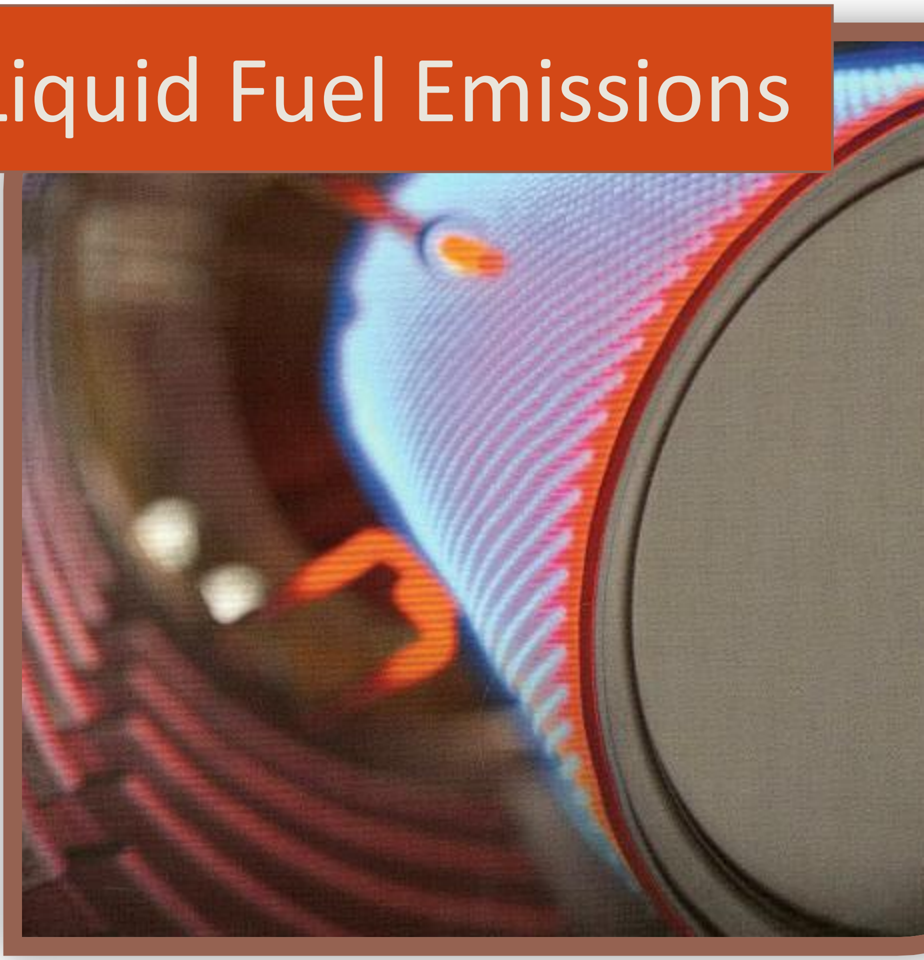
Assessment of Liquid Fuel Emissions



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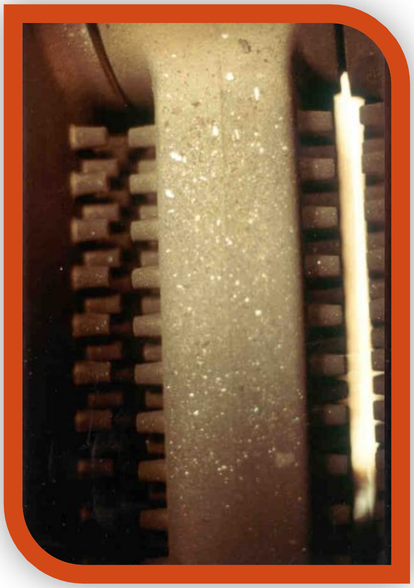
February 15, 2013

Executive Summary



The New York State Public Service Commission Case 12-G-0297, "Proceeding on Motion of the Commission To Examine Policies Regarding the Expansion of Natural Gas Service", cites as a principle reason to use ratepayer funds for market intervention to accelerate the conversion of oil fired boilers and furnaces to natural gas fired boilers and furnaces is that "[p]er unit of energy, natural gas emits approximately 28% less carbon dioxide than petroleum derived fuels and has significantly lower levels of nitrogen oxides (NO_x), sulfur dioxide (SO_2) and particulate matter." Based on studies by ICF International and testing performed at Brookhaven National laboratory, ultra-low sulfur heating oil and bio-blends emissions from modern appliances yield: CO_2 equivalent (CO_2e) lifecycle- emissions, nitrogen oxides (NO_x), sulfur dioxide (SO_2) and particulate matter ($MP_{2.5}$) emissions which are equal to or even less than those from natural gas appliances.

Contents

Executive Summary 1

Contents 2

Background..3

Heating Oil and Bio-Blends 3

Carbon dioxide emissions..3

20-Year Time Horizon Background...*4*

Delivered Fuel...*5*

End-use Energy Efficiency...*7*

Examining Emissions from High Efficiency Non-Condensing Boilers.....................*9*

CO_2e Emissions Conclusions...*10*

NOx Emissions 10

SO_2 Emissions 11

Particulate Emissions...11

Appendix A Shale Gas Life-Cycle Emissions...13

Background

In 2009, the ICF Corporation released a report titled Final Report. Resource Analysis of Energy Use and Greenhouse Gas Emissions from Residential Boilers for Space Heating and Hot Water. This report sought to understand the life cycle emissions of current heating oil (#2 oil), Ultra Low Sulfur Heating Oil (ULSD < 15 ppm sulfur), first generation biodiesel blends, natural gas delivered mixes and marginal LNG. The goal of the report was to assess the effectiveness of biofuels in heating oil in reducing greenhouse gases and to determine what levels of biofuels were necessary to obtain equivalence with competing fuels.

The New York State heating oil industry is seeking a scientific based response to the New York Public Service Commission (NYPSC) Case 12-G-0297 – Proceeding on Motion of the Commission to Examine Policies Regarding the Expansion of Natural Gas Service, and an assessment of the factual basis which serves as the foundation for the policy recommendations.

