# Potential Economic Impact of Renewable Fuels and Sustainable Biomass Feedstock for Pennsylvania: 2016

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## I. Introduction

In order to understand potential regional economic gains from advanced biofuels production, an economic impact assessment was conducted for the state of Pennsylvania. This analysis considers four producing regions and, respectively, miscanthus, switchgrass, and soft willow as the cellulosic feedstocks. In all, 12 models were developed to project economic impacts in each region and for each feedstock type. The modeling process combined inputs from Penn State experts in crop production, the transformation of that information so that it was suitable for entry into an impact modeling structure, technical production coefficients from the National Renewable Energy Laboratories (NREL) for enzymatic cellulosic ethanol production, and regionally-specific industrial production accounts generated from the IMPLAN input-output modeling system.

## II. Biomass Production

There were four production regions considered centered in Berks, Bradford, Crawford, and Washington County. These counties were chosen given their special geographical location in Pennsylvania alongside their larger amount (in comparison to other PA counties) of idle or abandon land. Furthermore, it was determined that this land had potential for producing each of the three feedstock types. Production enterprise budgets were used for each feedstock type to estimate per acre yield potential and average crop production costs considering plant establishment and ongoing annual crop maintenance costs. Table 1 shows the variance in the delivered cost of the feedstock by type. This includes all farmer production costs, storage, and transport to the ethanol producing facility. It is clear that miscanthus and willow have cost advantages over switchgrass when looking at the group averages. The Berks region produced the highest cost per delivered ton of both miscanthus and willow. Bradford had the highest switchgrass cost. Overall, the Washington region had the lowest feedstock costs.

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**Table 1. Delivered Feedstock Cost Per Ton**

| Region | Miscanthus | Switchgrass | Willow |
|---|---|---|---|
| Berks | $ 73.70 | $ 93.31 | $ 71.30 |
| Bradford | $ 63.94 | $ 97.16 | $ 63.73 |
| Crawford | $ 66.95 | $ 92.00 | $ 61.59 |
| Washington | $ 61.37 | $ 80.20 | $ 61.10 |
| Average | $ 66.49 | $ 90.67 | $ 64.43 |

For modeling purposes the total delivered price of the feedstock was broken into two major components. The biomass farmers' costs of production and storage were segregated from the total in building that new sector in the modeling system. Next, all transport costs, both to storage and to the ethanol plant, were isolated as distinct from the farming activity and storage.

Last, it was assumed in the modeling structure that all biomass farmers would rent multiple land tracts to achieve required scale economies for biomass cultivation, mowing, and baling. That meant all of the biomass farmers' costs of production would include land rent payments, which were separated out for each region and for each biomass type when specifying the production coefficients for the biomass producing sector in the regional-by-biomass type models.

## III. The Cellulosic Ethanol Base Model and Basic Assumptions

Aside from feedstock costs, the overall cost of producing cellulosic ethanol must be itemized before overall economic impact modeling can take place. This project relied on data from the National Renewable Energy Laboratories (NREL) to initially specify the production characteristics.[2] The project also relied on published information from actual cellulosic production facilities that are in production at scale or under construction and nearing the production stage. Table 2 displays some of the initial factors used for compiling the economic impacts of the miscanthus facility in the Washington region. All twelve regional models are similarly configured.

[2] NREL produces impact model spreadsheets to help demonstrate the potential job gains from constructing and operating ethanol facilities. Their multipliers, however, are crude and not transparent, and should therefore not be used for either state level or sub-state level evaluations for the purposes of policy development. More information about NREL's Jobs and Economic Development Impact models (JEDI) can be found at: http://www.nrel.gov/analysis/jedi/

**Table 2. Cellulosic Biofuels Basic Assumptions: Washington Region -- Miscanthus**

| Basic Factors and Assumptions | Scenario | $ Per Gallon | $ Per Ton |
|---|---|---|---|
| Plant Size (MGY) | 25 | | |
| Construction Costs Per Gallon | $8.50 | $8.50 | $680.00 |
| Percent Financed | 60% | | |
| Jobs | 35 | | |
| Total Labor Costs Per Job | $68,310 | | |
| Feedstock Cost Per Ton (gate & storage only) | $50.17 | $.63 | $50.17 |
| Conversion (gallons per ton) | 80 | | $80.00 |
| Required Tons | 312,500 | | |
| | | | |
| Debt to Equity Percent | 60% | | |
| Expected Return to Equity | 8% | | |
| Finance rate | 7% | | |
| Transport to Storage and to Plant Rate | $0.14 | $0.14 | $11.20 |

All regions were specified with a 25 million gallon per year (MGY) production facility. The corn stover facility in Emmetsburg, IA, is rated at 25 MGY. The corn stover facility near Nevada, IA, is expected to produce 30 MGY at full production. Finally, the primarily corn stover fed plant at Hugoton, KS, is also rated at 25 MGY. There are no commercial scale plants using in the feedstocks assessed in the Pennsylvania scenario, so the existing at-scale operations were used as the expected level of production for initial scale economies.

