Assessment of Bio-Oil as a Replacement for Heating Oil

By
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For
Northeast Regional Biomass Program
Managed by the
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Executive Summary

Key issues regarding bio-oil commercialization are assessed in this white paper, with a particular focus on the use of this fuel in heating oil applications. The report is intended to be a first cut assessment of the potential for future development of regional bio-oil production and markets. Markets for lower valued wood from the forest are important for preserving the economic viability of the forest products industry in the Northeast. One potential use for lower value wood is the production of bio-oil. In general, liquid fuels are more convenient to store, transport, and combust than solid fuels. Thus a primary benefit offered by converting solid biomass fuels into bio-oil is the production of a more convenient and thus more readily marketable liquid product. Although bio-oil has a number of physical characteristics that differ from conventional petroleum-based fuel oil, including lower energy content per gallon and higher acidity, tests and demonstrations to date indicate that bio-oil should be a reasonable fuel for applications such as heating or electricity generation. In circumstances where biomass can be obtained as a residue at near zero cost, bio-oil production is likely to be economically competitive. In the Northeast United States, where biomass such as wood chips often costs in the range of $18 per green ton, there will be a need for strong markets for the by-products of bio-oil production (such as specialty chemicals), or the existence of renewable energy mandates or incentives in order to make bio-oil applications economically attractive. There are a number of programs or market areas where the renewable nature of bio-oil may make it a viable option for nearer-term applications in heating commercial/institutional-scale buildings. These programs or market areas include federal buildings (where there are specific targets/requirements to increase the use of renewable energy sources), commercial-scale buildings/complexes that are targets of a new federal initiative to facilitate biomass fueled “super” energy saving performance contracts (ESPCs), state programs that are designed to encourage renewable energy use at state-owned facilities, and municipal governments (or institutions such as universities) that have formally adopted policies to reduce the net greenhouse gas emissions from their facilities.
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Overview

Markets for lower valued wood from the forest are important for preserving the economic viability of the forest products industry in the Northeast. One potential use for lower value wood is the production of a liquid fuel often called bio-oil.

Bio-oil is produced by a process known as pyrolysis, where biomass (such as wood) is essentially cooked rapidly in a high temperature oxygen-free environment, yielding a mix of liquid fuel (bio-oil), combustible gases, and solid char. On a weight basis, 60 to 80% of the incoming biomass is converted to bio-oil, depending on the conversion process and the type of biomass feedstock being converted. The char and gases can be used as fuel to provide heat to dry the incoming biomass feedstock and to run the pyrolysis conversion process. If the incoming biomass has less than about 50% moisture content, there may be residual heat available for other industrial heat applications. Alternatively, the char can potentially be sold for higher-value uses (e.g., for the production of activated carbon, various chemicals, or charcoal).

In general, liquid fuels are more convenient to store, transport, and combust than solid fuels. Thus, a primary benefit offered by pyrolysis is the production of a more convenient and thus more readily marketable liquid product.

Bio-oil producers claim a number of potential uses for bio-oil, including a fuel to power electric generators and to replace heating oil. The development of a successful bio-oil production facility is dependent on a number of factors. The following report is intended to be a first cut assessment of the potential for future development of regional bio-oil production and markets.

Bio-oil Characteristics

Bio-oil characteristics vary somewhat, depending on the production technology and the type of biomass feedstock from which the bio-oil is produced. This means that bio-oil fuel specifications are likely to be fairly important. Bio-oil’s energy content is in the range of 72,000 to 80,000 Btu/gallon. (At the higher end of this range, there will typically be greater amounts of suspended char in the bio-oil.) Conventional heating oil has an energy content of about 138,500 Btu/gallon, thus bio-oil has about 52% to 58% as much energy as heating oil per gallon. However, it is interesting to note that bio-oil weighs about 40% more per gallon than heating oil.

Bio-oil is typically a dark brown liquid with a smoky acrid smell. It tends to have a relatively high water content – typically in the range of 20 to 25% water. The water comes from the pyrolysis conversion process, as well as from the initial water in the biomass feedstock. When the water content of the bio-oil is in the 20 to 25% range, it is entirely miscible in bio-oil (i.e., it
does not separate). At higher moisture levels, the water can tend to separate from the bio-oil. To prevent this from happening, it is desirable to have the incoming biomass feedstock dried to 10% moisture content, or less, before it is fed into the pyrolysis conversion process.

