

**SCIENTIFIC INFORMATION STATEMENT  
Attachment B**

**Vermont Agency of Natural Resources  
Department of Environmental Conservation  
Air Pollution Control Division**

**PROPOSAL FOR A “PHASE II” PARTICULATE MATTER EMISSION  
STANDARD AND RELATED PROVISIONS FOR  
OUTDOOR WOOD-FIRED BOILERS**

February 27, 2009

**Field Services Section  
Air Pollution Control Division**

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I. Introduction

The primary purpose of this document is to provide scientific support for a more stringent (i.e., “Phase II”) particulate matter (fly ash, soot and condensable organics) emission standard for newly manufactured outdoor wood-fired boilers sold for use in Vermont. Such a standard would further reduce visible smoke and particle emissions from these devices, would be more protective of human health, and would also serve as a surrogate standard in reducing hazardous emissions, including polycyclic organic materials, from the units. The basic elements of existing Sections 5-204 and 5-205 of the Air Pollution Control Regulations (APCR) are incorporated into the new rule, and various clarifications and minor policy changes are also being proposed.

II. Background

Vermont Regulations:

In 1997, the Air Pollution Control Division of the Vermont Agency of Natural Resources (ANR) adopted a regulation (APCR §5-204) that set standards regarding the installation and operation of outdoor wood-fired boilers (“OWBs”) in the state. In particular, §5-204 established a 200 foot setback and minimum stack height requirements for OWBs installed after October 1, 1997.

In practice, it was found that the setback and stack height requirements were difficult to enforce, especially with a limited number of state investigators. But, more importantly, the ANR’s investigations indicated that the smoke and particle emissions from these boilers were exacerbated by the poor combustion efficiency of the units, as well as the routine operation of these units during warm seasons to heat domestic hot water, swimming pools and the like. Furthermore, mounting health effects studies by USEPA and others documented increased human health risks related to exposure to fine particulate matter (“PM<sub>2.5</sub>”), which constitutes the majority of particulate emissions from OWBs.

In coordination with other northeastern states, the Northeast States for Coordinated Air Use Management (NESCAUM), USEPA and OWB manufacturers, the ANR developed a performance standard for emissions from OWBs. In 2007, the ANR adopted APCR §5-205, which required, with certain limited exceptions, that OWBs sold in Vermont or for installation in Vermont after March 31, 2008 must be certified by the ANR to meet a particulate matter (PM) emission limit of 0.44 pounds of emissions per million BTUs (lb/mmBTU) of heat input (known as the “Phase I” limit). APCR §5-205 also provided in subsection (f) for the adoption of a future particulate matter emission limit as follows:

“(f) Future Particulate Matter Emission Standard

As soon as practicable, but no later than March 31, 2008, the Secretary shall file a proposed rule with the Secretary of State to establish a particulate matter emission limit for outdoor wood-fired boilers of 0.32 pounds per million BTUs of heat output, or such other limit that the Secretary determines may be necessary in accordance with 10 V.S.A. §558.”

This future standard is known as the “Phase II” emission limit, which is being proposed by this rule, and is identical to the Phase II limit included in NESCAUM’s model rule, EPA’s voluntary program and other northeast states’ statutes and regulations (see below).

#### Other States’ and USEPA’s Activities:

Concurrent with the development of Vermont’s Phase I emission limit, several northeastern states (including Vermont), USEPA, Environment Canada and NESCAUM worked with OWB manufacturers and independent laboratories to develop standard OWB certification emission test methods and a NESCAUM OWB model rule that includes Phase I and II particulate emission limits for OWBs.

Working on the foundation created by the above activities, other states in the northeast and Midwest have been actively pursuing the adoption of statutes and regulations that control the emissions and impacts from OWBs, through the use of emission limits and other tools. In June 2007, the Maine Legislature enacted LD 1824, “An Act To Regulate Outdoor Wood Boilers”. This legislation established emission standards for new outdoor wood boilers starting in 2008 and also directed the Maine Department of Environmental Protection to adopt rules related to OWBs. The Maine DEP thereafter adopted a regulation (“Chapter 150”) which establishes requirements concerning the sale and installation of new OWBs, including Phase I and II particulate emission standards and requirements for setbacks and minimum stack heights among other measures. This rule includes wood pellet fueled boilers and relies on the EPA Voluntary Program certification process. Maine’s Phase I emission limit (0.60 lb/mmBTU of heat input) applies to OWB sales after April 1, 2008, and its Phase II limit (0.32 lb/mmBTU of heat output) applies to OWB sales after April 1, 2010.

