Energy Value and Moisture Content Changes of Wood Fuel During Outdoor Storage

Michigan State University Extension Service
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Issued April 1992
6 pages

Michigan Energy Conservation Program for Agriculture and Forestry

Extension Bulletin E-2367 April 1992

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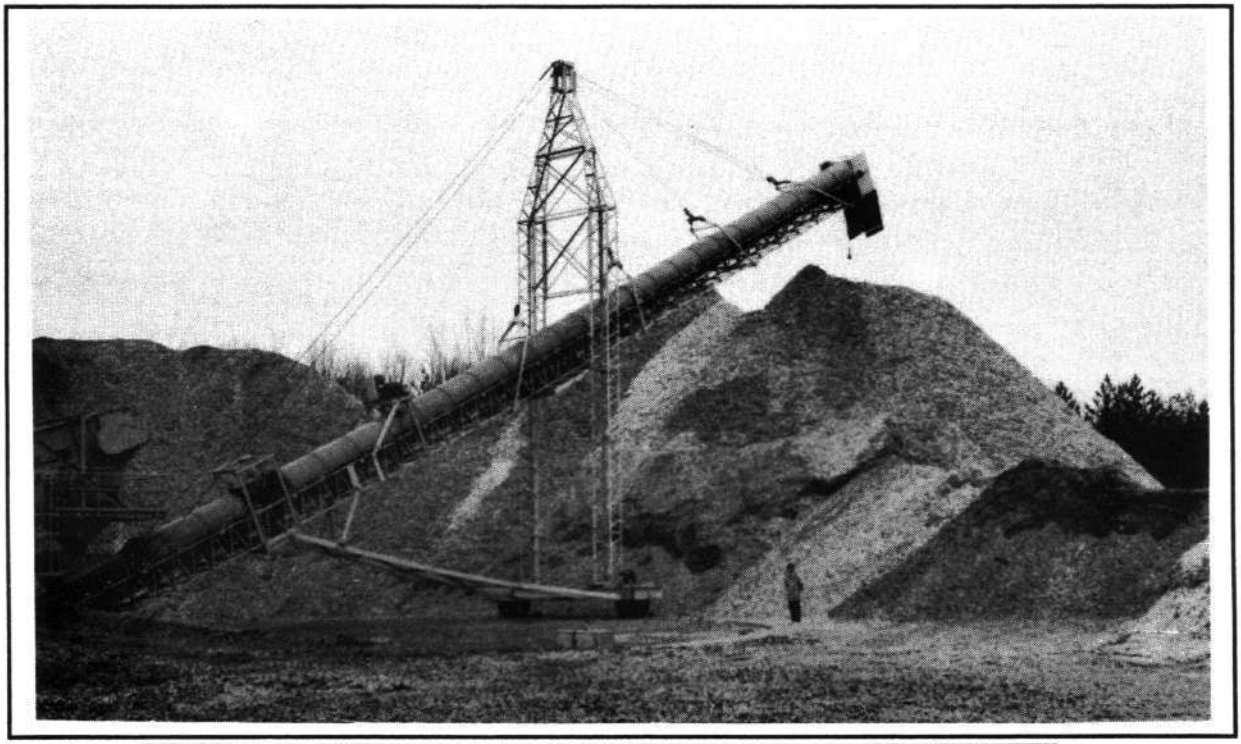
The Viking Energy Facility of McBain, Michigan cooperated with the Michigan Energy Conservation Program's (MECP) Wood Energy Demonstration Project to evaluate the effects of outdoor storage on the energy potential of wood fuel.

Viking Energy is a wood-fired electrical power plant generating 18 megawatts (16.4 MW net output). The facility constructed a 450-ton experimental wood chip pile for a 3 1/2-month study to evaluate changes in the moisture content and energy value of stored wood chips.

The $25 million facility provides electricity for approximately 4,000 residential households. At full operating capacity, this western Michigan power plant burns an average of 600 tons of wood chips per day. Residues from forest management and tree improvement activities are the primary fuel source for the power plant. Manufacturing residues from local sawmills supply much of the remaining fuel needs.

The objectives of this study were to evaluate changes in the fuel moisture content and to determine how these changes affect the energy value of wood chips in outside storage.