Bio-oil is a free flowing liquid. Its viscosity tends to be slightly higher than conventional no. 2 fuel oil. As the water content in bio-oil increases, its viscosity decreases (as does its energy content).

Bio-oil is moderately acidic, having a pH in the range of 2.5 to 3.0 (similar to the acidity of vinegar). This means that bio-oil fuel storage tanks will need to be made of material that will not corrode due to the acidic character of the fuel (i.e., they will need to be made of materials such as stainless steel, plastic, fiberglass, etc.). This raises a significant issue regarding the use of bio-oil in existing residential or commercial installations, since most of the existing fuel storage tanks used for heating oil are likely to be made of plain steel that is vulnerable to corrosion from bio-oil. As a result, it will generally be necessary to install a new fuel storage tank if bio-oil is to be used for an existing heating oil installation. [Note that New York State (NYS) has a program where it will pay $500 toward the replacement cost of an existing residential underground fuel storage tank, in an effort to reduce petroleum leakage from older tanks. With this program, NYS homeowners may be able to install replacement tanks that are made of material that can store bio-oil as well as conventional heating oil.]

Bio-oil is a complex mixture of oxygenated compounds, which provides potential drawbacks as well as potential benefits:

- From a fuel storage perspective, bio-oil is not as stable as petroleum fuel. However, bio-oil developers (such as DynaMotive) have found that bio-oil samples stored for over a year have remained stable. Producing bio-oil with lower ash (char) content and/or lower water content helps prolong the stability of bio-oil in storage.

- From an elemental analysis perspective, bio-oil produced from wood contains about 56% carbon, 6% hydrogen, 37% oxygen, 0.1% nitrogen, 0.1% ash, and negligible sulfur [Bridgwater, 2001], which could translate into a number of benefits:
  - The high oxygen content of bio-oil should help improve its combustion characteristics in comparison to petroleum-based fuels, which should help reduce the amount of carbon dioxide emissions/pollution produced when bio-oil is burned as a fuel. This could potentially enhance the energy value of the bio-oil beyond that expected based on a simple Btu’s per gallon perspective (i.e., similar to the oxygenation benefits found when combusting ethanol fuel, another bio-fuel that contains a substantial amount of fuel-bound oxygen).
  - The low nitrogen content of bio-oil should help reduce NOX emissions. For example, tests of a combustion turbine showed that NOX emissions were about half as much using bio-oil as they were using diesel fuel [Morris, 2000].
  - The low sulfur content of bio-oil should also result in reduced SOX emissions compared to the use of petroleum-based fuel oil or diesel fuel.

Bio-oil does not naturally blend with conventional petroleum fuel. It may be possible to add a solvent or to emulsify mixtures of bio-oil and fuel oil in order to get homogeneous blends. Bio-
oil manufacturers indicate that they are working on techniques that will allow for blending of bio-oil and fuel oil, and they are optimistic that workable approaches will be available in the future. An invention, known as the BDM Process, has been developed through efforts of the Canadian government (Natural Resources Canada) that produces a stable bio-oil/diesel fuel mixture with properties similar to those of No. 2 fuel oil [Hogan, 2002].

**Heating Oil Markets**

For the entire U.S., the amount of energy used in the form of heating oil for residential, commercial, and institutional uses is about 24% as much as that consumed in the form of diesel fuel for transportation (i.e., 1,228 trillion Btu’s, compared to 5,161 trillion Btu’s for transportation). However, for the eleven states encompassed by the Northeast Regional Biomass Program (NRBP), the amount of energy used in the form of heating oil for residential, commercial, and institutional uses is about 124% as great as the amount of diesel fuel energy used in the region for transportation (i.e., 869 trillion Btu vs. 698 trillion Btu as diesel fuel; see Table 1 for more details). Thus from an energy security perspective regarding dependence on petroleum supplies, heating oil is an important consideration for the Northeast. The ability of bio-oil to help reduce dependencies on petroleum supplies in applications such as heating oil replacement could warrant policies and incentives from state and federal governments that support bio-oil applications.

**Bio-Oil Economics**

The production of co-products in addition to bio-oil is very important for the economic competitiveness of bio-oil, as the following points illustrate.

- In 2001, the average wholesale price of fuel oil in the northeast was 76.7 cents per gallon; commercial/institutional users paid an average of 87.3 cents per gallon; and residential users paid an average of $1.26 per gallon (see Table 2 for a state-by-state breakdown of prices).