House Bill 1405-FN of the 2008 session of the New Hampshire Legislature establishes requirements for the sale, installation and use of OWBs. The act includes a Phase I particulate emission standard of 0.6 lb/mmBTU of heat input effective with regard to sales on or after January 1, 2009 and a Phase II particulate emission standard of 0.32 lb/mmBTU of heat output effective with regard to sales on or after April 1, 2010.

In December 2008, the Massachusetts Department of Environmental Protection adopted 310 CMR 7.26(50), “Outdoor Hydronic Heaters”, which establishes a comprehensive program to regulate OWB’s including particulate emission standards of 0.32 lb/mmBTU of heat output and a limit for residential size units of 18 grams/hour for an individual test run that apply to all OWBs sold or purchased on or after December 26, 2008. This regulation also includes several installation and operational restrictions, among other provisions. Note that this rule by-passed the adoption of a Phase I standard and requires compliance with the Phase II standards as of December 26, 2008.

The states of New York, Rhode Island and New Jersey are now working on draft regulations for OWBs. The ANR is aware that several Midwestern states are also developing regulations regarding OWBs.

In January 2007, the US EPA implemented its “Incentivized Voluntary Program for Outdoor Hydronic Heaters”, setting an emission guideline of 0.6 lb/mmBTU of heat input. In October 2008, EPA announced its Phase II program, including a Phase II particulate emission guideline of 0.32 lb/mmBTU of heat output, the same number as the Phase II limit in Vermont’s currently proposed rule, the NESCAUM Model Rule, and the rules and statutes of other New England states that have adopted OWB emission limits. (As in the ANR’s proposed rule, EPA’s guideline also requires that no individual test run’s emissions shall exceed 18 grams per hour for residential size units.) EPA also expanded its voluntary program in Phase II to include pellet/biomass fueled boilers and indoor boilers. The EPA program is limited to residential sized heating systems (i.e., units rated at less than 350,000 BTU/hr). Note that the EPA program is not regulatory, nor mandatory, and the EPA emission “guideline” is not enforceable against OWB manufacturers.

Copies of the above model rule, the Maine and Massachusetts regulations and the New Hampshire statute are included in Attachment B-1 of this document.

### III. Standard Development Approach

When the ANR developed its Phase I emission limit for OWBs in 2007, the focus was on setting a “performance based” standard that was a reasonable limit that could be achieved by modern combustion technology available at that time for other types of small wood burning equipment, such as indoor wood stoves. Several manufacturers have already demonstrated that they have OWB models capable of meeting Vermont’s Phase I limit. The ANR’s primary goal in developing the Phase II limits is to establish a standard that is adequate to protect human health and welfare for the foreseeable future, especially considering the increasing use of wood as a heating source and the growth of wood burning in more densely populated areas. Soaring oil prices and concerns about climate change have prompted increasing numbers of people to turn to wood as a fuel source causing the localized and general particulate and other emission impacts from wood smoke to increase. To better evaluate the impacts of all these changes, the ANR has considered the results of emission testing performed on several models of OWBs and the results of air pollution modeling of OWB emissions by other states. The ANR has also conducted its own comprehensive air pollution modeling to better represent the impacts of OWB emissions in Vermont settings, such as narrow valleys.

When developing the Phase II standards and related provisions, the ANR is also keeping in mind that there are legal, economic and other benefits to state regulators, manufacturers, dealers and consumers to having standards that are consistent across state lines and that can be tested for by mutually agreed upon test methods. Consistent standards also allow the states and EPA to use similar approval and certification processes which is a significant advantage to the manufacturers and the states. Several OWB manufacturers have already invested large sums of money into redesigning their boilers and retooling factories with the Phase II standards as the goal.

