TRANSITION TO A BIO ECONOMY
The Role of Extension in Energy

Economics of Crop Residues: Corn Stover

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Corn stover refers to the cobs, stalks, and leaves of the corn plant, i.e., it typically implies the material left over in the field after grain harvest.

Land Footprint: The ratio of corn stover to grain is typically assumed to be 1:1; thus, there is 56 pounds of corn stover produced for every 56 pound bushel of grain harvested. Thus, stover production estimates are typically based on grain harvest figures (this assumes ~ 15 percent moisture). Table 1 below shows some estimates of stover produced at various corn yields. Current estimates indicate that existing technology allows for only 30-40 percent of the stover produced to be harvestable.

Table 1. Stover Yield at Various Corn Yields

Corn Yield (bu/ac)	125	150	175
Stover Yield (dry tons/ac)	2.9	3.5	4.1
Harvestable Stover (dry tons/ac)	1.0	1.2	1.4

Expected Conversion Technologies: A recent study by Eidman *et al*. (2009) gives a detailed account of the profitability of a corn-stover-to-ethanol conversion facility under various conversion rates, plant sizes, internal rates of return, and ethanol and electricity prices. Please see reference at the end of this document for details on the study.

Harvest Methods: Harvest time is limited to roughly a three month period in the fall just after corn is harvested. Existing farm equipment can be used to harvest corn stover, although collection at a larger scale could be a challenge due to the short harvest window which falls during the harvest time for the primary crop (corn), when weather may also cause delays, etc. Please see Petrolia (2008a) for a detailed discussion on harvest, storage, and delivery issues and costs. It is reasonable to assume that if harvest of corn stover becomes widespread that alternative harvest methods would be developed such that the entire corn plant could be harvested at once, then separated off-farm. This would likely have the effect of substantially reducing harvest cost of the overall operation.

Environmental Impact: Because this crop is a residue, i.e., already being produced, the change in environmental impact with regard to carbon sequestration/emission is negligible. However, theoretically speaking increased use of stover-based fuels may reduce the use of non-renewable petroleum-based fuels, resulting in a net reduction in carbon emissions. The immediate environmental concern is soil erosion. Corn stover has historically been left in the field as cover to reduce erosion and for nutrient content. Use of stover for energy production, if harvested in excess of recommended levels, could produce erosion problems in some steeply sloped production areas. The harvest and cost estimates reported in Petrolia (2008a) assume that sufficient stover is left unharvested to satisfy tolerable soil-loss levels. There is some evidence that the economic incentive to harvest beyond tolerable soil-loss levels is small (Petrolia, 2008b).

Expected Cost of Production Per Acre: Cost of production is expected to be between $76-$90 per dry ton, depending on yield and transport distance. Assuming a conversion rate of 70 gallons per dry ton, feedstock production and delivery would account for $1.09 to $1.29 of the cost of a gallon of ethanol produced. Sensitivity analysis indicates that cost estimates are most sensitive to assumptions on bale moisture content, harvest efficiency, and producer participation rate (availability).

Storage: Because all of the stover would be harvested in a three month period, a considerable amount of storage for year-round ethanol production would be necessary. Storage adds between $7 and $13 per dry ton to feedstock cost. The ideal situation would be to identify other feedstocks that could be used throughout the year to reduce or eliminate the need for long-term storage, such as winter wheat straw during the winter and switchgrass during the summer.

Potential of Other Crops of Interest: Also of interest are residues from sorghum and wheat production. Table 2 shows a comparison of these with corn stover and the potential for ethanol production (Kim and Dale, 2004). Carbohydrates, which include starch, sugar, cellulose, and hemicellulose, are the main potential sources for producing ethanol, whereas lignin can be used to generated electricity and/or steam.

Table 2. Comparison of Corn Stover to Other Residue Feedstocks of Interest

Residue	Residue/Crop Ratio	Dry Matter (%)	Carbohydrates (%)	Lignin (%)	Ethanol Yield (gal/dry ton)
Corn Stover	1.0	79	58	19	69.5
Sorghum Straw	1.3	88	61	15	64.7
Wheat Straw	1.3	90	54	16	69.5

Source: Kim and Dale, 2004

Agronomy/Forestry

Useful Web Links for Further Information:

Department of Energy's Biomass Program - Information Resources

http://www1.eere.energy.gov/biomass/information_resources.html

Biomass Feedstock Composition and Property Database

http://www1.eere.energy.gov/biomass/information_resources.html

Key References:

Eidman, V., D. Petrolia, L. Pham, H. Huang, and S. Ramaswamy. 2009. "The Economic Feasibility of Producing Ethanol from Corn Stover and Hardwood in Minnesota." Applied Economics Staff Paper P09-0, University of Minnesota. Available at http://ageconsearch.umn.edu/bitstream/47055/2/p09-03.pdf.

Kim, S. and B. Dale. 2004. “Global potential bioethanol production from wasted crops and crop residues.” *Biomass & Bioenergy* 26(4):361-75.

Petrolia, D. 2008a. “The Economics of Harvesting and Transporting Corn Stover for Conversion to Fuel Ethanol: A Case Study for Minnesota.” *Biomass & Bioenergy* 32(7):603-12.

Petrolia, D. 2008b. “An Analysis of the Relationship between Demand for Corn Stover as an Ethanol Feedstock and Soil Erosion.” *Review of Agricultural Economics* 30(4):677-91.