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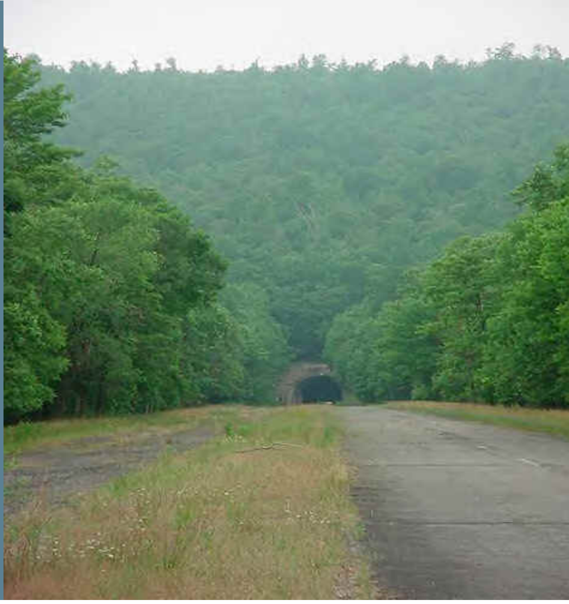
# AN ASSESSMENT OF THE FEASIBILITY OF BIOMASS ENERGY PRODUCTION FACILITIES IN THE SOUTHERN ALLEGHENIES REGION OF PENNSYLVANIA



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# An Assessment of the Feasibility of Biomass Energy Production Facilities in the Southern Alleghenies Region of Pennsylvania

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# EXECUTIVE SUMMARY

## MAJOR FINDINGS

The major findings of this study are as follows:

1. The Southern Alleghenies Conservancy (SAC) region, both the core and buffer counties, has a strong mix of rural land bases that can support the production of biomass fuels and feedstocks, including strong bases of hardwood forestland and a mix of agricultural land. This diversity provides a mix of potential biomass fuels, including forest harvesting residues, sawmill residues, corn, and soybeans. The region's principally available feedstocks are:
    - **Wood.** The total unused resource is 1.9 million tons, of which 475,000–650,000 is available. This is the equivalent of 40–50 MW of available electric power capacity.
    - **Manure**. The total resource is 6.16 million tons. The economically available resource is uncertain.
    - **Landfill gas (LFG)**. The total resource is 21 million tons of in-place waste, of which 15 million tons is potentially available. The economically available resource is uncertain.
    - **Corn for ethanol**. The total resource of 95 million bushels produced is equivalent to 237 million gal. of ethanol per year. The economically available resource is uncertain.
    - **Soybeans for biodiesel**. The total resource is 1.95 million bushels produced, equivalent to 2.7 million gal./year. The economically available resource is uncertain.

The diversity of landscape and crop type also means that some biomass feedstocks—particularly agricultural crops—cannot be grown in sufficient quantity to allow a user (e.g., an ethanol or biodiesel producer) to achieve necessary economies of scale.

2. The largest single biomass energy resource in the region is the existing resource of unused low-grade wood harvested from the forest. The region has very large volumes of forest residue potentially available, as this is currently left on the ground at most logging operations. This is a highly attractive and relatively low-cost source of biomass feedstock that could be used for the production of electricity, industrial-grade pellets, or potentially cellulosic ethanol. The total sustainable supply, including unused waste, is 650,000 green tons/year.

3. The collection, processing, and aggregation of this biomass resource during a timber harvest require equipment and logging infrastructure not currently in place in the region. The development of a large consumer of harvested wood chips, such as a wood-fired power plant, combined-heat-and-power (CHP) project, or cellulosic ethanol plant with an annual demand of over 200,000 tons is very important to develop a wood–chip-harvesting industry in the region. That harvesting infrastructure could then expand to provide wood chips for smaller consumers such as schools, colleges, and small commercial buildings.

4. Owing to the existing primary (sawmill) and secondary wood product facilities in the region, a large volume of mill residues is generated in the region. However, most of these mill residues currently have a market—either hardwood chips to the paper industry or sawdust for animal bedding. Development of a new market could pose a threat to the viability of these existing markets.

5. Existing significant biomass energy facilities in the region are confined to wood boilers, with some limited electric power generation at three pulp and paper mills and four sawmills. All these boilers are fired with wood waste or pulping waste predominantly from these mills' own operations. Small quantities of energy are provided by farm manure digestion at approximately seven farms and LFG recovery at approximately five landfills.

6. Resources of other types, including corn for ethanol production and soybeans for biodiesel, have limited potential for increased production in the region. Use of these feedstocks for energy is too expensive at present and would likely result in competition with existing higher value food and animal feed uses. The relatively small available supplies of manure and the low density within the region make manure-to-energy projects uneconomical at present except for on-farm applications.

## RECOMMENDATIONS

As a result of the study, we propose a number of recommendations to the advisory committee to consider for further investigation or action. These findings and recommendations are based on the following considerations:

- An assessment of the available biomass energy feedstock resources in the region and adjoining counties
- The current status of the energy conversion technologies that may apply to the region
- The economic feasibility of the energy conversion technologies in the context of the available biomass energy resources, current and near future markets for electric power, renewable energy credits (RECs), air emissions credits, fuels, and competing energy products
- The environmental considerations, including sustainability of the resource base and other impacts on air, water, and ecosystems
- The potential for biomass energy projects to contribute to additional economic development in the region without significant adverse impacts on existing economic activities, especially in agriculture and forest-based businesses

Our following recommendations have not been prioritized with respect to importance or urgency for action except as described in the text.

1. **Small to medium wood-chip–fired heating systems or CHP projects** with a heat input of 2–30 million Btu/hr are practical for schools, colleges/universities, and medium to large commercial buildings. Conversions are not yet economical, but new or expanded facilities may soon become economically attractive. Existing and new mechanisms should be explored to provide initial assistance to develop this sector until a time when expected changes in electric power prices and conventional fuel prices change the economic outlook. This sector is dependent on the development of a wood–chip-harvesting capacity in the region.

2. **Wood-fired electric power or CHP projects** with an equivalent electric generation capacity of 20–40 MW are ideal candidates for using the available unused low-grade wood. The annual demand for plants of this size would be 240,000–480,000 green tons/year. With the existing combination of wholesale electric power prices, REC prices, and wood prices in the region, electric generation or CHP projects are not currently economical. Expected increases in wholesale electric prices and REC prices in the next three or four years will improve the economics, but government incentives will still probably be needed to attract qualified companies to invest in this area. Therefore an effort should be made to find creative combinations of private financing and

government support to develop these facilities. These facilities with an annual wood demand of at least 200,000 green tons/year are very important to develop a wood-chip–harvesting industry in the region. That harvesting infrastructure could then expand to provide wood chips for smaller consumers such as schools, colleges, and commercial buildings.

3. **Co-firing wood with coal**, although practical and demonstrated, is not economical at prevailing wholesale electric power and REC prices. This situation may change if a national cap- and-trade program for greenhouse gas emissions is implemented, or if a carbon tax is imposed. However, neither of these outcomes is certain, and the detailed regulations for these programs may exclude co-firing with fossil fuels. Implementation of co-firing could occur with the active support of electric generation companies or distributing utilities, but this is uncertain. Although a wood-co-fired plant is large enough to start a wood–chip-harvesting industry in the region, loggers and lenders may view co-firing as an insecure market without a mandated market. In the short run, many premium voluntary or government-mandated REC markets may not accept co-fired RECs. Progress in developing this sector will depend on cooperation from the coal-fired electric generators and utilities. These might be approached as possible partners in an investigation of site-specific co-firing feasibility.

4. **Wood pellet production**, which in the past has typically depended on waste wood as its raw material, is likely to turn increasingly to wood chips. The availability of unused low-grade wood in the region, combined with good rail access, makes it possible that additional wood pellet manufacturing plants will be attracted to the region. These new plants are likely to be larger than existing plants and would supply a market in Europe for wood pellets at much higher prices. The higher prices in Europe reflect various EU government programs to combat global warming and encourage the use of renewable biomass resources. The development of these plants in Pennsylvania would also enable them to supply local markets when the price of wood pellets reaches EU levels.

5. **Cellulosic ethanol production** is at present in the precommercial stage. The availability of unused wood and good rail connections to eastern markets makes the region potentially attractive to some cellulosic ethanol development companies. Commercial plants would use amounts of wood comparable to wood-fired power plants and therefore could help develop regional infrastructure for biomass. There has been considerable competition among states to attract one of these new technology ethanol plants, and relatively large state and or local subsidies will be needed in addition to federal support. The regional economic development potential of cellulosic ethanol plants is comparable to a wood-fired power plant with a similar wood consumption. The risks of delays in development or plant failure, however, are much greater.

6. **Manure combustion** is a practical technology for disposal of manure and energy generation; it is not economical because of transportation cost. Manure disposal is not a major problem in the region, and digestion is a preferable technology. Air pollution and other environmental problems may make site selection difficult. No specific action is recommended.

7. **Manure digestion** is a practical and environmentally preferable technology for conversion of manure to energy. For larger animal operations, it is economical under existing support programs for on-farm applications. Local concentrations of livestock farms where transportation is less than 5–10 miles may be able to support a central digester. Further support and evaluation of manure digestion is recommended.

8. **LFG** capture is a viable enterprise for facilities in the region. However, owing to the small number of eligible facilities and their low generation capacity as compared with other technologies, the potential for significant economic impact is small. Extensive state and federal programs are in place to encourage use of LFG and provide funding. At this time, the only action recommended is to support partnerships between landfills and local businesses to use potential production for heat and power applications.

9. **Corn ethanol and biodiesel production** will occur in new plants that are at present under development close to the region. These plants will provide a market for local corn and soybean production. The production of corn and soybeans in the region is not sufficient to justify additional competitively sized plants. The effects of ethanol and biodiesel production on agriculture in the region are uncertain. No specific actions are recommended.

10. **Woody biomass plantations** on abandoned coal mined land would provide environmental benefits to the region and could provide a supplemental source of wood for energy. The potential for this should be investigated further.

# 1.0 INTRODUCTION

This report has been prepared by Resource Systems Group (RSG), in cooperation with Innovative Natural Resource Solutions LLC (INRS), under contract to the Southern Alleghenies Conservancy (SAC). The work was supported by a grant from the U.S. Department of Agriculture (USDA). It provides an assessment of the opportunities and feasibility of developing sustainable biomass energy in Blair, Bedford, Cambria, Fulton, Huntingdon, and Somerset counties in south central Pennsylvania. The study includes an assessment of the biological resources that could provide feedstocks for biomass-based energy in the region. It reviews the available technologies with the potential to use the biomass resources available and identifies the most promising opportunities for development that can contribute to economic development in the region. The report concludes with recommendations on which biomass energy development opportunities may be the most promising for further evaluation and development.

# 2.0 BIOMASS RESOURCE AVAILABILITY

## 2.1 INTRODUCTION

As part of an assessment of biomass energy opportunities in the SAC region, INRS conducted an assessment of biomass fuel availability. This assessment took into account a variety of biomass energy sources, including forest-derived wood, sawmill residue, and agricultural crops in both the counties that make up the SAC region (core counties) and those counties that directly border the SAC region counties (buffer counties).

## 2.2 GEOGRAPHIC AND DEMOGRAPHIC CHARACTERISTICS

### 2.2.1 Core Counties

The core counties for this analysis are Blair, Bedford, Cambria, Fulton, Huntingdon, and Somerset (Figure 1, in green). The combined land area of the six counties is 4,790 miles$^2$ (3,065,600 acres),[1] of which 64% is accessible forestland. Seventy percent of the forestland is in private ownership, with another 22% owned and managed by state agencies. The area has a population (2000 Census) of 484,373.[2]

Figure 1. Core counties of the SAC

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[1] U.S. Census Bureau, Population, Housing Units, Area and Density: 2000.

[2] Ibid.

### 2.2.2 Core and Buffer Counties

Because the use of biomass resources is not constrained by county lines, we have included all counties that directly border the "core counties" in a larger grouping referred to as "core and buffer counties" (Figure 2). This area includes all of the core counties listed above, as well as the Pennsylvania counties of Centre, Clearfield, Fayette, Franklin, Indiana, Juniata, Mifflin, and Westmoreland, and the Maryland counties of Allegany, Garrett, and Washington. The combined land area is 12,860 miles$^2$ (8,230,400 acres),[3] of which 60% is accessible forestland. Sixty-eight percent of the forestland is in private ownership, with another 26% owned and managed by state agencies.[4] The area has a population (2000 Census) of 1,747,074.[5]

Figure 2. Core and buffer counties of the SAC

## 2.3 BIOMASS SOURCES

### 2.3.1 Forests

The SAC region of Pennsylvania has significant resources, as noted above. A satellite view of the region (Figure 3) shows hardwood forests (green) covering hillside and hilltops, with other land uses (primarily agriculture, with former mine land and developed land likely) occupying the bottomland and river valleys.

Figure 3. Satellite view of SAC region (image created using Google Earth)

Both the core and buffer regions are heavily forested, with over 90% of the standing inventory in hardwood trees. This species mix presents the opportunity for in-woods chipping to provide exclusively or near exclusively hardwood chips, a somewhat unique circumstance that could be of significant value to fuel pellet manufacturers (particularly those producing an industrial-grade pellet, where limiting bark content is not a great concern) or cellulosic ethanol developers, some of which have technologies that favor hardwoods.

The information in Table 1 was developed using the USDA Forest Service's RPA (Resource Planning Act) Data Wiz, Version 1.0. This information is developed through the USDA Forest Service's Forest Inventory & Analysis, which samples fixed plots across the country. This information, al-

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[3] U.S. Census Bureau, Population, Housing Units, Area and Density: 2000.

[4] Ibid

[5] USDA Forest Service—Forest Inventory Mapmaker version 2.1.

though presented by county, is not always reliable at the county level. However, when multiple counties are combined, the sample size becomes large enough to mitigate this concern.

**TABLE 1. STANDING TIMBER VOLUME BY SPECIES TYPE**

**Standing Volume—Green Tons**

| COUNTY | STATE | SOFTWOOD | HARDWOOD | TOTAL | HW (%) |
|---|---|---|---|---|---|
| Bedford | Pennsylvania | 1,415,793 | 12,881,235 | 14,297,028 | 90 |
| Blair | Pennsylvania | 363,278 | 7,476,644 | 7,839,922 | 95 |
| Cambria | Pennsylvania | 1,201,842 | 11,294,166 | 12,496,009 | 90 |
| Fulton | Pennsylvania | 886,866 | 7,007,401 | 7,894,267 | 89 |
| Huntingdon | Pennsylvania | 1,775,697 | 14,512,499 | 16,288,196 | 89 |
| Somerset | Pennsylvania | 857,038 | 15,763,726 | 16,620,765 | 95 |
| **Subtotal (Core)** | | **6,500,514** | **68,935,671** | **75,436,185** | **91** |
| Centre | Pennsylvania | 2,256,589 | 18,329,296 | 20,585,885 | 89 |
| Clearfield | Pennsylvania | 3,430,852 | 19,617,922 | 23,048,774 | 85 |
| Fayette | Pennsylvania | 195,782 | 16,230,384 | 16,426,167 | 99 |
| Franklin | Pennsylvania | 370,225 | 7,489,679 | 7,859,903 | 95 |
| Indiana | Pennsylvania | 1,010,928 | 11,520,940 | 12,531,868 | 92 |
| Juniata | Pennsylvania | 322,398 | 6,227,724 | 6,550,122 | 95 |
| Mifflin | Pennsylvania | 589,046 | 7,782,464 | 8,371,510 | 93 |
| Westmoreland | Pennsylvania | 501,465 | 14,935,821 | 15,437,286 | 97 |
| Allegany | Maryland | 620,602 | 8,268,094 | 8,888,696 | 93 |
| Garrett | Maryland | 2,157,207 | 15,062,349 | 17,219,556 | 87 |
| Washington | Maryland | 560,941 | 5,702,366 | 6,263,307 | 91 |
| **Total** | | **18,516,550** | **200,102,711** | **218,619,260** | **92** |

Note: This standing volume inventory, developed from 2001 data, is similar to but does not agree perfectly with standing volume inventory presented later, developed using earlier data sets.

Of the standing volume, roughly 4% is live cull trees—trees with a diameter of greater than or equal to 5 in. (dbh ≥ 5”) that do not meet standards for merchantability as saw logs or pulpwood. These trees are likely scattered throughout the forest but provide an additional resource that could be harvested for use as a biomass fuel during a timber harvest. The data in Table 2 show that a remarkably higher percentage of the live cull volume is hardwood.

## TABLE 2. LIVE CULL VOLUME BY SPECIES TYPE

**Live Cull—Green Tons**

| COUNTY | STATE | SOFTWOOD | HARDWOOD | TOTAL | HW (%) |
|---|---|---|---|---|---|
| Bedford | Pennsylvania | 15,179 | 445,917 | 461,096 | 97 |
| Blair | Pennsylvania | 14,904 | 299,126 | 314,030 | 95 |
| Cambria | Pennsylvania | 56,702 | 507,446 | 564,148 | 90 |
| Fulton | Pennsylvania | 7,692 | 269,014 | 276,706 | 97 |
| Huntingdon | Pennsylvania | 17,733 | 284,507 | 302,240 | 94 |
| Somerset | Pennsylvania | 6,388 | 802,220 | 808,608 | 99 |
| **Subtotal (Core)** | | **118,597** | **2,608,230** | **2,726,828** | **96** |
| Centre | Pennsylvania | 23,457 | 428,499 | 451,956 | 95 |
| Clearfield | Pennsylvania | 62,522 | 712,274 | 774,797 | 92 |
| Fayette | Pennsylvania | — | 352,962 | 352,962 | 100 |
| Franklin | Pennsylvania | 6,016 | 250,696 | 256,713 | 98 |
| Indiana | Pennsylvania | 7,507 | 570,745 | 578,252 | 99 |
| Juniata | Pennsylvania | — | 585,421 | 585,421 | 100 |
| Mifflin | Pennsylvania | 11,244 | 184,993 | 196,238 | 94 |
| Westmoreland | Pennsylvania | 14,711 | 611,928 | 626,639 | 98 |
| Allegany | Maryland | 11,842 | 437,489 | 449,331 | 97 |
| Garrett | Maryland | 18,326 | 703,386 | 721,712 | 97 |
| Washington | Maryland | 9,866 | 635,808 | 645,673 | 98 |
| **Total** | | **284,089** | **8,082,431** | **8,366,521** | **97** |

USDA Forest Service—Forest Inventory Mapmaker version 2.1.

Of the standing volume, roughly 0.5% is sound dead—trees that are no longer alive but remain as sound, stable stems (Table 3). These trees are likely scattered throughout the forest but provide an additional resource that could be harvested for use as a biomass fuel during a timber harvest. Roughly 87% of the sound dead volume is hardwood.

## TABLE 3. SOUND DEAD WOOD VOLUME BY SPECIES TYPE

**Sound Dead Wood—Green Ton Equivalent**

| COUNTY | STATE | SOFTWOOD | HARDWOOD | TOTAL | HW (%) |
|---|---|---|---|---|---|
| Bedford | Pennsylvania | 19,434 | 251,722 | 271,156 | 93 |
| Blair | Pennsylvania | 12,793 | 81,608 | 94,402 | 86 |
| Cambria | Pennsylvania | 1,561 | 25,962 | 27,523 | 94 |

**Sound Dead Wood—Green Ton Equivalent**

| COUNTY | STATE | SOFTWOOD | HARDWOOD | TOTAL | HW (%) |
|---|---|---|---|---|---|
| Fulton | Pennsylvania | 12,323 | 67,679 | 80,002 | 85 |
| Huntingdon | Pennsylvania | 10,365 | 82,384 | 92,749 | 89 |
| Somerset | Pennsylvania | — | 66,763 | 66,763 | 100 |
| **Subtotal (Core)** | | **56,476** | **576,118** | **632,594** | **91** |
| Centre | Pennsylvania | 18,646 | 104,309 | 122,955 | 85 |
| Clearfield | Pennsylvania | 8,373 | 155,643 | 164,016 | 95 |
| Fayette | Pennsylvania | — | 48,327 | 48,327 | 100 |
| Franklin | Pennsylvania | 86 | 89,913 | 89,999 | 100 |
| Indiana | Pennsylvania | 9,239 | 35,880 | 45,119 | 80 |
| Juniata | Pennsylvania | 723 | 37,076 | 37,799 | 98 |
| Mifflin | Pennsylvania | — | 44,064 | 44,064 | 100 |
| Westmoreland | Pennsylvania | 5,239 | 40,758 | 45,997 | 89 |
| Allegany | Maryland | 170 | 59,588 | 59,758 | 100 |
| Garrett | Maryland | 82,381 | 25,643 | 108,024 | 24 |
| Washington | Maryland | 3,353 | 30,311 | 33,664 | 90 |
| **Total** | | **184,686** | **1,247,631** | **1,432,318** | **87** |

USDA Forest Service—Forest Inventory Mapmaker version 2.1.

Table 4 shows that the core region appears to have some modest level of growth exceeding loss (harvest and mortality), based on the USDA Forest Service Forest Inventory & Analysis data from a 1989 survey (covering a time period roughly a decade prior). Although these are the most recent data available, they are dated.

**TABLE 4. FOREST INVENTORY DATA—CORE COUNTIES**

| | GREEN TONS | | |
|---|---|---|---|
| | SOFTWOOD | SOFTWOOD | SOFTWOOD |
| Standing volume | 6,185,830 | 66,497,961 | 72,683,791 |
| Annual growth | 149,729 | 1,218,659 | 1,368,386 |
| Annual removals | 8,465 | 182,801 | 191,266 |
| Annual mortality | 19,637 | 899,229 | 918,866 |
| Annual loss | 28,102 | 1,082,030 | 1,110,132 |
| Growth less loss | 121,624 | 136,629 | 258,254 |

USDA Forest Service—Forest Inventory Mapmaker version 2.1.

Within the core and buffer counties, it appears that there are roughly 950,000 green tons of logging residues that are unused. The largest concentrations are found in Huntingdon and Clearfield counties. As noted above, INRS's experience is that no more than 50% of logging residue can be economically captured, even when strong markets exist in a region, so this would reduce likely available logging residue in the core and buffer counties to around 475,000 green tons. This is enough wood to supply a 45-MW wood-fired power plant, or enough to produce 19 million gal. of cellulosic ethanol[6] (assuming an appropriate conversion technology becomes commercial).