The average cost per gallon (or processed ton of biomass) is the next important factor. The NREL modeling structure assumes initial construction costs per gallon resembling that of corn ethanol refineries – just under $3.00 per gallon of nameplate capacity. Existing data on the three commercial scale plants suggests that number severely underestimates current costs. The Poet plant in Emmetsburg, IA, for example used a combination of private sector, federal government, and state government financing with total costs per gallon of capacity in excess of $10.00. Roughly that same construction cost threshold is evident in both the Nevada, IA, and the Kansas plant. This project set the complete cost of plant construction at $8.50 per gallon, which assumes the existing three plants' experiences will yield construction efficiencies for future plants. The construction cost-per-gallon is a very important factor in the long term viability of ethanol production. As Table 3 demonstrates, production costs drop sharply with reduced construction costs-per-gallon assumptions. Overall, a 29 percent reduction in construction costs from $8.50 to $6.00 yielded about an 18 percent reduction in ethanol costs per gallon produced in our working models.[3]

[3] This is an economic impact assessment using research-based inputs into the analysis. This research is not a feasibility analysis or a market study. Readers are cautioned to not infer project market viability from this study.

**Table 3. Washington Region Miscanthus Production Cost Variation By Initial Construction Cost Assumptions**

| Construction Cost Per Gallon Assumption | Final Cost Per Gallon Produced |
|---|---|
| $8.50* | $2.29 |
| $6.00 | $1.88 |
| $5.00 | $1.73 |
| $4.00 | $1.59 |

**This is the value used in all scenarios.*

All four plants are assumed to need 35 workers making an average of $68,310 per job in total wages, salaries, and benefits regardless of feedstock source. The plants are not assumed to have publicly funded construction subsidies, and 60 percent of the capital costs would be raised through borrowing at 7 percent APR. The remaining capital would be privately raised with an expected annual return on investment of 8 percent. As in Table 3, the cost of borrowing as well as expected returns to equity will also have an impact on the final cost of each gallon. For the model demonstrated above in Table 3, were costs of borrowing and expected returns on investment raised to 10 percent each as an example of higher risk assumptions, the production cost per gallon would go from $2.29 per gallon to $2.54 per gallon.

Each dry ton of biomass is expected to produce 80 gallons of ethyl alcohol from 312,500 dry tons of biomass. Those values are fixed for each region and for each biomass type. The costs of that biomass as well as total biomass transport costs vary by region and by biomass type, however. Those amounts vary by regional yield assumptions, the distribution of available land for cultivation, required labor, and, of course, resulting transportation costs given regional yields and acreage distributions.

Table 4 provides a basic summary of the total outlays for inputs for the Washington region miscanthus scenario to illustrate initial production costs. These values, except for the feedstock and the transport costs, were derived primarily from NREL coefficients.

**Table 4. Example Input Costs: Washington Region Using Miscanthus Feedstock**

| | |
|---|---|
| Crop based feedstock | 15,678,009 |
| Transport in | 3,500,000 |
| Materials | 820,417 |
| Facilities support | 125,000 |
| Other business support | 125,000 |
| Insurance | 361,535 |
| Marketing / commodity mgt. | 361,535 |
| Waste disposal | 954,523 |
| Water | 211,900 |
| Enzymes | 2,467,445 |
| Chemicals | 1,829,434 |
| Total Inputs | $ 26,434,799 |

Table 5 displays the final set of production costs. Value added payments are made to workers, investors, interest costs on indebtedness and to capital consumption (depreciation), and in the form of indirect tax payments to governments.

**Table 5. Total Payments to Value Added**

| | |
|---|---|
| All labor costs | 2,390,850 |
| Payments to investors | 16,250,391 |
| Other VA payments | 10,625,000 |
| Payments to governments | 1,577,813 |
| Total Value Added | $ 30,844,054 |

# IV. Regional Input-Output Models

## Initial Assumptions and Specifications

Four regional models were developed from the input-output data set for Pennsylvania.  Table 6 shows the composition of each.  The first county in each list is the hypothetical plant location.  All other counties represent the cohesive regional economy in terms of the plants' primary feedstock supply territories as well as the regional labor shed. The counties were selected based on their surplus of abandoned agriculture land, according to the Pennsylvania Census of Agriculture.

