

**Libby Annual PM-2.5 Standard Technical Support Document. Cyra Cain and James Carlin. Montana Department of Environmental Quality. Helena, MT 59620. September 2007.**

Background Information

The Montana Department of Environmental Quality (MDEQ) contracted the Global Engineering and Technology, PLLC, to conduct a wood stove use survey (2004 Survey) in Libby, Montana. During the winter of 2004-2005, this telephone survey queried 357 residents about their residential wood burning practices in the Libby PM-2.5 nonattainment area (NAA). According to the Lincoln County Environmental Health Department (LCEHD), the Libby wood burning season occurs from late August to late May, which was incorporated into the 2004 Survey. Information gathered from the 2004 Survey with other information obtained through the Libby wood stove changeout program are considered to be best available information to support the Libby PM-2.5 annual National Ambient Air Quality Standard (NAAQS) control plan.

The 2004 Survey gathered information about the amount of wood burned by wood burning device during the Libby 2004-2005 wood burning season. A single 2004 Survey respondent was considered an occupied residential housing unit in the Libby PM-2.5 NAA. The MDEQ assumed the number of wood burning devices in each housing unit was no more than one (1). Wood burning practices from commercial business were not addressed in this survey. Table 1 displays the average number of cords of wood burned by device obtained by the 2004 Survey.

**TABLE 1: 2004 SURVEY RESULTS FOR THE AVERAGE NUMBER OF CORDS BURNED IN HOMES, 2004-2005 WINTERTIME.**

Type of Wood Stove	Average Number of Cords Burned/Season <sup>1</sup>
Fireplace	3.60
Pre-certified	3.64
Certified I Catalytic	3.50
Certified I Non-catalytic	4.20
Certified II Catalytic	3.40
Certified II Non-catalytic	3.75
Cord Wood Furnace	4.20
Masonry Furnace	4.75
Pellet Stove / Furnace	3.68 tons <sup>2</sup>

<sup>1</sup> Average weight of a cord is 1.498 tons (2004 Survey).

<sup>2</sup> The 2004 Survey respondents reported actual tons of pellets burned.

SOURCE: Ganesan, Dr. Kumar, Cyra Cain and James Carlin. PM-2.5 Emissions From Residential Wood Burning In Libby, Montana. Contract #DEQ 505029. Air Resources Management Bureau. Montana Department of Environmental Quality. 1520 East 6<sup>th</sup> Avenue. P.O. Box 200901. Helena, Montana 59620-0901. December 2006.

This source will be frequently cited so it will be referred to as the residential wood burning document or simply, RWB document.

In 2005, the U.S. Environmental Protection Agency (EPA) in coordination with LCEHD, the Hearth Patio and Barbecue Association (HPBA), and MDEQ developed and implemented a wood stove changeout program. For simplification, the Libby wood stove changeout program will be referred to as the changeout program. In first phase of the changeout program (Phase I), the objective was to remove uncertified wood stoves used by low income households in the Libby NNA and replace them with free EPA certified wood stoves, thereby improving the air quality in Libby. Businesses were not qualified to participant. In Phase I, the number of replaced stoves was 260 out of the available donated 300 HPBA stoves.

SOURCE: Eagle, Brian and James E. Houck. Final Report. Phase I of the Libby, Montana Woodstove Changeout Program. Prepared for United States Protection Agency. OMNI Environmental Services, Inc. 5465 SW Western Ave, Suite G. Beaverton, OR 97005. June 30, 2007. (OMNI)

However, there were an estimated 281 low income households with conventional or uncertified woodstoves within the area eligible for the changout program, indicating the Phase I program had over a 90% success rate in removing uncertified wood stoves from the low income community. This estimate was based upon a survey of Low Income Energy Assistance Program Recipients (LIEAP) recipients, which showed that 32% of low income occupied homes had a wood burning appliance, and that 52% of those appliances were uncertified wood stoves. This also assumed that 1,680 residences, or 44.1% of the homes in the Libby changeout area met the income guidelines for the Phase I program.

SOURCE: Quenemoen, Kane and James Carlin. Libby Montana LIEAP Wood Stove Survey. Montana Department of Health and Human Services. Montana Department of Environmental Quality, State of Montana. Helena, MT. Fall 2004.

A second phase (Phase II) of the changeout program began in January 2006 to focus on the uncertified stoves used by the other Libby residents. Although in this stage the certified stoves were not free, a voucher system was developed to distribute EPA funding for replacement certified stoves. The LCEHD recorded 870 distributed vouchers including 857 households and 13 businesses, to replace pre-certified wood stoves; this data is provided in Table 2.