INRS does have some initial concerns regarding the growth-to-harvest ratio in the core and buffer counties region (Table 5). On the basis of USDA Forest Service Forest Inventory & Analysis data from 1989 (PA) and 1986 (MD) surveys (covering a time period roughly a decade prior), this region has growth below loss (harvest and mortality). Because these are dated numbers and may not accurately reflect current situation, this is highlighted to raise the issue only.

**TABLE 5. FOREST INVENTORY DATA—CORE AND BUFFER COUNTIES**

| | GREEN TONS | | |
|---|---|---|---|
| | SOFTWOOD | HARDWOOD | TOTAL |
| Standing volume | 17,073,573 | 189,765,485 | 206,339,059 |
| Annual growth | 491,956 | 4,076,349 | 4,568,305 |
| Annual removals | 167,347 | 3,223,641 | 3,390,988 |
| Annual mortality | 84,034 | 2,023,111 | 2,107,145 |
| Annual loss | 251,381, | 5,246,752 | 5,498,133 |
| Growth less loss | 240,575 | (1,170,403) | (929,827) |

USDA Forest Service—Forest Inventory Mapmaker version 2.1.

Using models produced by the USDA Forest Service, and supported by a series of conversations with loggers and foresters in the region, it appears that there are roughly 360,000 green tons of logging residue that are unused in the core counties.[7] Of this, roughly half is located in Huntingdon and Somerset counties. INRS's experience is that no more than 50% of logging residue can be economically captured, even when strong markets exist in a region, thus likely reducing available logging residue in the core counties to around 180,000 green tons. This is roughly enough wood to supply a 12-MW wood-fired power plant, or enough to produce 7.2 million gal. of cellulosic ethanol (assuming an appropriate conversion technology is developed). Much of the wood resource classified as logging residue has a high content of bark and sticks, and may present challenges for some technologies and feed systems. Figure 4 shows typical logging residue remaining in the forest.

Figure 4. Logging residue

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[6] New corn ethanol plants currently under construction in the U.S. are roughly this size.

[7] USDA Forest Service—Timber Products Output Mapmaker version 1.0.

On the basis of research and conversations with individuals active in the regional logging community, a strong logging infrastructure exists, but significant new capacity would need to be added to support a larger biomass operation. For example, in-woods chippers and chip vans are not common in the region, and are core to providing fuel to large biomass installations.

In other parts of the country, with established biomass markets, residue such as shown in Figure 4 is brought to the log landing, where it is chipped and blown directly into a van for transport to a biomass energy market (Figure 5). Owing to a lack of a market for significant volumes of biomass, in-woods chippers and chip vans are uncommon in the SAC region. Significant investment in new logging equipment would be required to develop the infrastructure necessary to capture the logging residue currently left on site.

Figure 5. In-woods chipper and chip van

## 2.3.2 Sawmills and Secondary Forest Product Manufacturers

As part of this study, INRS conducted a series of conversations with sawmills in the core region, with a focus on understanding logging infrastructure and residue generation. Sawmill residue refers to the sawdust, bark, edgings, and shavings that are generated when round logs are cut into rectangular boards.

Biomass derived from sawmill residue has a moisture content of 45–55% and contains an average of 4,625 Btu/lb (9.25 MMBtu/ton). Because of its reliability, uniform size, and a low number of impurities, sawmill residue makes an excellent fuel for small biomass thermal applications, such as are used in schools, hospitals, and campuses.

Using local contacts, the Pennsylvania Hardwood Development Council, national databases, the Pennsylvania Department of Conservation and Natural Resources—Bureau of Forestry and Pennsylvania State University, INRS identified over 50 sawmills and secondary forest product manufacturers. This information is shown in Figures 6 and 7 and Tables 6 and 7.

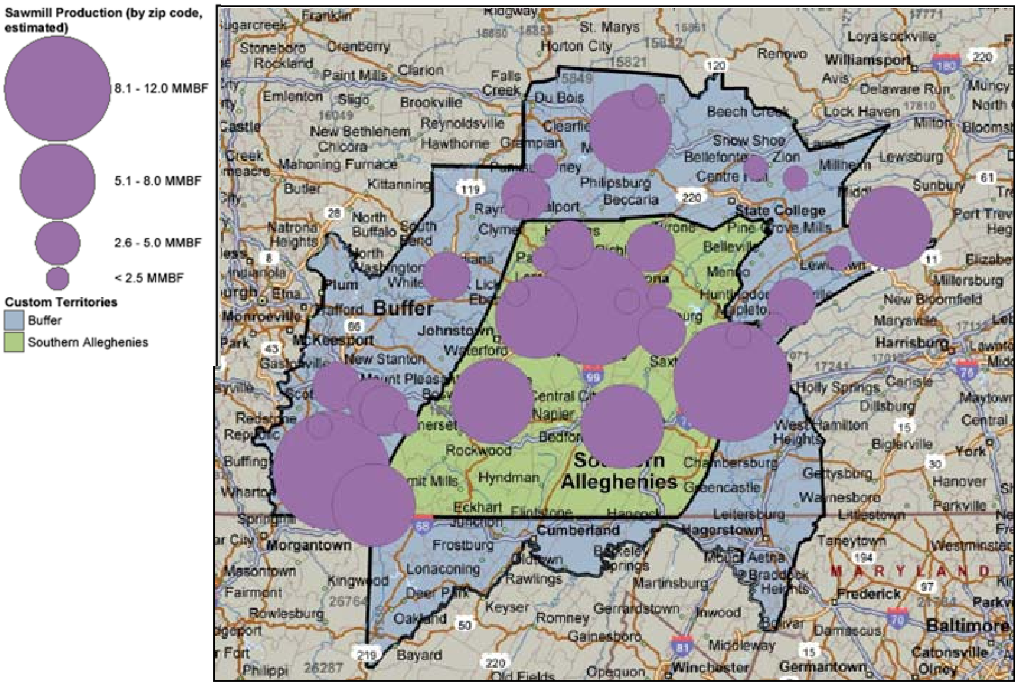

Figure 6. Sawmills in the core and buffer counties (NB: Not show all smaller facilities shown)

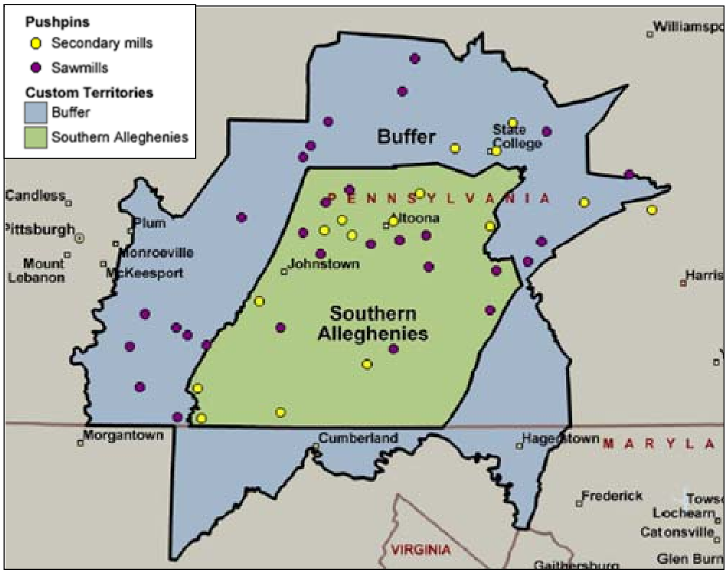

Figure 7. Sawmills and secondary forest products manufacturers (NB: Not all smaller facilities shown)

## TABLE 6. SAWMILLS—CORE AND BUFFER COUNTIES

| COMPANY | CITY | COUNTY | EST. ANNUAL PRODUCTION (MMBF) |
|---|---|---|---|
| Blue Triangle Hardwoods | Everett | Bedford | |
| Helsel Lumber Co. | Duncansville | Blair | 8.1–12.0 |
| Pennsy Lumber Products | Williamsburg | Blair | |
| Superior Lumber, Inc. | Tyrone | Blair | 2.6–5.0 |
| Van Jones Hardwood Co. | Hollidaysburg | Blair | |
| Baker's Lumber Co. | Cherry Tree | Cambria | <2.5 |
| Bruce Chappell Sawmill | Portage | Cambria | <2.5 |
| Cambria Hardwoods | Portage | Cambria | <2.5 |
| C&C Smith Lumber Co. | Summerhill | Cambria | 5.1–8.0 |
| D & D Wood Sales | Nicktown | Cambria | 2.6–5.0 |
| Fred Cherry Lumber | Nicktown | Cambria | <2.5 |
| George Long & Sons Lumber | Patton | Cambria | 2.6–5.0 |
| Krumenacker Lumber LLC | Carrolltown | Cambria | <2.5 |
| James Dolivera Lumber | Nanty-Glo | Cambria | <2.5 |
| Martindale Lumber Co. | Portage | Cambria | <2.5 |
| Venturine Bros Lumber Co. | Nicktown | Cambria | 2.6–5.0 |
| Brumbaugh Lumber LLC | Shirleysburg | Huntingdon | <2.5 |
| Garner Lumber | James Creek | Huntingdon | 2.6–5.0 |
| Interforest Lumber Corp. | Shade Gap | Huntingdon | |
| Kern Brothers Lumber Co. | Stoystown | Somerset | 5.1–8.0 |
| C.L. Price Lumber Co. | Aaronsburg | Centre | |
| Covalt Lumber | Spring Mills | Centre | |
| Robinson Lumber Co. | Bellefonte | Centre | |
| Bowser Lumber Co. | Mahaffey | Clearfield | <2.5 |
| Kovalick Lumber Co. | Frenchville | Clearfield | <2.5 |
| Lee Bros Lumber Co. | Grampian | Clearfield | <2.5 |
| Rorabaugh Lumber Co. | Burnside | Clearfield | 2.6–5.0 |
| Walker Lumber, Inc. | Woodland | Clearfield | 5.1–8.0 |
| Appalachian Timber Products | Markleysburg | Fayette | 5.1–8.0 |
| Brown Timber & Land Co. | Acme | Fayette | 2.6–5.0 |
| Bryner Lumber Co. | Vanderbilt | Fayette | <2.5 |
| Champion Lumber Co. | Champion | Fayette | <2.5 |

| COMPANY | CITY | COUNTY | EST. ANNUAL PRODUCTION (MMBF) |
|---|---|---|---|
| Coastal Lumber Co. | Hopwood | Fayette | 8.1–12.0 |
| Keslar Lumber Co. | White | Fayette | 2.6–5.0 |
| Cameron Lumber LLP | Homer City | Indiana | 2.6–5.0 |
| Gaston Lumber Co. | Punxsutawney | Indiana | 2.6–5.0 |
| Harmony Gas Oil & Timber | Cherry Tree | Indiana | <2.5 |
| Brian Short Sawmill | Dixonville | Indiana | <2.5 |
| Clugston Lumber Co. | East Waterford | Juniata | <2.5 |
| Hoffman Brothers Lumber | Richfield | Juniata | 5.1–8.0 |
| R.J. Junk Lumber | Honey Grove | Juniata | 2.6–5.0 |
| Gerald King Lumber | Ruffsdale | Westmoreland | 2.6–5.0 |
| Gutchess Lumber (hardwoods) | Latrobe | Westmoreland | 2.6–5.0 |

### TABLE 7. SECONDARY FOREST PRODUCT MANUFACTURERS—CORE AND BUFFER COUNTIES

| COMPANY | CITY | COUNTY |
|---|---|---|
| Bedford Pallet | Bedford | Bedford |
| Modern Cabinet & Construction | Altoona | Blair |
| Precision Dimension Inc. | Tyrone | Blair |
| Allegheny Molding & Planning | Loretto | Cambria |
| C&C Smith Lumber Co. | Summerhill | Cambria |
| Long's Hardwoods | Ebensburg | Cambria |
| Mark Penatzer | Summerhill | Cambria |
| New Germany Wood Products | Summerhill | Cambria |
| Wolf Lumber & Millwork | Cresson | Cambria |
| Big Valley Hardwoods | Allensville | Huntingdon |
| Boswell Lumber Co. | Boswell | Somerset |
| Clapper’s Industries | Myersdale | Somerset |
| Metheney’s Lumber Drying & Sales | Confluence | Somerset |
| Precision Pallets | Addison | Somerset |
| Summit Box & Pallet | Myersdale | Somerset |
| Collegiate Furnishings | State College | Centre |
| Pennwood Corp. | Pleasant Gap | Centre |
| Thomas Timberland Enterprises | Pleasant Gap | Centre |

| COMPANY | CITY | COUNTY |
|---|---|---|
| Woodcraft Industries | Bellefonte | Centre |
| Ziegler Packaging & Crating | Port Matilda | Centre |
| Scalese Millworks | Cherry Tree | Indiana |
| Excel Homes | Liverpool | Juniata |
| Gray's Pallets | Mifflintown | Juniata |
| Rockland Pallet Co. | Mifflintown | Juniata |
| Gutchess Lumber (Hardwoods) | Latrobe | Westmoreland |
| Metzler Forest Products | Belleville | Mifflin |

Using the production information above and models produced by the USDA Forest Service, and supported by a series of conversations with sawmills in the region, it appears that there are roughly 250,000 green tons of sawmill residues produced in the core counties. Over three quarters of this residue is generated in Cambria, Huntingdon, and Somerset counties. In the core and border counties, sawmills generate roughly 770,000 green tons of sawmill residues each year.

Much of this mill residue currently has a market, though mills were anxious to identify additional markets. Depending on the product, mill residues are sold as pulp chips, mulch, animal bedding, and feedstock for engineered wood products, used in on-site boilers or put to other uses. Handling this material is illustrated in Figure 8. On the basis of preliminary conversations, it appears that well over 90% of sawmill residues currently have a market, though all producers expressed a willingness to consider new markets as well.

Figure 8. Sawdust loaded at mill for delivery to animal bedding markets

### 2.3.3 Urban Wood

Urban wood refers to construction and demolition debris, wood from yard waste, utility and right-of-way clearings, and pallets (Figure 9). Pallets are a particularly attractive fuel for this region, as it sits at the intersection of major roadways and strategically between a number of east coast and Midwestern markets. Interstates 70, 99, and 76 all cross the core area; Interstates 80 and 68 cross the buffer region.

Figure 9. Broken pallets, Bedford, PA, manufacturing facility

### 2.3.4 Existing Major Markets for Low-Grade Wood

Biomass markets have the potential to compete with existing markets for low-grade wood, such as pulp mills. The core and buffer areas are logical procurement regions for four major pulp mills (Figure 10) with 90-min drive times.

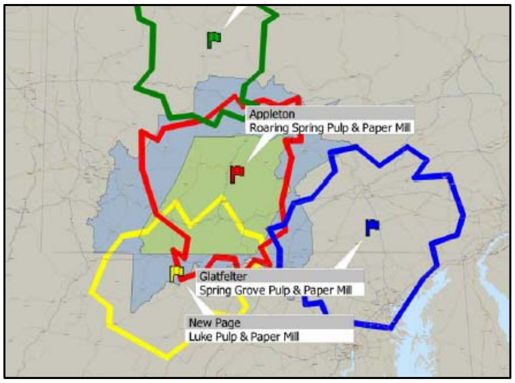

Figure 10. Regional pulp mills with 90-min drive times

The Appleton mill in Roaring Springs (Blair County) produces specialty papers on three machines. This facility is located in a core county, and purchases an estimated 325,000 green tons of pulpwood and sawmill residue annually.

The Roaring Springs facility (Figure 11) appears to be a good candidate for a future "biorefinery," where wood is processed into not only pulp and paper but also liquid fuels and other products. There is a strong possibility that production of wood-based fuels at a pulp mill will increase the profitability of the site and not directly compete for the wood resource (i.e., use of lower grades of wood for biofuel production). The facility has excess land, steam, water treatment facilities, a rail siding, and wood-handling infrastructure, allowing a biofuel developer to concentrate on the development of the technology. Wood-based biofuels are not yet in commercial production, though a number of firms are rapidly developing these technologies, and SAC and Appleton should review this opportunity periodically.

Figure 11. Roaring Springs Mill—pulpwood and chips

New Page has a mill in Luke, MD, at the edge of Garrett County. This facility uses an estimated 700,000 green tons of pulpwood and chips annually (roughly three quarters of which is hardwood) to produce coated freesheet, a grade of paper often used in annual reports and magazines. This facility recently announced that it was closing one of its paper machines permanently.

Glatfelter has a pulp mill in Spring Grove, PA (York County). This facility procures wood from core and buffer counties and produces uncoated and coated freesheet.

The Domtar (formerly Weyerhaeuser) mill in Johnsonburg, PA, produces an uncoated freesheet paper. The facility purchases an estimated 400,000 green tons of hardwood chips annually.

### 2.3.5 Woody Biomass Plantations

The state has approximately 200,000 acres of abandoned mined land. This is being revegetated in various ways, including tree planting under the requirement of the Surface Mining, Control and Reclamation Act (SMRCA) of 1977. Some of this acreage has the potential to become productive forest land that would support short rotation, fast-growing species such as willow (*Salix* sp) or hybrid poplar (*Populus* sp) that could provide an additional source of wood for biomass energy. In addition, trees provide numerous environmental benefits such as conserving soil and protecting downstream waters from flooding and pollution. Furthermore, surplus manure production or sewage sludge can be used for fertilization and soil enhancement on these lands.

We estimate that there are at least 20,000 acres of abandoned mine land in the six-county region. Growth rates on commercial plantations in the northeast states using willow range from approximately 8–16 green tons/acre/year in short rotations.[8] This indicates that the potential exists for annual production of approximately 160,000 green tons in the region. There are undoubtedly many obstacles to the realization of this potential, but the potential benefits to the region appear to warrant additional investigation and possibly the establishment of pilot projects in the region. A small experimental program has been initiated by PBS Coal Company on company-owned land.

Currently within the SAC region there are 487 unfunded Abandoned Mine Lands (AML) Priority 1 and 2 sites covering 3,689 acres. These sites are considered AML Priority features on account of their health and safety impact, thus qualifying for funding under SMRCA and the AML Fund. Most of these sites are less than 1 acre; only 94 are greater than 10 acres and could be potential wood plantation options. Of the larger sites, the greatest numbers are located in Clearfield, Cambria, and Somerset counties.

There are currently several funding and advocacy organizations actively involved in promoting reclamation of abandoned mine lands in the SAC region, including the Eastern and Western Pennsylvania Coalitions for Abandoned Mine Reclamation, Western PA Watershed Program, and Abandoned Mine Reclamation Clearinghouse. The state and federal agencies most connected with this issue include the Mining Reclamation Advisory Board, Bureau of Abandoned Mine Reclamation, Department of Environmental Protection (DEP), and the Department of the Interior's Office of Surface Mining Reclamation and Enforcement.[9]

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[8] Graham, R.L, et al. "The Economics of Biomass Production in the United States."

[9] Abandoned Mine Reclamation Clearinghouse, www.amrclearinghouse.org/

### 2.3.6 Agricultural Biomass Sources—Corn

The SAC region, as well as the buffer counties, has a significant portion of land planted to corn (grain and silage) annually, with an average of roughly 200,000 acres over the past 11 years (1996–2006) in the core counties, and an average of over 520,000 acres in the core and buffer counties.[10] These data are shown in Table 8 and Figure 12.

**TABLE 8. ACRES PLANTED TO CORN—CORE AND BUFFER COUNTIES**

| ACRES (planted) | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | Average (1996–2006) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Core Counties | 178,700 | 199,100 | 205,100 | 200,700 | 204,600 | 191,400 | 186,850 | 186,835 | 212,680 | 205,800 | 208,900 | 198,242 |
| Buffer Counties | 317,200 | 329,700 | 348,700 | 340,600 | 348,600 | 319,600 | 312,400 | 319,400 | 320,900 | 311,600 | 313,700 | 325,673 |
| Core & Buffer Counties | 495,900 | 528,800 | 553,800 | 541,300 | 553,200 | 511,000 | 499,250 | 506,235 | 533,580 | 517,400 | 522,600 | 523,915 |

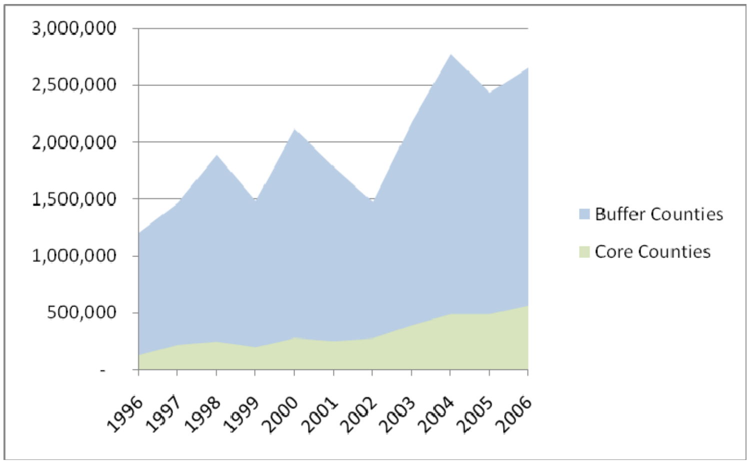

Figure 12. Acres planted to corn—core and buffer counties

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[10] USDA National Agricultural Statistics Service, www.nass.usda.gov

Table 9 shows total production of corn for grain (bushels) and silage (tons). The core and buffer counties have a combined average annual production of 95 million bushels[11] (using a conversion factor of 35 bushels/ton[12]).

