ENVIRONMENTAL FOOTPRINT COMPARISON TOOL

A tool for understanding environmental decisions related to the pulp and paper industry

EFFECTS OF NON-WOOD FIBER USE ON ENERGY USE

Differences in Fossil Fuel Demand

The cultivation and harvesting of wood fiber has a significant fossil fuel advantage over dedicated agricultural crops by virtue of the latter's greater requirements for irrigation, fertilization, and field operations associated with planting and harvesting. For the comparisons developed here, agricultural field operations and irrigation represent approximately 60% of the fossil fuel burden for a dedicated fiber crop. The balance is required for the production and distribution of fertilizers necessary to sustain the more intense annual cultivation of agricultural fiber. In contrast, on an <u>acreage</u> basis, the fossil fuel required to cultivate and harvest wood fiber is approximately 20% of that for a dedicated agricultural fiber crop, in the scenario developed below. The differences in energy are driven by the relative extent of fertilization and intensity of cultivation.

Fertilization - Fertilizer production is energy-intensive. As a generalization, 40 to 50% of the energy consumed for agricultural production is associated with the manufacture and distribution of fertilizers. Nitrogen fertilizer in particular is extremely fossil fuel-intensive, requiring about 1.5 pounds of oil equivalents to make 1 pound of fertilizer. According to a study by the Paper Task Force (1996), the embodied fossil fuel energy is the approximate equivalent of 10 gallons of diesel fuel per acre, assuming a 34 pound per acre fertilizer application rate that reportedly maximized yield in University of Mississippi studies (CNN 2008; Helsel 1993).

Where undertaken, forest silvicultural fertilization, over the course of a rotation of 10 to 20 years, *may* reach levels comparable to agricultural practice, though the latter is undertaken each year. Thus, agrifiber fertilization thought necessary to sustain high yields has at least 10 to 20 times greater application rates than those associated with silvicultural practice. Using the University of Mississippi benchmark for kenaf, the Paper Task Force has noted that the embodied fossil fuel energy for these forestlands would be proportionately at least an order of magnitude less than that for agrifiber, on the order of 0.5 to1.0 gallons of diesel fuel per acre (Paper Task Force 1996).

Irrigation - Among food production activities, energy use for irrigation ranks third behind 1) pesticide and fertilizer manufacture and use, and 2) farm energy use. For purposes of a benchmark, a review of irrigation practices among nine midwestern states is instructive (Graboski 2002). In that analysis, the approximate equivalent of about 1.7 gallons of diesel fuel per acre was required to provide 1.0 acre-feet of water.

Planting and Harvesting Estimates - The more intensive land management required for growth of dedicated fiber crops is high in fossil fuel use. Agricultural field operations associated with kenaf cultivation include 1) chisel plowing, 2) disking, 3) double disking with herbicide, 4) pre-planting fertilizer application, 5) bedding, 6) planting, 7) side dressing, and 8) cultivation (Scott and Taylor 1990). Equipment that might be used for harvesting and baling the crop would include a corn silage harvester, boll buggies, and module builders (Bazen, Roberts, and English 2007).

Published information showing fuel use associated with these various agricultural field operations allows an estimate of fuel requirements (Frisby 1993; University of Tennessee 2009). With the caveat that field crop budgets and fuel use may vary widely from farm to farm, fossil fuel required to plant, cultivate, harvest, bale, and collect kenaf is on the order of 12 gallons per acre. The estimate is not an unreasonable one when compared to a published figure showing use of 10.5 gallons of diesel and gasoline for a corn crop (Ryan and Tiffany 1998). Using a crop yield of 6.5 tons kenaf per acre, this translates into a fossil fuel use of about 1.8 gallons per ton of whole stalk kenaf.

As for forest silviculture, fuel requirements have been estimated in one life cycle impact review of forest resource activities that involved a rotation age of 25 years. The corresponding yield was 2.7 tons of wood per acre (Johnson et al. 2005). Fossil fuel requirements from planting through delivery of the wood amounted to 2.7 gallons per ton of wood. The fossil fuel required for growth and harvesting of the wood amounted to about 1.3 gallons per ton. Approximately 85% of that was for fuel and lubricants required for stump-to-truck operations.

Relative fuel intensities depend, of course, on pulp yields of the respective fiber crops. The most favorable case for kenaf involves mechanical pulping of the whole stalk. Commonly cited kenaf yields can be more than double the yield from wood-based mechanical pulping. In this case, kenaf fossil fuel intensity would be on the order of 2.2 gallons per ton of pulp, approximately 57% greater than fossil fuel intensity for wood pulp.

The margin is greater when considering pulp yields from chemically pulped kenaf bast and core component fibers apportioned for use in the manufacture of uncoated printing and writing papers. In that situation, wood and agrifiber pulp yields are similar. Fuel intensity of kenaf pulp would be more than three times greater than for an equivalent amount of wood-derived pulp. In absolute terms, the difference amounts to about seven gallons per ton of pulp.

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