Economic Analysis of Wood Fuel for Dry Kilns: Nine Case Studies
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Economic Analysis of Wood Fuel for Dry Kilns: Nine Case Studies

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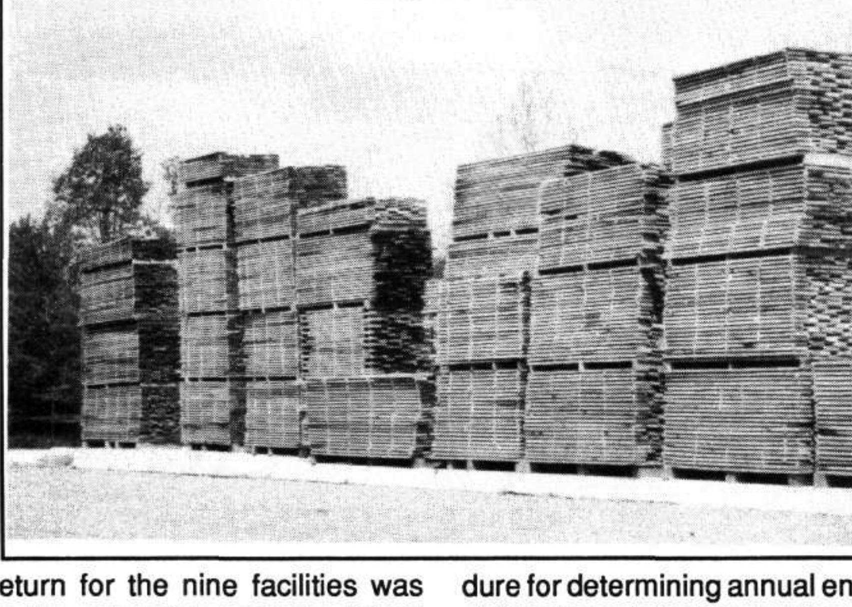
Economic analyses were conducted at nine commercial dry kiln installations to determine the cost-effectiveness of wood as an energy source for drying lumber. These studies, funded by the Michigan Energy Conservation Program for Agriculture and Forestry (MECP), show that wood energy is a viable economic alternative to natural gas in many operations. The payback period, the number of years needed to recover the cost of installing a wood energy system, was 3 years or less for three of the nine systems analyzed. The remaining six projects had payback periods ranging from 6 to 10 years.



The economic rate of return for the nine facilities was determined with the computer program Wood Energy Financial Analysis Model (WEFAM). The program, developed by the Michigan Department of Commerce, uses 10 basic operating inputs to determine drying costs (Table 2). Natural gas, because it is frequently used for lumber drying in Michigan, was selected as the alternative fuel for all nine analyses. WEFAM evaluated the cost of the natural gas at three price levels (Table 3). Wood fuel for the drying systems was waste wood generated by the facilities, available without charge.

Procedures

Dry Kiln Energy Requirement Estimates - The energy requirements for drying hardwood lumber vary greatly; factors such as wood species, moisture, and drying practices are important considerations when determing energy usage. Because of these variables, determining precise energy requirements for drying lumber is feasible only on an individual case study basis.

The procedure for determining annual energy requirements of dry kiln installations in this study was based on

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information regarding total kiln capacity and drying practices. Calculations for total annual energy consumption were based on requirements for lumber drying only; secondary demands such as space heating were not included. Energy requirements were based on total kiln capacity, total kiln cycles per year, and the energy requirements per thousand board feet (MBF) of lumber dried. Prior to kiln drying lumber, all facilities were assumed to use either air-drying (during warmer seasons), or accelerated air predriers (year round basis).

Total kiln drying capacity (in MBF), the use of a predrier, and air drying practices were all evaluated as each affects the total lumber drying capacity. Four facilities planned predriers, while the remaining five planned air-drying before kiln drying (Table 1). Total dry kiln capacity varied from 34 MBF to 195 MBF, and in most cases included several kilns.

Calculation of Energy Requirements

The lumber drying rate was assumed to be influenced by air-drying practices and use of a predrier. The economic analysis assumed that it would take eight days to reduce the moisture content of red oak from 30 to 7 percent for operations with predriers. Kiln cycles included one day each for loading and unloading, resulting in a 10-day cycle (36.5 kiln cycles per year).

