Cleaner, Greener Communities Program:

Biomass Heating System Program Requirements

Cleaner, Greener Communities (CGC) Program is administered by The New York State Energy Research and Development Authority. CGC Progam was announced by Governor Andrew M. Cuomo in his 2011 State of the State address as a competitive grant program to encourage communities to develop and implement regional sustainable growth strategies. Regional Sustainability Planning was the first phase of the CGC Program and as a result, each New York State region developed a comprehensive sustainability plan in coordination with the Regional Economic Development Councils (REDCs). The awarding of Implementation Grants is the second phase, and begins in June 2013. Funding will be provided on a competitive basis for implementation of specific projects that provide the greatest opportunities for achieving carbon reductions, energy efficiency savings and renewable energy deployment consistent with a region's sustainability and REDC strategic plans.

This document provides greater detail regarding the eligibility requirements for biomass heating system projects through Phase II of NYSERDA's Cleaner, Greener Communities Program.

The bulk pellet storage bin at the W!ld Center Museum in Tupper Lake, NY, is a re-purposed shipping container that also supports a solar-thermal hot water system. (NYSERDA photo)

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Eligibility Requirements for Biomass Heating Systems

Biomass heating systems in NYSERDA's Cleaner Greener Communities Program are limited to fully automatic high-efficiency and low-emissions wood pellet boiler heating systems rated less than 5 MMBtu/h with thermal storage, bulk pellet storage and emission control technology and use a sustainable premium wood pellet fuel. The heating system operation must be optimized using an energy management system to provide maximum efficiency on a seasonal and diurnal basis and minimize boiler cycling. Biomass heating projects must follow each of these criteria. No systems using wood-chips, cord-wood, non-woody biomass, or projects larger than 5 MMBtu/h will be considered. These other technologies/fuel types are considered R&D topics or low efficiency at this time.

Figure 1. Premium wood pellets. (Courtesy of Curran Renewable Energy)

Fuel Type: The eligible fuel type is a premium wood pellet (Figure1). The premium wood pellets must be 100% wood composition with no construction or demolition debris such as pressure treated or painted wood (which may contain heavy metals such as copper, chromium, arsenic, lead and cadmium) or plastic binders or fillers. Pellets must have a calorific value of no less than 8000 Btu/lb, low ash content (<1%), low moisture content (<8%), chlorides less than 300 ppm and no other additives (0%). Other commercially available fuel types in NYS (for example green wood chips and grass pellets) cannot facilitate high-efficiency and low emissions performance even in advanced technology boilers at this time. Awardees must agree to use only the eligible fuel type in the wood pellet boiler for a minimum of the length of pay-back time on the system from fuel-cost savings. Applicants should identify and obtain a bulk fuel price quote from at least two pellet suppliers located in NYS.

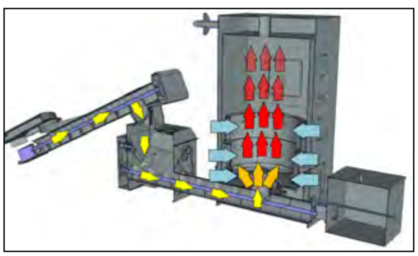

Figure 2.Pellet flow path of a fully-automatic pellet boiler with a staged combustion design. (Courtesy of ACT Bioenergy)

High-Efficiency Wood Pellet Boiler: Boilers must be fully automatic, low mass (low volume) and have sensors and controls to optimize combustion performance (Figure 2). This is most easily achieved using a staged combustion design with lambda control. The wood pellet boiler must have a minimum thermal efficiency of 85% at rated output using the higher heating value (HHV) of the pellet fuel if tested using an input/output method. Alternatively a simple full load, steady-state combustion efficiency measurement by the stack loss method (Canadian Standards Association B415) may be used, but in this case, the minimum efficiency requirement is 88% HHV. Where combustion efficiency is used, the return water temperature must be greater than 130 degrees Fahrenheit, no energy credit may be taken for any flue gas condensate collected, and the flue gas temperature measurement and flue gas composition measurement must meet or exceed the requirements of the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Standard 103. Prior to contracting, successful applicants will be required to submit thermal efficiency performance verification by an independent third-party.

