Economic Impacts of Expanded Woody Biomass Utilization on the Bioenergy and Forest Products Industries in Florida

Sponsored Project Final Report to Florida Department of Agriculture and Consumer Services--Division of Forestry

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Executive Summary

This study evaluated the economic impacts in the state of Florida from expanded use of biofuels under selected policies and incentives, as mandated by the Florida legislature in 2008 (HB 7135). The study focused on use of woody biomass fuels for electric power generation, since this is a mature technology that is poised to rapidly expand under enabling legislation.

The analysis was conducted using Input-Output analysis and Social Accounting Matrices (I-O/SAM) for Florida, together with a Computable General Equilibrium (CGE) model of the state's economy. The *Impact Analysis for Planning* (IMPLAN) Professional software and associated databases (MIG, Inc.) provided regional information on industry output, value added, employment, personal income, commodity supply and demand, state-local and federal government taxes and spending, capital investment, business inventories, and domestic and foreign trade. The I-O/SAM model was used to generate a snapshot of the Florida economy that served as the starting point for implementation of the CGE model, which finds a solution where all markets are in equilibrium, i.e. supply equals demand. The model was customized to reflect the makeup of the forestry sector (timber production, logging and support services), wood products manufacturing (sawmills, pulp and paper, etc.), and use of biomass fuels as a substitute to fossil fuels (coal, natural gas, oil) for electric power generation. It was assumed that biomass fuels could be provided from domestic and international imports as well as Florida resources, since commodity trade is a feature of the CGE model. Forestry sector production is assumed to include sources such as urban wood waste, short rotation energy crops, and logging residues, as well as merchantable timber resources.

The impact of increasing biomass fuel supply for electric power generation was simulated over a range of 1 to 80 million green tons annually, at an average price of $30 per ton. The upper end of this range represents approximately 26 percent of current electricity production in Florida, and about 21 percent of projected generation in the year 2025. These levels can compared to a proposed Renewable Electricity Standard, which would mandate a certain minimum percentage of renewable fuels for electric power sales to final consumers by a given date. Simulations were also conducted to test the effect of a $0.010 or $0.011 per kilowatt-hour state or federal renewable electricity production tax credit, and a 100 percent federal subsidy for biomass fuel producers under the *Biomass Crop Assistance Program* (BCAP). Assumptions about mobility of capital to meet changes in industry output and intermediate commodity demand were tested with different model settings.

It was estimated that increasing biomass use for electric power generation would bring about a relatively small increase in Gross Domestic Product (GDP) of Florida, overall employment, and state government revenues, while modestly decreasing imports of fossil fuels. At the biomass supply level of 40 million tons, with capital assumed to be mobile, GDP would increase by 0.32 percent above the base level, representing $2.2 billion. Output or sales of the forestry sector would be increased dramatically, about 69 percent above current levels, to meet new demand for woody biomass fuels. Output of the electric power sector would decrease by up to 0.33 percent as a result of marginally higher costs for biomass fuels. Output of the forest products manufacturing sector would decrease by 6.7 percent due to competition for the forest resource. Imports of fossil fuels would decrease by 2.5 percent, representing a savings in import purchases of $1.14 billion, while imports of forestry commodities would increase. Employee income would increase by $1.61 billion. Tax revenues to state government would increase by 0.06 percent ($108 million).

Under the same conditions, i.e. 40 million tons biomass supply, prices for forest commodities may increase by up to 18 percent in the short run (with fixed capital) due to resource competition, but would likely be much lower in the long run as capital resources are reallocated to biofuel production. When the CGE model was modified to disaggregate timber production and logging/forestry support services, much larger price effects were observed, with composite prices for timber increasing by 42 percent, prices for logging/support services increasing by 143 percent, and prices for manufactured wood products increasing by 2.4 percent. When the model was further modified to restrict imports of timber and logging/support services, prices for forestry products increased by 150 percent, prices for logging/support services increased by 280 percent, and prices for manufactured wood products increased by 4.6 percent.

Incentives such as a renewable energy production tax credit for electricity generated from biomass, and a subsidy to forestry biomass producers, would further increase forest sector output and state GDP and employment, and reduce imports of fossil fuels. In particular, an electricity production tax credit equivalent to $0.010-$0.011 per kilowatt-hour would substantially increase output of the electric power sector, and decrease imports of fossil fuels, while reducing the negative impact of higher electricity prices on all other sectors. However, assuming that the tax credit is unlimited, the state-sponsored incentive would significantly reduce state government revenues by nearly $200 million at the 40 million ton biomass supply level. The 100 percent biomass feedstock federal subsidy to forestry producers would dramatically increase both electric power and forestry commodity output, but would not appreciably affect state government revenues.

The models used in this analysis represent a "snapshot" in time, and do not incorporate a time dimension, however, it is assumed that the estimated economic impacts would occur within a relatively short period of a year or less. It may be expected that the results for the mobile capital scenario would hold in the long run, say 10 years or more, while fixed capital would prevail in the short run, subject to limitations on capital movement, especially for highly fixed assets such as forest inventories. The I-O/ SAM and CGE models with mobile capital do not explicitly incorporate any physical capacity limitations on production of a commodity such as biomass fuels. This stands in contrast to bioeconomic models such as the Southern Region Timber Supply (SRTS) model used in a companion study, which dynamically represents timber inventories, forest growth and harvest removals. The relatively modest effects on forest commodity prices observed in the fixed capital CGE analysis, even in the face of a threefold increase in demand, may be attributed to the moderating effect of increased imports, substitution effects, the diverse mix of different biomass resources available, and the fact that commercial timber production in the CGE model represents less than 25 percent of the total forestry sector.

