ASSESSMENT

Potential for Expanding the Fuels for Schools Concept to other Institutions and Industries

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Bitter Root RC&D

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EXECUTIVE SUMMARY

The USFS *Fuels for Schools* program is designed to facilitate the removal of hazardous fuels from our forests by assisting in the development of economically viable heating systems in public and private buildings that use woody biomass for fuel. The USFS is now interested in expanding beyond the demonstration phase of the program and moving the concept towards commercialization.

The purpose of this study is to assess the potential commercial opportunities and challenges in converting or replacing a significant number of Montana's 7,239 existing boilers with SDU wood-fueled boilers. The first part of the study involves analyzing the limited information available in the State's boiler certificate database. Findings include:

- 60% of boilers in the database are less than 1,000,000 BTU/hr in size. Almost 45% are less than 500,000 BTU/hr in size.
- 89% list "Gas" or "Gas/Oil" as their existing fuel source.
- 62% were installed within the past 20 years, 25% are 21 to 40 years old, 9% are 41 to 60 years old, and 4% are more than 60 years old.
- 62% of the boilers list "Not applicable" as their facility type, but 21% list schools; 5% list churches; 4% list hospitals; 4% list rest home, retirement center, or assisted living facilities; 3% list public assembly; and 0.2% list daycares.
- 68% of the boilers are used for water heating, 16% for steam heating, 8% for hot water supply, 6% for process water, and 1% for power.
- 257 cities in Montana have at least one boiler. 15 cities have more than 100 boilers, 25 cities have more than 50 boilers, 91 cities have 10 or more boilers, and 90 cities have only one or two boilers. As might be expected, the largest cities also have the greatest number of boilers.

The second part of the study uses information presented in the State's boiler database to estimate the potential size and scope of a commercial wood-fired boiler market in Montana. The analysis is based solely on calculations of simple payback through annual fuel savings on a boiler conversion investment.[1] While limited in accuracy, simple payback[2] is an initial indicator, from a facility owner's point of view, of how attractive an investment in conversion might be given current economic conditions. Two scenarios were developed to differentiate between payback periods when boiler replacement is likely necessary and when it is not.

The primary observations of the analysis are:

1. There appear to be 79 boilers with payback periods less than 10 years when boiler replacement is not required (none had paybacks between 10 and 15 years). Of

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[1] This study does not include commercialization for new facilities, but is limited to modification and/or replacement of existing boiler systems listed in the State's boiler certificate database.
[2] "Simple Payback" measures the time required to recover investment costs. Though useful, it is a limited analysis because it ignores the time value of money.

these 79 boilers, all currently use electricity as their existing fuel source, and almost all are less than 500,000 BTU/hr size.

Observation: *The commercial potential for boiler conversion in situations where a new boiler is not needed appears quite limited in terms of market size on a statewide scale. Furthermore, this relatively low number does not represent a substantial end-use potential for USFS fuel reduction efforts.*

2. There appear to be 2,567 boilers with payback periods less than 15 years when boiler replacement is required. Analysis of this group of boilers indicates that 44 are over 60 years old, and total of 367 are at least 30 years old; ages that suggest replacement may be needed in the relatively near future.

   Observation: *There appears to be a potential market size of 367 boilers that are likely ready for replacement and that would have a payback of less than fifteen years. These boiler conversions represent an estimated market size of $8.2 million in aggregate investment requirement.*

There are many additional issues that would need to be thoroughly analyzed in order to refine this initial assessment of the commercial potential for large-scale boiler conversion. Some of the issues identified by this study include: government programs and drivers, economic development and a service infrastructure, feedstock issues, environmental and political issues, air quality issues, and facility-specific issues.

Successful transition of the Fuels for Schools program to commercialization will depend on the development of a *business ecosystem*[3] that encompasses USFS goals for forest thinning operations and market incentives for conversion to wood-fueled boilers. A complete shift to commercialization requires market-driven economics that support investment in boiler conversion from both the consumer and the vendor perspectives.

The findings of this study indicate the need to pursue three activities to further efforts towards commercialization of the Fuels for Schools concept:

- Engage key stakeholders in next steps
- Assess wood resource viability
- Explore additional partnerships, drivers, and opportunities
- Disseminate information

[3]A *business ecosystem* is a community of organizations and stakeholders (players) operating within a particular business environment, which collaborate and compete in an economic web of relationships. These relationships co-evolve through time subject to the general forces in the business environment and the specific moves made by the web of players.

INTRODUCTION

Background

The U.S. Forest Service (USFS) is interested in facilitating the removal of hazardous fuels from our forests by assisting in the development of viable commercial uses of removed woody materials. The Fuels for Schools program is the demonstration phase of a 3-phase USFS initiative to promote and encourage the use of wood biomass as a renewable, natural resource to provide a clean, readily available energy source suitable for use in heating systems in public and private buildings.

The Fuels for Schools program was developed in response to the aftermath of the Bitterroot Valley Fires of 2000, and now includes three pilot projects in Montana located in Darby, Philipsburg, and Victor. An additional three to five projects may be granted funds for construction in 2005. The program has also been expanded to Idaho, Nevada, and North Dakota. Pre-feasibility assessments for more than 100 buildings in 31 communities have been developed at this point in time.

The next phase of the initiative is the expansion of this concept to other schools, institutions, and industries. It is thought that large-scale conversions or replacements of existing boilers to use SDU (Small Diameter Underutilized) wood as a fuel source has the potential to:

- create significant local outlets for SDU wood generated by proposed forest thinning operations
- help support fire hazard reduction programs
- help stabilize the forest products industry
- enable long-term cost stabilization and savings for boiler owners
- provide (thermal) energy independence which contributes to economic and national security
- develop a local renewable fuel resource
- reduce local and regional pollution caused by forest fires

Purpose

The purpose of this study is to assess the potential opportunities and challenges presented by converting or replacing existing boilers in the state of Montana with SDU wood-fueled boilers. The report describes and identifies the potential candidates for boiler conversion in the state of Montana based on selected criteria, and highlights potential strategies to focus efforts for concept expansion and commercialization.

BOILER SURVEY

Boiler Database

The Montana Department of Labor and Industry maintains a database of certificates issued for boilers installed in the state which currently includes listing for 7,239 active boiler certificates. The database includes the following information for each active boiler certificate:

- Boiler size
- Current fuel source
- Year of manufacture
- Facility type
- Boiler use
- Boiler location
- Owner

The information available in the boiler database was sorted and summarized in various ways to help describe the characteristics of existing boilers operating in the state, and then get a better sense of the potential for expanding the Fuels for Schools concept to other institutions and industries. It should be noted that the database does not provide complete or logical information for all boilers listed, and some of the boilers listed may be inactive. For the purposes of this study, we used all of the data that were available and logical for each parameter analyzed, ignoring boilers when data were unusable. For this reason, numbers may not always add up between tables. Below are summaries of information for boiler size, current fuel source, age of boiler, facility type, use, and boiler location.

Boiler Size

The database lists boiler size in units of BTU. For the purposes of this study, it was assumed that the boiler sizes listed represent installed boiler output in actual units of BTU per hour. It was also assumed that the listed boiler size was a representative indicator of the annual fuel use. Table 1 presents the number of boilers listed in the database within selected size ranges.

Table 1. Number of boilers listed for selected size ranges

BOILER SIZE RANGE (BTU/hr)	NUMBER OF BOILERS
50,000,000 +	11
10,000,000 – 49,000,000	108
5,000,000 - 9,999,000	255
1,000,000 - 4,999,000	1,829
500,000 - 999,000	1,264
100,000 - 499,000	3,040
< 100,000	196

As can be seen from the table, more than half of boilers in the state (60%) are less than 1,000,000 BTU/hr in size, and almost 45% are less than 500,000 BTU/hr in size.

The largest boiler listed in the database is Stimson Lumber's 80,000,000 BTU/hr boiler located at their Libby facility. Sidney Sugars Inc. has two 72,000,000 BTU/hr boilers. The University of Montana has two boilers over 70,000,000 BTU/hr. Table 2 lists selected information for the ten largest boilers in the state. Table 3 presents information for the ten cities with the largest combined boiler sizes.

Table 2. The ten largest boilers in the state

SIZE (BTU/hr)	FACILITY	FUEL	MANU YEAR	USE	CITY
80,000,000	STIMSON LUMBER CO - BLR RM	Gas	1993	Process	LIBBY
72,000,000	SIDNEY SUGARS INC -	Gas/Oil	1946	Process	SIDNEY
72,000,000	SIDNEY SUGARS INC -	Gas/Oil	1946	Process	SIDNEY
70,203,000	UNIV OF MONTANA-P HOUSE	Gas	1962	Power	MISSOULA
70,203,000	UNIV OF MONTANA-P HOUSE	Gas	1965	Power	MISSOULA
62,853,000	ADVANCED SILICON MATERIALS	Gas	1997	Wtr Ht	BUTTE
60,000,000	ROSEBURG FOREST PROD-BLRM	Gas	1969	Process	MISSOULA
60,000,000	SIDNEY SUGARS INC -	Gas/Oil	1966	Process	SIDNEY
60,000,000	PLUM CREEK TIMBER - BLR RM	Wood	1990	Process	PABLO
50,000,000	MSU - CENTRAL PLANT	Gas	1968	Stm Ht	BOZEMAN

Table 3. Ten cities with the largest sum of boiler sizes

CITY	SUM OF BOILER SIZES (BTU/hr)	NUMBER OF BOILERS
GREAT FALLS	865,090,239	620
HELENA	612,840,594	457
BUTTE	539,816,008	314
BOZEMAN	412,060,121	321
KALISPELL	383,314,630	261
SIDNEY	286,582,623	90
HAVRE	259,418,698	175
DILLON	196,523,701	70
COLUMBIA FALLS	184,037,402	58
MILES CITY	176,979,544	132

Small boiler systems can often be replaced or displaced with small wood chip or pellet fuels systems with low capital costs. Large systems have greater capital costs, but also may have greater annual demand for fuel. The boiler size listed in the database may or may not be a good indicator of actual BTU demand or boiler usage. Experience suggests that boiler size is not a direct indicator of potential project viability.

Current Fuel Source

The boiler database lists the current fuel source used to power each boiler. The fuel sources listed are gas, gas/oil, wood, hog, coal, electric, and other. Unfortunately, the database does not distinguish between natural gas and propone. Gas/oil indicates that the boiler can use either gas or oil as a fuel source; however, it is believed that the majority of the gas/oil boilers use gas as their primary fuel source, with oil used only as a back-up fuel. Table 4 presents the number of boilers listed in the database for each fuel type available.

Table 4. Number of boilers listed for each available existing fuel type

EXISTING FUEL	NUMBER OF BOILERS
Gas*	6,202
Gas or Oil	299
Oil	273
Other	208
Coal	116
Electric	101
Wood	34
Hog Fuel	2

*The database does not distinguish between natural gas and propane.

The vast majority (89%) of the 7,239 boilers in the database list "Gas" or "Gas/Oil" as the existing fuel source.

In order for a boiler conversion project to be viable, the existing fuel source should cost more than the potential biomass fuel cost. Estimated current costs for existing fuel sources are presented below.

- Electric: $25/ million BTU[4]
- Fuel Oil: $10/ million BTU
- Natural Gas: $8/ million BTU
- Coal: $3/ million BTU

These costs can be compared to the estimated biomass fuel costs presented below:

- Wood Chips: $3/ million BTU (based on $35/green ton)
- Wood Pellets: $7/ million BTU

The fuel cost estimates suggest that electric boilers would make strong candidates for conversion. A list of the 101 boilers with electricity listed as the fuel source is presented in the appendix. The ten largest electric boilers are presented in Table 5. Table 6 presents a list of the ten oldest electric boilers in the state. Table 7 presents a list of cities that have 2 or more electric boilers.