The NYPSC order issued November 30, 2012 stated on page 3 that as a primary reason for state intervention in the market “natural gas is a cleaner fuel than No. 2 oil, kerosene or propane in terms of emissions of particulate matter, nitrous oxide, sulfur dioxide, and carbon dioxide. It is also significantly cleaner than coal. Per unit of energy, natural gas emits approximately 28% less carbon dioxide than petroleum derived fuels and has significantly lower levels of nitrogen oxides (NOx), sulfur dioxide (SO2) and particulate matter.[1] Use of natural gas that displaces oil or coal consumption will result in lower overall emissions.”

The conclusion that “use of natural gas that displaces oil or coal consumption will result in lower overall emissions” is based on outdated data and thus leads to erroneous conclusions which the NYPSC should fully understand and evaluate before proceeding and which are the subject of this report.

Heating Oil and Bio-Blends

Carbon dioxide emissions

While ultimate energy choices as to which fuel to consume are made by builders, remodelers and consumers, and these choices are most often based on economics, these choices are also influenced by perceptions of how efficiently, or inefficiently, our energy resources are being used and how such choices impact the environment, including the release of greenhouse gases into the atmosphere. Focusing on sustainability in the built environment requires life cycle assessments of building products and equipment. Sustainable energy production and consumption should also require life cycle, or fuel cycle, assessments from wellhead to burner tip. It is important, therefore, that consumers,

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[1] Energy Information Administration, Natural Gas 1998 – Issues and Trends, April 1999, at http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/natural_gas_1998_issues_trends/pdf/it98.pdf.

builders and policy makers have the most accurate estimates of energy consumption, energy efficiency and environmental impacts when making energy choices for their homes. However, most efficiency standards and regulations that pertain to residential space heating and hot water appliances are “site-based” - that is, they only consider the impacts at the site where the energy is ultimately delivered. Given that the energy consumption and environmental impacts along the total energy production and supply chain are not included, reliance on site-based data can thus lead to inaccurate comparisons which may result in higher energy resource consumption, as well as higher levels of pollution.

Total resource energy and fuel cycle emissions analysis are more comprehensive and accurate methods to assess the total energy and emissions impacts of fuel consumption at the point of use. These methods examine all energy consumption and emissions impacts associated with fuel use, including those from the extraction/production, processing, transmission, distribution, and ultimate energy consumption stages of the fuel cycle. Site energy analysis only takes into consideration the ultimate consumption stage. Significant energy is consumed, with resulting emissions of $CO_2$and other greenhouse gases (GHG), during all stages of energy use. Greenhouse gas emissions are usually reported in pounds or metric tons of CO_2 equivalent (CO_2e). CO_2e is a measure used to compare different types of greenhouse gas emissions by converting all the various greenhouse gases to a carbon dioxide equivalent. This conversion to a common metric is accomplished using each gas’s Global Warming Potential (GWP). GWP values have been established for the various GHGs by the Intergovernmental Panel on Climate Change (IPCC), the premier inter-governmental organization examining climate change and its impact on society. Therefore, it should be clear that CO_2e emissions should drive policy and not CO_2 emissions.

20-Year Time Horizon Background

A 2009 study conducted by ICF International[2] compared the relative energy resources consumed and GHG impacts associated with natural gas (pipeline and LNG), heating oil (current product and ultra-low sulfur [ULS]), and biofuels (B5, B20 and B100) used for residential space heating boilers and water heating.

The baseline data compiled for this comprehensive study used the United Nations Intergovernmental Panel on Climate Change’s Third Assessment Report (IPCC-TAR, 2001) on the effects of GHGs over a 100-year time horizon. This assessment weights the methane GHG impact at 23 times CO_2 over the 100 year timeframe and 62 times CO_2 over a 20-year timeframe.

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[2] “Final Report. Resource Analysis of Energy Use and Greenhouse Gas Emissions from Residential Boilers for Space Heating and Hot Water” Revised February 2009, Submitted to: Consortium of State Oilheat Associations Greenhouse Gas Project

IPCC Third Assessment Report (2001) TAR			
	20 year	**100 year**	**500 year**
Carbon dioxide	1	1	1
Methane	62	23	7
Nitrous oxide	275	296	156

The IPCC Working Group 1 presents GWP values based on the most up-to-date science, but does not recommend any rules on application of those values. Note that the latest science presented in the Fourth Assessment Report (AR4) released in 2007 rates the 100-year impact of methane at 25 times CO_2 and the20-year impact of methane emissions at 72 times the global warming potential of CO_2.

IPCC Fourth Assessment Report (2007) AR4			
	20 year	**100 year**	**500 year**
Carbon dioxide	1	1	1
Methane	72	25	7.6
Nitrous oxide	289	298	153

Short-lived pollutants that scientists are targeting today which actually warm the atmosphere are methane and hydrofluorocarbons (HFCs) which are greenhouse gases like $CO_{2,}$ trapping radiation after it is reflected from the ground. Black carbon and tropospheric ozone, an element of smog, are not greenhouse gases, but they warm the air by directly absorbing solar radiation. Black carbon remains in the atmosphere for only two weeks and methane for no more than 15 years.

Focusing on near term targets for GHG impacts is both an effective strategy and recommended policy as it can have a more dramatic effect in the short term than reductions in carbon dioxide, thus providing more time to develop appropriate carbon dioxide reduction strategies. This renewed focus on 20-year GHG targets stimulated a reassessment of the ICF life-cycle study using the AR4 20-year numbers for methane emissions in the production, transportation, delivery and combustion of heating oil, ultra-low sulfur diesel, bio-blends, natural gas and LNG.

Delivered Fuel

The fuel cycle GHG emissions comparison graph shows the amount of CO_2 equivalent emissions associated with delivering each MMBtu of the selected fuels to the burner-tip with complete combustion, (not including end use equipment efficiency).