Based on these findings, it is concluded that the various policies and incentives for bioenergy development would have an overall positive impact on the economy of Florida in terms of increased GDP, employment and state government revenues, and decreased imports of fossil fuels. The forestry sector would particularly benefit from increased demand and prices. However, the forest product manufacturing sector would be adversely affected by competition for wood resources and higher prices for material inputs.

Introduction

Interest in development of renewable energy resources has been motivated by economic, environmental, and national security concerns. Reliable and cost-effective supplies of fuels for transportation and electric power generation are a key driver of economic development, and are in large part responsible for the mobility and high standard of living enjoyed in the United States. Replacement of fossil fuels with renewable energy sources such as wind, solar and biomass is an important strategy for reducing greenhouse gas emissions, mitigating effects of global climate change, reducing expenditures on imports, and reducing dependence on petroleum from politically unstable regions. Costs for natural gas and petroleum (gasoline, diesel) have dramatically increased in recent years, motivating development of alternatives to these fuels. Although coal remains an abundant, low-cost and domestically available fuel, its high carbon emissions have raised concerns about its dominant use for electric power generation.

Biofuels are a primary candidate for renewable energy in Florida, due to the year-round growing conditions and relatively abundant forest and water resources, while potential wind and hydropower resources are considered relatively small (Navigant Consulting, 2008). Woody biomass fuels may be used directly for electric power generation by utilities, for combined heat and power systems in industrial facilities, or as a feedstock for production of ethanol biofuel via cellulosic conversion technology. Solid biomass fuels are currently used for electric power generation in Florida at 23 facilities. The types of biofuels in use include agricultural crop byproducts, wood and wood waste, biogenic municipal solid waste and landfill gas. Total electric power generation from biomass fuels in Florida was 2.98 terawatt-hours in 2008, or about 1.4 percent of total generation (USDOE-EIA). In 2006, there were 380 megawatts of installed electric generating capacity in Florida fueled with woody biomass, and the technical potential for additional electricity generation from woody biomass and short rotation woody crops was estimated at 2.1 to 4.4 Gigawatts, or 3.9 to 8.3 percent of total capacity in 2006 (Navigant Consulting, 2008). Although there is considerable research and development effort ongoing for use of wood and biogenic waste materials for production of liquid transportation fuels (ethanol, biodiesel) via cellulosic conversion technology, major barriers remain for its full scale commercialization (USDOE, 2006).

It is anticipated that the need for bioenergy sources will lead to rapid exploitation of forests and other biomass resources. This has raised concerns about the potential for ecosystem degradation and adverse impacts on their sustainability. Also, greater use of biomass will inevitably lead to more competition for forest resources between traditional users of forest products and the emerging bioenergy sector, with the result that prices may increase significantly. The forest products industry in Florida generated approximately $16.7 billion in output (revenue) impacts, $7.0 billion in value added (income) impacts and employment impacts of 89,000 jobs in 2006, and is a leading economic sector in many rural counties in the northern part of the state (Hodges et al, 2008).

Based on these concerns, the 2008 Florida Legislature mandated an evaluation of the economic and market impacts of increased utilization of woody biomass resources for bioenergy (HB7135, section 113, page 236), with the Florida Department of Agriculture and Consumer Services (FDACS) designated as the agency responsible for this mandate. The intent of the legislation is to assure that future supplies of forest resources and other biomass materials are sufficient to support expanded bioenergy production, as well as traditional forest products, without undue market disruption.

Federal and state incentive policies are used to encourage electric utility industry to use resources that have less pollution to the environment. These incentives include investment and production tax credits, biofuel production subsidies, and a quota system known as a Renewable Portfolio Standard (RPS). Some incentives reimburse users for part or all of the cost of woody biomass feedstock delivered to users, while other incentives provide a credit for fuels or electricity generated from biomass resources. Any type of monetary incentive would have an impact on the cost of biomass feedstock in comparison to other fuels. Although there may be some non-monetary incentives such as Healthy Forest Restoration Act of 2003, which recommends forest thinning programs for reducing the risk of wildfire, only those incentives were taken into account which may have direct monetary effects on using woody biomass for electricity generation.

Perhaps the most important incentive for electric power generators is the Renewable Portfolio Standard (RPS), also known as a Renewable Electricity Standard (RES), which consists of a schedule of targets that prescribe a minimum share of electric power to be generated from renewable energy sources by certain dates in the future. Under this policy, similar to cap-and-trade programs, electric utilities may chose to develop and operate biofuel facilities or purchase credits from other generators with a surplus of credits. The RES has been widely used to evaluate the potential costs and benefits of increasing renewable energy and controlling greenhouse gas emissions. For example, a recent study estimated that a 25 percent federal RES in Florida would generate $11.2 billion in new industry output and create 42,800 jobs from operations of renewable energy facilities by the year 2025 (English et al, 2009). The study considered a mix of dedicated energy crops, solid wastes, biogas, solar, and cofiring of wood with coal. Although the study determined that electric power rates would be increased as a result of a RES, raising costs to utility customers by $2.96 billion, the net impacts on the economy were still overwhelmingly positive. However, this analysis was conducted with a simple regional input-output model (*Implan*) that does not consider substitution effects for capital and labor resources.