**Table 6. Counties in Each Regional Model**

| Berks | Bradford | Crawford | Washington |
|---|---|---|---|
| Bucks | Lycoming | Armstrong | Allegheny |
| Carbon | Sullivan | Butler | Beaver |
| Chester | Susquehanna | Erie | Butler |
| Lancaster | Tioga | Lawrence | Fayette |
| Lebanon | Wyoming | Mercer | Greene |
| Lehigh | | Venango | Westmoreland |
| Montgomery | | | |

Three separate initial models were created for each region so that each model represented a region and a specific feedstock. There were 12 working models in all. Each model required the insertion of a biomass supply sector that does not exist in the regions. That was accomplished by appropriating the empty cotton production sector in each model and renaming it for the feedstock to be analyzed. That sector was then modified to reflect the annual output (and input) of the biomass farmers, the number of workers required, their labor incomes, and other components of value added that was estimated for each regional model and each feedstock type. For this research, separate annual labor requirements per acre were established for switchgrass, miscanthus, and willow. Conversations with NRCS officials in Nebraska and Iowa State University researchers suggested that 1.3 hours per acre was appropriate for switch grass considering a full year's worth of activity, to include amortized crop establishment labor. Miscanthus acres have higher yields per acre, so fewer acres are required to produce necessary tonnage, but that requires slower machinery speeds, plus their establishment is much more ponderous than switchgrass, so their labor hours per acre were set at 1.6. Willow hours per acre were 1.7 owing to, again, labor intensive establishment, assumed slower harvest speeds as well as the roughness and bulk of the biomass. All biomass farm workers were paid $11.5 an hour, which included employer paid benefits, and each biomass farming and harvesting job was assumed to work 700 hours annually.[4]

The models were further modified so that each feedstock's production recipe was reflective of that type of farming activity. Initially, as all farmers in this analysis are expected to rent a vast array of idle or abandoned acres, the model required the insertion of rental payments. Rental payments for each county were obtained from the 2012 U.S. Census of Agriculture. All models assumed a 50 percent probability that the rental payments accrued to regional landowners and the remaining 50 percent leaked out of the regions to absentee owners. The remaining major inputs into production were adjusted based on enterprise budget information associated with each feedstock.[5]

[4] Hours per acre are also affected by the dispersion of the acres. Labor is more efficient when biomass land is contiguous or located nearby. Land that has high biomass densities will generate slower harvest and baling speeds. Land that is dispersed will require more hours. More land is required for land with lower yields. Those fields will be processed more rapidly per acre, but it will require more acres to produce the needed biomass.

[5] It is important to modify the major input category assumptions like chemical and fertilizer usage, fuel requirements, utilities, machinery repair, transportation needs, etc. It is not necessary to modify all production requirements, nor is it feasible, in order to produce reliable multipliers for the new feedstock-producing industry.

After making identical modifications to each model was re-estimated so as to produce the tables of multipliers required for the impact assessments.

## Bill of Goods Impact Analysis

The analysis was conducted as a "bill of goods" (BOG) projection of the potential regional economic impacts of biomass to energy production. A BOG approach uses an itemization of basic industrial production expenditures (inputs plus payments to the components of value added), and then applies total multipliers times the amount of those purchases. An advantage of BOG analysis is that it allows for a clear evaluation of the relative contribution of different expenditure categories to the total impacts. A disadvantage is that it is difficult to obtain high levels of expenditure detail for most industries. In this analysis BOG procedures were applied to the payments listed in Table 4 and to the payments to labor in Table 5. Each item has a particular set of multipliers, 12 distinct versions of which were generated (as described above) producing unique multipliers for each region and for each particular feedstock scenario.

Each item in the BOG also has its unique probability of being purchased within the region of analysis. That probability is used to deflate the actual spending level by our ethanol factories to the amount spent in the region, which is the only number that is appropriate to apply to each region's table of multipliers. These probabilities are called the regional purchase coefficients (RPC). In our analysis, RPCs for biomass farming and for truck transportation were set at 1.0, which means 100 percent of purchases would come from firms within the study region. All other RPCs for the factories' inputs were set at the default values produced by the estimated models. Every region has different RPCs given their overall industrial structure and their size.

Table 7 illustrates the structure of the finished models. Each measured activity had an input level which was then multiplied times its RPC and then times each of four multiplier tables: output, jobs, labor compensation, and value added to produce total impact estimates for each itemized input. Summing the input detail, then results in the total economic impact projection.

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The modifications in this step plus the previous step (inserting jobs, labor income, sales, etc.) will account for upwards of 70 to 75 percent of all production costs and will produce multipliers that are highly reflective of the industry of scrutiny.

