

The Potential for Grass Biofuel Pellets

An Ecological Response to North America's Energy Concerns

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Executive Summary

- A combination of circumstances has opened up unprecedented opportunities for biofuel development.
- They include higher energy costs, low commodity prices and the need to reduce greenhouse gas emissions.
- The use of switchgrass as an alternative heating fuel is emerging as a solution that addresses all these problems simultaneously.
- North American farmland has a unique natural capacity for producing grasses that are highly suitable for use as a substitute fuel.
- The development of new burning systems for pelletized grass has opened the door to cost-efficient use of switchgrass as a heating fuel.
- In terms of carbon dioxide emissions, the burning of biofuel pellets is far superior to rates for conventional fuels.
- The economic advantages of widespread conversion to the use of biofuel pellets for thermal energy are considerable.
- Further development of this nascent industry will profoundly alter North American energy markets in a positive direction.

Introduction

A combination of factors—including rising costs for oil, natural gas and electricity, concerns for energy security in Ontario and the U.S. and the need to reduce greenhouse gas emissions—are creating unprecedented opportunities for biofuel development. Recent advances in combustion technologies have allowed densified fuels derived from crop-milling residues and energy crops to emerge as a promising new way to reduce heating costs.



Farmers are particularly vulnerable to higher energy costs; as primary producers, they are often expected to swallow them. These high prices, combined with low food-commodity prices, represent a double threat to the prosperity of farmers. One solution to resolve these problems would be to commercialize renewable biofuel crops. This would help diversify the farm economy, as well as allow farmers to increase their energy self-reliance and control their energy costs.

The need to find alternatives to fossil fuels and reduce greenhouse gas emissions has peaked interest in biofuels by energy specialists around the world. REAP-Canada has pioneered the research and development of biofuel pellets made from switchgrass¹ for use in space heating applications. Switchgrass, when pelletized, has considerable potential to displace oil, natural gas and electricity used for heating fuel. This development can significantly reduce greenhouse gases and heating costs and sustainably assist the development of rural communities. Fast-growing warm-season perennial grasses have been identified as ideal candidates for biomass fuel production due to their high net energy yield per hectare and low cost of production. Switchgrass is one type of warm-season perennial grass native to the Great Plains and eastern North America. It is favourably viewed as it easily adapts to marginal soils and arid climates with minimal fertility and management requirements.

The 1.1 billion acres of farmland in North America could help mitigate these concerns if currently viable biofuel production systems were expanded. In most agricultural regions, warm-season grasses such as switchgrass can be successfully grown at a cost of US\$2-\$3 per gigajoule(GJ)². Much of this farmland can collect 100-250 GJ of energy per hectare with existing production technology and plant materials. Efforts have been made to produce power and liquid fuels from this material, but the development strategies demonstrated so far appear to be sustainable only with subsidies. Converting this feedstock into a viable energy option suitable for widespread application requires an energetically efficient, economical, and convenient energy transformation pathway to meet consumer energy needs.

Finding Energy Farming's Comparative Advantage

The recent development of "close coupled" gasifier pellet stoves and furnaces³ capable of burning moderately high ash pelleted agricultural fuels provides a completely new fuel cycle for energy farming development.⁴ When burned in the gasifier stoves and furnaces, pelleted switchgrass provides fuel conversion efficiencies and particulate emissions in the same range as modern oil furnaces. Each GJ of grass pellet energy delivered to consumers therefore directly substitutes for one GJ of delivered oil, and can be utilized on a large scale without significant air pollution. The pelletized grass biofuel systems builds on, and is likely to overtake, the existing wood pellet heating industry, which is rapidly developing without any significant level of government intervention.



Pelletized grass biofuel is poised to become a major fuel source because this fuel pathway is capable of meeting some heating requirements at less cost than all available alternatives. The cost-effectiveness of pelletized grass as a fuel results from:

- efficient use of low-cost marginal farmland for solar energy collection
- minimal fossil-fuel input use in field production and energy conversion
- minimal biomass quality-upgrading, which limits energy loss from the feedstock
- efficient combustion in advanced yet modestly priced and simple-to-use devices and
- replacement of expensive, high-grade energy forms in space and water heating.

Contrary to the prevailing wisdom that reducing greenhouse gas emissions will raise societal energy costs, pelletized biofuels can provide consumers with lower and more stable heating costs while dramatically cutting greenhouse gas emissions. Given that agricultural commodity prices are declining in real dollars, pellet fuels are likely to become cheaper over time. By

contrast, wood-based pellets have been rising in cost due to ongoing improvement in industrial wood utilization which is reducing the waste fraction of delivered roundwood. Furthermore, the development of a grass pellet biofuel industry has great potential to revitalize the rural economy of North America by absorbing the surplus production capacity of the agricultural sector and cutting on-farm fuel costs in heating intensive sectors like greenhouses.