- As illustrated in Table 3, this means that the equivalent energy value of bio-oil on a dollar per Btu basis is 41 cents/gal in wholesale markets, 47 cents/gallon in commercial/institutional markets, and 68 cents/gallon delivered to residential users.

- At a yield of 115 gallons of bio-oil per dry ton of wood, the total revenue for each green ton of wood processed would be $26.20 if the bio-oil were sold at wholesale prices, and $43.10 if it were sold at residential retail prices.

The price of wood chips in Vermont and New Hampshire has been in the vicinity of $18 per green ton. If the total revenue per green ton of wood processed were $26.20, when the bio-oil is sold at wholesale fuel oil prices, this would leave about $8.20 of net revenue to cover operation and maintenance costs, as well as capital recovery costs, when the cost of wood feedstock is $18 per green ton. This helps illustrate why additional co-product revenue is important to make the economics work for bio-oil production.
Table 1. Fuel Oil Consumption Estimates, 1999 (trillion Btu)

<table>
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<tr>
<th>State</th>
<th>Distillate</th>
<th>Commercial</th>
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<th>Utility</th>
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<td>65.7%</td>
<td>96.4%</td>
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</table>

“Dist.” – Distillate fuel -- primarily no. 2 fuel oil for residential, commercial, industrial, and utility uses; for transportation distillate is diesel fuel.

“Resid.” – Residual fuel oil, primarily no. 6 fuel oil

Source: U.S. Energy Information Administration, [www.doe.eia.gov](http://www.doe.eia.gov)
Table 2. No. 2 Distillate Prices by Sales Type and State – Annual Average Prices for 2001
(cents per gallon, excluding taxes)

<table>
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<tr>
<th>Geographic Area</th>
<th>Residential Consumers&lt;sup&gt;a&lt;/sup&gt; (C/gal)</th>
<th>Commercial/Institutional Consumers&lt;sup&gt;a&lt;/sup&gt; (C/gal)</th>
<th>Industrial Consumers&lt;sup&gt;a&lt;/sup&gt; (C/gal)</th>
<th>Through Retail Outlets&lt;sup&gt;b&lt;/sup&gt; (C/gal)</th>
<th>Other End Users&lt;sup&gt;c&lt;/sup&gt; (C/gal)</th>
<th>Average (C/gal)</th>
<th>Sales for Resale (wholesale) (C/gal)</th>
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<sup>a</sup> Sales of No. 2 fuel oil
<sup>b</sup> Includes sales of diesel fuel
<sup>c</sup> "Other End Users" includes sales not included in the other end-user categories, such as sales to agricultural customers or utilities.

Source: U.S. Energy Information Administration, [www.doe.eia.gov](http://www.doe.eia.gov)
Table 3. Fuel Oil Prices for Different End Users vs. Bio-Oil Values

<table>
<thead>
<tr>
<th>Fuel Oil Market:</th>
<th>Fuel Oil</th>
<th>Bio-Oil</th>
<th>Bio-Oil</th>
</tr>
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<tr>
<td></td>
<td>Ave. NE (PADD I) Price&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Market Value&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Yield&lt;sup&gt;c&lt;/sup&gt;</td>
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<tr>
<td>Wholesale</td>
<td>138,690 Btu/gal</td>
<td>$0.77/gal</td>
<td>$5.52/MMBtu</td>
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<td>Industrial</td>
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<td>$0.89/gal</td>
<td>$6.40/MMBtu</td>
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<td>138,690 Btu/gal</td>
<td>$1.26/gal</td>
<td>$9.09/MMBtu</td>
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<sup>a</sup> Fuel oil price data from the U.S. Energy Information Administration, [www.doe.eia.gov](http://www.doe.eia.gov).

<sup>b</sup> This market value does not reflect the potential value of the oxygen content of bio-oil, which can include a mix of 10 to 25% oxygenated compounds. Testing is needed to determine the impact of the oxygen content on the “delivery” of Btu’s and on combustion emissions, particularly if bio-oil is co-combusted with other fossil fuels, either via separate injection ports or via blending (e.g., by emulsifying bio-oil with petroleum fuel oil).

<sup>c</sup> Yield values for gallons of bio-oil produced per dry ton of biomass feedstock processed are based on data reported by DynaMotive [see the reference - Morris, 2000]

<sup>d</sup> Assuming green wood has an average moisture content of 45%.

