The Wild Center is Installing a High Efficiency Commercial Scale Wood Gasification Boiler Integrated with a Solar Tube Hot Water System:

How will it work and Why did we choose this system?

FREQUENTLY ASKED QUESTIONS (FAQ)

July 2009

1. General Interest Questions

Describe the Boiler System.

The System will be an integrated wood-pellet fired boiler and solar-thermal system that is efficient, clean burning, cost-effective, user-friendly, and educational. It will demonstrate low-emission and renewable heating using a 1.7 million BTU (MMBtu) wood pellet boiler, augmented by a hot water storage vessel and solar tube collector system to provide most of The Wild Center's heating needs.

This project will be a model for other institutional and commercial building owners in New York to implement similar renewable energy heating projects. In addition to being a high-efficiency system, this will be among the first few built in the United States and in New York State.

This demonstration project will also "interpret" the technology for the public much more directly through The Wild Center's signature innovative signage and hands-on museum education activities, including viewing windows, tour maps, and web-based videos, for example. An interpretive 'station' will be added to the Museum's new "New Path" exhibit/self-guided tour, to share information about the biomass boiler and solar tube system.

The project will showcase a new ASME-certified boiler design of Advanced Climate Technologies, a New York manufacturer of high efficiency commercial scale wood boilers. Currently most commercial wood boiler technology achieves only 70-75 percent energy efficiency; the advanced design to be used at The Wild Center is expected to achieve 88 percent with the boiler alone.

In the North Country most solar technologies employ photovoltaic panels, such as The Wild Center's 190-panel array to produce electricity. This project will also include solar tubes for producing hot water in a pumping and storage system to augment the boiler's hot water production, furthering the reduction of fuel use and emissions. By integrating with the solar thermal system, wood pellet consumption will be reduced. The addition of a thermal storage system allows the boiler to operate at maximum output most of the time and avoid short-cycling, which adds to the overall system efficiency.

How Will it Work and Why is it So Much More Efficient?

The ACT Bioenergy Boiler achieves high efficiency and low emissions by carefully controlling the combustion process. Wood pellet fuel is fed by a screw-auger up through the center of the burn plate in the combustion chamber. A fan supplies primary air through holes the burn plate. On the burn plate, the fuel undergoes partial combustion and volatile gases are released from the fuel. Above the burn plate, secondary and tertiary air are fed tangentially into the volatile gases and the fuel is completely combusted. The resulting hot exhaust gases then are sent to the heat exchanger section of the boiler where the water is heated. The boiler control system continuously monitors building heat requirements, boiler temperatures, pressures and exhaust gas composition. The boiler control system makes constant adjustments to fuel feed rates, and the various fan speeds to ensure optimal combustion efficiency. See Figure 1. for a schematic of the ACT Bioenergy Boiler that The Wild Center will install.

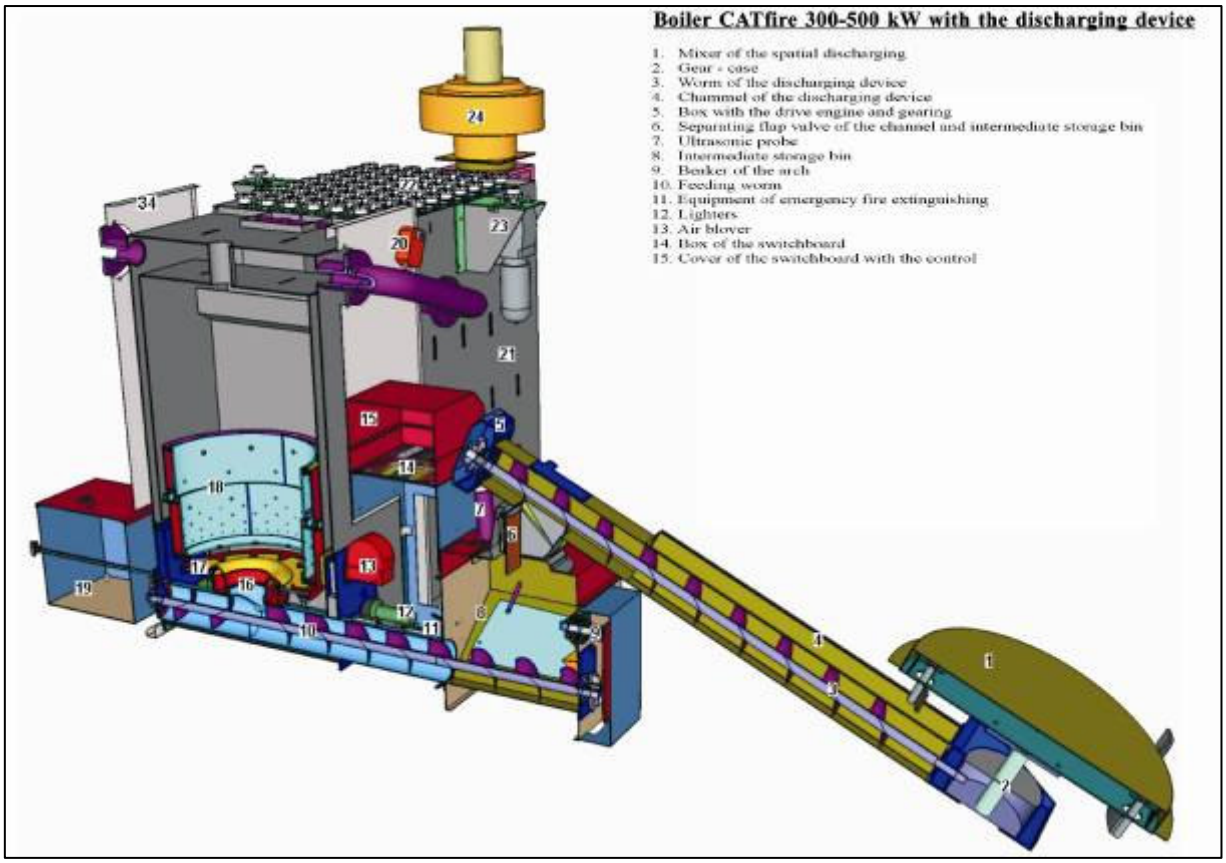


Figure 1. Schematic of The Wild Center's ACT Bioenergy Boiler (Source: ACT Bioenergy)

With high-efficiency combustion, not only is fuel consumption reduced, but the emission of volatile organic compounds (VOCs) and noxious compounds such as tars and creosote are virtually eliminated in the exhaust. The advanced ACT boiler design achieves very significant reductions in particulate emissions compared with conventional large scale wood boilers measured by US EPA data. See Figure 2.

