

**ENERGY CROPS AND THEIR USE IN
STOVES, BOILERS AND GASIFIERS**

James T. Cobb, Jr., P.E., Associate Professor Emeritus
Department of Chemical and Petroleum Engineering, University of Pittsburgh
1178A Benedum Hall, Pittsburgh, PA 15261
(412)624-7443, FAX (412)624-9639, cobb@engr.pitt.edu

INTRODUCTION

Switchgrass, hybrid willow and hybrid poplar are the principal energy crops being developed for the northern tier of the United States. Pennsylvania is focusing on switchgrass, Monona Farms being the agricultural leader in establishing and utilizing it. Switchgrass can be pelletized for use in home stoves and on-farm gasifiers, and it can be shipped to central electric power utility boilers for cofiring with coal. These uses are currently under development. The Pennsylvania Biomass Working Group is monitoring all aspects of bioenergy development and use in the Commonwealth, including energy crop establishment and utilization. This presentation surveys these subjects.

WOOD AS AN ENERGY CROP IN PENNSYLVANIA

A good example of the integrated production and utilization of an energy crop is the willow breeding and establishment program of the College of Environmental Science and Forestry of the State University of New York (SUNY-ESF). A recent article describing this program is found in the following website – http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/008/a0026e/a0026e12.htm Over 730 willow accessions have been collected from natural sites across the United States and provided by international collaborators. Controlled breeding work carried out at SUNY-ESF has produced some willow crosses with growth improved 20 to 40 percent over that of a standard cultivar. The Salix Consortium, described in the following website – http://www.eere.energy.gov/biomass/pdfs/factsheets/fy04/salix_consortium.pdf was formed to establish hybrid willow on 400 acres in western New York State to provide fuel to the coal-fired Dunkirk Power Station which installed biomass cofiring equipment several years ago to produce 9 MW of electric power on the grid in that area. Unfortunately, for a number of reasons the project was never completed.

In Pennsylvania there have been several demonstrations of the cofiring of wood with coal, but to date there has been no commercial use of this technology in the Commonwealth. The Pennsylvania Bureau of Forestry has recently begun to explore the possibility of facilitating the use low-value wood from state forest land in coal-fired and waste coal-fired boilerplants in our state. A project similar to the one envisioned by the Salix Consortium is certainly possible for Pennsylvania using hybrid willow, established and grown on farms in the Commonwealth.

SWITCHGRASS AS AN ENERGY CROP IN PENNSYLVANIA

An excellent primer on biofuels from switchgrass is provided on the following website – <http://bioenergy.ornl.gov/papers/misc/switgrs.html>. Switchgrass is a major component of tall grass prairie that, at one time, could be found from the Rocky Mountains to Pennsylvania. With its tall, dense stand and deep root system, it is drought-tolerant, erosion-resistant, wildlife-friendly and offers significant potential for carbon sequestration in soils. Thus it is very environmentally friendly. Its tall, dense stand also makes it an ideal energy crop. According to research, a one-acre field of switchgrass has the potential to provide enough energy to heat one home for an entire year. In recognition of this important potential, the U.S. Department of Agriculture (USDA) allows farmers to harvest, export and sell energy crops, such as switchgrass, from Conservation Reserve Program land, the only crop so allowed by the Department. Like hybrid willow, switchgrass can be used as a supplementary fuel for utility boilerplants. Two demonstrations have been conducted for cofiring switchgrass to a utility boilerplant – (1) at the Ottumwa Station in Iowa (<http://www.iowadnr.com/energy/renewable/switchgrass.html>) and (2) at the Gadsden Station in Alabama (http://www.poweringthesouth.org/articles/static/1/1012843819_1012401156.html).

Elements of this technology have been studied at the Energy Institute here at Penn State (http://www.energy.psu.edu/factsheets/Biofuels_Boilers_Program.pdf).

Another use for energy crops is as a feedstock for pelletizers producing biomass pellets for residential heating stoves. The process of hardwood sawdust pelletization has been in commercial use for many years. According to the Pellet Fuels Institute (PFI, www.pelletheat.org), “pellet manufacturers take by-products (like wood waste) and refine them into pencil-sized pellets that are uniform in size, shape, moisture, density and energy content. . . . The residential wood pellet fuel industry in North America was created in the early 1980s . . . [Today] there are more than 70 mills in North America that manufacture wood pellets.” The PFI website lists over 60 existing pellet mills in the United States that use wood as a feedstock. Five of these are in Pennsylvania. Two of these are Allegheny Pellet Corporation (APC) in Youngsville and Penn Wood Products, Inc., in East Berlin.