MECP is a cooperative effort of the:
Michigan Department of Agriculture - Michigan Soil Conservation Districts - USDA Soil Conservation Service
Michigan State University's Agricultural Experiment Station and Cooperative Extension Service

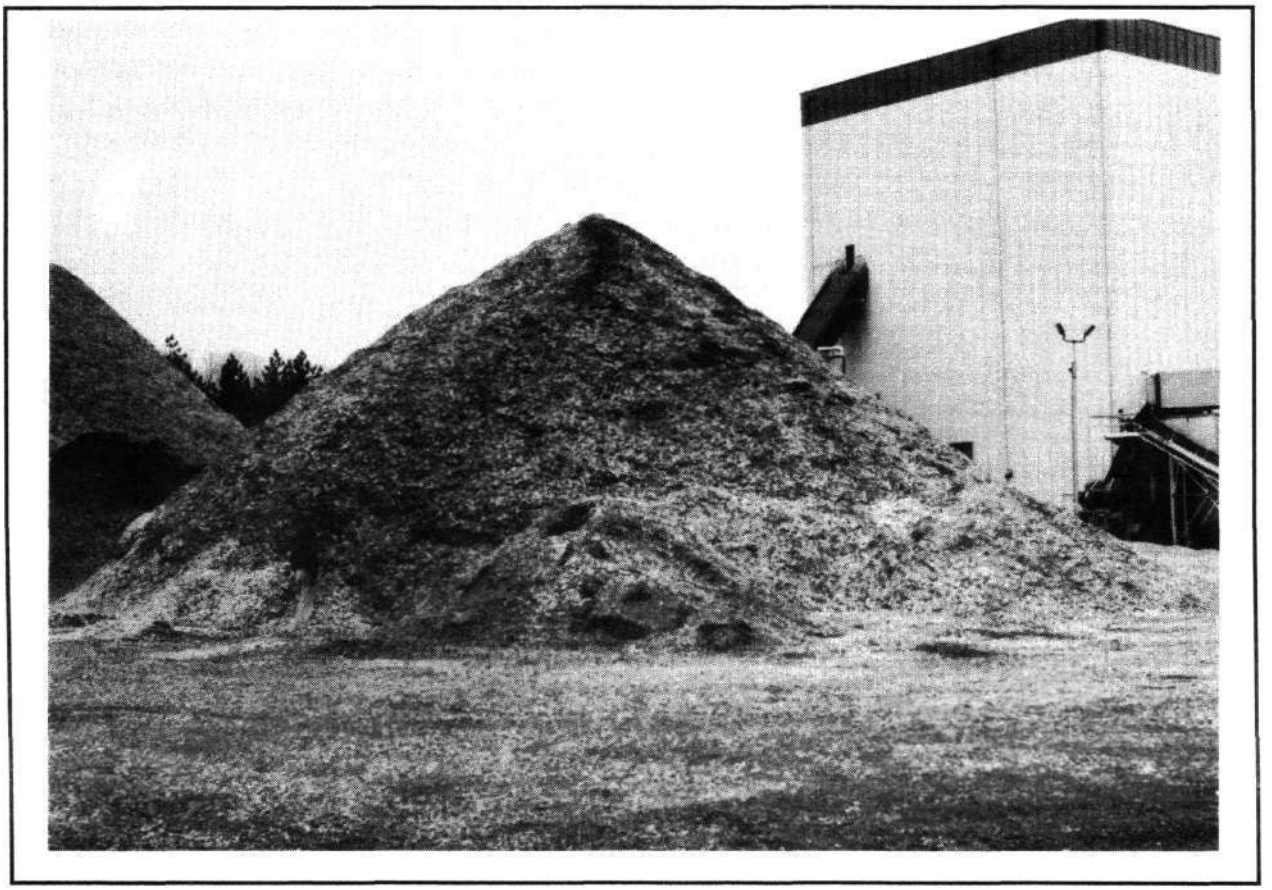
Although most incoming fuel is used within seven to ten days, storage periods of more than two months are sometimes necessary. This information will help plant managers adopt specific strategies for optimizing fuel inventory conditions, including pile height, storage time, and species composition.

PROCEDURES

The outdoor experimental storage pile was constructed at the McBain site in late January, 1990. The 30-ft high, 450-ton pile was formed as an uncompacted cone containing approximately equal volumes of hardwood and softwood species. Samples were taken twice a week at the start of the study and less frequently as the study progressed. Samples were collected on 13 dates during the 106-day study. Wood chips were collected on a gradient from the pile surface to a maximum depth of 20 ft. Samples were also collected from surface areas of the top half of the cone. At each sampling date, 16 samples were collected. On the final sampling date, sections of the pile were removed so additional interior samples could be taken.

