United States Department of Agriculture
Forest Service
Pacific Northwest Research Station
Research Note PNW-RN-450
August 1986

Drying Firewood in a Temporary Solar Kiln: A Case Study

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Abstract

A pilot study was undertaken to determine drying rates for small diameter, unsplit paper birch firewood that was dried: (1) in a conventional top-covered pile; (2) in a simple, temporary solar kiln; and (3) in tree length. Drying rates were the same for firewood piles whether they were in the temporary solar kilns or only covered on top to keep rain or snow from entering the pile. Trees that were severed at the stump and left to dry in tree length form, complete with branches and leaves, however, dried slower than firewood cut to length, stacked, and top-covered or placed in the temporary solar kilns.

Keywords: Kiln drying (solar), drying rate, firewood, paper birch, *Betula papyrifera,* Alaska (interior), interior Alaska.

Firewood in Interior Alaska

A large volume of wood is used for heating homes in interior Alaska. Estimates of such use of firewood for the Fairbanks North Star Borough range from 32,000 to 69,000 cords annually (Laroe 1982; State of Alaska, Department of Natural Resources 1983). Laroe estimated that 59 percent of the 16,700 households in the Borough use wood as a primary or secondary source of heat.

High moisture content in firewood results in less effective burning of the wood and in a loss of energy in evaporating the water during burning. A cord of paper birch (*Betula papyrifera* Marsh.) firewood with 15 percent moisture (dry weight basis) would be expected to use an energy amount equal to 470,000 British thermal units (Btu) during burning to evaporate this moisture. An equivalent cord of paper birch that had a moisture content of 80 percent would be expected to use 2.5 million Btu (Ince 1979). The dry cord will produce more than a 12-percent increase in usable heat.

Unsplit paper birch cut to 16- to 18-inch lengths will not air dry to 20 percent moisture content in a single season. Any system that would accelerate drying to permit burning of dry wood the same year it is cut would be useful. Two solar kilns for drying lumber have been operated in Alaska (Northern Engineer 1982). This type of kiln could be used in drying firewood, but the cost is too high to justify its construction solely for this use.

Wengert (1979) suggested a less expensive solar kiln for drying firewood. An even simpler version of Wengert's design can be built by letting the stack of firewood substitute for the lumber framework in his design. The only investment necessary is the polyethylene film and a strip of roofing paper or other material to serve as a solar collector.

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Objective

The objective of this study was to determine the effectiveness of covering stacked paper birch firewood with polyethylene to raise the temperature and accelerate drying in the Fairbanks, Alaska, area.

Methods

During mid-May 1983, three stacks of cut-to-length, unsplit firewood were built from freshly cut paper birch trees averaging 6 inches in diameter at breast height. As each tree was cut into firewood length, pieces 3 inches in diameter and larger were randomly assigned to the three stacks. Each stack was about 18 inches wide, 8 feet long, and 5.5 feet high and contained approximately one-half cord. In two of the piles, individual pieces were oriented north-south and conventionally stacked. In the third pile, alternate tiers of pieces were oriented east-west to provide for better air circulation. The piles were on a gently sloping southern exposure.

Ten pieces in each pile were selected as indicators of moisture content. A small disk cut from the end of each sample piece was weighed, ovendried, and reweighed to establish green moisture content. The remainder of each sample piece was weighed before it was placed into the pile, so that both green weight and ovendry weight could be established. At the end of the study on September 16, these pieces were again weighed to determine the ending moisture content.

Four temperature sensors were placed in each pile. One sensor was placed in the approximate center of each quarter of the pile. These sensors were attached to an electrically operated data logger which printed the temperature readings for each sensor five times per day.

One of the conventionally stacked piles served as a control and was top covered with a strip of roofing paper to prevent wetting from above. The other two piles had the top and four sides covered with 6-mil polyethylene film to form a temporary solar kiln. Air inlet holes were provided at the bottom and vent holes at the top on each end. On the front side (south) the polyethylene was extended from the top to a point about 5 feet in front of the pile (fig. 1). In both temporary solar kiln piles, occasional pieces of firewood were extended 4 to 6 inches in the rear to provide space for air circulation between the cover and the stacked firewood. After 20 days, the ground area under the polyethylene film in front of each pile was covered by black roofing paper to provide material that would absorb more radiation than the ground.