Low Emissions from Combustion:
a) Fine Particles (PM): The wood pellet boiler heating system for commercial installations must have a PM emissions rate of no more than 0.080 lb/MMBtu. This emission rate is comparable to that of No. 6 fuel oil. All institutional applications at schools, health care facilities, nursing homes, or other locations with similar sensitive populations, must have a PM emissions rate of no more than 0.030 lb/MMBtu. Applicants are strongly encouraged to include advanced emissions control technology to achieve emissions rates lower than these basic requirements. Emissions control technologies such as condensing units can also improve energy efficiency of the heating system. Prior to contracting, successful applicants will be required to submit emissions performance verification results of the same boiler model and pellet fuel combination. Testing for PM must have been performed by an independent third-party using the U.S. Environmental Protection Agency (EPA) Conditional Test Method 39, EPA Federally Referenced Methods 5 and 202, or EPA Other Test Method 15. Alternatively, European Norm 303-5 test results may also be considered, but must include dust and organic gases.

b) Carbon Monoxide (CO): The wood pellet boiler must have a flue gas CO concentration at rated output of no more than 270 ppm at 7% oxygen at high load. Emissions performance must be verified by an independent third-party. For health and safety, a CO detection system must be included in the boiler room design. For commercial heating projects, the CO monitoring system must have the ability to sound an audible alarm, provide phone notification to facilities staff and trigger an automatic pellet boiler shutdown if necessary.

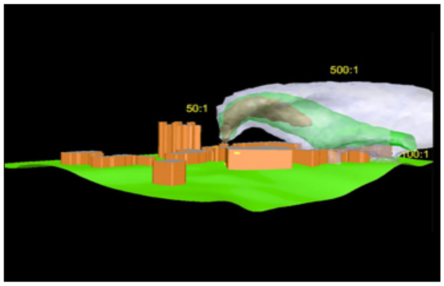

Figure 3. Vertical cross sectional diagram of the wake and cavity regions in the lee side of building. (Courtesy of M/E Engineering)

c) Stack Height: The design of the exhaust stack and location should be done carefully to prevent exposure to building occupants and visitors or to people in frequently occupied outdoor areas such as playgrounds. The boiler's stack height must be sufficient to adequately disperse emissions from the immediate vicinity and prevent entrainment of exhaust gases and particles into the building air intakes and to minimize exposure at ground level adjacent to the building on which the stack is being located (Figure 3). Poor dispersion characteristics are generally associated with short stacks that have little plume rise. This happens when stacks are too short relative to the building height or the exhaust flow is not sufficient, resulting in the plume not escaping the building's aerodynamic effects and becoming entrained in or near the building. At a minimum, the stack should be 5 feet above the highest point of the building that it is heating and above the roof height of any other taller building within 100 feet of the unit. In no case should the stack height be at or below the building height. In addition, the stack should not be placed in close proximity to an air intake or operable window. Stack design should also minimize horizontal piping and bends.

d) Health Assessment: The New York State Department of Health recently released a Prevention Agenda to promote a healthy and safe environment (www.health.ny.gov/prevention/prevention_agenda/2013-2017/). Some communities in NYS experience very high concentrations of woodsmoke comprised of fine particle matter and CO. One goal of the Prevention Agenda is to "reduce exposure to outdoor air pollutants with a particular focus on burdened communities." Consistent with the Prevention Agenda goal, all projects selected for pellet heating systems at schools, hospitals or locations with similar populations will be required to perform a health assessment (e.g. air impact assessment) to evaluate the potential public health risks associated with burning biomass, particularly for rural communities where wood smoke pollution is common. This assessment consists of modeling the anticipated emissions due to the new heating system and evaluating the resulting concentrations with a focus on ambient concentrations in the schoolyard, near doors and windows, and at building air intakes. An estimate of the number of deliveries by the pellet truck and a comparison to the current fuel delivery schedule must be included as well. The resulting ambient particulate and gaseous concentrations are then, compared to the conditions existing prior to the pellet heating system installation. If there is a net increase in ambient concentrations, then an assessment of exposure is performed. Proposers are also encouraged to include in their proposals any higher emitting biomass sources (e.g. outdoor wood boilers or pre-certification wood stoves) to be switched-out with a pellet boiler to result in no net increase in emissions for the immediate vicinity.