**Table 7. Pennsylvania State Biofuels Impact Model**

| Activity | Enter Inputs or Output (in millions$) | Total Output ($M) | Jobs (Actual) | Labor Compensation ($M) | Value Added ($M) | RPC | Model RPC |
|---|---|---|---|---|---|---|---|
| Miscanthus | 19.4585 | 33.127 | 181.48 | 5.404 | 11.036 | 1.000 | 0.000 |
| Transport by truck | 3.5719 | 5.976 | 44.32 | 2.399 | 3.258 | 1.000 | 0.985 |
| | 0.0000 | 0.000 | 0.00 | 0.000 | 0.000 | 0.000 | 0.000 |
| Wholesale trade businesses | 0.2051 | 0.323 | 1.96 | 0.140 | 0.230 | 0.997 | 0.997 |
| Business support services | 0.1250 | 0.191 | 2.15 | 0.103 | 0.127 | 0.847 | 0.847 |
| Other support services | 0.1250 | 0.204 | 1.98 | 0.076 | 0.129 | 0.985 | 0.985 |
| Insurance agencies, brokerages, and related activities | 0.3615 | 0.606 | 4.30 | 0.269 | 0.399 | 0.931 | 0.931 |
| Securities, commodity contracts, investments, and related | 0.3615 | 0.360 | 2.48 | 0.116 | 0.160 | 0.466 | 0.466 |
| Waste management and remediation services | 0.9545 | 1.531 | 9.10 | 0.506 | 0.846 | 0.930 | 0.930 |
| Water, sewage and other treatment and delivery systems | 0.2119 | 0.362 | 1.94 | 0.137 | 0.237 | 1.000 | 1.000 |
| Other basic organic chemical manufacturing | 2.4674 | 0.512 | 1.00 | 0.071 | 0.118 | 0.152 | 0.152 |
| All other basic inorganic chemical manufacturing | 1.8294 | 0.142 | 0.42 | 0.029 | 0.050 | 0.050 | 0.050 |

# V. Findings

## Understanding Terminology

Prior to describing the findings, it is useful for a short primer on impact analysis terminology. The following three tables will present impact summaries for each feedstock type by region.

- Output represents the value of goods or services produced in the industries of scrutiny.
- Labor income is composed of all wages and salaries plus payments to proprietors.
- Value added subsumes labor income and then adds payments to investors and indirect tax payments to governments. Value added is the same thing as gross domestic (regional) product (or GDP), and it is the preferred measure of the size of the economic activity generated in each scenario.
- Finally, jobs include full and part-time jobs that would be required over the course of a production year. As many people have more than one job, there are more jobs in an economy than there are employed persons.

There are levels of activity reported by the items above:

- The direct data refer directly to the original firm of scrutiny: in this case it is the cellulosic ethanol plant.
- Indirect values reflect the sum of all inputs into production required by the direct firm -- initially all of the amounts listed in the first data column of Table 7. Those firms will in turn require inputs, as will *their* suppliers, and so on. Consequently, the input values reflect all of the supply needs in all industries indirectly associated with supply the direct firm or *its* suppliers.
- Induced values occur when the workers in the ethanol factories and the workers in all of the affected supplying industries convert their labor incomes into household spending, which in turn stimulates all sectors that support households.
- The sums of the direct, indirect, and induced amounts are the total economic impacts for each category.

## Miscanthus

Table 8 contains the regional impact summaries for miscanthus production. The combined table (the last table in the set) indicates the four regions would produce $235.5 million in annual direct output, which would require 140 job holders at the plants making $9.56 million in labor income, which is an adjusted wage for Pennsylvania based on Iowa's average wage for a plant worker. Because these plants require an entirely new feedstock and represent nearly all net new up-stream productivity in the feedstock supply sector since they are using vacant land, there is a very robust job impact in feedstock supply and in transportation. Once those effects are compiled, to include all other inputs into production and the value of household spending (the induced values), $144.8 million in additional output is generated requiring 875 jobs earning $26.9 million in labor income.

Overall the four regions would produce $380.36 million in total output, which would yield $172.4 million in value added (or GDP). In total, the plants would stimulate $36.5 million in labor income to 1,016 job holders.

A last line reflects the multiplied-through total impacts in the regional economy per $1 (or $1 million) of initial direct output in then ethanol plants. The output multiplier of 1.62 means that for every $1 of direct ethanol plant output, $.62 in additional output is supported in the regional economy. Every $1 of direct output change supports a total of $.73 in regional value added. Every $1 of direct output change supports $.18 in labor income. And each $1 million in direct output sustains 4.3 jobs in total in the regional economy.

It is important in this and the next two tables to not focus on the totals solely when determining the value of these plants. The Washington region produces the lowest direct output at $57.3 million and the Berks region has the highest at $61.13 million. That difference represents differences in production costs, which means, on average, a plant in Washington County may indeed maintain profitability better than a plant in Berks County, even though higher labor income and job impacts are realized in the Berks region.