Moisture content determinations were made for all samples, while energy value determinations were performed only for samples along one of the gradients. Gradients were horizontal lines approximately 3 ft above ground level, running from the pile surface to interior regions. Gradient samples extracted at depths of 7, 15, and 20 ft were analyzed along with surface samples for energy values (BTU/lb). All bark and foliage was included with the wood samples. Energy value determinations were made on four sampling dates, while moisture content determinations were made on all 13 sampling dates.

Internal pile locations were sampled with a segmented 1.5-inch diameter steel probe to a depth of 20 ft. The probe included an end bucket chamber to ensure that each sample was removed from an exact location. A front-end loader was used to push the probe to the desired depth. All specifications for the probe, including the collection chamber design were based on work by M.S. White, et al. (1980).



106-Day Samples - Procedures

At the end of the study period, two new transects were formed to evaluate final moisture content distributions from the pile surface to an 8-ft depth. Major sections of the pile were removed to expose interior regions of the north and south sides. Samples were taken from both sides of the pile at 1-ft increments to a depth of 8-ft. Three moisture content determinations were made at each increment, resulting in 27 observations each for the north and south sides.

Results

Moisture contents and net heating values of wood chips were greatly affected by depth from the pile surface. Surface chips increased in average moisture content from less than 50 percent to about 65 percent (green basis) during the 106-day study (Figure 1). Surface moisture contents increased uniformly over the study period except for one sample taken on day 41. This sample had considerably lower moisture content, which was probably due to local variations in surface conditions.

Using wood fuel with moisture contents approaching 65 percent (green basis) may result in difficult combustion. At the start of the study, when surface chips had a moisture content of less than 50 percent, the net heating value (NHV) was about 4,000 BTU/lb (Figure 1). This value declined to about 2,100 BTU/lb as the moisture content approached 65 percent by the end of the study. With the exception of the sample taken on day 41, the net heating value followed a well-defined decreasing trend throughout the study.

The higher heating value (HHV) of the wood chips, based on the energy content at zero percent (0%) moisture content, remained virtually unchanged at about 8,800 BTU/lb throughout the study.

Samples taken 7 ft from the pile surface showed different characteristics than did the surface samples. The moisture content of these chips increased gradually over the first 30 days of storage, then decreased over the remainder of the study period. Net heating values gradually increased as the moisture content decreased. Higher heating values remained almost constant at about 8,300 BTU/lb.

Samples taken 15 ft from the pile surface showed the greatest drying effect of any pile depth. Moisture contents varied from 48 to 52 percent (green basis) during the first 41 days of storage, then decreased to about 35 percent by the end of the study (Figure 1). Net heating values increased from less than 4,000 BTU/lb initially, to about 5,200 BTU/lb for the final sampling date. Higher heating values decreased only slightly over the study period.

Samples taken from a 20-ft depth showed similar trends to 15-ft samples, except they were not as pronounced. The average moisture content decreased gradually from 48 to about 36 percent, while net heating values increased from about 4,000 to 5,000 BTU per lb (Figure 1).

106-Day Samples - Results

Wood chip moisture contents for the final sampling date were generally higher at surface regions than at interior zones of the 8-ft gradient. For the south transect, the moisture content was highest 1 ft from the surface (69.1 percent green basis) and lowest 7 ft from the surface (38.0 percent green basis). Two distinct zones were apparent on the south aspect: high moisture content from the pile surface to a 3-ft depth, and a somewhat dryer zone at 4- to 8-ft depths. The average moisture content for samples from the south transect was 55.2 percent (green basis). The final moisture content of chips sampled from the north side ranged from 60 percent at the pile surface to about 47 percent (green basis) at a 5-ft depth. North side moisture contents decreased gradually through the 8-ft gradient rather than decreasing abruptly as with the south gradient. The average moisture content of the north gradient was 53.1 percent.

Precipitation records

Precipitation records were obtained from two weather stations approximately 10 and 15 miles from McBain. Precipitation events likely influenced surface moisture contents for two of the sampling dates. From day 26 to day 33 the average surface moisture content rose sharply, from 50 to about 56 percent (green basis). During this period, more than 13 inches of snow were recorded at a nearby weather station. Air temperatures were below freezing for much of this time, but the south aspects of the pile may have experienced some thawing from the sun.