**TABLE 2: NUMBER OF DISTRIBUTED AND REDEEMED LCEHD VOUCHERS FOR PRE-CERTIFIED WOOD STOVE REPLACEMENT IN PHASE II.**

Manner of Replacement	Number of Distributed Vouchers For Pre-Certified Wood Stove Replacement	Actual Number of Pre-Certified Wood Stoves Removed By Redeemed Voucher
Installed Wood Stove Insert	53	53
Installed Certified Wood Stove	439	439
Installed Certified Wood Furnace	9	9
Returned Voucher	2	0
Removed Stove/No Replacement	9	9
Rebuilt Stove	1	1
Installed Pellet Stove	89	89
Removed/Changed to Propane	46	46
Installed Pellet Furnace	35	35
Installed Pellet Insert	25	25
Installed Oil Stove	20	20
No Changeout	113	0
Moved	1	0
Removed/Changed to Electric	13	13
Cancel Changeout	2	0
Business: Installed Wood Stove	6	6
Business: Installed Wood Certified Furnace	1	1
Business: Installed Pellet Stove	1	1
Business: Installed Pellet Furnace	2	2
Business: Removed/Changed to Oil	1	1
Business: No Changeout	2	0
<b>Total</b>	<b>870</b>	<b>750</b>

As shown in Table 2, the number of identified pre-certified wood stoves in Phase II was 870: 857 residences and 13 businesses. However, only 750 wood stoves were removed using the vouchers or about an 86% replacement efficiency similar to Phase I results.

The total number of identified pre-certified wood stoves in the changeout program was 1,130 (260 in Phase I and 870 in Phase II), which included the 1,117 residences and 13

businesses. However, the actual number of pre-certified wood stove removed by the changeout program was 1,010 (260 from Phase I and 750 during the Phase II) indicating 120 stoves were not replaced. Only eleven (11) of the 750 redeemed vouchers were businesses in comparison to 739 households in Phase II.

Of the 750 removed wood stoves, 92 were wood cord furnaces according to the LCEHD voucher spreadsheets (Robert Jeffrey, Personal Communications, Ron Anderson, LCEHD, March 12, 2007). Wood cord furnaces are exempt from EPA New Source Performance Standard if the appliances have air to fuel ratios greater than 35:1 or weighs more than 800 kilograms (40 CFR Part 60, Subpart AAA, pp. 350-368, July 1, 1997). However, these appliances are still not EPA certified so the LCEHD changed their regulations eliminating the use of any wood burning device that were not EPA certified (75.1.203(5) and 75.1.203(6), Lincoln County Health and Environmental Regulations, 2006).

The changeout program also revealed there were more uncertified wood stoves (1,010) in the Libby NAA than were determined by the 2004 Survey, which identified only 958 pre-certified stoves. Due to the increased accuracy of the changeout program documentation, the number of uncertified wood stoves identified in the changeout program was used in this demonstration.

In both phases of the changeout program, both certified catalytic and non-catalytic stoves were available for installation. After excluding replacement to pellet or another heat source (such as propane), the certified catalytic and non-catalytic wood stoves were installed at overall percentages of 10 and 90%, respectively. (Jim Carlin, Personal Communications, John Crouch, HPBA, March 3, 2007).

SOURCE: LCEHD Voucher Tracking Spreadsheets for the Phase II Wood Stove Changeout Program. July 2007.

During July 2007, the MDEQ conducted a supplemental telephone survey (2007 Survey) in the Libby NAA. The objective was to determine whether their wood consumption had changed from using their old uncertified compared to the newly installed EPA certified wood stoves. This 2007 Survey queried 233 (out of 260 or ~ 90%) Phase I participants and 227 (out of 750 or ~30%) Phase II participants. Only 30% of Phase II participants were contacted since only these respondents had a full year of use with the new certified wood stoves. Therefore, the MDEQ assumed that this population of wood cord users was representative of the remaining Phase II 523 wood burners.

The percentage of changed stoves in Phase I (260) was approximately 26% of the total changeout stoves (1,010), whereas Phase II (750) replaced stoves represented 74% of the total population. With this information, the average number of cords consumed during the wood burning season could be calculated based on these proportions and the average amounts consumed before and after the changeout program; the results are in displayed in Table 3.

TABLE 3: COMPARISON OF CORD WOOD CONSUMPTION BEFORE AND AFTER THE CHANGEOUT PROGRAM IN LIBBY, MT.

