Should Construction and Demolition Wood Be Burned?

An Evaluation of NESCAUM's May 2006 Report

by

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Executive Summary

The report issued by the Northeast States for Coordinated Air Use Management ("NESCAUM") in 2006 titled Emissions from Burning Wood Fuels Derived from Construction and Demolition ("C&D") Debris was critically evaluated. This evaluation indicates that the report's conclusions are not supported by the data NESCAUM reviewed, and that the NESCAUM report should not be relied upon in developing any public policies relative to the burning of C&D wood.

The NESCAUM report is seriously flawed. NESCAUM based its conclusions on a very small data set, and those sparse data do not support NESCAUM's conclusions. In addition, the quality of much of the data is questionable. Furthermore, no specific data were available regarding a number of expected air toxics, leaving significant data gaps. The NESCAUM report contained significant errors and never defined key terms.

Contrary to NESCAUM's conclusions, the data NESCAUM reviewed indicated that air emissions are higher when C&D wood is included in the fuel, at least as far as arsenic and dioxin are concerned. According to the data cited by NESCAUM, concentrations of arsenic and dioxin were doubled and quadrupled, respectively, when burning 50% C&D wood/50% forest biomass compared to burning 100% forest biomass.

Copper-chromium-arsenic-treated ("CCA-treated") wood, painted wood, and fines are included in the C&D wood fuel. NESCAUM says it is critical to eliminate CCA-treated wood from the fuel, but does not say how this could be accomplished. Literature indicates that this is a challenge because CCA-treated wood cannot always be identified visually. In addition, NESCAUM says it is critical to minimize fine-grained particles in the fuel, but does not say to what extent this is necessary. In addition, data indicate that painted wood has relatively high concentrations of toxic chemicals such as arsenic, copper, and dioxin, yet NESCAUM does not suggest that painted wood should be minimized or eliminated.

C&D wood is inherently contaminated with a variety of hazardous chemicals. NESCAUM provides no basis for its conclusion that requirements for comprehensive fuel testing will assure that fuel quality will be maintained, nor does it provide any guidance on what level of fuel testing would be adequate.

NESCAUM only evaluated air. Ash is a significant concern that was not addressed. In contrast to forest biomass plants, ash from C&D wood burning facilities must be disposed of in lined landfills due to high concentrations of heavy metals. In addition, toxic chemicals in the C&D wood present material handling issues that NESCAUM did not address.

Dispersion modeling of the stack gas concentrations from several C&D test burns indicated that ambient air concentrations of arsenic and dioxin would be below applicable guidelines. However, the modeling used flawed data and only evaluated direct inhalation. It did not consider another more indirect route of exposure from contaminant deposition onto soil and surface water, followed by subsequent uptake in the food chain. Thus, a realistic and comprehensive assessment of risks to human health and the environment from burning C&D wood has not been carried out.

Introduction

At the request of Ridgewood Power Management (www.ridgewoodpower.com), the report issued in May 2006 by NESCAUM titled Emissions from Burning Wood Fuels Derived from Construction and Demolition Debris (2006, http://www.nescaum.org/activities/major-reports) was critically evaluated. This evaluation indicates that the report's conclusions and recommendations are not supported by the data NESCAUM relied upon.

The NESCAUM report discussed current and future C&D wood generation in the Northeast, the current status of use of C&D wood for energy generation in the region, and air emission requirements in the region. The report then briefly summarized the results of C&D wood test burns at three facilities in Maine, as well as a Best Available Control Technology ("BACT") determination to predict emissions from a fourth facility, which at the time was proposed to be developed in Maine. The report ended with a number of conclusions, and recommendations arising from the conclusions, suggesting that it is safe to burn C&D wood for energy as long as fuel and air emissions are properly managed. Several key conclusions of the report will be examined in this evaluation, namely:

- "A review of the data shows that the use of appropriately processed C&D wood is similar in its emission profile to that of virgin wood."

- "The critical element in minimizing air emissions, especially air toxics, is the elimination of copper-chromium-arsenic-treated ("CCA-treated") and pentachlorophenol-treated ("penta-treated") wood from the fuel and minimizing fines."

- "Requirements for comprehensive testing and sampling of the fuel at both the processing facility and the location of the end user will assure that the fuel quality is maintained."

The most definitive way to evaluate the environmental impacts of burning C&D wood is to examine the actual performance of facilities that have done so. To evaluate emissions, it is necessary to review concentration data. The NESCAUM report did not provide much detail about the aforementioned test burns. Therefore, in preparing this evaluation, concentration data relative to the test burn fuel, air emissions, and ash were reviewed and are summarized below.

This evaluation provides a brief background on C&D wood and then evaluates the test burn data in some detail. The BACT determination described in the NESCAUM report is briefly discussed, and several additional concerns besides air emissions and ash are mentioned. Then each of the three conclusions above is evaluated in light of the data NESCAUM reviewed, and conclusions and recommendations of this evaluation are presented.

Background

C&D debris is a mixture that may contain wood, drywall, brick, roofing, concrete, plastics, metals, and fines (NESCAUM, 2006). C&D wood may be treated or painted and can contain heavy metals such as copper, chromium, arsenic, cadmium, lead, mercury, zinc, and beryllium, and organic contaminants such as creosote, pentachlorophenol, dioxin, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, solvents, and volatile organic compounds (USEPA, 1999). Processing facilities attempt to separate out the wood fraction from the C&D debris and remove creosote-, penta-, and CCA-treated wood, primarily through visual inspection. The remaining wood, which also contains some fines (small particles), plastic, and non-burnable materials, is then chipped to produce the combustion fuel. Additional fines are generated in the chipping process. Fines may be comprised of disproportionate amounts of paint and other coatings containing toxic chemicals.

CCA is the most common waterborne preservative and it represented over 90% of the U.S. waterborne preservative market until 2004, when it was banned for residential use due to its toxicity (Wu et al., 2006). The amount of CCA-treated wood entering the waste stream is expected to peak around 2015 (Tom, 2001). Simple visual sorting is ineffective for distinguishing CCA-treated wood from untreated wood (Holton, 2001; Solo-Gabriele et al., 2000); stains that react with copper can be used as an aid for identifying CCA-treated wood. Data from the University of Florida (Wu et al., 2006), which are summarized in Table 1, indicate that CCA-treated wood and its ash contain high concentrations of copper, chromium, and arsenic compared to untreated wood. A University of Maine study (Humphrey, 2005) measured arsenic concentrations in CCA-treated wood at 2,010 to 2,409 milligrams per kilogram (mg/kg), approximately double the concentration of 1,200 mg/kg reported by Wu et al. (2006). Copper, chromium, and arsenic in CCA-treated wood are somewhat leachable. Toxicity Characteristic Leaching Procedure ("TCLP") concentrations of arsenic at 8 milligrams per liter (mg/l) as reported by Wu et al. (2006, Table 1 below) would classify the CCA-treated wood as "hazardous" were it not granted a specific exemption under the federal Resource Conservation and Recovery Act (see 40 Code of Federal Regulations 261.4).