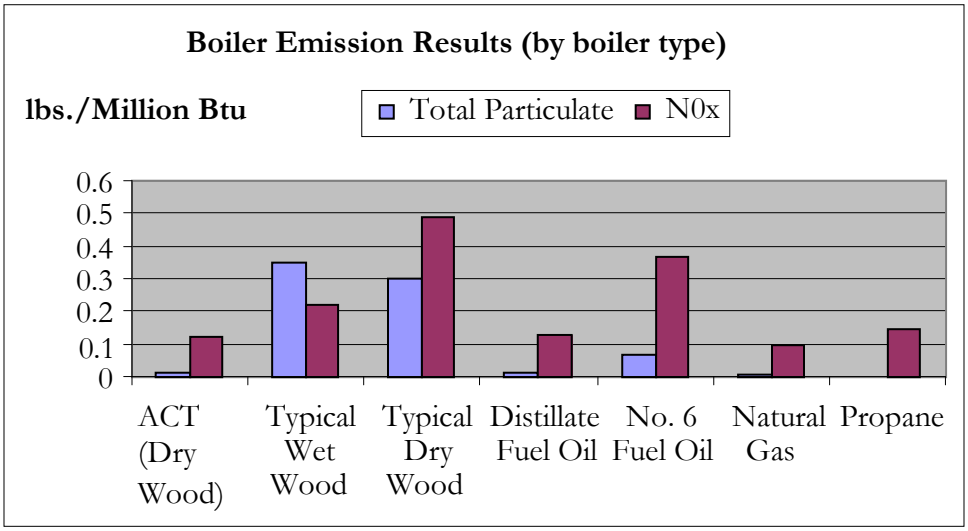


Figure 2. Boiler Emission Results
Definition: Dry (seasoned) wood is <30 percent moisture, Wet (green) wood is >30 percent moisture
(Source: ACT Bioenergy from Environmental Protection Agency data: AP-42 Standard Emission Factors (2007) and independent boiler test data).

What Size Facility is it Appropriate for?

This project will demonstrate the feasibility of mid-sized, clean-burning high efficiency biomass boiler

systems that are widely used in Europe but have not yet been adopted in the U.S. The key market for this technology is institutional and commercial buildings – e.g. small to mid-size schools in rural or suburban areas which desire automated heating systems with low maintenance requirements.

Institutional, commercial and multi-family residential building owners are all potential users of this kind of heating system. Hot water boilers at office buildings, health care facilities and educational establishments account for almost two-thirds of commercial boiler units and capacity in the U.S and this technology can be suitable for both new and retrofit situations. In upstate New York, more than 7,000 small and medium sized institutional and commercial buildings have heating loads of less than 3MMBtu (NYSERDA, 2005). Twenty-six percent of these sites are schools which are aggressively looking for ways to decrease the costs of energy use.

Energy is a significant part of schools' budgets. In 2005-06 when natural gas prices spiked, the impact on school budgets was severe. Schools in New York State experienced an average 38 percent budget shortfall in their operations and maintenance budget due to high energy costs. State-wide this translates to a total shortfall of $96 million. Typical costs of heating with wood pellets are 25-50 percent less than propane or heating oil. Many New York schools and other institutional buildings would significantly reduce their heating costs by switching to wood heating.

The currently available wood boiler systems in the U.S. are industrial systems that are adapted from forest industry applications which are suitable only for larger applications (>3 MMBtu). Over the last 20 years, 41 schools have established biomass heating systems in Vermont. According to the Biomass Energy Research Center in Montpelier, in the next 12-18 months, more than 15 schools in Vermont are likely to implement biomass heating projects. Similar school biomass heating programs are also being considered in New York by the School Superintendent's Association. These school projects are part of a larger trend within both the public and private sectors to invest in renewable energy solutions. To date, most of these biomass conversion programs have focused on larger schools due to the poorer economics of available systems less than 2 MMBtu. However, commercial scale high-efficiency systems will allow smaller schools to have attractive economic paybacks for biomass systems. Simple paybacks of 5 to 10 years are considered attractive for most school projects. (Source: ACTBioenergy, 12/08.)

NYSERDA has launched a biomass heating research and development program to foster the development and use of the highest performing technologies possible. NYSERDA has helped to fund approximately 20 ongoing research projects with more than $3 million. These projects will help to evaluate the energy-efficiency and emissions- performance of biomass-fired heating technologies; commercialize advanced technology designs; and demonstrate advanced technologies in representative heating applications in New York State.

Where Will It Be Placed?

The boiler unit and hot water storage tank will be in The Wild Center's basement boiler room, next to the Museum's existing propane boilers. The pellets will be stored in a cabin-shaped container next to the Administration wing of the Museum, between the Parking Lot and Greenleaf Pond. The cabin will house the Solar Tube array to preheat water for the system. Pellets will be augured through overhead pipes into the basement and directly into the boiler. Hot water from the solar system will heat the water in the storage tank.

What Makes this Boiler System New or Different?

The boiler system will represent the first highly efficient, commercial-sized, gasification wood-pellet boiler of its kind and size manufactured and installed in New York State and in fact, the nation. Furthermore, the solar hot water tube collection system will be among the first few of its kind used in a commercial application in the Adirondack Park.

The successful installation and operation of the boiler and solar hot water system will add significantly to The Wild Center's green building exhibit and sustainable operations. The project will serve as a highly visible demonstration project for the purposes of establishing bio-mass and evacuated hot water solar collection as technologies that are energy efficient, clean, and fiscally viable and that contribute to the economy.

The project will bring ACT Bioenergy (boiler manufacturer), Clarkson University (emissions testing role), a solar tube manufacturer (to be determined), NYSERDA and The Wild Center together to demonstrate and evaluate these technologies. This will support The Wild Center's role as a leader in addressing the science of climate change and environmental sustainability education. The advantages of integrating the wood boiler and solar thermal system are to improve efficiency, reduce emissions and expand boiler life. Wood boilers (as all boilers) prefer to operate at a constant heat load rather than repeatedly being turned on and off (cycling). The solar panel helps reduce boiler cycling by supplying the required building heat during the times of the year when minimal heat is required, for example in the summer, when boilers are most prone to cycling.

Why is The Wild Center a Good Location and Venue for this System?

The Wild Center is a 54,000 square foot, world-class natural history museum located on a 31-acre campus in the heart of the Adirondacks. The Wild Center showcases how science museums can be an effective disseminator of sustainability and environmental solutions. The Museum provides wildlife encounters, naturalist talks and K-12 school programs on acid rain, climate change, watershed protection, wildlife, and other issues. Its facilities provide a modern, year-round example of sustainable design – the Museum earned its Silver Leadership in Energy and Environmental Design (LEED) certification – a national benchmark for standards of green building efficiency – in early 2008. The Wild Center is the first museum in the state of New York to earn this distinction. The Wild Center "BioBuilding" is a laboratory of current "green" building technologies ranging from photovoltaic solar panels which power most of the building's needs, to flooring made from recycled tires, green roofing, use of local lumber milled within a 50 mile radius, and water-conserving systems.