[4] 1 million BTU = 1 decatherm

Table 5. Ten largest electric boilers in the state

SIZE (BTU/hr)	FACILITY	MANU YEAR	FAC TYPE	USE	CITY
8,000,000	INLAND TRUCK PARTS	2001	N/A	Wtr Ht	MISSOULA
3,600,000	NORMAN DALE PROPERTIES	1984	N/A	Wtr Ht	BILLINGS
3,280,420	SHERATON HOTEL - 23RD FLOOR	1965	N/A	Wtr Ht	BILLINGS
1,560,000	PRINCE INC-TRUCK REPAIR SHOP	1975	N/A	Wtr Ht	FORSYTH
900,000	ST LUKES HOSPITAL – BLR RM	1975	Hospital	Wtr Sp	RONAN
856,800	EDGERTON ELEM-BLR RM	1987	School	Wtr Ht	KALISPELL
765,000	JC PENNEY STORE #1981-PEMT	1979	N/A	Wtr Ht	MISSOULA
735,000	CENTURYTEL	1972	N/A	Wtr Ht	KALISPELL
666,000	GLENDIVE MEDICAL CTR-SRGRY RM	1980	Hospital	Stm Ht	GLENDIVE
630,000	MEMORIAL HOSP-SURGERY RM	1996	Hospital	Power	HARDIN

Table 6. Ten oldest electric boilers

MANU YEAR	SIZE** (BTU/hr)	FACILITY	FAC TYPE	USE	CITY
1900*	57,800	ENDO BIOLOGICS INC	N/A	Proc	MISSOULA
1908*	1	GARY YAEGER - YARD	N/A	Other	KALISPELL
1965	1	RAND HATS-MECH RM	N/A	Power	BILLINGS
1965	3,280,420	SHERATON HOTEL - 23RD FLOOR***	N/A	Wtr ht	BILLINGS
1966	1	MISSOURI RIVER MEDICAL CENTER	N/A	Proc	FORT BENTON
1970	120,000	KEG BAR & CASINO	N/A	Wtr ht	ROUNDUP
1972	735,000	CENTURYTEL	N/A	Wtr ht	KALISPELL
1975	204,000	ST LUKES HOSPITAL-PENT 2ND FLR	Hospital	Other	RONAN
1975	1,560,000	PRINCE INC-TRUCK REPAIR SHOP	N/A	Wtr ht	FORSYTH
1975	900,000	ST LUKES HOSPITAL - BLR RM	Hospital	Wtr sp	RONAN
1977	126,000	PENGUIN BREWERY	N/A	Proc	MISSOULA
1977	126,000	STAR OFFICE MACHINES	N/A	Wtr ht	BILLINGS

*These dates may represent data entry errors.
**Boiler sizes listed as "1" appear to be placeholders and were ignored for the purpose of data analysis.
***A boiler located on the 23rd floor would not be a likely candidate for conversion unless the boiler was moved.

Table 7. Cities with two or more electric boilers

CITY	NUMBER OF ELECTRIC BOILERS	SUM OF BOILER SIZES (BTU/hr)
MISSOULA	12	9,621,202
BILLINGS	13	7,621,422
FORSYTH	2	2,160,000
KALISPELL	6	1,837,323
RONAN	5	1,778,000
GREAT FALLS	7	1,415,001
LIBBY	4	994,115
BROWNING	6	959,250
FRENCHTOWN	2	932,000
FORT HARRISON	2	532,000
CROW AGENCY	3	306,000
WOLF POINT	3	275,000
ROUNDUP	2	190,000
HAMILTON	2	142,800
HELENA	2	123,600

Age of Boiler

The boiler database presents the age of boilers in terms of the year the boiler was manufactured. For the purposes of this study, it was assumed that the boilers were installed and put into operation the same year that they were manufactured.

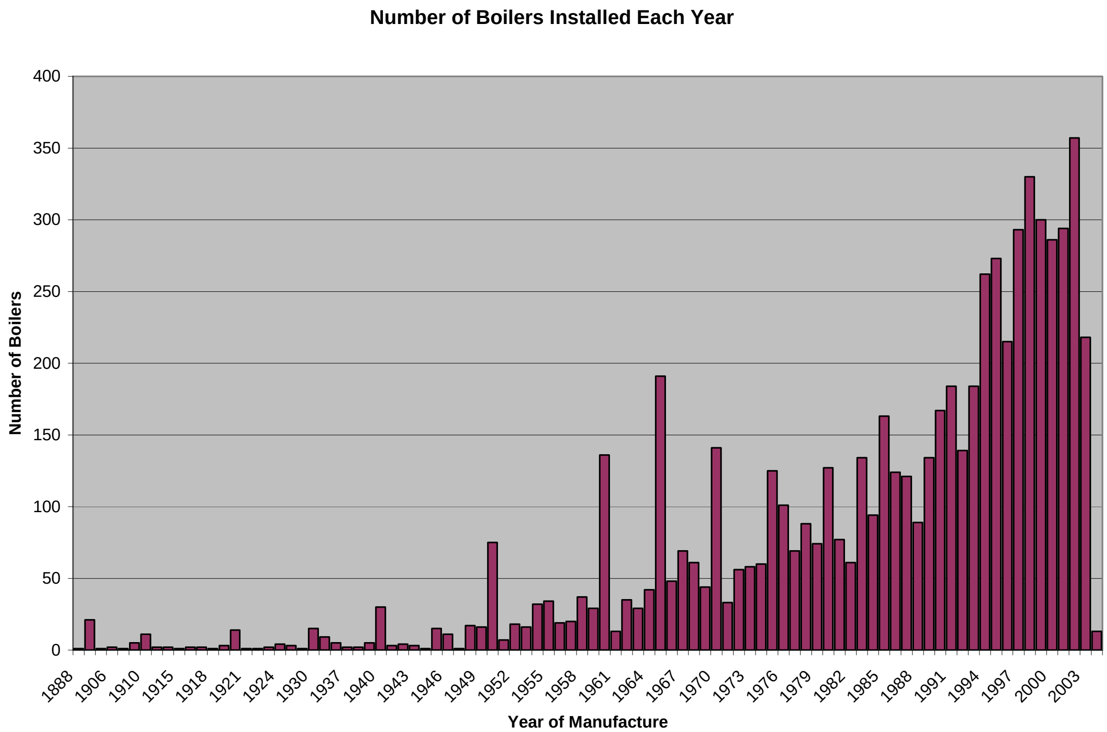
Examination of the database indicates that 4,455 (62%) of the active boilers in the state were installed within the past 20 years (since 1985); 1,842 boilers (25%) are 21 to 40 years old; 644 (9%) are 41 to 60 years old; and 298 (4%) are more than 60 years old. Table 8 presents the number of boilers that fall within selected age ranges.

Table 8. Number of boilers listed for each age range based on year manufactured

BOILER AGE RANGE	NUMBER OF BOILERS
0-20 years	4,455
21-40 years	1,842
41-60 years	644
61+ years	298

Boiler age data are also presented in Figure 1 which illustrates the number of boilers installed each year in Montana.

Figure 1. Number of boilers installed each year in Montana



The useful service life of most boilers is between 20 and 40 years depending upon fuel type, annual use, and maintenance history. Boilers less than 20 years old are not likely to be replaced; however, if a facility is currently heated with an electric or propane boiler, even a building with a very new boiler might remain a viable conversion project. Boilers greater than 40 years of age are often scheduled for replacement. Although some facilities managers maintain boiler systems that are up to 100 years old, it can be assumed that boilers over 60 years old would be good candidates for replacement. Table 9 presents selected information for the ten cities with the greatest number of boilers over 60 years old. A more complete version of this table can be found in the appendix.

Table 9. Ten cities with the greatest number of boilers over 60 years old

CITY	NUMBER OF BOILERS	LARGEST (BTU/hr)	AVERAGE SIZE (BTU/hr)	SUM OF SIZES (BTU/hr)
MISSOULA	42	8,156,000	832,131	34,949,501
GREAT FALLS	25	14,000,000	1,623,928	40,598,205
BUTTE	20	4,500,000	876,100	17,522,004
KALISPELL	19	6,000,000	1,182,632	22,470,002
HELENA	18	8,500,000	2,131,722	38,371,002
BILLINGS	17	5,000,000	1,615,118	27,457,004
BOZEMAN	13	4,000,000	929,539	12,084,005
DILLON	12	2,500,000	619,583	7,435,000
BELGRADE	11	1,820,000	165,455	1,820,010
ANACONDA	7	7,000,000	1,862,857	13,040,000

Facility Type

The boiler certificate database provides listings of facility type for boilers that are located in schools, hospitals, day care centers, rest homes, assisted living facilities, retirement centers, public assembly building with occupancies over 100, and churches; all other boilers are listed with a facility type of "Not Applicable". A more in-depth examination of the boilers with a "Not Applicable" listing could reveal many of the facility types based on the owner and facility listed, but that level of analysis was beyond the scope of this study. Table 10 presents the number of boilers listed for each of the facility types provided in the database.

Table 10. Number of boilers listed for each available facility type

TYPE OF FACILITY	NUMBER OF BOILERS
Not Applicable	4,520
School	1,501
Church	362
Hospital	318
Public Assembly	227
Rest Home	190
Assisted Living	52
Retirement Center	52
Day Care	17

Boilers with the greatest viability for conversion are those used in facilities that have a sustained demand for space heat and hot water and/or a large power or process demand, such as hospitals, nursing homes, prisons, and industries. Facilities that provide only space heat (such as civic and commercial buildings) are not as viable for conversion as facilities that add a hot water load to the system (such as commercial buildings, schools, and dormitories with showers and kitchens).

For the purposes of this study, the facility type listed in the database was represented by an assumed facility utilization factor (FUF). The FUF is equivalent to the fraction of time a boiler is running at full capacity. Facilities with heavy or more uniform boiler demands have higher FUFs. Facilities with lighter or more intermittent boiler demands have lower FUFs. Hospitals, for example, have a relatively high facility utilization factor, whereas the FUF for a building used for public assembly would be relatively low. For this study, FUFs were assigned based on the stated facility type; however, many other factors could affect actual boiler usage. For example, facilities with redundancy or over-capacity in the boiler system would have a lower FUF than a similar facility type without redundancy or over-capacity. The FUF is a relative index and cannot be used to directly estimate fuel consumption.

Hospitals were assumed to have the highest FUF of the facility types listed in the database, which makes them strong candidates for conversion. The database indicates that there are 318 boilers located in hospitals. Table 11 presents selected information for the ten cities with the greatest number of hospital boilers. A more complete version of this table can be found in the appendix.

Table 11. Ten cities with the greatest number of boilers located in hospitals

CITY	NUMBER OF HOSPITAL BOILERS	AVERAGE BOILER SIZE (BTU/hr)	SUM OF SIZES (BTU/hr)	OLDEST	NEWEST	AVG MANU YEAR
BILLINGS	29	3,304,138	95,820,004	1964	2002	1991
GREAT FALLS	18	4,959,333	89,268,000	1975	2003	1995
BOZEMAN	17	2,110,882	35,885,000	1967	2003	1993
MISSOULA	17	5,117,588	86,999,001	1970	2001	1987
RONAN	12	537,333	6,448,000	1975	2001	1991
WARM SPRINGS	10	3,662,700	36,627,000	1970	1999	1995
BROWNING	10	2,063,475	20,634,750	1961	1990	1982
CHESTER	10	339,000	3,390,001	1989	2001	1993
BUTTE	9	5,890,000	53,010,000	1987	2002	1997
KALISPELL	8	1,096,940	8,775,520	1977	1998	1995

Boiler Use

The boiler database list 6 different kinds of boiler uses: space heating using water (water heating), space heating using steam (steam heating), hot water supply, process heat, power, and other. About two thirds of the boilers are used for water heating, with another 16% used for steam heating. Table 12 presents the number of boilers listed for each of the uses provided in the database.

Table 12. Number of boilers listed for each available boiler use

BOILER USE	NUMBER OF BOILERS
Water Heating	4,900
Steam Heating	1,176
Hot Water Supply	621
Process	418
Power	73
Other	51

As indicated above, boilers that are used only for space heating are not as viable for conversion as boilers that are also used for supplying hot water supply (such as commercial buildings, schools and dormitories with showers and kitchens). Boilers with the greatest viability for conversion include those with a sustained demand for space heat and hot water such as hospitals, nursing homes, prisons, industrial users (including facilities with a large power demand).