#### IV. Air Pollution Dispersion Modeling of OWB Emissions

Air pollution dispersion modeling is a means of estimating the impacts of air pollution emissions from an air pollution source on the geographical area surrounding the source. In the last few years, the impacts of particulate emissions from OWBs have been modeled by state regulators in Michigan and New York State. More recently, the ANR has conducted its own modeling that evaluates the effects of actual Vermont terrain features on local impacts of OWB emissions. All the modeling studies evaluated the impacts of OWB emissions with regard to the 24 hour National Ambient Air Quality Standards (NAAQS) for fine particulate matter (“PM<sub>2.5</sub>”). The 24 hour NAAQS, now set at 35 micrograms per cubic meter of air ( $\mu\text{g}/\text{m}^3$ ), is of the greatest potential concern from a health standpoint.

Although the earlier Michigan modeling showed significant impacts of OWB particulate emissions, more recent modeling by New York is more refined. The original modeling by New York, finalized in January 2007, modeled OWB particulate emissions at several rates: 161 g/hr for existing, uncontrolled OWBs, and for NESCAUM Model Rule Phase I compliant OWBs an average emission rate of 43 g/hr and a maximum emission rate of 70 g/hr. The emission rate used for modeling a Phase II compliant OWB was 15 g/hr because the model rule establishes an emission limit of 0.32 lb/mmBtu of heat output, with no individual test run to exceed 15 grams per hour. (Vermont’s proposed rule would limit emissions from an individual test run to 18 gr/hr for residential units.) Other input variables included stack heights of 10 and 18 feet and various adjacent building configurations. All modeling assumed flat terrain. This round of modeling concluded the following:

“The results of the modeling demonstrate that under current emission rates, as well as the proposed Phase I emission limit, there will be localized exceedences of EPA’s 24 hour PM<sub>2.5</sub> standard. In order to avoid exceedences of EPA’s 24 hour PM<sub>2.5</sub> standard, units must move to emission rates proposed in Phase II of NESCAUM’s model rule.”

At the request of the Hearth, Patio and Barbecue Association (HPBA), RTP Environmental (RTP) reviewed and commented on the New York modeling study and performed its own modeling study which showed lesser Phase I impacts and commented particularly that New York did not use the 98<sup>th</sup> percentile when determining modeled violations of the NAAQS. The RTP model inputs included weighted average emission rates and stack heights of 35 feet and 22 feet as per manufacturers’ recommendations.

The detailed discussions and responses regarding the modeling exercises are found in Attachment B-2. The ANR agrees with New York’s comments that the use of weighted average emission rates are inappropriate because it minimizes emission rates and does not conform to modeling guidance. Furthermore, all the emission rates used in all the modeling exercises, with the exception of the 161 g/hr rate for uncontrolled OWBs, are from laboratory tests of OWBs rather from actual in-use field testing which is likely to produce higher emission rates. Regarding stack heights, it has been the Agency’s experience that very few OWBs are voluntarily installed with stacks higher than 12 to 14 feet, even though Vermont’s regulations

require taller stacks in many situations. Even in two instances where the OWB owners installed stacks 30 feet or higher in an effort to resolve complaints, the tall stacks failed to resolve the smoke impacts on neighbors. Both those OWBs were eventually removed due to the unresolved nuisance issues. In addition, under APCR §5-205, OWBs complying with the Phase I standard of 0.44 lb/mmBTU of heat input are not required to be installed with higher stacks. It is therefore not appropriate to use high stacks in modeling exercises to determine impacts of emissions from OWBs complying with the Vermont Phase I standard.

The US EPA, in a letter dated December 14, 2007, supported the results of the New York modeling and concluded that they provided the basis for EPA to move forward with its Phase II voluntary program. On October 23, 2008, the US EPA formally announced the adoption of 0.32 lb/mmBTU of heat output and an 18 g/hr emission cap for any test run as the Phase II guideline for its voluntary outdoor hydronic heater program, effective March 31, 2010. In addition, the US EPA is expanding its voluntary program to include other biomass fuels besides wood, such as corn and switch grass pellets.