### TABLE 9. ANNUAL CORN PRODUCTION—CORE AND BUFFER COUNTIES

| GRAIN (bushels) | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|
| Core Counties | 5,909,000 | 5,909,000 | 6,899,400 | 3,276,600 | 5,432,400 | 3,654,300 | 6,172,000 | 11,521,500 | 10,366,400 | 10,569,000 |
| Buffer Counties | 10,468,500 | 15,144,100 | 5,445,100 | 23,404,800 | 12,821,500 | 6,785,600 | 11,902,700 | 18,110,600 | 15,132,000 | 16,595,000 |
| Core & Buffer Counties | 16,377,500 | 21,053,100 | 12,344,500 | 26,681,400 | 18,253,900 | 10,439,900 | 18,074,700 | 29,632,100 | 25,498,400 | 27,164,000 |
| **SILAGE (tons)** | | | | | | | | | | |
| Core Counties | 869,600 | 1,047,000 | 944,700 | 1,209,700 | 1,202,500 | 868,400 | 996,500 | 996,500 | 889,100 | 988,900 |
| Buffer Counties | 1,112,300 | 1,266,100 | 952,800 | 1,184,400 | 1,078,200 | 949,900 | 1,405,300 | 1,333,900 | 956,400 | 929,200 |
| Core & Buffer Counties | 1,981,900 | 2,313,100 | 1,897,500 | 2,394,100 | 2,280,700 | 1,818,300 | 2,401,800 | 2,330,400 | 1,845,500 | 1,918,100 |
| **BUSHELS (total)** | | | | | | | | | | |
| Core Counties | 36,966,142 | 43,301,856 | 40,638,685 | 46,480,171 | 48,378,828 | 34,668,585 | 41,761,285 | 47,110,785 | 42,119,971 | 45,886,856 |
| Buffer Counties | 50,193,499 | 60,361,956 | 39,473,671 | 65,704,799 | 51,328,642 | 40,710,599 | 62,091,985 | 65,749,885 | 49,289,142 | 49,780,714 |
| Core & Buffer Counties | 87,159,641 | 103,663,813 | 80,112,356 | 112,184,970 | 99,707,470 | 75,379,184 | 103,853,270 | 112,860,670 | 91,409,113 | 95,667,570 |

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[11] USDA National Agricultural Statistics Service, www.nass.usda.gov

[12] Ontario Corn Producers Association, www.ontariocorn.org/classroom/bushel022405.htm

| GRAIN (bushels) | Average (1996–2006) |
|---|---:|
| Core Counties | 7,195,564 |
| Buffer Counties | 13,918,009 |
| Core & Buffer Counties | 21,113,573 |
| **SILAGE (tons)** | |
| Core Counties | 975,900 |
| Buffer Counties | 1,107,945 |
| Core & Buffer Counties | 2,083,845 |
| **BUSHELS (total)** | |
| Core Counties | 42,049,134 |
| Buffer Counties | 53,487,489 |
| Core & Buffer Counties | 95,536,623 |

If *all* of the corn harvested in the core and buffer counties was redirected toward ethanol production, assuming 2.5 gal. of ethanol/bushel of corn, there would be enough feedstock to make roughly 238.84 million gal. of ethanol annually[13] (Table 10). Commercial corn-based ethanol facilities currently under construction in the United States range from 37 to 110 million gal./year.[14]

### TABLE 10. POTENTIAL ETHANOL PRODUCTION—ALL CORN PRODUCTION—CORE & BUFFER COUNTIES[15]

| Ethanol Equivalent (gal.) | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---:|---:|---:|---:|---:|
| Core Counties | 92,415,356 | 108,254,641 | 101,596,713 | 116,200,426 | 120,947,069 |
| Buffer Counties | 125,483,748 | 150,904,891 | 98,684,177 | 164,261,998 | 128,321,605 |
| Core & Buffer Counties | 217,899,104 | 259,159,532 | 200,280,889 | 280,462,424 | 249,268,674 |
| | **2002** | **2003** | **2004** | **2005** | **2006** |
| Core Counties | 86,671,463 | 104,403,213 | 117,776,963 | 105,299,927 | 114,717,141 |
| Buffer Counties | 101,776,498 | 155,229,962 | 164,374,712 | 123,222,855 | 124,451,784 |
| Core & Buffer Counties | 188,447,961 | 259,633,174 | 282,151,674 | 228,522,782 | 239,168,925 |
| | **Average** | | | | |
| Core Counties | 105,122,836 | | | | |
| Buffer Counties | 133,718,722 | | | | |
| Core & Buffer Counties | 238,841,558 | | | | |

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[13] Ibid.

[14] Ethanol Producer Magazine, “Ethanol Plant Construction,” Vol. 13, Is. 6, June 2007.

[15] USDA National Agricultural Statistics Service, www.nass.usda.gov

## 2.3.7 Agricultural Biomass Sources—Soybeans

In addition to corn for ethanol, oil crops can be grown to produce biodiesel. Although canola oil is a potential crop, the oil crop with existing production and ancillary markets (meal for cattle feed) is soybeans. As such, soybeans are likely the preferable oil crop for the SAC region. Over the last 11 years, farmers in the core counties have grown an average of 325,000 bushels of soy, whereas the total production for the core and buffer counties averages almost 2,000,000 bushels per year[16] (Table 11 and Figure 13).

**TABLE 11. ANNUAL SOYBEAN PRODUCTION—CORE & BUFFER COUNTIES**

| BUSHELS | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | Average (1996–2006) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Core Counties | 131,200 | 222,900 | 251,800 | 202,600 | 282,900 | 256,100 | 280,400 | 395,900 | 492,900 | 493,300 | 569,000 | 325,364 |
| Buffer Counties | 1,076,700 | 1,246,500 | 1,641,800 | 1,281,900 | 1,838,700 | 1,528,500 | 1,196,300 | 1,781,300 | 2,287,600 | 1,944,000 | 2,088,000 | 1,628,300 |
| Core & Buffer Counties | 1,207,900 | 1,469,400 | 1,893,600 | 1,484,500 | 2,121,600 | 1,784,600 | 1,476,700 | 2,177,200 | 2,780,500 | 2,437,300 | 2,657,000 | 1,953,664 |

Assuming that 1.4 gal. of biodiesel can be produced from a bushel of soybeans,[17] the SAC region has historically grown enough soy to produce almost 0.5 million gal. of biodiesel, considered uneconomically small by current standards. Table 12 shows that the core and buffer counties produce enough soybeans to support production of 2.5 million gal. Large commercial facilities in current operation produce 20–45 million gal. of biodiesel annually.[18]

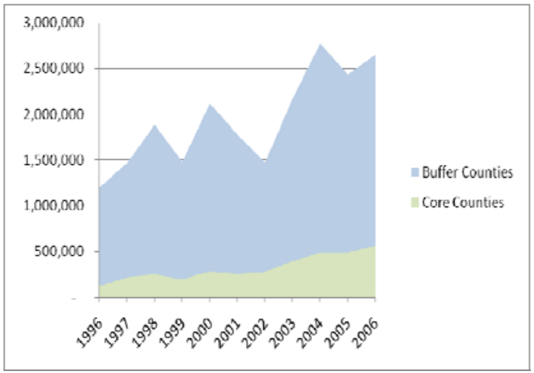

Figure 13. Annual soybean production—core & buffer counties

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[16] Ibid.

[17] US Department of Energy, Alternative Fuels Data Center, www.eere.energy.gov/afdc/progs/ddown.cgi?afdc/FAQ/13/0/0

[18] Acadia Environmental Technology. "Feasibility Analysis of Biodiesel Production in Aroostook County from Canola Oil and Other Locally Available Feedstocks."

## TABLE 12. ACTUAL ANNUAL SOYBEAN PRODUCTION IN BIODIESEL EQUIVALENTS—CORE & BUFFER COUNTIES

| Biodiesel Equivalent (gal.) | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|
| Core Counties | 183,680 | 312,060 | 352,520 | 283,640 | 396,060 | 358,540 |
| Buffer Counties | 1,507,380 | 1,745,100 | 2,298,520 | 1,794,660 | 2,574,180 | 2,139,900 |
| Core & Buffer Counties | 1,691,060 | 2,057,160 | 2,651,040 | 2,078,300 | 2,970,240 | 2,498,440 |
|  | **2002** | **2003** | **2004** | **2005** | **2006** | **Average** |
| Core Counties | 392,560 | 554,260 | 690,060 | 690,620 | 796,600 | 455,509 |
| Buffer Counties | 1,674,820 | 2,493,820 | 3,202,640 | 2,721,600 | 2,923,200 | 2,279,620 |
| Core & Buffer Counties | 2,067,380 | 3,048,080 | 3,892,700 | 3,412,220 | 3,719,800 | 2,735,129 |

If all agricultural land planted in the core and buffer counties were planted to soybeans annually (a practical impossibility used to demonstrate a theoretical maximum production level), soy production would be enough to support somewhere between 17 and 35 million gal. of biodiesel production annually. Figure 14 and Table 4 show the theoretical biodiesel production (in gal.) if all planted agricultural land were in soybeans for the years 1996–2006, with yields of 25 bushels/acre and 45 bushels/acre.

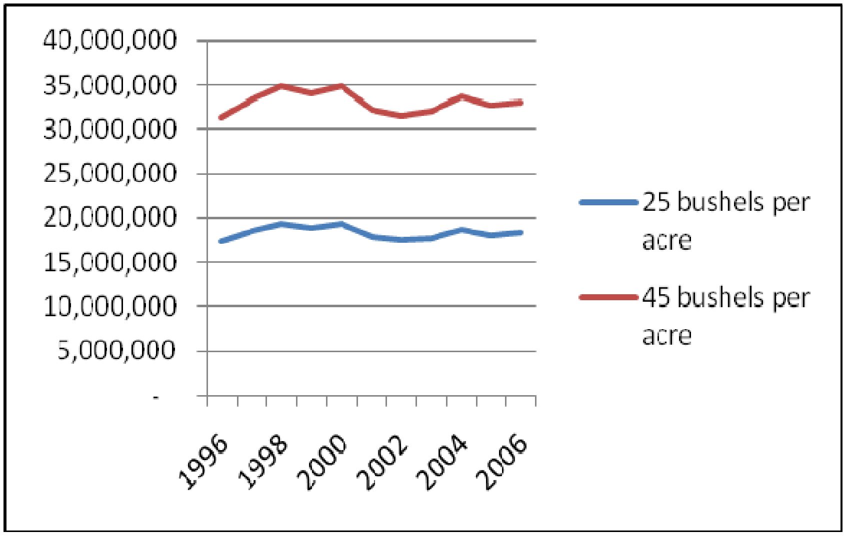

Figure 14. Theoretical maximum biodiesel production—core & buffer counties

**TABLE 4. THEORETICAL MAXIMUM BIODIESEL PRODUCTION—CORE & BUFFER COUNTIES**

| 25 bushels/acre | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|
| Core Counties | 6,254,500 | 6,968,500 | 7,178,500 | 7,024,500 | 7,161,000 | 6,699,000 |
| Buffer Counties | 11,102,000 | 11,539,500 | 12,204,500 | 11,921,000 | 12,201,000 | 11,186,000 |
| Core & Buffer | 17,356,500 | 18,508,000 | 19,383,000 | 18,945,500 | 19,362,000 | 17,885,000 |
| **45 bushels/acre** | | | | | | |
| Core Counties | 11,258,100 | 12,543,300 | 12,921,300 | 12,644,100 | 12,889,800 | 12,058,200 |
| Buffer Counties | 19,983,600 | 20,771,100 | 21,968,100 | 21,457,800 | 21,961,800 | 20,134,800 |
| Core & Buffer | 31,241,700 | 33,314,400 | 34,889,400 | 34,101,900 | 34,851,600 | 32,193,000 |
| **25 bushels/acre** | **2002** | **2003** | **2004** | **2005** | **2006** | |
| Core Counties | 6,539,750 | 6,539,225 | 7,443,800 | 7,203,000 | 7,311,500 | |
| Buffer Counties | 10,934,000 | 11,179,000 | 11,231,500 | 10,906,000 | 10,979,500 | |
| Core & Buffer | 17,473,750 | 17,718,225 | 18,675,300 | 18,109,000 | 18,291,000 | |
| **45 bushels/acre** | | | | | | |
| Core Counties | 11,771,550 | 11,770,605 | 13,398,840 | 12,965,400 | 13,160,700 | |
| Buffer Counties | 19,681,200 | 20,122,200 | 20,216,700 | 19,630,800 | 19,763,100 | |
| Core & Buffer | 31,452,750 | 31,892,805 | 33,615,540 | 32,596,200 | 32,923,800 | |

## 2.3.8 Agricultural Biomass Sources—Switchgrass

Switchgrass (*Panicum virgatum*) is a summer perennial grass native to North America that has significant potential as an energy crop. Switchgrass is naturally resistant to many insects and diseases, and is capable of producing relatively high yields with low applications of fertilizer or other amendments. The grass is tolerant of flooding, drought, and poor soils, and as such has been identified as an excellent conservation crop.

Switchgrass grows 5–12 ft tall, depending on the variety, soil, climate, and other factors (Figure 15).[19] Yield is estimated at 4–8 dry tons per year, and the crop does not reach full yield until the third year of production. Switchgrass has a fuel value of roughly 8 million Btu per ton (as harvested, or 14.4 million Btu per ton oven dry), compared with 9.25 million Btu per ton (as harvested) for wood. Switchgrass can be co-fired with coal, can be used as a feedstock for pellet production, and may serve as an important feedstock for cellulosic ethanol production.

Because of its no/low till nature, the highly reduced need for agricultural chemicals, and the soil and climate tolerance, switchgrass may make an excellent

Figure 15. Switchgrass in the field

crop to grow on land enrolled in the USDA's Conservation Reserve Program (CRP). In 2004, roughly 48,000 acres of land in the core and buffer counties was enrolled in the CRP.[19] The maximum theoretical production of switchgrass has been estimated at yield levels of 4–8 tons per acre (Table 14). If all of the CRP land was devoted to switchgrass production, one could expect 192,000–384,000 tons of switchgrass per year. The likely future production of switchgrass in the region cannot be estimated because of the lack of existing markets for switchgrass, the uncertainty surrounding the technologies for using switchgrass as a feedstock, and the future competition for agricultural land resources.

TABLE 14. THEORETICAL MAXIMUM SWITCHGRASS PRODUCTION—CORE & BUFFER COUNTIES

| | Acres in CRP (2004) | Yield (tons/year with 4 tons/acre) | Yield (tons/year with 8 tons/acre) |
|---|---|---|---|
| Core Counties | 21,645 | 86,580 | 173,160 |
| Buffer Counties | 26,415 | 105,660 | 211,320 |
| **Total** | **48,060** | **192,240** | **384,480** |

## 2.4 SUMMARY OF FINDINGS ON RESOURCE AVAILABILITY

The SAC region, both the core and buffer counties, has a strong mix of rural land bases that can support the production of biomass fuels and feedstocks, including strong bases of hardwood forestland and a mix of agricultural land. This diversity provides a mix of potential biomass fuels, including forest harvesting residues, sawmill residues, corn, and soybeans. However, the diversity of landscape and crop type also means that some biomass feedstocks—particularly agricultural crops—cannot be grown in sufficient quantity to allow a user (e.g., a biodiesel producer) to achieve necessary economies of scale.

The region has very large volumes of forest residue potentially available, as this is currently left on the ground at most logging operations. This is a highly attractive source of biomass feedstock, and could be used for the production of electricity (most easily), industrial-grade pellets, or potentially cellulosic ethanol. However, the collection, processing, and aggregation of this biomass resource during a timber harvest require equipment and logging infrastructure not currently in place in the SAC region. Addition of this infrastructure and capacity is possible, but requires development of a market and could be costly.

Owing to the existing primary (sawmill) and secondary wood product facilities in the region, there is a large volume of mill residues generated in the region. However, because most of these mill residues currently have a market, either hardwood chips to the paper industry or sawdust for animal bedding, development of a new market could pose a threat to the viability of these new markets.

The hardwood resource is somewhat unique, and is a great advantage of the region. Some existing biomass processes (pellets) and emerging markets (including some cellulosic ethanol technologies) have a strong preference for hardwoods. The very high volume of hardwoods found in the region's forests could allow the direct procurement of hardwood biomass chips from the

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[19] Cumulative CRP Enrollment by County, FY 2004, Farm Service Agency, U.SDA,www.fsa.usda.gov

woods, eliminating the costly sorting and additional handling required in areas with a greater mix of forest types and species.

Corn, both for grain and silage, is grown in the region. The current corn production is enough to create 237 million gal./year (MGY) of ethanol; however, the share of corn production not taken up by other industries is very small. At present, it is not feasible to shift enough additional agricultural resources to corn production to make an economically viable ethanol production facility.

Soybeans are grown in the region, though historically in volumes grossly insufficient to supply a modern biodiesel facility. Growth of soybeans in volumes necessary to support a modern biodiesel production facility would likely require dedication of the great majority of agricultural land in the region to soybeans, a shift that could have negative economic consequences and tie the region's agricultural base to one product. Switchgrass is a potential biomass energy crop in the region, but it is difficult to estimate today's the market or competitive production potential.

Table 15 summarizes the main feedstocks in the core and border counties and their potential heat, fuel yield and electricity generation capacities.

**TABLE 15. SUMMARY OF FEEDSTOCK AVAILABILITY**

| Feedstock | Resource Total | Heat Yield (Million Btu/ton) | Heat Content (Billion Btu/hr) | Electricity Generation Potential (MW capacity) |
|---|---|---|---|---|
| Wood (total) | 1.9 mil. green tons | 10.4 | 19.7 | 158 |
| Wood (available) | 475,000–650,000 green tons | 10.4 | 4.9–6.2 | 40–50 |
| Manure (total) | 6.16 mil. tons | 1.21 | 7.45 | 60 |
| Manure (available) | Unknown | 1.21 | —— | —— |
| Landfills (total) | 20.84 mil. tons | 9.11 | 0.19 | Unknown[20] |
| Landfills (available) | 14.75 mil. tons | 9.11 | 0.13 | Unknown |

| Feedstock | Total Production | Fuel Yield | Total Yield (MGY) |
|---|---|---|---|
| Corn (ethanol) | 95 mil. bushels | 2.5 gal./bushel | 237 |
| Soybeans (biodiesel) | 1.95 mil. bushels | 1.4 gal./bushel | 2.7 |
| Switchgrass | Unknown | Depending on application | Unknown |

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[20] The electric generation potential depends on specific gas flow rates, which depend on unknown site-specific factors.

# 3.0 EXISTING BIOMASS RESOURCE USE

Table 16 shows the current state of biomass resource use within the SAC region's core and border counties. The table is divided into five sections to reflect the technologies currently represented. The table includes facilities where co-firing tests have been undertaken, though none are currently in place. Additionally, the ethanol section shows plants that are under construction or in the advanced planning stages. At this time, there are no biofuels facilities in the region. With these two exceptions, Table 16 represents a snapshot of current biomass heat and power usage in the SAC region.

**TABLE 16. EXISTING BIOMASS RESOURCE USE[21]—SAWMILLS (SMALL WOOD BOILERS)**

| Name | Town | County | Heat Capacity Million Btu/hr | Fuel Type |
|---|---|---|---|---|
| Blue Triangle Hardwoods | Everett | Bedford | Over 3 | Wood |
| C&C Smith Lumber Co. | Summerhill | Cambria | 3–13 | Wood |
| Interforest Lumber Corp. | Shade Gap | Huntingdon | 3–13 | Wood/No. 2 oil |
| Walker Lumber, Inc. | Woodland | Clearfield | 3–13 | Wood |
| Coastal Lumber Company | Hopwood | Fayette | 13.8 | Wood |
| Gutchess Hardwoods | Latrobe | Westmoreland | Unknown | Wood /sawdust |

**Coal Co-firing Tests**

| Plant Name | Town | County | Owner | Total Electric Capacity (MW) | Wood % of Total | Test Date |
|---|---|---|---|---|---|---|
| Shawville #3 | Johnstown | Clearfield | Reliant | 190 | 3 | 1995 |
| Shawville #2 | Johnstown | Clearfield | Reliant | 138 | 3 | 1995 |
| Seward #12 | New Florence | Indiana | Reliant | 32 | 12 | 1998 |

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[21] Adapted from IEA Bioenergy Task 32, "Co-firing Database," www.ieabcc.nl/database/co-firing.php
Lusk, P., " Methane Recovery from Animal Manures: The Current Opportunities Casebook," www.nrel.gov/docs/fy99osti/25145.pdf
EPA, "Energy Projects and Candidate Landfills," Landfill Methane Outreach Program, www.epa.gov/lmop/proj/index.htm

### Manure Digesters

| Name | Town | County | Feedstock | Animals | Capacity (kWh) |
|---|---|---|---|---|---|
| Morrison Cove Regional Digester | Martinsburg | Blair | Dairy | 25,000 head | |
| Penn England Farm | Williamsburg | Blair | Dairy | 700 head | 1,401,000 |
| Brendle Farms | Somerset | Somerset | Chicken | 75,000 layers | 365,000 |
| Dovan Farm | Berlin | Somerset | Dairy | 450 head | 700,000 |
| Hillcrest Saylors Dairy | Rockwood | Somerset | Dairy | 600 head | 910,000 |
| Hogs Galore Farm | Phillipsburg | Centre | Swine | | 200,000 |
| Brookside Dairy | Homer City | Indiana | Dairy | | 770,000 |
| Teczak Veal Farm | Punxsutawney | Indiana | Cattle | | |
| Unknown | | Juniata | Dairy | | 831,000 |

### Landfills

| Name | Town | County | Owner | Waste in Place (tons) | Start Date | LFG Use |
|---|---|---|---|---|---|---|
| Laurel Highlands LF | Johnstown | Cambria | Waste Management | 683,559 | 7/1/2006 | Direct |
| Southern Allegheniеs LF | Davidsville | Somerset | Waste Management | 2,644,903 | 1/1/2001 | Direct |
| Mountain View Landfill | Greencastle | Franklin | Waste Management | 5,511,556 | 6/30/2003 | Electricity |
| Valley LF | Irwin | Westmoreland | Waste Management | 6,000,000 | 2/27/2004 | Direct |
| Greenridge Reclamation | Alverton | Westmoreland | Allied Waste | 6,000,000 | 8/1/2001 | Direct |

### Ethanol

| Name | Town | County | Capacity (MGY) | Operation Date |
|---|---|---|---|---|
| BioEnergy International | | Clearfield | 108 | Early 2009 |
| Sunnyside Ethanol | Curwensville | Clearfield | 80 | Early 2008 |
| Commonwealth Renewable Energy | Hempfield | Westmoreland | 200 | Dec. 2007 |

# 4.0 BIOMASS ENERGY CONVERSION TECHNOLOGIES

## 4.1 DIRECT WOOD COMBUSTION

Direct combustion and close-coupled gasification are the dominant technologies for wood and other cellulosic biomass conversion. Direct combustion, as in fireplaces, wood stoves, furnaces, and boilers, occurs when heat is initially applied to wood to begin the pyrolysis process, and then the combustion of the resultant gases occurs in the same chamber or zone of the firebox. In gasification, the pyrolysis and gasification of the wood and the subsequent combustion of the derived gas are in separate chambers. This can improve the efficiency of combustion, especially at low-firing rates. As used in section 4.0, direct combustion and gasification combustion are considered together. In smaller boilers, gasification combustion, or multistaged combustion, has some advantages in air emissions reductions. In larger boilers, these difference are less important. Considerable research has been devoted to improvement in the design of gasifiers in recent years, but direct combustion boilers are still the dominant design in wood-fired boilers in the medium to large size (over 10 million Btu/hr heat input).