The Wild Center is an ideal location compared to a location at a private company for example. The Museum will clearly label and interpret the technology in user-friendly language, explain what we as a society know and what we have yet to learn about the use of wood fuels and how they compare to fossil fuels, take visitors on tours, and provide information via The Wild Center web site. The Wild Center's special mission is to present science in an understandable and relevant way to the lay public. Our facility already has a "green building" tour that will be expanded to include this new technology. The interpretive staff members frequently provide tours and demonstrate new technologies for colleagues and partner institutions contemplating the use of these technologies. The Museum is easy to access, has trained staff, is centrally located in the Adirondacks and North Country, maintains rich on-line resources, and is open all year. Finally, the facility is also designed for meetings and conferences, which exposes thousands of professionals in relevant fields to these technologies.

Green interpretation is everywhere on the campus, with installation in 2008 of the Museum's aptly titled "New Path" Exhibit, which showcases elements of green design and how these features benefit the health of the human and natural world. The planned boiler, solar hot water array, hot water storage system, and interpretative panels will be added to this exhibit and website. The Wild Center organized and hosted the sold-out Building a Greener Adirondacks Symposium in October 2008.

In June 2008 The Wild Center hosted "Land of Opportunity: The American Response to Climate Change," a conference to give invited participants an opportunity to explore possible greenhouse gas abatement policies, programs and private sector initiatives for the U.S. More than 200 low-carbon

economy leaders in the United States gathered in upstate New York's Adirondack Park for two days, to develop consensus on an economically valid action plan that would place the U.S. in a leadership position in moving toward a lower carbon and lower pollution economy. In November, The Wild Center also hosted a conference that addressed how the Adirondack region could take action on climate change. "Land of Opportunity: The American Response to Climate Change - The Adirondack Model: Using Climate Change Solutions to Restore a Rural American Economy" gave participants an opportunity to create a replicable action plan to address economic development ('green jobs'), energy efficiency improvements, alternative fuels and renewable energy sources, specific rural challenges, necessary policy changes, and potential impacts on natural systems in the Adirondack Park. More than 190 leaders from businesses, government, academia, non-profits, and experts in climate mitigation and adaptation examined building efficiency, alternative fuels, transportation, natural systems, and rural economies. The "green economy" working group memorandum for this conference prioritized "developing and disseminating information on alternative fuel sources" for the Adirondack region as a whole, making the proposed project a priority of consensus for the participants.

The Museum also was the site of a conference in May 2008 on the North Country Woody Biomass Alternative Energy Feasibility Project, a collaborative effort between the New York State Department of Environmental Conservation and the Adirondack Energy $mart Park Initiative. The project raised awareness among municipal, school, and other institutional facility managers throughout the region that wood heat was possible and affordable. The project provided subsidized pre-feasibility studies on 10 facilities in the Adirondack / North Country region. Six sites were deemed appropriate for the use of wood pellets.

Are There Any "Downsides" to Acquiring the System?

Because of the high efficiency and low emissions of this boiler system design, the performance is anticipated to be comparable to that of a modern oil burning system; this will be evaluated by Clarkson University. The project will support local economic development, whenever possible, through the purchase of local renewable fuels instead of imported fossil fuels. The Wild Center will continue to use its existing propane boilers as required in winter to supplement the pellet boiler, and if the cost of wood pellets goes up significantly or pellets become difficult to obtain The Wild Center will need the propane system as backup and gap coverage. Experts estimate that a pellet shortage is unlikely to occur over a long period of time, given long-term trends in the use and cost of fossil fuels. In addition, there are currently 2 large-scale pellet producers within 120 miles of Tupper Lake, and a growing interest in the pellet production industry, both commercial and residential-scale, within the region. Experts advise that a range of 25-50 miles is optimal for keeping prices in check and focusing on 'buying local.' "With cost of diesel fuel, transport of material becomes one of the biggest input costs" notes Thomas Lindberg of Mesa Reduction Engineering & Processing, Inc., a company founded to process wood biomass. The Wild Center will continue to seek pellet sources within a closer range as the industry in the region matures.

There is debate about the impacts and sustainability of the use of wood biomass fuels on the forest ecosystem, however. See below for more details on that discussion.

Why is it Appropriate to Consider This Kind of System in the Adirondacks / North Country of New York?

In New York State, renewable energy for heating is gaining increased interest as it addresses the goals of reducing fuel costs, reducing greenhouse gas emissions and stimulating local economic development and security by replacing imported fossil fuels with locally available renewable fuels. In the Adirondacks, the most abundant and inexpensive renewable fuel is wood. However, traditional wood burning stoves, some commercial wood boilers, and more recently, outdoor wood boilers suffer from low efficiency and high levels of pollution from incomplete combustion. The project at The Wild Center will demonstrate a very

clean-burning, highly efficient alternative use of wood fuel. Currently between 10 and 18 facilities in the Adirondack / North Country region are considering the application of this kind of biomass heating system but have no working models in the region to learn from and study.

The Adirondack region encompasses approximately 6 million acres of mostly forested land, roughly 57percent (3.4 million acres) of which is privately owned, including 44 percent or 2.6 million acres with varying levels of forest management and 13 percent or 767,200 acres managed primarily under "working forest" conservation easements; the remaining 43 percent (2.6 million acres) is owned by New York State and is considered Forest Preserve where timber harvest is prohibited by amendment to the NYS Constitution (Source: Adirondack Nature Conservancy, 2009; Adirondack Park Agency, 2009). It is not known precisely what the ecological carrying capacity of the private forests would be, were they to be more intensively managed and used for biomass production for heat. Two studies are beginning to assess this question on a regional scale, and this FAQ will be updated when more is known. Jerry Jenkins, an ecologist with an extensive knowledge of Adirondack region forests, sums it up this way: "The sustainability issue with wood chips is tricky. With timber harvest, a minimum requirement is that the harvests of timber not exceed the growth of timber, and that is fairly clear and measureable. But with biomass it is less clear, because you can harvest a lot of things for biomass that aren't timber. And, while a normal harvest leaves perhaps 80 percent of the harvested material from the forest, with chippers you can remove close to 100 percent of the harvested material. So it is possible that a biomass operation might harvest 'less than growth' but still be removing too many nutrients from the forest." See more detail below.

Will it be Easy to Understand How the Boiler System Works?