Figures 1 through 4 contain two lines representing natural gas CO_{2e} emissions which are derived from two studies conducted by ICF. The line described as "*Original Natural Gas Mix*" is from the ICF report cited in footnote 2 above. The line described as *"Projected*

Shale Gas Mix" uses the ICF projected shale gas mixture CO_{2e} emissions[3] from the ICF NYC report cited in footnote 8. It should be noted that the delivered fuel CO_{2e} emissions for the new shale gas dominated mixture in this report is based on a positive view of energy consumption and methane discharges during shale gas development. It does not incorporate the much more negative views expressed in several reports. Further research is required to better determine more accurate estimates of CO_{2e} emissions from shale gas development. For the purposes of this report, the more positive emissions profile for shale development does not compel a conclusion that converting customers to natural gas will have a meaningful impact on emissions.

Figure 1 covers the New York, New Jersey and Pennsylvania Region[4]. The 100-year IPCC AR4 data shows that a B30 blend approximates projected shale gas mix emissions[5] and a B25 ULS blend approaches the current delivered natural gas mixture to the region.

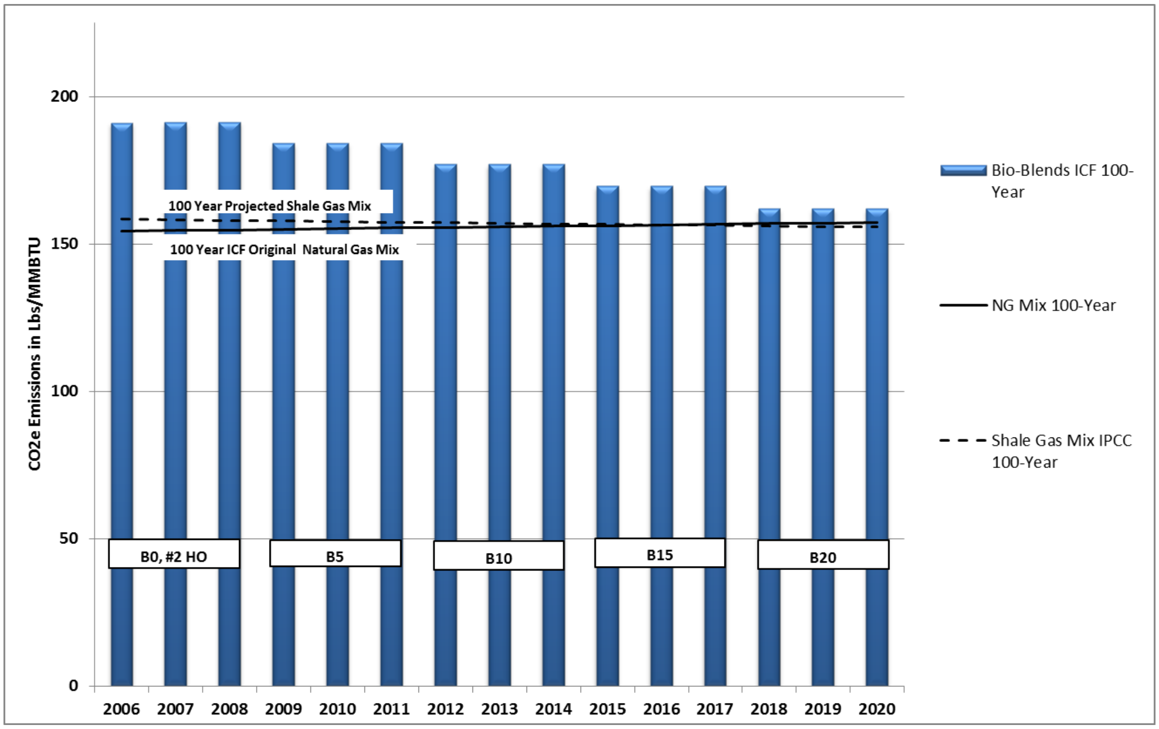

Figure 1: 100 -Year CO_{2e} Emissions in Lbs/Year in the NY/NJ/PA Region using AR4 Data

Shifting the focus on near-term GHG mitigation changes the weighting of methane emissions for the exploration, production and delivery of these fuels by a factor of 72/25 (AR4). Using the

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[3] 100-year atmospheric lifetime numbers used from Table 1. 20-year atmospheric lifetime numbers calculated from the 00-year atmospheric lifetime numbers based on IPCC AR-4 values.

[4] Regional differences are import to note as fuel supply, production and delivery mixes differ widely by region significantly impacting life-cycle emission results.

[5] Marginal shale gas refers to the fact that conventional domestic natural gas is fully committed and new customer supplies will likely come from shale supplies (see appendix A for shale gas assumptions).

20-year IPCC AR4 data shows that an approximate B5 blend approximately equals projected shale gas mix emissions and a B8 blend approaches the ICF 2012-2014 historically delivered natural gas mixture to the region.