A modeling exercise completed by the ANR in July 2008, estimates particulate emission impacts from a single OWB in varying actual terrain situations typical of Vermont. The modeled emission rates were derived from certification test data for two Phase I and two Phase II compliant OWBs (a 0.32 lb/mmBTU output Phase II standard is presumed). The modeled emission rates used included maximum rates for two hours in the morning and two hours in the evening with average rates for the balance of the day. The modeling demonstrates that maximum 24 hour average impacts are greater than  $35 \mu\text{g}/\text{m}^3$  (the 24 hour  $\text{PM}_{2.5}$  NAAQS) in the 0-25 and 25-60 meter (0-82 feet and 82-197 feet) distance categories for both Phase I and II compliant emissions. Phase I maximum impacts still exceeded  $35 \mu\text{g}/\text{m}^3$  for all five terrain scenarios in the 60 to 80 m (197-262 feet) range but only two of the five scenarios in the 80-100 m (262-328 feet) range. The Phase II emission modeling showed no maximum 24 hour impacts above  $35 \mu\text{g}/\text{m}^3$  beyond 60 meters (197 feet). See Attachment B-2 for the full modeling report.

To obtain a complete picture of the potential health risks caused by exposures to particulate matter from single sources, as estimated in most of the OWB modeling exercises, the background levels of particulate should be added to the OWB impacts. Do the emissions from the OWBs elevate existing ambient concentrations to unhealthy levels? It is clear from the modeling studies that particulate levels caused by OWBs alone can exceed health standards and that including background concentrations only exacerbates the situation and expands the area of potentially excessive impacts.

Durations of exposure of less than 24 hours is an issue that is not addressed by the standard models that yield 24 hour average particulate concentrations for comparison to the NAAQS standard. However, shorter exposures to fine particulate are known to cause adverse health impacts.

## V. Status of OWB Technologies

Since the adoption of Vermont's Phase I standard (APCR §5-205), manufacturers have made significant progress toward redesigning OWBs to reduce particulate emissions and increase

combustion and heating efficiency. As of February 2009, six companies are manufacturing a total of nine OWB models that the companies have had tested and that the ANR has certified as meeting the Phase I standard. Two of those units, Central Boiler’s E-Classic 2300 and Greenwood’s Aspen Model 175 would also comply with the proposed Phase II standards of 0.32 lb/mmBTU output and 18 grams/hr (maximum for individual test run). Both of these units incorporate downdraft gasification type technologies. These units confirm the feasibility of designing and manufacturing clean and efficient OWBs. Moreover, significant numbers of both models have been sold in Vermont over the last year and appear to be competitive in the marketplace. Note also that, as a part of Phase II of its OHH Voluntary Program, US EPA has qualified three (3) wood pellet fueled OWBs as meeting its Phase II emission guideline, which is identical to Vermont’s proposed Phase II limits. Under the ANR’s proposed rule, these three models would also likely be certified by the ANR as meeting the Phase II limits.

The following table summarizes the test data from Vermont’s Phase I certification applications:

<b>Manufacturer</b>	<b>Model</b>	<b>8-hr. heat Output Rating (BTU/hr)</b>	<b>Average Emission Rate (grams/hr)</b>	<b>Average Emission Rate (lb/mmBTU heat input)</b>	<b>Vermont Emission Limit (lb/mmBTU heat input)</b>	<b>Average Emission Rate (lbs/mmBTU heat output)</b>
<u>Greenwood Technologies</u>	Aspen 175	66,290	8.4	0.18	0.44	0.27
<u>Central Boiler</u>	E-Classic 2300	160,001	6.4	0.20	0.44	0.31
<u>Dectra Corporation</u>	Garn WHS 1350	*NA	*NA	** 0.32	0.44	** 0.49
<u>Dectra Corporation</u>	Garn WHS 1500	*NA	*NA	** 0.32	0.44	** 0.49
<u>Dectra Corporation</u>	Garn WHS 2000	*NA	*NA	** 0.32	0.44	** 0.49
<u>Heatmor</u>	200 SSR	71,923	20.3	0.35	0.44	0.76
<u>Sequoyah Paradise</u>	E3400	101,020	20.1	0.37	0.44	1.48
<u>Greenwood Technologies</u>	100	18,248	13.64	0.42	0.44	1.36
<u>Alternative Fuel Boilers</u>	EBW 150	27,441	14.1	0.43	0.44	0.80

To date, none of the units submitted for Vermont certification utilize advanced technologies such as oxygen sensors or variable speed blowers. All the units listed in the table achieved the standard without extraordinary innovations. The Garn models are unique in that they employ a mass water storage system integral to the design of the boiler itself. Although mass storage is more common in Europe, the installations there generally use remote mass storage systems. In short, the technology for units that meet the existing Phase I standard and/or the proposed Phase II standards exists and is being successfully manufactured and marketed.