The Wild Center has won numerous accolades for its skills interpreting the "science behind the scenery" of the Adirondack region in exciting ways. This demonstration project will "interpret" the technology for the public directly through The Wild Center's signature innovative signage and hands-on museum education activities, including viewing windows, tour maps, and web-based videos, for example. An interpretive 'station' will be added to the Museum's new "New Path" exhibit/self-guided tour, to share information about the biomass boiler, hot water storage, and solar tube system. The system will be widely viewed through the on-line "New Path" exhibit as well. See Photo above – the "Green roof" station of the New Path tour – to illustrate one of many elements of The Wild Center's popular green building exhibit.

2. Questions Related to Fuel

What are the Benefits of Using Woody Biomass for Heating?

Experts note that the following benefits apply:

- *Wood is a sustainable renewable fuel. Wood can be grown in ecologically sustainable methods and can be endlessly renewable whereas fossil fuels will run out eventually.* New York can do more with biomass; there are 215.7 million cubic feet of removals each year in NYS – mostly from the Adirondacks and Southern Tier; 6.2 million tons (3 million oven dry tons - ODT). Forest resources regenerated at a rate of 3:1 from 1980 to 1993; maybe closer to 2.5:1 since that time. This leaves an estimated

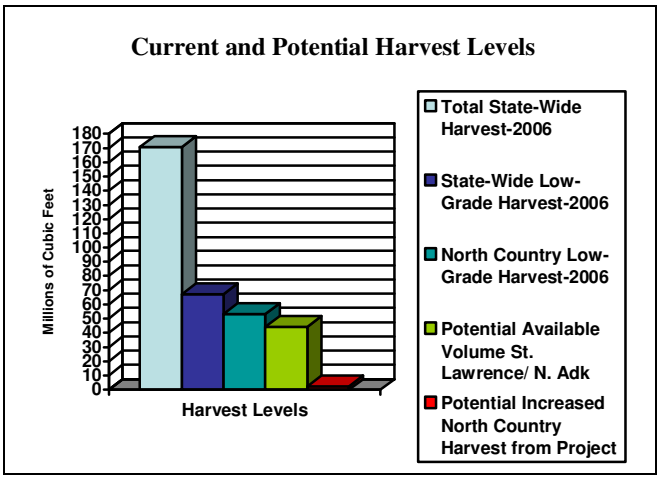


Figure 3.Harvest Level Calculation relative to 2008 DEC Biomass Project (Source: Tony Woods, 2008)

1.275 million tons of processing residues (Source: Sloane Crawford, NYDEC Forester, 2008).

- *Using low-grade wood for heat can be a cost-effective waste management strategy.* Often, the materials used in pellet production and wood chips are considered "waste" in logging and sawmill operations, which require high-quality hard and soft wood for their operations. They consider the low-grade lumber, sawdust, and unusable tops of trees as "waste" which they must pay to remove. Other sources of raw pellet and chip production include whole log chips and old pallets.
- *Removing low-grade wood can promote healthier production forests.* Forestry industry professionals consider it important to remove low-grade timber so that high-value trees can grow unimpeded. See Figure 3., which refers to the potential impact of the DEC–E$PI Biomass project in 2008, which offered subsidized feasibility studies to 10 schools/facilities around the North Country interested in wood heat (Source: Tony Woods, Wagner Forest Management and chip procurement for

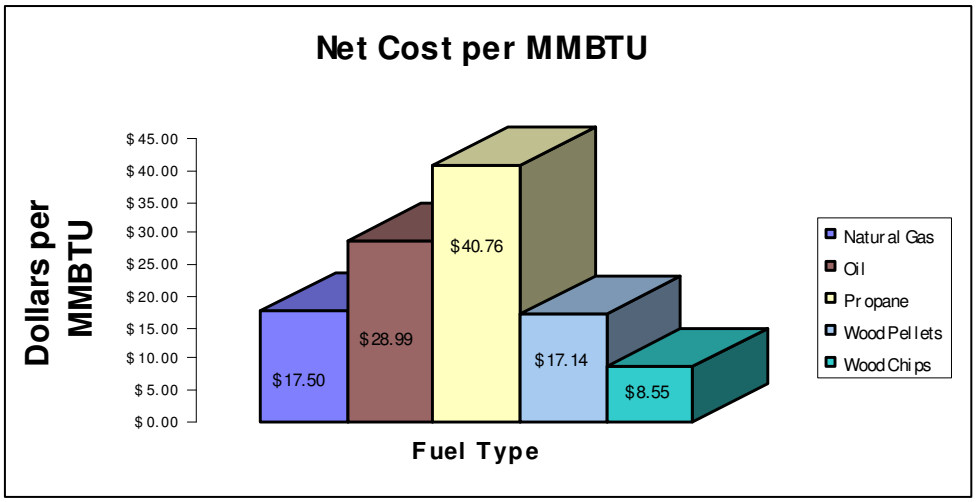


Figure 4. Net Cost by Fuel Type (Source: Jeff Forward 2008)

Schuyler Wood Pellet Plant, Schuyler, NY, 2008). Ecologists in the region are working to create their own definition of "healthy" forests as interest in woody biomass fuel grows, but currently many agree that harvesting trees at levels at or below the rate of annual growth and using methods that avoid mining certain species for timber (to the extent this changes the species mix) are key components of a sustainable management regime. Related criteria for sustainability are

reducing excessive fragmentation, retaining soil nutrients, maintaining biotic processes, avoiding disturbances of rare and/or valuable species, and not overtaxing the overall system if it is already stressed by climate disruption, invasive species, and/or acid deposition.

- *Finding a market and an economically viable industry for plentiful local raw materials is a key to establishing new and maintaining existing economic development opportunities.* Using wood for fuel helps to keep fuel "dollars" local, which is important considering the estimated $263 million per year that currently leaves the Adirondack region to pay for heating and electric demand, according to the Adirondack Energy and Greenhouse Gas Emissions Inventory, released by The Wild Center and Adirondack Climate Action Plan in early 2009 (see www.adkcap.org). It also provides a relatively low cost fuel, may help to create employment opportunities in boiler, pellet, and chip production and maintenance industries, and supports a growing market for forest products in what has recently been a regional industry in decline.