As a check on the effectiveness of drying roundwood in short lengths, two trees were felled into a clearing near the three firewood piles and their crowns and limbs were left intact through the drying season. For each tree, two disks were removed from the bole 1 foot above the stump for weighing, ovendrying, and reweighing to establish initial moisture content. At the end of the study two disks were taken from each bole 2 feet above the butt to determine final moisture content.

Results

The firewood under the polyethylene film was no drier at the end of the study than the firewood in the control pile (table 1). At the beginning of the study, moisture content of individual pieces ranged from 73 to 108 percent (dry weight basis); at the end of the study, from 28 to 38 percent.

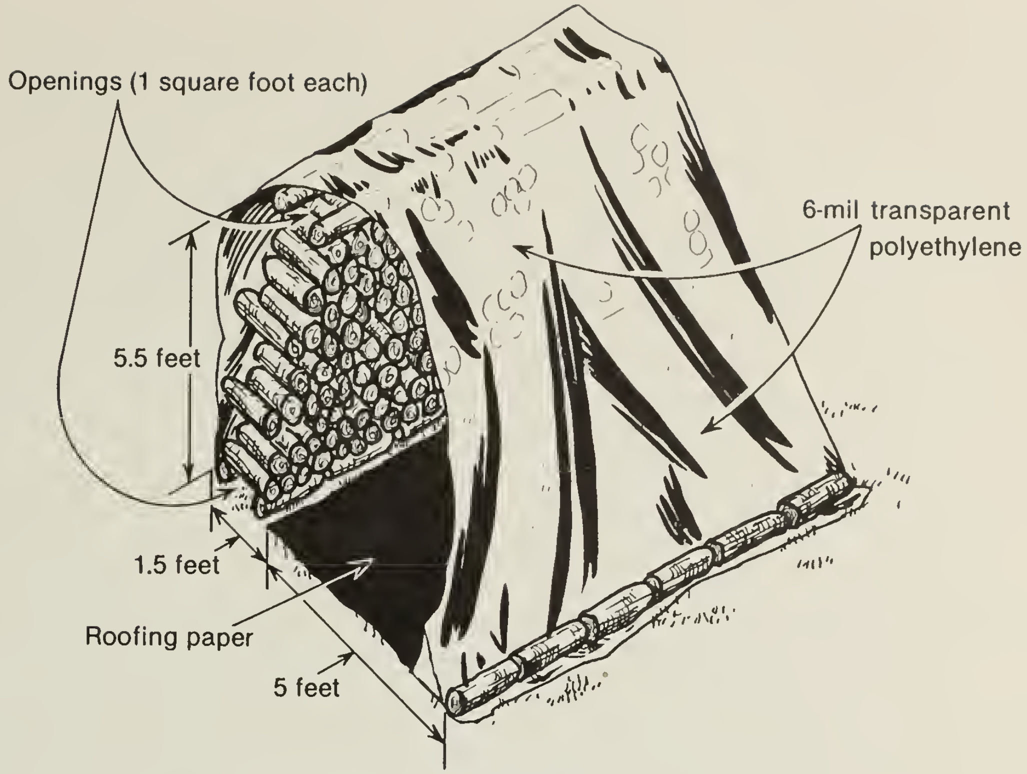

Figure 1—Firewood stack enveloped in polyethylene film to form a temporary solar kiln.