Phase of Changeout Program	Pre-Changeout Uncertified Wood Stove (cords/season)	Post-Changeout Uncertified Wood Stove (cords/season)	Percent Reduction Post-Changeout (%)
Phase I (Low 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
Combined Incomes (778 stoves)	5.38	4.20	22.0

According to Table 3, the average amount of wood cords burned after the changeout program was 22.0% less than before this program. This information was incorporated into this demonstration for the newly installed certified catalytic and non-catalytic wood stoves only, since this analysis does not involve pellet stoves or alternative heat sources (i.e., propane). The MDEQ considers the information gathered from the 2007 Survey is the best available data on post-changeout residential wood burning in Libby.

SOURCE: Robert Gallagher and James Carlin. Cord Wood Usage Before and After a Community-Wide Wood Stove Changeout Program. Montana Department of Environmental Quality. Air Resources Management Bureau. (*In Preparation*).

The MDEQ used the PM-2.5 wood stove emission factors (Efs) listed in Table 4. Most of these Efs are EPA published PM-10 Efs, except for the cord wood furnace. The MDEQ assumed these factors are the best available estimates for PM-2.5 Efs. Roy Huntley, EPA, supplied the PM-2.5 emission factor for the cord wood furnace (Jim Carlin, Personal Communications, Roy Huntley, EPA, September 26, 2005).

TABLE 4: WOOD STOVE EMISSION FACTORS.

Type of Wood Stove	PM-2.5 Ef (lb/ton) <sup>1</sup>
Fireplace (no insert)	34.6
Pre-certified	30.6
Phase I Catalytic	19.6
Phase I Non-catalytic	20.0
Phase II Catalytic	16.2
Phase II Non-catalytic	14.6
Cord Wood Furnace	30.6 <sup>2</sup>
Masonry Furnace	5.6
Pellet Stove / Furnace	6.6

<sup>1</sup> EPA AP-42. Fifth Edition. Vol. I. Chapter 1: External Combustion Sources. (<http://www.epa.gov/ttn/chief/ap42/ch01/index.html>).

<sup>2</sup> Cord Wood Furnace PM-2.5 emission factor was obtained from Jim Carlin, Personal Communications, Roy Huntley, EPA, September 26, 2005.

<sup>3</sup> Average of Certified and Exempt Pellet stoves EPA AP-42 PM-10 emission factors.

**SOURCE:** EPA. Guidance for Quantifying and Using Emissions Reductions from Voluntary Woodstove Changeout Programs in State Implementation Plans. Information Transfer and Program Implementation Division. Office of Air Quality and Standards. Research Triangle Park, NC. 2771. November 2006. ([http://www.epa.gov/woodstoves/pdfs/guidance\\_quantifying\\_jan.pdf](http://www.epa.gov/woodstoves/pdfs/guidance_quantifying_jan.pdf)).

For the Libby PM-2.5 annual standard control plan, the WINTER season is defined by the following months: January, February, March, October, November, and December. To reiterate, the 2004 Survey was based on the Libby wood burning season from late August to late May. These two time periods overlap, but not completely (late May and early August) so an adjustment was needed and heating degree days (HDD) data were used.

To calculate the HDD for a particular day, find the day's average temperature (in Fahrenheit) by adding the day's high and low temperatures and divide by two. If the number is above 65, there are no heating degree days for that day. If the number is less than 65, subtract the average temperature from 65 to find the daily number of heating degree days. The following table displays the HDD data (1895 - 2007) for Libby from the National Weather Service. The percentage of HDD apportioned to each month of the year can be estimated after removing the degree days in July from each month's HDD. The degree days in July were removed from each month's HDD total because little or no heating with wood was thought to occur in July in Libby. Using this very conservative technique would represent a nominal amount of HDD that when subtracted

from each month's degree day total would characterize the wood burning degree days for Libby as shown in Table 5.

TABLE 5: PERCENT WOOD BURNED DURING THE CONTROL AND NON-CONTROL PLAN PERIODS.

Month	Heating Degree Days (HDD) <sup>1</sup>	Percent Remaining HDD (%)	Percent Remaining HDD (%)	Percent of Wood Burned During Non-Control Months (%)	Percent of Wood Burned During Control Period Months (%)
January	1,282	1,236	18.15		18.15
February	999	953	14.00		14.00
March	857	811	11.91		11.91
April	571	525	7.71	7.71	
May	345	299	4.39	4.39	
June	156	110	1.62	1.62	
July	46	0	0.00	0.00	
August	63	17	0.25	0.25	
September	258	212	3.11	3.11	
October	600	554	8.14		8.14
November	958	912	13.40		13.40
December	1,225	1,179	17.32		17.32
Annual	7,360	6,808	100.00	17.08	82.92

<sup>1</sup> Western Regional Climate Center. Libby 1 NE Ranger Station, Montana (245015). Period of Record Monthly Climate Summary. Period of Record: 6/ 9/1895 to 4/30/2007. (<http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?mt5015>).