Boiler Location

The location of each boiler in the database is listed as a complete street address or, at a minimum, by city or town. Figure 2 presents the location of the boilers across the state, using the town as the locator (only those boilers with complete addresses are mapped).

The database lists 257 cities across Montana that have at least one boiler. Fifteen of the cities represented in the database have more than 100 boilers; 25 have more than 50 boilers; 91 cities have 10 or more boilers; and 90 of the cities in the database (35% of them) have only one or two boilers. As can be seen from Table 13 some of Montana's largest cities also have the greatest number of boilers, as might be expected. The boilers in these 20 cities represent about 70% of all the boilers in the state.

Figure 2. Locations of Existing Boilers in Montana

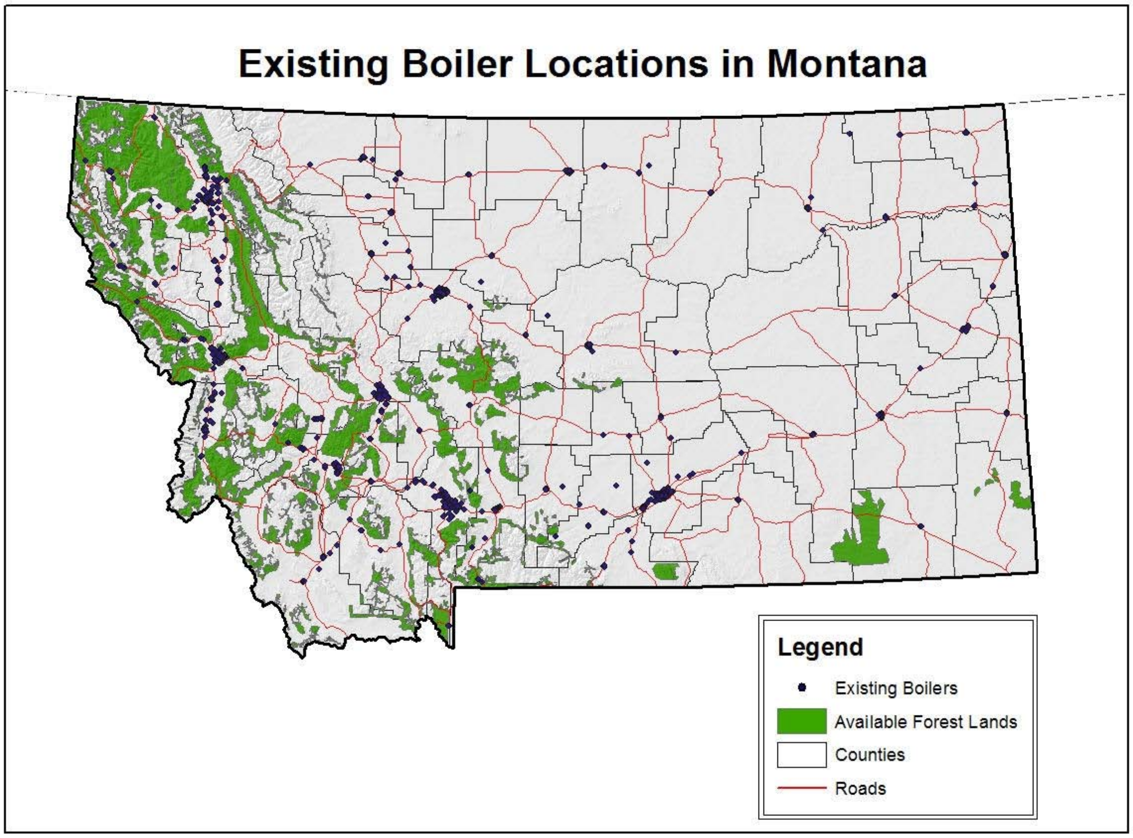


Table 13. Twenty cities with the greatest number of boilers

CITY	NUMBER OF BOILERS
BILLINGS	924
MISSOULA	718
GREAT FALLS	620
HELENA	457
BOZEMAN	321
BUTTE	314
KALISPELL	261
HAVRE	175
LEWISTOWN	149
DEER LODGE	136
MILES CITY	132
GLENDIVE	123
LIVINGSTON	109
BELGRADE	107
HAMILTON	102
SIDNEY	90
RED LODGE	74
DILLON	70
WHITEFISH	70
ANACONDA	63

Boilers located in cities closer to forested lands – the source of woody biomass fuel – would typically have lower biomass fuel costs. Proximity to forested lands may also be an indicator of a viable forest products industry that may be able to provide the infrastructure necessary to supply the wood chips or pellet fuel to the facility.

Table 14 presents the acreage of potentially harvestable forested lands on National Forests within a 50-mile radius of the boilers within the cities with the greatest number of boilers. The forested area listed for each city excludes forests in national parks, wilderness areas, and roadless areas. It also excludes areas outside of the state of Montana. It also excludes forested lands on school trust lands and other state lands and on all corporate and other private lands. It was beyond the scope of this initial analysis to fully examine wood chip and wood pellet supply issues. The acreages listed in Table 14 represent the average of the acreages of potentially harvestable National Forest lands within 50 miles of all the boilers in each city. Of the total of 7,239 boilers in the state, only 5,301 boilers had addresses listed that could be used to determine forested acres with the GIS method used. Of those boilers, 4,938 were within 50 miles of a forested area. A list of forested lands for all cities for which data were available is presented in the Appendix.

Table 14. National forest lands within 50-mile radius of selected cities

CITY	NUMBER OF BOILERS	FORESTED LANDS (acres)
BILLINGS	924	72,128
MISSOULA	718	1,336,114
GREAT FALLS	620	223,847
HELENA	457	1,060,114
BOZEMAN	321	848,380
BUTTE	314	1,203,426
KALISPELL	261	1,829,127
HAVRE	175	0
LEWISTOWN	149	0
DEER LODGE	136	1,283,853
MILES CITY	132	21,210
GLENDIVE	123	7,212
LIVINGSTON	109	786,840
BELGRADE	107	894,579
HAMILTON	102	1,180,310
SIDNEY	90	8,051
RED LODGE	74	210,979
DILLON	70	598,770
WHITEFISH	70	1,752,546
ANACONDA	63	1,411,842
COLUMBIA FALLS	58	1,623,457

The sum of boiler sizes for each of the 20 cities with the greatest number of boilers is presented in Table 15. The sum of boiler sizes can be used to estimate the total BTU/hr demand if all of the boilers in the city were converted to use wood as their fuel source. Boiler age information for the 20 cities with the greatest number of boilers is presented in Table 16.

Table 15. Sum of boiler sizes for the 20 cities with the greatest number of boilers

CITY	NUMBER OF BOILERS	SUM OF BOILER SIZES (BTU/hr)
BILLINGS	808	1,208,784,113
MISSOULA	651	1,059,931,390
GREAT FALLS	578	863,207,200
HELENA	441	611,640,579
BOZEMAN	295	411,925,098
BUTTE	275	536,452,975
KALISPELL	221	379,215,598
HAVRE	172	259,418,695
LEWISTOWN	138	123,806,999
DEER LODGE	131	163,137,000
MILES CITY	119	176,674,532
GLENDIVE	117	136,571,000
LIVINGSTON	103	105,278,500
HAMILTON	98	74,456,410
BELGRADE	95	62,516,386
SIDNEY	74	286,582,609
RED LODGE	71	37,465,500
WHITEFISH	64	83,658,000
ANACONDA	63	104,685,400
DILLON	62	194,588,700

Table 16. Boiler age statistics for the 20 cities with the greatest number of boilers

CITY	NUMBER OF BOILERS	OLDEST BOILER	NEWEST BOILER	AVERAGE BOILER AGE	STANDARD DEVIATION OF BOILER AGE
		(Year of Manufacture)			(Years)
BILLINGS	808	1910	2004	1984	15
MISSOULA	651	1900	2003	1986	18
GREAT FALLS	578	1900	2003	1983	18
HELENA	441	1908	2004	1983	19
BOZEMAN	295	1888	2004	1985	17
BUTTE	275	1917	2004	1981	18
KALISPELL	221	1900	2003	1985	21
HAVRE	172	1950	2003	1988	13
LEWISTOWN	138	1940	2003	1985	15
DEER LODGE	131	1900	2003	1984	14
MILES CITY	119	1930	2004	1986	17
GLENDIVE	117	1950	2003	1985	14
LIVINGSTON	103	1920	2003	1986	14
HAMILTON	98	1935	2003	1989	15
BELGRADE	95	1910	2003	1992	14
SIDNEY	74	1935	2002	1979	14
RED LODGE	71	1922	2003	1982	19
WHITEFISH	64	1924	2003	1988	18
ANACONDA	63	1917	2003	1980	24
DILLON	62	1910	2002	1982	21

COMMERCIAL POTENTIAL

Determining the commercial potential of a product or service requires attempting to measure the likely degree of market acceptance. An accurate measurement requires analysis of a range of market, technical, economic, financial, and oftentimes broad stake-holder issues.

Using the data compiled in the previous section, this study attempts to identify the potential size and scope of a commercial wood-fired boiler market in Montana. The analysis is based solely on simple payback through annual fuel savings on a boiler conversion investment.[5] While limited in accuracy, simple payback[6] is an initial indicator, from a facility owner's point of view, of how attractive the investment in conversion would or would not be given current conditions. There is a range of other factors and drivers including receptivity to new technologies, confidence in availability and price stability with wood fuel, government subsidies, and logistical uncertainty of wood handling and storage. These issues are discussed in the next section, but an in-depth analysis of these factors is beyond the scope of this study.

The simple payback calculations (spreadsheet provided separately on CD) rely on a set of assumptions regarding facility utilization factors, boiler efficiencies, fuel prices, and new boiler system costs. These assumptions and the equations used to calculate paybacks are presented in the Appendix. Two scenarios were developed to differentiate between payback periods when boiler replacement is likely necessary (payback if you are planning on replacing the boiler anyway), and when it is not (payback if you don't have to replace the boiler). Table 17 presents the results of the analysis divided into the two scenarios:

Table 17. Payback periods for all boilers

PAYBACK SCENARIOS -- ALL BOILERS				
payback if replacing anyway	**number of boilers**		**payback if you don't have to replace**	**number of boilers**
< 5 years	222		< 5 years	31
5 to <10 years	170		5 to <10 years	48
10 to <15 years	2,175		10 to <15 years	0
15 to 20 years	484		15 to 20 years	14
> 20 years	3,538		> 20 years	6,496

Tables illustrating the number of boilers in selected payback ranges for boilers sorted by existing fuel source, size, and city are presented in the Appendix.

[5] This study does not include commercialization for new facilities, but is limited to modification and/or replacement of existing boiler systems given the data for the state of Montana.
[6] "Simple Payback" measures the time required to recover investment costs. Though useful, it is a limited analysis because it ignores the time value of money.

For the purposes of this study, it was assumed that the commercial potential for conversion was strongest for boilers that have a *payback of 15 years or less*. The 15 -year threshold is somewhat arbitrary, but is used to indicate a limit at which the attractiveness of the investment begins to diminish. This 15-year payback threshold may decrease or increase depending on a number of factors, including the type of facility (small business, hospital, school, nursing home, etc.). For example, it is expected that institutional facilities will have a greater tolerance for longer payback periods than small business.

Boilers Not Requiring Replacement -- Payback < 15 Years

The "lowest hanging fruit" for boiler conversion would be those boilers that have a payback period of less than 15 years even when boiler replacement is not required. In these cases, the annual fuel savings generated by the conversion would pay for the installation of a new wood boiler system in less than 15 years.

As indicated in Table 17, the analysis indicates that there are 79 boilers with payback periods less than 10 years when boiler replacement is not required (none had paybacks between 10 and 15 years). These 79 boilers represent about 1% of all existing boilers in the state. Replacing all of these boilers with new wood burning boilers would require approximately $1.3 million in aggregate investment.