## Table 8 Miscanthus Results

### Berks Miscanthus Economic Impact Summary

Dollar Amounts in $Millions

| | Jobs | Labor Income | Value Added | Output |
|---|---|---|---|---|
| Direct | 35.0 | $ 2.39 | $ 30.84 | $ 61.13 |
| Indirect and Induced | 251.1 | $ 9.25 | $ 16.59 | $ 43.33 |
| Total | 286.1 | $ 11.64 | $ 47.43 | $ 104.47 |
| Multiplier Per $1 Million in Direct Output | 4.7 | $ 0.19 | $ 0.78 | $ 1.71 |

### Bradford Miscanthus Economic Impact Summary

Dollar Amounts in $Millions

| | Jobs | Labor Income | Value Added | Output |
|---|---|---|---|---|
| Direct | 35.0 | $ 2.39 | $ 30.84 | $ 58.08 |
| Indirect and Induced | 199.6 | $ 5.29 | $ 9.60 | $ 29.74 |
| Total | 234.6 | $ 7.68 | $ 40.44 | $ 87.82 |
| Multiplier Per $1 Million in Direct Output | 4.0 | $ 0.13 | $ 0.70 | $ 1.51 |

### Crawford Miscanthus Economic Impact Summary

Dollar Amounts in $Millions

| | Jobs | Labor Income | Value Added | Output |
|---|---|---|---|---|
| Direct | 35.0 | $ 2.39 | $ 30.84 | $ 59.02 |
| Indirect and Induced | 221.2 | $ 6.48 | $ 11.90 | $ 37.28 |
| Total | 256.2 | $ 8.87 | $ 42.75 | $ 96.31 |
| Multiplier Per $1 Million in Direct Output | 4.3 | $ 0.15 | $ 0.72 | $ 1.63 |

### Washington Miscanthus Economic Impact Summary

Dollar Amounts in $Millions

| | Jobs | Labor Income | Value Added | Output |
|---|---|---|---|---|
| Direct | 35.0 | $ 2.39 | $ 30.84 | $ 57.28 |
| Indirect and Induced | 203.6 | $ 5.90 | $ 10.93 | $ 34.48 |
| Total | 238.6 | $ 8.29 | $ 41.78 | $ 91.76 |
| Multiplier Per $1 Million in Direct Output | 4.2 | $ 0.14 | $ 0.73 | $ 1.60 |

### All Four Counties Combined Miscanthus Economic Impact Summary

Dollar Amounts in $Millions

| | Jobs | Labor Income | Value Added | Output |
|---|---|---|---|---|
| Direct | 140.0 | $ 9.56 | $ 123.36 | $ 235.51 |
| Indirect and Induced | 875.5 | $ 26.92 | $ 49.02 | $ 144.83 |
| Total | 1,015.5 | $ 36.48 | $ 172.40 | $ 380.36 |
| Multiplier Per $1 Million in Direct Output | 4.3 | $ 0.15 | $ 0.73 | $ 1.62 |

## Switchgrass

Table 9 contains the regional impact summaries for switchgrass production. The combined table (the last table in the set) indicates the four regions would produce $265.7 million in annual direct output, which would require 140 job holders at the plants making $9.56 million in labor income. Because these plants require an entirely new feedstock and represent nearly all net new up-stream productivity in the feedstock supply sector, there is a very robust job impact in feedstock supply and in transportation. Once those effects are compiled, to include all other inputs into production and the value of household spending (the induced values), $196.7 million in additional output is generated requiring 1,231 jobs earning $37.51 million in labor income.

Overall the four regions would produce $462.5 million in total output, which would yield $191.8 million in value added (or GDP). In total, the plants would stimulate $47.1 million in labor income to 1,370 job holders.

A last line reflects the multiplied-through total impacts in the regional economy per $1 (or $1 million) of initial direct output in then ethanol plants. The output multiplier of 1.74 means that for every $1 of direct ethanol plant output, $.74 in additional output is supported in the regional economy. Every $1 of direct output change supports a total of $.72 in regional value added. Every $1 of direct output change supports $.18 in labor income. And each $1 million in direct output sustains 5.2 jobs in total in the regional economy.

Again, the Washington county region produces the lowest direct output at $63.16 million, while the Bradford region has the highest at $68.46 million. That difference represents differences in production costs, which means, on average, a plant in Washington County may indeed maintain profitability better than a plant in Bradford County, even though higher job impacts are realized in the Bradford region.

