	**CORR SCI Rockview**	6,167.6 GAL	$ 10,782.17
				Resul		**6,167.6 GAL**	**$ 10,782.17**
		13	**Military & Veterans Affairs**	**1300**	**MIL/VET AFF**	19,175.5 GAL	$ 33,134.06
				Resul		**19,175.5 GAL**	**$ 33,134.06**
		Result				**25,343.1 GAL**	**$ 43,916.23**
Overall Result						**2,091,719.5 GAL**	**$ 3,442,133.22**