By comparison, it is interesting to note that ethanol fuel (which has an energy content of about 76,000 Btu’s, on a lower heating value basis), currently sells for about $1.20 per gallon, or approximately $15.80 per million Btu’s, whereas the wholesale value of fuel oil is only $5.52 per million Btu’s (as noted in Table 1). A primary reason that ethanol can sell at this higher price is the federal excise tax exemption provided for ethanol fuel, which currently equals $0.51 per gallon of ethanol, or a subsidy of about $6.70 per million Btu’s of ethanol fuel value. This incentive has been justified on the basis of the benefits it provides to U.S. farmers (increasing the markets and value of their crops, primarily corn), and on the benefits it provides to the U.S. in terms of increased energy security, expanded domestic transportation fuel supplies, as well as reduced dependencies on petroleum imports.

From a point of view of equitable public policy, it could be argued that incentives are justified for bio-oil, similar to those offered for ethanol fuel. As discussed earlier, it can clearly be argued that bio-oil usage can help reduce petroleum imports, and bio-oil production would also provide benefits to the wood/forest products industry (as well as farmers, if crop residues are used as a feedstock for bio-oil production).
Residential Applications

Testing is needed to determine the performance of bio-oil in existing residential oil-fired furnaces, including the impact of the lower energy content of the fuel, its viscosity (which is higher than No. 2 fuel oil, as noted earlier), its acidity, its high moisture content, and its storage characteristics, especially when stored in outside, underground tanks where the bio-oil could get quite cool, increasing its viscosity. Testing is also needed to demonstrate the stability/storage characteristics of bio-oil over time.

As noted earlier, residences with existing fuel oil heating systems will probably need new fuel storage tanks to accommodate the acidic character of bio-oil. Based on discussions with heating oil industry representatives, there appears to be little likelihood that residential customers will pay a premium for renewable/“green” heating oil, in the form of bio-oil. (Appendix C provides a list of heating oil associations and related industry organizations, including their Internet addresses.)

Commercial/Institutional Applications

Commercial and institutional buildings appear to offer a much more attractive near term market for bio-oil than residential heating applications. A large single building or building complex could be retrofitted with a bio-oil storage tank, and would represent a substantial demand at a single location, which would reduce transportation costs for fuel delivery. Education of a single customer, and related negotiations, would be easier in comparison to marketing to a large number of smaller residential customers.

Testing appears to have demonstrated that bio-oil can be combusted in existing commercial boilers without adverse impacts, although test data seems somewhat scarce. More data is likely to be needed to convince building owners that bio-oil is an acceptable fuel for their boilers.

There are many different strategies that could be pursued for bio-oil use in commercial/institutional-scale buildings, ranging from dedicated 100% usage of bio-oil as a boiler fuel, coinjection of bio-oil into a boiler via a dedicated fuel port to cofire with fuel oil, or blending the bio-oil with fuel oil via some form of emulsification technology (development work is needed in this area—it appears that some proprietary work is underway).

Institutional “Green” or Renewable Markets

There are a number of circumstances where institutional buildings could offer attractive opportunities for “green” or renewable markets for bio-oil applications, as discussed below.

- Required Renewable Energy Use in Federal Buildings

Federal agencies and the buildings they occupy (which are scattered throughout the northeast region) have a mandate to increase their use of renewable energy. Under Executive Order 13123, federal agencies are required to increase their use of renewable electricity to 2.5% of their supplies by 2005. Under the guidance established for implementing this requirement, renewable
energy used for heating applications can be converted into its equivalent electricity value and counted toward meeting an agency’s renewable goal (see the guidance document in Appendix A).

- State Requirements for Renewable Energy Use

From a policy perspective, it would be desirable for states to take a similar approach to this federal initiative. For example, New York State (NYS) has Executive Order No. 111, which directs state agencies to be more energy efficient and environmentally aware. This includes a requirement that state agencies obtain 10% of their electricity from renewable sources by 2005, and 20% by 2010. However, in the NYS guidance, thermal sources of renewable energy will not count toward meeting the mandate, only electricity supplies. In its relationship with Northeast governors’ offices, the CONEG Policy Research Center, Inc., may want to consider educating and/or working with governors’ offices to facilitate the adoption of approaches similar to that taken under Federal Order 13123, that allow for broader inclusion of renewable alternatives (such as bio-oil heating applications).