Gasifiers specifically designed to produce synthetic gas as a basis for producing liquid fuels, chemical feedstocks, or for pipeline quality gas have different characteristics and are not considered here. Pyrolysis, which is a closely related process, can be used to produce bio-oil. Pyrolysis oil production is evaluated in section 4.5.

Wood combustion in commercial wood-fired boilers can be considered in three size categories: small (2–10 million Btu/hr), medium (10–30 million Btu/hr), and large (greater than 30 million Btu/hr). The medium- and large-size boilers include those that produce high-pressure steam for electric power generation or for CHP. All sizes of boilers typically use wood chips as fuel, although some sawdust and waste wood shavings and ground (or hogged) fuel, including bark, may be used. Wood pellets could be used, but their high cost makes that uneconomical. (See also the section 4.3 for a discussion of wood pellets.)

Table 17 shows the current status of wood combustion for heat and power in the United States and Pennsylvania. Of the five facilities within the state, one is in the SAC region and three are collocated with paper or wood products manufacturers.

TABLE 17. CURRENT STATUS OF WOOD COMBUSTION[22]

| Size (million Btu/hr) | US Number of Facilities | Total US Capacity (MW electric) | PA Number of Facilities | PA Capacity (MW electric) |
|---|---:|---:|---:|---:|
| Small (2–10) | 29 | 13.5 | 2 | 0.9 |
| Medium (10–30) | 23 | 38.9 | 0 | 0 |
| Large (30+) | 444 | 7,444.3 | 3 | 70.2 |
| **Total** | **496** | **7,496.7** | **5** | **74.1** |

### 4.1.1 Combustion—Small Wood-Fired Boilers

Small wood-fired boilers (2–10 million Btu/hr) are typically used in sawmills and wood products factories to use the waste products of their operations. They may be used for space heating, kiln drying, or for process heat. This is a relatively economical application in the region as long as the supply comes from the manufacturer's own waste or from nearby waste wood sources. Scrap pallets are also a good supply source for this type of boiler. There are approximately seven boilers in this or slightly larger sizes at wood products companies in the region. The opportunities for expansion of this use are limited as most of the waste wood is in use. There are also competing markets for waste sawdust and bark, such as animal bedding and landscaping mulch.

The ideal fuel for this sector is bole chips, which are produced by chipping the bole of the tree after the tops and limbs have been removed. This process usually occurs at a processing site. It is the way most hardwood and softwood pulp chips are produced. The process produces an even sized, clean chip with consistent properties that reduce problems with fuel handling and firing. These chips are more expensive to produce and cannot easily be produced in the woods by whole–tree-chipping methods. The price of these chips is controlled by the pulp market, which is the direct competitive consumer. The use of whole tree chips—including tops, limbs, and bark—results in more wood-handling and firing problems, which increase operational cost and reliability. In addition, the use of whole tree chips typically increases particulate air pollution because of dirt in the bark.

Expansion of this sector depends on two critical factors. First, the development of a chip harvesting and delivery infrastructure capable of delivering wood chips, including bole chips, in the region. The small wood boiler sector is not large enough to justify investment in chip harvesting, but would need to be jump started by the demand from a large wood-fired power plant, CHP plant, or a cellulosic ethanol manufacturer. Second, existing prices for conventional fuels and electric power have been too low to stimulate conversions to wood fuel in this sector. However, where new or expanded heating capacity is needed and natural gas or oil is the competitive fuel, wood chips may soon become attractive in some applications. Incentive programs will still be needed to stimulate conversions. Typical application in this sector would be in schools, colleges, prisons, municipal buildings, and medium-size commercial buildings. A wood-fired boiler in a school is shown in Figure 16.

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[22] Adapted from NREL's REPIS database, http://www.nrel.gov/analysis/repis/

Figure 16. Wood-fired boiler, Hanover, NH

This sector will require incentives and technical assistance. The existing Pennsylvania Fuels for Schools Program does not provide support for the use of wood fuel in school buildings. A viable approach would be to identify one or two schools or small municipal facilities that can be investigated in detail to provide models for other facilities. For this to happen, technical assistance and probably capital cost assistance will be required. The model used in Vermont schools and led by the Biomass Energy Resource Center could be a useful approach.[23] This needs to happen in parallel with the development of a wood chip supply infrastructure based on the demand from a large user. In areas such as New England, energy service companies are now providing this assistance to schools and colleges on a commercial basis. They may also be approached to see if a partnership can be developed.

### 4.1.2 Combustion—Medium Wood-Fired Boilers

Medium wood-fired boilers (10–30 million Btu/hr) are also used in larger sawmills, wood products manufacturers, and pulp and paper mills. Those plants in the region that can economically use wood chips have probably already done so. Further expansion of the use of wood in boilers of this size would require expansion into other sectors. Candidate facilities include colleges, larger municipal and government buildings, district heating systems, and large commercial building complexes. Boilers in this size range are equipped with more robust fuel-handling systems and air pollution control systems, such as multiple cyclones and baghouses that make possible economical operation with less expensive whole tree chips, processed tops, and limbs or waste wood and bark. Medium-size boilers are also suitable for the production of high-pressure steam needed for electric power generation. Co-generation or CHP—especially in larger units—is also more economically viable because of the high value of electric power generation, especially for customers paying high electric power rates. This “behind the meter” generation has the economical advantage of displacing retail electric power. This benefit is likely to increase as electric power prices rise after 2010.

Our analysis shows that these applications are not yet economical in the region. This is because of a combination of relatively low conventional electric power prices, low REC prices, and high-priced and uncertain supplies of wood chips. Like the small boiler sector, this sector cannot grow without the development of a supply infrastructure for whole tree chips.

When a supply of whole tree chips becomes available and electric power prices increase, this sector will still need incentives to develop. This observation is consistent with the experience in New England and other states where electric power prices are already higher and there is already a consistent supply of wood chips.

This is a priority area for development of wood biomass in the region along with larger facilities. This sector will not take off until there is a reliable wood chip supply, which needs at least one major wood chip user in the region. This will require suitable partners and sites. Conversions from conventional fuels will need some incentives in addition to the expected increase in electric

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[23] Maker, Timothy, “Wood-Chip Heating Systems.”

power price after 2010. Likely candidates that have shown interest elsewhere are municipal and state buildings and colleges/universities.

### 4.1.3 Combustion—Wood Fired Boilers Electric Generation and CHP

Boilers over 30 million Btu/hr in capacity are mainly used to generate high-pressure steam for industrial process heat and electric power generation. In CHP systems, the benefits of using some of the waste heat for low-temperature space heating, including applications such as greenhouses, improve both the project economics and the local economic development benefits. Plants in this size sector typically use direct combustion, although close-coupled gasifiers and fluidized-bed combustion systems are also used. These plants have robust wood-handling systems that make whole tree wood chips an ideal fuel. Electric power generation, either for customer use or for sale to the grid, is a key component of these systems as it enables plants to take advantage of premium pricing for renewable power in both in-state and out-of-state markets. Wood-fired plants of this size should soon be able to benefit, directly or indirectly, from avoided air emissions credits. These plants would be eligible for the Pennsylvania Alternative Energy Portfolio Standard (AEPS) and other PJM power market region RPS programs. Co-firing municipal solid waste (MSW), treated wood, or construction and demolition waste will eliminate many of those renewable energy program benefits. Figure 17 shows the 50-MW McNeil Station in Burlington, VT, which is typical of large wood-fired power plants.

Figure 17. 50-MW McNeil Station, Burlington, VT

The present available and sustainable wood resource in the region at approximately 650,000 green tons/year is enough to support approximately two 25-MW capacity wood-fired power plants or CHP plants or one 50-MW plant. Depending on a number of factors, the optimal economic size for a wood-fired power plant is typically 25–50 MW. As a 50-MW plant would consume the total regional resource, it is more likely that a prudent developer would choose to build a plant smaller than 50 MW in this region. This would provide some resources available for smaller users.

Our economic analysis indicates that, as this is the case for small and medium wood-fired boilers, these plants are not economical under current conditions. This is because of the same combination of relatively low conventional electric power prices, low REC prices, and high-priced and uncertain supplies of wood chips. A wood-fired power plant can create the conditions for the development of a supply infrastructure for whole tree chips that would be essential for its own success and help jump start development in other sectors.

When a supply of whole tree chips becomes available and electric power prices increase, a wood-fired power plant will still need incentives to develop. These incentives may come in the form of higher power process, REC prices, capital cost assistance, and/or carbon control programs. This conclusion is consistent with the experience in New England and other states where electric power prices and REC prices are already higher and there is already a consistent supply of wood chips. The present situation in Pennsylvania is in a state of flux, and considerable changes are likely after about 2010, which is probably the earliest date that a large wood-fired power plant could be built.

The development of a wood fired-power plant or a major CHP plant is probably one of the key actions that is needed to ensure the development of the woody biomass in the region. In addition to its own economic development potential, a power plant provides the basis for the development of the other sectors that will use wood chips. Investigation of suitable partners and sites are needed, but it is also important that incentives are available in addition to the expected increase in wholesale electric power price after 2010. We recommend that this sector be a priority for further investigation and action.

## 4.2 WOOD CO-FIRING WITH COAL

Coal co-firing is the process of burning coal with wood biomass in traditional coal-fired power plants. There are three main points in the coal-firing process where wood can be added: in the fuel yard before entering the boiler, direct injection into the boiler, and gasifying the biomass and injecting the gas into the boiler. Typically, wood is burned as wood chips, although some co-fired plants also burn scrap tires and other waste, which substantially reduces the average cost of the fuel. The feedstock wood supplies in the SAC region have been previously discussed in sections 2.0 and 4.1. As an example, firing wood at 5% of input in a 500-MW coal-fired power plant would provide about 25 MW of power capacity and use approximately 375,000 green tons/year if it were a base load plant. That fuel consumption is almost 80% of the total available wood resource estimated at 475,000 tons by INRS (see section 2.0).

Currently in the United States, there is one commercially operating coal plant that co-fires wood. Ashland, Wisconsin's Bay Front Station, owned by Xcel Energy, has co-fired up to 40% wood continuously since 1980. This 76-MW project also co-fires rubber and railroad ties as supplies are available. Though only one coal power plant is currently co-firing wood, during the 1990s six others throughout the country were commercially co-firing 1–30% wood with their coal. Twenty other coal plants conducted tests to investigate co-firing potential at their plants, including the 572-MW Shawville plant in Clearfield County, PA, and the 521-MW Seward Plant in Indiana County, PA. Table 18 shows the five coal facilities in the core counties and seven in the border counties that could become candidates for co-firing.[24]

**TABLE 18. COAL-FIRED BOILERS IN THE SAC REGION**

| Facility | Operator | City | County | Capacity (MW) |
|---|---|---|---|---:|
| American Eagle Paper Mills | American Eagle Paper Mills | Tyrone | Blair | 10 |
| Juniata Locomotive Shop | Norfolk Southern Corp. | Altoona | Blair | 4 |
| Cambria Cogen | Northern Star Generation | Ebensburg | Cambria | 98 |
| Colver Power Project | Inter-Power/AhlCon Partners | Colver | Cambria | 131.1 |
| Ebensburg Power | Ebensburg Power | Ebensburg | Cambria | 57.6 |
| Shawville | Reliant Energy Inc. | Shawville | Clearfield | 572 |
| Conemaugh | Reliant Energy Inc. | New Florence | Indiana | 1883.2 |
| Homer City Station | Edison Mission Energy | Homer City | Indiana | 2012 |
| Seward | Reliant Energy Inc. | New Florence | Indiana | 521 |
| AES Warrior Run Cogen | AES NUGs | Cumberland | Allegany | 229 |
| Luke Mill | NewPage Corp. | Luke | Allegany | 65 |
| R Paul Smith Power Station | Allegheny Energy Supply | Williamsport | Washington | 109.5 |

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[24] EPA, "Emission and Generation Resource Integrated Database," www.epa.gov/cleanenergy/egrid/index.htm

The base cost of jointly firing wood and coal is estimated to be $50–100/kW. This cost is primarily associated with the acquisition and storage of the wood feedstock as well as the injection method and the small decrease in efficiency some tests found when burning wood as opposed to coal. Pennsylvania ranks as one of the states with the greatest potential for a coal co-firing project owing to abundance of coal-fired power projects, biomass supply, high landfill tipping fees, and coal prices.

Burning biomass in place of coal provides significant air quality improvement benefits and decreases use of fossil fuels at a relatively low cost. In the Seward demonstration tests during 1998, co-firing of 12% sawdust led to $NO_x$ reductions of 15% as well as a reduction in $CO_2$ and $SO_x$ emissions.[25] Other environmental considerations with the co-firing of wood and coal include the decreases in wood waste that would otherwise end up in landfills and a decrease in the amount of coal burned. The Federal Emergency Management Program lists six prerequisite factors for developing a successful coal co-firing project:

- Operating coal-fired boiler
- Boiler plant equipped with baghouse
- Local expertise for collection of biomass
- On-site storage space
- Interested plant owners/operators
- Regulatory climate[26]

Of the 12 coal-fired power plants in the SAC region, 4—Cambria Cogen, Colver, Ebensburg, and Seward—are equipped with baghouses, which can help counter the increased particulates associated with burning biomass. The third component of the list, collection expertise, is present in the SAC region owing to the strong forestry and paper products industries. Interested owners/ operators will be most subject to individual site differences as none of the current owners have worked with coal co-firing projects before. As for the final component, at present there is little regulatory push for developing a coal co-firing project in the SAC region or the state as a whole.

The main advantages of co-firing for the coal plant are decreased air emissions. From the perspective of using the available wood biomass resource, existing coal plants, which are much larger, have relatively lower capital costs and good existing particulate emissions control systems. It is relatively easy to convert coal-fired boilers to wood with modification to the fuel-handling and burners systems. On the other hand, the lower heat content of wood reduces the maximum output and, without incentives to reduce emissions and significant premiums for renewable generation, the additional capital and operating costs makes co-fired plants less profitable. Although co-firing biomass qualifies for the PA AEPS, the premiums are not sufficient at present to make co-firing economically attractive.

Co-firing wood with coal, although practical and demonstrated, is not economical at prevailing wholesale electric power and REC prices. This situation may change if a national cap-and-trade program for greenhouse gas (GHG) emissions is implemented or if a carbon tax is imposed. However, neither of these outcomes is certain, and the detailed regulations for these programs may exclude co-firing with fossil fuels. Implementation of co-firing could occur with the active support of electric generation companies or distributing utilities. This, too, is uncertain. Although a wood co-fired plant is large enough to start a wood–chip-harvesting industry in the region, loggers and lenders may view co-firing as an insecure market without a mandated market. In the short run, many premium voluntary or government-mandated REC markets may not accept co-

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25 Tillman, David, "Co-firing Biomass in Coal-Fired Boilers: Results of Utility Demonstrations."
26 U.S. Department of Energy, "Biomass Co-firing in Coal-Fired Boilers."

fired RECs. Progress in developing this sector will depend on cooperation from the coal-fired electric generators and utilities. These might be approached as possible partners in an investigation of site-specific co-firing feasibility.

## 4.3 WOOD PELLET PRODUCTION

Wood pellet production is a process for using waste sawdust or other granulated wood into a concentrated high-efficiency fuel source. Pellet production has two main steps, drying and pressing. The drying process heats the pulverized sawdust, which lowers the moisture content from 45–55% to 6–10%. The sawdust is then sent to a press, where it is formed under high pressure into pellets with a length of approximately 1.5 in. and diameter of 0.25 in. (Figure 18). Pellets are better for burning than wood chips and cordwood because of their low moisture content and smaller size. Pellets can be manufactured of either hard or softwoods sawdust—though softwood is preferred—and pellet plants are often co-located with mills or furniture manufactures to take advantage of waste wood generated by these industries.


Figure 18. Wood pellets[27]

There are 60 U.S. manufacturers of wood pellets who produce 680,000 tons/year of fuel. Within the SAC region, there are 2 pellet manufacturers, Wood Pellets Co. in Summerhill, Cambria County, and Energex Pellets in Mifflintown, Juniata County. Wood Pellets Co., a division of C&C Smith Lumber Company, produces 28,000 tons/year from furniture scrap. The Energex plant is one of two plants owned by the largest pellet manufacturer in North America. Energex as a whole produces 200,000 tons of pellets/year from both its U.S. and Canadian plants.[27]

Over the past several years, the U.S. wood pellets market has undergone a severe supply shortage with irregular distribution and delivery to retailers. This shortage has spurred a major increase in pellet manufacture and interest throughout the country. Additionally, the North American and European wood pellet markets grew 60% between 2001 and 2004, a trend that is expected to continue. This large demand in Europe has led to a strong export market as well as deepened the domestic supply shortage. Another factor that has contributed significantly to the domestic supply problem is the lack of large volumes of sawdust near production facilities.[28]

Pellet production is a process with high equipment start-up costs and significant seasonal lags in demand. Estimated base cost for a 3-metric ton/hr project is $3 million, with a highly variable operating cost of ~$55/ton. U.S. retail prices for pellets are currently running at around $200/ton; however, even with high demand, it often takes 6–18 months for these facilities to become profitable. Over the past two years, pellet prices have fluctuated wildly from $125 to $165/ton in 2005 to as high as $250/ton in late 2006.[29]

Figure 19 shows the price per million Btus of energy for each of the four main sources of heating fuels. At its current price of $200/ton, wood pellets are more expensive than natural gas; however, when pellet prices are $170 and below, pellets are a competitive fuel for home heating. As can be seen from this graph, wood chips are significantly less expensive than any other fuel source. However, the technology is not currently in place to for burning wood chips in a residential setting. Though wood chips have significantly higher moisture content and lower efficiency—

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27 Pellet Fuels Institute. www.pelletheat.org/3/industry/index.html
28 Karwandy, Jeremy, "Pellet Production from Sawmill Residue: a Saskatchewan Perspective," www.saskforestcentre.ca/uploaded/Karwandy_-_2007_-_Pellet_Production_from_Sawmill_Residue.pdf
29 Urbanowski, Ernie, "Strategic Analysis of a Pellet Fuel Opportunity in Northwest British Columbia," ir.lib.sfu.ca/retrieve/2213/etd1891.pdf

65% as opposed to 80%—their low cost makes them a more cost-effective combustion material for commercial and institutional burners.

In the United States, pellets are primarily used as a fuel source for home heating and small commercial projects. European users have found additional uses for wood pellets as a fuel for large-scale central heating facilities. In this application, up to 100-MW boilers are able to burn both pellet and chips with efficiencies in excess of 90%. Increased efficiency, coupled with high taxes on fossil fuels and expensive pellet production, has created a viable pellet export market for North American manufacturers. There is increasing interest in using harvested wood chips as raw material for pellet production. The availability of unused low-grade wood in the region, combined with good rail access, makes it possible that additional wood–pellet-manufacturing plants will be attracted to the region. These new plants are likely to be larger than existing plants and would supply a market in Europe for wood pellets at much higher prices. The development of these plants in Pennsylvania would also enable them to supply local markets when the price of wood chips reaches EU levels.

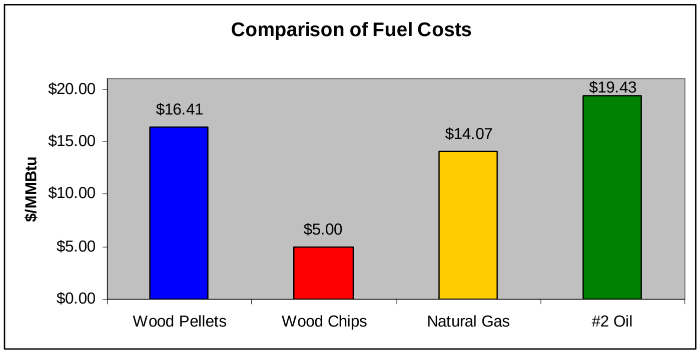

Figure 19. Comparison of fuel costs

## 4.4 CELLULOSIC ETHANOL PRODUCTION

Cellulosic ethanol production is the process of converting cellulose-based feedstocks to five and six carbon sugars and refining those sugars into ethanol. This process is accomplished in three major chemical steps: pretreatment, hydrolysis, and fermentation (see Figure 20 for a schematic diagram of the process[30]). The pretreatment step is designed to break down the raw components of cellulosic feedstock—cellulose, lignin, and hemicellulose—into their component sugars. This step is usually accomplished by means of a dilute acid or high-pressure steam. The second step is fermentation, when the cellulose is hydrolyzed by adding a genetically engineered enzyme or acid, which releases these sugars in the form of glucose. Though acid hydrolysis has a long history in chemical processing, the development of hearty enzymes to accomplish this step will greatly increase yield and efficiency. The final step, fermentation, involves the refining of glucose into ethanol. The process of fermentation is very similar to that undertaken in the production of corn ethanol. The major difference between these two processes is the need to break bonds between lignin and cellulose and extract glucose, steps that are not needed in the refining of corn ethanol.

