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CORD WOOD USAGE BEFORE AND AFTER A COMMUNITY-WIDE WOODSTOVE CHANGEOUT PROGRAM

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Introduction

Libby, Montana is a small town with a population of 2,674, and lies along the Kootenai River in the northwestern corner of Montana. [1] The greater "Libby Valley" in 2005 had roughly a population of 9,484 people within 3,888 occupied homes. [1, 2] The climatic conditions and Libby's location in the deep mountain valley cause the community to be subjected to some of the poorest atmospheric dispersion in Montana. During the fall and winter, winds are light or nonexistent, and temperature inversions are common. Temperature inversions can last for days or weeks and trap particulate matter in the valley.

A monitor in Libby has recorded some of the highest total suspended particulate, particulate matter of 10 micrograms per meter or less (PM-10) and 2.5 micrograms per meter or less (PM-2.5) concentrations ever documented in Montana. Historically, woodstove combustion has been found to be major contributors of PM-10 and PM-2.5 ambient levels in Libby. During 2005, a chemical mass balance (CMB) study was conducted in Libby in addition to carbon 14 measurements that identified 82% of the PM-2.5 resulted from wood combustion. [3] PM-2.5 from diesel exhaust and oil burning for space heating in homes and commercial establishments were other sources of PM-2.5 emissions in the Libby area. [2]

In attempt to reduce the emissions from old uncertified woodstoves, a community-wide woodstove changeout program was undertaken in Libby in two phases. These woodstoves were replaced with EPA certified wood and pellet stoves, and alternative heat sources such as propane, electric, and oil. The first phase focused on replacing old wood stoves in low income households eligible for the Low Income Energy Assistance (LIEAP); that phase started in 2005. A second phase was initiated in 2006 to focus on higher income households. A total of 1,010 old woodstoves were replaced with 778 EPA certified woodstoves, 21 oil, 46 propane, 152 pellet and 13 electric appliances.

One of the fundamental questions about a woodstove changeout program that has not been addressed is whether the amount of wood burned is the same before (as identified by a wood burning survey) as after a changeout program. Under laboratory conditions, the EPA certified woodstoves have a greater thermal efficiency than the older technology uncertified wood burning appliances. [4] It has been suggested that due to this higher thermal efficiency, less cord wood would be used in the newer woodstoves over the burning season. [4] This investigation was initiated to attempt to answer this question.

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Methods

During the summer of 2007, a brief wood burning telephone survey was completed by homeowners and renters who participated in the Libby, Montana Woodstove Changeout Program. The objective was to determine if the newer EPA certified woodstoves burned less wood over the course of a wood burning season compared to their older uncertified counterparts. To the authors' knowledge, this study is the first report of the pre- and post wood usage study in a whole community after a woodstove changeout program.

The changeout woodstove users must have had at least one complete year of wood burning experience with the new EPA certified woodstoves. The total number of potential respondents was 460: 233 from the LIEAP program group referred to as Phase I group, and 227 with higher income called Phase II group. Of the Phase I group, 153 (~ 66%) successful survey contacts were made compared to 124 (~55%) successful survey contacts in the Phase II group. More Phase I participants were contacted since that program was initiated earlier (2005) than the Phase II program (2006) so more Phase I respondents had one year of experience with their new woodstoves. All members of both groups were called during the evening and weekends in order to increase the success rate of the survey. When necessary, a respondent was contacted repeatedly over a 3 to 4 week period if the initial attempt to contact them was unsuccessful. A successful survey contact was defined as when the interviewer was able to fill out the questionnaire with at least a determination of the pre- and post-changeout wood use information. Other questions asked from the questionnaire were considered secondary such as the size of the home, number of bedrooms, and whether other sources of heat were available other than wood. Table 1 shows the results of the wood use survey for both the Phase I and Phase II groups. By assuming that the wood consumption by both Phase I and II participants were representative of their respective group, a weighted average could also be developed.

Results

TABLE 1. COMPARISON OF BEFORE AND AFTER CHANGEOUT CORD WOOD USAGE IN LIBBY, MT.