Note that even with the restrictions under the NYS Executive Order, it may help create opportunities for bio-oil applications. For example, there are a number of state-owned and operated university campuses that have cogeneration systems that provide electricity and district heating for the buildings on their campuses. The NYS Executive Order could provide an incentive for these universities to consider using bio-oil in their boilers to meet the state’s renewable energy use mandate, even if bio-oil is somewhat more expensive than fuel oil.

- Regional Initiatives to Reduce Greenhouse Gas Emissions

In 2001, the New England Governors’ Conference and the Eastern Canadian Premiers adopted a Climate Change Action Plan aimed at reducing emissions of greenhouse gas (GHG) in the Northeast region [New England Governors Conference, 2002]. In addition, individual states, such as New York, have established greenhouse gas task forces that are developing strategies for reducing GHG emissions in their state(s). Since bio-oil is a renewable fuel, produced from renewable biomass feedstocks, it offers an attractive option for reducing GHG emissions by displacing fossil-based petroleum fuel. As specific requirements are implemented for these regional and state GHG initiatives, it could help create markets for the use of bio-oil fuel in the Northeast.

- Federal “Biomass and Alternate Methane Fuels Super ESPC” Program

There may also be opportunities to pursue the use of bio-oil in federal facilities in the Northeast region under the new “Biomass and Alternate Methane Fuels Super ESPC” program. The federal government has awarded contracts to five energy service companies to implement “Super Energy Savings Performance Contracts” that will use biomass and alternate methane fuels to reduce energy consumption and/or costs at federal facilities (the total maximum contract value is worth $200 million for the five contracts). Under this Super Biomass ESPC, it may be possible to use bio-oil as a basis for supplying a space heating (or space-conditioning) system as the core component in a biomass ESPC, even if the energy from the bio-oil system is more expensive than a conventional fuel-oil system, by taking additional energy conservation steps to provide a net reduction in a facility’s operating costs. It is clearly possible to use this approach, since the
Department of Energy Federal Energy Management Program (FEMP) also has a similar Photovoltaic (PV) Super ESPC program where expensive energy costs from a core PV system are offset by additional energy conservation treatments at federal facilities. (See the webpage: www.eren.doe.gov/femp/financing/espc/biomass.html).

- **University and Municipal “Green” Initiatives**

A variety of other government agencies, as well as public and private institutions, have independently made commitments to increase their use of renewable energy resources, or reduce their greenhouse gas emissions (which can be interpreted or implemented as mandates to increase their renewable energy usage). For example, some universities have established initiatives to reduce their greenhouse gas emissions and they may be willing to pay a premium for renewable supplies of energy (e.g., biomass, such as bio-oil). A number of municipalities have also made this type of formal commitment to reduce their greenhouse gas emissions. (See the list of cities in Appendix C.)

A key issue for many of these organizations will be their overall approach or attitude with regard to biomass energy. There has been considerable debate and varied opinions by environmentalists regarding the extent to which biomass is embraced as a “green” option, often requiring very narrow specifications regarding the feedstocks and conversion technologies that are accepted as “green” supplies of energy – for example, the Green-e certification criteria for biomass energy supplies has been addressing this issue in depth.

**Industrial Applications**

Fuel oil No. 6 (residual fuel oil) may also represent a credible target for bio-oil replacement in industrial applications. No. 6 fuel oil tends to be relatively high in sulfur content and with new federal regulations clamping down on allowable SO\(_x\) emission levels, many industrial users of No. 6 fuel oil may be willing to seriously consider paying a premium for bio-oil, particularly as a fuel that would be co-fired in their boilers. There are real costs that must be paid by industry for SO\(_x\) emission credits if they exceed allowable limits. Key considerations are that No. 6 fuel oil has close to 150,000 Btu per gallon, even higher than the energy per gallon for No. 2 fuel oil. Thus the impact of using bio-oil with 75,000 Btu per gallon must be carefully considered. In addition, fuel oil No. 6 is also less expensive than fuel oil, thus its low cost per million Btu is another significant hurdle that must be assessed on a case-by-case basis. Fuel oil No. 6 generally has a high viscosity (the viscosity of bio-oil will generally be lower than No. 6 fuel oil, and higher than No. 2 fuel oil). There are a range of testing activities that would be helpful to determine the acceptability of bio-oil as a replacement for No. 6 fuel oil, including combustion testing, fuel storage tests, as well as materials testing/assessments (e.g., tests of storage tank materials, pumps, and piping).
Selected References