Analysis of these boilers indicate that all currently use electricity as their existing fuel source, and almost all are less than 500,000 BTU/hr size. It is interesting to note that for boilers in this size range, it is likely to be more economical to use wood pellets rather than wood chips as a fuel. Of these 79 boilers, 34 are located in hospitals (the remaining 28 were listed as "not applicable").

Observation: *The commercial potential for boiler conversion in situations where a new boiler is not needed appears quite limited in terms of market size on a statewide scale.*

Boilers Requiring Replacement – Payback < 15 Years

The next "lowest hanging fruit" for boiler conversion would be those boilers that have a payback period of less than 15 years when boiler replacement is required. In these cases, the annual fuel savings generated by the conversion would pay for the *additional expense* of installing a new wood boiler over that required for a new gas boiler.

Table 17 indicates that there are 2,567 boilers with payback periods less than 15 years when boiler replacement is required. Replacing all of these boilers with new wood burning boilers would require approximately $49 million in aggregate investment.

Analysis of this group of boilers indicates that 44 of them are over 60 years old, and total of 367 of them are at least 30 years old; ages that indicate that they may be scheduled for replacement in the relatively near future. Replacing all of boilers that are at least 30 years old would require approximately $8.2 million in aggregate investment.

All but 13 of these 2,567 boilers are less than 500,000 BTU/hr in size, which, as stated above, indicates a greater likelihood to use pellets rather than wood chips if conversions were to occur. 2,108 of these boilers are listed with "not applicable" as the facility type, but 172 are listed as public assembly; 132 are listed as assisted living, rest home, or retirement center; 100 are located in hospitals; and 40 are listed as being located in schools. Most of these boilers (2,286) list gas or gas/oil as their existing fuel source, but 88 of them currently use electricity.

Observation: *There appears to be a potential market size of 367 boilers that are likely ready for replacement and that would have a payback of less than fifteen years. These boiler conversions represent an estimated market size of $8.2 million in aggregate investment.*

ADDITIONAL OPPORTUNITIES and BARRIERS

Converting existing boilers to wood burning boilers represents several types of potential opportunities and barriers. The commercialization section of this report discusses the opportunities and barriers associated with finances and market size. This section presents a selection of additional issues that could represent potential opportunities or potential barriers to large-scale boiler conversion.

Governments Drivers

The Healthy Forest Restoration Act (2003) is intended to result in the thinning of thousands of acres of forest, generating large quantities of woody biomass. Much of this biomass is expected to be of low value, requiring disposal. Large scale boiler conversions have the potential to provide a steady, long-term demand for this material, creating a win-win situation for forest managers and boiler owners. The draft Energy Bill and the 2002 Farm Bill support this Act by including incentives for the removal and beneficial use of excess woody biomass.

These drivers are reflected in the formation of the USDA Forest Service Woody Biomass Utilization Team, designed “to promote and facilitate the planning and delivery of an integrated, interdisciplinary approach to the recovery and utilization of woody biomass from ecological restoration and hazardous fuels reduction work as a result of the National Fire Plan’s 10-year Comprehensive Strategy, the Healthy Forests Initiative, and the Healthy Forests Restoration Act.” [i]

Other potential government drivers for boiler conversions to wood-based fuel include those programs related to renewable energy, homeland security, energy independence, distributed energy (avoidance of massive blackouts), carbon sequestration, rural development, economic development, and pollution prevention.

Economic Development and Service Infrastructure

According to the Montana Wood Products Association (MWPA), about 11,100 people in Montana currently hold job in logging and milling, down from a peak of 13,500 in 1978. In the late 1990’s, Montana's forest products industry accounted for 15% of basis industry labor income and 10% of the state's basic employment. MWPA suggests that future stability in these employment areas depends on increases in the national forest timber sale program, which in turn hinges on wide public acceptance of Forest Service plans for thinning Montana's national forests. [ii] Large scale boiler conversion projects could help drive the demand for otherwise low-value forest thinning materials and, in doing so, help stabilize and enhance the wood products industry in Montana. Large scale boiler conversions could also lead to the creation of new boiler-related industries that are now concentrated in the mid-west and east.

Environmental and Political Issues

The feasibility of a given boiler conversion project will depend on resolution of a number of regulatory, permitting, and political issues. In order to be feasible, the proposed conversion project must be able to mitigate environmental impacts to the satisfaction of the regulatory agencies, citizens, communities, and other stakeholders. Investigating the full range of regulations that would need to be addressed when developing a boiler conversion project is beyond the scope of this study; however, selected issues that are likely to have the be addressed are described in this section.

For smaller boilers, conversion to using wood pellets may be more economical than converting to using wood chips as a fuel source. Pellet consistency and burn efficiency produces significantly less particulate emissions of raw wood. Pellet burners generate lower particulate matter emissions than all other solid fuels burners and meet even the most stringent EPA requirements. [iii] An additional benefit of pellets is that materials other than wood can be used as a raw material. For example, fuel pellets are being made from such materials as agricultural wastes, animal wastes, and municipal solid wastes. These options both diversify the sources of potential raw materials for pellet manufacturing, but also provide a beneficial outlet for waste materials. Wood pellet manufacturing is very limited in Montana at this time.

Issues Related to Feedstock

The Fuels for Schools program originated, in part, from "the need to provide a safe and timely means of disposing of unmarketable small woody material that was removed from the land to reduce the risk of catastrophic forest fires." [iv]

Estimates suggest that forest thinning operations in western Montana could generate roughly 10 wet tons/acre on a 35-year harvest cycle. Assuming a wood fuel value of 10.8 million BTU/wet ton, these values suggest that forest thinning operations could provide roughly 108 million BTU/acre each time it is harvested, or an average of 3 million BTU per acre as a sustainable yield. This can be compared to a ballpark boiler demand that might be estimated to be 1,250 million BTU/year per million BTU/hr boiler size[7]. Based on these values, it would take the thinning of about 12 acres per year, or a total of 400 acres total on a 35 years harvest cycle, to supply the needs of a 1 million BTU boiler. These estimates will, of course, vary significantly depending on the characteristics of the boiler and the facility it serves as well as the characteristics and harvest objectives of the forest used for supply.

The most notable limitation to feedstock availability is that the federal government currently does not enter long-term contracts for harvesting on National Forest lands, which is usually required for financing. Private lands make up a large percentage of potentially harvestable forest lands in Montana; however, it is unknown whether or not these lands are in a condition suitable to meet yields described above.

[7] Based on a wood boiler efficiency of 70% in a facility with a utilization factor of 0.10.

A rule-of-thumb for private financing and development of a biomass power plant is that feedstock availability must be 2 to 3 times the amount necessary for sustained operations.[v] This requirement came out of negative experiences of financial institutions in the 1980's. Adding this requirement suggests there would need to be 800 to 1,200 acres of forest available to supply the fuel needed for a 1,000,000 BTU/hr boiler.

With proper forest management, woody material can be continually replenished and thus has the potential to provide a sustainable and dependable feedstock supply[vi] . Under these conditions, wood-fueled boilers represent a use of renewable energy. Unlike renewable energy derived from wind, solar, hydropower, and geothermal resources, using wood as a source of energy has the potential to benefit the resource from which is was derived. [vii] However, regardless of perceived benefits, the potential environmental impacts of forest thinning activities will attract the concern of environmental organizations, and they may choose to take political actions to restrict such activities. The political activities that may result from real and perceived environmental impacts of forest thinning activities represent a risk to feedstock reliability and feasibility.

In addition to increasing forest harvest activities, feedstock deliveries would increase truck traffic in the region, particularly in the immediate vicinity of the boiler facility. Deliveries would typically be achieved with a 15-20 ton tractor-trailer chip van with a live floor. A facility burning 500 tons of wood chips may have as many as 25-30 truck loads during a heating season (from October-April), with more frequent deliveries during the peak heating season (December-February). Like forest thinning activities, additional truck traffic created by the facility may be opposed by local organizations which may choose to take political action to restrict such activities. The political activities that may result from real and perceived impacts of increased truck traffic represent a risk to feedstock feasibility.

In western Montana, weather conditions limit harvesting and hauling activities to about 200 days per year[viii]. Because deliveries cannot be made year-round, the boiler facility would need storage space for wood fuel. The footprint of a biomass boiler building would be approximately 30 x 50 feet in size and requires access for delivery vehicles. Most boiler rooms are not sized adequately to allow for the installation of a wood chip boiler. The need for storage increases capital costs and increases the impact that the facility has on local land use. The level of local impact created by a wood fuel storage area may also be opposed by local organizations which may choose to take political action to restrict such land use.

Issues related to Air Quality

Wildfires in overstocked and fire-suppressed forests pour huge quantities of smoke into the air that spreads across the country and beyond. The U.S. Forest Service (USFS) reports that "dense plumes of smoke (from wildfires) can be transported over hundreds of kilometers across State and international boundaries." It also reports that "several communities in the United States have experienced particulate matter concentrations from wildfire smoke that exceeded EPA's significant harm emergency action level of 600 ug/m^3, defined as an 'imminent and substantial endangerment of public health'" (EPA 1992b).[ix] Prescribed burning and burning of slash piles result in localized, but more frequent, generation of air pollution. The Forest Service reports that "On a national basis, PM10 emissions from prescribed burns in 1989 were estimated to be over 600,000 tons. Seven states (including Montana) were estimated to have annual emissions over 10,000 tons of PM10 from prescribed forest and rangeland burning (EPA 1992a; Peterson and Ward 1990)."[x]

One driver in the conversion of existing boilers to wood-fueled boilers is finding beneficial uses for SDU to help reduce the amount of air pollution caused by wildfires, prescribed burns, and burning of slash piles. Though modern boilers can be designed to burn wood very cleanly, any proposed boiler conversion project would be closely scrutinized for potential pollution discharges, particularly discharges affecting air quality.

There are several areas in Montana that experience various problems with air quality, including several areas that are listed as state or federal air quality non-attainment areas for different constituents. Although wood-burning boilers have the potential to reduce pollution compared to in-situ burning or compared to existing fuel burning, non-attainment status will make it more difficult and more expensive to establish a new wood burning facility that has the potential to discharge pollutants to the air[xi]. Permitting such a facility would likely fall under the jurisdiction of the Montana DEQ and may, under some circumstances, require an EA (Environmental Assessment) which could take years to complete.[xi]

In addition to local air quality issues, Regional Haze Laws are scheduled to be coming into effect soon in Wyoming and Montana. It is as yet unclear what these laws will mean for Montana or for a wood-burning facility. It is likely that these laws would prohibit slash burning, which could be beneficial for feedstock availability, but hauling and burning slash at a co-gen plant may or may not be viewed as a positive trade-off.[xi]

Facility-Specific Issues

The previous section of this report presented economic issues related to boiler conversion; however, there are numerous other factors that might affect the potential likelihood of converting a boiler system at a particular facility. Some considerations are listed below.

Boiler conversions are more likely for the following situations:

- Facilities located near other biomass boiler systems.
- Facilities located near wood waste producers (for example: log home builders, post and pole mills, and other mills).
- Facilities that have significant forested acres under their control (for example: Stevensville and Seeley Swan High School each have forest acres owned by the school).
- Facilities located in areas without access to natural gas.
- Facilities located in rural areas.

- Facilities that could burn pellets

Boiler conversions are less likely for the following situations:

- Facilities with intermittent heating demands and high peak loads.
- Facilities with electric base board heat or numerous heat sources.
- Facilities lacking access to the boiler room.
- Facilities requiring significant buried pipe between biomass boiler building and existing system.
- Facilities with energy efficient building envelopes that consume very little heat energy.
- Facilities with significant space constraints.

STRATEGIC RECOMMENDATIONS

The USFS is interested in assisting in the development of viable commercial uses of woody materials removed from our forests for hazardous fuel reduction. The Fuels for Schools program is the demonstration phase of a 3-phase USFS initiative to promote and encourage the use of wood biomass as a renewable, natural resource to provide a clean, readily available energy source suitable for use in heating systems in public and private buildings. The next phase of this initiative involves expanding this concept and transitioning towards commercialization.