Table 1
Metals in CCA-Treated Wood and Ash

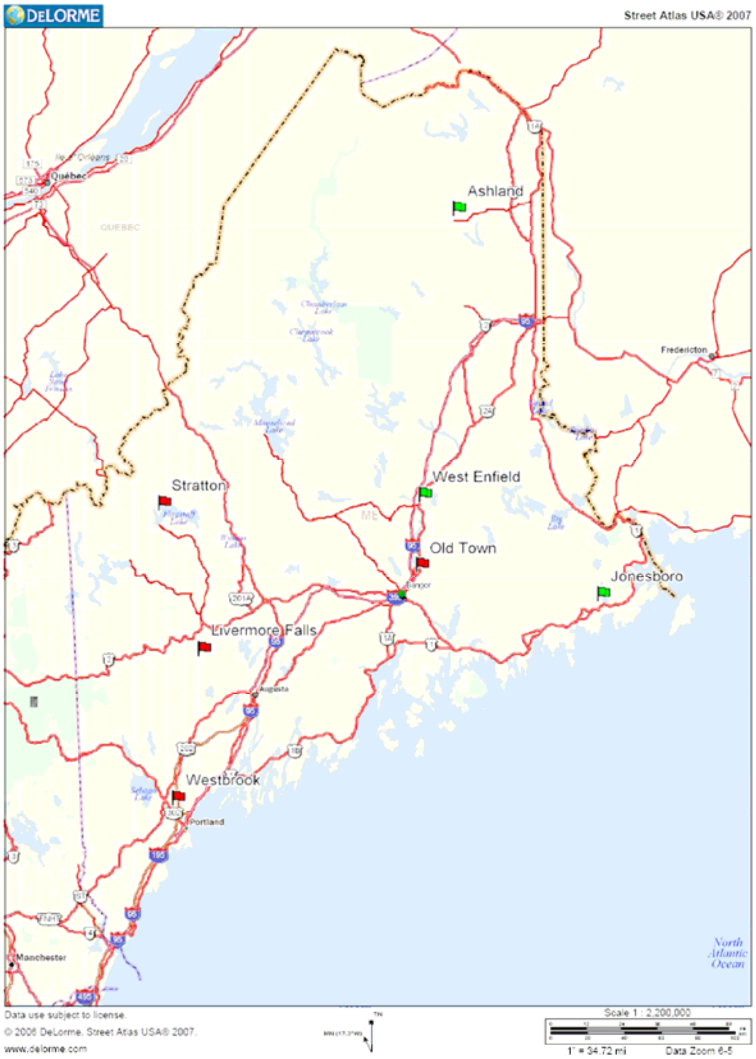
Metal	**CCA-Wood**	**Untreated Wood**	**TCLP Limit**
Arsenic (mg/kg)	1,200	2	NA
Chromium (mg/kg)	2,100	7	NA
Copper (mg/kg)	1,100	4	NA
TCLP Arsenic (mg/l)	**8**	0.1	**5**
Metal	**CCA-Wood Ash**	**Untreated Wood Ash**	**TCLP Limit**
Arsenic (mg/kg)	33,000	67	NA
Chromium (mg/kg)	16,000	51	NA
Copper (mg/kg)	22,000	120	NA
TCLP Arsenic (mg/l)	**180**	0.2	**5**

CCA = copper-chromium-arsenic
mg/kg = milligrams per kilogram
mg/l = milligrams per liter
TCLP = toxicity characteristic leaching procedure
NA = not applicable

Source: Wu, Chang-Yu, Timothy Townsend, Helena Solo-Gabriele, Anadi Misra, and Brajesh Dubey. 2006. Evaluation for Thermal Processes for CCA Wood Disposal in Existing Facilities, Florida Center for Solid and Hazardous Waste Management, Contract 00053522

Connecticut (except for two grandfathered exceptions) and New Hampshire are New England states that have banned the burning of C&D wood. In addition, Rhode Island has excluded C&D wood from its Renewable Energy Standards. As of this writing, there are three facilities in New England that currently burn C&D wood, all located in Maine: a 40 megawatt ("MW") wood-burning facility in Stratton owned by Boralex Energy, Inc. ("Boralex"); a 34 MW wood-burning facility in Livermore Falls, also owned by Boralex; and a 20 MW wood-burning facility in Old Town owned by Red Shield that had been closed and re-started operation in December 2006 (Dolloff, 2006). Two other facilities have conducted test burns of C&D wood but do not currently burn C&D wood: a 9 MW wood-burning facility in Hopkinton, New Hampshire, owned by Bio-Energy Corporation (also known as Regenesis), and a 62.5 MW wood-burning facility in Westbrook, Maine, owned by South African Paper Products, Inc. ("SAPPI"). The locations of the facilities in Maine are shown on Figure 1, along with three facilities in Ashland, Jonesboro, and West Enfield that burn only forest biomass.

Figure 1. Wood Burning Facilities in Maine
(Used with permission)



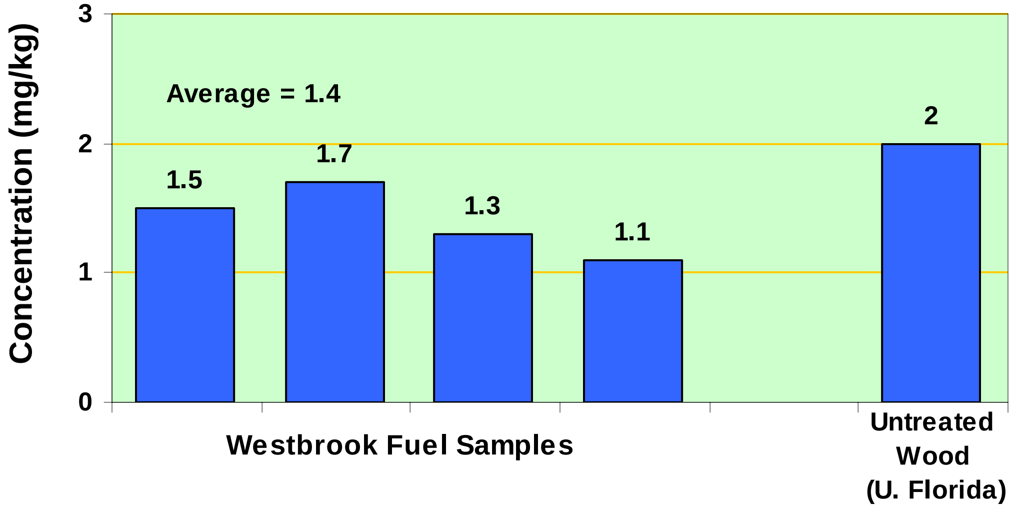
Test Burns Considered by NESCAUM

This section presents information on the test burns discussed in the NESCAUM report. They took place in 2005 at the facilities in Westbrook, Stratton, and Livermore Falls, Maine. (The Hopkinton, New Hampshire facility is somewhat atypical, which is perhaps why NESCAUM did not review the test burn that was conducted there.)

Fuel

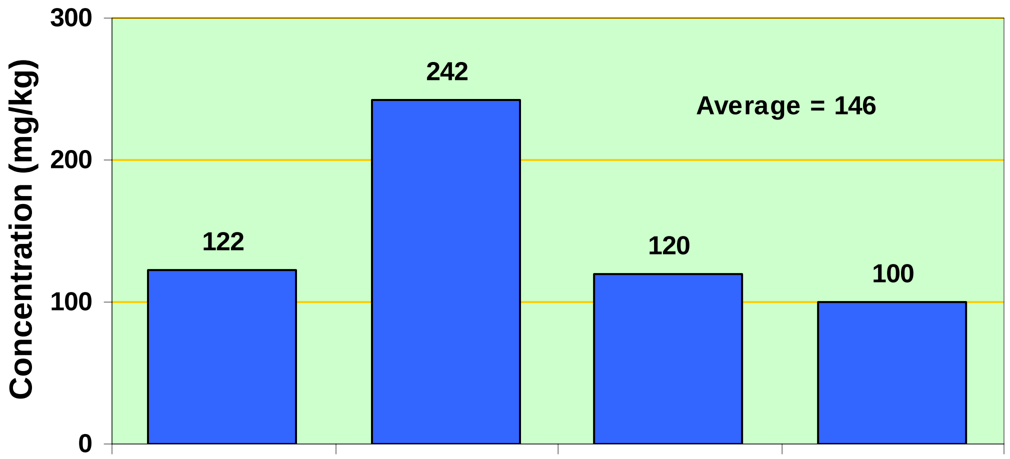
Fuel burned in the test at Westbrook consisted of approximately 50% forest biomass and 50% C&D wood (McMullin, 2006). Fuel samples were tested for 25 total metals and 8 TCLP metals (S.D. Warren Company, 2005). Total metals results for arsenic and lead are shown on Figures 2a and 2b. Arsenic and lead are of special interest because C&D wood can contain significant arsenic from CCA-treated wood and lead from lead-painted wood. Westbrook arsenic concentrations were relatively low, similar to concentrations in untreated wood reported by Wu et al., (2006). For additional perspective, it is worth noting that the arsenic concentrations are also well below the limit of 50 mg/kg for arsenic specified in the Maine Department of Environmental Protection ("Maine DEP") rules for burning C&D wood that were issued shortly after the NESCAUM report (Maine DEP, 2006). Westbrook lead concentrations illustrate the variability of concentrations in C&D wood fuel, and incidentally are also well below the 375 mg/kg limit for lead specified in the Maine rules.

Figure 2a. Arsenic in Fuel for the Westbrook Test Burns



Source: S.D. Warren Company. 2005. "Application for Beneficial Use of Wood Chips from Construction/Demolition Debris as a Fuel in #21 Boiler," submitted to Maine DEP.