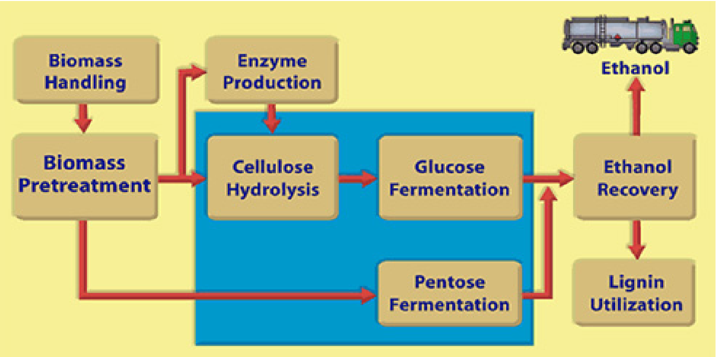

Figure 20. Cellulosic ethanol process

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[30] Renewable Fuels Association, “Cellulosic Ethanol Process,” www.ethanolrfa.org/resource/made/

Cellulose is the building block of plants and is found in everything from grains to wood chips. Common feedstocks for ethanol production have included these as well as switchgrass, corn stover, algae, rice straw, and MSW. These feedstocks are especially attractive because of their limited alternative uses, low prices, and high availability. Within the SAC region, the most abundant feedstock is hardwood chips as wood waste from the logging and pulp and paper industries. Within the core and border counties, enough wood waste is produced to manufacture 26.2 MGY of cellulosic ethanol.

Cellulosic ethanol development is characterized by the construction of three levels of plants. Any project that produces less than 1 MGY is considered a pilot project, and there are a number of these projects in operation throughout the United States and Canada. A project of 1–10 MGY is considered a demonstration plant and, though not in operation in the United States, several of these plants are currently under construction. The final stage is commercial scale, which applies to any project greater than 10 MGY. At this point there are seven commercial-scale projects in the planning stages.

There is significant debate within the energy industry as to the timeline for commercialization of cellulosic ethanol technology. Though there are a number of projects in planning or under construction, the technology has not yet been optimized to the point where it can be implemented on a wide scale. Estimates of the timeline for this level of development ranges anywhere from 6 months to 15 years and depend on the speed of scientific refinement of the different subtechnologies. They will remain difficult to predict until a developing technology is shown as commercially viable.[31]

There are currently 22 firms nationwide that are actively involved in the cellulosic ethanol industry. Of these, 10 are currently in the process of planning or building demonstration or test commercial plants located primarily in the southeastern and western parts of the country. The first of these projects, the 1.4-MGY Jennings, LA, plant, is scheduled to begin operation by the end of 2007; the first commercial-scale plants are expected in 2008 or 2009. Table 19 shows the firms that are active in the cellulosic ethanol industry, and includes the developers of the components and technology required for plant development as well as the developers.

In addition to development within North America, these firms also have a number of projects in Europe and Asia that seek to move this technology toward commercial operation. Two international plants of note include the CRAC (China Resources Alcohol Corporation) project in Zhaodong, China, and Abengoa's wheat straw project in Salamanca, Spain. These two commercial demonstration projects, which use technology from the SunOpta Bioprocesses Group, are currently both operational and produce 1.7 MGY and 1.3 MGY, respectively. A 50+ MGY commercial plant is expected in Europe as soon as 2008 from a joint venture between Mascoma and Royal Nedalco, a Dutch ethanol producer.

The U.S. Department of Energy's (DOE) Biomass Program is a strong supporter of commercial development of cellulosic ethanol. The program's Biomass Initiative has two main goals: to get cellulosic ethanol competitive with gasoline by 2012 and to replace 30% of gasoline consumption with biofuels by 2030 (the 30x30 program). This initiative was generated from President Bush's Advanced Energy Initiative (2005) and was designed to provide support, education, and funding to foster the development of a viable biofuels industry. The ultimate goal of the biomass program is to develop an integrated commercial biorefinery, which can produce both high-volume transportation fuels and quality chemicals to further replace the petrochemical industry.

The DOE is currently funding four areas of biofuels development: large projects, small projects, enzymes, and research labs. In February the DOE released a $385 million grant to fund six large cellulosic ethanol projects. These projects range in size from 11.4 to 40 MGY for a total of 133.6

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[31] Burke, Murray, "Cellulosic Ethanol," www.sunopta.com/uploadedFiles/bioprocess/News_and_Events/061031%20Platts%20conference.pdf

MGY and will be operational by 2011. The goal of this program is to jumpstart commercial ethanol development by funding two of the best established technologies and companies. The second program, which is currently soliciting bids, is designed to fund smaller-scale refineries that use

**TABLE 19. CELLULOSIC ETHANOL DEVELOPERS**

| Name | Location | Technology | Feedstock | Notes |
|---|---|---|---|---|
| Abengoa Bioenergy | St. Louis, MO | Syngas | Cereal | 11.4-MGY demo plant in York, NE; additional plants in Seville, Spain and St. Louis |
| Alico | LaBelle, FL | Gasification | Citrus waste | Planned 13.9-MGY demo |
| American Process | Atlanta, GA | AVAP | Softwood chips, pulp liquor | Partner with Flambeau River, WI project |
| Archer Daniels Midland | Decatur, IL | High-yield yeast | Corn | Joint research project with Purdue |
| Blue Fire | S. California | Acid hydrolysis | Landfill wood waste | Planned 19 MGY; collocate with landfill |
| BRI Energy | AR | Gasification | Coal | Planned 7 MGY |
| Colusa | Colusa, CA | Pretreatment | Rice straw | 10 MGY facility under construction |
| DuPont | Wilmington, DE | Enzymes | Corn | Partner with Poet |
| Dyadic | Jupiter, FL | Enzymes |  | Partner with Abengoa |
| Genencor | Denmark | Enzymes |  | Subsidiary of Danisco |
| Green Star Products | Chula Vista, CA |  | Algae | Demo plant under construction in Montana |
| Greenfield Ethanol | Toronto, CN |  | Wood chips | Partner with SunOpta to construct commercial scale project |
| Iogen | Ottawa, CN | Enzymes | Straw, cereal grains | 1-MGY demonstration plant, partners with VW and Shell; planned 18 MGY in Shelley, ID |
| Lignol Energy | Vancouver, CN |  | Wood residues |  |
| Mascoma | Cambridge, MA | Enzymes | Hardwood chips | Partner with Nedalco |
| Nova Fuels | Fresno, CA | Novohal, gasification | MSW | Planning five projects |
| Novozymes | Denmark | Enzymes |  | Partner with Abengoa and Broin |
| Poet (Broin) | Emmetsburg, IA |  | Corn stover | Planned 31.3 MGY; collocate with current corn ethanol |
| Range Fuels | S. California | Syngas | Wood chips | Planning 40 MGY demo plant in Soperton, GA |
| SunOpta | Brampton, ON | Pretreatment | Straw | Partner with Abengoa, Celunol, and CRAC; |
| Verenium | Cambridge, MA | Enzymes | Bagasse, wood chips | 1.4-MGY demo plant under construction in Jennings, LA; Celunol and Diversa merged |

more experimental technologies. This grant of $200 million is expected to fund 5–10 small projects at 10% of commercial scale for 5 years. The third area of funding is to labs and companies to develop high-efficiency enzymes to be used in the processing of cellulosic feedstocks. A $23 million grant announced in late March 2007 is helping to fund five companies and Purdue University. The reason for this grant program is to specifically target a critical component of biofuels development that is currently a major block to commercialization of the technology. The final area of funding is for three major government labs to work on advancing ethanol technology. The labs chosen for this grant are the Oak Ridge National Laboratory in Tennessee, the Lawrence Berkley National Laboratory in California, and the University of Wisconsin. In addition to investing $375 million in these three labs, the research component of the grant program will also fund $18 million for projects in FY 2007.[32]

As demonstration and commercial plants continue to be built in the United States, there emerges an opportunity to attract one of these plants to locate in the SAC region. The major factors involved in locating one of these plants include feedstock accessibility, state/local incentives, and local support. With the region's stocks of hardwood-logging waste and waste products from the pulp and paper industry, the first requirement can be fulfilled. As there is strong competition between towns and counties for location of a cellulosic project, the development of local support and optimal local economics would be other key factors in bringing a project to the region.

According to the economic impact assessment (EIA), the price for production of cellulosic ethanol in 2000 was $1.15–1.43. Depending on the increased efficiencies of the technology development, that price is expected to drop by 30–50% over the next 15 years. This drop will help cellulosic ethanol to become competitive with both corn ethanol and gasoline as a transportation fuel. Figure 21 shows the 2000 EIA forecasts for gasoline and ethanol prices.[33] This outdated forecast shows far lower gasoline prices than have been experienced over the past five years. If the price of ethanol was independent of gasoline, it would already be economically competitive. However, the price of ethanol itself depends in part on oil prices, which makes this analysis questionable.

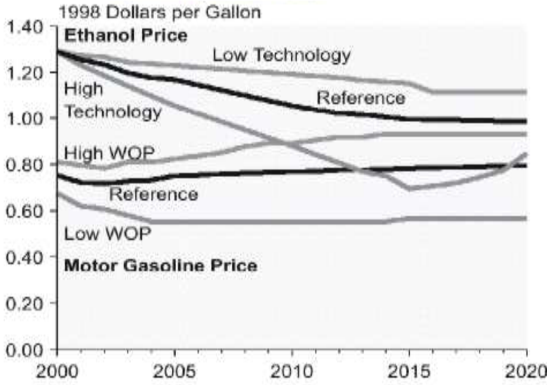

Figure 21. Comparison of cellulosic ethanol and gasoline prices

The low- and high-technology cases used in Table 19 refer to the development of acid hydrolysis and enzymatic hydrolysis as a means for synthesizing ethanol. The price decreases for these two technologies are $0.30 and $0.60/gal. by 2015, respectively. Of the projects currently under construction, most use acid hydrolysis technology; however, most ethanol research is being done on enzymes that will prove dominant in the future.

Cellulosic ethanol production is at present in the precommercial stage. The availability of unused wood and good rail connections to eastern markets make the SAC region potentially attractive to some cellulosic ethanol development companies. Commercial plants would use amounts of wood comparable to wood-fired power plants and therefore could help develop regional infrastructure for biomass. There has been considerable competition among states to attract one of these new technology ethanol plants, and relatively large state and or local subsidies will be needed in addition to federal support. The regional economic development potential of cellulosic ethanol plants is comparable to a wood-fired power plant with a similar wood consumption, but the risks of delays in development or plant failure are much greater.

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[32] US Department of Energy, "DOE Selects Six Cellulosic Ethanol Plants for Up to $385 Million in Federal Funding," http://www.energy.gov/news/4827.htm

[33] DiPardo, Joseph, "Outlook for Biomass Ethanol Production and Demand," www.eia.doe.gov/oiaf/analysispaper/biomass.html

# 4.5 PYROLYSIS OIL PRODUCTION

Pyrolysis oil is produced by the heating of wood or other cellulosic material in a restricted oxygen environment to produce a gas that condenses to form oil. The oil produced has properties similar to petroleum oil and can be used as fuel or as a feedstock for the production of many of the same end products. It also has advantages over petroleum products as a feedstock for the production of food additives, flavorings, fragrances, and adhesive resins. Red Arrow meat flavorings are produced using this process.

Pyrolysis oil production normally uses wood and clean wood waste, but paper, MSW, and other cellulosic materials can also be used for oil production but probably not for chemicals. Pyrolysis oil production has many similarities to gasification and with the production of oil from coal. This type of bio-oil has been produced for many years in situations where it did not have to compete directly with petroleum. Considerable research was undertaken with U.S. and Canadian government support during the 1970s and 1980s. None of that research produced a commercial product. At present, there are two major producers of pyrolysis oil, both predominantly operating in Canada: the Ensyn Group, Inc., and Dynamotive Corp. These companies have been supported by the U.S. DOE and by the Canadian Federal and provincial governments in part because of their ability to produce chemical by products such a food flavorings and bio-based resin adhesives for use in oriented strand board production (OSB).[34]

An evaluation of this technology by RSG, in cooperation with Eric Kinsley of INRS and Gerald Stewart of Cole Hill Associates, found that although the technology apparently worked, the resultant pyrolysis oil was not a marketable product under open-market conditions, even at prices equal to or less than distillate oil.[35] As a co-product of a biorefinery producing food flavorings or resin adhesives for OSB, it could be used by the plant or by affiliated users, but the volume of production from such plants was insufficient to market it generally. The major disadvantage of pyrolysis oil was that it could not be produced at a price competitive with distillate heating oil in New Hampshire. Pyrolysis oil is produced in Ontario, Canada, where there are large volumes of low-cost waste wood; this was only possible with very large government subsidies for capital construction. The conclusion from this study would also apply to Pennsylvania. Furthermore, the state does not have a supply infrastructure available to produce wood chips and has no significant surplus of waste wood from the wood products industries. The special conditions that would favor the production of resins for OSB or food additives are also absent in Pennsylvania.

The typical size of a pyrolysis oil production plant is about 35,000–55,000 green tons/year of wood consumption. Like small- and medium-size wood combustion systems, it would need an existing wood-chip supply infrastructure to be developed, and its economic development potential is limited. At present, this technology has little potential in the region.

# 4.6 MANURE COMBUSTION

One option for disposal of poultry and cattle manure is direct combustion in a moving-grate boiler and steam cycle. This process is very similar to the combustion of other types of biomass, including wood, MSW, and tires. It involves heating the manure to a temperature of 1,500°F to drive a steam turbine and produce electricity. The optimal feedstock for this process is poultry litter, as it has a far lower moisture content than dairy or swine manure. Other raw materials

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[34] Resource Systems Group, "New Hampshire Bio-Oil Opportunity Analysis." New Hampshire Office of Energy and Planning, Concord NH.September 2004 . http://www.nh.gov/oep/programs/energy/documents/nhbio-oilopportunityanalysis.pdf

[35] Op cit.

that can be co-combusted with poultry litter include horse bedding, straw, and wood chips. A schematic of the process is shown in Figure 22.

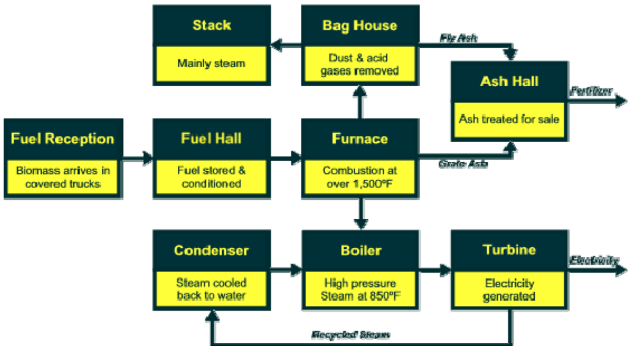

Figure 22. Manure combustion process diagram (from Fibrowatt USA, www.fibrowattusa.com/US-Benson/index.html)

Pennsylvania ranks 14th in state poultry production nationwide and, although Lancaster County dominates the state's production with 15 million birds/year, the SAC region and border counties produce 5.3 million birds/year. The poultry in the SAC and border counties generate 243,000 tons of manure/year, which is currently disposed of through either liquid or solid storage or field application.[36]

The first U.S. commercial poultry-biomass project was recently completed in Benson, MN, by Fibrowatt LLC, of Newtown, PA, is shown in Figure 23.[37] This 55-MW plant combusts 700,000 tons of turkey litter/year collected from area farms.[38] Though this is the first completed plant in the United States, Fibrowatt's UK parent company, Energy Power Resources, has built five plants in the UK over the past 15 years. These plants range in size from 9.8 to 38.5 MW and burn turkey and chicken litter as well as waste straw and horse bedding. Currently, Fibrowatt is seeking to build a chicken–litter-based plant in either Maryland or Mississippi. In addition to Fibrowatt, several other states have explored constructing facilities for combusting poultry biomass.[39] From the experience of the Fibrowatt plants, it has been determined that the ideal plant size is between 30 and 50 MW with 200,000–300,000 tons/year of manure combusted.

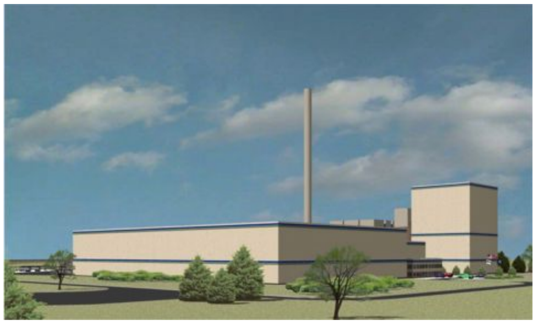

Figure 23. Fibrowatt plant, Benson, MN

In connection with its AEPS,[40] Pennsylvania has programs in place to fund renewable energy programs through its Energy Harvest program and the Pennsylvania Energy Development Authority (PEDA). These programs can help defray part of the large capital costs associated with such a project. Federal initiatives to protect the Chesapeake Bay Watershed are another potential funding source for a manure management projects. A $200 million facility—such as that built in Benson, MN—would provide 30 on-site and 100–200 indirect local jobs and $6–10 million yearly in local investment.

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[36] USDA. "Pennsylvania State and County Profiles," www.nass.usda.gov/census/census02/profiles/pa/index.htm

[37] Fibrowatt USA, www.fibrowattusa.com/US-Benson/index.html

[38] For more information see: Arora, Sumesh, "Biorefinery Approach to a Poultry Litter Anaerobic Digester," www.msenergy.ms/poultry%20litter%20biorefinery.pdf

[39] McCallum Sweeney Consulting, "Pre-feasibility study for 40-50 MW Poultry Litter Fueled Power Generation Facility," www.msenergy.ms/Report.pdf

[40] Pennsylvania Public Utilities Commission, "Alternative Energy Portfolio Standards Act of 2004," www.puc.state.pa.us/electric/electric_alt_energy.aspx

The combustion of poultry litter for energy is a less-efficient process than the combustion of fossil fuels. Poultry litter has 4,000 Btus/lb, which is approximately one-third the heat content of coal. However, biomass combustion also produces fewer emissions than the combustion of fossil fuels. Fabric filters (or baghouses) have been installed in the Fibrowatt plants to capture particulate matter and fly ash residue, which is the byproduct of combustion. Manure combustion ash is a good fertilizer. Additionally, combustion addresses the volume and nutrient management issues that are a major environmental concern of the poultry industry. The traditional means for disposal of poultry manure is land application, where its nutrients can fertilize the soil. When high concentrations of manure are applied, there is significant potential for excess manure to run off into the Chesapeake Bay Watershed, where it leads to high levels of phosphates and nitrates. This results in significant long-term impacts on the aquatic ecosystem and fisheries. This problem is made more serious because of the accumulation of manure owing to seasonal limitations on when manure can be field spread.

Owing to the major excess of manure in certain parts of the state, Pennsylvania has instituted a program to enable the transfer of manure to less heavily concentrated areas of the state. An opportunity exists through this program to inexpensively bring manure to the SAC region for combustion. This program is critical for the development of a biomass combustion project in this region, and its expansion and continuation are necessary for the economic feasibility of such a project. The limited and dispersed nature of the region's own poultry manure reserves does not allow for easy acquisition or centralization. If a system of acquisition can be established to create an efficient and inexpensive means of transporting feedstock to the core counties, such a project could be feasible for the SAC region; however, at this time, no specific action is recommended.

## 4.7 MANURE DIGESTION

Digestion is the process by which manure is decomposed in a controlled environment to capture methane that would be otherwise lost to the atmosphere. The main steps involved in this process are the dilution of manure to an ideal solids ratio, followed by its addition to a digester system for a period of 20–60 days at a mesophilic temperature range. While the manure resides and decomposes in the digester, the produced gas is pumped out and combusted in a small-scale internal combustion engine at 25% efficiency. The end products of this process are biogas, which contains ~60% methane, and an enriched manure sludge, which has increased fertilizing properties when subsequently spread on fields. The primary benefits of digestion are the ability to reduce odors by 50–90% and the capture of methane for generating electricity. There are four different digester types associated with this process: slurry, plug flow, covered lagoons, and complete mix. The main difference between these types is the type of storage vessel used and whether the feedstock is mechanically aerated. Figure 24 illustrates an on-farm anaerobic digester in Clymer, NY.[41]


Figure 24. Anaerobic Digester, Clymer, NY

Manure production is estimated at 2.1 million tons/year in the SAC region; with the additional production of the 11 border counties, total feedstock availability is 6.2 million tons/year. The majority of this manure, 90%, is from dairy production, and the highest manure-producing counties within the region are Somerset and Bedford at 560,000 and 460,000 tons, respectively. The remaining 10% is from limited swine and poultry production within the region. Though this may seem like a large feedstock supply, acquisition of the supply is limited because of the high associ-

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[41] RCM Digesters, http://www.rcmdigesters.com/Digesters/Complete_Mix.html

ated transportation costs. Previous studies have indicated a 5–10-mile limit for centralized manure collection owing to high trucking and tipping fees.

The first digestion plant was built in Bombay, India, in 1859, and digesters have been used in the United States since 1953. Over the past several years, their numbers have increased significantly due to concern about GHGs and increased incentive programs.[42] Currently in the SAC region, there are 7 operating digesters; 2 others are planned. Nationwide there are 125 operating digestion facilities that produce 275,000 MWh/year and capture 80,000 tons of methane. Of the 2 facilities in the planning process, the Morrison Cover Regional Digester Project in Martinsburg provides a model for the possibility of developing regional digestion capability. This project, which aims to provide digestion capability for 25,000 head of cattle, will create a means for local small farmers to take advantage of the economic benefits associated with digestion economies of scale. At present, there are 3 operating regional digestion facilities throughout the United States and 18 in Denmark, a country with extensive experience in large-scale biogas production.

Cattle manure digester costs are estimated at $150–400/animal with an additional requirement of $750/kW to generate electricity. At this rate, the break-even herd size is 500–700 head, depending on the digester type constructed.[43] Several grant programs through the DEP and the USDA can offset capital costs by 30–50%. The Energy Harvest Program operated by the DEP has an excellent record of funding digester projects, including 22 projects since 2003. Additionally, there are several private organizations promoting digesters in the Chesapeake Bay Watershed, including Alliance for the Chesapeake Bay, Chesapeake Bay Foundation, and Earth Share. A large part of the SAC region is included in the Chesapeake Watershed.