Successful transition of the Fuels for Schools program to commercialization will depend on the development of a *business ecosystem*[8] that encompasses USFS goals for forest thinning operations and market incentives for conversion to wood-fueled boilers. A complete shift to commercialization requires market-driven economics that support investment in boiler conversion from both the consumer and the vendor perspectives.

The findings of this study indicate the need to pursue three activities to further efforts towards commercialization of the Fuels for Schools concept:

- Engage key stakeholders
- Assess wood resource viability
- Explore additional partnerships, drivers, and opportunities
- Disseminate information

Engage key stakeholders in next steps

The USFS should engage key stakeholders within the potential wood-fired boiler business ecosystem to highlight the areas where USFS should focus future efforts in facilitating commercialization.

USFS should start with facility owners from among the groups of boilers considered to be strong candidates for conversion, then continue by engaging boiler manufacturers, with a focus on smaller boilers; wood suppliers, processors, and distributors (logger, haulers, mills, etc.), and pellet manufacturers. These conversations should be used to elicit feedback, identify additional information needs, and explore additional drivers and barriers.

Information generated to date suggests that wood-fired boilers can be a viable in some applications and that there could be a potential commercial market for boiler conversions and replacements. Refining this general information will require input from the stakeholder groups that would have to take financial risks to make commercialization

[8]A *business ecosystem* is a community of organizations and stakeholders (players) operating within a particular business environment, which collaborate and compete in an economic web of relationships. These relationships co-evolve through time subject to the general forces in the business environment and the specific moves made by the web of players.

happen. Such discussion might focus on issues related to business expansion requirements, retooling requirements, financing issues, fuel costs and availability, site logistics and boiler parameters, etc. The resulting information would further clarify the potential size, scope, and viability of the market for wood-fueled boilers.

Assess wood resource viability

The USFS should identify and evaluate harvestable forested acreages, ownership classes, and potential yields within selected distances of boilers or boiler clusters.

Successful large-scale boilers conversions will require a long-term supply of woody biomass fuel that is economically and environmentally viable. Although the goal of the Fuels for Schools program is to find viable commercial uses of woody materials removed for hazardous fuel reduction, to date, accessing that wood supply has been challenging and represents an investment risk. The attraction of annual fuel savings in boiler conversion could be nullified by a perception of risk in the wood fuel supply. For example, financial institutions may require a secure fuel supply for a defined period of time. If wood is to compete with natural gas, fuel oil, coal, and electricity, there must be some assurances that changes in forest management policy will not endanger the reliable long-term fuel supply that would secure a boiler conversion investment.

Explore additional partnerships, drivers, and opportunities

The USFS should also explore the potential for partnering with other interests that may have additional unique drivers and opportunities that could leverage steps towards commercialization. Such potential partners might include:

- American Institute of Architects (AIA)
- American Society of Mechanical Engineers (ASME)
- School Trust Lands (DNRC & State Lands Board)
- Local Economic Development Agencies
- The Pellet Fuels Institute (PFI)
- The American Boiler Manufacturers Association (ABMA)
- U.S. Department of Energy (DOE) Energy Efficiency and Renewable Energy (EERE) program and National Renewable Energy Lab (NREL)
- The Energy Services Coalition (ESC). ESC is a national nonprofit organization composed of a network of experts from a wide range of organizations working together at the state and local level to increase energy efficiency and building upgrades through energy savings performance contracting. Energy savings performance contracting enables building owners to use future energy savings to pay for up-front costs of energy-saving projects, eliminating the need to dip into capital budgets. ESC provides its members with many resources to facilitate performance contracting projects, energy efficiency improvements, and building upgrades. xii
- Energy Service Companies (ESCO). Energy Services Companies (ESCOs) offer performance contracting services that can identify and evaluate energy-saving opportunities and then recommend a package of improvements to be paid for

through savings. The ESCO will guarantee that savings meet or exceed annual payments to cover all project costs—usually over a contract term of seven to 10 years. If savings don't materialize, the ESCO pays the difference, not the consumer. To ensure savings, the ESCO offers staff training and long-term maintenance services. ESCOs typically:

  - Identify and evaluate energy-saving opportunities;
  - Develop engineering designs and specifications;
  - Manage the project from design to installation to monitoring;
  - Arrange for financing;
  - Train your staff and provide ongoing maintenance services; and
  - Guarantee that savings will cover all project costs. [xii]

- Other states' programs. For example, the State of Vermont Department of Public Service (DPS) and the Department of Forests, Parks and Recreation (FPR) is a national leader in the research, development and commercialization of wood energy, in particular, the clean combustion of wood chips for heat and electricity production.

Disseminate information

Currently there appears to be a general lack of awareness among most facility owners, engineers, and architects that modern wood-fired boiler systems are an available option, and that they could reduce facility fuel costs. Simply disseminating this information among key stakeholders and stakeholder groups would be an important step towards commercialization.

One mechanism to make information available to stakeholders might include an on-line calculator that facility owners and others could use to evaluate the economics of a boiler conversion using site-specific conditions. In addition, a set of more detailed pro forma investment scenarios for actual boiler conversions could be developed and used to refine the payback model, boiler rankings, and commercial potential projections that were developed for this study.

APPENDIX

Table 18. Rank of cities based on number of boilers

Rank	City	Number of Boilers
1	BILLINGS	924
2	MISSOULA	718
3	GREAT FALLS	620
4	HELENA	457
5	BOZEMAN	321
6	BUTTE	314
7	KALISPELL	261
8	HAVRE	175
9	LEWISTOWN	149
10	DEER LODGE	136
11	MILES CITY	132
12	GLENDIVE	123
13	LIVINGSTON	109
14	BELGRADE	107
15	HAMILTON	102
16	SIDNEY	90
17	RED LODGE	74
18	DILLON	70
19	WHITEFISH	70
20	ANACONDA	63
21	COLUMBIA FALLS	58
22	GLASGOW	56
23	LAUREL	55
24	BIG SKY	53
25	WOLF POINT	51
26	LIBBY	47
27	CHOTEAU	46
28	CONRAD	43
29	FORSYTH	42
30	SHELBY	41
31	CORVALLIS	40
32	STEVENSVILLE	40
33	FORT BENTON	39
34	POLSON	39
35	ROUNDUP	38
36	HARDIN	36
37	MALTA	36

38	POPLAR	36
39	BAKER	30
40	CHINOOK	30
41	CUT BANK	29
42	PLENTYWOOD	29
43	COLUMBUS	28
44	RONAN	28
45	BROWNING	27
46	CHESTER	27
47	BIG TIMBER	25
48	EAST HELENA	25
49	THREE FORKS	25
50	FORT HARRISON	24
51	HARLOWTON	23
52	MANHATTAN	23
53	SEELEY LAKE	23
54	BOULDER	20
55	ENNIS	18
56	GARDINER	18
57	THOMPSON FALLS	18
58	WEST YELLOWSTON	18
59	FAIRVIEW	17
60	COLSTRIP	16
61	CULBERTSON	16
62	LOLO	16
63	PLAINS	16
64	TOWNSEND	16
65	BIG SANDY	15
66	HARLEM	15
67	WHITE SULPHUR S	15
68	SHERIDAN	14
69	CASCADE	13
70	CLANCY	13
71	SCOBEY	13
72	WHITEHALL	13
73	BIGFORK	12
74	BROADUS	12
75	TERRY	12
76	ABSAROKEE	11
77	CIRCLE	11
78	EAST GLACIER	11
79	JOLIET	11
80	MONTANA CITY	11
81	NASHUA	11
82	PHILIPSBURG	11
83	ST IGNATIUS	11
84	WARM SPRINGS	11
85	DARBY	10

86	EUREKA	10
87	FRENCHTOWN	10
88	LAKESIDE	10
89	SACO	10
90	STANFORD	10
91	VALIER	10
92	ASHLAND	9
93	EMIGRANT	9
94	NYE	9
95	TROY	9
96	BRIDGER	8
97	CLYDE PARK	8
98	CROW AGENCY	8
99	FLORENCE	8
100	RYEGATE	8
101	WIBAUX	8
102	CAMERON	7
103	CORWIN SPRINGS	7
104	DUTTON	7
105	GALLATIN GATEWA	7
106	HAYS	7
107	HEART BUTTE	7
108	JORDAN	7
109	LINCOLN	7
110	ST MARIE	7
111	ST REGIS	7
112	VICTOR	7
113	WEST GLACIER	7
114	WORDEN	7
115	BELT	6
116	BLACK EAGLE	6
117	BROADVIEW	6
118	FAIRFIELD	6
119	HYSHAM	6
120	MOORE	6
121	SUPERIOR	6
122	TWIN BRIDGES	6
123	BONNER	5
124	EKALAKA	5
125	FORT PECK	5
126	FOUR CORNERS	5
127	HOT SPRINGS	5
128	LODGE GRASS	5
129	MEDICINE LAKE	5
130	ST MARY	5
131	SWEETGRASS	5
132	VAUGHN	5
133	WOLF CREEK	5

134	ALBERTON	4
135	BAINVILLE	4
136	BELFRY	4
137	COOKE CITY	4
138	FRAZER	4
139	GERALDINE	4
140	JOPLIN	4
141	LIMA	4
142	MARION	4
143	NEIHART	4
144	PABLO	4
145	PRAY	4
146	PRYOR	4
147	RICHEY	4
148	RUDYARD	4
149	SHEPHERD	4
150	SIMMS	4
151	VIRGINIA CITY	4
152	ARLEE	3
153	BABB	3
154	BROCKTON	3
155	CHARLO	3
156	DECKER	3
157	DENTON	3
158	DRUMMOND	3
159	HOBSON	3
160	HUNGRY HORSE	3
161	ROBERTS	3
162	ROSEBUD	3
163	SAVAGE	3
164	SOMERS	3
165	SWAN LAKE	3
166	UNKNOWN	3
167	WILSALL	3
168	AUGUSTA	2
169	BOX ELDER	2
170	BRADY	2
171	CLINTON	2
172	CONDON	2
173	CUSTER	2
174	DAYTON	2
175	DODSON	2
176	FROMBERG	2
177	GALEN	2
178	GEYSER	2
179	GILDFORD	2
180	GREENOUGH	2
181	HALL	2

182	HIGHWOOD	2
183	HINSDALE	2
184	INVERNESS	2
185	JACKSON	2
186	JUDITH GAP	2
187	KREMLIN	2
188	LAVINA	2
189	LORING	2
190	MELSTONE	2
191	MILLTOWN	2
192	OUTLOOK	2
193	PEERLESS	2
194	PINESDALE	2
195	POLARIS	2
196	RAPELJE	2
197	REEDPOINT	2
198	SAND COULEE	2
199	ST XAVIER	2
200	SUN RIVER	2
201	SUNBURST	2
202	TURNER	2
203	UTICA	2
204	WESTBY	2
205	WINNETT	2
206	WISDOM	2
207	AMSTERDAM	1
208	CARTER	1
209	CHURCHILL	1
210	CRESTON	1
211	DIVIDE	1
212	DIXON	1
213	DUPUYER	1
214	EAST MISSOULA	1
215	ELLISTON	1
216	ESSEX	1
217	FLAXVILLE	1
218	FORT MISSOULA	1
219	FORT SHAW	1
220	FORT SMITH	1
221	FORTINE	1
222	FROID	1
223	HARRISON	1
224	KILA	1
225	LAMBERT	1
226	LAME DEER	1
227	LEDGER	1
228	LOCKWOOD	1
229	LODGEPOLE	1

230	LOGAN	1
231	LUTHER	1
232	MCALLISTER	1
233	MOLT	1
234	MONARCH	1
235	NOXON	1
236	OPHEIM	1
237	PARADISE	1
238	PENDROY	1
239	PLEVNA	1
240	POWER	1
241	RAMSAY	1
242	RESERVE	1
243	ROY	1
244	SILVER BOW	1
245	STOCKETT	1
246	TOSTON	1
247	VIDA	1
248	VOLBORG	1
249	WALKERVILLE	1
250	WATERLOO	1
251	WHIEFISH	1
252	WHITEWATER	1
253	WILLOW CREEK	1
254	WINIFRED	1
255	WYOLA	1
256	ZORTMAN	1
257	ZURICH	1