Figure 2b. Lead in Fuel for the Westbrook Test Burns



Source: S.D. Warren Company. 2005. "Application for Beneficial Use of Wood Chips from Construction/Demolition Debris as a Fuel in #21 Boiler," submitted to Maine DEP.

As a University of Maine research project, three blends of fuel were tested at each of the facilities in Stratton and Livermore Falls: 0% C&D wood (i.e., 100% forest biomass, "0% test"), 10% C&D wood/90% forest biomass ("10% test"), and 50% C&D wood/50% forest biomass ("50% test") (Humphrey, 2005). Some (less than 1% by mass) penta-treated wood was also added to the latter two fuels. The NESCAUM report erroneously stated that the last blend was 50% C&D wood and 50% penta-treated wood, whereas the mixture consisted of 50% C&D wood and only 1% penta-treated wood, the balance consisting of forest biomass.

Samples of the C&D wood for the Stratton test burns, which was received from three commercial and five municipal sources, were first evaluated. The volume of each sample was approximately 15 gallons. One sample from each commercial source and two samples from each municipal source were sorted visually and the various fractions were weighed. The composition of individual samples ranged as follows: 0.1 to 5.4% CCA-treated wood, 12.1 to 43.4% fines (material passing through a #4 sieve with 0.187-inch square openings), 2.1 to 13.5% painted wood, 0.1 to 1.6% plastics (such as plastic laminates and synthetic carpets), 0.1 to 4.8% non-burnable materials (such as nails, stones, and wire), and 48.1 to 74.9% non-painted non-CCA wood and paper. The average composition of the municipal samples and the commercial samples was found to be generally similar. However, as indicated above, there was a great deal of variability among samples. Much variability was seen even among duplicate samples from the same municipal source. The data also indicate the C&D "wood" may contain significant quantities of materials other than wood, with the maximum percentage of non-painted non-CCA wood in any sample being only 74.9%.

The above-described sample fractions and the three fuel blends to be test burned at each facility were then chemically analyzed, but only for total arsenic, polychlorinated dibenzo-p-dioxin/furan (“PCDD/F,” or “dioxin/furan,” hereafter abbreviated as “dioxin” for simplicity), copper, and chlorine. (This evaluation will focus mainly on arsenic and dioxin, because air samples were not analyzed for copper or chlorine.) Average results (for duplicate samples) for the fuel blends are shown on Figures 3a and 3b. (Results for the C&D wood sample fractions are discussed later.) Arsenic concentrations for the 50% test were less than half of the target level, which may indicate difficulty in testing or blending of the non-homogeneous fuel mixture. Arsenic concentrations are also well below the limit currently specified in the Maine rules (Maine DEP, 2006). Dioxin concentrations were also lower than target levels for the 50% test.

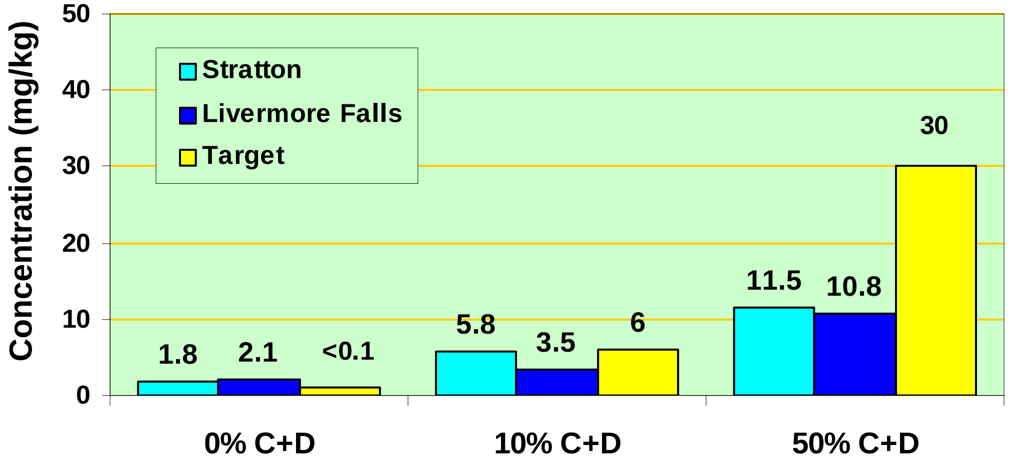


Figure 3a. Arsenic in Fuel for the Stratton and Livermore Falls Test Burns

Source: Humphrey, Dana. 2005. <u>Fate of Dioxin and Arsenic from the Combustion of Construction and Demolition Debris and Treated Wood: A Study for Boralex Energy, Inc.</u>, May 27.

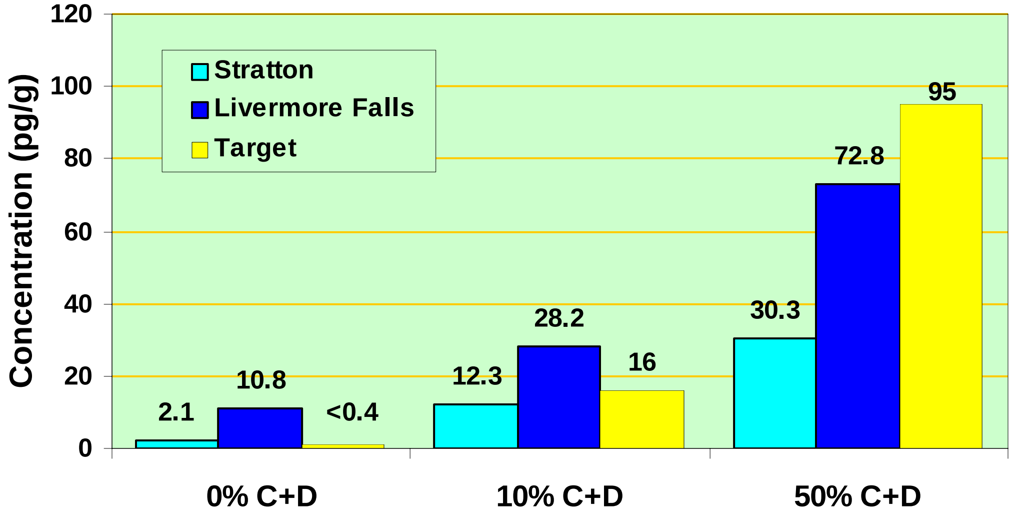


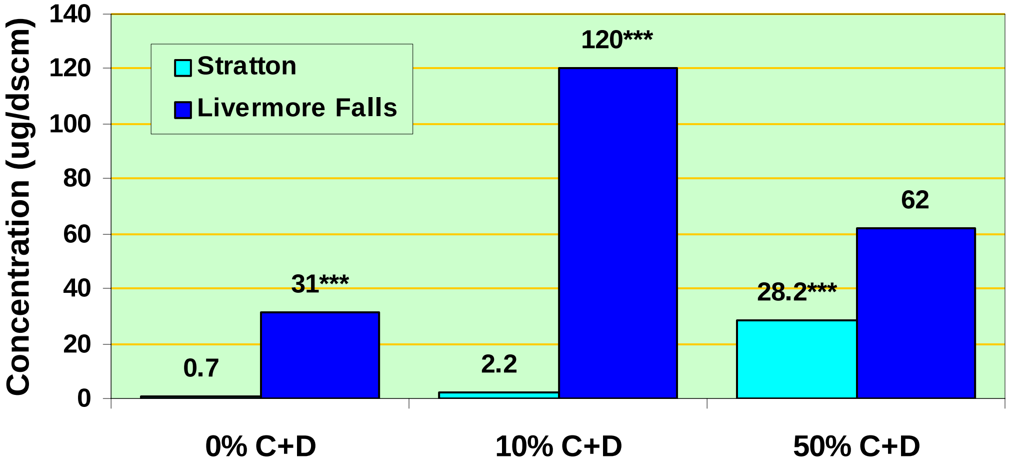
Figure 3b. Dioxin in Fuel for the Stratton and Livermore Falls Test Burns

Source: Humphrey, Dana. 2005. *<u>Fate of Dioxin and Arsenic from the Combustion of Construction and Demolition Debris and Treated Wood: A Study for Boralex Energy, Inc.</u>, May 27.*

Air

Each test burn at Stratton and Livermore Falls lasted approximately nine hours. Stack gas samples were analyzed for arsenic and dioxin. Average concentrations (for triplicate samples) are shown on Figures 4a and 4b. Arsenic and dioxin concentrations were two to forty times higher when C&D wood was included in the fuel than when it was not, with the exception of the dioxin concentrations from the Stratton 10% test which were similar to the dioxin concentrations from the 0% test at the same facility. Arsenic results did not follow the pattern expected, i.e., lowest concentrations from the 0% test, intermediate concentrations from the 10% test, and highest concentrations from the 50% test. For example, Livermore Falls air samples from the 10% test had twice the concentration of arsenic as from the 50% test. One possible explanation for this that was given in the University of Maine report was that one of the three Livermore Falls electrostatic precipitator ("ESP") fields was off during the 10% test. Since dioxin may be consumed or generated during the combustion process, a similar pattern would not necessarily be expected for this chemical.