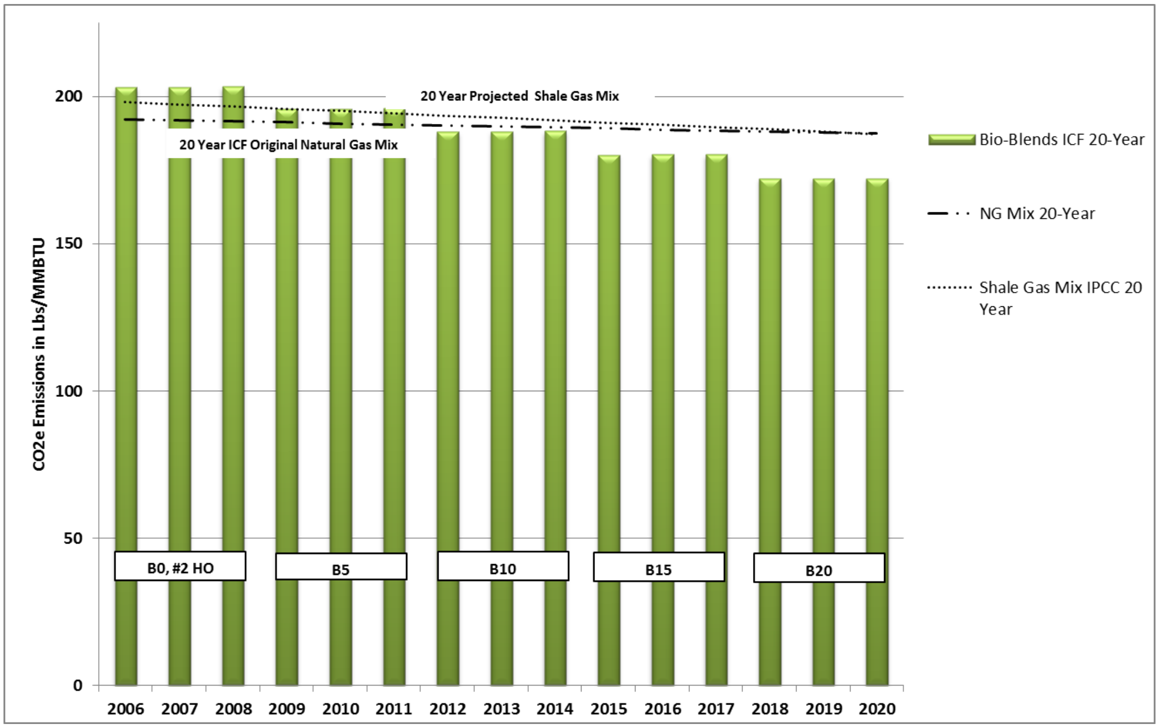

Figure 2: 20-Year CO_{2e} Emissions in Lbs/Year in NY/NJ/PA Region using AR4 Data

End-use Energy Efficiency

Brookhaven National Laboratory[6] (BNL) developed an accurate method to determine system efficiency for integrated heating and domestic hot water residential systems[7]. The BNL model is more accurate in predicting actual building heating and DHW performance than the commonly used AFUE methodology. Three boiler configurations were examined: An average efficiency boiler (based on sales), a high efficiency boiler and a condensing boiler. The comparison was performed on a 2,500 ft^2 ranch home with a basement and typical “code” construction. Figure 3 and 4 provide the total annual resource energy requirements to provide heating and hot water services to the modeled 2,500 square foot house (including energy use along the fuel cycle and end use equipment efficiency) for 2006 and 2020 respectively. Total energy requirements to provide the annual heating and hot water services is higher for natural gas for both the average, high efficiency non-condensing units in 2006 (Figure 3), reflecting two important factors: 1) The large amount of Gulf Coast and Western Canadian gas supply to the region; and 2) the non-

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[6] Performance of Integrated Hydronic Systems, Project Report, May 1, 2007, Thomas A. Butcher, Brookhaven National Laboratory.

[7] AFUE leads to low estimates of the energy savings potential of modern, integrated systems, particularly where advanced controls are used.

condensing appliance and system efficiency advantage which oil and biofuel blends have versus natural gas and shale gas through less hydrogen content[8].