Table 19. Electric Boilers, ranked by size

SIZE (BTU/hr)	FACILITY	MANU YEAR	FAC TYPE	CITY
8,000,000	INLAND TRUCK PARTS	2001	N/A	MISSOULA
3,600,000	NORMAN DALE PROPERTIES	1984	N/A	BILLINGS
3,280,420	SHERATON HOTEL - 23RD FLOOR	1965	N/A	BILLINGS
1,560,000	PRINCE INC-TRUCK REPAIR SHOP	1975	N/A	FORSYTH
900,000	ST LUKES HOSPITAL - BLR RM	1975	Hospital	RONAN
856,800	EDGERTON ELEM-BLR RM	1987	School	KALISPELL
765,000	JC PENNEY STORE #1981-PEMT	1979	N/A	MISSOULA
735,000	CENTURYTEL	1972	N/A	KALISPELL
666,000	GLENDIVE MEDICAL CTR-SRGRY RM	1980	Hospital	GLENDIVE
630,000	MEMORIAL HOSP-SURGERY RM	1996	Hospital	HARDIN
600,000	ROSEBUD CO HOSPITAL - MECH RM	1986	Hospital	FORSYTH
504,000	RONAN STATE BANK-2ND FLR MECH	1980	N/A	RONAN
500,000	MCCAMBELLS BUILDING-BSMNT	2001	N/A	RED LODGE
466,000	FRENCHTOWN HI –BOY'S LCKER RM	1980	School	FRENCHTOWN
466,000	FRENCHTOWN HI-GIRL'S LCKER RM	1980	School	FRENCHTOWN
463,000	GREAT FALLS CLINIC SURGERY CTR	1999	Hospital	GREAT FALLS
463,000	GREAT FALLS CLINIC SURGERY CTR	1999	Hospital	GREAT FALLS
448,000	HYSHAM SCHOOL- BLR RM	1984	School	HYSHAM
358,365	LINCOLN COURTHOUSE-PENTHOUSE	1978	N/A	LIBBY
350,000	M COR INC	2003	N/A	EAST HELENA
349,000	DEER PARK CHALET-B	1996	N/A	BOZEMAN
349,000	DEER PARK CHALET-BLR RM	1996	N/A	BOZEMAN
341,340	MARIAS MEDICAL CNTR-BLR RM	1985	Hospital	SHELBY
275,000	FLATHEAD ELECTRIC COOP INC	1992	N/A	LIBBY
275,000	FLATHEAD ELECTRIC COOP INC	1992	N/A	LIBBY
266,000	NAT'L GUARD BLDG 410	1991	N/A	FT HARRISON
266,000	NAT'L GUARD BLDG 411	1992	N/A	FT HARRISON
263,000	FERGUS ELECTRIC	1981	N/A	LEWISTOWN
255,000	NORTH VALLEY HOSPITAL-BLR RM	1999	Hospital	WHITEFISH
245,520	THE SUMMIT-BLR RM	1998	Hospital	KALISPELL
235,000	HOT SPRINGS HI SCHOOL-BLR RM	1980	School	HOT SPRINGS
204,000	ST LUKES HOSPITAL-PENT 2ND FLR	1975	Hospital	RONAN
204,000	CROW NORTHERN CHEYENE HOSP	2001	Hospital	CROW AGENCY
180,000	LOCKWOOD SCHOOL	1999	School	LOCKWOOD
168,000	MISSOURI RIVER MANOR-KITCHEN	2000	Rest Hme	GREAT FALLS
163,200	MISSOULA CNTY DETENTION CTR	1998	As'd Lvg	MISSOULA
163,200	MISSOULA CNTY DETENTION CTR	1999	As'd Lvg	MISSOULA
159,000	BIG SKY COAL COMPANY	1980	Pub Aably	COLSTRIP
157,500	RAINBOW HOUSE	1000	Ret Ctr	GREAT FALLS
157,500	RAINBOW HOUSE	1000	RetCtr	GREAT FALLS
136,000	MUSEUM OF MOUNTAIN FLYING	2002	N/A	MISSOULA
126,000	STAR OFFICE MACHINES	1977	N/A	BILLINGS

126,000	STAR OFFICE MACHINES	1977	N/A	BILLINGS
126,000	PENGUIN BREWERY	1977	N/A	MISSOULA
126,000	LAKE CO COURTHOUSE-MECH RM	1995	PubAssembly	POLSON
123,000	MANUFACTURING FACILTY-BLR RM	1988	N/A	BILLINGS
120,000	KEG BAR & CASINO	1970	N/A	ROUNDUP
109,000	JAMES F BATTEN	1993	N/A	316 N 26TH ST
105,000	BEARTOOTH HOSPITAL	1982	Hospital	- BLRM
105,000	SWAN VALLEY SCHOOL-GYM	1985	School	CONDON
105,000	BEARTOOTH HOSPITAL	1995	Hospital	- BLRM
105,000	TRINITY HOSPITAL	1999	Hospital	WOLF POINT
105,000	ROCKY MT SURGICAL CENTER	2003	Hospital	BOZEMAN
103,000	SURGI CENTER	2000	Hospital	BILLINGS
102,000	OPERATING ROOM	2001	Hospital	RONAN
100,000	HEALTH CENTER UNIT 1	1999	N/A	WOLF POINT
95,000	BILLINGS ATHLETIC CLUB-STEAM	2003	PubAssembly	BILLINGS
85,750	LINCOLN COURTHOUSE-PENTHOUSE	1978	N/A	LIBBY
81,912	PHILLIPS COUNTY HOSPITAL	1996	Hospital	MALTA
81,840	SCOTTS AUTO BODY	2001	N/A	CHINOOK
81,600	BROADWATER ATHLETIC-BLR RM	1994	Pub Assmbly	HELENA
81,600	MARCUS DALY HOSPITAL-SURGERY	2000	Hospital	HAMILTON
75,020	WESTBY SCHOOL	1995	School	WESTBY
70,000	HOSPITAL-STERILIZER/SURGERY RM	1980	Hospital	SCOBEY
70,000	MONTANA ATHLETIC CLUB	1987	N/A	MISSOULA
70,000	TRINITY HOSPITAL	1996	Hospital	WOLF POINT
70,000	MSU - HUFFMAN BLDG	1998	School	BOZEMAN
70,000	MANUF PREP ROOM	1999	N/A	MISSOULA
70,000	MONTANA ATHLETIC CLUB	2002	N/A	MISSOULA
70,000	ROUNDUP MEMORIAL HOSPITAL	2002	Hospital	ROUNDUP
68,200	SHERIDAN MEM.HOSP-AUTO CL	1990	Hospital	PLENTYWOOD
68,000	CROW NORTHERN CHEYENE HOSP	1993	Hospital	CROW AGENCY
68,000	V & G HLTH CNTR	1996	N/A	POPLAR
68,000	OPERATING ROOM	2001	Hospital	RONAN
66,000	24 HR FITNESS	2003	N/A	BILLINGS
61,200	MARCUS DALY HOSPITAL-SURGERY	2000	Hospital	HAMILTON
60,000	ROCKY MT SURGICAL CENTER	2003	Hospital	BOZEMAN
57,800	ENDO BIOLOGICS INC	1900	N/A	MISSOULA
42,000	CROSSROADS FITNESS CENTER	1980	N/A	HELENA
34,000	CROW NORTHERN CHEYENE HOSP	2001	Hospital	CROW AGENCY
34,000	YELLOWSTONE SURGERY	2002	Hospital	BILLINGS
34,000	YLLWSTN SRGRY-STERILE STRG 1	2002	Hospital	BILLINGS
34,000	YLLWSTN SRGRY-STERILE STRG 2	2002	Hospital	BILLINGS
26,250	PENTHOUSE #4	1984	Hospital	BROWNING
11,000	MOUNTAIN VIEW MEMORIAL	2003	Hospital	WH SULPHUR
6,000	RIDDLES JEWELRY-REPAIR ROOM	1994	N/A	BUTTE
6,000	RIDDLES JEWELRY-REPAIR ROOM	1994	N/A	GREAT FALLS
5,000	FORT BELKNAP HOSPITAL	1995	Hospital	HARLEM
1	SURGICAL OUTPATIENT CNTR-BSMT	1000	N/A	KALISPELL
1	GARY YAEGER - YARD	1908	N/A	KALISPELL

1	RAND HATS-MECH RM	1965	N/A	BILLINGS
1	MISSOURI RIVER MEDICAL CENTER	1966	N/A	FORT BENTON
1	UNIV OF MONTTANA-HLTH SCI BLDG	1978	N/A	MISSOULA
1	TROY UNIT MINE-BLR RM	1980	N/A	TROY
1	TROY UNIT MINE-BLR RM	1980	N/A	TROY
1	BOILER ROOM	1981	N/A	MILES CITY
1	UNIVERSITY PHYSICAL PLT-BLR RM	1993	School	GREAT FALLS
1	POWELL CO HOSPITAL-BLR RM	1999	Hospital	DEER LODGE
1	SURGICAL OUTPATIENT CNTR-BSMT	2000	N/A	KALISPELL
1	CLEAN UTILITY ROOM	2001	N/A	MISSOULA
1	SURGI CENTER	2002	Hospital	BILLINGS

Table 20. Boilers over 60 years old

CITY	Number of Boilers	Smallest (BTU/hr)	Largest (BTU/hr)	Average Size (BTU/hr)	Sum of Sizes (BTU/hr)
MISSOULA	42	1	8,156,000	832,131	34,949,501
GREAT FALLS	25	1	14,000,000	1,623,928	40,598,205
BUTTE	20	1	4,500,000	876,100	17,522,004
KALISPELL	19	1	6,000,000	1,182,632	22,470,002
HELENA	18	1	8,500,000	2,131,722	38,371,002
BILLINGS	17	0	5,000,000	1,615,118	27,457,004
BOZEMAN	13	1	4,000,000	929,539	12,084,005
DILLON	12	110,000	2,500,000	619,583	7,435,000
BELGRADE	11	1	1,820,000	165,455	1,820,010
ANACONDA	7	240,000	7,000,000	1,862,857	13,040,000
LIBBY	7	164,000	627,000	405,429	2,838,000
RED LODGE	6	29,000	2,600,000	866,500	5,199,000
COLUMBIA FALLS	5	6,495,000	10,000,000	9,299,000	46,495,000
MILES CITY	5	90,000	1,250,000	761,000	3,805,000
WHITEFISH	4	1	8,720,000	2,255,001	9,020,002
WORDEN	4	1	3,000,000	1,302,500	5,210,001
LIVINGSTON	4	200,000	2,400,000	848,750	3,395,000
HAMILTON	4	136,000	1,000,000	525,250	2,101,000
ST IGNATIUS	3	1	4,785,000	1,638,334	4,915,001
DEER LODGE	3	1	396,000	202,000	606,001
THOMPSON FALLS	2	14,520,000	14,520,000	14,520,000	29,040,000
EUREKA	2	4,500,000	5,990,000	5,245,000	10,490,000
HARLOWTON	2	2,000,000	2,500,000	2,250,000	4,500,000
COLSTRIP	2	1	4,304,000	2,152,001	4,304,001
FORT BENTON	2	1	3,360,000	1,680,001	3,360,001
MANHATTAN	2	1	3,240,000	1,620,001	3,240,001
WIBAUX	2	1,512,000	1,512,000	1,512,000	3,024,000
ROUNDUP	2	140,000	1,900,000	1,020,000	2,040,000
BIG TIMBER	2	300,000	1,250,000	775,000	1,550,000
BIG SANDY	2	1	1,000,000	500,001	1,000,001
CUT BANK	2	210,000	722,000	466,000	932,000
TERRY	2	350,000	350,000	350,000	700,000
DARBY	2	267,400	333,000	300,200	600,400
THREE FORKS	2	263,000	270,000	266,500	533,000
SIDNEY	2	1	250,000	125,001	250,001
LEWISTOWN	2	60,000	140,000	100,000	200,000
GLASGOW	2	1	140,000	70,001	140,001
BELFRY	2	1	1	1	2
MARION	2	1	1	1	2
UNKNOWN	2	1	1	1	2