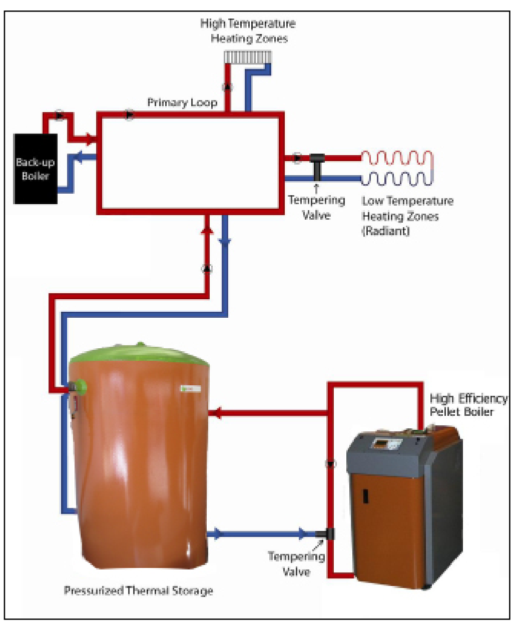

Figure 4. High-efficiency wood pellet heating system with thermal storage. (NYSERDA diagram)

Proper Boiler Sizing: The high-efficiency wood pellet boiler must be properly sized for the application with particular attention to avoid oversizing the boiler. Boilers must be sized and systems planned to optimize performance throughout the heating season using thermal storage. Use of a cleaner heat source during heating season shoulders (late October or March) and for supplemental needs is strongly encouraged. These cleaner heat sources may include, for example, natural gas-, propane-, or oil-fired boilers and solar thermal sources. A bin-hour analysis of heating needs based on an energy audit, previous heating needs, and historical local temperatures during the heating season should be performed. The annual heat load profile, diurnal heat load profile on demand day, and diurnal heat load profile on a shoulder day should also be determined. Commercial pellet boilers should be sized to ≤60% of the design load as it will capture the majority of the heating season and promote higher performance. Higher loads may be met by utilizing an existing natural gas-, propane-, or oil-fired boiler, a new boiler, staging of wood pellet boilers, or some other strategy involving careful energy management and thermal storage (Figure 4). Low loads, common during shoulder months, can be met by an auxiliary boiler or other energy management strategy. A well-designed residential system must be sized based on the heat load of the building where the heat load is determined using a well defined protocol such as Manual J of the Air Conditioning Contractors of America (ACCA) or an equivalent energy simulation program.

Figure 5. Thermal storage tanks and a commercial pellet boiler. (Courtesy of EvoWorld)

Figure 6. Bulk pellet storage silo. (Courtesy of ACT Bioenergy)

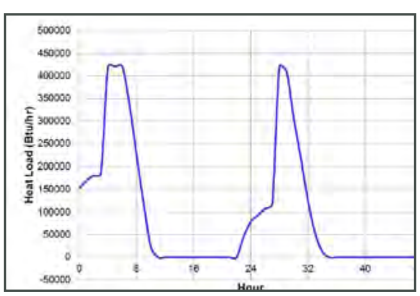

Figure 7. Diurnal heat load profile for a 25,000 square foot school building. (Courtesy of Brookhaven National Laboratory)

Thermal Storage: Pellet heating systems must include thermal storage (Figure 5) to minimize boiler cycling and to assist in energy management strategies. The minimum size thermal storage should be based on the boiler manufacturer's recommendation for the application and size of the boiler but must not be less than 20 gallons per 10,000 Btu/h. For example, a commercial 1.0 MMBtu/h boiler would require a minimum storage of 2,000 gallons, a residential boiler with a rating of 50,000 Btu/h would need 100 gallons of thermal storage.