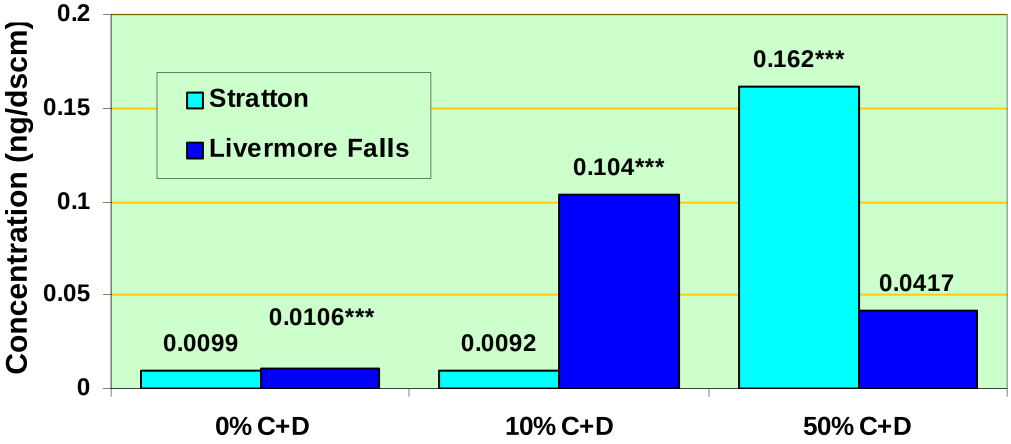
Figure 4a. Arsenic in Stack Gas for Stratton and Livermore Falls Test Burns



*** An ESP field may have been off

Source: Humphrey, Dana. 2005. <u>Fate of Dioxin and Arsenic from the Combustion of Construction and Demolition Debris and Treated Wood: A Study for Boralex Energy, Inc.</u>, May 27.

Figure 4b. Dioxin in Stack Gas for Stratton and Livermore Falls Test Burns



*** An ESP field may have been off

Source: Humphrey, Dana. 2005. <u>Fate of Dioxin and Arsenic from the Combustion of Construction and Demolition Debris and Treated Wood: A Study for Boralex Energy, Inc.</u>, May 27.

Air samples from the Livermore Falls 0% test had 15 times the arsenic concentrations as air samples from the Stratton 10% test and a somewhat higher arsenic concentration than from the Stratton 50% test. The University of Maine report states that one of the three Livermore Falls ESP fields may have been off during the 0% test, and the above data would seem to corroborate this. It is not clear, because the report says "The hand-written logs of precipitator field operation could indicate that field #1 was off for the control *[i.e., 0%]* run on May 26, 2004 and that field #3 was off for the low *[i.e. 10%]* run on June 16, 2004. However, Mr. Michael Daigle from the Livermore Falls plant states that to the best of his knowledge for May 26, 2004, the precipitator 'was operating under normal parameters.'"

At Stratton, one of four ESP fields was intentionally turned off during the last three hours of the 50% test in an attempt to demonstrate compliance with Stratton's particulate matter limit while operating in a three-field configuration. (The report does not say whether or not compliance was demonstrated.) Non-functioning ESP fields may help explain some of the variability and deviation from the expected pattern that is apparent in the air emissions results. It introduces an element of lack of experimental control because one cannot tell how much of the differences in concentrations were due to differences in the fuel and how much they were due to differences in operation of the air pollution control equipment. This complication renders some, but not all, of the data unusable, as explained below.

All three ESP fields were operational during the 50% test at Livermore Falls. For the 50% test, the arsenic concentrations were doubled and the dioxin concentrations were quadrupled compared to the 0% Livermore Falls test, even though one of the ESP three fields may not have been operational for the 0% test. This would certainly indicate that air emissions are higher when C&D wood is present in the fuel than when it is not. A similar comparison of 50% and 0% test concentrations is not appropriate for Stratton since an ESP field was off part of the time for the 50% test, which by itself could account for any increase in concentration.

For both the Stratton 0% and 10% tests, all four ESP fields were operating, thus the concentration data may be compared. The 10% test had three times the arsenic concentration of the 0% test, providing more evidence that air emissions are higher when C&D wood is present in the fuel, while the dioxin concentration was slightly lower for the 10% test. Because of the uncertainty as to whether all ESP fields were operating for the 0% test at Livermore Falls, a similar comparison of 0% and 10% test concentrations is not appropriate here, because the non-operational ESP field in the 10% test could by itself account for any increase in concentration if all fields were in fact operational for the 0% test.

As inferred in the University of Maine report, when any of the ESP fields are not operating, the air emissions tend to be higher, and the data bear this out. Despite the complications caused by some ESP fields being off, the report does say that a general trend is that as the arsenic and dioxin input in the fuel increases, the output in stack gas and ash (which is discussed below) increases.

Other operational problems occurred during the Stratton and Livermore Falls test burns. At Livermore Falls, the forced draft fan discharge pressure was recorded as zero for the entire 0% test and all but the last hourly reading of the 10% test. The University of Maine report says that it is possible that this sensor was malfunctioning. Another problem was that one page of the hourly combustion parameters records for Livermore Falls was missing; this page dealt with precipitator and stack gas parameters.

Air dispersion modeling was performed on the maximum Stratton and Livermore Falls test burn concentrations to predict the concentrations of arsenic and dioxin in air some distance from the stack where people would be breathing the air. These modeled concentrations were compared to Maine Ambient Air Guidelines ("MAAGs," Maine Bureau of Health, 2004) and found to be below the MAAGs.[1] Modeled ambient arsenic concentrations were 30% and 3.5% of arsenic MAAGs, and modeled dioxin concentrations were 0.47% and 0.24% of dioxin MAAGs, for the Stratton and Livermore Falls 50% and 10% tests, respectively. The Stratton modeled ambient arsenic concentration is troubling in light of the fact that the arsenic concentration in the 50% test fuel was only 10.8 mg/kg, approximately 36% of the target level of 30 mg/kg intended for the test burn. Had the fuel target level been achieved, modeled ambient arsenic concentrations could be projected to have been more like 30% divided by 0.36, or 83% of the MAAG (assuming a linear relationship). However, the situation is again complicated by the fact that one of the Stratton EPS fields was turned off for the last third of the 50% test.

Furthermore, MAAGs only deal with one route of potential exposure. MAAGs are established such that there is a 1 in 100,000 incremental lifetime cancer risk for a person breathing the MAAG concentration for 70 years. However, some pollutants that are released into the air are subsequently deposited onto soil and water and can make their way into the food chain and bioaccumulate. Recent U.S. Environmental Protection Agency (USEPA) guidance (2007) on metals risk assessment states that "deposition processes represent an important route of exposure for plants, animals, and humans." Therefore, compliance of modeled concentrations of two air toxics of concern with MAAGs, dealing with only one route of exposure, does not necessarily mean that the air emissions are safe for human health and the environment.

The NESCAUM report erroneously stated that the Stratton and Livermore Falls report (incorrectly attributed to Maine DEP rather than University of Maine) "concluded that an electrostatic precipitator was an effective control technology for lead removal." The University of Maine report (Humphrey, 2005) said nothing about lead. It also did not state that an ESP was an effective control technology for any other chemical. NESCAUM does seem to be referencing the University of Maine report (Humphrey, 2005), but this is not entirely certain. One problem throughout the NESCAUM report is that it is not always entirely clear what documents are being referred to, and citations are not given in a number of instances.

Westbrook average air emissions of heavy metals (from triplicate samples) are summarized both as concentrations and as emission rates in Table 2 (SAPPI Westbrook, 2005). There was no 0% test at Westbrook with which to compare the results. Compared to Stratton arsenic concentrations, the Westbrook arsenic concentration exceeded concentrations from the 0% and 10% tests but was less than the concentration from the 50% test (during which an ESP field was turned off part of the time). The Westbrook arsenic concentration was much less than concentrations from all three Livermore Falls tests.