FRAZER	1	35,000,000	35,000,000	35,000,000	35,000,000
LOGAN	1	4,800,000	4,800,000	4,800,000	4,800,000
CULBERTSON	1	2,720,000	2,720,000	2,720,000	2,720,000
SHERIDAN	1	1,620,000	1,620,000	1,620,000	1,620,000
SCOBEY	1	1,323,000	1,323,000	1,323,000	1,323,000
NASHUA	1	1,300,000	1,300,000	1,300,000	1,300,000
NYE	1	1,300,000	1,300,000	1,300,000	1,300,000
DENTON	1	1,236,000	1,236,000	1,236,000	1,236,000
HYSHAM	1	1,200,000	1,200,000	1,200,000	1,200,000
VIRGINIA CITY	1	1,000,000	1,000,000	1,000,000	1,000,000
RONAN	1	982,000	982,000	982,000	982,000
DIXON	1	880,000	880,000	880,000	880,000
ABSAROKEE	1	800,000	800,000	800,000	800,000
HALL	1	750,000	750,000	750,000	750,000
PABLO	1	700,000	700,000	700,000	700,000
BABB	1	650,000	650,000	650,000	650,000
STEVENSVILLE	1	527,000	527,000	527,000	527,000
HIGHWOOD	1	500,000	500,000	500,000	500,000
PENDROY	1	500,000	500,000	500,000	500,000
BIGFORK	1	462,000	462,000	462,000	462,000
SWEETGRASS	1	432,000	432,000	432,000	432,000
WHITEHALL	1	400,000	400,000	400,000	400,000
SHELBY	1	300,000	300,000	300,000	300,000
STANFORD	1	290,000	290,000	290,000	290,000
PRAY	1	190,000	190,000	190,000	190,000
CHOTEAU	1	1	1	1	1
GEYSER	1	1	1	1	1
HAVRE	1	1	1	1	1
JORDAN	1	1	1	1	1

Table 21. Cities with boilers located in hospitals

CITY	Number of Hospital Boilers	Sum of Sizes (BTU/hr)	Oldest	Newest	Avg Year
BILLINGS	29	95,820,004	1964	2002	1991
GREAT FALLS	18	89,268,000	1975	2003	1995
BOZEMAN	17	35,885,000	1967	2003	1993
MISSOULA	17	86,999,001	1970	2001	1987
RONAN	12	6,448,000	1975	2001	1991
WARM SPRINGS	10	36,627,000	1970	1999	1995
BROWNING	10	20,634,750	1961	1990	1982
CHESTER	10	3,390,001	1989	2001	1993
BUTTE	9	53,010,000	1987	2002	1997
KALISPELL	8	8,775,520	1977	1998	1995
GLENDIVE	8	37,254,000	1967	1997	1982
HARLEM	8	9,374,997	1995	2001	1998
HAVRE	8	33,759,001	1981	1996	1987
COLUMBUS	7	4,773,000	1969	2000	1988
CROW AGENCY	7	16,706,000	1993	2001	1995
POLSON	7	14,160,001	1959	2002	1987
CHOTEAU	7	3,737,003	1974	1995	1988
DILLON	6	7,140,000	1970	2000	1989
BAKER	6	6,371,000	1949	1995	1977
RED LODGE	6	5,809,000	1950	1998	1973
HAMILTON	6	11,966,800	1974	2001	1991
ROUNDUP	6	8,975,002	1966	2002	1985
SHELBY	5	13,862,540	1980	1994	1985
ANACONDA	5	15,390,000	1974	1997	1982
WHITEFISH	5	26,180,000	1969	2001	1986
WOLF POINT	5	7,055,000	1959	1999	1975
PLAINS	5	3,365,002	1972	1993	1984
MILES CITY	5	14,800,001	1976	1995	1991
HELENA	4	61,390,000	1968	1969	1969
HARDIN	4	9,780,000	1958	1998	1978
LEWISTOWN	4	16,444,000	1976	1995	1981
GLASGOW	4	14,415,300	1969	2001	1979
PLENTYWOOD	4	8,010,200	1967	1998	1981
WHITE SULPHUR	4	4,641,000	1995	2003	1997
LIVINGSTON	3	8,984,000	1960	1996	1983
SCOBEY	3	6,005,000	1952	1980	1971
SUPERIOR	3	5,668,000	1974	1975	1974
ENNIS	3	1,478,000	1986	1998	1994
LIBBY	3	6,561,200	1983	2002	1995
DEER LODGE	3	9,442,001	1998	1999	1998
SIDNEY	2	20,086,000	1969	1969	1969

EKALAKA	2	8,450,000	1950	1994	1972
POPLAR	2	8,120,000	1966	1966	1966
TERRY	2	7,200,000	1968	1968	1968
JORDAN	2	5,815,000	1981	1987	1984
SHERIDAN	2	2,040,000	1963	2000	1982
CONRAD	2	5,940,000	1970	1971	1971
FORSYTH	2	4,784,000	1972	1986	1979
HAYS	2	1,040,000	1998	1998	1998
HEART BUTTE	2	1,000,000	1997	1997	1997
CUT BANK	1	8,370,000	1987	1987	1987
HARLOWTON	1	4,181,000	1967	1967	1967
TOWNSEND	1	2,940,000	1986	1986	1986
MALTA	1	81,912	1996	1996	1996

Table 22. Average potentially harvestable forested area within 50 miles of all boilers within each city

City	Number of Boilers	Forested Area (acres)
ABSAROKEE	11	177,938
ALBERTON	4	1,337,701
ANACONDA	63	1,411,842
BAKER	30	54,401
BELGRADE	107	894,579
BELT	6	425,295
BIG SKY	53	872,426
BIG TIMBER	25	345,248
BIGFORK	12	1,479,181
BILLINGS	924	72,128
BLACK EAGLE	6	182,778
BOULDER	20	1,158,675
BOZEMAN	321	848,380
BRIDGER	8	131,470
BROADUS	12	458,365
BROADVIEW	6	5,209
BROWNING	27	274,855
BUTTE	314	1,203,426
CASCADE	13	398,632
CHESTER	27	0
CHINOOK	30	0
CHOTEAU	46	41,556
CIRCLE	11	0
CLANCY	13	1,061,616
CLINTON	2	1,388,272
COLUMBIA FALLS	58	1,623,457
COLUMBUS	28	147,978
CONRAD	43	12,456
CORVALLIS	40	1,278,325
CULBERTSON	16	4,133
CUSTER	2	0
CUT BANK	29	16,506
DARBY	10	936,314
DEER LODGE	136	1,283,853
DENTON	3	238,256
DILLON	70	598,770
DUTTON	7	5,370
EAST HELENA	25	1,093,669
EAST MISSOULA	1	1,339,079
EMIGRANT	9	793,614
ENNIS	18	759,330

EUREKA	10	1,767,973
FAIRFIELD	6	53,890
FAIRVIEW	17	8,051
FLORENCE	8	1,293,811
FORSYTH	42	25,407
FORT BENTON	39	20,104
FORT PECK	5	0
FRENCHTOWN	10	1,389,684
GALEN	2	1,244,381
GALLATIN GATEWA	7	811,105
GARDINER	18	726,964
GLASGOW	56	0
GLENDIVE	123	7,212
GREAT FALLS	620	1,336,114
HAMILTON	102	1,180,310
HARDIN	36	0
HARLEM	15	0
HAVRE	175	0
HELENA	457	1,060,114
HIGHWOOD	2	165,463
HOT SPRINGS	5	1,798,103
HUNGRY HORSE	3	1,614,544
JOLIET	11	144,309
KALISPELL	261	1,829,127
KILA	1	1,969,224
LAKESIDE	10	1,658,556
LAUREL	55	79,725
LAVINA	2	38,436
LEWISTOWN	149	0
LIBBY	47	2,203,391
LIVINGSTON	109	786,840
LOLO	16	1,305,254
MALTA	36	0
MANHATTAN	23	899,348
MARION	4	2,276,661
MILES CITY	132	21,210
MISSOULA	718	1,336,114
MOLT	1	41,594
MONTANA CITY	11	1,086,415
NYE	9	316,451
PHILIPSBURG	11	1,401,900
PLAINS	16	1,415,684
PLENTYWOOD	29	0
POLSON	39	1,483,820
POWER	1	5,859
RED LODGE	74	210,979
REEDPOINT	2	183,746
RONAN	28	1,545,918

ROUNDUP	3	29,005
RYEGATE	8	77,552
SAVAGE	3	8,051
SCOBEY	13	0
SHELBY	41	14
SHEPHERD	4	0
SHERIDAN	14	734,007
SIDNEY	90	8,051
SILVER BOW	1	1,265,493
SOMERS	3	1,679,126
ST IGNATIUS	11	1,571,701
ST REGIS	7	1,220,041
STANFORD	10	540,735
STEVENSVILLE	40	1,295,054
SWEETGRASS	5	0
TERRY	12	0
THOMPSON FALLS	18	1,448,056
THREE FORKS	25	995,925
TOWNSEND	16	1,134,844
TROY	9	1,689,800
TWIN BRIDGES	6	792,040
VALIER	10	49,820
VAUGHN	5	77,135
VICTOR	7	1,239,914
VIRGINIA CITY	4	732,113
WALKERVILLE	1	1,206,651
WEST YELLOWSTON	18	507,237
WHITE SULPHUR S	15	1,049,254
WHITEFISH	70	1,752,546
WHITEHALL	13	955,049
WILSALL	3	711,875
WINNETT	2	15,256
WOLF POINT	51	68
WORDEN	7	0

Notes:

- Forest areas within 50 miles of boilers (average for all boilers in a city)
- Wilderness, roadless areas, and national parks were removed from the forested areas
- Only forests within Montana were considered in the forested areas calculation
- 5301 boilers were located and used in the overlay with forest areas.
- Of those boilers, 4938 were within 50 miles of a “forested” area

Assumptions used for Payback Calculations

Assumed Input Variables

Table 23. Assumed facility utilization factors (FUFs) for each facility type

Facility Utilization Factors (FUF)	Facility Type
0.15	Assisted Living
0.15	Hospital
0.15	Rest Home
0.06	Day Care
0.06	School
0.03	Church
0.03	Public Assembly
0.03	Retirement Center
0.08	Not Applicable
0.03	Low
0.08	Medium
0.15	High

Table 24. Assumed boiler efficiencies and fuel costs for each fuel source

Fuel Source	boiler efficiency	fuel cost ($/green ton)	fuel value (mm BTU/ green ton)	fuel cost ($/mm BTU)
wood	0.70	$35	10.8	$3.24
gas	0.80	---	---	$8.00
electric	0.98	---	---	$25.00
pellets	0.80	---	---	$7.00
oil	0.83	---	---	$10.00
coal	0.75	---	---	$3.00
pellets	0.80	---	---	$7.00
other/unknown	0.81	---	---	$9.37

Table 25. Assumed new boiler system cost by boiler size range (total installed cost)

Boiler Size assumed wood boiler system type	New Boiler System Cost ($/mm BTU/hr boiler size)	
	wood	gas
<0.5 mm BTU/hr boiler size small pellet system	$70,000	$60,000
0.5 to <3 mm BTU/hr boiler size semi-automated, day bin, wood chips	$200,000	$50,000
3 to 6 mm BTU boiler size automated, large storage bin, wood chips	$200,000	$50,000
> 6 mm BTU boiler size automated, large storage bin, wood chips	$200,000	$50,000

Equations used to Calculate Paybacks

Fuel required by a wood-fueled boiler, mm BTU/yr =
(boiler size, BTU/hr)/(wood boiler efficiency)*(8,760 hrs/yr)*(FUF)/(1,000,000)

Existing Annual Fuel Cost, $/yr =
(Fuel req'd for wood boiler, mm BTU/yr)*(wood boiler eff)/(existing boiler eff)*(existing fuel cost, $/mm BTU)

Wood Fuel Cost, $/yr =
(Fuel req'd for wood boiler, mm BTU/yr)*(wood fuel cost, $/mm BTU)

Annual Fuel Savings with wood fueled boiler, $/yr =
(Existing Annual Fuel Cost, $/yr) – (Wood Fuel Cost, $/yr)

New Wood Boiler Cost, $ =
(boiler size, BTU/hr)/(1,000,000)*(new wood boiler system cost, $)

New Gas Boiler Cost, $ =
(boiler size, BTU/hr)/(1,000,000)*(new gas boiler system cost, $)

Extra Cost for Wood Boiler, $ =
(New Wood Boiler Cost, $) – (New Gas Boiler Cost, $)

Payback if Replacing Anyway, yrs =
(Extra Cost for Wood Boiler, $)/(Annual Fuel Savings with wood fueled boiler, $/yr)

Payback if you Don't Have to Replace, yrs =
(New Wood Boiler Cost, $)/(Annual Fuel Savings with wood fueled boiler, $/yr)

Numbers of boilers within selected payback ranges

There are a total of 7,239 boilers listed in the State's boiler certificate database. Complete or accurate data were not available for all boilers, so several set of boilers were eliminated from the database before computing payback periods. Boilers eliminated from calculations:

- boilers with boiler size listed as "1" (514 boilers) or left blank (21 boilers), because payback period calculations require a valid boiler size
- boilers with coal listed as existing fuel source (99 boilers), because using coal as a fuel is always cheaper than wood, thus the payback period for converting from coal to wood boilers is always negative
- boilers with wood or hog listed as existing fuel (13 boiler), because these boilers are already using wood

After eliminating the boilers listed above, there were 6,591 boilers remaining that were sorted based on payback periods. Boilers with invalid city listings were eliminated (21 boilers) for the sort by location.