Among several other federal and state incentives, the most relevant to biomass resources is the Renewable Energy Production Tax Credit in Florida (N.C. Solar Center). The program in Florida, enacted in July 2006, provides a $0.01 per kilowatt-hour credit to cogeneration or combined heat-and-power (CHP) facilities that use eligible renewable sources such as biomass. The tax credit may be claimed for electricity produced and sold between January 2007 and June 2010, however, the unused credit may be carried forward for up to 5 years. A similar federal program provides a $0.011 per kilowatt-hour tax credit for electricity generation from renewable sources.

A recent incentive introduced by the USDA Farm Service Agency is the *Biomass Crop Assistance Program* (BCAP) which allows matching payments for collection, harvest, storage, and transportation of certain eligible materials to be used by qualified biomass conversion facilities (USDA-FSA, 2009). The agency began accepting applications for BCAP in July 2009. Under this program, owners of qualified biomass materials can receive financial assistance for delivering it to conversion facilities that use biomass fuels for heat, power, biobased products or advanced biofuels. Matching payments are made at a rate of 100 percent of the price of biomass delivered to a qualified conversion facility, up to $45 per dry ton equivalent. Biomass owners are eligible to receive payments for two years. Qualified biomass conversion facilities must be located in the U.S. or U.S. territories, must be a separate legal entity from owners of biomass materials purchased, and must conduct the purchase in arms-length transactions.

The purpose of this study was to estimate the potential economic impacts in Florida, both positive and negative, from expanded use of biofuels under selected federal and state policies, including a Renewable Electricity Standard, a renewable electricity production tax credit, and a biomass feedstock subsidy. The study focused on use of woody biomass fuels for electric power generation, since this is a mature technology that is poised to rapidly expand under enabling legislation. Estimates of economic impacts were developed for the forestry sector, forest product manufacturing, electric power, and other major industry sectors in Florida.

Methodology

The economic impacts of changes in demand for woody biomass due to expanded renewable energy production in Florida were assessed using a regional Input-Output model and Social Accounting Matrix (I-O/SAM) coupled with a Computable General Equilibrium (CGE) model. The *Impact Analysis for Planning* (IMPLAN) Professional software and associated databases for Florida (MIG, Inc. 2008) were used to construct the I-O/SAM, and the General Algebraic Modeling System software (GAMS Development Corporation) was used to build and run the CGE model. The I-O/SAM generated by IMPLAN includes information on industry output, value added, employment, personal income, commodity supply and demand, state-local and federal government taxes and spending, capital investment, business inventories, and domestic and foreign trade. Information is detailed for 440 individual industry sectors, nine household income classes, and six state-local or federal government institutions. The I-O/SAM represents a snapshot of the Florida economy in the base year of 2007 that serves as a starting point for the implementation of the CGE model, which finds an optimal solution where all markets are in equilibrium, i.e. supply equals demand. The particular CGE model used in this analysis was originally developed for national economies (Lofgren et al., 2002), and was later adapted for use on regional economies and analysis of biofuel policies (Holland, Stodick and Devadoss, 2009).

Significant components of the *IMPLAN* databases for industry and institutional transactions are based on national averages, including the industry production functions that represent the proportion of industry expenditures on intermediate inputs and value-added components. The *IMPLAN* production function coefficients for the Electric Power Generation sector were adjusted to match data available from the Department of Energy (DOE-EIA) and the Federal Energy Regulatory Commission for Florida for the year 2007, as shown in Tables 1 and 2. In particular, Florida's electric power industry uses a much larger proportion of natural gas than the nation on average. Also, like many eastern states, Florida has no hydro-electric or geo-thermal based generation. The same EIA data also indicated that the proportion of total expenditures on fuel by Florida's power generators was much larger than that specified in the *IMPLAN* databases. Adjusting the total output, production function coefficients and value added components for this industry to match published data enabled the I-O/SAM model to more accurately represent the economy of Florida and the activity of the electric power sector. Once the *IMPLAN* production function and study-area data for Electric Power Generation and Transmission were updated, unaggregated I-O/SAM matrix files were produced with the *IMPLAN Professional* software using procedures described in the *IMPLAN Users Guide* (MIG, 2004).

Table 1. Modification of *IMPLAN* fuel-related production function coefficients for the electric power generation sector in Florida, 2007.

IMPLAN Sector Number	*IMPLAN* Sector Name	Original Coefficient	Modified Coefficient [1]
9	Sugarcane Farming	0.000000	0.001660
15	Forestry	0.000000	0.000830
16	Logging	0.000000	0.000830
20	Oil and Gas Extraction	0.087734	0.056140
21	Coal Mining	0.042305	0.073960
32	Natural Gas Distribution	0.000001	0.000010
115	Petroleum Refining	0.013523	0.008650
125	Nuclear Fuel Manufacturing	0.000000	0.006570
337	Pipeline Transportation	0.022228	0.302650
	Total	0.165791	0.451300

1. Derived from Department of Energy (DOE-EIA) and the Federal Energy Regulatory Commission published data.

Table 2. Modifications to electric power sector study area data for Florida.