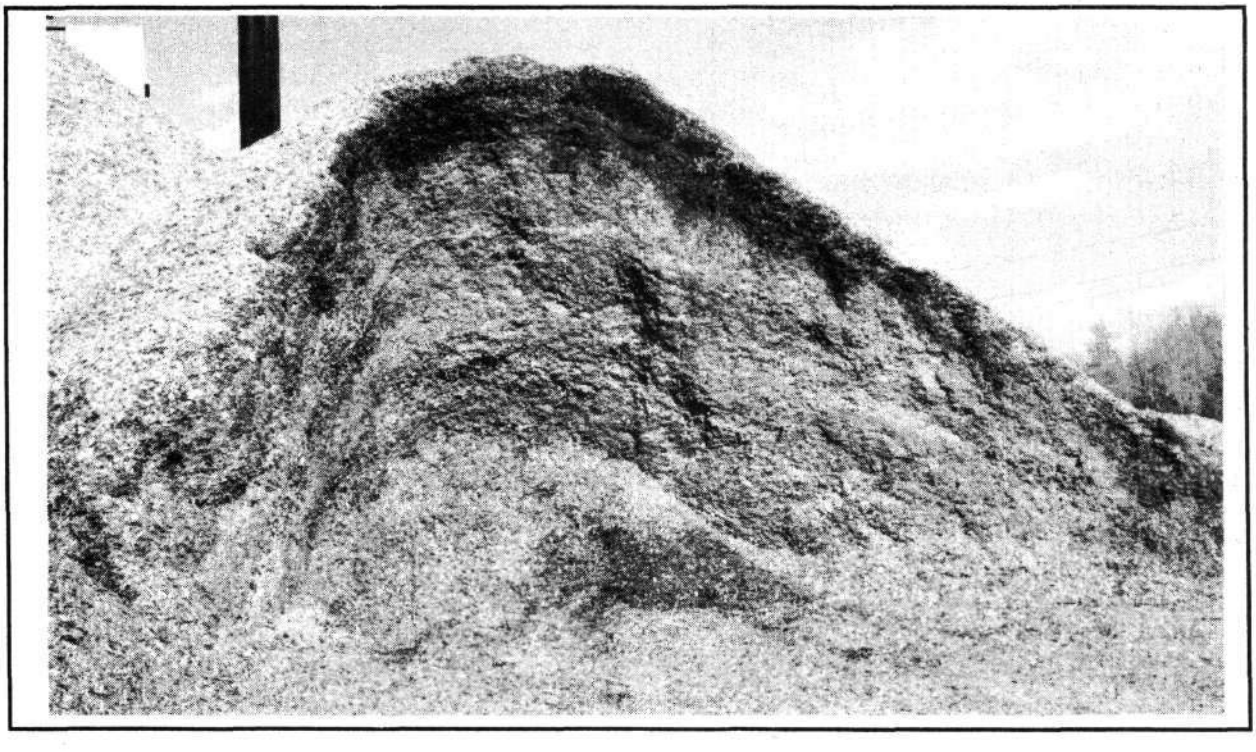
The moisture content of surface samples increased from less than 60 percent to about 64 percent (green basis) between days 92 and 106. Much of this moisture increase was probably due to a storm that delivered almost two inches of rain to the area on day 105. It is unlikely that interior measurements at 7-, 15-, and 20-ft depths were greatly influenced by precipitation events.

Qualitative changes

The top region of the pile underwent a number of changes during the first 1 1/2 months of storage. This area warmed, started steaming, and the wood chips became discolored. The surface of the cone functioned as a vent for dissipating moisture from the lower interior regions of the pile throughout the study. Samples from interior regions of the pile also showed some biological activity (including stain) during the first 1 1/2 months.

Overall conclusions

Surface layers of the 30-ft high experimental wood chip pile increased in moisture content during the 3 1/2-month storage period, while interior locations at 7, 15, and 20 ft from the surface decreased in moisture content. By definition, net heating values were inversely related to moisture content. Higher heating values of wood fuel samples remained almost constant regardless of pile location or storage time. The moisture content decreased sharply over a gradient from the surface to a sampling depth of 8 ft during the 3 1/2-month storage period. Final moisture contents were highest in a zone from the pile surface to a depth of about 4 ft. Biological activity became noticeable at interior pile locations within the initial 6 weeks of the study and was extensive on the final sampling date.