Phase of Program (number of replaced stoves)	Pre-Changeout Uncertified Woodstove (cords/season)	Post-Changeout Certified Woodstove (cords/season)	Percent Reduction (%)
Phase I (Lower Income – average of 260 stoves)	5.67	4.81	15.2
Phase II (Other income – average of 518 stoves)	5.23	3.90	25.4
Weighted Average of Combined Incomes (778 total stoves)	5.38	4.20	22.0

The Phase I group reported that they burned 5.67 cords of wood with their older woodstove and 4.81 cords with their new EPA certified woodstoves, or a 15.2% reduction over the wood burning season. The Phase II group reported that they burned about 5.23 cords before the changeout program compared to 3.90 cords with their new stoves or a 25.4% reduction in the amount of wood burned over the wood burning season. As shown in Table 1, lower income households burned more wood than the higher income households both before and after the wood stove changeout program. While not shown here, other considerations such as the type of other heating sources available, or the size of the home did not seem to influence the percent reduction in cord wood usage in either group.

Discussion

As Table 1 illustrates, the decrease in wood used over the heating season were different between the Phase I and Phase II groups with the Phase I showing a smaller decrease in wood used after the changeout relative to the Phase II group. During the telephone survey, the Phase I group frequently commented that the new stoves tended to produce less smoke in the indoor living environment compared to their older stoves, and that their old stoves were not used at times because it smoked up the interior of their home. Since the Phase I group had less deposable income, it is not unreasonable to think that their pre-changeout stoves were likely older and less professionally maintained which produced more indoor smoke due to poor door closures, poor drafting, leaking stove pipe, and other maintenance issues. Thus, the percent reduction in the amount of wood consumed by the Phase I group before and after the changeout program may be even greater if the stoves had actually been used to the same extent pre- and post-changeout.

The thermal efficiency of the newer EPA certified woodstoves is the result of several factors including a pre-heated combustion air introduced through small holes above the fuel in the firebox. Also, the heat recovery baffle structure produces a longer, hotter gas flow path for a more even delivery of air to the insulated firebox and hotter combustion on fire startup. These are important features of an EPA certified woodstove that promotes better fuel efficiency. More information concerning the woodstove efficiency is provided by Houck et al.[4] As illustrated in Table 2, woodstove efficiencies are higher in the EPA certified woodstoves.[4] However, this study shows that by calculating the change in woodstove thermal efficiency by the simple ratio of the efficiency of the uncertified woodstove divided by the efficiency of the EPA certified woodstove results in the values in column three in Table 2. The ratio of the efficiencies is a calculation of the reduction in cord wood that would be used in heating a home with the newer EPA certified wood burning appliance. The last row shows the result of this study that was calculated as the result of the decrease in cord wood used by the Phase I and II programs (1-0.220 = 0.780).

TABLE 2. COMPARISON OF THERMAL EFFICIENCY EFFECT ON FUEL USAGE TO LIBBY SURVEY RESULTS. [4]

Woodstove Type	Woodstove Thermal Efficiency (%)	Fraction of Wood Used Post-Changeout Due to Change in Efficiency (%)
Conventional Cordwood Stove	54	NA[1]
EPA Certified Non-catalytic Cordwood Stove	63	0.857
EPA Certified Catalytic Cordwood Stove	63	0.857
Conventional Cordwood Stove Changeout to a EPA Certified Woodstove (Libby, MT)	NA[1]	0.780

1. NA, Not Applicable.

As indicated in this table, the reduction in cord wood used is higher than that merely resulting from the change in thermal efficiency of using the newer EPA stove. There are other factors that may decrease the amount of wood used that go beyond the change in thermal efficiency, such as how hot the fire was allowed to burn on stove startup during the initial ignition process. A great deal of time and effort was spent by the Lincoln County Environmental Health Department during the entire changeout program on teaching the new stove owners the proper burning techniques. Better wood burning practices in themselves may have led to more heat production from more complete combustion with less wood essentially leaving the stovepipe as particulate matter.

It is important to point out that the increased thermal efficiency of a woodstove is just one way that the EPA certified woodstoves reduce emissions, such as PM-2.5, an air pollutant of major concern. Just as a car that uses less gasoline to travel the same distance would intuitively have lower air emissions, there are other features of the vehicle, such as an aerodynamic design and engine performance that reduces emissions of the automobile beyond

a simple reduction in fuel use. Similarly, a woodstove has other features that reduce emissions beyond those that would increase the thermal efficiency and decrease the amount of wood burned over the wood burning season. Our early analysis of the pre- verses post-reduction in emissions (PM-2.5) is greater than that that would occur from a mere reduction in the amount of wood burned from a greater thermal efficiency reported here, and will be the subject of a subsequent report.

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