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[1] The MAAG for arsenic is 0.002 micrograms per dry standard cubic meter ("ug/dscm"), and the MAAG for dioxin is 0.0003 nanograms per dry standard cubic meter ("ng/dscm").

Table 2
Westbrook Metals in Air Samples
(averages of three samples)

Metal	Concentration (ug/dscm)*	Emission Rate (pounds/hour)
Arsenic	3.79	0.002664
Cadmium	0.24	0.000169
Chromium	1.78	0.001248
Copper	2.40	0.001689
Lead	20.98	0.014712
Manganese	5.38	0.0037362
Mercury	<1.79	<0.001256

***** ug/dscm = micrograms per dry standard cubic meter

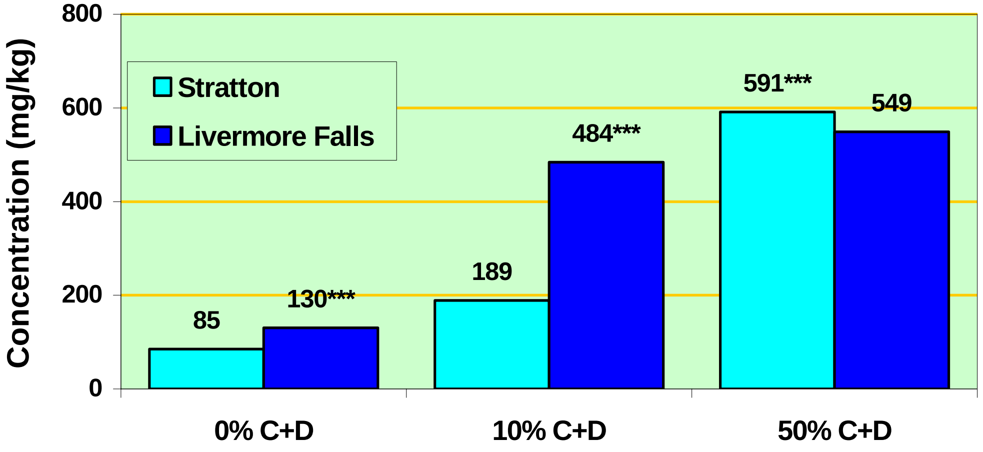
Source: SAPPI Westbrook. 2005. "Summary of Multi-Metals." One page table of analytical results for air samples during stack testing, received from Robert Hartley of Maine DEP.

Ash

Although NESCAUM did not discuss ash in its report, ash is important because toxic chemicals present in the wood may end up in the air and/or in the ash. Fly ash samples from the Stratton and Livermore Falls test burns were analyzed for arsenic and dioxin. Average results (for duplicate samples) are summarized in Figures 5a and 5b. Unlike the arsenic air emissions data, the arsenic ash data did follow the expected pattern (i.e., lowest concentrations for the 0% tests, intermediate concentrations for the 10% tests, and highest concentrations for the 50% tests). Dioxin ash data did not follow this pattern but would not be expected to, as noted earlier.

Average fly ash data for Westbrook (S.D. Warren Company, 2005), Stratton (50% test), and Livermore Falls (50% test) are summarized on Figures 6a, 6b and 6c, along with fly ash data for two facilities that burn 100% forest biomass in West Enfield and Jonesboro, Maine (Maine Environmental Laboratory, 2005). Arsenic, lead, and mercury concentrations were much higher in ash from the facilities that burn C&D wood than in ash from the facilities that do not. It is unclear why the arsenic concentrations in the 0% tests at Stratton and Livermore Falls (85 and 130 mg/kg, see Figure 5a) are so much higher than the arsenic concentrations at West Enfield and Joneboro (4 and 6 mg/kg). Since air pollution control equipment captures most but not all of the fly ash, the ash concentration data have implications for air emissions. Given two facilities emitting the same amount of particulate matter, one burning C&D wood and the other burning forest biomass, the data indicate that particulate matter from the C&D burning facility will contain relatively more arsenic, lead, and mercury.

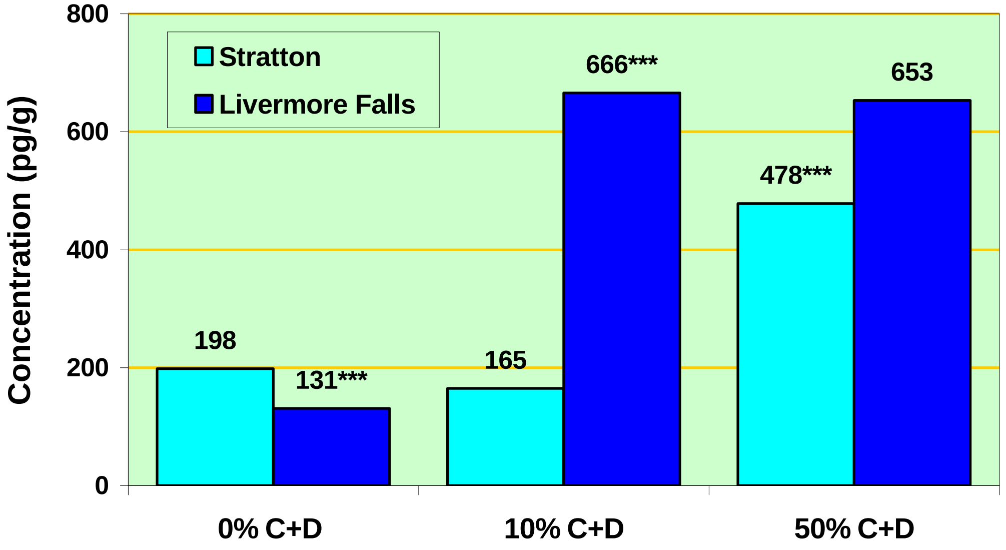
Figure 5a. Arsenic in Fly Ash for the Stratton and Livermore Falls Test Burns



*** An ESP field may have been off

Source: Humphrey, Dana. 2005. <u>Fate of Dioxin and Arsenic from the Combustion of Construction and Demolition Debris and Treated Wood: A Study for Boralex Energy, Inc.</u>, May 27.

Figure 5b. Dioxin in Fly Ash for the Stratton and Livermore Falls Test Burns



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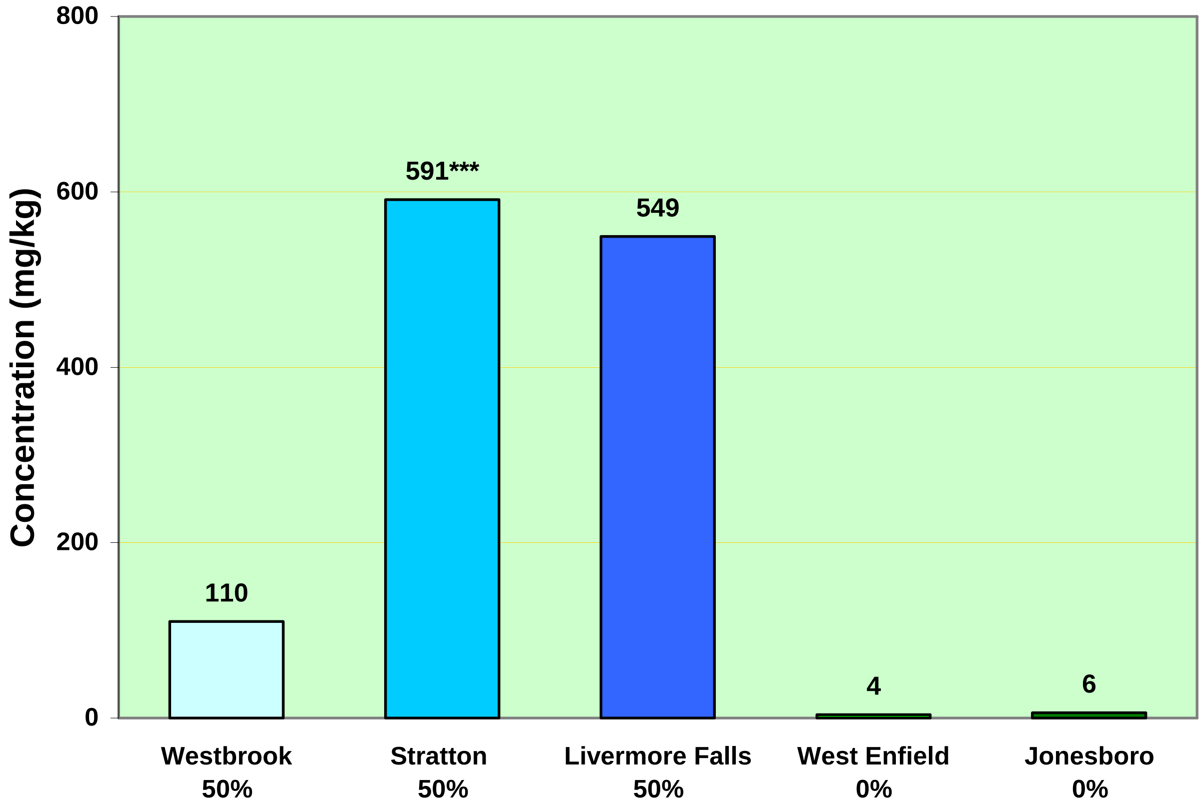
Source: Humphrey, Dana. 2005. <u>Fate of Dioxin and Arsenic from the Combustion of Construction and Demolition Debris and Treated Wood: A Study for Boralex Energy, Inc.</u>, May 27.