	Original *IMPLAN* Study Area Data (Million $)	Revised Study Area Data[1] (Million $)
Industry Output	12,734.520	23,878.430
Value-added components		
Employee Comp	1,919.534	2,571.558
Proprietary income	707.714	936.606
Other Prop. Income	5,021.370	6,645.406
Indirect Business Taxes	1,523.313	2,015.990
Total Value Added	9,171.931	12,138.362
Expenditure Shares		
Value Added	0.720242	0.508340
Intermediate Inputs	0.279758	0.491660
Total	1.000000	1.000000
Employment (jobs)	19,250	36,096

1. Department of Energy (DOE-EIA) and the Federal Energy Regulatory Commission (FERC).

Although *IMPLAN* databases contain data on over 460 industry and institutional sectors, it is impractical to include all these sectors in a CGE model because of the computational requirements, so it was necessary to aggregate many of these sectors. For the biofuels CGE model this aggregation was designed to keep industry sectors of interest relatively disaggregated while combining sectors of lesser interest into broad general categories. In Table 3, the overall aggregation scheme for the CGE model is presented in which the 460 *IMPLAN* industry and institutional sectors are consolidated into 40 aggregate sectors. Industry sectors such as Infrastructure, Construction, and Wholesale Trade that are unique in their role in the economy, as well as Federal and State government sectors were left unaggregated because they did not fit well into other aggregate industry classifications. The sectors for Proprietary Income and Other Property Income were combined, and sectors for Corporations and Capital were aggregated into a single sector called Capital (Table 3).

Since this analysis is focused on woody biofuels and electric power generation, the aggregation scheme for these two sectors, and certain other closely related sectors is detailed in Table 4. The aggregated Forestry sector for the CGE model is comprised of *IMPLAN* sectors for Forestry, Commercial Logging, and Support Activities for Agriculture and Forestry. It should be noted that this industry sector represents forest harvest and transportation activities, as well as forest management and timber production. Additional runs of the model were also conducted with Forestry and Logging/Support Activities disaggregated as separate sectors. Industries involved with fossil fuels are of interest because woody biofuels substitutes for fossil fuels in the overall fuel mix used by electric power generators. The aggregate fossil fuel sector is comprised of eight *IMPLAN* sectors that represent oil, natural gas, and coal extraction, support activities for these sectors, and petroleum refineries (Table 4). Electric power generation was not aggregated with any other *IMPLAN* sectors. This was critical for the simulation of specific scenarios with the CGE model that were used to estimate the economic impacts of renewable portfolio standards and various other government incentive programs designed to encourage a shift to this technology. Since the increased use of Forestry products as biofuel will compete with their use by wood-product manufacturing industries (such as solid wood and paper products), seventeen wood related manufacturing industries were aggregated into a wood manufacturing sector, separate from all other types of manufacturing (Table 4).

Table 3. Aggregation scheme for the Florida woody biofuels computable general equilibrium model.

Aggregate Sector	Aggregate Sector Name	*IMPLAN* Sector Numbers
Industry/Enterprise Sectors		
1	Agriculture	1 – 14
2	Forestry & Related	15,16, 19
3	Fishing And Hunting	17 and 18
4	Fossil Fuels Related	20,21,28, 29, 30, 32, 115, 337
5	Mining	22 – 27
6	Electric Power Generation	31
7	Infrastructure	33
8	Construction	34 – 40
9	Manufacturing	41 – 318
10	Wood Related Manufacturing	95 – 112
11	Wholesale Trade	319
12	Retail Trade	320 – 331
13	Transportation	332- 336 & 338 – 340
14	Information	341 – 353
15	Finance	354 – 360
16	Renting	361 – 366
17	Services Professional	367 – 381
18	Services	382 – 426
19	Government Enterprises & Other	427 – 440
Institutional Sectors		
20	Labor	5001
21	Property Income	6001 – 7001
22	Indirect Business Taxes	8001
23	Households Less Than $10K	10001
24	Households $10K To $15K	10002
25	Households $15K To $25K	10003
26	Households $25K To $35K	10004
27	Households $35K To $50K	10005
28	Households $50K To $75K	10006
29	Households $75K To $100K	10007
30	Households $100K To $150K	10008
31	Households Greater Than $150K	10009
32	Federal Government Non-Defense	11001
33	Federal Government Defense	11002
34	Federal Government Investment	11003
35	State Government Non-Education	12001
36	State Government Education	12002
37	State Government Investment	12003
38	Investment	13001, 14001, 14002
39	Foreign Trade	25001
40	Domestic Trade	28001

An Excel spreadsheet of the IMPLAN industry sector scheme is available at:
http://implan.com/v3/index.php?option=com_docman&task=doc_download&gid=148&Itemid=138

Table 4. Detailed aggregation scheme for selected industry groups in the Florida woody biofuels computable general equilibrium model.