According to Table 5, 17.08% of the wood burned in Libby occurred during the months other than the control plan months of October through March. To adjust the emissions that occurred during the control plan time period, all of the average number of cords in Table 1 were multiplied by 0.8292 to correct for the fraction of wood not burned during the control plan months.

#### Table 6 and Specific Assumptions

Table 6 summarizes the types of heating device/source, PM-2.5 emission factors, the amount of wood burned by wood burning device from both homes and businesses, and associated PM-2.5 emissions that occurred during the 2004 - 2005 winter burning

season in the Libby NAA. This information was obtained from the 2004 Survey (RWB document), 2007 Survey, changeout program, and the LCEHD vouchers. This table is organized into two sections: changeout program results and associated data, and the 2004 Survey (RWB document).

The PM-2.5 emissions are calculated based upon the amount of wood burned by appliance type in the RWB document as listed in Table 1, except for the pre-certified stoves identified in the changeout program. In this case, the amount of wood burned was an average of the 2004 Survey value in Table 1 (3.6 cords) and the pre-changeout value in Table 3 (5.4 cords), or 4.5 cords. An average was used because a larger amount of cord wood was burned from the larger number of identified pre-certified wood stoves in the changeout program than determined by the 2004 Survey. The 2004 Survey queried only 357 Libby NAA households that completed a telephone wood stove survey, yet only 201 (over 56%) used a wood burning device. Since data from both sources was used for this demonstration, the MDEQ considered utilizing both set of values as a more conservative approach.

The first section of Table 6 was derived from the 2007 Survey, the LCEHD Phase II Voucher Tracking Spreadsheets, and the OMNI Phase I report, which represents the changeout program. The total number of distributed vouchers (1,130) includes the individual homeowners (1,117 total: 260 in Phase I and 857 in Phase II) and businesses (13 in Phase II). Out of the total 1,130 distributed vouchers, only 1,010 vouchers were redeemed (260 in Phase I and 750 in Phase II). The number of wood stoves after the changeout program is nine (9) less than before this program (1,130 – 1,121) since these pre-certified wood stoves were removed, but not replaced as noted in the last row of this section.

This first section also reflects the installation of the certified catalytic and non-catalytic wood stoves as replacement wood stoves. After excluding replacement to pellet or another heat source (such as propane), the percentages of installation for catalytic and non-catalytic wood stoves were 10 and 90%, respectively. In addition, the post-changeout average amount of cord wood burned by these devices was reduced by 22.0%.

The second section was obtained from the 2004 Survey, which does not have any information on wood stove usage by businesses within the Libby NAA. These emissions remained constant since these appliances were not affected by the changeout program.

All of the emissions in Table 6 represent the winter season for application in the Libby PM-2.5 annual NAAQS control plan by using heating degree data.

TABLE 6: WOOD STOVE PM-2.5 EMISSIONS IN THE LIBBY NAA, OCTOBER - MARCH, 2004 - 2005.