**Table 9. Switchgrass Results**

**Berks Switchgrass Economic Impact Summary**

| | | Dollar Amounts in $Millions | | |
|---|---|---|---|---|
| | Jobs | Labor Income | Value Added | Output |
| Direct | 35.0 | $ 2.39 | $ 30.84 | $ 67.26 |
| Indirect and Induced | 289.3 | $ 10.75 | $ 19.62 | $ 53.47 |
| Total | 324.3 | $ 13.14 | $ 50.46 | $ 120.73 |
| Multiplier Per $1 Million in Direct Output | 4.8 | $ 0.20 | $ 0.75 | $ 1.79 |

**Bradford Switchgrass Economic Impact Summary**

| | | Dollar Amounts in $Millions | | |
|---|---|---|---|---|
| | Jobs | Labor Income | Value Added | Output |
| Direct | 35.0 | $ 2.39 | $ 30.84 | $ 68.46 |
| Indirect and Induced | 329.2 | $ 7.30 | $ 13.34 | $ 42.00 |
| Total | 364.2 | $ 9.69 | $ 44.18 | $ 110.47 |
| Multiplier Per $1 Million in Direct Output | 5.3 | $ 0.14 | $ 0.65 | $ 1.61 |

**Crawford Switchgrass Economic Impact Summary**

| | | Dollar Amounts in $Millions | | |
|---|---|---|---|---|
| | Jobs | Labor Income | Value Added | Output |
| Direct | 35.0 | $ 2.39 | $ 30.84 | $ 66.85 |
| Indirect and Induced | 302.4 | $ 8.10 | $ 15.08 | $ 48.44 |
| Total | 337.4 | $ 10.49 | $ 45.92 | $ 115.29 |
| Multiplier Per $1 Million in Direct Output | 5.1 | $ 0.16 | $ 0.69 | $ 1.72 |

**Washington Switchgrass Economic Impact Summary**

| | | Dollar Amounts in $Millions | | |
|---|---|---|---|---|
| | Jobs | Labor Income | Value Added | Output |
| Direct | 35.0 | $ 2.39 | $ 30.84 | $ 63.16 |
| Indirect and Induced | 309.7 | $ 11.36 | $ 20.37 | $ 52.81 |
| Total | 344.7 | $ 13.75 | $ 51.22 | $ 115.98 |
| Multiplier Per $1 Million in Direct Output | 5.5 | $ 0.22 | $ 0.81 | $ 1.84 |

**All Four Counties Combined Switchgrass Economic Impact Summary**

| | | Dollar Amounts in $Millions | | |
|---|---|---|---|---|
| | Jobs | Labor Income | Value Added | Output |
| Direct | 140.0 | $ 9.56 | $ 123.36 | $ 265.73 |
| Indirect and Induced | 1,230.6 | $ 37.51 | $ 68.41 | $ 196.72 |
| Total | 1,370.6 | $ 47.07 | $ 191.78 | $ 462.47 |
| Multiplier Per $1 Million in Direct Output | 5.2 | $ 0.18 | $ 0.72 | $ 1.74 |

## Willow

Table 10 contains the regional impact summaries for willow production. The combined table (the last table in the set) indicates the four regions would produce $232.95 million in annual direct output, which would require 140 job holders at the plants making $9.56 million in labor income. Because these plants require an entirely new feedstock and represent nearly all net new up-stream productivity in the feedstock supply sector, there is a very robust job impact in feedstock supply and in transportation. Once those effects are compiled, to include all other inputs into production and the value of household spending (the induced values), $142.96 million in additional output is generated requiring 1,102 earning $29.42 million in labor income.

Overall the four regions would produce $375.9 million in total output, which would yield $179.4 million in value added (or GDP). In total, the plants would stimulate $38.98 million in labor income to 1,242.2 job holders.

A last line reflects the multiplied-through total impacts in the regional economy per $1 (or $1 million) of initial direct output in then ethanol plants. The output multiplier of 1.61 means that for every $1 of direct ethanol plant output, $.61 in additional output is supported in the regional economy. Every $1 of direct output change supports a total of $.75 in regional value added. Every $1 of direct output change supports $.17 in labor income. And each $1 million in direct output sustains 5.3 jobs in total in the regional economy.

The Washington region produces the lowest direct output at $57.2 million, while the Berks region has the highest at $60.4 million. In all, however, the Washington region produces the most job impacts with this feedstock.

## Table 10. Willow Results

### Berks Willow Economic Impact Summary

| | | Dollar Amounts in $Millions | | |
|---|---|---|---|---|
| | Jobs | Labor Income | Value Added | Output |
| Direct | 35.0 | $ 2.39 | $30.84 | $60.38 |
| Indirect and Induced | 277.4 | $ 6.53 | $12.25 | $41.10 |
| Total | 312.4 | $ 8.92 | $43.09 | $ 101.48 |
| Multiplier Per $1 Million in Direct Output | 5.2 | $ 0.15 | $ 0.71 | $ 1.68 |