Aggregate Sector Number	Aggregate Sector Name	*IMPLAN* Sector Number	*IMPLAN* Sector Name
2	Forestry & Related	15	Forestry, Forest Products & Timber Tracts
		16	Commercial Logging
		19	Support Activities for Agriculture & Forestry
4	Fossil Fuels	20	Oil and Gas Extraction
		21	Coal Mining
		28	Drilling Oil And Gas Wells
		29	Support Activities for Oil & Gas Operations
		30	Support Activities for Other Mining
		32	Natural Gas Distribution
		115	Petroleum Refineries
		337	Pipeline Transportation
6	Electric Power	31	Electric Power Generation, Transmission and Distribution
10	Wood Product Manufacturing	95	Sawmills and Wood Preservation
		96	Veneer and Plywood Manufacturing
		97	Engineered. Wood Member & Truss Manufacturing
		98	Reconstituted Wood Product Manufacturing
		99	Wood Windows and Doors And Millwork
		100	Wood Container and Pallet Manufacture.
		101	Manu Fact. Home (Mobile Home) Manufacturing
		102	Prefabricated Wood Building Manufacturing
		103	All Other Misc. Wood Product Manufacturing
		104	Pulp Mills
		105	Paper Mills
		106	Paperboard Mills
		107	Paperboard Container Manufacturing
		108	Coated & Laminated Paper & Packaging Paper
		109	All Other Paper Bag, Coated & Treated Paper Manuf.
		110	Stationery Product Manufacturing
		111	Sanitary Paper Product Manufacturing

GAMS routines originally developed by Rutherford and by Stodick, Holland, and Devadoss were used to aggregate the *IMPLAN* I-O/SAM files for use in the CGE model, as shown in Appendix Table 1. The SAM represents the flows of dollars between the various sectors of the economy. Activities represent industries, commodities represent goods and services sold or purchased, and institutions represent income and expenditures for capital, labor, taxes, inventory and trade. Purchases of, or expenditures on commodities by activities, and revenues derived from the manufacture of commodities by different Activities are represented by the table columns. Receipts for commodities and factors, and revenues to activities are represented by table rows. Rows and columns of the SAM must balance, so there is a complete accounting of all transactions or transfers in the economy.

For the SAM that was derived from the *IMPLAN* model of Florida, some imbalances occurred due to the parameter modifications made for the Electric Power Generation sector, however, these imbalances were subsequently resolved by running a null counterfactual through the CGE model.

The GAMS CGE model used for this analysis is a comparative-static regional CGE model that was adapted by Holland et al. (2007, 2009) from a national CGE model developed by Lofgren et al. (2002). Compared to Input-Output models like *IMPLAN*, where goods and factors are transacted in fixed proportions, at fixed prices, and without global supply constraints, CGE models include price changes in response to changes in quantities demanded or supplied, and allow for substitution between goods and factors based on those relative prices. The demand and supply relationships specified in this general equilibrium model are derived from neo-classical economic theory where firms maximize profits, households or consumers maximize a utility function, and all markets clear, i.e. supply equals demand. In this model, firms maximize a hybrid Leontief/constant-elasticity-of-substitution (CES) type production function and households or consumers are modeled as maximizing a Stone-Geary utility function. The Leontief-CES production function uses fixed proportions for intermediate inputs, but employs a nonlinear CES functional form for the primary factors of capital and labor for each industry in the model.

The CGE model encompasses both domestic and foreign trade with imperfect substitution, so the composition of supply depends on the relative prices of foreign, domestic and regional products and imports. Likewise the mix of domestically marketed and exported goods and services is also determined by relative prices. The model is constrained by accounting rules or equilibrium conditions that require production to satisfy all demands. In this case, markets are required to clear for goods and factors, firms earn zero profits above normal returns to capital, household endowments are fully employed, and household spending exhausts income.

The biofuels CGE model was constructed in GAMS as a simultaneous system of non-linear equations and solved using the PATH solver. Initially, consumer prices of domestic goods and imports, the world price of exports, factor prices, and the currency exchange rate were all set equal to one. The model was then solved to replicate the *IMPLAN* SAM, and calibrate many of the model parameters. However, elasticities of income, substitution or transformation between goods produced and sold in different markets, and for capital-labor substitution in production, must be specified by the user. For this application, these elasticities were specified using default values provided in the published CGE model by Holland et al., and by Bilgic et al (2002). The elasticity parameter values used are shown in Table 5. Further details on the technical specification of the CGE model and choice of elasticity parameter values can be found in Holland, Stodick, and Painter (2007).

Table 5. Elasticity parameters for the Florida woody biofuels computable general equilibrium model.

Parameter	Value	Definition
Xed(C,T)	-5	Elasticity of demand for world export function
Esubp(A)	0.99	Elasticity of substitution for production
Esubd(C)	2	Elasticity of substitution (Armington) between regional output and imports
Esubs(C)	2	Elasticity of substitution (transformation) between domestic/regional and foreign demand
Esube(C)	2	Elasticity of substitution (transformation) for exports between Rest of World and Rest of U.S.
Esubm(C)	2	Elasticity of substitution (Armington) of imports between Rest of World imports and Rest of U.S.
Ine(C,H)	1	Income elasticity
Income_Ine	1	Investment on commodities elasticity
Frisch(C)	-1	Consumption flexibility (determines minimum subsistence level of consumption)
Ifrisch(C)	-1	Investment demand flexibility (-1 implies no minimum investment level)
Efac(LAB)	4	Demand elasticity for labor
Efac(CAP)	0.5	Demand elasticity for capital

The CGE model includes additional parameters for government taxes and macro-economic closure settings that can be exogenously specified by the user. Government tax rates can be specified for sales taxes, consumption taxes paid by households, excise taxes on domestic production, and taxes on imports and exports. Options for various macro-economic closures are also available for capital, labor, savings and investment, and current account balances. For the biofuels model, the base run included the assumption that capital is activity specific and fixed, labor is mobile and unemployment is possible, savings and investment are not linked, and foreign and rest of U.S. savings are variable through the export column of the SAM. An alternative set of model runs were made where capital is mobile and endowment is variable. Over the short-run, capital movement may be a limiting factor for implementation of a Renewable Electricity Standard or other incentives, however, in the long run, say ten years or more, it may reasonably be assumed that capital would be mobile and would move to those areas of highest and best use.