Table 26 presents the number of boilers with payback periods within selected ranges for the circumstances when boiler replacement is pending or planned for (replacing boiler anyway), and also when it is not (boiler does not need to be replaced). The payback period for the scenario where a boiler needs to be replaced is calculated based on the time it would take for annual fuel saving to pay for the extra expense of buying a new wood boiler rather than buying a new gas boiler. For the scenario where a boiler doesn't need to be replaced, the payback period is time it takes for annual fuel saving to pay for a new wood boiler.

Table 26. Sort of all boilers into payback periods

PAYBACK SCENARIOS -- ALL BOILERS				
payback if replacing anyway	**number of boilers**		**payback if you don't have to replace**	**number of boilers**
< 5 years	222		< 5 years	31
5 to <10 years	170		5 to <10 years	48
10 to <15 years	2,175		10 to <15 years	0
15 to 20 years	484		15 to 20 years	14
> 20 years	3,538		> 20 years	6,496

Tables 27 through 29 present the number of boilers in selected payback ranges for boilers sorted by existing fuel source. Tables 30 through 36 present the number of boilers in selected payback ranges for boilers sorted by size. Tables 37 through 43 present the number of boilers in selected payback ranges for boilers sorted by city for the cities with the greatest number of boilers. Tables 44 through 46 present payback periods for example boilers within selected size ranges and existing fuel types.

Table 27. Sort of electric boilers into payback periods

ELECTRIC BOILERS				
payback if replacing anyway	**number of boilers**		**payback if you don't have to replace**	**number of boilers**
< 5 years	75		< 5 years	31
5 to <10 years	12		5 to <10 years	48
10 to 20 years	1		10 to 20 years	9
> 20 years	0		> 20 years	0

Table 28. Sort of gas and gas/oil boilers into payback periods

GAS AND GAS/OIL BOILERS				
payback if replacing anyway	**number of boilers**		**payback if you don't have to replace**	**number of boilers**
< 5 years	0		< 5 years	0
5 to <10 years	122		5 to <10 years	0
10 to 20 years	2,472		10 to 20 years	0
> 20 years	3,508		> 20 years	6,102

Table 29. Sort of oil boilers into payback periods

OIL BOILERS				
payback if replacing anyway	**number of boilers**		**payback if you don't have to replace**	**number of boilers**
< 5 years	56		< 5 years	0
5 to <10 years	14		5 to <10 years	0
10 to 20 years	28		10 to 20 years	6
> 20 years	113		> 20 years	205

Table 30. Sort of 50+ mm BTU/hr boilers into payback periods

BOILERS 50,000,000+ BTU/hr				
payback if replacing anyway	**number of boilers**		**payback if you don't have to replace**	**number of boilers**
< 5 years	0		< 5 years	0
5 to <10 years	0		5 to <10 years	0
10 to 20 years	0		10 to 20 years	0
> 20 years	10		> 20 years	10

Table 31. Sort of 10 to <50 mm BTU/hr boilers into payback periods

BOILERS 10,000,000 to 49,999,999 BTU/hr				
payback if replacing anyway	**number of boilers**		**payback if you don't have to replace**	**number of boilers**
< 5 years	0		< 5 years	0
5 to <10 years	0		5 to <10 years	0
10 to 20 years	0		10 to 20 years	0
> 20 years	100		> 20 years	100

Table 32. Sort of 5 to <10 mm BTU/hr boilers into payback periods

BOILERS 5,000,000 to 9,999,999 BTU/hr				
payback if replacing anyway	**number of boilers**		**payback if you don't have to replace**	**number of boilers**
< 5 years	0		< 5 years	0
5 to <10 years	0		5 to <10 years	0
10 to 20 years	3		10 to 20 years	1
> 20 years	242		> 20 years	244

Table 33. Sort of 1 to <5 mm BTU/hr boilers into payback periods

BOILERS 1,000,000 to 4,999,999 BTU/hr				
payback if replacing anyway	**number of boilers**		**payback if you don't have to replace**	**number of boilers**
< 5 years	0		< 5 years	0
5 to <10 years	0		5 to <10 years	0
10 to 20 years	20		10 to 20 years	3
> 20 years	1,747		> 20 years	1,764

Table 34. Sort of 0.5 to <1 mm BTU/hr boilers into payback periods

BOILERS 500,000 to 999,999 BTU/hr				
payback if replacing anyway	**number of boilers**		**payback if you don't have to replace**	**number of boilers**
< 5 years	0		< 5 years	0
5 to <10 years	4		5 to <10 years	4
10 to 20 years	13		10 to 20 years	5
> 20 years	1,235		> 20 years	1,243

Table 35. Sort of 0.1 to <0.5 mm BTU/hr boilers into payback periods

BOILERS 100,000 to 499,999 BTU/hr				
payback if replacing anyway	**number of boilers**		**payback if you don't have to replace**	**number of boilers**
< 5 years	171		< 5 years	14
5 to <10 years	151		5 to <10 years	29
10 to 20 years	2,499		10 to 20 years	10
> 20 years	200		> 20 years	2,968

Table 36. Sort of <0.1 mm BTU/hr boilers into payback periods

BOILERS < 100,000 BTU/hr				
payback if replacing anyway	**number of boilers**		**payback if you don't have to replace**	**number of boilers**
< 5 years	51		< 5 years	17
5 to <10 years	7		5 to <10 years	15
10 to 20 years	132		10 to 20 years	4
> 20 years	4		> 20 years	158

Table 37. Sort of boilers in Billings into payback periods

BILLINGS				
payback if replacing anyway	**number of boilers**		**payback if you don't have to replace**	**number of boilers**
< 5 years	11		< 5 years	4
5 to <10 years	15		5 to <10 years	5
10 to 20 years	302		10 to 20 years	1
> 20 years	479		> 20 years	797

Table 38. Sort of boilers in Missoula into payback periods

MISSOULA				
payback if replacing anyway	**number of boilers**		**payback if you don't have to replace**	**number of boilers**
< 5 years	12		< 5 years	0
5 to <10 years	16		5 to <10 years	8
10 to 20 years	267		10 to 20 years	0
> 20 years	373		> 20 years	660

Table 39. Sort of boilers in Great Falls into payback periods

GREAT FALLS				
payback if replacing anyway	**number of boilers**		**payback if you don't have to replace**	**number of boilers**
< 5 years	6		< 5 years	3
5 to <10 years	4		5 to <10 years	3
10 to 20 years	210		10 to 20 years	0
> 20 years	359		> 20 years	573

Table 40. Sort of boilers in Helena into payback periods

HELENA				
payback if replacing anyway	**number of boilers**		**payback if you don’t have to replace**	**number of boilers**
< 5 years	3		< 5 years	0
5 to <10 years	5		5 to <10 years	2
10 to 20 years	174		10 to 20 years	0
> 20 years	260		> 20 years	440

Table 41. Sort of boilers in Bozeman into payback periods

BOZEMAN				
payback if replacing anyway	**number of boilers**		**payback if you don't have to replace**	**number of boilers**
< 5 years	6		< 5 years	2
5 to <10 years	12		5 to <10 years	3
10 to 20 years	128		10 to 20 years	0
> 20 years	150		> 20 years	291

Table 42. Sort of boilers in Butte into payback periods

BUTTE				
payback if replacing anyway	**number of boilers**		**payback if you don't have to replace**	**number of boilers**
< 5 years	2		< 5 years	0
5 to <10 years	1		5 to <10 years	1
10 to 20 years	99		10 to 20 years	0
> 20 years	178		> 20 years	279

Table 43. Sort of boilers in Kalispell into payback periods

KALISPELL				
payback if replacing anyway	**number of boilers**		**payback if you don't have to replace**	**number of boilers**
< 5 years	6		< 5 years	1
5 to <10 years	10		5 to <10 years	0
10 to 20 years	88		10 to 20 years	0
> 20 years	122		> 20 years	225

Table 44. Paybacks for example boilers using gas as a fuel source

EXISTING FUEL SOURCE = GAS			
Boiler Size (BTU/hr)	Boiler Utilization	payback if you have to replace anyway (years)	payback if you don't have to replace (years)
50000	Low	30	213
50,000	Medium	11	80
50,000	High	6	43
250,000	Low	30	213
250,000	Medium	11	80
250,000	High	6	43
750,000	Low	106	142
750,000	Medium	40	53
750,000	High	21	28
2,500,000	Low	106	142
2,500,000	Medium	40	53
2,500,000	High	21	28
7,500,000	Low	106	142
7,500,000	Medium	40	53
7,500,000	High	21	28
25,000,000	Low	106	142
25,000,000	Medium	40	53
25,000,000	High	21	28
75,000,000	Low	106	142
75,000,000	Medium	40	53
75,000,000	High	21	28

Table 45. Paybacks for example boilers using electricity as a fuel source

EXISTING FUEL SOURCE = ELECTRIC			
Boiler Size (BTU/hr)	**Boiler Utilization**	**payback if you have to replace anyway (years)**	**payback if you don't have to replace (years)**
50,000	Low	2	16
50,000	Medium	1	6
50,000	High	0	3
250,000	Low	2	16
250,000	Medium	1	6
250,000	High	0	3
750,000	Low	27	36
750,000	Medium	10	14
750,000	High	5	7
2,500,000	Low	27	36
2,500,000	Medium	10	14
2,500,000	High	5	7
7,500,000	Low	27	36
7,500,000	Medium	10	14
7,500,000	High	5	7
25,000,000	Low	27	36
25,000,000	Medium	10	14
25,000,000	High	5	7
75,000,000	Low	27	36
75,000,000	Medium	10	14
75,000,000	High	5	7

Table 46. Paybacks for Example Boilers using Oil as a Fuel Source

EXISTING FUEL SOURCE = OIL			
Boiler Size (BTU/hr)	**Boiler Utilization**	**payback if you have to replace anyway (years)**	**payback if you don't have to replace (years)**
50,000	Low	12	81
50,000	Medium	4	30
50,000	High	2	16
250,000	Low	12	81
250,000	Medium	4	30
250,000	High	2	16
750,000	Low	77	103
750,000	Medium	29	38
750,000	High	15	21
2,500,000	Low	77	103
2,500,000	Medium	29	38
2,500,000	High	15	21
7,500,000	Low	77	103
7,500,000	Medium	29	38
7,500,000	High	15	21
25,000,000	Low	77	103
25,000,000	Medium	29	38
25,000,000	High	15	21
75,000,000	Low	77	103
75,000,000	Medium	29	38
75,000,000	High	15	21

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