### Bradford Willow Economic Impact Summary

| | | Dollar Amounts in $Millions | | |
|---|---|---|---|---|
| | Jobs | Labor Income | Value Added | Output |
| Direct | 35.0 | $ 2.39 | $30.84 | $58.02 |
| Indirect and Induced | 264.1 | $ 6.24 | $11.43 | $31.27 |
| Total | 299.1 | $ 8.63 | $42.27 | $89.29 |
| Multiplier Per $1 Million in Direct Output | 5.2 | $ 0.15 | $ 0.73 | $ 1.54 |

### Crawford Willow Economic Impact Summary

| | | Dollar Amounts in $Millions | | |
|---|---|---|---|---|
| | Jobs | Labor Income | Value Added | Output |
| Direct | 35.0 | $ 2.39 | $30.84 | $57.35 |
| Indirect and Induced | 255.3 | $ 6.35 | $11.35 | $30.32 |
| Total | 290.3 | $ 8.74 | $42.19 | $87.67 |
| Multiplier Per $1 Million in Direct Output | 5.1 | $ 0.15 | $ 0.74 | $ 1.53 |

### Washington Willow Economic Impact Summary

| | | Dollar Amounts in $Millions | | |
|---|---|---|---|---|
| | Jobs | Labor Income | Value Added | Output |
| Direct | 35.0 | $ 2.39 | $30.84 | $57.20 |
| Indirect and Induced | 305.4 | $10.30 | $17.00 | $40.27 |
| Total | 340.4 | $12.69 | $47.84 | $97.47 |
| Multiplier Per $1 Million in Direct Output | 6.0 | $ 0.22 | $ 0.84 | $ 1.70 |

### All Four Counties Combined Willow Economic Impact Summary

| | | Dollar Amounts in $Millions | | |
|---|---|---|---|---|
| | Jobs | Labor Income | Value Added | Output |
| Direct | 140.0 | $ 9.56 | $ 123.37 | $ 232.95 |
| Indirect and Induced | 1,102.2 | $29.42 | $52.02 | $ 142.96 |
| Total | 1,242.2 | $38.98 | $ 175.39 | $ 375.91 |
| Multiplier Per $1 Million in Direct Output | 5.3 | $ 0.17 | $ 0.75 | $ 1.61 |

## Comparison of Biofuel Type for Each County

Table 11 is organized in a way that allows for easy comparison of using the 3 different types of biofuels within each county. As with the prior tables, it is important to keep in mind that the differences in output represent differing production costs, with higher costs leading to larger output impacts. Yet the plants will need to be profitable to remain in production, so lower costs (and output impacts) are thus more competitive than the higher cost alternatives. In general across the counties, willow and miscanthus had the smallest output multipliers, while switchgrass had the largest.

**Table 11. Comparisons of Feedstocks Within Each County**

**Berks Economic Impact Summary- Comparison**

| | Jobs | Labor Income | Value Added | Output |
|---|---|---|---|---|
| | | Dollar Amounts in $ Millions | | |
| **Direct** | | | | |
| Miscanthus | 35.0 | $2.39 | $30.84 | $61.13 |
| Switchgrass | 35.0 | $2.39 | $30.84 | $67.26 |
| Willow | 35.0 | $2.39 | $30.84 | $60.38 |
| **Indirect & Induced** | | | | |
| Miscanthus | 251.1 | $9.25 | $16.59 | $43.33 |
| Switchgrass | 289.3 | $10.75 | $19.62 | $53.47 |
| Willow | 277.4 | $6.53 | $12.25 | $41.10 |
| **Multiplier Per $1 Million in Direct Output** | | | | |
| Miscanthus | 4.7 | $0.19 | $0.78 | $1.71 |
| Switchgrass | 4.8 | $0.20 | $0.75 | $1.79 |
| Willow | 5.2 | $0.15 | $0.71 | $1.68 |

## Bradford Economic Impact Summary- Comparison

| | Jobs | Labor Income | Value Added | Output |
|---|---|---|---|---|
| | | Dollar Amounts in $ Millions | | |
| **Direct** | | | | |
| Miscanthus | 35.0 | $2.39 | $30.84 | $58.08 |
| Switchgrass | 35.0 | $2.39 | $30.84 | $68.46 |
| Willow | 35.0 | $2.39 | $30.84 | $58.02 |
| **Indirect & Induced** | | | | |
| Miscanthus | 199.6 | $5.29 | $9.60 | $29.74 |
| Switchgrass | 329.2 | $7.30 | $13.34 | $42.00 |
| Willow | 264.1 | $6.24 | $11.43 | $31.27 |
| **Multiplier Per $1 Million in Direct Output** | | | | |
| Miscanthus | 4.0 | $0.13 | $0.70 | $1.51 |
| Switchgrass | 5.3 | $0.14 | $0.65 | $1.61 |
| Willow | 5.2 | $0.15 | $0.73 | $1.54 |