Table 1—Initial and ending moisture content for firewood piles and whole trees, by drying method

Drying method	Initial moisture	Ending moisture
	Percent	
Polyethylene covered piles:		
Conventional stack	86	34
Tiers in alternate directions	89	33
Control pile	92	33
Whole trees	72	49

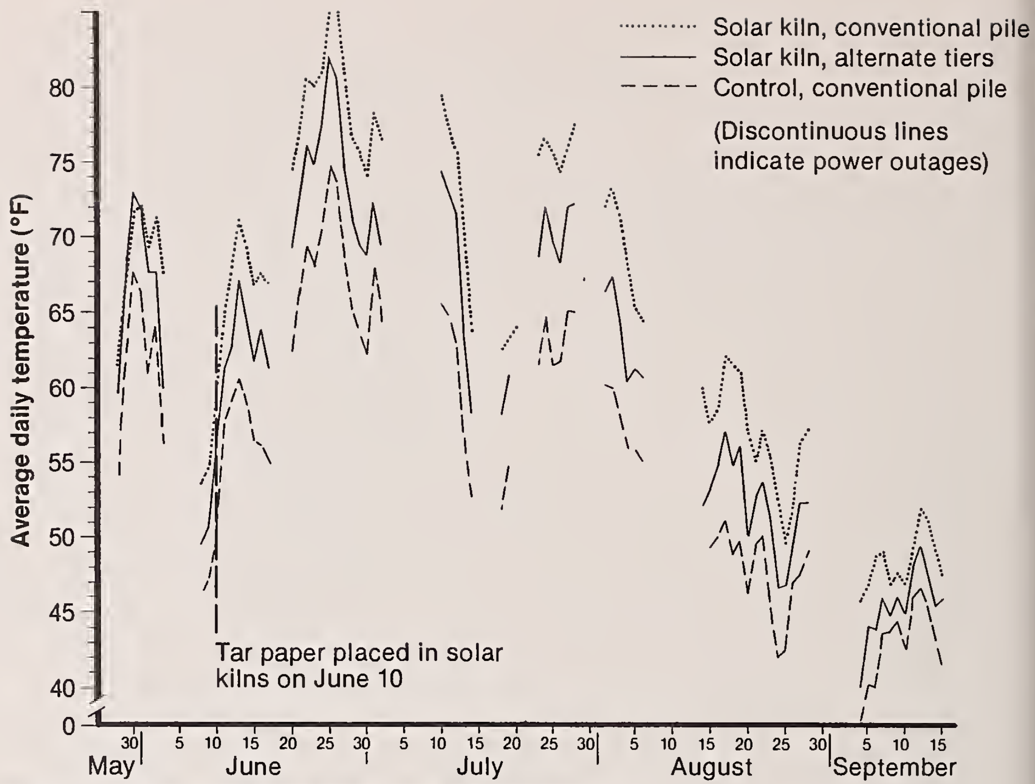

Figure 2—Average daily temperatures within the three firewood piles.

Temperatures within the polyethylene covered piles were consistently above those in the control pile (fig. 2). Temperature differences between the solar kiln and the control increased slightly after addition of the roofing paper; however, these temperatures were not high enough to result in faster drying compared with the control pile. Mold developed on the ends of pieces within the kilns, but there was no mold on pieces within the control pile.

The boles of the two trees that were felled and left to dry with limbs intact did not dry as rapidly as the cut-to-length and piled firewood (table 1).

Discussion and Conclusions

During the drying period, the temporary solar kiln with all pieces oriented in a north-south direction had an average daily temperature of 4.4 °F higher than the temporary solar kiln with alternate tiers oriented east-west. No specific measurements were made to determine whether this was caused by differences in radiation absorption, airflow, or the slight difference in location. Average temperatures within the solar kilns were 9.7 °F (north-south) and 5.3 °F (east-west) higher than average temperatures in the control pile.

During the 120-day drying period of this pilot study, the weather station at Fairbanks International Airport (5 miles from the study site) reported 9 clear days and 40 partly cloudy days based on observations between sunrise and sunset. The 30-year average for this period is 13 clear days and 34 partly cloudy days. The occurrence of mold on the ends of firewood pieces in the solar kilns may have been a result of higher temperatures and/or higher relative humidities than in the control pile. Data on relative humidities were not collected. Mold can develop on green lumber in dry kilns. It is prevented by sterilizing with near 100 percent relative humidity at a temperature of 130 °F or higher for 1 hour (Rasmussen 1961).

