Heat of Combustion and Energy Potential of Tree Species in Western Canada

by Teja Singh

The search for alternate fuels has increasingly focused on the role of forests as reservoirs of renewable energy. The existing levels of management in Canada have to be intensified to fully utilize the forestry resources for timber, fiber, and energy production.

HEAT OF COMBUSTION

Heat of combustion values are useful in determining energy estimates of standing trees and logging residues. Heat of combustion information is also needed for determining potential flammability of combustible materials and the release of total energy in forest fires.

Samples taken from tree stem sections are the basis for much of the data reported in the literature on heat of combustion. Other components need to be considered because of the calorific variations present within a tree species.

A recent statistical summary by the Tropical Products Institute, London, on 402 species for wood and 66 species for bark showed a heat of combustion range of 15.584 to 23.723 MJ/kg for hardwoods and 18.608 to 28.447 MJ/kg for softwoods. Forintek Canada has also compiled heat of combustion data for 48 Canadian tree species, based primarily on American literature sources because there is a dearth of published data for most species within Canada.

In a study I conducted at the Northern Forest Centre, heat of combustion values were determined for the main tree species of the prairie provinces (Alberta, Saskatchewan, Manitoba). The species were: white spruce [*Picea glauca* (Moench) Voss], black spruce [*Picea mariana* (Mill.) B.S.P.], jack pine [*Pinus banksiana* Lamb.], northern white cedar [*Thuja occidentalis* L.], tamarack [*Larix laricina* (Du Roi) K. Koch], balsam fir [*Abies balsamea* (L.) Mill.], Manitoba maple [*Acer negundo* L.], quaking aspen [*Populus tremuloides* Michx.], balsam poplar [*Populus balsamifera* L.], and white birch [*Betula papyrifera* Marsh.]. An electrically monitored bomb calorimeter was used to determine heat of combustion values. Statistical analyses included determination of variations present in tree species and in tree parts such as stump, stem, branches, foliage, and bark.

The study showed that the range of heat of combustion (mean values) for the major tree species in the prairie provinces was from 19.122 to 21.099 MJ/kg for softwoods and 18.396 to 20.091 MJ/kg for hardwoods. The mean values for heat of combustion for the oven-dry softwoods and hardwoods were 20.178 and 19.146 MJ/kg, respectively.

Analysis of variance performed on the data showed that the heat of combustion values were highly significantly different ($P < 0.05$) between hardwoods and softwoods as main groups, but not among tree species within the same main group. However, individual components within a tree species differed highly significantly ($P < 0.01$) from each other.

Heat of combustion variation between hardwoods and softwoods was highly significant ($P < 0.01$) for stump, and significant ($P < 0.05$) for stem, treetop, and foliage. Bark and branches did not show a statistically significant difference.

Heat of combustion values were generally lower for the main stem but increased toward stump and branches, including foliage. Treetop had the highest value (20.696) and stem the lowest (18.832). Heat of combustion values were intermediary for (1) foliage and branches, and (2) bark and stump. The components (from highest to lowest) ranked as tree top, branches, foliage, bark, stump, and stem.

Editor's Note: Heat of Combustion of a substance is the amount of heat evolved by the combustion of 1 gram molecular weight of the substance. It is measured in calories per gram of substance. The joule is another measure of energy, and 1 gram calorie equals 4.183 joules. The symbol MJ/kg refers to 1000 joules per kilogram. Thus, measurements of calories per gram can be converted to joules (or 1000 joules) per kilogram as the author provides in this article. For example, one textbook provides a heat of combustion value for beech as 4,774 calories per gram. Its heat of combustion in MJ/kg is determined by multiplying 4,774 by 4.183; a value of 19,970 joules per gram is obtained. This is the same as 19.97 MJ/kg and it falls within the range given by the author for hardwoods.

ENERGY POTENTIAL

Based on volumetric information presented in Canada's Forest Inventory 1981, the gross energy potential of tree species on *stocked, productive, non-reserved forest land* in the prairie provinces was estimated by the author as:

Manitoba	Conifers	4,351 PJ
	Hardwoods	2,056 PJ
Saskatchewan	Conifers	3,049 PJ
	Hardwoods	1,900 PJ
Alberta	Conifers	8,206 PJ
	Hardwoods	6,243 PJ

The symbol PJ means 10^{15} joules and is used to refer to very large quantities. For example, the sum of heat energy stored in all the conifers in Manitoba is 4,351 X 10^{15} joules.

The PJ values were calculated on the basis of oven-dry biomass; these will be considerably less for biomass at field moisture conditions. As a rule of thumb, the energy equivalency is reduced to about one-half when calculated on green-weight basis.

Conifers make up the bulk of energy potential (60.5%), more than 1.5 times that of hardwoods (39.5%). The major portion of the total energy potential resides in the merchantable components of trees--80.3% in conifers and 78.6% in hardwoods. These are the tree components that are principally committed for timber and fiber production from forest lands. Hardwoods such as aspen, balsam poplar, and white birch, however, represent a viable alternative for supplementing energy sources because no large-scale utilization of these tree species is being made at present in the prairie provinces. Major considerations such as access and economic return will greatly influence the future utilization of this potential for augmenting energy supplies.

Continued

Updated forest inventory data, including biomass from unproductive forests and previously uninventoried lands in northern areas, have considerably increased the estimates of gross energy potential from forest resources of the prairie provinces. Details on these additional sources and other related data are provided by Bonnor in a recently completed inventory of forest biomass for Canada.

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Teja Singh is a forester and Research Scientist at the Northern Forestry Centre, Canadian Forestry Service, at Edmonton, Alberta. Dr. Singh is also Canadian Editor for National Woodlands.