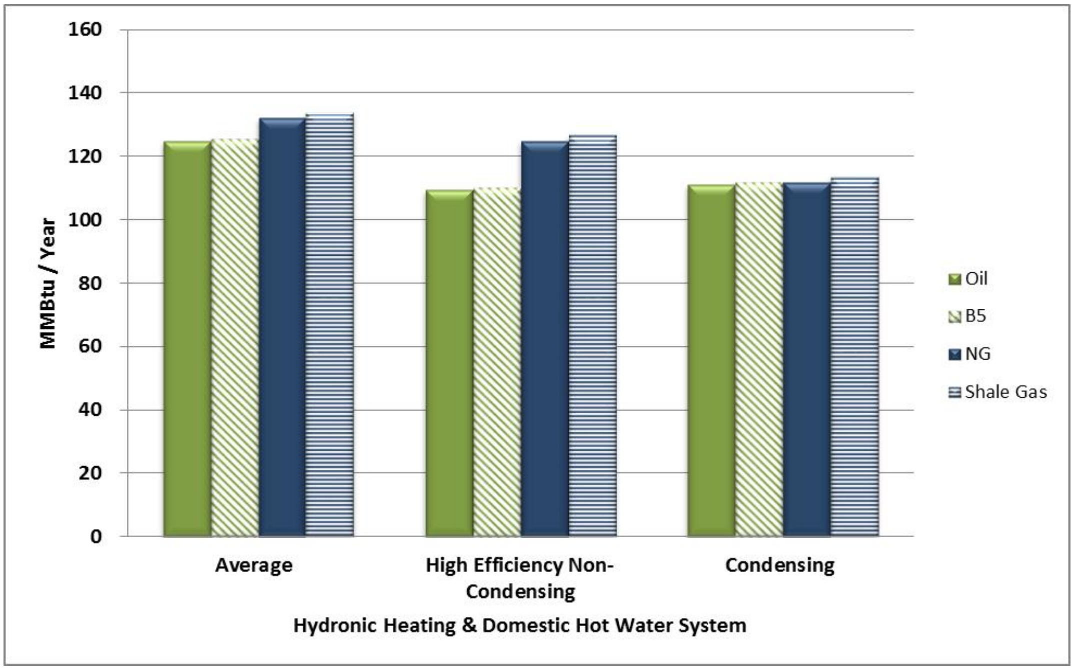

Figure 3: 2006 Fuel Cycle Energy

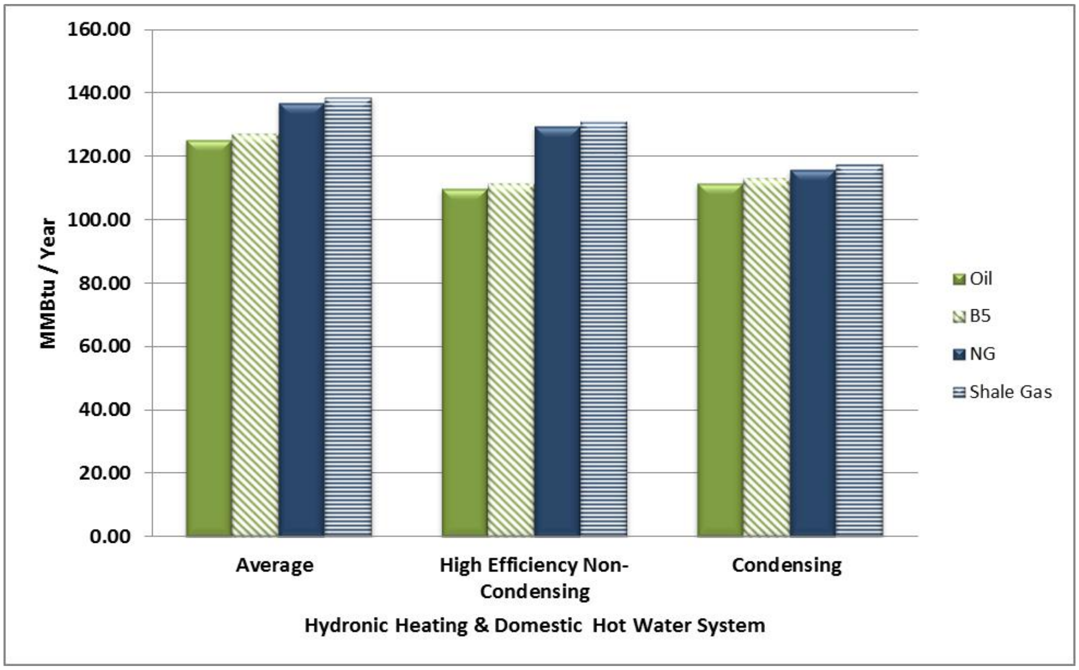

Figure 4: 2020 Fuel Cycle Energy

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[8] With respect to current non-condensing appliances - natural gas maximum boiler AFUE efficiency is 83% and oil maximum boiler AFUE efficiency is 88% with the reason for this differential being the hydrogen content in the fuel and resultant combustion gas dewpoint affecting performance.

Examining Emissions from High Efficiency Non-Condensing Boilers

Comparing AR4 100-year CO_{2e}emissions generated from a high efficiency natural gas boiler with an indirect domestic hot water tank versus a high efficiency non-condensing oil or bio-blend boiler with an indirect domestic hot water tank yields the results shown in Figure 5. This Figure uses the 100 year evaluation criteria, and a B6 blend equals the historic gas mixture and a B5 blend produces about the same CO_2e emissions as the projected shale gas mix in 2015.

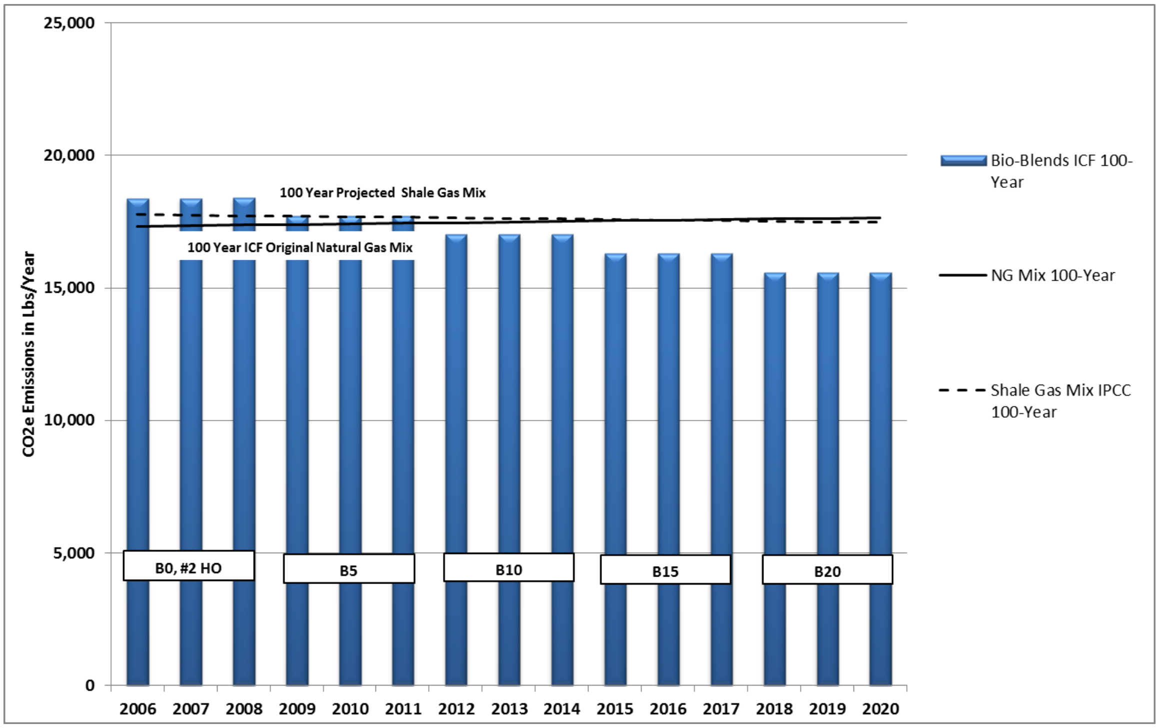


Figure 5: 100-Year CO2e Emissions in NY/NJ/PA Region using AR4 Data in Lbs/Year

Comparing AR4 20-year CO_{2e} emissions generated from a high efficiency natural gas boiler with an indirect domestic hot water tank versus a high efficiency non-condensing oil or bio-blend boiler with an indirect domestic hot water tank, yields the results shown in Figure 6 where in all cases, liquid fuels produce less CO_{2e} emissions than natural gas or shale gas mixtures studied.