For operations practicing air-drying, the model assumed a considerably slower drying rate. During warm seasons, when air-drying would reduce the moisture content from an initial 80 percent to about 30 percent, kiln drying was assumed to be completed in 10 days. This would result in an annual rate of 36.5 kiln cycles per year in year-

Table 1

Kiln capacity, use of predrier, and use of air-drying for nine hardwood dry kiln installations in Michigan

Dry Kiln Installation	Total Kiln Capacity[1] (MBF)	Use of Predrier (Yes/No)	Use of Air-Drying (Yes/No)	Kiln Cycles/Yr[2]	Lumber Volume/Yr (MBF)
1	150	No	Yes	26.5	3,975
2	100	Yes	No	36.5	3,650
3	48	No	Yes	26.5	1,272
4	50	No	Yes	26.5	1,325
5	40	Yes	No	36.5	1,460
6	34	Yes	No	36.5	1,241
7	30	No	Yes	26.5	795
8	195	No	Yes	26.5	5,168
9	40	Yes	No	36.5	1,460

[1] may include more than one dry kiln.
[2] estimated kiln cycles per year, based on drying practices.

round warm climates. However, during cooler months when air drying is not feasible, lumber must be kiln dried from the initial moisture content of about 80 percent. This increased moisture content results in a drying time of 20 days. Loading and unloading times increase total drying time to 22 days for an annual rate of 16.6 kiln cycles per year. Because of these variabilities in air-drying time, 26.5 kiln cycles per year was used as an average for firms using air-drying practices.

The economic analyses in this bulletin were conducted for drying energy requirements of 6 million BTUs per MBF for red oak and 4.5 million BTUs per MBF for species that were more easily dried than oak or had lower green moisture contents.

Alternative fuel costs - Natural gas was selected as the alternative fuel in this analysis because of its frequent use for drying lumber in Michigan. The three price levels used in the economic analysis were $2.75, $3.00, and $3.25 per million (MM) BTUs for delivered natural gas.

Financial Analysis

The financial analysis was performed with the computer program WEFAM, developed by the Michigan Public Service Commission. The computer program required 10 basic inputs to complete the energy use calculations (Table 2). Annual fuel costs assumed different values in the sensitivity analysis to reflect changes in energy consumption and pricing. Other input values remained constant in the analysis.

The WEFAM program was used to calculate energy savings, internal rates of return, payback periods, and 20-year cash flows (present and cumulative values). These profitability measures were calculated for the operating cost of the dry kiln only, not for the profitability of the entire production of dried lumber.

Results

Energy Requirements: 6 Million BTU/Thousand Board Ft.

Results for an assumed energy requirement of 6 MM BTU/MBF (million BTUs per thousand board feet of lumber dried) indicated large variations between projects for both the internal rate return (IRR) and the payback period (Table 3). Projects can be grouped into two classes based on rate of return portion of the program -- three projects had IRRs greater than 30 percent while

Table 2

Inputs needed for the WEFAM (Wood Energy Financial Analysis Model) computer program

1.	Energy System Size	MM BTUs per hour
2.	Alternative Fuel	Fuel type if wood were not used
3.	Expected Usage of Alternative Fuel	(appropriate to fuel type)
4.	Alternative Fuel Cost	$ per year
5.	Moisture Content of Wood Fuel	% of total weight
6.	Cost of Wood Fuel	$ per ton
7.	System Operation	hours per day
8.	System Operation	days per year
9.	Average Wage Rate of Boiler Operator	$ per hour
10.	Capital Cost of Wood Energy System	$

Table 3

Internal rate of return (IRR) and payback period for nine proposed wood energy systems for heating dry kilns

Dry Kiln Installation	Alternative fuel cost for natural gas ($/MM BTU)[1]	Energy Requirements (MM BTU/MBF)[2] 4.5 IRR (%)	4.5 Payback Period/Yrs	6.0 IRR	6.0 Payback Period/Yrs
1	2.75	33.9	4	44.2	3
	3.00	36.7	4	48.0	3
	3.25	39.5	3	51.7	3
2	2.75	38.4	3	50.6	3
	3.00	41.8	3	55.0	2
	3.25	45.1	3	59.4	2
3	2.75	5.9	14	9.6	11
	3.00	7.0	13	10.8	10
	3.25	8.0	12	12.0	10
4	2.75	10.2	11	14.6	8
	3.00	11.5	10	16.0	8
	3.25	12.7	9	17.4	7
5	2.75	11.9	10	16.7	7
	3.00	13.3	9	18.3	7
	3.25	14.6	8	19.9	6
6	2.75	11.0	10	15.9	8
	3.00	12.4	9	17.5	7
	3.25	13.8	9	19.1	7
7	2.75	9.1	11	13.4	9
	3.00	10.3	11	14.8	8
	3.25	11.5	10	16.2	8
8	2.75	26.2	5	34.0	4
	3.00	28.4	5	36.8	4
	3.25	30.5	4	39.6	3
9	2.75	9.0	11	13.1	9
	3.00	10.2	11	14.5	8
	3.25	11.3	10	15.8	8

[1] delivered cost.
[2] million BTUs per thousand board feet of lumber dried. Total energy requirements assumed to be 4.5 million or 6.0 million BTU per thousand board ft. of lumber dried.

the remaining six projects had IRRs less than 20 percent. Returns varied from less than 10 percent to almost 60 percent for an average return of 25.7 percent for all nine dry-kiln installations (Table 3). As might be expected, projects with high fuel demands benefited the most from substituting wood for more expensive alternative fuels.