One major environmental consideration associated with animal waste is its potential to release methane, a GHG with an impact 21 times that of $CO_2$. When manure is stored in a liquid such that it decomposes anaerobically, it naturally releases 66% of its methane content (0.22 tons/cow-year) into the atmosphere. When field-spread, this number is lower, though still 0.055 tons/cow-yr.[44] When processed through a digester, methane that would otherwise be lost to the atmosphere and contribute to global warming can be captured and burned to generate electricity. Table 20 shows the methane and $CO_2$ production per animal and per ton of manure for digestion of poultry and dairy manure. If cattle and other animal manure is digested rather than being stored or field-spread, $CO_2$ reductions of 3.7 tons/animal can be achieved in addition to savings from offset heating and electricity generation from the captured methane.

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[42] Lusk, P, "Methane Recovery from Animal Manures: The Current Opportunities Casebook," www.nrel.gov/docs/fy99osti/25145.pdf

[43] EPA, "Livestock Manure Management," www.epa.gov/methane/reports/05-manure.pdf.

[44] Wightman, Jenifer, "Carbon Trading Opportunities for Anaerobic Digesters: Estimating Methane Emissions and Offsets," www.climateandfarming.org/pdfs/CaseStudies/V.6Trading.pdf

**Table 5. Greenhouse Gas Savings from Manure Digestion**[45]

| | Dairy | Poultry | Swine |
|---|---|---|---|
| VS(lb/1000 lb animal-day) | 8.6 | 10.700 | 8.500 |
| % VSd | 48.0 | 60.000 | 50.000 |
| Gas (ft$^3$/day) | 44.0 | 82.000 | 51.400 |
| Methane yield (ft$^3$) | 17.6 | 32.800 | 20.500 |
| Tons methane/year | 0.128 | 0.239 | 0.150 |
| Tons $CO_2$ equiv/1,000 lb | 2.698 | 5.028 | 3.149 |
| **Tons $CO_2$ equiv/animal** | **3.777** | **0.020** | **0.630** |
| **Tons $CO_2$ equiv/ton manure** | **0.351** | **0.437** | **0.329** |

The primary economic benefits of manure digestion are achieved through the production of methane, which can be combusted on site in a 50–200-kW internal combustion engine to generate electricity. The generated electricity and heat can be used to power farm operation as well as being sold on the grid through Pennsylvania's Net Metering Rules. The payback times on digester installations vary widely, although for a well-engineered project, average payback is 6–8 years with a profit of $40–100/cow in subsequent years.[46] Most currently operating digester projects are located on farm; therefore the associated costs and benefits of a larger centralized project would be somewhat different. The main costing differences are the tipping fees associated with manure collection and the economies of scale that can be achieved with greater volumes of manure processed.

Manure digestion is a practical and environmentally preferable technology for conversion of manure to energy. For larger animal operations, it is economical under existing support programs for on-farm applications. Local concentrations of livestock farms where transportation is less than 5–10 miles may be able to support a central digester. Further support and evaluation of manure digestion is recommended.

## 4.8 LANDFILL GAS CAPTURE

LFG production is the process of capturing and using gases that are produced through decay of landfill contents. This gas contains approximately 50% methane and 50% $CO_2$, so it qualifies as a significant GHG. Methane from MSW landfills is the largest source of human-generated methane emissions at 25% of total U.S. methane. The process of capturing this gas involves sinking a perforated pipe into a capped and closed landfill. The gas produced in the landfill cell flows into this area of lower gas density and from this point is piped out for use. LFG projects have been installed in facilities anywhere from 300,000 to 108 million tons in size and have been in operation since 1979.[47]

There are several uses for LFG, including electricity generation, direct-use, and as an alternative fuel. In electricity generation, which occurs at two-thirds the sites nationally, the gas is used as

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[45] Adapted from: Hansen, R.W., "Methane Generation from Livestock Wastes," www.ext.colostate.edu/pubs/farmmgt/05002.html

[46] Roos, Kurt; et al., "Funding On-Farm Biogas Recovery Systems," www.epa.gov/agstar/pdf/ag_fund_doc.pdf

[47] EPA, Landfill Methane Outreach Program, www.epa.gov/lmop/index.htm

fuel for a gas turbine, or in an internal combustion engine. These engines range in size from 30 kW to 10.5 MW. In its direct-use application, LFG replaces another fuel for heating or power. Direct-use provides opportunities for synergy with other industries and facilities as well as the opportunity to directly replace the consumption of fossil fuels. The final use of LFG is as an alternative fuel, delivered to the natural gas pipeline system. To make LFG eligible for high-Btu pipelines, extensive processing is required to remove all non-methane components. Though this processing has already been adopted at 13 sites nationwide, this is one aspect of LFG technology that continues to be improved.[48]

Currently, there are 424 operational projects nationwide, which generate 1,195 MW of electricity. There are also 560 landfills that the EPA's Landfill Methane Outreach Program has identified as good candidates for extraction. Within the SAC region, there are 5 operational and 5 candidate LFG sites (Table 21).

## TABLE 21. LFG SITES IN THE SAC REGION

| Landfill Name | Landfill City | Landfill County | Waste in Place (tons) | Project Status |
|---|---|---|---|---|
| Laurel Highlands | Johnstown | Cambria | 683,559 | Operational |
| Southern Alleghenies | Davidsville | Somerset | 2,644,903 | Operational |
| Mountain View Landfill | Greencastle | Franklin | 5,511,556 | Operational |
| Greenridge Reclamation | Alverton | Westmoreland | 6,000,000 | Operational |
| Valley LF | Irwin | Westmoreland | 6,000,000 | Operational |
| Mostoller Landfill, | Somerset | Somerset | NA | Candidate |
| Shade LF (RCC LF) | Cairnbrook | Somerset | 3,500,000 | Candidate |
| Veolia ES Chestnut Valley Landfill | McClellandtown | Fayette | 570,000 | Candidate |
| Westmoreland Waste Landfill | Belle Vernon | Westmoreland | 1,000,000 | Candidate |
| Resh Road II SLF | Hagerstown | Washington | 2,055,978 | Candidate |

Of the operational landfill projects, 2 are used to generate high-Btu pipeline gas, 2 are used for direct heating, and 1 drives a 1.2-MW reciprocating engine to generate electricity. These projects achieve a net reduction in GHGs of 0.884-MMTCO$_2$ equivalent. In addition to these 10 projects, there are also 17 landfills in the SAC region that are considered potential sources of LFG.

As the fuel for a LFG project is free, the costs associated with these projects are largely from the costs of acquiring and installing equipment. Table 22 shows the estimated capital and operating costs for using LFG for electricity generation or direct-use combustion.

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[48] Ibid.

### TABLE 22. LANDFILL GAS COSTS[49]

| Use | Capital Costs | Operating Costs |
|---|---|---|
| Electricity Generation | $900–1300/kW | 1.5–1.8 cents/kWh |
| Direct Use | $6–13/mmBtu/year | 13–74 cents/MBtu/year |

The economic benefits associated with LFG use are largely due to revenues from selling the gas or the electricity generated from its combustion. With direct-use, synergy with a local corporation to use LFG for its heating needs can create an offset for capital costs and generate a steady revenue stream. There are also several funding opportunities available for projects in Pennsylvania. There is currently one federal program, the Renewable Energy Production Incentive (REPI), which gives a refund of 1.5 cents/kWh generated for the first 10 years of a project's operation. There are also three PA state grant and loan programs operated by the Energy Harvest, PEDA, and PA Sustainable Energy Funds. The grants received by Energy Harvest LFG projects have varied from $25,000 to $235,000 and tend to be allocated at a rate of one project per year.

As LFG is half composed of methane, it is considered a GHG of major concern. Without extraction and capture, this gas is either stored in closed landfill cells or vented directly to the atmosphere to prevent buildup and possible explosion. When harnessed and combusted, methane is destroyed and its impact eliminated. Although there are emissions associated with methane combustion after collection, the impact is greatly decreased as compared with direct methane emission. In addition, LFG combustion reduces emissions of air toxic components of the gas by over 90% and reduces LFG odors.

LFG capture is a viable enterprise for facilities in the region. However, owing to the small number of eligible facilities and their low generation capacity as compared with other technologies, the potential for significant economic impact is small. Extensive state and federal programs are in place to encourage the use of LFG and provide funding. At present, the only action recommended is to support partnerships between landfills and local businesses to use potential production for heat and power applications.

## 4.9 CORN ETHANOL PRODUCTION

Corn ethanol is a fuel additive that has recently garnered attention as a gasoline replacement. Though used as a fuel in the early 1900s, production of corn ethanol was very small through the latter half of the century until it was shown to be an ideal replacement for the oxygenation additive MBTE, in 1988. Since production numbers have increased for this use, ethanol has also been shown as an effective fuel in blends up to 85% ethanol with gasoline (E85). Corn ethanol production has been an established technology for hundreds of years through the fermentation of grain alcohols. Though some improvements to help efficiency continue, the base process is very well established. Figure 25 shows a schematic diagram of the production process.

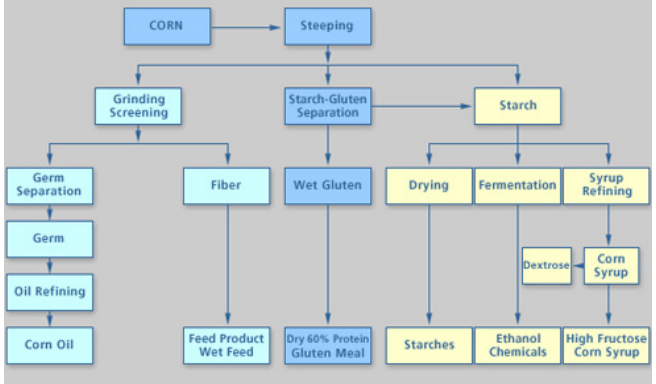

Figure 25. Corn ethanol production

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[49] Kerr, Tom, "Landfill Gas to Energy Economics," www.eere.energy.gov/greenpower/conference/5gpmc00/tkerr.pdf

The key chemical process for ethanol production is fermentation, a process used in the creation of alcohol. Corn or corn stover, the waste stalks remaining after harvest, are crushed and fermented with yeast to convert the starch into sugar. The resultant alcohol is then distilled and purified. This process can be undertaken with sorghum, rice, and sugarcane, but its most common feedstock in the United States is corn. Pennsylvania ranks 15th nationwide in corn production—124 million bushels/year—with the core and border counties accounting for 95 million bushels/year. The heaviest corn-producing counties are Blair and Bedford among the core counties and Franklin in the bordering counties.

With the institution of the Governor's Energy Independence Strategy (EIS) and increased funding and attention at the state and federal levels, the number of corn ethanol production facilities has increased significantly in the region and nationwide. Nationwide, corn ethanol production has jumped from 870 MGY in 1989 to 6.3 billion gal./year (BGY) in 2007, with 83 more plants with 6.2-BGY capacity currently under construction.[50] In Pennsylvania and the SAC region, a corresponding increase has also been seen, with nine projects in planning for the state and two large projects under construction in the border counties. These projects, the 108-MGY BioEnergy International project in Clearfield County, and the 200-MGY Commonwealth Renewable Energy project in Westmoreland County, are two of the largest in the country. Scheduled to go online in early 2009 and December 2007, respectively, these projects will have a significant impact on the ability to acquire an inexpensive feedstock at a potential downstream project.

As in the case of most biomass technologies, price and availability of the feedstock are the key factors in determining economic feasibility. Corn ethanol production is no different in this respect, as the key economic factor is the ability to acquire a local or inexpensively transported corn supply. For a 75-MGY project (the average size of new plants), a corn supply of 30 million bushels/year is required.[51] Though corn can be imported from Ohio, Indiana, or Kentucky, state and local incentives required to overcome the transportation costs must be quite large. The economic advantage held by PA over Midwest locations is the proximity to Northeast fuel markets. As ethanol produced in Pennsylvania is cheaper to transport after production, one deciding factor in siting ethanol facilities in the state will be the relative difference in costs between transporting raw corn and finished ethanol.

The federal government currently has two rebate programs and one grant program in place for developing ethanol production facilities. These rebate programs grant a $0.51/gal. tax credit for production of ethanol with an additional $0.10/gal. credit for the first 15 MGY of small producers who make less than 60 MGY. The federal government also has a grant program through the USDA Office of Rural Development to defray up to $750,000 of capital costs associated with renewable energy improvements, including ethanol production. Additionally, Pennsylvania has at least 12 grant programs to defray capital costs, including the Energy Independence Capital Assistance Program, which can cover up to 50% of the capital costs of a project. The majority of these programs have been generated in response to the Governor's AEPS and EIS, the goal of which is producing 900 MGY of the state's energy needs by alternative fuels by 2020. Analysis of this proclamation by LECG predicts that corn ethanol would account for 338 MGY in the form of three to four new ethanol production facilities.[52] With 308 MGY already under construction, this goal is well on its way to being met.

In comparison with other fuels, corn ethanol is an improvement over fossil fuels, though not as strong as biodiesel and other biofuels. Over its lifecycle, corn ethanol is 25% less fossil fuel intensive than gasoline; however, it is not as good as biodiesel or cellulosic ethanol, which have 70%

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[50] Renewable Fuels Association, "Ethanol Refinery Locations," www.ethanolrfa.org/industry/locations/

[51] Shapouri, Hossein; et al. "The Economic Feasibility Production from Sugars in the United States," www.usda.gov/oce/EthanolSugarFeasibilityReport3.pdf

[52] Urbanchuk, John, "Economic Impact of the Increased Use of Biofuels and Coal Derived Transportation Fuels for the Commonwealth of Pennsylvania."

and 90% fossil fuel reductions, respectively.[53] The development of the corn ethanol infrastructure and market is generally considered to be a necessary transition strategy to creating a viable environment for cellulosic ethanol and other more efficient biofuels.

In the SAC region, farmers now have an alternative market for corn at the two new corn ethanol plants. However, at the present cost of corn production in the region, local farmers are unlikely to be able to compete with corn transported from the Midwest. Some very efficient producers may be able to provide corn for this market. No ethanol-specific programs or incentives for local corn producers are available. No specific actions are recommended at this time.

## 4.10 BIODIESEL PRODUCTION

There are three main types of feedstocks for biodiesel production: vegetable oils, animal products, and recycled oil. The most common vegetable oil used is soybean oil, which is made by crushing soybeans and extracting their oil with commercial hexane. Other commonly used vegetable oils include canola, corn, sunflower, and peanut; the determining factor between oils is most often price. The second potential feedstock is animal products, which include tallow, poultry fat, and white and yellow grease. These feedstocks are created as the byproducts of animal rendering and therefore can often be obtained at extremely low cost without any sacrifice in performance as compared with vegetable oils. The third feedstock source is recycled cooking oil or grease, available from restaurants. Though use of this oil solves an additional waste disposal problem, it requires some pretreatment and filtering prior to use.[54]

With growing concerns about GHG emissions and energy security, the size of the biodiesel industry has increased by nearly 500 times since 1999. Figure 26 shows U.S. biodiesel sales over the past eight years.[55]

### Biodiesel: A New Future for an Old Technology?

Biodiesel is a transportation fuel produced from agricultural feedstocks that is compatible with diesel engines without modification. It is produced by mixing an oil or fat with methanol in the presence of a catalyst. This transesterification process produces biodiesel and glycerin, a sugar alcohol used in pharmaceutical products. The technology for producing biodiesel has been in use since Rudolph Diesel developed the first compression ignition engine that ran on peanut oil for the 1900 World Exhibition. Vegetable oils were used until the 1920s, when they were replaced by cheap petroleum-based diesel.

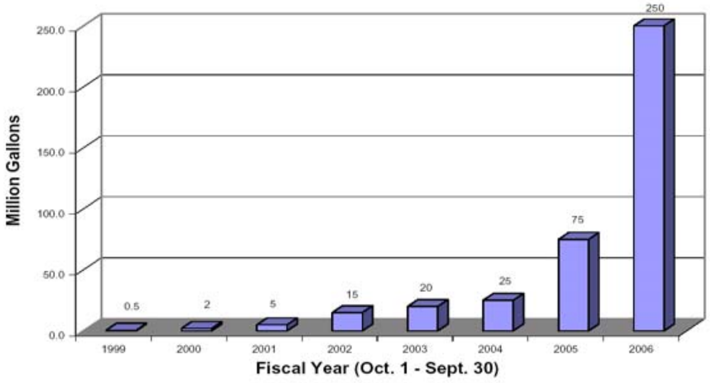

Figure 26. U.S. biodiesel sales

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[53] Ibid.

[54] Stroup, Robert, "Feedstock Considers for Future U.S. Producers," www.biodieselmagazine.com/article.jsp?article_id=649

[55] National Biodiesel Board, "U.S Biodiesel Production Capacity," www.biodiesel.org/pdf_files/fuelfactsheets/Production_Capacity.pdf

This trend is expected to continue as current U.S. biodiesel production is 1.39 BGY and expected to increase to 3.28 BGY over the next 18 months. Within Pennsylvania, current biodiesel production is 11.5 MGY in five plants, with four more plants currently under construction or expansion with additional capacity of 64 MGY. According to a report by LECG, state biodiesel production is expected to reach 135 MGY by 2017 to comply with the Governor's EIS.[56] Thus far, biodiesel production has been scattered throughout the state; however, there are no projects currently operating or under construction in the SAC core or border counties.

For a biodiesel facility to be economically feasible for the SAC region, an inexpensive supply of feedstock must be acquired. As Table 23 shows, nearly 80% of the production costs associated with biodiesel is in acquisition of feedstock.

### TABLE 23. SAMPLE ECONOMICS OF BIODIESEL PRODUCTION FOR 5-MGY PLANT IN IOWA[57]

| | Price ($) | % of Total |
|---|---|---|
| Feedstock ($.30/lb soybean oil) | 2.280 | 76.5 |
| Feedstock transport | 0.076 | 2.5 |
| Chemical | 0.274 | 9.2 |
| Energy | 0.023 | 0.8 |
| Labor | 0.079 | 2.7 |
| Depreciation | 0.128 | 4.3 |
| Maintenance | 0.040 | 1.4 |
| Overhead | 0.050 | 1.7 |
| Marketing | 0.030 | 1.0 |
| **Total** | **2.981** | |

Potential sources of feedstocks include locally produced vegetable oil products and recycled cooking oil. Production of soybeans within the SAC core counties is fairly small—at 1.95 million bushels/year—whereas soybean production for the state is 17 million bushels/year. The entire soybean crop of the core and border counties would produce enough oil for 2.8 MGY of biodiesel. Within the state there are relatively few soybean oil manufacturers, so much of this production must go out of state to be made into oil. As for recycled oils, there are very few available numbers as to supplies of waste grease in the state or the SAC region. To fuel a 20-MGY plant, the average size of new biodiesel production facilities, 76,000 tons/year of waste oils would need to be collected.[58]

Pennsylvania has put together a number of grant programs to help defray the capital costs associated with biofuels production. These programs, which apply to all biofuel producers, are available to defray up to 50% of infrastructure costs and are administered by the DEP and state utilities. Federally, the Biodiesel and Ethanol Tax Credit gives a $1/gal. credit for agri-biodiesel and

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[56] Urbanchuk, John, "Economic Impact of the Increased Use of Biofuels and Coal Derived Transportation Fuels for the Commonwealth of Pennsylvania."

[57] Pruzko, Rudy, "Biodiesel Basics," www.uwex.edu/CES/cty/outagamie/ag/documents/BiodieselBasicsWorksandCost-RPruszko.pdf

[58] Using 7.6-lb oil/gal. of biodiesel and 1.4 gal. biodiesel/bushel soybeans.

$0.50/gal. credit for biodiesel produced from waste grease. This credit is scheduled to expire in 2008, though it has already been extended once. The Pennsylvania Biofuel Producers Group is currently lobbying for a $1/gal. tax credit on in-state biodiesel production. If this tax credit becomes a reality, it will greatly help keep PA refining competitive with that in high feedstock-producing states.

In comparison with petroleum-based diesel fuel, biodiesel can reduce air emissions by up to 85%. The only emissions type that increases with biodiesel is $NO_x$ (by 15%). Additionally, in the production stage, biodiesel can be produced with little to no GHG emissions as it does not require heating by fossil fuels. Biodiesel production is also environmentally beneficial from a recycling standpoint. In the production process, there are no waste components generated as both the biodiesel and glycerin are commercially viable products, and the methanol and catalyst that are used in processing can be easily extracted and reused. Finally, when waste oils are used as a feedstock, recycling via biodiesel production provides a profitable disposal mechanism for products that would otherwise go into a landfill or sewer.

Biodiesel production will continue to increase, and plants are in production or under development close to the region. These plants will provide a market for local soybean production. However, local production alone is not sufficient to justify an additional competitive plant in the core or border counties. Additionally, the effects of biodiesel production on the region's agriculture are uncertain. Therefore, no specific actions are recommended at this time.

# 5.0 ECONOMIC ANALYSIS OF BIOMASS ENERGY OPPORTUNITIES

## 5.1 OPPORTUNITY ANALYSIS

With an understanding of the feedstock availability, current resource use and technological feasibility, we now compare the biomass options for the SAC region. The factors across which these technologies are judged are technology status, existing facilities, feedstock availability, economic feasibility, action needed for development, and priority. Except in the case of wood and LFG, we only know the total production capacity of the region but not the availability. This is because all of the other feedstocks currently being produced are being taken up by other industries. At this time, it is not known how individual feedstock availability would respond to the addition of other facilities. The priority analysis is derived by determining the relative feasibility of a project as well as its potential impact on the region. Projects ranked high or very high are technologically and economically feasible with high potential net benefit for the community. Finally, wood plantations are one area that is analyzed here but not previously discussed in the technology section. Rather than using a specific end-use technology, development of a wood plantation would benefit the region by providing additional marketable wood resources while improving the environment by rehabilitating abandoned mine lands. Such a project could be potentially collocated with another wood based technology to secure a dedicated feedstock. Table 24 shows the results of the opportunity analysis for biomass in the SAC region.

## 5.2 AVAILABLE FUNDING

As discussed in each of the relevant technology sections, there are many grant and incentive programs designed to encourage development of renewable technologies. These programs are found at the federal, state and local levels though the majority are administered by the Pennsylvania Department of Environmental Protection, PEDA, and USDA. These programs distribute grants of up to 75% of the capital costs of an energy project and many overlap to provide a major source of funding for new projects. In addition to state and federal level grant programs, there are also several federal tax incentives in place to defray the operating costs of renewable energy facilities. Table 25 summarizes many of the grants and incentives available for biomass facilities in the SAC region. This list, though not exhaustive of the potential funding opportunities, highlights many of the larger and more prominent programs.