Type of Heating Unit	Pre-Changeout Number of Appliances	Post-Changeout Number of Remaining, Removed or New Clean Heating Units	Pre-Changeout PM-2.5 Efs (lb/ton)	Pre-Changeout Average Number of Cords Burned (HDD Adjusted)	Post-Changeout PM-2.5 Efs (lb/ton)	Post-Changeout Average Number of Cords Burned (HDD Adjusted)	Pre-Changeout PM-2.5 Emissions (tons) <sup>1</sup>	Post-Changeout PM-2.5 Emissions (tons) <sup>1</sup>	PM-2.5 Emissions Reduced (tons)	Percent Reduction (%)
<b>FIRST SECTION, CHANGEOUT PROGRAM: Emissions from pre-certified wood stoves replaced by certified wood stove device or alternative heating source.</b>										
1. Pre-certified <sup>2</sup>	1,029	120 (remaining)	30.6	3.73	30.6	3.09	87.97	0.00	87.97	100.0
From #1 - Pre-certified Changeout to EPA Certified Catalytic Wood Stove including Certified Wood Furnace (10% Wood Stove certified population)		77	30.6	3.73	16.2	2.20	0.00	2.05	-2.05	-2.1
From #1 - Pre-certified Changeout to EPA Certified Non-Catalytic Wood Stove including Certified Wood Furnace (90% of Certified Wood Stove population)		692	30.6	3.73	14.6	2.43	0.00	18.39	-18.39	-18.4
Cord Wood Furnace – All Removed and All Replaced	92	0	30.6	3.73	30.6	3.48	7.87	0.00	7.87	7.9
From #1 - Pre-Certified Wood Stoves Replaced With Pellet Stove / Pellet Furnace/ or Pellet Insert		152	30.6	3.73	6.6	3.05	0.00	1.53	-1.53	-1.5
From #1 - Pre-certified Wood Stove Replaced with Propane <sup>3</sup>		46	30.6	3.73	0.0	0.00	0.00	0.02	-0.02	0.0
From #1 - Pre-certified Wood Stoves Replaced with Oil <sup>3</sup>		21	30.6	3.73	0.0	0.00	0.00	0.04	-0.04	0.0
From #1 - Pre-certified Wood Stove Replaced with Electric		13	30.6	3.73	0.0	0.00	0.00	0.00	0.00	0.0
Pre-certified Wood Stove – All Removed and <u>None</u> Replaced	9	0	30.6	3.73	0.0	0.00	0.77	0.00	0.77	0.0
<b>Subtotal</b>	<b>1,130</b>	<b>1,121</b>					<b>96.61</b>	<b>22.03</b>	<b>74.58</b>	
<b>SECOND SECTION, EXISTING WOOD STOVE EMISSIONS: Other wood stove emissions in the area will remain the same because they were not affected by the changeout program. <sup>4</sup></b>										
Fireplace (no insert) <sup>2</sup>	87	87	34.6	2.99	34.6	2.99	6.74	0.00	6.74	100.0
EPA Certified Catalytic Wood Stove	54	54	19.6	2.90	19.6	2.90	2.30	2.30	0.00	0.0
EPA Certified I Non-catalytic Wood Stove	76	76	20.0	3.48	20.0	3.48	3.96	3.96	0.00	0.0
EPA Certified II Catalytic Wood Stove	327	327	16.2	2.82	16.2	2.82	11.19	11.19	0.00	0.0
EPA Certified II Non-catalytic Wood Stove	457	457	14.6	3.11	14.6	3.11	15.54	15.54	0.00	0.0
Masonry Furnace	22	22	5.6	3.94	5.6	3.94	0.36	0.36	0.00	0.0
Pellet Stove / Pellet Furnace/ or Pellet Insert	207	207	6.6	3.05 <sup>5</sup>	6.6	3.05	2.08	2.08	0.00	0.0
<b>Subtotal</b>	<b>1,230</b>	<b>1,230</b>					<b>42.17</b>	<b>35.43</b>	<b>6.74</b>	<b>0.00</b>
<b>Total</b>	<b>2,360</b>	<b>2,351</b>					<b>138.78</b>	<b>57.46</b>	<b>81.32</b>	

<sup>1</sup> Average weight of a cord is 1.498 tons. SOURCE: RWB document.

<sup>2</sup> 75.1.203(5) and 75.1.203(6). Lincoln County Health and Environmental Regulations. 2006.

<sup>3</sup> Emissions from oil and propane post-changeout were calculated using AP-42 emission factors: 0.6 pounds (lb) PM-2.5 per 1,000 gallons (gal) of propane and 3.0 lb of PM-2.5 per 1,000 gal of oil. Based on professional judgement, an average of 1,200 gallons of oil or propane was consumed during the 2004 - 2005 Libby heating season. EPA AP-42. Fifth Edition. Vol. I. Chapter 1: External Combustion Sources. (<http://www.epa.gov/ttn/chief/ap42/ch01/index.html>).

<sup>4</sup> SOURCE: RWB document.

<sup>5</sup> The 2004 Survey respondents reported actual tons of pellets burned. SOURCE: RWB document.

The LCEHD regulations restrict the use of pre-certified wood stoves and fireplaces. To reflect these rules, the emissions from the remaining 120 pre-certified stoves were reduced to zero in the first section as well as the emissions from the 87 fireplaces in the second section.

About 138.8 tons of PM-2.5 emissions were emitted from wood burning devices during the 2004 – 2005 Libby winter burning season before the changeout program in comparison to 57.5 tons after the program, almost a 59% reduction.

The Libby PM-2.5 annual standard control plan winter season contains 182 days. Before the changeout program, the amount of daily PM-2.5 emissions from wood burning devices in the Libby NAA was approximately 0.8 tons or 1,525 pounds. After this program, the daily PM-2.5 emissions are about 0.3 tons or 629 pounds per day in the Libby PM-2-5 nonattainment area.

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