Ash from facilities that burn C&D wood is typically not classified as “hazardous” (i.e., it does not exceed TCLP limits); however, it must be disposed of in a secure lined landfill. By contrast, ash from facilities burning only forest biomass may be reused beneficially in a number of ways, provided it meets applicable standards and appropriate permits are obtained (McMullin, 2007). It may be spread on agricultural fields to raise the pH, used as a component of aggregate for road construction, added to sludge as a thickener, used as a filter medium for leachate treatment, or used for landfill capping (Irving, 2006).

Figure 6a. Arsenic in Fly Ash of Several Facilities



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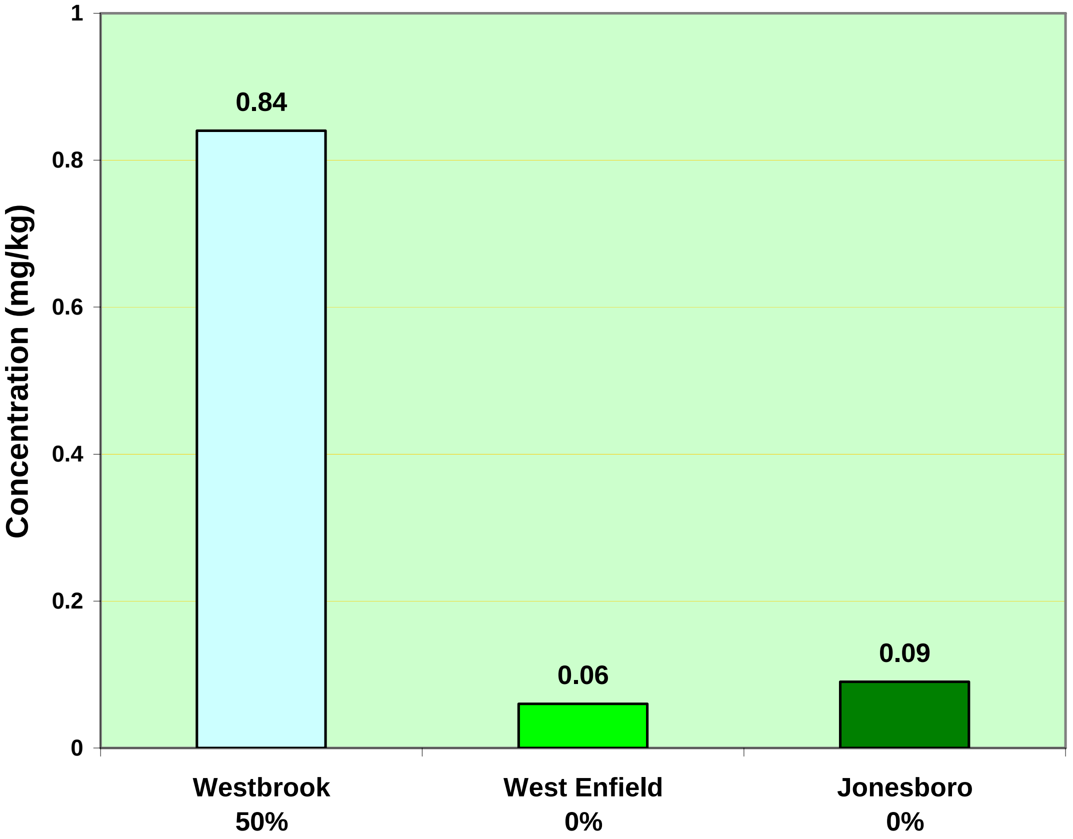
Sources:

S.D. Warren Company. 2005. “Application for Beneficial Use of Wood Chips from Construction/Demolition Debris as a Fuel in #21 Boiler,” submitted to Maine DEP.

Humphrey, Dana. 2005. Fate of Dioxin and Arsenic from the Combustion of Construction and Demolition Debris and Treated Wood: A Study for Boralex Energy, Inc., May 27.

Maine Environmental Laboratory. 2005. Laboratory analytical reports for ash samples collected November 14 from biomass plants in West Enfield and Jonesboro, Maine.

Figure 6b. Mercury in Fly Ash of Several Facilities

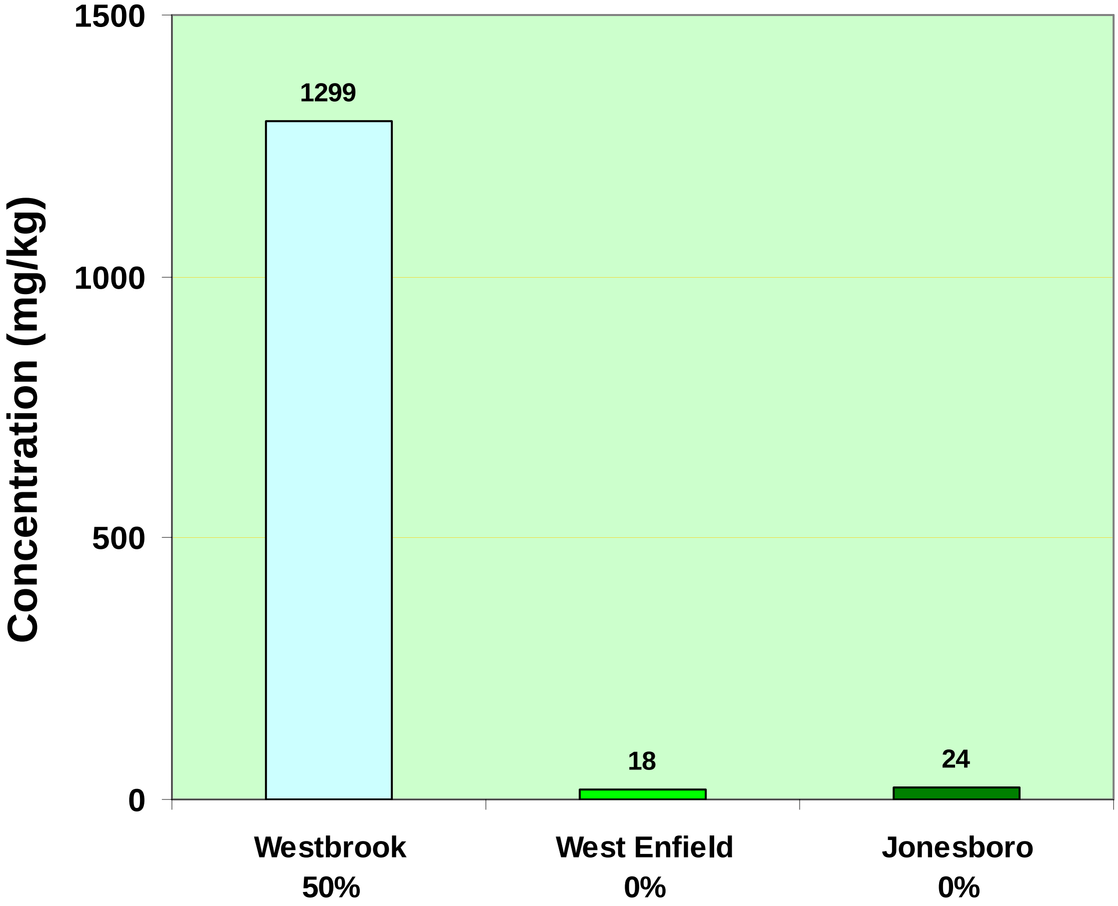


Sources:

S.D. Warren Company. 2005. "Application for Beneficial Use of Wood Chips from Construction/Demolition Debris as a Fuel in #21 Boiler," submitted to Maine DEP.