There is one farm that has taken the lead nationally in developing and demonstrating the production of switchgrass as an energy crop and its use as an ingredient in pellets for residential heating stoves, as well as in on-farm gasifiers for heat and power production. That farm is the 500-acre Monona Farms near Ligonier. Over 200 acres of mature stands of switchgrass have been established during the past five years as Conservation Reserve Program cover crop on its fields, and the farm is in near proximity to additional switchgrass-producing fields on both private and public land. The owner of Monona Farms is currently

organizing a project to purchase, install and operate equipment to produce pellet fuels from sawdust and switchgrass.

Three types of pellets will be produced. Switchgrass contains relatively low ash content for an herbaceous crop, but its ash content (~3.5 %) is too high to make premium and standard grade pellets without blending it with wood. Therefore, the pellets are (1) a 16% switchgrass/wood pellet, a direct substitute for the premium grade biomass pellet for residential heating stoves; (2) an 84% switchgrass/wood pellet, having the properties of a standard grade biomass pellet that can be sold as a supplemental fuel for utility boilerplants; and (3) a 100% switchgrass pellet, able to be fed to an on-farm gasifier that is designed especially to operate on switchgrass.

In preparation for the purchase and installation of a pelletization system on its property, Monona Farms has conducted several developmental activities to assure its success. Here is a brief survey of those activities.

1. Working closely with the John Deere Company for the past two years, Monona Farms has developed a new simple, economic two-step procedure to mow and bale switchgrass. In this procedure, mowing is accomplished using a small John Deere Diskbine with a finger conditioner system (that eliminates roller-crushing) to mow the switchgrass, and immediately following that, a small John Deere Silage Special Round Baler is used to chop the freshly mowed switchgrass into 3"—3½" pieces and bale them. An important feature of this new procedure is its capability to harvest in spring, in summer and in fall. Using the standard haying procedure, the yield during the spring harvest was 30% lower than that in the harvests at the other two times; using the new procedure, the yield during the spring harvest is only 10-15% lower.
2. Monona Farms rented a hammermill (the first device through which switchgrass passes in the pelletization system) and successfully tested its ability to receive and process the baled 3"—3½" switchgrass without additional chopping being needed.
3. Switchgrass from Monona Farms, as well as switchgrass grown in Alabama, was successfully pelletized in the research laboratories of the School of Agriculture at Auburn University.
4. A pelletization system, manufactured by the Andritz Pellet Company and now located at Environmental Pellets Inc. of New Paltz, NY, was used to test the pelletization of pure switchgrass from Monona Farms. This system produced pellets with great difficulty, and the ones it did produce were not acceptable. The staff of Andritz has assured Monona Farms that they are able and want to develop adjustments to their pelletizer that will allow successful production of pellets from switchgrass. Monona Farms will be providing Andritz with switchgrass for their developmental work.

5. Staff of Monona Farms provided switchgrass to two pelletizers, manufactured by California Pellet Mill (CPM) Company – one in West Virginia and the other a development unit in Ohio. Both are designed to feed blends of plastic and wood and neither showed the capability to properly feed or pelletize switchgrass. Monona Farms provided switchgrass to a third CPM system in Pennsylvania. This one was able to pelletize a one-ton lot of switchgrass and will try a larger lot soon.

6. From this experience it appears that pelletizer systems can be adapted through normal, modest development programs by pelletizer manufacturers. Bliss Industries has given Monona Farms assurance that the pelletizer that has been designed into the pelletization system for installation on Monona Farms will be adapted to produce acceptable pellets.

The company from which the pelletization system for this project is expected to be purchased (Equipment Dynamics, Inc., Schnecksville, PA) has significant experience in the sales and installation of pelletization systems. Once the system has been installed at Monona Farms, Equipment Dynamics will work with the pelletizer manufacturer to make post-installation adjustments to assure proper operation and production of acceptable pellets. It is a purpose of this project, in fact, to demonstrate the proper configuration of the pelletization equipment for this new set of feedstocks. The successful operation of the pelletization system at Monona Farms will provide a proven and replicable design for others to use in the future.

Monona Farms has a preliminary agreement with a nearby lumber finishing mill, for purchase of sawdust from that mill for this project. The mill, which currently supplies wood products to Wal-Mart on a national basis, has also agreed to broker most of the premium pellets that will be produced during the first year of this project at Monona Farms. In addition, Monona Farms has commitments with two pellet manufacturers in the region to market the pellets through their established network of retail outlets. Monona Farms will also seek its own agreements with chain stores and local retailers.

The economics of this project are quite favorable. Currently there is a serious shortage of biomass pellets for the home heating market in the northeastern United States as residents there switch from expensive imported heating oil to competitive, high-value-added, indigenous biomass pellets. Present trends show that satisfying this shortage has already led to a doubling of the production and consumption of premium pellet fuel in the northeastern U.S in the past ten years. The shortage has driven the sale prices commanded by wood pellets to historic highs, much higher than Monona Farms business plan requires for a profitable operation.

