ENVIRONMENTAL AND ECONOMIC RESEARCH AND DEVELOPMENT PROGRAM

Wisconsin Farm Biomass Production and the Emerging Carbon Economy

Executive Summary
May 2012

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This report was funded through the Environmental and Economic Research and Development Program of Wisconsin's Focus on Energy.

EXECUTIVE SUMMARY

This report describes factors governing the feasibility of switchgrass production for bioenergy in the State of Wisconsin, from the farm perspective. Here we assume that a minimal condition of feasibility is that the farmer profits from the combination of switchgrass production and (1) sales or (2) bioenergy use on-farm. To determine a range of possible net incomes from bioenergy we used three scenarios: switchgrass production and use on-farm in a 50 kW combined heat and power (CHP) unit; switchgrass production and sale for use in an 8.8 MW CHP unit, such as might be found in a school, hospital or district heating system; and switchgrass production and sale to a 50 MW power plant that produces electricity only. The outcome of each scenario was reported by county as annual net income from bioenergy, and as the net present value (NPV) of the bioenergy enterprise for a twenty-year term.

Switchgrass yield varied from 3.5 to 8.7 Mg ha^{-1} across the state, with highest values in the southern counties due to greater heat accumulation during the growing season. Temporal yield variability, simulated over a 57-year record of heat and precipitation data, was significant and quite consistent across counties, with 90% confidence intervals of ~ 6 Mg ha^{-1}. Soil effects on switchgrass yield introduced further spatial variation, with increased yields (and thus decreased production cost) in southwestern counties. Greater farm size also decreased production costs. State median production cost was \$74.21 Mg^{-1}, or \$4.28 $MMBtu^{-1}$. Income from switchgrass use depended on a few major factors. First, income from offsetting fossil fuel use with switchgrass depended on the cost of fossil fuel. Offsetting propane (\$15.38 $MMBtu^{-1}$), which is commonly used in rural Wisconsin, was more advantageous than offsetting natural gas (\$9.15 $MMBtu^{-1}$), or coal (\$2.06 $MMBtu^{-1}$). Second, use of heat produced by the CHP units was necessary to achieve feasibility, with at least 25% of heat use required in the state median farm case, when offsetting propane. Offsetting fossil fuel-generated electricity alone was not feasible due to its low cost, especially when generated from coal. Analysis of income and cost together as NPV gave a more complete picture of feasibility: the 8.8 MW scenario had positive NPV in 20 of 72 counties (at a 6.5% discount rate). NPV was quite sensitive to discount rate due to high costs in the first year of switchgrass production.

Feasibility of switchgrass production for bioenergy - and other societal goals - may be enhanced by compensating farmers for the environmental benefits of perennial grass production. Carbon sequestration is one of those benefits. We analyzed the CO_2 (*i.e.* carbon) balance of switchgrass production in Wisconsin, including net CO_2 emissions due to plant growth, soil erosion, diesel fuel combustion and other materials use. We also calculated carbon balances of other common Wisconsin crops and crop rotations. Carbon storage by switchgrass production was similar to that of continuous corn grain: 1001.31 vs. 1328.84 kg C ha^{-1}, respectively, both largely due to high plant productivity relative to the other crops analyzed (soybeans, oats, alfalfa). Corn silage stored twice as much carbon as corn grain and switchgrass, due to a carbon credit for using manure on-farm. This result highlights the sensitivity of carbon accounting to assumptions and life cycle analysis methods. In the event that a market for farm carbon credits re-emerges, careful documentation will be needed to show a real and lasting improvement in farm carbon storage from producing switchgrass.

Switchgrass production for heat and power on Wisconsin farms is feasible in many but not all instances. In the case of on-farm biomass use, the best economic outcome requires high yield and a relatively large amount of tillable but uncultivated land; these conditions occur mostly in the central and southern counties. For the bioenergy systems analyzed in this project, economic feasibility also depends on a market for the electricity generated, and significant demand for bioheat, such as a greenhouse, large heated barn, or higher than average grain-drying needs. On the other hand, total Wisconsin residential propane use is currently 23.1 million MMBtu, which is approximately equal to the total heat content of all the potential switchgrass cultivation on Wisconsin CRP land, at similar conversion efficiency. This parity suggests that a sufficient market for switchgrass could develop, depending on the particular scale, efficiency and deployment of bioenergy systems. The general trend toward feasibility would strengthen as fossil fuel prices increase.

ACKNOWLEDGEMENTS

The investigators would like to thank Bob Battaglia of the Wisconsin Agricultural Statistics Service for assistance and access to USDA Census of Agriculture data. We also thank Mike Casler of the U.S. Dairy Forage Research Center for sharing switchgrass trials data and advising on their interpretation.

Mitch Myhre's and Keith Cronin's M.S. theses were based on this project, and we thank their committee members for their expertise and contributions: University of Wisconsin-Madison Professors Chris Kucharik, Pete Nowak and Steve Ventura.

The investigators would also like to thank Mary Sternitzky for her assistance in preparation of this report.

CONTENTS

List of Figures

List of Tables

List of Acronyms and Abbreviations

BCAP	Bioenergy Crop Assistance Program
CDP	Center for Dairy Profitability
Ch	harvested carbon
CHP	combined heat and power
CO2	carbon dioxide
CRP	Conservation Reserve Program
CSP	Conservation Stewardship Program
CV	coefficient of variation
GDD	growing degree days
GHG	greenhouse gas
GREET	Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation
LCA	life cycle analysis
NASS	National Agricultural Statistics Service
NBP	net biome production
NEP	net ecosystem production
NPP	net primary production
NPV	net present value
NRCS	Natural Resources Conservation Service
PDF	probability density function
Rh	heterotrophic respiration
RUSLE	Revised Universal Soil Loss Equation
SOC	soil organic carbon
SSURGO	Soil Survey Geographic Database
USDA	United States Department of Agriculture
WHIP	Wildlife Habitat Incentives Program