## TABLE 24. OPPORTUNITY ANALYSIS

| Technology | Technology Status | Existing Facilities in Region | Feedstock Produced | Feedstock Availability | Economic Feasibility | Action Needed for Development | Priority |
|---|---|---|---|---|---|---|---|
| Direct Combustion (<10 million Btu/hr) | Commercial | Yes (7 plants) | 475,000–650,000 tons wood residues | Potentially up to 650,000 tons, but chip harvesting problematic at this size | Mainly in facilities with own waste | Higher competitive fuel prices, capital grants/ loans (this situation is changing) | Moderate |
| Direct combustion (10–30 million Btu/hr) | Commercial | No | 475,000-650,000 tons wood residues | Potentially up to 650,000 tons but chip harvesting problematic at this size | Only in facilities with own waste | Higher electric power/ REC prices/competitive fuel prices, capital grants/loans | High |
| Direct combustion (electric/ CHP) (<40 MW) | Commercial | No | 475,000–650,000 tons wood residues | 475,000–650,000 tons wood residues | Not at present electric prices | Higher electric power/REC prices | Very High |
| Wood co-firing with coal (wood <40 MW) | Precommercial | No, Nationwide (1) | 475,000–650,000 tons wood residues | 475,000–650,000 tons wood residues | No | Partnership with coal power plant/boiler, incentives | Moderate |
| Wood pellets | Commercial | Yes (1) | 475,000–650,000 tons wood residues | Small available but uncertain quantity | Yes | None | High |
| Cellulosic ethanol | In development | No | 475,000–650,000 tons wood residues | Small available but uncertain quantity | Possibly after 2010–2015 | None | Low |
| Pyrolysis oil | In development | No | 475,000–650,000 tons wood residues | Small available but uncertain quantity | No | None | Low |
| Manure combustion | Commercial | No, nationwide (1) | 6.16 million tons manure | Small available but uncertain quantity | No | Incentives | Low |
| Manure digestion (centralized) | Commercial | Yes (1 planned) | 6.16 million tons manure | Small available but uncertain quantity | Possibly | Centralized transportation | High |
| Manure digestion (on farm) | Commercial | Yes (9) | 6.16 million tons manure | Small available but uncertain quantity | Yes | None | High |

| Technology | Technology Status | Existing Facilities in Region | Feedstock Produced | Feedstock Availability | Economic Feasibility | Action Needed for Development | Priority |
|---|---|---|---|---|---|---|---|
| Landfill gas | Commercial | Yes (5) | 22 landfills | 5 candidates, 12.8 MW | Yes | Partnership with landfill | Moderate |
| Biodiesel production | Commercial | No, statewide (9) | 1.95 million bushels/year soybeans | Small available but uncertain quantity | Yes | Incentives | Moderate |
| Corn ethanol production | Commercial | Yes (3 under construction) | 95 million bushels/year corn | Small available but uncertain quantity | Yes | Incentives | Moderate |
| Wood plantations on reclaimed mine land | Established | No (1 experimental project) | N/A | 20,000+ acres available | Uncertain | Partnerships with landowners and large wood users | Moderate |

## TABLE 25. AVAILABLE GRANT PROGRAM FUNDING

**GRANT PROGRAMS**

| Program Title | Area | Local/State/Federal | Agency | Website | Notes |
|---|---|---|---|---|---|
| 319 Nonpoint Source Management Program | Manure | State | DEP | www.dep.state.pa.us/dep/deputate/watermgt/wc/subjects/nonpointsourcepollution/default.htm | $9.8 MM for remediation and pollution prevention |
| Agrilink | Manure | State | DEP | panutrientmgmt.cas.psu.edu/pdf/broc hure_agri-link.pdf | $75,000 loan for animal waste management systems |
| CB Implementation Grant | Manure | State | DEP | www.depweb.state.pa.us/chesapeake | $21 MM spent, nutrient credit trading program |
| Conservation Reserve Enhancement Program | Manure | Federal | PGC | www.pgc.state.pa.us/crep | Grants for land improvement |
| Conservation Reserve Program | Manure | Federal | USDA | www.pa.nrcs.usda.gov/programs/crp.html | $1.5 MM for land and water quality improvements |

| Program Title | Area | Local/State/ Federal | Agency | Website | Notes |
|---|---|---|---|---|---|
| Environmental Quality Incentive Program | Manure | Federal | USDA | www.pa.nrcs.usda.gov/programs/eqip/Index.html | $450,000 grant and technical assistance |
| Nutrient Management Act | Manure | State | PDA | www.panutrientmgmt.cas.psu.edu | $6.4 MM for remediation and pollution prevention |
| Alternative Fuels Incentive Grant | Biofuels | State | DEP | www.depweb.state.pa.us/enintech/cwp/view.asp?a=1412&q=502176 | Small producer subsidy, <12.5 million gal.=$0.05/gal. |
| Energy Independence Capital Assistance Program | Biofuels | State | PEDA | www.depweb.state.pa.us/energindependent | $50 million, Office of the Budget, requires 50% matching |
| Energy Independence Fund | Biofuels | State | PEDA | www.depweb.state.pa.us/energindependent | $500 million for clean energy projects, announced February 2007 |
| Penelec Sustainable Energy Fund | Biofuels | Local | Community Foundation for the Alleghenies | www.cfalleghenies.org/penelec.htm | |
| PennSecurity Fuels Initiative | Biofuels | State | Governor | www.depweb.state.pa.us/energindependent | 1 billion gal. of domestic clean and renewable fuels |
| Pennsylvania Energy Development Authority | Biofuels | State | DEP | www.dep.state.pa.us/dep/deputate/pollprev/PA_Energy/PAENERGY/PEDA_home.htm | Investment in 25 clean energy projects |
| Renewable Agriculture Energy Program/Council | Biofuels | State | PEDA | www.oa.state.pa.us/oac/cwp/view.asp?A=351&Q=204284 | Started in October 2006 |
| Sustainable Development Fund | Biofuels | Local | TRF | www.trfund.com/ | $9.1 MM fund for clean energy |
| USDA Renewable Energy Improvements Grant | Biofuels | Federal | USDA | www.rurdev.usda.gov/rbs/farmbill/ | $750,000 grant to build biofuels project |
| Energy Harvest Grant Program | Multiple | State | DEP | www.depweb.state.pa.us/energy | $15.9 MM spent |

| Program Title | Area | Local/State/ Federal | Agency | Website | Notes |
|---|---|---|---|---|---|
| First Industries Funding | Multiple | State | Dept. of Community & Economic Develop. | www.newpa.com/programDetail.aspx?id=47 | Up to $250,000 grant for agriculture |
| Growing Greener | Multiple | State | DEP | www.growinggreener2.com | $13.5 MM spent, interagency grants for green projects |
| Rural Development | Multiple | Federal | USDA | www.rurdev.usda.gov | $20 MM spent on developing rural industries |
| **INCENTIVE PROGRAMS** | | | | | |
| Biodiesel Tax Credit | Biofuels | Federal | Energy Policy Act (2005, Expires 2008) | www.eere.energy.gov/afdc/progs/ind_fed__incentive.cgi | $0.51/gal. ethanol, $1/gal. agri-biodiesel |
| Small Ethanol Producers Credit | Biofuels | Federal | Energy Policy Act (2005, Expires 2008) | www.energy.gov/taxbreaks.htm | $0.10/gal. tax credit up to 15 MGY, capacity limit 30 MGY |
| VEETC Tax Credit | Biofuels | Federal | American Jobs Creation Act (2004, Expires 2010) | www.eere.energy.gov/afdc/progs/ind_fed__incentive.cgi | $0.0051/% ethanol blended |
| Renewable Energy Production Tax Credit | Multiple | Federal | Energy Policy Act (2005, Expires 2008) | www.irs.gov/pub/irs-pdf/f8835.pdf | $0.019/kWh production credit for first 10 years of operation |
| Renewable Energy Production Incentive | Multiple | Federal | Energy Policy Act (2005, Expires 2026) | www.eere.energy.gov/wip/program/repi.html | $0.015/kWH production incentive |

# 6.0 MAJOR FINDINGS AND RECOMMENDATIONS

## 6.1 MAJOR FINDINGS

The major findings of this study are as follows:

1. The SAC region, both the core and buffer counties, has a strong mix of rural land bases that can support the production of biomass fuels and feedstocks, including strong bases of hardwood forestland and a mix of agricultural land. This diversity provides a mix of potential biomass fuels, including forest-harvesting residues, sawmill residues, corn, and soybeans. Table 26 shows the region's principally available feedstocks and their energy potential. However, the diversity of landscape and crop type also means that some biomass feedstocks —particularly agricultural crops—cannot be grown in sufficient quantity to allow a user (e.g., a biodiesel producer) to achieve necessary economies of scale.

### TABLE 26. SUMMARY OF FEEDSTOCK AVAILABILITY

| Feedstock | Resource Total | Heat Yield (million Btus/ton) | Heat Content (billions of Btus) | Electricity Generation Potential (MW capacity) |
|---|---|---|---|---|
| Wood (total) | 1.9 million green tons | 10.4 | 19.7 | 158 |
| Wood (available) | 475,000–650,000 green tons | 10.4 | 4.9–6.2 | 40–50 |
| Manure (total) | 6.16 million tons | 1.21 | 7.45 | 60 |
| Manure (available) | Unknown | 1.21 | —— | —— |
| Landfills (total) | 20.84 million tons | 9.11 | 0.19 | Unknown[59] |
| Landfills (available) | 14.75 million tons | 9.11 | 0.13 | Unknown |

| Feedstock | Total Production (mil. bushels) | Fuel Yield (gal./bushel) | Total Yield (MGY) |
|---|---|---|---|
| Corn (ethanol) | 95 | 2.5 | 237 |
| Soybeans (biodiesel) | 1.95 | 1.4 | 2.7 |

2. The largest single biomass energy resource in the region is the existing resource of unused low-grade wood harvested from the forest. The region has very large volumes of forest residue potentially available, as this is currently left on the ground at most logging operations. This is a highly attractive and relatively low-cost source of biomass feedstock that could be used for the production of electricity, industrial grade pellets, or potentially cellulosic ethanol. The total sustainable supply, including unused waste, is 650,000 green tons/year.

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[59] The electric generation potential depends on the specific gas flow rates which depend on unknown site-specific factors.

3. The collection, processing, and aggregation of this biomass resource during a timber harvest requires equipment and logging infrastructure not currently in place in the region. The development of a large consumer of harvested wood chips, such as a wood-fired power plant, CHP project, or cellulosic ethanol plant with an annual demand of over 200,000 tons, is very important to develop a wood–chip-harvesting industry in the region. That harvesting infrastructure could then expand to provide wood chips for smaller consumers such as schools, colleges, and small commercial buildings.

4. Owing to the existing primary (sawmill) and secondary wood product facilities in the region, there is a large volume of mill residues generated in the region. However, most of these mill residues currently have a market, either hardwood chips to the paper industry or sawdust for animal bedding. Development of a new market could pose a threat to the viability of these existing markets.

5. Existing significant biomass energy facilities in the region are confined to wood boilers, with some limited electric power generation at three pulp and paper mills and four sawmills. All these boilers are fired with wood waste or pulping waste predominantly from these mills' own operations. Small quantities of energy are provided by on-farm manure digestion at approximately seven farms and LFG recovery at approximately five landfills.

6. Resources of other types, including corn for ethanol production and soybeans for biodiesel, have limited potential for increased production in the region. Use of these feedstocks for energy is too expensive at present and would likely result in competition with existing higher value food and animal feed uses. The relatively small available supplies of manure and the low density within the region make manure-to-energy projects uneconomical at present except for on-farm applications.

## 6.2 RECOMMENDATIONS

As a result of the study, we propose a number of recommendations to the advisory committee to consider for further investigation or action. These findings and recommendations are based on the following considerations:

- An assessment of the available biomass energy feedstock resources in the region and adjoining counties
- The current status of energy conversion technologies that may be applicable in the region
- The economic feasibility of the energy conversion technologies in the context of the available biomass energy resources, current and near future markets for electric power, RECs, air emissions credits, fuels, and competing energy products
- The environmental considerations, including sustainability of the resource base and other impacts on air water and ecosystems
- The potential for biomass energy projects to contribute to additional economic development in the region without significant adverse impacts on existing economic activities, especially in agriculture and forest based businesses

We have not prioritized our following recommendations with respect to importance or urgency for action except as described in the text:

1. **Small to Medium Wood–Chip-Fired Heating Systems or CHP projects** with a heat input of 2–30 million Btu/hr are practical for schools, colleges/universities, and medium to large

commercial buildings. Conversions are not yet economical, but new or expanded facilities may soon become so. We recommend that existing and new mechanisms be explored to provide initial assistance to develop this sector until a time when expected changes in electric power prices and conventional fuel prices change the economic outlook. This sector is dependent on the development of a wood-chip harvesting capacity in the region.

2. **Wood-Fired Electric Power or CHP projects** with an equivalent electric generation capacity of 20–40 MW are ideal candidates for using the available unused low-grade wood. The annual demand for plants of this size would be between 240,000 and 480,000 green tons/year. With the existing combination of wholesale electric power prices, REC prices, and wood prices in the region, electric generation or CHP projects are not currently economical. Expected increases in wholesale electric prices and REC prices in the next three or four years will improve the economics, but government incentives will still probably be needed to attract qualified companies to invest in this area. We therefore recommend that an effort be made to find creative combinations of private financing and government support to develop these facilities. These facilities with an annual wood demand of at least 200,000 green tons/year are very important to develop a wood-chip–harvesting industry in the region. That harvesting infrastructure could then expand to provide wood chips for smaller consumers such as schools, colleges, and commercial buildings.

3. **Co-firing Wood with Coal,** although practical and demonstrated, is not economical at prevailing wholesale electric power and REC prices. This situation may change if a national cap-and-trade program for GHG emissions is implemented, or if a carbon tax is imposed. However, neither of these outcomes is certain, and the detailed regulations for these programs may exclude co-firing with fossil fuels. Implementation of co-firing could occur with the active support of electric generation companies or distributing utilities, but this is uncertain. Although a wood-co-fired plant is large enough to start a wood-chip–harvesting industry in the region, loggers and lenders may view co-firing as an insecure market without a mandated market. In the short run, many premium voluntary or government-mandated REC markets may not accept co-fired RECs. Progress in developing this sector will depend on cooperation from the coal fired electric generators and utilities. These might be approached as possible partners in an investigation of site-specific co-firing feasibility.

4. **Wood Pellet Production**, which in the past has typically depended on waste wood as its raw material, is likely to turn increasingly to wood chips. The availability of unused low-grade wood in the region, combined with good rail access, makes it possible that additional wood-pellet manufacturing plants will be attracted to the region. These new plants are likely to be larger than existing plants and would supply a market in Europe for wood pellets at much higher prices. The higher prices in Europe reflect various EU government programs to combat global warming and encourage the use of renewable biomass resources. The development of these plants in Pennsylvania would also enable them to supply local markets when the price of wood pellets reaches EU levels.

5. **Cellulosic Ethanol Production** is at present in the precommercial stage. The availability of unused wood and good rail connections to eastern markets make the region potentially attractive to some cellulosic ethanol development companies. Commercial plants would use amounts of wood comparable to wood-fired power plants and therefore could help develop regional infrastructure for biomass. There has been considerable competition among states to attract one of these new technology ethanol plants; relatively large state and or local subsidies will be needed in addition to federal support. The regional economic development potential of cellulosic ethanol plants is comparable to a wood-fired power plant with a similar wood consumption, but the risks of delays in development or plant failure are much greater.

6. **Manure Combustion** is a practical technology for disposal of manure and energy generation. It is not economical because of transportation cost. Manure disposal is not a major

problem in the region, and digestion is a preferable technology. Air pollution and other environmental problems may make site selection difficult. No specific action is recommended.

7. **Manure Digestion** is a practical and environmentally preferable technology for conversion of manure to energy. For larger animal operations, it is economical under existing support programs for on-farm applications. Local concentrations of livestock farms where transportation is less than 5–10 miles may be able to support a central digester. Further support and evaluation of manure digestion is recommended.

8. **LFG** capture is a viable enterprise for facilities in the region. However, owing to the small number of eligible facilities and their low generation capacity as compared with other technologies, the potential for significant economic impact is small. Extensive state and federal programs are in place to encourage the use of LFG and provide funding. At this time, the only action recommended is to support partnerships between landfills and local businesses to use potential production for heat and power applications.

9. **Corn Ethanol and Biodiesel Production** will occur in new plants that are at present under development close to the region. These plants will provide a market for local corn and soybean production. The production of corn and soybeans in the region is not sufficient to justify additional competitively size plants. The effects of ethanol and biodiesel production on agriculture in the region are uncertain. No specific actions are recommended.

10. **Woody Biomass Plantations** on abandoned coal-mined land would provide environmental benefits to the region and could provide a supplemental source of wood for energy. The potential for this should be investigated further.

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# APPENDICES

## APPENDIX A: SAC REGION COLLEGES AND UNIVERSITIES

Appendices A, B, and C list candidate facilities within the SAC core and border counties that would be possible locations for installation of a small- or medium-size wood boiler. These appendices, which detail the region's colleges/universities, prisons, and hospitals, use enrollment counts to estimate heat demand and possible boiler size.

| College and Universities | Town | Country | Enrollment | Heat Demand (MBtu) |
|---|---|---|---|---|
| Allegheny College of Maryland | Everett | Bedford | | |
| Penn State—Altoona | Altoona | Blair | 3,800 | 76 |
| Mount Aloysius College | Cresson | Cambria | 1,600 | 56 |
| Pennsylvania Highlands Community College | Richland Township | Cambria | 1,300 | 26 |
| St. Francis University | Loretto | Cambria | 2,000 | 70 |
| University of Pittsburgh at Johnstown | Johnstown | Cambria | 2,700 | 54 |
| Juniata College | Huntingdon | Huntingdon | 1,460 | 51.1 |
| Allegheny College of Maryland | Somerset | Somerset | | |
| Cambria-Rowe Business College | Johnstown | Somerset | | |
| Penn State—State College | University Park | Centre | 43,000 | 1,505 |
| DuBois Business College | DuBois | Clearfield | | |
| Penn State—Fayette | Uniontown | Fayette | 1,100 | 22 |
| Shippensburg University | Shippensburg | Franklin | 7,500 | 150 |
| Wilson College | Chambersburg | Franklin | 300 | 10.5 |
| Indiana University of PA (3 campuses) | Indiana | Indiana | 14,000 | 280 |
| Penn State—New Kensington | Kensington | Westmoreland | 1,000 | 20 |
| St Vincent College | Latrobe | Westmoreland | 1,600 | 56 |
| Seton Hill University | Greensburg | Westmoreland | 1,800 | 63 |
| University of Pittsburgh—Greensburg | Greensburg | Westmoreland | 1,800 | 36 |
| Westmoreland Community College | Youngwood | Westmoreland | | |
| Allegheny College of Maryland | Cumberland | Allegany | 3,000 | 60 |
| Frostburg State University | Frostburg | Allegany | 5,200 | 182 |
| California University of Pennsylvania | California | Washington | 6,000 | 210 |

# APPENDIX B: SAC PRISONS

| Name | Federal/State | Town | County | Population |
|---|---|---|---|---|
| Cresson | State | Cresson | Cambria | 1,400 |
| Cambria County | County | Ebensburg | Cambria | 510 |
| Huntingdon | State | Huntingdon | Huntingdon | 1,700 |
| Laurel Highlands | State | Somerset | Somerset | 900 |
| Smithfield | State | Huntingdon | Huntingdon | 1,000 |
| Somerset | State | Somerset | Somerset | 1,900 |
| Fayette | State | LaBelle | Fayette | 2,000 |
| Greensburg | State | Greensburg | Westmoreland | 800 |
| Houtzdale | State | Houtzdale | Clearfield | 1,900 |
| Rockview | State | Bellafonte | Centre | 1,700 |
| Pine Grove | State | Indiana | Indiana | 660 |
| Cumberland | Federal | Cumberland | Cumberland | 1,400 |
| Loretto | Federal | Loretto | Westmoreland | 1,290 |
| Moshannon Valley | Federal | Phillipsburg | Centre | 1,470 |
| Maryland Corrections | State | Hagerstown | Washington | |

# APPENDIX C: SAC HOSPITALS

| Name | City | County | Beds |
|---|---|---|---|
| UPMC Bedford Memorial | Everett | Bedford | 59 |
| 7Altoona Center | Altoona | Blair | 138 |
| Altoona Hospital | Altoona | Blair | 300 |
| HealthSouth Rehabilitation | Altoona | Blair | 70 |
| Nason Hospital | Roaring Spring | Blair | 42 |
| Tyrone Hospital | Tyrone | Blair | 59 |
| VA Medical Center | Altoona | Blair | 68 |
| Conemaugh Memorial | Johnstown | Cambria | 386 |
| Laurel Crest Manor | Ebensburg | Cambria | 370 |
| Miners Hospital | Hastings | Cambria | 30 |
| UPMC Lee Regional | Johnstown | Cambria | 209 |
| Blair Memorial Hospital | Huntingdon | Huntingdon | 71 |
| Meyersdale Medical Center | Meyersdale | Somerset | 20 |
| Somerset Hospital | Somerset | Somerset | 134 |
| Windber Medical Center | Windber | Somerset | 57 |

| Name | City | County | Beds |
|---|---|---|---|
| Meadows Psychiatric Center | Centre Hall | Centre | 101 |
| Mount Nittany Medical Center | State College | Centre | 201 |
| Clearfield Hospital | Clearfield | Clearfield | 83 |
| Highlands Hospital | Connellsville | Fayette | 71 |
| Uniontown Hospital | Uniontown | Fayette | 209 |
| Chambersburg Hospital | Chambersburg | Franklin | 235 |
| Waynesboro Hospital | Waynesboro | Franklin | 64 |
| Indiana Regional | Indiana | Indiana | 162 |
| Lewistown Hospital | Lewistown | Mifflin | 139 |
| Brook Lane Psychiatric Center | Hagerstown | Washington | 42 |
| Frick Hospital | Mount Pleasant | Westmoreland | 100 |
| Jeannette District Hospital | Jeannette | Westmoreland | 149 |
| Latrobe Area Hospital | Latrobe | Westmoreland | 157 |
| Torrance State Hospital | Torrance | Westmoreland | 233 |
| Westmoreland Regional | Greensburg | Westmoreland | 295 |
| Memorial Hospital | Cumberland | Allegany | 157 |
| Sacred Heart Hospital | Cumberland | Allegany | 255 |
| Garrett County Memorial Hospital | Oakland | Garrett | 56 |
| Washington County Health System | Hagerstown | Washington | 293 |
| Western Maryland Health System | Hagerstown | Washington | 120 |