## Crawford Economic Impact Summary- Comparison

| | Jobs | Labor Income | Value Added | Output |
|---|---|---|---|---|
| | | Dollar Amounts in $ Millions | | |
| **Direct** | | | | |
| Miscanthus | 35.0 | $2.39 | $30.84 | $59.02 |
| Switchgrass | 35.0 | $2.39 | $30.84 | $66.85 |
| Willow | 35.0 | $2.39 | $30.84 | $57.35 |
| **Indirect & Induced** | | | | |
| Miscanthus | 221.2 | $6.48 | $11.90 | $37.28 |
| Switchgrass | 302.4 | $8.10 | $15.08 | $48.44 |
| Willow | 255.3 | $6.35 | $11.35 | $30.32 |
| **Multiplier Per $1 Million in Direct Output** | | | | |
| Miscanthus | 4.3 | $0.15 | $0.72 | $1.63 |
| Switchgrass | 5.1 | $0.16 | $0.69 | $1.72 |
| Willow | 5.1 | $0.15 | $0.74 | $1.53 |

## Washington Economic Impact Summary- Comparison

| | Jobs | Labor Income | Value Added | Output |
|---|---|---|---|---|
| | | Dollar Amounts in $ Millions | | |
| **Direct** | | | | |
| Miscanthus | 35.0 | $2.39 | $30.84 | $57.28 |
| Switchgrass | 35.0 | $2.39 | $30.84 | $63.16 |
| Willow | 35.0 | $2.39 | $30.84 | $57.20 |
| **Indirect & Induced** | | | | |
| Miscanthus | 203.6 | $5.90 | $10.93 | $34.48 |
| Switchgrass | 309.7 | $11.36 | $20.37 | $52.81 |
| Willow | 305.4 | $10.30 | $17.00 | $40.27 |
| **Multiplier Per $1 Million in Direct Output** | | | | |
| Miscanthus | 4.2 | $0.14 | $0.73 | $1.60 |
| Switchgrass | 5.5 | $0.22 | $0.81 | $1.84 |
| Willow | 6.0 | $0.22 | $0.84 | $1.70 |

## All Four Counties Combined Economic Impact Summary- Comparison

| | Jobs | Labor Income | Value Added | Output |
|---|---|---|---|---|
| | | Dollar Amounts in $ Millions | | |
| **Direct** | | | | |
| Miscanthus | 140.0 | $9.56 | $123.36 | $235.51 |
| Switchgrass | 140.0 | $9.56 | $123.36 | $265.73 |
| Willow | 140.0 | $9.56 | $123.37 | $232.95 |
| **Indirect & Induced** | | | | |
| Miscanthus | 875.5 | $26.92 | $49.02 | $144.83 |
| Switchgrass | 1,230.6 | $37.51 | $68.41 | $196.72 |
| Willow | 1,102.2 | $29.42 | $52.02 | $142.96 |
| **Multiplier Per $1 Million in D.O.** | | | | |
| Miscanthus | 4.3 | $0.15 | $0.73 | $1.62 |
| Switchgrass | 5.2 | $0.18 | $0.72 | $1.74 |
| Willow | 5.3 | $0.17 | $0.75 | $1.61 |

## VI. Implications & Limitations

As with all economic impact analysis, the results are highly dependent upon the assumptions used in the study. Critically, the analysis assumed that the land used for growing the feedstocks was all surplus or vacant agricultural land. If in reality existing agricultural land was converted to producing feedstocks, the economic impacts would be much less because the local economies would be losing the economic value of the crops formerly grown on that land. From an economic impact standpoint, it thus is critical that recruitment efforts target land currently unused for agricultural or other purposes.

An equally important assumption was that all landowners of vacant agricultural land within the geographical scope would be willing to rent their land for feedstock production. Convincing all landowners to do so is likely unrealistic and therefore could present a barrier to the biofuel project. To the extent that owners of such land are unwilling to lease for biofuel production, it would be necessary to travel further away from the processing plant, increasing transportation costs, and thus decreasing the profitability of such an enterprise. Indeed, lack of sufficient landowner interest could make some plant locations financially infeasible.

Because the transportation costs used in the analysis were modeled after experience in Iowa, it is likely that such costs have been underestimated for this particular analysis. Iowa's flat topography allows transport vehicles to travel more direct routes to the storage and plant destinations for the energy crops. Pennsylvania on the other hand has many mountains and hills that can make ground travel more circuitous, increasing travel times and travel distance.

Finally, it is important to understand that this analysis is focused solely on the potential economic impact of biofuel plants if they are built and operate in Pennsylvania; it does not consider whether such plants actually would be financially feasible, and if so, under what conditions. Financial feasibility is highly dependent on prices, the market, and subsidies, and requires different methods of analysis than conducted in this study.

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