A simple, temporary solar kiln fashioned by covering a pile of firewood with polyethylene as was done in this study was not effective in reducing the moisture content of unsplit birch firewood below that of a covered control pile during a single summer. Others (Baker and others 1977, Wengert 1979) have suggested that a solar wood dryer built from polyethylene attached to a frame around a stack of wood is effective. Based on our observations, the only way to maintain high temperatures and avoid high humidities in the early stages of drying would be to have the stack of wood occupy much less space within the dryer or kiln or to add solar collectors and a system of fans. This means a more complex structure far more expensive in time and material than envisioned in our original design.

As in all case studies, the lack of replications limits the statistical validity of some of the conclusions. Because of the apparent ineffectiveness, we do not plan further research with this type of kiln.

Recommendations

For most types of firewood in interior Alaska, a waterproof top covering the stack is the most expense that can be economically justified. In Fairbanks, firewood stacked in piles 5 feet high would intercept the precipitation equivalent of 110 gallons of water per cord during June, July, August, and September of the average year (based on local climatological data). This amounts to more than half the volume of water that would be lost from a cord of birch from green wood to 15 percent moisture content. The actual effect of precipitation on drying of firewood is compounded by other factors. The bark of paper birch is almost waterproof, so theoretically, unsplit birch firewood would be little affected by wetting from the top. Split birch is subject to wetting from precipitation. Therefore, firewood piles should have a top cover to prevent rain or snow from entering the pile.

Our limited sample of two severed trees left to dry with limbs intact indicate that this method is less effective in producing dry paper birch at the end of the season than is cutting to length and stacking at the time of felling. Where wood is to be hauled a long distance before cutting to length, transport costs might be reduced by letting the trees dry before they are limbed and bucked. A study of moisture loss from felled eastern hardwoods showed that felling the trees and leaving the crowns intact resulted in a 5- to 10-percent reduction of moisture content in less than 7 days (Garrett 1983).

Metric Equivalents

1 mil = 0.00254 centimeter
1 inch = 2.54 centimeters
1 foot = 0.3048 meter
°F = 1.8 (°C) + 32
1 British thermal unit (Btu) = 1055 joules
1 cord = 3.625 cubic meters of stacked wood

Literature Cited

Baker, L.D.; Bartok, J.W., Jr.; Hamilton, L.S. [and others]. Burning wood. NRAES NE-191. Ithaca, NY: Cornell University, Northeast Regional Agriculture Engineering Service; **1977.** 30 p.

Garrett, Lawrence D. Moisture loss from felled eastern hardwood and softwood trees. In: The sixth international FPRS industrial wood energy forum '82, volume 1; 1982 March 8-10; Washington, DC. Madison, WI: Forest Products Research Society; **1983:** 210-214.

Ince, Peter J. How to estimate recoverable heat energy in wood or bark fuels. Gen. Tech. Rep. FPL 19. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory; **1979.** 6 p.

Laroe, Steve. Fuel wood utilization in the Fairbanks North Star Borough. Fairbanks, AK: Interior Woodcutters Association; **1982.** 19 p.

Northern Engineer. Solar kilns to dry wood. Northern Engineer. 14(4): 4-8; **1982.**

Rasmussen, Edmund F. Dry kiln operators manual. Agric. Handb. 188. Washington, DC: U.S. Department of Agriculture; **1961.** 197 p.

State of Alaska, Department of Natural Resources. Tanana Basin area plan, phase I resource inventory, forestry element. Fairbanks, AK: State of Alaska Department of Natural Resources; **1983:** 1-1 to 7-6. In cooperation with: U.S. Department of Agriculture, Soil Conservation Service.

Wengert, Eugene M. Solar heated firewood dryer. MT #13C. Utilization and Marketing. Blacksburg, VA: Virginia Polytechnic Institute and State University Cooperative Extension Service; **1979:** 6.

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