The first set of simulation runs with the CGE model were made for fixed increases in biofuel inputs for electric power generation at levels of 1, 5, 10, 20, 40, 60 and 80 million tons in a given year. This range of biomass fuels covers the spectrum of alternative scenarios contemplated for biofuels to meet a Renewable Electricity Standard in Florida. A supply of 40 million tons of woody biomass (freshweight basis) for electric power generation would produce approximately 28.2 billion KWhr of electricity at current technical efficiencies, representing about 13.1 percent of current annual power generation in Florida, and about 10.6 percent of projected electrical generation in the year 2025, while the maximum biomass supply level of 80 million tons would account for about 21 percent of projected electrical generation demand in 2025, as shown in Table 6. The cost of biomass fuels was estimated at $30 per ton, based on 2007 average delivered prices for timber in Florida (Timber Mart South), which would represent a total value of $1.20 billion for 40 million tons, and $2.41 billion for 80 million tons.

Table 6. Biomass supply levels for computable general equilibrium model simulations.

Biomass Supply (million tons, freshweight basis)	Gross Heat Energy Content (trillion BTU) (1)	Electrical Generation (million kilowatt-hours) (2)	Share of Electrical Generation in Florida, 2007 (3)	Share of Electrical Generation in Florida, 2025 (4)	Value of Biomass Fuel (million $) (5)
1	9.6	706	0.3%	0.3%	30.1
5	48.2	3,529	1.6%	1.3%	150.6
10	96.3	7,057	3.3%	2.7%	301.2
20	192.6	14,115	6.5%	5.3%	602.4
40	385.3	28,230	13.1%	10.6%	1,204.8
60	577.9	42,345	19.6%	15.9%	1,807.2
80	770.6	56,460	26.1%	21.2%	2,409.6

(1) 12.04 million BTU per ton semi-dry woody biomass (USDA, Fuel Value Calculator, 2004). Semi-dry biomass has 30% moisture content (80% of freshweight).

(2) Reflects steam-to-electrical energy conversion factor 3,412 BTU/KWh and 25% thermal efficiency factor (USDOE-EIA).

(3) Florida electrical generation in 2007: 216.09 billion kilowatt-hours (USDOE-EIA, EIA-906-920 report, Monthly generation and fuel stock data at electric power generating facilities).

(4) Projected Florida electrical generation in 2025: 266.01 billion kilowatt-hours (USDOE-EIA, Annual Energy Outlook, 2009).

(5) Value of biomass fuel estimated at composite average delivered price for timber in Florida, 2007: $30.12 per ton (Timber Mart South).

In the parlance of CGE analysis these alternative scenarios are known as counterfactuals. The counterfactual increases in biofuel inputs were imposed on the CGE model by modifying the Leontief coefficients for the intermediate inputs, including fuel, in the production function for the Electric Power Generation sector. Based on 2007 EIA data, it was determined that costs per-kilowatt-hour (KWH) of generating electricity from woody biofuels were 13.8 percent higher, on average, than the average cost per KWH for power generated from all types of fossil fuels in the State. Thus, for example, when biofuel inputs to electric power generation were increased by 10 million tons, or $30 million dollars, fossil fuel inputs were reduced by 87.8 percent, or $26.4 million. These unequal substitutions in production function result in a small increase in the sum of the Leontief coefficients for the intermediate inputs in model, so to keep the production function from over-estimating production, the shift parameter to the function was calibrated downward to keep output constant. The parameters to the CES part of the production function for capital and labor are assumed to be independent of substitutions between types of fuel in the model. The counterfactual Leontief coefficients for the CGE model are given in Table 7. As would be expected, the largest changes occur in the Leontief coefficients are for Forestry and Fossil fuels. The reduced shift parameters, shown in the last row, represent the effect of increases in the cost of electric power generation for biofuels.

Table 7. Leontief coefficients and production function shift parameters for biofuels CGE counterfactual simulations.

Industry Sector	Additional Woody Biofuels For Electric Power Generation (Million Tons)							
	Calibrated	1	5	10	20	40	60	80
	Leontief Coefficients							
Agriculture	0.00169	0.00169	0.00169	0.00169	0.00169	0.00168	0.00168	0.00167
Forestry	0.00200	0.00330	0.00852	0.01503	0.02801	0.05387	0.07956	0.10509
Fishing-Hunting	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Fossil-Fuel	0.44810	0.44688	0.44201	0.43594	0.42382	0.39969	0.37572	0.35190
Mining	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Electric Power	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Infrastructure	0.00009	0.00009	0.00009	0.00009	0.00009	0.00009	0.00009	0.00009
Construction	0.00735	0.00734	0.00734	0.00733	0.00732	0.00730	0.00728	0.00725
Manufacturing	0.00971	0.00971	0.00971	0.00970	0.00968	0.00965	0.00962	0.00959
Wood Manufacturing	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006
Wholesale	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079	0.00078	0.00078
Retail	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003	0.00003
Transportation	0.00938	0.00938	0.00937	0.00936	0.00935	0.00932	0.00929	0.00926
Information	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062	0.00062
Finance	0.00422	0.00422	0.00422	0.00421	0.00421	0.00419	0.00418	0.00417
Renting	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011
Services, Professional	0.00926	0.00926	0.00925	0.00925	0.00923	0.00920	0.00917	0.00914
Services, Other	0.00446	0.00446	0.00446	0.00445	0.00444	0.00443	0.00442	0.00440
Government, Other	0.00028	0.00028	0.00028	0.00028	0.00028	0.00028	0.00028	0.00028
Total	0.49816	0.49824	0.49856	0.49896	0.49975	0.50133	0.50290	0.50445
	Shift parameters							
	1.75924	1.75890	1.75756	1.75588	1.75254	1.74589	1.73929	1.73272