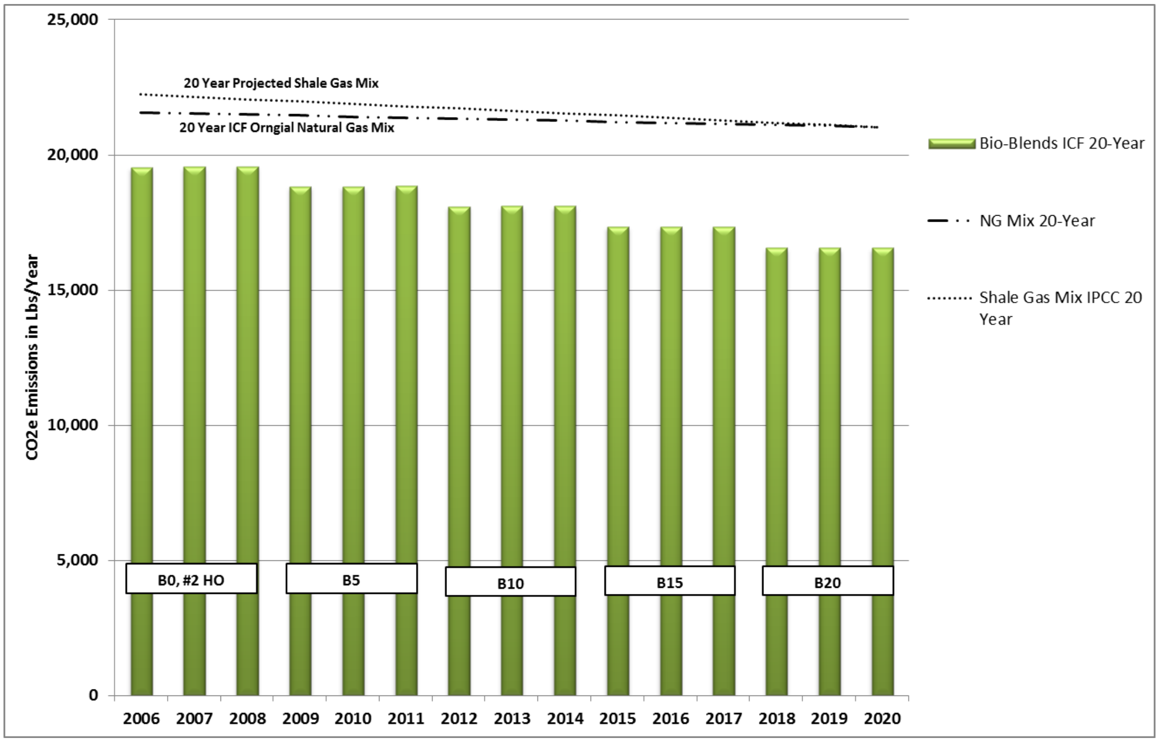


Figure 6: 20-Year CO_{2e} Emissions in NY/NJ/PA Region using AR4 Data in Lbs/Year

CO_2e Emissions Conclusions

1. The scientific community and U.S. energy policy leaders are now focusing on short-lived carbon forcers like methane as a means to quickly impact global warming issues.
2. Using the 20-year IPCC AR4 data shows that, with respect to a complete combustion fuels basis, an approximate B5 blend equals projected shale gas mix emissions and a B6 blend approaches the ICF 2012-2014 historically delivered natural gas mixture to the region.
3. It is essential to understand the end-use application of heating appliances and the ability to apply them to existing homes. For example, condensing boilers, applied to existing homes with radiant heat generally do not operate in condensing mode as the return temperatures are too high. Therefore, applying these appliances for policy purposes does not reflect scientific reality.
4. Using the 20-year IPCC AR4 data and comparing high efficiency non-condensing appliances shows all oil, ULSD and bio-blends significantly lower in CO_{2e} emission than shale gas or historical delivered natural gas mixtures to the region.
5. Thus in the short term, less than 20 years, use of natural gas may have a stronger impact on global warming than heating oil. An evaluation over a hundred years, heating oil may have a stronger impact on global warming; however, this long-term effect is easily ameliorated by blending in biodiesel at percentages of approximately 5 percent.

NOx Emissions

Nitrogen oxides (NOx) includes both NO and NO_2 and are a pollutant emissions from all combustion sources. NOx is a concern nationally, mainly because it combines with hydrocarbons in the atmosphere and, under the influence of sunlight, forms ozone. With conventional yellow flame systems the NOx emissions depend upon the firing rate and the combustion chamber. Higher firing rates and increased refractory lining in the combustion chamber (hotter chamber) tend to produce higher flame temperatures and higher NOx. Current U.S. systems range from roughly 75 ppm to 180 ppm. Arguably, 110 ppm is about the average for oil combustion with yellow flame burners.

Low-NOx residential oil burners based on high rates of recirculation of combustion products within the combustion chamber are available today. These burners have higher air velocity, and more of the air is introduced to the flame zone along the burner centerline, flame tubes to control recirculation, and flame tube slots or holes which control the amount and location of the recirculated flue gas. With these burners, achievable NOx emissions range from 40 to 65 ppm.

It is technically feasible to achieve NOx emissions under 10 ppm with a nitrogen free fuel. Routes which have been developed towards achieving this goal include: 1) Increased recirculation rates with current low-NOx burner designs with special provisions for startup; 2) new burner head designs; and 3) oil vaporization followed by combustion in radiant, porous media.

SO_2 Emissions

The sulfur in any fuel results in sulfur oxides being released into the atmosphere when it is burned. During combustion in residential heating systems, roughly 98-99% of the sulfur in the fuel is oxidized to form sulfur dioxide (SO_2) and emitted from the stack. BNL testing shows that changing to lower sulfur content fuel (500 ppm) eliminates about 75-80 percent of the sulfur dioxide emissions from residential oil heating systems. Ultra-Low Sulfur heating oil fuels (15ppm) produce immeasurable amounts of sulfur dioxides in the flue stack similar to natural gas. The New York State Legislature enacted policies reducing the sulfur content in fuel to less than 15 ppm effective July 1, 2012. As a result of this legislative initiative, the petroleum industry has invested to manufacture and distribute these qualifying fuels throughout the state and they are in use today.