According to the PFI and the Energy Information Agency of the U.S. Department of Energy (USDOE), the cost of heating oil was already rising toward \$13 per million BTU near the end of 2004 while the cost of bagged wood pellets was holding steady at \$10 per million BTU. Heating oil has continued to rise steeply in 2005 and may now be above \$15 per million BTU. At 8,000 BTU/pound, a ton of bagged pellets contains 16 million BTU and should be priced at \$130. The equivalent heating oil currently would then be selling for \$195/ton (or \$70 per barrel). According to the PFI website, the national average price of wood pellets for this market is \$165/ton. In the future, the net revenue from the sale of pellets containing switchgrass may be adjusted even higher if a carbon trading system is put in place in the United States; this incremental increased revenue stream can be captured not only because of the renewability of its feedstock but also because of the carbon that is sequestered in the root system of the switchgrass.

The market for switchgrass-containing pellets for electric utilities is yet to be established. Certainly, producing pellets for an on-site gasifier/electricity generator set to produce electricity for use in the process and on the rest of the farm is economic, in that it avoids the purchase of electricity at retail prices from the grid. The future sale prices of electricity to the grid and of pellets as renewable fuel to local utilities has yet to be set as the Alternative Energy Portfolio Standard becomes implemented across the Commonwealth.

BIOMASS GASIFICATION

This process involves the partial combustion of organic fuels to a mixture of carbon monoxide and hydrogen, called synthesis gas that is a relatively clean combustion gas. The gas can then be fed to boilers to provide heat or to energy-efficient gas turbines to generate electricity. A number of initiatives have been taken in the Commonwealth toward biomass gasifier installations.

1. The Fraunhofer Center for Energy and Environment prepared a guidance document on wood gasification in Clarion County that was placed last year on the website of the Pennsylvania Department of Environmental Protection.
2. Cinergy Solutions has been working for the past three years to develop a project at the Philadelphia Naval Business Center whereby a biomass gasifier, manufactured by the Future Energy Resources Corporation (FERCO) of Norcross, GA, would produce synthesis gas that will be sold to satisfy nearby thermal loads. A FERCO wood gasifier was installed several years ago at the Joseph C. McNeil Generating Station in Burlington, VT. It converts up to 200 tons of wood per day into a gas that is used to co-fuel a wood-fired boiler to generate electricity. This project is thoroughly described in an article in *Mechanical Engineering* magazine: <http://www.memagazine.org/backissues/dec01/features/preaching/preaching.html>
3. Monona Farms received an Energy Harvest grant in 2003 to test of a small-scale biomass gasifier, provided by either Community Power ([6](http://bioproducts-</div><div data-bbox=)

bioenergy.gov/pdfs/bcota/abstracts/9/141.pdf) or Taylor Energy (http://www.eere.energy.gov/biomass/pdfs/factsheets/fy04/onfarm_smallscale_wasteenergy.pdf), on its property. It is in the process of purchasing this gasifier which, as noted above, will use pure switchgrass pellets from its pelletization system to fuel it.

4. The Piney Creek Generating Plant near Clarion received an Energy Harvest grant in 2004 to install a wood gasifier, but chose not to pursue the project.
5. U.S. Congressman John Peterson has recently obtained federal funding for the installation of a Community Power wood gasifier at Kane High School.

PENNSYLVANIA BIOMASS WORKING GROUP

An important mission of the USDOE's Northeast Regional Biomass Program (NRBP) in the past five years has been to provide information on bioenergy in its region. Its website is <http://www.nrbp.org/>. Pennsylvania's designated representative to NRBP's steering committee, and coordinator of the Pennsylvania Biomass Working Group, is David Bingaman, Division Chief, Conservation & Agricultural Technology, Bureau of Plant Industry, Department of Agriculture, 2301 North Cameron Street, Harrisburg, PA 17110-9408, (717)772-5208. The website of the working group is <http://www.wppsef.org/PAbioenergy.html?state=PA>. The vision of the working group is "to establish Pennsylvania as a national leader in the development of sustainable biomass feedstocks and conversion technologies to produce energy, biofuels, and bioproducts. This will contribute to the creation and growth of a new bioindustry, which is vital to the economic, social, and environmental success of Pennsylvania."

The working group meets three times each year to discuss issues in the areas of biomass resources, transportation fuels from biomass, anaerobic digestion of animal wastes, and the combustion and gasification of biomass. In these meetings also discusses regulatory and developmental aspects, as carried out by the Pennsylvania Department of Environmental Protection's Energy Office, the Pennsylvania Energy Development Authority, the U.S. Department of Agriculture and the U.S. Department of Energy.