The model was used to simulate the effect of a $0.011 per kilowatt-hour production federal tax credit for electric power generated from renewable sources, and a $0.010 per kilowatt-hour state (Florida) tax credit, corresponding to the existing *Renewable Energy Production Tax Credit* enacted in 2006 (N.C. Solar Center). The tax credit was modeled as a negative excise tax rate of 11 percent and 10 percent, respectively, on power sales, which is equivalent to $0.011 or $0.010 per KWhr, since the average cost of power generation in Florida is approximately $0.10 per KWhr, and applied to the proportion of total fuel expenditures for electrical generation represented by biofuels. Although the Florida law limits the total value of the tax credit to $5 million annually, and the provision expires in 2010, for this exercise no limitations were considered, in order to illustrate its effect at full scale policy implementation. A 100 percent subsidy for biomass feedstocks, based upon the federal *Biomass Crop Assistance Program* (BCAP), was simulated in the model as a negative sales tax on purchases of biomass by the electric power sector from the forestry sector.

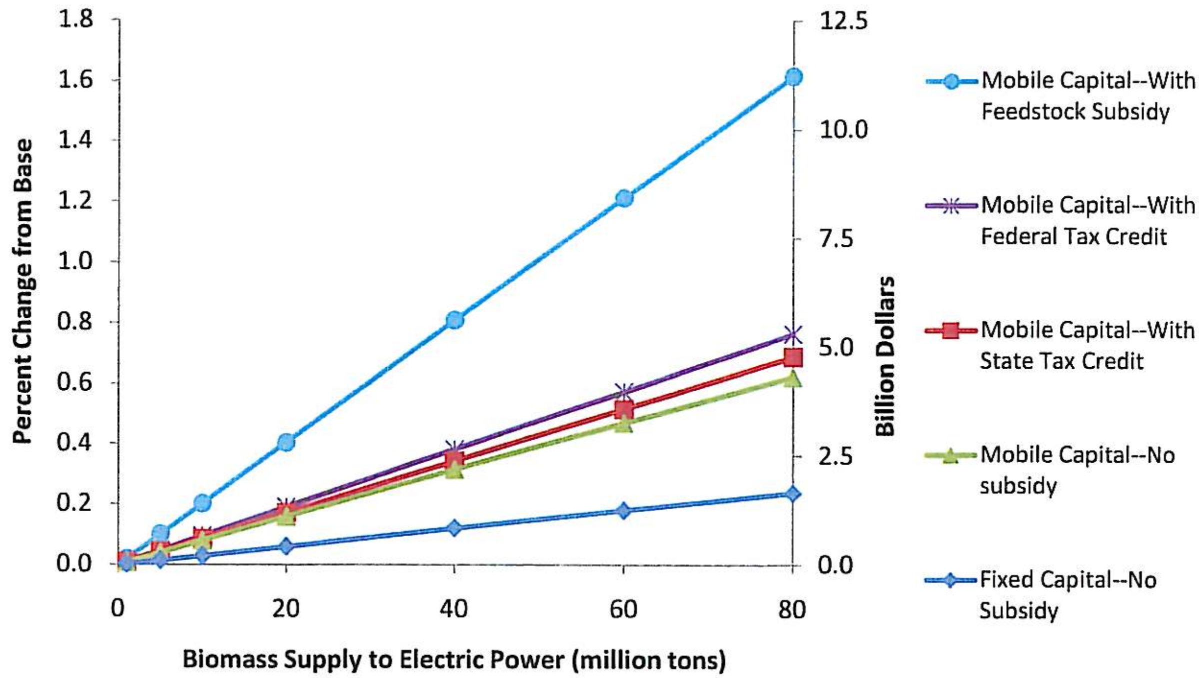
Additional simulations with the model were done with no domestic or international imports allowed for Forestry and Logging/Support Services sectors, to determine the effect on prices without import substitution possibilities, in order to make equivalent comparisons with results from SRTS bioeconomic model used in a companion study.

Results

Effects on Gross Domestic Product

Gross domestic product (GDP) is the broadest measure of economic activity, representing the net value of all goods and services produced in the region (value added), or alternatively, the total personal and business income received. The GDP of Florida in 2007 was about $701 billion. Estimated changes in GDP of Florida under the scenarios for increased use of biomass for electrical power are illustrated in Figure 1. In general, changes in output were directly proportional to the change in amount of biomass supplied to displace fossil fuels. As expected, impacts were somewhat greater for the scenario where capital was mobile rather than fixed, such that it does not become a limiting factor. For an increase in biomass supply of 40 million tons, GDP of Florida increased by 0.32 percent or $2.12 billion above the base level (2007) under the mobile capital scenario, and by 0.12 percent or $848 million for the fixed capital scenario. For the maximum biomass supply level of 80 million tons, GDP would increase by 0.24 to 0.62 percent ($1.67 to $4.37 billion), respectively, for fixed and mobile capital scenarios.