Appendix A

Federal Government Executive Order 13123
Greening the Government Through Efficient Energy Management

Guidance on Federal Government Renewable Energy Goal

May 15, 2000
This guidance fulfills the requirement for the Secretary of Energy to establish a Federal renewable energy goal under section 503(b) of Executive Order 13123, and consistent with Section 204:

“Sec. 204. Renewable Energy. Each agency shall strive to expand the use of renewable energy within its facilities and its activities by implementing renewable energy projects and by purchasing electricity from renewable energy sources.”
“Sec. 503. Within 1 year of this order, the Secretary of Energy, in collaboration with other agency heads, shall:
(b) develop goals for the amount of energy generated at Federal facilities from renewable energy technologies;”

Recommendation
The Secretary of Energy recommends that the Federal Government strive to have the equivalent of 2.5 percent of facilities’ electricity consumption come from new renewable energy sources by 2005. New renewable energy would include any renewable energy acquired by the Federal Government after 1990. Using 1998 Federal energy consumption data, the goal would equal 1,355 gigawatt-hours (GWh) of electricity consumption annually or 4.6 trillion Btu. A preliminary analysis found 173 GWh of new renewable energy already in use or available under contract in the Federal sector.

To accomplish a meaningful goal, agencies will require maximum flexibility to obtain renewable energy in a manner that makes the most economic sense, and apply it wherever it is most advantageous. Although the goal is measured against facility electricity use because that is where the greatest opportunity for renewable energy exists, agencies will be allowed to substitute renewable energy generated or used in many situations, including transportation, energy-intensive facilities, or outside a facility. For example:

- on- and off-grid power technologies;
- thermal technologies;
- renewable transportation fuels (ethanol, hydrogen derived from renewable energy, etc.);
- passive solar energy captured by equipment and building design;
- renewable energy mechanical power;
- renewable energy from projects on Federal facilities facilitated by the host agency – for example, a geothermal project on Federal land where the host agency assisted with siting; and
- renewable energy used by clients of a Federal agency, if the agency provided financial or project development support – for example, solar energy on public housing.
For purchases of renewable energy, agencies will be required to submit information in their annual reports. The Federal Energy Management Program (FEMP) will offer a voluntary, on-line reporting system that will request a minimum amount of information for all other projects in order to estimate renewable energy output. FEMP will be responsible for developing engineering estimation techniques for converting project information into estimates of renewable energy use. Agencies will not be required to develop their own estimates, beyond the information requested by the on-line reporting system.

Since the goal is based on 2.5 percent of the Government’s consumption of electricity, the targeted level of renewable energy use will be recalculated each year to account for changes in Federal energy consumption.

Agencies should also report in their scorecards and annual reports the efforts they have made to create opportunities for renewable energy use. Reports should focus on agency efforts to implement the mechanisms cited in the Executive Order: renewable power purchasing, use of energy savings from other projects to purchase renewable energy, bundling renewable energy with other measures in ESPCs, sustainable building design, and purchasing renewable energy equipment.

Reference: see the Internet site: http://www.eren.doe.gov/femp/resources/renewableguide.html
Appendix B

Cities for Climate Protection Campaign US Participants

Organized by the International Council for Local Environmental Initiatives
(Note: the underlined cities below have a webpage hot link to the respective city’s webpage, click on the city name to connect to their webpage.)