Maine Environmental Laboratory. 2005. Laboratory analytical reports for ash samples collected November 14 from biomass plants in West Enfield and Jonesboro, Maine.

Figure 6c. Lead in Fly Ash of Several Facilities



Sources:

S.D. Warren Company. 2005. "Application for Beneficial Use of Wood Chips from Construction/Demolition Debris as a Fuel in #21 Boiler," submitted to Maine DEP.

Maine Environmental Laboratory. 2005. Laboratory analytical reports for ash samples collected November 14 from biomass plants in West Enfield and Jonesboro, Maine.

Mass Balance Evaluation at Stratton and Livermore Falls

University of Maine researchers performed calculations on the fuel, air, and ash data in an attempt to perform a mass balance on arsenic and dioxin. (They also attempted mass balances on copper and chlorine in fuel and ash.) Mass balance calculations are predicated on the assumption that the amount of arsenic and dioxin coming out of the facility in the stack gas and ash should equal the amount going into the facility in the fuel. This should be the case for arsenic, which is an element that cannot be created or destroyed. Because dioxin can be generated or consumed during the combustion process, mass balance would not necessarily be expected for dioxin. Mass balance on arsenic was not achieved for 5 of the 6 test burns, which calls into question either the sampling and analytical methods used or the calculations performed.

Other evidence of potential sampling and analysis problems was noted in the University of Maine report. For example, two composite samples were created for each of the three runs at the Stratton and Livermore Falls facilities, “Fly Ash A” and “Fly Ash B.” The composites were made by alternately depositing scoops of fly ash into the A and B containers, so they were essentially taken over the same time period. Yet on analysis, Fly Ash A had nearly twice the arsenic concentration as Fly Ash B for the 10% test at Livermore Falls. The report said that “there is no ready explanation for the difference between the arsenic concentrations in the Fly Ash A and B samples.”

BACT Determination Considered by NESCAUM

In addition to the test burns discussed above, NESCAUM reviewed a BACT analysis prepared by GenPower for their proposed Athens, Maine, facility. NESCAUM summarized proposed BACT limits for the GenPower facility and compared them with emission limits for forest biomass plants and with emissions limits for facilities burning other types of fuel. Table 4-4 of the NESCAUM report indicates that GenPower proposed a BACT level of 0.01 pounds of particulates per million British Thermal Units ("lb/MMBtu"), compared to a 0.025 lb/MMBtu level given for a forest biomass burning plant. The last forest biomass burning biomass plant in the Northeast (i.e., in Ashland, Maine) went into service in 1993, and the design was likely set in the late 1980s. To compare a modern design for a C&D wood burning facility with an older design for a forest biomass burning plant is to compare apples and oranges, because air emissions are more tightly restricted today than in the past. Table 4-4 of the NESCAUM report thus merely suggests that C&D burning facilities designed today would utilize more advanced combustion and/or emissions control technologies than forest biomass plants designed nearly two decades ago. Because the C&D wood burning facility uses fuel containing more heavy metals than a forest biomass burning facility, heavy metals emissions would be expected to be greater regardless of the BACT level.

NESCAUM concluded that GenPower would emit no more pollution than facilities burning other types of fuel. However, this is based on general criteria pollutant emission rates, and no data were presented regarding specific air toxics such as arsenic and lead that would be of particular concern with C&D wood. The analysis ignores the fact that, as demonstrated above, the particulate matter from combusting C&D wood contains relatively more heavy metals due to the increased heavy metal content of the fuel. Therefore, NESCAUM's conclusion, at least with respect to metals, is not supported by data.

Evaluation of NESCAUM Report Conclusions

Key conclusions of the NESCAUM report are revisited below. In summary, the first conclusion is not based on sufficient data and is actually refuted by the scant data that NESCAUM did review. The second conclusion is vague, incomplete, and potentially infeasible. Finally, no data at all are presented to support the third conclusion.

NESCAUM's Conclusion Regarding Similar Air Emissions

> "A review of the data shows that the use of appropriately processed C&D wood is similar in its emission profile to that of virgin wood."

Too few data were reviewed to support a blanket statement such as this. The air data described above (Westbrook, Stratton, and Livermore Falls test burns) and the Athens BACT analysis were the only information upon which NESCAUM based its assessment. This small handful of analyses is inadequate because of inherent heterogeneities in C&D wood and variations in C&D wood burning facility equipment and operational parameters. The variability in both the fuel and the facilities would demand that a much larger data set be reviewed in order to evaluate whether air emissions are generally similar or different.

The analyte list was very limited. Only seven heavy metals were evaluated in all media in the Westbrook 50% test, and there was no Westbrook 0% test with which to compare the results. Only arsenic and dioxin were evaluated in all media in the Stratton and Livermore Falls tests, with no information developed for a number of other air toxics of potential concern such as lead, cadmium, chromium, mercury, antimony, nickel, selenium, and vanadium. (These are analytes that were included in later stack tests at Stratton and Livermore Falls that were not reviewed by NESCAUM.)

Furthermore, much of the data were of limited quality and usefulness. The test burns at Stratton and Livermore Falls were flawed in that two variables were changed at the same time (the fuel and the operation of the ESP fields), thus the experiment was not well controlled. In addition, the quality of the data is questionable because mass balance of arsenic inputs and outputs was not achieved in the study. Other analytical problems were noted as well.

The fuel tested apparently had lower than expected concentrations of arsenic. In the Westbrook 50% test, arsenic concentrations were similar to literature values for untreated wood. In the Stratton and Livermore Falls 10% and 50% tests, arsenic concentrations were less than the study target concentrations. Thus, the range of conditions that was intended to be tested apparently was not tested, thereby limiting the usefulness of the results.

The Stratton and Livermore Falls test burns provided the only information comparing emissions of any air toxics that result from burning C&D wood versus 100% forest biomass. The air concentrations of the only chemicals evaluated, arsenic and dioxin, were two to forty times higher from the 50% tests compared to the 0% tests. The only similar concentrations were the dioxin concentrations from the 0% and 10% tests at Stratton. Some of the variation in air concentrations of arsenic and dioxin at Stratton and Livermore Falls may be explained by non-functioning ESP fields during the tests as opposed to variations in the fuel burned. What can be gleaned from the University of Maine data, taking into account the variably operating ESP fields, during the 50% test at Livermore Falls (with three of three ESP fields operating) at a minimum, arsenic concentrations were doubled and dioxin concentrations were quadrupled compared to the 0% test (with either two or three ESP fields operating). During the 10% test at Stratton (with four of four ESP fields operating), arsenic concentrations were tripled compared to the 0% test (again with four of four ESP fields operating), while dioxin concentrations were similar. Thus the preponderance of the few available data that may be compared indicates that the air emissions are **not** similar when burning C&D wood versus forest biomass, in direct contradiction to NESCAUM's conclusion. Air emissions are in fact higher.

NESCAUM did not compare the air toxics emissions of C&D wood test burns with air toxics emissions of other facilities that burn only forest biomass, other than the above-mentioned Stratton and Livermore Falls 0% tests (Rector, 2006). Facilities that do not burn C&D wood, at least in New England, are not typically required to test for air toxics such as heavy metals.

It should be noted that NESCAUM never defines the term "appropriately processed C&D wood." One would have to presume that NESCAUM considered the C&D wood containing fuels tested at Westbrook, Stratton, and Livermore Falls as "appropriate processed" since NESCAUM based its conclusions on the data from these test burns and little else.

Finally, NESCAUM did not say that air emissions are similar when burning C&D wood versus forest biomass; it said the "air emissions profiles" are similar. "Air emissions profile" is another key term that NESCAUM does not define. If "similar air emissions profiles" means that both the chemicals and their concentrations are similar from burning C&D wood and from burning forest biomass, then the data described above contradict that claim.

NESCAUM's Conclusion Regarding Fuel Processing

> "The critical element in minimizing air emissions, especially air toxics, is the elimination of CCA-treated and penta-treated wood from the fuel and minimizing fines."