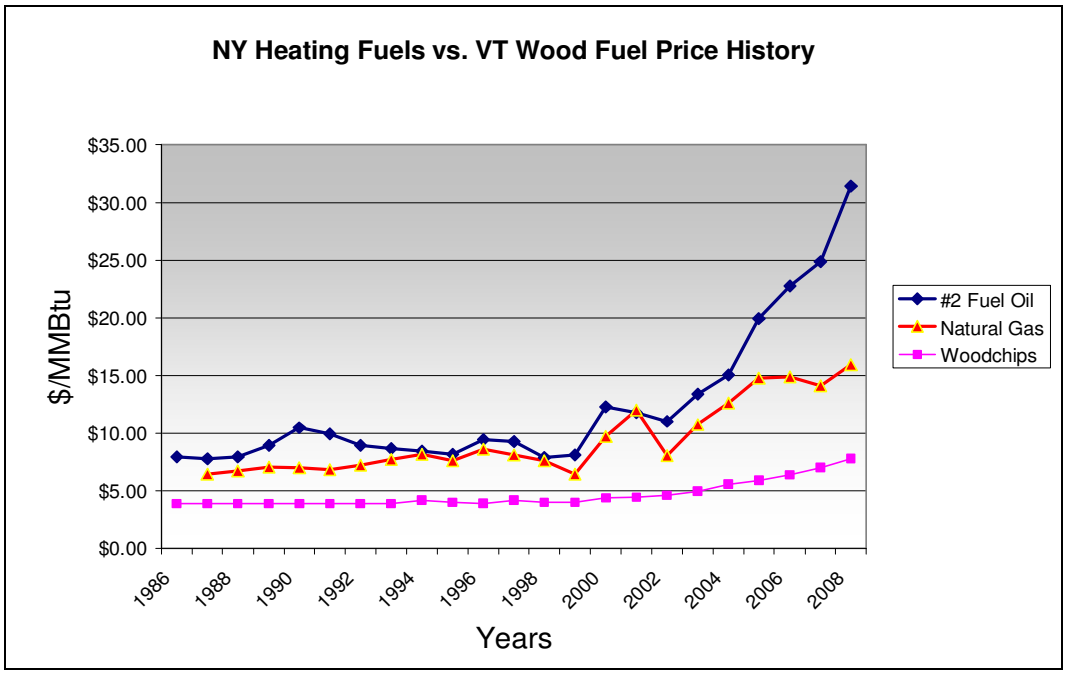


Figure 5. The Cost of Usable Heat: NY Heating Fuels vs. VT Wood Fuel Price History; Accounting for Seasonal Efficiency of Boilers (Natural Gas 80%, Heating Oil 75%, and Wood Chip 65%)
(Source: Jeff Forward, 2009, Data: EIA and VT School Superintendents Association. See "For further information" for explanation of calculations.)

- *Prices of wood fuels have been relatively stable compared to other fuels.* (See Figures 4 and 5.) Prices for wood pellets and chips have been relatively stable over time. The cost of The Wild Center's current heating needs using propane is approximately $70,000 per year at about $41/MMBtu; converting to pellets may save roughly $40,000 per year if LPG prices go up to that level again as they were in mid-2008, although some fluctuation would be expected. LPG, fuel oil, and other fossil-based fuels will increase in price as the global economy recovers. The price of pellet fuel is not expected to be heavily impacted even if The Wild Center purchases exclusively certified pellets. Hauling from pellet production plants will significantly affect the price, however.
- *Wood fuels may be considered to be "Carbon neutral," if harvested sustainably.* Forest industry specialists note that as forests grow back after harvesting, they - particularly young saplings - consume carbon from the atmosphere, making the use of wood fuel a zero-sum equation, although no precise calculations demonstrate the exact amount of carbon extracted by newly growing trees and lost in chip or pellet harvest and production. Ecologists note that forest soils – which are known to hold much of the carbon in intact forest systems – are often disturbed in the harvesting

process and likely to release significant carbon and other important nutrients for forest ecosystems when exposed to forces of erosion such as wind and water. According to Dirk Bryant of the Adirondack Nature Conservancy, "The carbon neutral argument only works if total harvest in an area is at or below net growth. Over past decades there has been an increase in timber inventory in New York State. One concern is that new markets for biofuels will 'release' this surplus into the atmosphere when it is burned. In the long run as harvested lands regenerate it is carbon neutral, but in the short term it could lead to a CO2 'pulse.'" This is therefore a question that The Wild Center hopes will receive further study.

Why Use Pellets Instead of Wood Chips?

The Wild Center selected a system that can burn both pellets and wood chips (if they are pre-dried), yet it will pursue pellets as the primary fuel for several reasons: chip boilers can be much more expensive at installation, they are more appropriate to larger facilities with extensive space, chips have a shorter shelf-life and require more outdoor storage area, and particulate emissions can be greater than those from pellet boilers, especially the technology being adopted at The Wild Center, which is moderately-sized and very clean-burning. Pellet fuels provide a consistently high quality product, whereas chips can range widely in terms of moisture content and size. Pelleting increases the specific density of the product, for example the density of sawdust can be increased from 9 Lb/ft^3 to $40Lb/ft^3$ by pelleting; this makes for easier handling, predictable transport costs, reduced auger blockages, and easier storage.

See Table for a comparison of these two types of wood biomass fuels in general as they apply to North Country / Adirondack region facilities.

Considerations / Types of Wood Fuel	***Pellets***	***Chips***
Distance to source	Access to bulk delivery of pellet fuel within 200 miles	Have good access to wood chip fuel within 100 miles
Particulate emissions	Pellet gasifier technology very low emissions. Comparable to oil-fired heating systems.	Much higher emissions than pellet systems.
Moisture content	6-10 percent	30-50 percent
Fuel treatment	Compressed waste wood, inputs of energy needed to produce.	Chipped waste / whole log wood, less treatment needed than pellets.
Size of facility	5,000 – 50,000 SF of conditioned space	50,000 SF – 1 mil SF+
Space and wood fuel storage	Space available for boiler and pellet storage on site	Sufficient space for new boiler house and chip bin storage and deliveries.
Maintenance	Staff available for cleaning several times per month	Staff available for cleaning several times per week, occasional blockages.
Cost of construction and installation of boiler to facility	Incremental equipment costs can be $15,000 - $100,000 +	Incremental equipment costs can be up to 3 x higher than ACT Bioenergy pellet boiler and there are extensive site work requirements.

(Source: Jeff Forward, 2008.)

How are Pellets Made? Are there additives to the wood fuel during the manufacturing process?

Pellets are made from sawdust, chips, bark, low-grade lumber and sometimes whole trees. The raw materials are dried to less than 12 percent moisture content if necessary, milled or ground, superheated to

soften the fibers, then compressed into pellets using either a ring die (pellets are pressed between rings from inside to outside) or flat die (pellets are pressed from top to bottom) press. No binders are required, according to several manufacturers, as the natural lignin binds the pellets itself, although some processes use corn starch or soybean oil as well. Pellets are then cut to length with an adjustable blade, cooled, bagged (if for residential users), and shipped.