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Wood Energy Demonstration Project

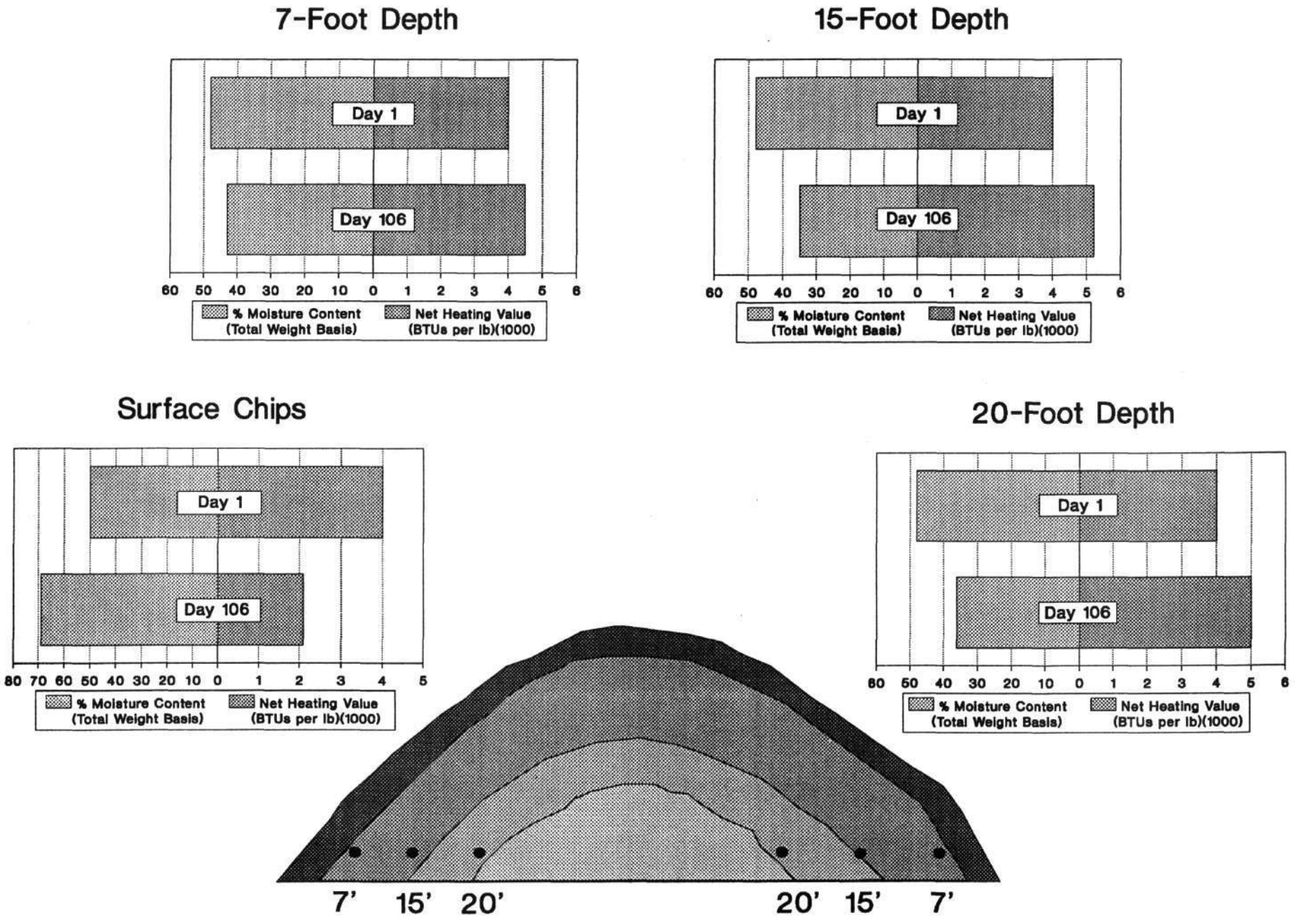
The Michigan Energy Conservation Program has been established to help farmers and wood energy users reduce energy costs by practical conservation methods. Reduced dependence on fossil fuels will enable more productive management of agricultural and forest resources in Michigan.

The Wood Energy Demonstration Project is designed to help wood fuel users establish wood energy systems, providing model demonstrations for other organizations. All businesses, governmental units, and not-for-profit organizations within Michigan were eligible for the grant program. A total of $300,000 has been allocated to 8 wood energy demonstration sites. The Viking Energy Facility is participating in the program on a voluntary basis. Its activities have included facility tours and the wood energy demonstration project.

"This bulletin was prepared with the support of the U.S. Department of Energy, Grant No. DE-FG0276CS60204. However, any opinions, findings, conclusions or recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of DOE"

Issued in furtherance of Cooperative Extension work in agriculture and home economics, acts of May 8, and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Dr. Gail Imig, Director, Cooperative Extension Service, Michigan State University, E. Lansing, MI 48824.

FIGURE 1



Moisture contents and net heating values for wood fuel on Day 1 and Day 106 of outdoor storage: Surface, 7-foot, 15-foot, and 20-foot depths.