Particulate Emissions

According to testing performed by Brookhaven National Laboratory, with respect to small particle emission for combustion of heating oil, they found a direct correlation between sulfur content and particulate emissions. Test data displayed in Figure 7 shows that small particulate emissions for ULSD to be in the immeasurable range below 0.1 mg/MJ, which is essentially the same as natural gas.

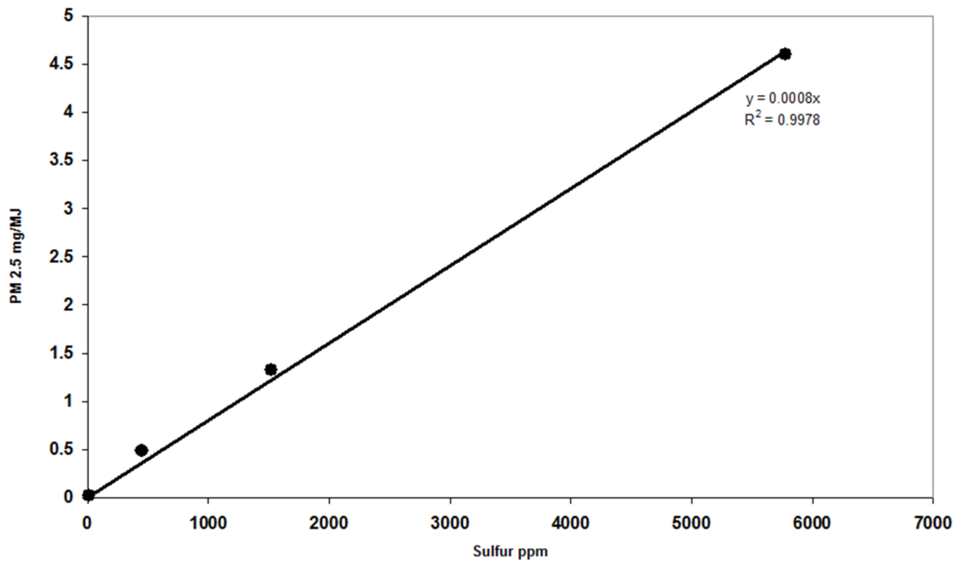


Figure 7: Brookhaven National Laboratory Sulfur Test Results

Brookhaven National Laboratory (BNL) tests show that PM 2.5 emissions for Ultra Low Sulfur heating oil are on the same order of magnitude as natural gas (Figure 8).

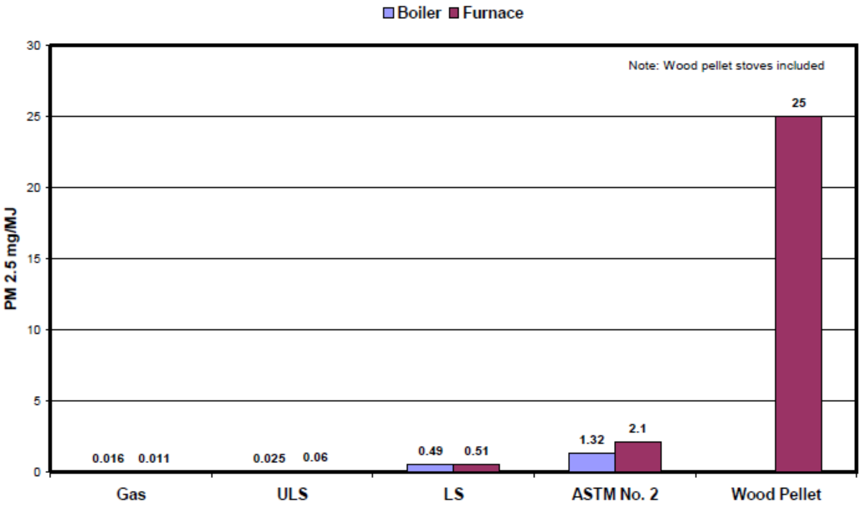
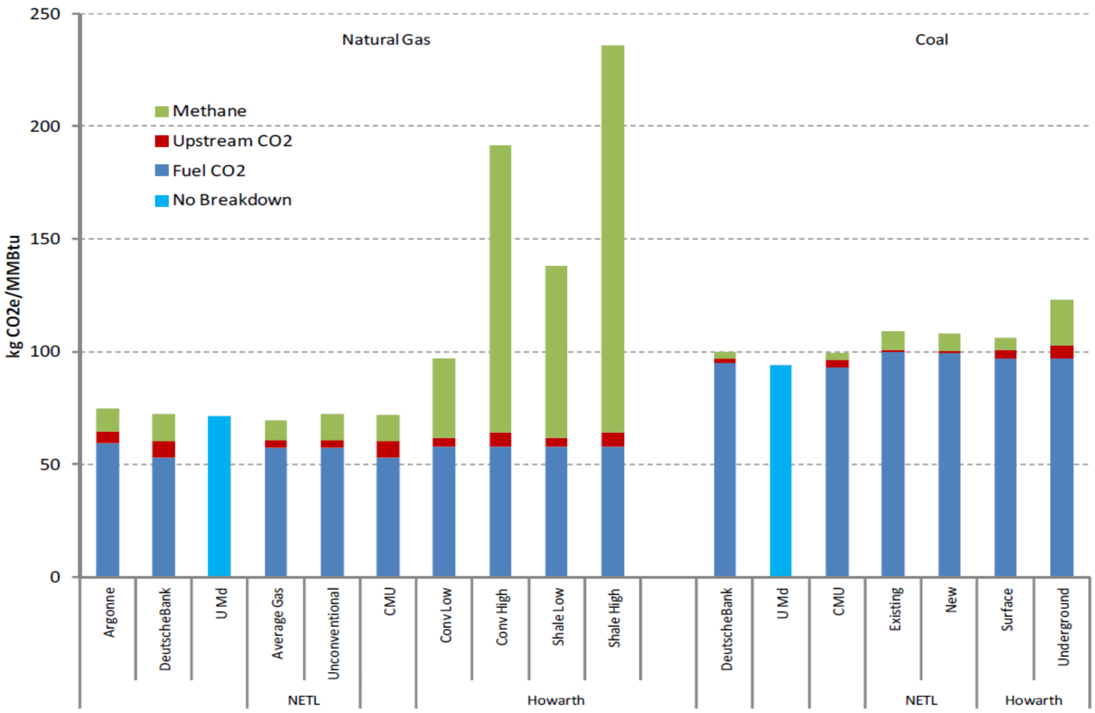