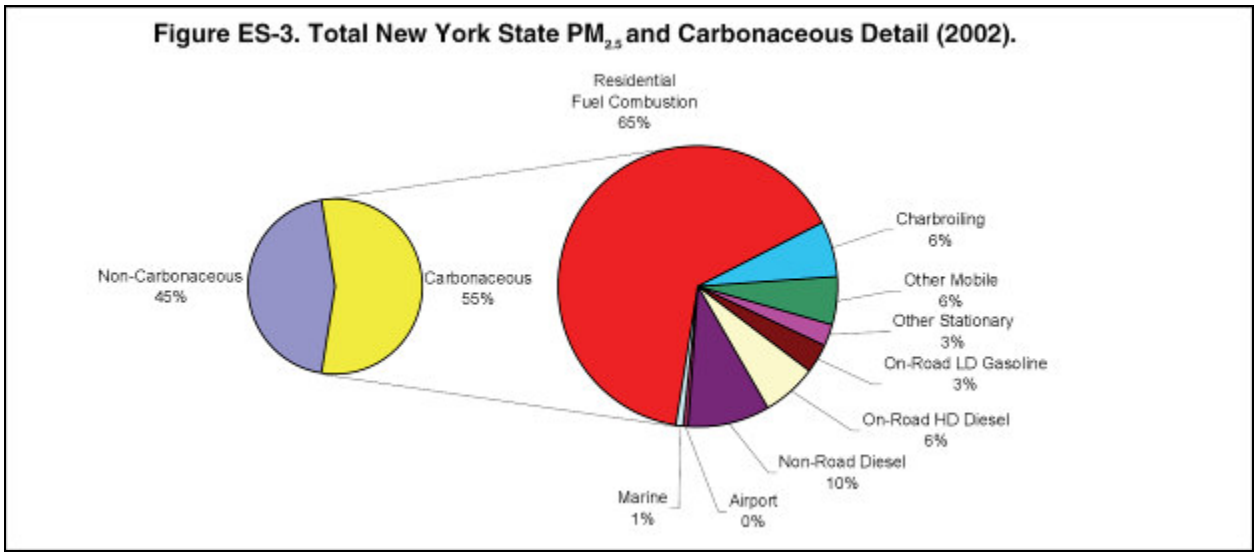
Where do Pellets and their Raw Materials Come From?

In the Adirondack / North Country region, there are currently two large-scale wood pellet manufacturers targeting wholesale customers within 120 miles of Tupper Lake, and a growing number of small-scale manufacturers targeting residential market. An undetermined portion of their raw wood materials come from within the Adirondack region's working forest lands.

3. Questions about the Emissions

What Comes Out of the Stack?

Wood combustion is an important source of fine particles (PM2.5) in New York State. Residential heating with wood accounts for about 35 percent of fine particles emissions state-wide (NYSERDA, 2008). In rural areas, this proportion is higher.



(Source: http://www.nyserda.org/programs/Environment/EMEP/Carbonaceous_PM_2.5_Volume_I.pdf)

Based on European studies, the emissions from advanced pellet-fired boilers are two to three times (considered to be "comparable") higher than oil-fired systems in contrast to conventional commercial wood boiler systems, which are more than 30 times higher. This improved emissions performance is due to the 2-stage combustion design which results in high combustion efficiency and low emissions without the need for additional emission control technology. This project will help demonstrate an advanced clean-burning wood technology that is superior to conventional commercial wood boilers. Clarkson University will conduct the energy and emissions performance evaluation of the boiler on site and will determine energy efficiency of the overall system as well as its components, and emissions of fine particles less than 2.5 micrometers (PM 2.5), elemental carbon (EC), organic carbon (OC), poly-cyclic aromatic hydrocarbons (PAHs), carbon monoxide (CO), carbon dioxide (CO2), nitrogen oxides (NOx), sulfur dioxides (SOx) and volatile organic compounds (VOCs).

Due to the automatic fuel feed of the pellet boiler, when the building's "call for heat" is satisfied, the auger can immediately stop feeding fuel into the combustion chamber, avoiding low-efficiency

smoldering phases. Documentation of the performance of even renewable fuel systems is essential to avoiding unintended consequences such as high particle or gas emissions. Renewable fuel systems such as this and other wood-fired systems need to demonstrate their high energy efficiency and emissions performance as fossil fuel systems do.

4. Questions about the Solar Hot Water System

Why are there Solar Tubes Instead of Panels? What is the Difference between Tubes and Panels?

Currently in the North Country most solar technologies employ photovoltaic panels to produce electric power, as The Wild Center's 190-panel array does. A photovoltaic cell, commonly called a solar cell or PV, is the technology used to convert solar energy directly into electrical power. A photovoltaic cell is a non-mechanical device usually made from silicon alloys.

A more efficient use of solar energy is by directly using its thermal (heat) component. At the Wild Center this will be accomplished by utilizing evacuated tube collectors to heat water. Tubes, similar to the inside of a thermos, are placed in the sun. Their round shape exposes them to the sun at every angle during the day, and tubes performs well in cold weather conditions, while conventional flat plate collectors lose some collected heat on cold and cloudy days.

There are two types of evacuated tube collectors: direct flow and indirect flow. Both types use the insulating properties of a vacuum wherein the loss of heat due to convection (how heat moves through water and gases) and conduction (how heat moves through solids) is virtually eliminated. Heat is still lost through radiation but special coatings are used to minimize this.

Sunlight heats a heat sink that runs the length of the inner tube. The heat sink, in turn, heats a small volume of water and glycol solution which changes to steam, travels up the collector tube and into a manifold where the solution changes state from steam to liquid. This is called latent vaporization and it is this changing from steam to liquid that gives the tubes their ability to produce about 40 percent more hot water than a flat plate collector. In a direct flow system the water/glycol solution will flow from the manifold directly into the evacuated tubes via piping connected to an absorber thereby capturing the solar energy. With an indirect flow system the solution never enters the evacuated tubes, but instead captures the solar energy indirectly from a heat pipe. After the manifold gets heated, it transfers its heat by conduction into the water flowing through the manifold and the process repeats. The heated water is pumped to the solar storage tank inside the building. The Wild Center is evaluating which type of system it will use.

The evacuated tube system is well suited for the North Country as it provides superior cold weather performance. Solar water heaters may offer a large potential savings, with residential system owners saving an estimated 50 – 85 percent annually on their utility bills over the cost of electric water heating. New customers in the North Country may expect a "simple payback" of an estimated 10-15 years on a well-designed and properly installed solar domestic water heater. (Simple payback is the length of time required to recover your investment through reduced or avoided energy costs.) (Source: Solar Energy International http://www.solarenergy.org/resources/energyfacts.html and NYSERDA Energy Efficiency Research Program.)

How Does the Solar Hot Water and Storage System Increase the Building's Heating Performance?