- Alachua County, U.S.A, FL
- Albuquerque, NM
- Amherst, MA
- Ann Arbor & Washtenaw County, MI
- Arcata, CA
- Arlington County, VA
- Arlington, MA
- Aspen, CO
- Atlanta, GO
- Augusta, ME
- Austin, TX
- Barnstable, MA
- Berkeley, CA
- Boston, MA
- Boulder, CO
- Brattleboro, VT
- Bridgeport, CT
- Brookline, MA
- Broward County, FL
- Buffalo, NY
- Buri en, WA
- Burlington, VT
- Cambridge, MA
- Carrboro, NC
- Chapel Hill, NC
- Charleston, SC
- Chicago, IL
- Chittenden County, VT
- Chula Vista, CA
- Cloverdale, CA
- College Park, MD
- Corvallis, OR
- Cotati, CA
- Dane County, WI
- Davis, CA
- Decatur, GA
- Delta County, FL
- Denver, CO
- Duluth, MN
- Durham, NC
- Fairfax, CA
- Fairfield, CT
- Falmouth, MA
- Fort Collins, CO
- Gainesville, FL
- Georgetown, SC
- Gloucester, MA
- Healdsburg, CA
- Hennepin County, MN
- Hillsborough County, FL
- Honolulu, HI
- Huntington, NY
- Ithaca, NY
- Keene, NH
- King County, WA
- Little Rock, AR
- Los Angeles, CA
- Louisville, KY
- Lynn, MA
- Madison, WI
- Maplewood, NJ
- Marin County, CA
- Medford, MA
- Memphis, TN
- Mesa, AZ
- Miami Beach, FL
- Miami-Dade County, FL
- Milwaukee, WI
- Minneapolis, MN
- Missoula, MT
- Montgomery County, MD
- Mount Rainer, MD
- Mount Vernon, NY
- Multnomah County, OR
- Nashua, NH
- New Haven, CT
- New Orleans, LA
- New Rochelle, NY
- New York, NY
- Newark, NJ
- Newton, MA
- Northampton, MA
- Oakland, CA
- Olympia, WA
- Orange County (NC), NC
- Orange County, FL
- Overland Park, KS
- Pawtucket, RI
- Philadelphia, PA
- Portland (Maine), ME
- Portland, OR
- Prince George's County, MD
- Ramsey County, MN
- Riviera Beach, FL
- Rohnert Park, CA
- Sacramento, CA
- Saint Paul, MN
- Salt Lake City, UT
- San Antonio, TX
- San Diego, CA
- San Francisco, CA
- San Jose, CA
- Santa Cruz, CA
- Santa Fe, NM
- Santa Monica, CA
- Santa Rosa, CA
- Saratoga Springs, NY
- Schenectady County, NY
- Seattle, WA
- Sebastopol, CA
- Shutesbury, MA
- Somerville, MA
- Sonoma City, CA
- Spokane Co., WA
- Spokane, WA
- Springfield, MA
- Suffolk County, NY
- Tacoma, WA
- Takoma Park, MD
- Tampa, FL
- Toledo, OH
- Tompkins County, NY
- Tucson, AZ
- Washtenaw County, MI
- Watertown, MA
- West Hollywood, CA
- Westchester County, NY
- Williamstown, MA
- Windham, CT
- Windsor, CA
Appendix C

Oil Heating Industry Links

API - [www.api.org](http://www.api.org) - The American Petroleum Institute

NYOHA - [www.nyoha.org](http://www.nyoha.org) - The home of the New York Oil Heating Association

ICPA - [www.ctoilheat.com](http://www.ctoilheat.com) - Independent Connecticut Petroleum Association

COHA - [www.coha.ca](http://www.coha.ca) - The Canadian Oil Heating Association

ESPA - [www.espa.net](http://www.espa.net) - Empire State Petroleum Association

FMANJ - [www.fmanj.org](http://www.fmanj.org) - Fuel Merchants Association of New Jersey

fueloil.com - [www.fueloil.com](http://www.fueloil.com) - fueloil.com

MAPDA - [www.mapda.org](http://www.mapda.org) - Mid-Atlantic Petroleum Distributors' Association

MOC - [www.massoilheat.org](http://www.massoilheat.org) - Massachusetts Oilheat Council

MODA - [www.meoil.com](http://www.meoil.com) - The Maine Oil Dealers Association

NAOHSN - [www.naohsm.org](http://www.naohsm.org) - National Association of Oil Heating Service Managers

NEFI - [www.nefi.com](http://www.nefi.com) - The New England Fuel Institute

OHIENY - [www.oilheat-ny.com](http://www.oilheat-ny.com) - Oil Heat Institute of Eastern New York

OMA - [www.oma-oilheat.org](http://www.oma-oilheat.org) - The Oilheat Manufacturers Association

OOHC - [www.teleport.com/~ohc](http://www.teleport.com/~ohc) - The Oregon Oil Heat Commission

OSI - [www.osi-ny.com](http://www.osi-ny.com) - Oil Services, Inc.

Peterson School - [www.petersonschool.com](http://www.petersonschool.com) - The Peterson School

PMAA - [www.pmaa.org](http://www.pmaa.org) - The Petroleum Marketers Association of America

VOHI - [www.vtweb.com/vohi](http://www.vtweb.com/vohi) - The Vermont Oil Heat Institute

WSPA - [www.wspa.org](http://www.wspa.org) - The Western States Petroleum Association