#### European Technologies:

Advances in wood combustion technologies in Europe include the use of electronic sensors to regulate combustion air to maximize combustion and minimize excess air. European biomass burning devices also frequently employ mass water storage or “accumulator tanks” which store the excess heated water for later use. This allows the device to burn at a maximum rate during an entire burn cycle thus maximizing efficiency and reducing overall emissions. Attempts to convert European emission standards into lb/mmBTU standards for comparison with the ANR’s proposal are complicated due to differences in test methods and standard units. Calculations by various sources have put the converted value at about 0.2 lb/mmBTU output. A number of entities are now importing, distributing and selling European indoor wood boiler technologies. Because the US EPA has expanded its voluntary program to include indoor wood boilers, some of the imported European units may be tested using US EPA Test Method 28 OWHH in the future. Such testing would demonstrate the potential for advanced wood heating technologies that may be transferable to the U.S. OWB market.

#### VI. Conclusions

Air pollution dispersion modeling by Vermont and New York State indicate that particulate emissions from OWBs that comply with Vermont’s current Phase I emission limit (0.44 lb/mmBTU of heat input) may still cause significant air quality impacts at distances that could easily adversely affect adjoining or nearby properties, especially when multiple units are located in the same village or neighborhood. This modeling has also shown that the proposed 0.32 lb/mmBTU of heat output limit is significantly more protective of health than the Phase I limit. In several scenarios, the Phase I modeling showed impacts above  $35 \mu\text{g}/\text{m}^3$  (the federal 24 hour NAAQS) beyond 200 feet while the Phase II modeling did not. All modeling was for emissions from a single OWB. If multiple units are located in close proximity, even if they are Phase II units, their combined emissions may cause excessive particulate levels at times.

The US EPA and the states of Maine, Massachusetts and New Hampshire have adopted a Phase II emission limit of 0.32 lb/mmBTU of heat output for new OWBs, the same standard required to be considered by APCR §5-205(f). These states’ Phase II limits are either already in effect (Massachusetts) or will become effective on essentially the same date being proposed in the ANR’s current proposed regulation (April 1, 2010). This same standard is being considered by Ohio and other states in draft regulations which will likely be adopted in the near future. Vermont’s adoption of this limit would provide consistency across most of New England, a benefit to consumers and dealers who are crossing state lines when buying and selling OWBs.

In addition to adopting a limit expressed in pounds of emissions per million BTUs of heat output, the ANR proposes to adopt companion limits of 18 grams per hour for residential size units and 20 grams per hour for commercial size units. These limits would apply to each individual emission test run during certification testing. These limits are the same as limits that have been adopted by Massachusetts and US EPA for Phase II OWBs and are similar in concept to the federal EPA emission limits applicable to indoor wood stoves. The purpose of these companion limits is to prevent the certification of OWB models that create excessive smoke and particle emissions under one operating condition, but not under others.

## VII. Standard Proposal

Therefore, in order to protect human health and welfare in Vermont, to provide for regional consistency and a common market area with Maine, Massachusetts and New Hampshire, and for the other reasons described in this document, the Vermont ANR proposes to adopt the following Phase II particulate matter emission limits for OWBs sold for use in Vermont on or after March 31, 2010:

“To be certified as a *Phase II OWB* under subdivision (e)(1) of this section, the *OWB* shall not emit, or cause or allow to be emitted, any gases that contain particulate matter in excess of 0.32 pounds per million BTUs of heat output, as determined in accordance with the test methods and procedures in this subsection. In addition, within each of the burn rate categories established in USEPA test method 28 OWHH (when this method is used), no individual test run shall exceed 18 grams per hour for OWBs generating less than 350,000 BTUs per hour of heat output and 20 grams per hour for OWBs generating 350,000 BTU per hour or more of heat output.”