## APPENDIX D: COAL CO-FIRING TESTS

Appendices D and E address the technology of co-firing wood with coal as discussed in section 4.2. Appendix D lists the facilities nationwide that have co-fired either experimentally or at a commercial scale. Of these facilities, only Bay Front Station in Ashland, WI, is currently co-firing at a commercial scale. Appendix E lists the large coal boilers in the SAC region that could be candidates for commercial co-firing.

| Plant Name | City | State | Owner | Capacity (MW) | Wood (%) | Test/ Commercial |
|---|---|---|---|---|---|---|
| Allen Fossil Plant | Memphis | TN | TVA | 272 | 20 | Test |
| Ames Municipal | Ames | IA |  | 75 |  | Test |
| Bailey Station #7 | Chesterton | IN | NIPSCO | 160 |  | Test |
| Bay Front Station | Ashland | WI | Xcel Energy | 76 | 40 | Commercial |
| BL Station #1 | England | NJ | Northern States Power | 120 | 12 | Test |
| City of Tacoma #2 | Tacoma | WA | Tacoma Public Utility | 18 | ~50 | Commercial |
| Colbert #1 | Tuscumbia | AL | TVA | 182 | 4 | Commercial |
| Dunkirk #1 | Dresden | NY | Niagara Mohawk Power | 90 | 20 | Test |

| Plant Name | City | State | Owner | Capacity (MW) | Wood (%) | Test/ Commercial |
|---|---|---|---|---|---|---|
| Escalante #1 | Prewitt | NM | Tri-State Generating | 250 | 1 | Commercial |
| Gannon #3 | Tampa | FL | Tampa Electric Company | 165 | 5 | Test |
| Greenridge #6 | Dresden | NY | NYSEG | 108 | 30 | Commercial |
| Hammond Station #1 | Coosa | GA | Georgia Power Co | 100 | 13 | Test |
| Harlee Branch | Milledgeville | GA | Georgia Power Co | 1,539 | 1 | Commercial |
| Jeffries #3 and #4 | Moncks Corner | SC | Santee Cooper | 165 | 20 | Test |
| King #1 | Stillwater | MN | Northern States Power | 560 | 5 | Commercial |
| Kingston #5 | Oakridge | TN | TVA | 180 | 5 | Test |
| Kraft / Riverside #2 | Port Wentworth | GA | SEPCO | 46 | 36 | Test |
| La Cygne #1 | Kansas City | KS | Kansas City Power & Light | 840 | 5 | Test |
| Lakeland Electric #3 | Lakeland | FL | Lakeland Electric | 350 | 5 | Test |
| Lee Steam #3 | Pelzer | SC | Duke Power Co | 170 | 5 | Test |
| McNeil Generating Station | Burlington | VT | Future Energy Resources | 50 |  | Test |
| Michigan City #12 | Lake Michigan | IN | NIPSCO | 469 | 20 | Test |
| Seward #12 | Pittsburgh | PA | Reliant | 32 | 12 | Test |
| Shawville #3 | Johnstown | PA | Reliant | 190 | 3 | Test |
| Shawville #2 | Johnstown | PA | Reliant | 138 | 3 | Test |
| Thomas Hill #2 | Columbia | MO | Associated Electric Coop | 175 | 7 | Test |
| Vermillion #1 | Oakwood | IL | Illinois Power Co | 75 | 25 | Test |

# APPENDIX E: SAC REGION COAL POWER PLANTS AND LARGE BOILERS

| Facility Name | Operator | City | County | Capacity (MW) |
|---|---|---|---|---|
| American Eagle Paper Mills | American Eagle Paper Mills | Tyrone | Blair | 10 |
| Juniata Locomotive Shop | Norfolk Southern | Altoona | Blair | 4 |
| Cambria Cogen | Northern Star Generation | Ebensburg | Cambria | 98 |
| Colver Power Project | Inter-Power/AhlCon Partners | Colver | Cambria | 131.1 |
| Ebensburg Power | Ebensburg Power | Ebensburg | Cambria | 57.6 |
| Shawville | Reliant Energy | Shawville | Clearfield | 632 |
| Conemaugh | Reliant Energy | New Florence | Indiana | 1,883 |
| Homer City Station | Edison Mission Energy | Homer City | Indiana | 2,012 |
| Seward | Reliant Energy | New Florence | Indiana | 803.2 |
| AES Warrior Run Cogen | AES NUGs | Cumberland | Allegany | 229 |
| Luke Mill | NewPage Corporation | Luke | Allegany | 65 |
| R Paul Smith Power Station | Allegheny Energy Supply | Williamsport | Washington | 109.5 |

# APPENDIX F: COMPARISON OF HEATING FUEL COSTS

Appendix F shows the relative costs of a variety of heating fuels per million Btus of heat generated. The table is used to create Figure 18 in section 4.3. The efficiencies in this chart are derived from combustion in a small- to medium-size commercial boiler and all data is obtained from the Energy Information Administration and Biomass Energy Resource Center.

| As of March 2007 | Unit | Cost/Unit | Heat Capacity (Btu) | Moisture Content (%) | Vaporization loss (MBtu/ton) | Net Heat Capacity (MBtu) | Efficiency (%) | Delivered MBtu/Unit | Cost/ MBtu |
|---|---|---|---|---|---|---|---|---|---|
| Wood Pellets | Ton | $170.00 | 15,478,000 | 10 | 0.24 | 15.238 | 80 | 12.1904 | $13.95 |
| Wood Chips | Ton | $30.00 | 10,200,000 | 40 | 0.96 | 9.24 | 65 | 6.006 | $5.00 |
| Natural Gas | 1,000*SCF | $11.82 | 1,050,000 | —— | —— | 1.05 | 80 | 0.84 | $14.07 |
| #2 Oil | Gallon | $2.04 | 140,000 | — | — | 0.14 | 75 | 0.105 | $19.43 |

# APPENDIX G: SAC REGION MANURE ESTIMATES

Appendix G relates specifically to the technology sections focused on manure disposal—Manure Combustion (4.5) and Manure Digestion (4.6). The table shows the manure estimates for all core and border counties broken down by county, animal type, and county. For comparison, manure estimates from Lancaster County, a major livestock area, are also included. The data are from the USDA Census at http://www.nass.usda.gov/census; scorecard.org/

| County | Cattle | Poultry | Swine | Manure (ton/yr) |
|---|---|---|---|---|
| Bedford | 40,500 | 4,052 | 12,000 | 459,161 |
| Blair | 35,000 | 150,000 | 3,000 | 389,423 |
| Cambria | 12,100 | 4,600 | 1,800 | 133,917 |
| Fulton | 16,900 | 78,000 | 24,800 | 233,033 |
| Huntingdon | 24,800 | 13,700 | 26,000 | 317,418 |
| Somerset | 51,300 | 150,000 | 2,000 | 562,977 |
| **SAC Region Total** | | | | **2,095,929** |
| Centre | 30,400 | 23,000 | 5,900 | 339,618 |
| Clearfield | 8,300 | 1,200 | 400 | 90,171 |
| Fayette | 19,300 | 3,500 | 1,500 | 210,800 |
| Franklin | 104,500 | 2,200,000 | 84,200 | 1,387,470 |
| Indiana | 21,300 | 2,200 | 1,000 | 231,312 |

| County | Cattle | Poultry | Swine | Manure (ton/yr) |
|---|---|---|---|---|
| Juniata | 18,600 | 2,400,000 | 30,300 | 368,684 |
| Mifflin | 32,300 | 230,000 | 30,000 | 415,770 |
| Westmoreland | 26,200 | 20,000 | 2,300 | 287,370 |
| Allegheny | 5,254 | unknown | 16 | 56,590 |
| Garrett | 19,273 | unknown | 540 | 208,508 |
| Washington | 42,681 | unknown | 5,718 | 470,417 |
| **Border County Total** | | | | **4,066,709** |
| Lancaster | 228,900 | 15,000,000 | 313,000 | 3,753,817 |
| **Total Animals** | **508,708** | **5,280,252** | **231,474** | |
| **Total Manure (ton/year)** | **5,476,242** | **242,892** | **443,504** | **6,162,637** |
| **Average Manure Generation Rates (tons/animal/year)** | | | | |
| Swine | 1.916 | | | |
| Cattle | 10.765 | | | |
| Poultry | 0.046 | | | |

# APPENDIX H: SAC REGION LANDFILLS

As discussed in section 4.7 there are 26 landfills in the SAC core and border counties, 5 of which have active LFG extraction projects. In addition, 5 other landfills are considered by the EPA's Landfill Methane Outreach Program to be good candidates for extraction programs. The table lists the landfills in the region with their waste capacity and EPA ranking.

| Landfill Name | Landfill City | Landfill County | Waste in Place (tons) | Project Status |
|---|---|---|---|---|
| Laurel Highlands LF | Johnstown | Cambria | 683,559 | Operational |
| Mountain View Landfill | Greencastle | Franklin | 5,511,556 | Operational |
| Southern Allegheny LF | Davidsville | Somerset | 2,644,903 | Operational |
| Mostoller Landfill, Inc. | Somerset | Somerset | | Candidate |
| Shade LF (RCC LF) | Cairnbrook | Somerset | 3,500,000 | Candidate |
| Sandy Run LF | Hopewell | Bedford | 311,509 | Potential |
| Lasky LF | Hollsopple | Cambria | | Potential |
| Guilford Township LF | Chambersburg | Franklin | | Potential |

| Landfill Name | Landfill City | Landfill County | Waste in Place (tons) | Project Status |
|---|---|---|---|---|
| Southern Alleghenies LF | Davidsville | Somerset | 2,644,903 | Potential |
| Greenridge Reclamation | Alverton | Westmoreland | 6,000,000 | Operational |
| Valley LF | Irwin | Westmoreland | 6,000,000 | Operational |
| Veolia ES Chestnut Valley Landfill | McClellandtown | Fayette | 570,000 | Candidate |
| Resh Road II SLF | Hagerstown | Washington | 2,055,978 | Candidate |
| Westmoreland Waste Landfill | Belle Vernon | Westmoreland | 1,000,000 | Candidate |
| Kennedy LF | Lemont Furnace | Fayette |  | Potential |
| Marilungo Disposal Service Landfill | Lemont Furnace | Fayette |  | Potential |
| Evergreen Landfill | Coral | Indiana | 350,225 | Potential |
| Richard's LF | Marion Center | Indiana |  | Potential |
| Mifflin County Solid Waste Authority | Lewistown | Mifflin | 400,677 | Potential |
| Loyalhanna LF | Slickville | Westmoreland |  | Potential |
| MAWC SLF | Greensburg | Westmoreland |  | Potential |
| Sanitary LF | Greensburg | Westmoreland | 398,041 | Potential |
| Wach's LF | West Newton | Westmoreland |  | Potential |
| Mountainview SLF | Frostburg | Allegany | 501,140 | Potential |
| Vale Summit and Cabin Run LF |  | Allegany | 1,470,000 | Potential |
| Round Glade SLF | Oakland | Garrett | 800,000 | Potential |
| Hancock SLF |  | Washington | 40,963 | Potential |

# APPENDIX I: PENNSYLVANIA BIOFUEL PRODUCERS

Appendix I applies to sections 4.8 and 4.9 and lists the biofuels producers in Pennsylvania. Of the facilities on this list, 8 are currently in operation and 10 are either under construction or late in the planning process. Of the operating facilities, none are in the SAC region; however, 3 of the largest ethanol facilities in planning are sited for Clearfield and Westmoreland counties.

| Name | Fuel | Town | County | Capacity (MGY) | Operation Date |
|---|---|---|---|---|---|
| Agra Biofuels | Biodiesel | Middletown | Dauphin | 3 | Jan 2006 |
| Biodiesel of Pennsylvania | Biodiesel | White Deer | Union | 3.6 | Jan 2007 |

| Name | Fuel | Town | County | Capacity (MGY) | Operation Date |
|---|---|---|---|---|---|
| Choice FuelCorp | Biodiesel | South Williamsport | Lycoming | 2 | May 2007 |
| Keystone Biofuels | Biodiesel | Shiremanstown | Cumberland | 2 | Jan 2006 |
| Lake Erie Biofuels | Biodiesel | Erie | Erie | 45 | Aug 2007 |
| PA Biodiesel | Biodiesel | Monaca | Beaver | 4 .5 | |
| Soy Energy | Biodiesel | New Oxford | Adams | 1.5 | Apr 2007 |
| United Biofuels | Biodiesel | York | York | 0.5 | Apr 2006 |
| United Oil Company | Biodiesel | Pittsburgh | Pittsburgh | 5 | Dec 2004 |
| Alex Color Company | Ethanol | Shenandoah | Schuylkill | | |
| Armstrong County Farm Bureau | Ethanol | | Armstrong | | |
| BioEnergy International | Ethanol | | Clearfield | 108 | Early 2009 |
| Commonwealth Renewable Energy | Ethanol | Hempfield Township | Westmoreland | 200 | Dec 2007 |
| Green Renewable Energy | Ethanol | Tremont | Schuylkill | 110 | |
| Keystone Ethanol | Ethanol | | Crawford or Mercer | 20 | |
| NW PA Farm Bureau | Ethanol | Meadville | Crawford | 80 | |
| Sunnyside Ethanol | Ethanol | Curwensville | Clearfield | 80 | Early 2008 |
| Sunnyside Ethanol | Ethanol | Aliquippa | Beaver | 88 | 2010 |

# APPENDIX J: ENERGY HARVEST GRANTS

The table shows the PA Energy Harvest Grant recipients for biomass technologies. Energy Harvest, a funding program administered by the PA DEP, is designed to promote green energy within the state and is a major funding source for smaller scale energy projects. The average size of an Energy Harvest Grant is ~$275,000 and manure digesters are one of the most heavily funded areas.

| Year | Name | County | Amount ($) | Type | Notes |
|---|---|---|---:|---|---|
| 2006 | Applied Reclamation Techniques | Schuylkill | 346,884 | Manure | Poultry biomass for Schuylkill Agricultural Center |
| 2006 | Dillon Floral Corp. | Columbia | 206,691 | Wood | Wood-fired boiler for greenhouse |
| 2006 | John Koller & Son | Mercer | 375,134 | Manure | Fairview Swiss Cheese |
| 2006 | Kane Area School District | McKean | 355,653 | Wood | Wood-fired boiler for high school |
| 2006 | Northern Tier Solid Waste Authority | Bradford | 70,000 | Landfill Gas | Greenhouse run on LFG |
| 2006 | Pocono Northeast Resource Council | Lackawanna | 393,590 | Wood | Mobile pelletizing unit |
| 2006 | Southern Alleghenies Conservancy | Juniata | 285,038 | Manure | Complete mix digester for dairy |
| 2005 | Carnegie Mellon University | Allegheny | 120,000 | Biofuels | CHP system using biodiesel |
| 2005 | Centre County Conservation District | Centre | 323,100 | Manure | Digester for Hogs Galore Farm |
| 2005 | Environmental Management Group | Cumberland | 225,000 | Manure | Digester for Mains Dairy Farm |
| 2005 | Environmental Management Group | Lancaster | 390,055 | Manure | Digester for Red Knob Dairy |
| 2005 | Guilford Mills | Schuylkill | 100,000 | Landfill Gas | Direct use LFG boiler |
| 2005 | Lancaster County Conservation District | Lancaster | 600,000 | Manure | Digester for Brubaker Farm |
| 2005 | Penn Ag Industries Council | Multiple | 48,758 | Manure | New technology for poultry litter |
| 2005 | Potter County Conservation District | Potter | 130,000 | Manure | Digester for Four Winds Farm |
| 2005 | PP&L Sustainable Energy Fund | Multiple | 440,584 | Manure | Biodigester funding |

| Year | Name | County | Amount ($) | Type | Notes |
|---|---|---|---|---|---|
| 2005 | Somerset Country Conservation District | Somerset | 275,000 | Manure | Digester for Hillcrest Saylors Dairy |
| 2004 | Beaver Ridge Farm | Perry | 326,936 | Manure | Digester |
| 2004 | Granger Energy of Honey Brook | Multiple | 235,000 | Landfill Gas | LFG-fueled engine |
| 2004 | Indiana County Conservation District | Indiana | 25,500 | Manure | Digester for Terczak veal farm |
| 2004 | Philadelphia Fry-o-Diesel | Philadelphia | 369,696 | Biofuels | Biodiesel from waste grease |
| 2004 | Piney Creek Partnership | Clarion | 225,000 | Wood | Installation of wood boiler for CHP |
| 2004 | Potter County Conservation District | Potter | 255,000 | Manure | Digester for Four Winds Farm |
| 2004 | Princeton Energy Systems | Multiple | 280,000 | Manure | Biogas processing from digesters |
| 2004 | Somerset Country Conservation District | Somerset | 325,000 | Manure | Digester for Hillcrest Saylors Dairy |
| 2004 | Southern Alleghenies Conservancy | Blair | 280,500 | Manure | Digester for Penn England Farms |
| 2004 | Sun-Re Cheese Corp | Northumberland | 300,000 | Manure | Digester from cheese whey |
| 2004 | Worley and Obetz | Dauphin | 219,908 | Biofuels | Biofuels infrastructure |
| 2003 | Acadia Water Technologies | Multiple | 241,702 | Landfill Gas | LFG from wastewater treatment facility |
| 2003 | Chester County Industrial Development Authority | Chester | 150,000 | Biofuels | Ethanol from mushroom compost |
| 2003 | Clinton County Conservation District | Clinton | 357,000 | Manure | Digester for Schrack Farms (dairy), |
| 2003 | Indiana County Conservation District | Indiana | 408,577 | Manure | Digester for Brookside Dairy |
| 2003 | Lancaster County Conservation District | Lancaster | 367,412 | Manure | Digester for 400-head Wanner's Pride-n-Joy |
| 2003 | Lancaster County Conservation District | Lancaster | 294,208 | Manure | Digester for 800-head Graywood Farm |
| 2003 | Pocono Northeast Resource Conservation Council | Multiple | 400,000 | Manure | 3 Digesters, 919,000 kwh/year |
| 2003 | Seneca Landfill | Butler | 145,000 | Landfill Gas | LFG project |
| 2003 | Solvent Green | Lehigh | 100,000 | Pyrolysis | Pyrolysis demonstration facility |
| 2003 | Somerset Country Conservation District | Somerset | 373,206 | Manure | Digester for 400-head Doven Farms |

# APPENDIX K: SUMMARY OF NEW BIOMASS ENERGY PROJECTS IN FEASIBILITY ASSESSMENT STAGE

Appendix K summarizes new biomass energy projects that are currently being investigated or planned in the SAC region or adjoining counties in the fall of 2007. These are provided to help readers of this report understand the range of possibilities that are under active consideration by private and public sector developers. The authors are not at present convinced that all of these projects will be feasible, but they all fall into the categories that have been described in this report as good possibilities for development. In addition, the continued rise in gas and oil prices and growing likelihood of GHG reduction programs at the national level may have shifted the economic calculus. Most, if not all, of these projects are at a stage where they have not yet been announced to the general public; thus the locations and names of the developers are not given.

## College Campus Wood-Fueled Heating System

A small college is currently evaluating the conversion of its existing natural gas-fired campus heating system to wood chips. The college will need to install a new boiler and wood–fuel-handling and storage facilities. On the basis of the present use of natural gas and the last 12 months' gas prices, the college is likely to reduce its cost of fuel by about 60%. It is expected that it would use approximately 7,000 green tons of wood chips/year. As this report has shown, there is adequate wood available, but one of the issues that will face the college and any other small wood chip user is locating a reliable wood fuel supplier. The other issue is likely to be financing the capital cost of a new wood boiler and wood-handling facilities. Because the cost savings compared with natural gas are substantial, a new wood-fired boiler should have a relatively good return on investment. This could attract outside capital or an ESCO that would work with the college on a shared-savings basis or a guaranteed heat price. On the basis of experience in the New England states, where conventional energy prices have been higher for some time, outside capital or ESCO services are a possible route for development. The fuel supplier issues would be easier if a large wood fuel user such as a wood-fired power plant or coal plant co-fired with wood were to be developed. One or more colleges converting to wood heat would also encourage other developments including school heating systems.

For this college campus, there is also an advantage that renewable energy use is viewed as a socially responsible action that would contribute to achieving sustainability objectives and support local economic development.

## Co-firing Wood in an Existing Coal Plant

This report identified the advantages and opportunities for co-firing wood with coal in existing plants. In the past, several coal plants have successfully demonstrated co-firing wood but found that co-firing could not be justified economically. One coal-fired power plant is reconsidering the situation. Our analysis showed that the short-term economics of co-firing remain unattractive. However, it is possible that in light of available incentives through the Alternative Energy Portfolio Standard and the prospect of higher electricity prices may change the situation in the intermediate term. In addition, the increasing likelihood of a national GHG cap-and-trade program is probably also a factor to be considered.

## Wood Pellet Manufacturing

At least two companies are understood to be evaluating the region for new wood pellet manufacturing facilities. This is to be expected and is consistent with the conclusions of this report. The demand for wood pellets in both the United States and Europe continues to increase. If these are large wood pellet facilities, they will need to harvest wood chips and this could be the beginning of a significant demand for wood chips that will be helpful to smaller users such as schools and colleges.

## School Heating Systems

At least one school district is evaluating wood chips for heating systems. The rapid increase in natural gas prices and oil prices in recent months, the probability of increased electric prices, and the prospect of improved availability of wood chips and pellets may be responsible for this new interest.

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