Figure 8: Comparison of Average PM2.5 for Five Heating Fuel Types for Hydronic Boilers and Warm Air Furnaces

Appendix A Shale Gas Life-Cycle Emissions

A recent study of natural gas emissions for New York City focused on emissions from shale gas[9] delivered to New York City. This study recognized that "some analysts became concerned in early 2011 that the overall impact would be very large, resulting in high life-cycle emissions estimates for gas, especially shale gas produced through hydraulic fracturing. These concerns resulted in the release of several new studies of the life-cycle emissions of natural gas and coal in 2011…" These studies had wide variations, largely due to methane emissions assumptions and atmospheric lifetime assumptions.

The ICF study recognized the validity of focusing on 20-year atmospheric lifetime when concerned with understanding short term (20 year) global warming potential. "The IPCC also establishes 20-year GWPs. Some analysts believe that the 20-year GWP is more appropriate to use for short-lived GHGs like methane, especially to show the potential benefits of short-term mitigation options for these GHGs. Because methane is more potent over its shorter life, the IPCC 20-year GWP for methane is 72." Yet, ICF chose only to report 100-year lifetime results with respect this natural gas report. We believe this is a flawed approach as policymakers seeking to influence global warming issues today must focus on 20 year lifetime emissions to bend the curve as 100 years is simply too long.



Source: Cited studies and ICF Analysis.

Figure 9: Comparison of Recent Studies of Life-Cycle Emissions from Natural Gas and Coal (kg CO$_2$e/MMBtu) (ICF Figure 5.4)

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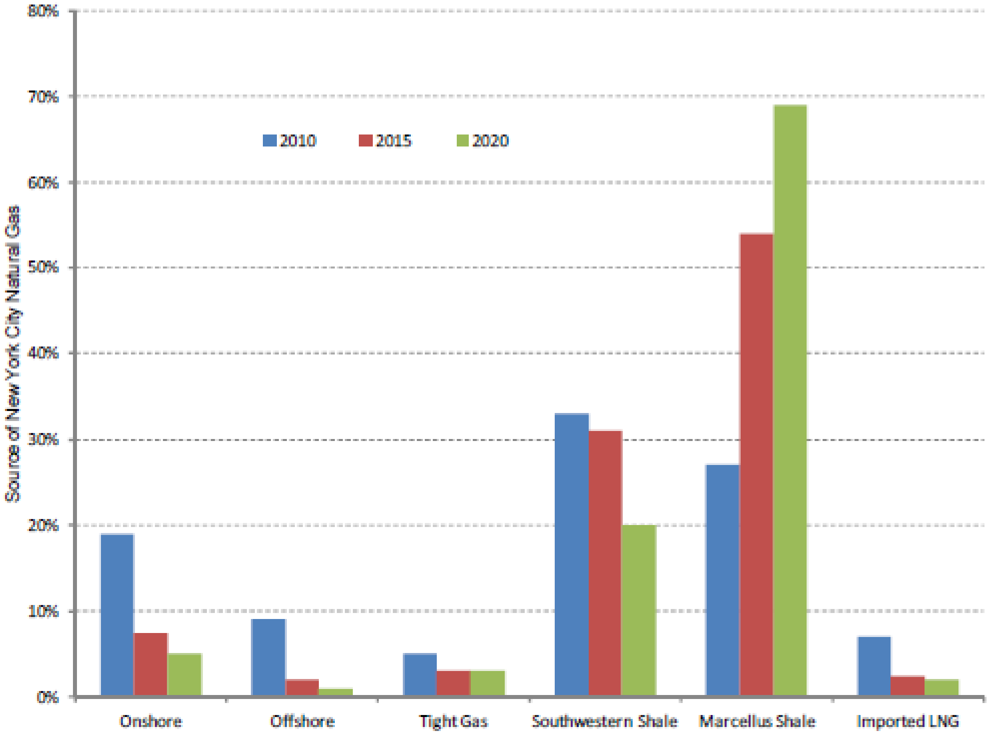
[9] "Assessment of New York City Natural Gas Market Fundamentals and Life Cycle Fuel Emissions" ICF International, New York City Mayor's Office of Long-Term Planning and Sustainability, Aug 28, 2012



Source: ICF Analysis.

Figure 10: Sources of New York Gas Supply - 2010 to 2020

Figure 10 shows ICF's calculations for natural gas supply to NYC in 2010 through 2020. Using these IPCC 100-year lifetime numbers ICF concluded *"gas delivered to New York City were estimated to range from 72.0 kg* CO_{2e} */MMBtu in 2010 to 70.8 kg* CO_{2e} */MMBtu in 2020, varying based on the sourcing of the gas and the life-cycle emissions from each source."*

This report utilized the extensive analytical work compiled by ICF for Oilheat dealers[10] as a basis and updating the natural gas delivered figures to account for shale gas development in a conservative manner Table 1 contains the delivered lb CO_{2e} /MMBtu used in the preceding graphs and analysis.

Table 1 Delivered Gas to New York State (100-year Atmospheric Lifetime)

	2010	2020	Units
ICF NYC NG Report	72	70.8	*kg* CO_{2e} */MMBtu*
ICF NYC NG Report	158.4	155.76	*lb* CO_{2e} */MMBtu*
Used in this Report	158.4	155.76	*lb* CO_{2e} */MMBtu*

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[10] "Final Report Resource Analysis of Energy Use and Greenhouse Gas Emissions from Residential Boilers for Space Heating and Hot Water" Revised February 2009, Submitted to: Consortium of State Oilheat Associations Greenhouse Gas Project