Pellet Storage: Pellets can produce high levels of dust and off-gas CO in storage presenting an explosion hazard and health and safety concerns. Carbon monoxide is a colorless, odorless gas that has health effects below the levels at which common CO detector alarms are triggered. There have been cases of fatalities aboard ships carrying pellets and in commercial bulk storage facilities in Europe. Research is underway in Europe, Canada and NYS to better understand the chemical reaction that produces the CO. According to the US EPA:

> *CO can cause harmful health effects by reducing oxygen delivery to the body's organs, such as the heart and brain, and tissues. At extremely high levels, CO can cause death. Exposure to CO can reduce the oxygen-carrying capacity of the blood. People with several types of heart disease already have a reduced capacity for pumping oxygenated blood to the heart, which can cause them to experience myocardial ischemia (reduced oxygen to the heart), often accompanied by chest pain (angina), when exercising or under increased stress. For these people, short-term CO exposure further affects their body's already compromised ability to respond to the increased oxygen demands of exercise or exertion.*

Due to concerns regarding explosive dust and CO exposure and the absence of a documented effective ventilation strategy for pellet storage, all pellet storage must be outside of the building (Figure 6). Confined spaces are areas that are: 1) large enough for a person to enter to perform work, 2) have limited means of ingress and egress, and 3) are not intended for human occupancy. Pellet storage silos meet these criteria and because of the CO off-gassing, require an Occupational Safety and Health and Administration (OSHA) permit. Applicants may request funds for bulk pellet storage silos and pellet conveyance systems, but large capital construction costs for bunkers or modification of coal bins will not be considered. Applicants should identify fire and building code and health and safety features including all applicable training requirements for personnel. Signs communicating potential CO hazards associated with bulk pellet storage must also be posted.

Energy Management System: The high-efficiency pellet boiler heating system must use an energy management system and optimize boiler operation to meet seasonal and diurnal heating needs of the particular building's heat load. The system design should consider a strategy that optimizes the use of both the pellet boiler and thermal storage and the temperature requirements of the heat distribution system. For example, consider a 25,000 square foot school with a nighttime setback. Figure 7 shows the heat load (Btu/h) for two days in February. Notice the building has a large demand in the early morning (425,000 Btu/h) to make up heat from the nighttime setback. By approximately 11 AM, the building load reduces to zero due in part to solar gain. By using a large enough thermal storage tank to help meet the peak demand and a properly sized boiler, the call for heat may be met with a smaller boiler without the need for additional heat input from the existing oil-fired boilers. The hot water storage can be recharged during periods when there is little call for heat in the building, which, in this case, is several hours each day.

Cost-effectiveness: High-efficiency and low-emissions commercial and residential wood pellet heating systems are estimated to have a simple payback period (i.e. no public incentives or tax credits) of about 12 years. Containerized high-efficiency wood pellet heating systems that offer substantial savings compared to boiler room renovations are encouraged, but not required (Figure 8). When containers are used, the stack height must be sufficient to adequately disperse emissions from the immediate vicinity and prevent entrainment of exhaust gases and particles into the building air intakes. Steps should be taken to minimize thermal losses to non-heated spaces including, but not limited to insulating the container that houses the boiler and insulating pipes between the container and building(s) being heated.

Figure 8. High-efficiency pellet boiler installed in a container outside of existing building. (Courtesy of ACT Bioenergy)

Heating System Commissioning: All commercial and institutional projects must include commissioning of the wood pellet heating system and components. A data acquisition system and monitoring plan must be included to facilitate measurement and verification for the first heating season of operation. For residential systems, boiler operation (water temperature and flow, cycling, load) is often recorded on the pellet boiler computer. This information and pellet use must be reported for the first heating season. Fuel costs must be reported for the period of pay-back on the heating system.