The project payback represents the time necessary for a capital investment to accumulate a savings or income equivalent to the original investment. The payback period is inversely related to the IRR; shorter payback periods are associated with higher IRR values. In this analysis, payback periods for the dry kiln wood energy projects ranged from as short as 2 years (59.4 percent IRR) to as long as 11 years [9.6 percent IRR (Table 2)]. As was the case with the IRR results, project paybacks could be grouped into two distinct classes; six projects had payback periods of six years or greater, and three projects had payback periods of four years or less. Applicants 1, 2, and 8 (Table 3) had the highest alternative fuel costs and also the highest project IRR. The remaining six applicants all had lower energy requirements and project IRR values.

Energy Requirements: 4.5 Million BTU/Thousand Board Ft.

The economic analysis was repeated at an energy requirement level of 4.5 MM BTU per MBF to account for species other than oak (Table 2). Assuming this lower energy level, energy cost savings from wood fuel were lower than at 6 MM BTU/MBF energy requirement, and all IRR values were correspondingly reduced. Applicants could again be grouped into two distinct classes. Three applicants had IRR values greater than 25 percent, while the remaining six had values less than

Table 4

Year one (1) energy savings ($), Year one (1) energy savings (% of project cost), and Year 20 energy savings ($) for nine proposed wood energy systems for heating dry kilns[1]

6 million BTUs per thousand board ft.

	Energy Savings		
Dry Kiln Installation	Year 1 ($)	Year 20 $	% of project cost[2]
1	71,550	230,940	45.6
2	65,700	212,058	53.7
3	22,896	73,901	9.8
4	23,850	76,980	14.1
5	26,280	84,823	16.4
6	22,338	72,100	16.5
7	14,310	46,188	13.5
8	93,015	300,222	33.7
9	26,280	84,823	12.7

[1] total energy requirements assumed to be 6 MM BTU per thousand board ft. of lumber dried; alternative fuel cost for natural gas assumed to be $3.00 per MM BTU.

[2] project cost includes all capital costs associated with the initial investment in a wood energy system.

15 percent. Payback period and year-one energy cost savings show results similar tothe IRR analysis (Tables 2 and 4).

Again, higher alternative fuel costs were associated with greater savings and higher IRR values.

Summary

Many lumber drying installations producing manufacturing residues or other wood wastes are well positioned to benefit from wood energy. Among the advantages of using wood for energy are lower fuel costs and reduced landfill costs.

An economic analysis of nine dry-kiln installations in Michigan indicates favorable project economics for proposed wood energy installations under a wide range of operating conditions. Up to 50 percent of the capital investment for a wood energy system could be recovered in energy savings during the first year of operation. Dry kilns with higher fuel requirements realized higher internal rates of return (IRR) for wood energy projects. Greater energy requirements for drying lumber also resulted in more favorable economics through greater substitution of wood for more costly fuels such as natural gas. For each project, the IRR and energy savings were greater under energy requirement assumptions of 6 MM BTU per thousand board feet of lumber dried than of 4.5 MM BTU per thousand board feet.

Table 5

Year 1 energy savings ($), Year 1 energy savings (% of project cost), and Year 20 energy savings ($) for nine proposed wood energy systems for heating dry kilns[1]

4.5 million BTU's per thousand board ft.

	Energy Savings		
Dry Kiln Installation	Year 1 ($)	Year 20 ($)	% of project cost[2]
1	53,663	173,205	34.2
2	49,275	159,044	40.2
3	17,172	55,426	7.3
4	17,888	57,735	10.6
5	19,710	63,618	12.3
6	16,754	54,075	12.4
7	10,733	34,641	10.1
8	69,761	225,167	25.3
9	19,710	63,618	9.5

[1] total energy requirements assumed to be 4.5 MM BTU per thousand board ft. of lumber dried; alternative fuel cost for natural gas assumed to be $3.00 per MM BTU.

[2] project cost includes all capital costs associated with the initial investment in a wood energy system.

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The Wood Energy Demonstration Project

The Michigan Energy Conservation Program for Agriculture and Forestry's Wood Energy Demonstration Project was designed to help businesses and organizations throughout the state realize cost and energy savings through the use of wood as an energy source. A $300,000 direct grant program provided competitive awards to facilities to offset the cost of installing and maintaining wood energy systems. The maximum individual grant award was $75,000.

Under terms of the grant, recipients documented all installation and operating costs. Information on operating conditions and energy savings is available to any organization interested in the economics of wood as an energy source for heat or manufacturing.

Twenty-nine applicants submitted grant proposals, including primary and secondary forest products manufacturers, schools, agricultural related businesses, and a medical care facility. Nine proposals were received from businesses that use kilns to dry lumber, representing the largest single project type.

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