There are several problems with this conclusion. One issue is whether in reality CCA-treated and penta-treated wood can be eliminated from the fuel and whether fines can be adequately minimized. It may be unrealistic to think that CCA-treated wood can be completely eliminated because, as discussed previously, visual inspection is not a reliable method for identifying CCA-treated wood. In addition, NESCAUM does not say to what extent fines should be minimized in order to have acceptable air emissions. The Maine rules for burning C&D wood (Maine DEP, 2006) allow in the C&D wood portion of the fuel (which can be up to 50% of the total, the remainder being forest biomass) up to 1.5% CCA-treated wood and 10 to 20% fines by weight.

Another issue is whether NESCAUM has accurately identified the problematic components of C&D wood that need to be addressed during fuel processing. In speaking of the University of Maine study, NESCAUM stated: "The study concluded that, the fines in the fuel had the highest concentrations of metals and dioxin." This is believed to be a misunderstanding as the University of Maine report did not state this conclusion, and NESCAUM appears to have based the conclusion above relative to fuel processing at least partly on this misunderstanding. To the contrary, the University of Maine analytical data for the visually sorted sample fractions of C&D wood for the Stratton test burns indicate that CCA-treated wood had the highest average concentrations of the only two metals tested, arsenic and copper, in both the commercial and the municipal samples. Painted wood had the second highest average arsenic and copper concentrations in the municipal samples, while fines had the second highest average arsenic concentration and plastic had the second highest average copper concentration in the commercial samples.

Fines had the highest average dioxin concentrations in both the commercial and municipal samples, while painted wood had the second highest average dioxin concentrations in both the commercial and municipal samples. (Dioxin concentrations in the plastic fraction were not reported in the University of Maine report due to analytical difficulties; it is unknown whether such data would change either of the above statements.) Thus NESCAUM's statement about the fines containing the highest concentrations of metals and dioxin may be true with respect to dioxin but it is not true with respect to the data for the only two metals (copper and arsenic) included in the University of Maine report.

In addition, because the analyte list was limited to a small subset of the contaminants expected to be found in C&D wood, the number of samples was small, and the results were highly variable, it is difficult to see how NESCAUM could draw general conclusions about the composition of C&D wood from such limited data. Furthermore, the University of Maine data indicate that painted wood also contains relatively high arsenic, copper, and dioxin concentrations, which suggests that painted wood should also be eliminated or minimized, yet NESCAUM makes no such suggestion.

NESCAUM's Conclusion Regarding Fuel Testing

> "Requirements for comprehensive testing and sampling of the fuel at both the processing facility and the location of the end user will assure that the fuel quality is maintained."

NESCAUM offers no evidence to support this statement. This assertion is not even discussed in the report; it is simply stated in the NESCAUM report conclusions. NESCAUM provides no basis for its conclusion that requirements for comprehensive fuel testing will assure that fuel quality will be maintained, nor does it provide any guidance on what level of fuel testing would be adequate. Sampling and analyzing this heterogeneous material for the array of hazardous constituents of concern that may be present could be seen as a major challenge, especially if it is to be both thorough and economical. Yet NESCAUM simply glosses over this issue.

Additional Concerns

Fuel Management Issues

NESCAUM's focus is on air, so it is understandable that NESCAUM did not evaluate other issues relative to burning C&D wood that do not involve air. However, human health and the environment are affected by all media, so it is worth at least mentioning other concerns regarding burning C&D wood.

Ash issues were discussed above in connection with the test burns NESCAUM reviewed. Dust generated by C&D sorting and fuel and ash handling or, if the fuel or ash is stored outdoors, wind, may be a concern, particularly for facility workers. Splinters of CCA-wood are also a worker safety concern (Florida Center for Solid and Hazardous Waste Management and Florida Department of Environmental Protection, 2005). In addition, if fuel or ash is exposed to precipitation during transportation or storage, runoff may contaminate groundwater or surface water. At some facilities, fuel is stored outdoors, for example, at one of the two Boralex C&D burning facilities in Maine.

Disincentive to Reduce, Reuse, and Recycle

Allowing C&D wood to be burned provides a disincentive to reduce, reuse, and recycle. There are a number of alternatives for dealing with C&D wood that do not involve combustion. It is beyond the scope of this evaluation to discuss these in any detail, but it is worth noting that some wood may be reused as dimensional lumber (O'Connor, 2006), or made into particle board and fiber board (McQuade, 2006).

Conclusions and Recommendations of this Evaluation

This evaluation has examined three key conclusions of the NESCAUM report on burning C&D wood for energy, namely:

- "A review of the data shows that the use of appropriately processed C&D wood is similar in its emission profile to that of virgin wood."
- "The critical element in minimizing air emissions, especially air toxics, is the elimination of CCA-treated and penta-treated wood from the fuel and minimizing fines."
- "Requirements for comprehensive testing and sampling of the fuel at both the processing facility and the location of the end user will assure that the fuel quality is maintained."

The NESCAUM report ends with two recommendations: 1) "States should establish fuel specifications and fuel management procedures for C&D wood if they plan to support the use of C&D wood for energy generation"; and 2) Existing biomass plants may need to upgrade emission controls if they wish to burn C&D wood." The recommendations suggest that burning C&D wood can be done safely and that states should go ahead, as long as they manage the fuel and air emissions properly. However, NESCAUM's analysis was not sufficient to support the conclusions on which these recommendations are predicated, as summarized below.

<u>The NESCAUM report is seriously flawed.</u> NESCAUM based its conclusions on a very small data set, and those sparse data do not support NESCAUM's conclusions. In addition, the quality of much of the data is questionable. Furthermore, no specific data were available regarding a number of expected air toxics, leaving significant data gaps. The NESCAUM report contained significant errors and never defined key terms such as "appropriately processed C&D wood" and "air emissions profile."

<u>Air emissions are higher when C&D wood is included in the fuel.</u> Contrary to NESCAUM's conclusions, the data NESCAUM reviewed indicated that air emissions are higher when C&D wood is included in the fuel, at least as far as arsenic and dioxin are concerned. Livermore Falls data indicate that concentrations of arsenic and dioxin are doubled and quadrupled, respectively, when burning 50% C&D wood compared to burning forest biomass.

<u>CCA-treated wood, painted wood, and fines are included in the C&D wood fuel</u>. NESCAUM says it is critical to eliminate CCA-treated and penta-treated wood from the fuel, but does not say whether this is feasible. Literature indicates that eliminating CCA-treated wood is a challenge because it cannot always be identified visually. In addition, NESCAUM says it is critical to minimize fines in the fuel, but does not say to what extent this is necessary nor to what extent it is feasible. In addition, data indicate that painted wood has relatively high concentrations of toxic chemicals such as arsenic, copper, and dioxin, yet NESCAUM does not suggest that painted wood should be minimized or eliminated.

There is no basis for saying that testing will assure fuel quality. C&D wood is inherently contaminated with a variety of hazardous chemicals. NESCAUM provides no basis for its conclusion that "requirements for comprehensive fuel testing at both the processing facility and at the location of the end user will assure that the fuel quality is maintained." That assertion is simply stated in the NESCAUM report conclusions. NESCAUM does not say what the testing requirements are or should be, let alone evaluate whether or not they are adequate.

NESCAUM only evaluated air. Ash is a significant concern that was not addressed by NESCAUM. Ash from facilities that do not burn C&D wood may be reused in several beneficial ways. By contrast, ash from C&D wood burning facilities must be disposed of in lined landfills due to high concentrations of heavy metals. In addition, arsenic, lead, and other toxic chemicals in the C&D wood present material handling issues. Dust, splinters, and contaminated surface water runoff are among the potential concerns. NESCAUM did not address any of these issues.

Assessment of risks to human health and the environment is incomplete. Although dispersion modeling of the stack gas concentrations at Stratton and Livermore Falls indicated that ambient air concentrations of arsenic and dioxin would be below MAAGs, the stack gas concentration data that were modeled are sparse and of questionable quality, as explained above. In addition, the modeling only evaluated one route of exposure to two chemicals, namely direct inhalation of arsenic and dioxin. It did not consider another more indirect route of exposure from contaminant deposition onto soil and surface water, followed by subsequent uptake in the food chain. Nor have risks from dust and contaminated runoff from fuel piles been considered. Thus, a realistic and comprehensive assessment of risks to human health and the environment from burning C&D wood has not been carried out.

Recommendation: The NESCAUM report should not be relied upon in developing any public policies relative to the burning of C&D wood.

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