Pellet Production in New York State

There are nine pellet mills in NYS with an annual capacity of 500,000 tons per year (Figure 9). Several manufacturers produce premium wood pellets that are low in ash and moisture content, and contain no construction debris or non-wood additives. Some mills have pellets that also meet criteria for sustainability by the Forest Stewardship Council or Sustainable Forestry Initiative certification.

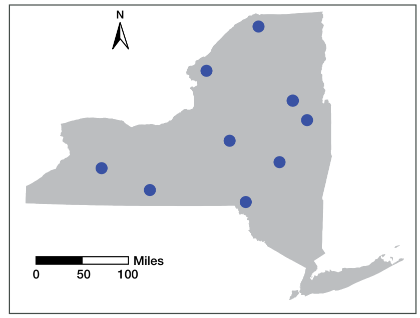

Figure 9. Wood pellet production in NYS

High-Efficiency Pellet Boiler Demonstrations

NYSERDA works with manufacturers across NYS to develop advanced, high-efficiency and low emissions heating technologies, regardless of fuel type. As interest in biomass heating has increased, NYSERDA has undertaken efforts to support a clean biomass industry in NYS, including funding demonstrations to measure and verify system performance. Research to date has shown that wood pellets combusted in an advanced boiler yields the highest and most consistent performance among the biomass fuels.

Figure 10. First Made-in-NY commercial high-efficiency wood pellet boiler by Advanced Climate Technologies. (NYSERDA photo)

Advanced Climate Technologies Bioenergy LLC, of Schenectady, New York, produced the first Made-in-NY commercial high-efficiency pellet boiler (Figure 10). High performance is achieved via staged combustion that includes a flue gas oxygen (lambda) sensor to promote optimum combustion conditions. A 1.7 million Btu per hour boiler was demonstrated at the W!ld Center Museum in Tupper Lake, New York. The performance of the boiler was measured by Clarkson University's Center for Air Resources Engineering and Science, and was able to achieve high-efficiency (>85%) at full load, similar to the efficiency level of an oil-fired heating system. A solid fuel system's performance decreases more rapidly under a reduced load than propane-, natural gas-, or oil-fired heating systems. Thermal storage can help mitigate these losses. The W!ld Center did not have thermal storage, and annual efficiency was measured to be about 65%. Despite this, the cost difference between wood pellets and propane yielded an annual fuel savings of $31,000 or about 45%. Clarkson University has recommended adding a thermal storage tank with an anticipated additional annual savings of $5,000. A second manufacturer, EvoWorld of Troy, N.Y., is manufacturing high-efficiency wood pellet boilers for both commercial and residential applications. The first Made-in-NY residential high-efficiency pellet boiler is shown in Figure 11.

Figure 11. First Made-in-NY residential wood pellet boiler by EvoWorld. (Courtesy of EvoWorld)

School Children—A Unique Population

Other states have focused their biomass heating programs on schools because they are large energy users and face ever increasing budget constraints. However, children comprise a population uniquely susceptible to air pollution.

According to the 2009 NYS Asthma Surveillance Report, 11% of children (ages 0–17) have asthma, which exposure to fine particulate matter (PM2.5) is known to exacerbate. In NYS, the commitment to reducing exposures to PM2.5 has included retrofitting more than 2,800 school buses with diesel emission control devices. In selecting school heating technologies, it is essential to avoid installing systems that emit more PM2.5 and other pollutants (CO, NOx) than existing heating systems. Due to this concern, the NYS High Performance Schools (NY-CHPS) Guideline States:

While the use of renewable resources is important in New York State, schools must also evaluate potential environmental effects from the use of renewable resources. Combustion of biomass for example could cause circumstances where the products of combustion are not properly dispersed (as a result of equipment technology or localized climatic conditions), thereby creating a potential health impact for students, staff and community members.