An Ecological Response to Energy Concerns

During combustion of plant-based biofuels, the carbon dioxide emitted is considered to be sequestered during the growth cycle of the plant. Carbon emissions are largely neutral except for energy associated with their production and conversion into fuel pellets. The savings in greenhouse gas emissions for biofuel pellets is considerable because burning them produces much fewer emissions than coal or natural gas.⁵ The ecological rewards are substantial.⁶

The Potential for Energy Farming with Grasses



Of the farmland in North America—932 million acres in the U.S. and 168 million acres in Canada—it has been estimated that 150 million acres could be dedicated to energy farming without appreciably affecting North America's food production capacity.

Assuming biomass energy crop yields are 50% higher than the current harvested hay yields, harvested perennial grass yields of 5.9 and 8.1 tonnes per hectare in Canada and the US respectively can be expected. By energy farming 130 million acres in the U.S. and 23.4 million acres in Canada, a total production capacity of 424 and 55 million tonnes could be achieved in the two respective countries.⁷

Assuming grass fuel pellets contain 18.5 GJ of energy per tonne, 8.9 billion GJ—the energy equivalent of 1.5 billion barrels of oil—could be produced each year from energy-crop production on 14% of North American farmland. With U.S. crude oil imports at approximately 3.4 billion barrels per year, the U.S. could displace the equivalent of 39% of its oil imports by growing biofuels on 14% of its farmland.

The Economics of Pelleted Biofuels

The most promising regions to develop a grass pellet fuel industry are those where hay production costs are low—generally indicated by low land rents—and heating costs are high—due to a long winter heating period and high fossil fuel costs. Based on hay prices, land costs and warm-season grass performance data in North America, and the relative winter heat costs of the various regions of North America, the best regions are the states of North Dakota, South Dakota, Nebraska, Minnesota, Wisconsin, and the provinces of Manitoba, Ontario, and Québec.

An ideal location for a biofuel pellet industry is the province of Manitoba. This largely agricultural region has amongst the lowest hay prices in North America and no indigenous fossil energy reserves. The spread between delivered heat costs of conventional energy sources and hay costs is rapidly growing. In real dollars, long-term hay prices remain flat at US\$2 per GJ (US\$35 per tonne), while delivered heat costs for natural gas, oil and electricity are rising and are now in the range of US\$10-\$13 per GJ. With current pellet production costs estimated to be \$2 per GJ (US\$35 per tonne) and a conversion efficiency of 80%, delivered heat costs for on-farm and residential grass pellet fuels are projected to be in the range of US\$5-\$7.50 per GJ.

There are major opportunities for Manitoba households to switch from electrical heating, currently used by 32% of households, to biofuel heating systems. Widespread implementation of this energy substitution strategy would enable hydro-rich regions such as Manitoba and Québec to expand electricity exports into the US market.

Conclusion

This paper makes the case that the easiest way to move biomass energy ahead in North America in the future is to focus on the development of pelletized grass biofuels as an ecological substitute for high-grade energy forms such as oil, natural gas and electricity in heat-related energy applications. North American energy markets could be profoundly transformed by the development of a large-scale, pelletized grass biofuel industry. As prices continue to rise for high-grade energy forms, low-priced farm-derived biofuel pellets will increasingly become the heating fuel of choice for many North American energy consumers.



About the Author: Roger Samson is Executive Director of Resource Efficient Agricultural Production-Canada (REAP), a charitable organization working to research and develop ecological solutions to challenges in energy, fibre and food production. He has been working since 1991 on bioenergy development systems that use prairie grasses as densified biofuels and for bioethanol production, and believes perennial grasses are poised to become the largest new renewable energy source for the industrial and developing world. He recently authored a comprehensive paper for *Critical Reviews in Plant Science* titled: "The Potential of C4 Perennial Grasses as a Global Bioheat Source". In 2005 Samson was also involved in bioenergy and agro-ecological farming projects in China, the Philippines and West Africa.

Footnotes

¹ Panicum virgatum

² A joule is a unit of energy equal to the work done by a force of one Newton acting through a distance of one metre, and a gigajoule is one billion such units.

³ See www.pelletstove.com.

⁴ *The use of Switchgrass Biofuel Pellets as a Greenhouse Gas Offset Strategy*, by R.Samson, M. Drisdelle, L. Mulkins, C. Lapointe and P. Duxbury, a paper presented at the Bioenergy 2000 Conference, Buffalo, New York, October, 2000.

⁵ When burned, pellets produce emissions of 5 kg CO₂ per GJ, compared to 96 kg CO₂ per GJ for coal and 62.13 kg CO₂ per GJ for natural gas.

⁶ For further discussion of the emission advantages of burning pelletized grass, log on to the REAP-Canada website at <http://www.reap-canada.com>, especially the powerpoint presentation, *The Use of Switchgrass Biofuel Pellets as a Greenhouse Gas Offset Strategy*, op. cit.

⁷ The REAP-Canada website at <http://www.reap-canada.com> also contains a valuable powerpoint presentation called *Opportunities for Growing, Utilizing and Marketing Biofuel Pellets*.