The increase in the building's heating performance by utilizing a solar thermal and storage system is realized in several ways. First, any energy supplied by the solar thermal system is less energy that must be supplied by the boiler. During the shoulder and summer months the solar hot water system can meet the majority of the building's heating and hot water loads. However, if more is needed short boiler run times and frequent cycling become a concern. Under such conditions emissions are worse as they spike at start up and shut down, efficiency drops off, and constant cycling stresses the boiler and reduces it life. To combat this problem a hot water storage system is used.

The hot water storage system is a very large, well insulated tank with a series of heat exchangers to transfer heat from both the boiler and solar system as well as to supply heat to the building. As heat is needed, energy from the tank is released to meet the load; this drops the temperature of water in the tank. Once the temperature drops to a certain point it will trigger the boiler to fire, and/or the solar thermal system to cycle, to heat the water again.

In the winter the need for heat will be often, requiring the boiler, with assistance from the solar thermal system, to run for long periods of time. That is the ideal operating condition for the boiler. By reducing fuel consumption, resources are conserved and each million BTU of propane energy avoided reduces carbon dioxide emissions by 139 pounds. Over the year it is expected that by replacing propane with wood pellets and solar to reduce carbon dioxide emissions by about 320 tons per year.

5. Questions Related to Environmental and Economic Sustainability

Isn't Wood a "Dirty" Fuel?

By burning wood in a highly efficient staged combustion system The Wild Center anticipates that energy efficiency rates greater than 85 percent and emissions 10 to 20 times lower than those of conventional wood burning systems can be achieved. This boiler will maintain approximately 1200 degrees F in the gasification chamber. Lower temperature gasification helps to reduce soot formation by reducing fuel rich, high temperature zones in flame; it also reduces ash-based particle formation. (Source: Ray Albrecht, DEC–E$PI Biomass conference, May 2008.)

The boiler design is a proven design from Europe that is adapted to meet US-certification standards. The air emissions will be tested by Clarkson University using the EPA's Conditional Test Method (CTM-39) (U.S. EPA, 2004) for dilution tunnel sampling of source emissions. The captured sample will be analyzed in a mobile lab for CO, NOx, SO_2, and CO_2. Particle size distributions and fine particles ($PM_{2.5}$) will be measured. A filter will be used to collect and measure elements, ions, organic and elemental carbon and selected organic compounds.

Thermal efficiency will be measured by determining the heat content of the pellet fuel through calorimetry and this will be matched against the metered flows of hot water from the boiler. Results of this evaluation will be published in scientific and professional journals.

Is This System "Carbon Neutral?" Why? Why Not?

Forest industry specialists note that as forests grow back after harvesting, they - particularly young saplings - consume carbon from the atmosphere, making the use of wood fuel a zero-sum equation, although no precise calculations demonstrate the exact amount of carbon extracted by newly growing trees and lost in chip or pellet harvest and production. Ecologists note that forest soils – which are known to hold much of the carbon in intact forest systems – are often disturbed in the harvesting process and likely to release significant carbon and other important nutrients for forest ecosystems when exposed to forces of erosion such as wind and water. According to Dirk Bryant of the Adirondack

Nature Conservancy, "The carbon neutral argument only works if total harvest in an area is at or below net growth. Over past decades there has been an increase in timber inventory in New York State. One concern is that new markets for biofuels will 'release' this surplus into the atmosphere when it is burned. In the long run as harvested lands regenerate it is carbon neutral, but in the short term it could lead to a CO2 'pulse.'" This is therefore a question that The Wild Center hopes will receive further study.

How Do Consumers of Wood Fuels Track "Environmental Sustainability?"

Finding the highest efficiency boiler available is the primary action one can take to ensure sustainability. Subsequent to this critical decision, seeking a "green" label on a product is one way many consumers ensure they are using their purchasing power to buy sustainably produced products, from organically farmed food to sustainably harvested wood to fairly traded coffee. Wood pellets are the same. Yet which certification system should they trust to certify their source of wood pellets?

According to a 2008 report by the Yale Program on Forest Policy and Governance, developed to assist the US Green Building Council in assessing certification programs for its LEED system, "The suite of forest certification programs of greatest relevance to the U.S. building industry (i.e. that together account for more than 99percent of wood by volume used in US construction) include:

- the American Tree Farm System (ATFS),
- the Canadian Standards Association (CSA),
- Sustainable Forest Management (SFM) system,
- the Forest Stewardship Council (FSC), [and]
- the Sustainable Forestry Initiative (SFI), …[yet]

There is dispute among environmental and industry groups regarding the relative merits of each of these forest certification schemes." Some ecologists feel that no certification system is adequate in tracking impacts on biodiversity habitat and soil disturbance during the harvesting process.

There is widespread agreement that some certification schemes are better than others. For example, NYS DEC currently considers only FSC and SFI as suitable certification schemes for working forest conservation easements.

In the Adirondacks, much of the forested land still in wood production is certified using one, sometimes two of these schemes; most often FSC and SFI. Using pellets produced from these lands would therefore not only provide The Wild Center and other facilities using pellets for heat with a certified source but would also keep their "energy dollars" local and strengthen forest industries in the region. Thus The Wild Center is seeking to find a sustainably produced source of pellets for their heating needs, within the region if it can be done. We will follow the science of forest ecology and management as it indicates what is the most sustainable approach for our facility, location in the Adirondacks, and the environment and economy around us, and we will adapt this approach as the market changes to serve the demand we are helping to create locally.

Will the Use of Wood Fuels in the Adirondacks Negatively Impact Forests?

The science on this issue is not yet conclusive. As noted above, forest industry analysts feel we can use wood fuels comprised of low grade timber for years without too many negative impacts, if those forests are managed in a sustainable manner. Ecologists often agree with this analysis, yet feel there must also be more research on the issue specific to the Adirondack region forest lands and economy to know exactly *how much, where, and how we can harvest for fuel without undermining natural systems.* For this reason, the Adirondack Climate Action Plan task force on Lands and Forests has endorsed a research agenda proposal developed by the Adirondack Research Consortium, Empire State Forest Products Association

and the Adirondack Council to study the issue; this process may begin as soon as the fall of 2009. The use of wood biomass fuels for heat is of increasing interest at the national level as well. A recent study of woody biomass (willow) technical availability in Tupper Lake and Syracuse, New York found that "Both of the supply sheds in this study have an abundant supply of forest biomass that is technically available for the production of traditional forest products and bioenergy. However, just because the biomass is technically available does not mean that it will all be produced and sold for bioenergy or other products. [Yet…] a key issue that needs to be resolved is the need for a forestry infrastructure to harvest and collect the material" (Source: P.J. Castellano, T.A. Volk*, L.P. Herrington, Estimates of technically available woody biomass feedstock from natural forests and willow biomass crops for two locations in New York State, Biomass and Bioenergy 33 (2009) 393 – 406). A recent policy paper by the Environmental and Energy Study Institute notes that "Federal policies should strive to ensure the *sustainability* of woody biomass harvesting; this will go a long way towards winning the public trust that is so essential if bioenergy is to be become a trusted and utilized component of the national energy system." (Source: Jesse Caputo, Sustainable Forest Biomass: Promoting Renewable Energy and Forest Stewardship, 2009.)