In addition, the New York State Education Department Manual of Planning and Standards (Part V, S501(b)) states:

A school building must provide for the health, comfort, and safety of children, teachers, and other occupants. No mechanical equipment or construction materials shall be used, nor any type of construction permitted, which will endanger the health, safety, or comfort of all occupants in the school building.

Fine Particulate Matter (PM2.5) Emissions Performance

US EPA and other agencies are concerned about fine particle pollution because as stated on EPA's website:

Health studies have shown a significant association between exposure to fine particles and premature mortality. Other important effects include aggravation of respiratory and cardiovascular disease, decreased lung function, asthma attacks, heart attacks, and cardiac arrhythmia. Individuals particularly sensitive to fine particle exposure include older adults, people with heart and lung disease, and children.

PM2.5 is a pollutant of concern from all combustion systems. A comparison of emissions is made for several fuel and heating technology combinations (Figure 12). The highest emissions are from a green wood chip–stoker boiler heating system at 0.28 lb MMBtu. The high-efficiency staged combustion boiler with a premium wood pellet fuel, which has much lower moisture content, has approximately 75% lower emissions. This is about the same as PM2.5 emissions from a No. 6 oil-fired boiler and more than seven times higher than PM2.5 emissions from a No. 2 oil-fired boiler, and 1,000 times higher than PM2.5 emissions from an oil-fired boiler burning ultra-low sulfur heating oil. As of July 2012, all No. 2 heating oil in NYS must be ultra-low sulfur, which is commonly used in schools.

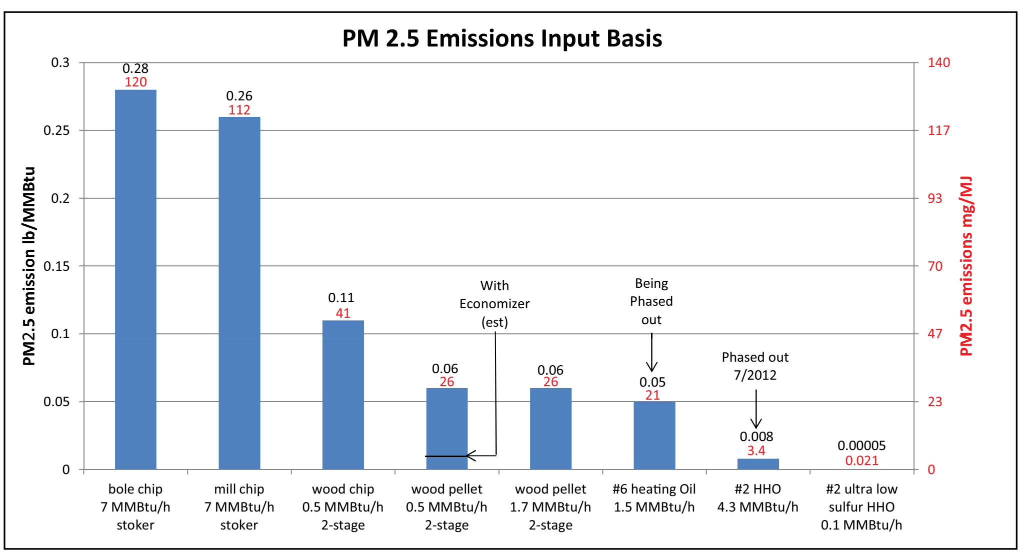

Figure 12. Comparative fine particulate matter (PM2.5) emissions from several fuel-heating technology combinations including wood chips, wood pellets, #5 fuel oil, and #2 home heating oil (HHO). (Rector, L. (2010), Chandrasekaran, S. et al. (2011), McDonald (2009))

To reduce fine particle emissions from a high-efficiency pellet boiler, Clarkson University will install and evaluate a condensing economizer on a high-efficiency pellet boiler. This emission control technology has the advantage of increasing energy efficiency while removing PM2.5, and it is anticipated that the resulting emissions will be 100 times higher than those from an oil-fired boiler burning ultra-low sulfur heating oil.

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NYSERDA – High Efficiency Hydronics for Wood-Fired Boilers - Presentation

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