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For Further Information

- The **Biomass Energy Resource Center** (BERC) is an independent, national nonprofit organization located in Montpelier, Vermont. BERC assists communities, colleges and universities, state and local governments, businesses, utilities, schools, and others in making the most of their local energy resources. http://www.biomasscenter.org/

- **Energy Information Administration:** http://www.eia.doe.gov/kids/energyfacts/sources/renewable/solar.html#Solar Thermal Heat

- **Environmental and Energy Study Institute Policy Paper:** Sustainable Forest Biomass: Promoting Renewable Energy and Forest Stewardship, Jesse Caputo, July 2009: http://www.eesi.org/files/eesi_sustforbio_final_070609.pdf

- **The Cost of Usable Heat:** This graph, produced by Jeff Forward of Richmond Energy Associates, LLC, used historical fuel price data over twenty years for New York State from:
  - Natural gas: http://tonto.eia.doe.gov/dnav/ng/hist/n3020ny3m.htm
    http://tonto.eia.doe.gov/dnav/ng/xls/ng_pri_sum_dcu_SNY_a.xls
  - OIL: http://tonto.eia.doe.gov/dnav/pet/xls/pet_sum_mkt_dcu_SNY_a.xls
    http://tonto.eia.doe.gov/dnav/pet/hist/d200112362m.htm

  Forward used woodchip price data from the Vermont Superintendent's Association School Energy Management Program. He used 8,250 Btu per pound as an average BTU content for woodchip fuel, discounts the woodchip Btu's for an average moisture content of 40 percent, leaving 9.9 MBTU per ton. He applied seasonal equipment efficiencies for commercial boilers for the various fuel types as follows: 80 percent efficiency for Natural Gas; 75 percent efficiency for fuel oil boilers; and 65 percent efficiency

for wood chip boilers. Seasonal efficiency is an assumption; equipment for all of these fuels will typically have higher steady state efficiencies as they are typically tested under ideal conditions. Many tables that show $/MBTU for fossil fuels do not take into account equipment efficiencies.

- **New York State Energy Research and Development Authority (NYSERDA)** www.nyserda.org:
  - **Biomass Heating R&D:** This research area is a collaboration of NYSERDA's Environmental and Buildings R&D Programs. NYSERDA has a history of evaluating heating technologies, characterizing fuels, and performing air quality and emissions studies. Due to the high emissions of conventional wood-fired technologies and great advancements that are possible with improved combustion design, NYSERDA has embarked on program to: evaluate the energy-efficiency and emissions- performance of biomass-fired heating technologies; assist in-state manufacturers to commercialize advanced technology designs; and demonstrate advanced technologies in representative heating applications in New York State.

    http://www.nyserda.org/programs/Environment/EMEP/Carbonaceous_PM_2.5_Volume_I.pdf
    http://www.nyserda.org/programs/Environment/EMEP/Report%2008-03%20-%20Biomass%20Combustion%20in%20Europe-complete-after%20corrections.pdf
    http://www.nyserda.org/energy_information/patterns%20&%20trends%201993-2007.pdf

  - **Renewable Fuels Roadmap:** "Development of a Renewable Fuels Roadmap and Sustainable Biomass Feedstock Study for New York" http://www.nyserda.org/funding/1249rfp.pdf was designed to provide policy makers with a better understanding of the possible impacts that increased use of renewable fuels might have on economic development, energy supplies and diversity, the environment and public health. A draft of the Roadmap will be done at the end of 2009. Two annual updates will be prepared in 2010 and 2011, to document technical advances, policy changes and their potential economic impacts, changes to the body of literature, etc. appropriate to the rapidly changing field of renewable fuels. The goal is to answer the most basic questions for New Yorkers and New York leaders: What resources do we have for a sustainable biofuels industry? What is the best use of these resources for New Yorkers?

- The Web Site of the 2007–2008 **North Country Woody Biomass Alternative Energy Feasibility Project**, a collaborative effort between the New York State Department of Environmental Conservation and the Adirondack Energy $mart Park Initiative, contains valuable information in the form of PowerPoint presentations from experts around the region:
  http://www.adksc.org/epi_dec/epi_dec.htm

- **US. Department of Energy "Energy Savers"** web site:
  http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=12850

- The **Yale Program on Forest Policy and Governance** wrote "Assessing USGBC's Policy Options for Forest Certification & the Use of Wood and Other Bio-based Materials: A summary report," February 25, 2008. http://www.yale.edu/forestcertification/index.html

Acronyms and Definitions

ASME: American Society of Mechanical Engineers

BERC: The Biomass Energy Resource Center in Vermont

EC: Elemental carbon

LEED: Leadership in Energy and Environmental Design. The Wild Center was the first LEED certified museum in New York State and the first certified facility in the entire Adirondacks. The certification is considered the international benchmark for green building design, and is issued by the United States Green Building Council (USGBC).

LPG: Liquified propane gas.

MMBtu:
Million British Thermal Units (BTU)
A standard unit of measurement used to denote both the amount of heat energy in fuels and the ability of appliances and air conditioning systems to produce heating or cooling. A BTU is the amount of heat required to increase the temperature of a pint of water (which weighs exactly 16 ounces) by one degree Fahrenheit. Since BTUs are measurements of energy consumption, they can be converted directly to kilowatt-hours (3412 BTUs = 1 kWh) or joules (1 BTU = 1,055.06 joules). A wooden kitchen match produces approximately 1 BTU, and air conditioners for household use typically produce between 5,000 and 15,000 BTU.

MBTU stands for one million BTUs, which can also be expressed as one decatherm (10 therms). MBTU is occasionally used as a standard unit of measurement for natural gas and provides a convenient basis for comparing the energy content of various grades of natural gas and other fuels. One cubic foot of natural gas produces approximately 1,000 BTUs, so 1,000 cu.ft. of gas is comparable to 1 MBTU. MBTU is occasionally expressed as MMBtu, which is intended to represent a thousand thousand BTUs. Source: http://www.energyvortex.com/energydictionary/british_thermal_unit_(btu)__mbtu__mmbtu.html

NYSERDA: New York State Energy Research and Development Authority

ODT: Oven dry tons, an amount of wood that weighs 2,000 pounds at zero percent moisture content. Source: Biology Online.

PM 2.5: Particulate matter down to 2.5 micrometers in diameter (less than one-third the width of a human hair).