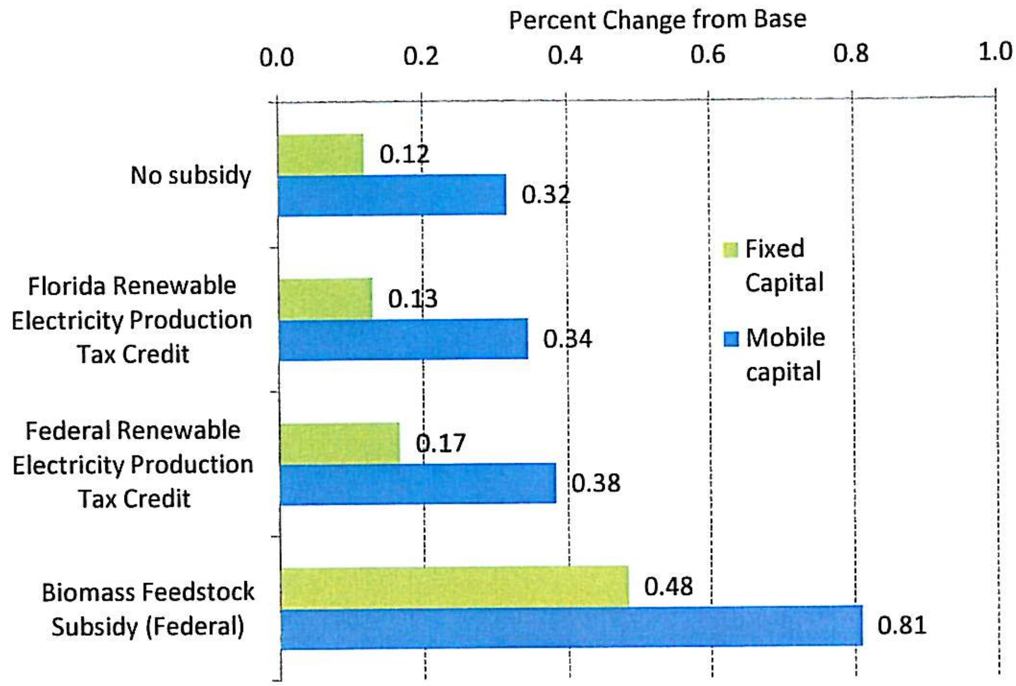
Figure 1. Changes in gross domestic product (GDP) of Florida from increased biomass supply for electric power generation.



When the $0.01 per KWhr renewable energy production Florida (state) tax credit was simulated in the CGE model, at 40 million tons biomass supply, with capital assumed to be mobile, state GDP increased by 0.35 percent ($2.42 billion), or by an additional 0.03 percent ($203 million) above the case without subsidy, as shown in Figure 2. The federal renewable energy production tax credit of $0.011 per KWhr increased state GDP by 0.38 percent ($2.68 billion) above the base level, and by an additional 0.07 percent above the no subsidy case, under the 40 million ton biomass supply scenario.

A 100 percent federal biomass feedstock subsidy paid to biomass producers in the forestry sector, modeled after the *Biomass Crop Assistance Program* (BCAP), increased state GDP by 0.81 percent ($5.68 billion) compared to the base case, and by 0.49 percent ($3.46 billion) compared to no subsidy at the 40 million tons biomass supply level (Figure 2). The effects of all subsidies on GDP were smaller under the fixed capital scenario than for the mobile capital scenario.

Figure 2. Changes in gross domestic product (GDP) of Florida due to subsidies for 40 million tons biomass supply to electric power generation.



Effects on Industry Output

Changes in output or sales of major sectors of the Florida economy are summarized in Table 8 and Figures 3 and 4. Of course, the largest impacts, in percentage terms, were to the forestry, electric power and fossil fuels sectors, which were directly affected by the change in fuel sources, and also to the mining sector, which reflects derived demand for fossil fuels (Figure 3). For forestry, the presumed source of new biomass supply, commodity output increased by 36 percent ($1.47 billion) from the current base level to supply 40 million tons under the fixed capital scenario and by 69 percent ($2.81 billion) under the mobile capital scenario (Figure 4). Wood products manufacturing decreased in output by 7.5 percent ($587 million) under the fixed capital scenario at the maximum biomass volume, but by only 0.5 percent under the mobile capital scenario. This greater decrease for the fixed capital scenario was because of an increase in prices for forest commodities (see below). The electric power sector experienced decreased output of 0.2 to 0.7 percent at the 40 million ton biomass level, due to marginally higher prices resulting from the greater cost of biomass fuels compared to fossil fuels. Output of fossil fuels decreased by up to 0.8 to 2.4 percent at the maximum biomass level because of decreased demand from the electric power sector as fossil fuels were replaced with biomass. Output of the mining sector also decreased by 2.9 percent under the mobile capital scenario, as derived demand for fossil fuels, but not at all under the fixed capital scenario. Output of the agriculture sector decreased by 1.4 percent under the fixed capital scenario, but very little (0.1%) under the mobile capital scenario. All other sectors had very small changes in output value of less than 0.2 percent (Table 8).

The state production tax credit for renewable energy generation would increase the value of output of the electric power sector by 0.33 percent ($76 million) compared to the base level, and by 0.58 percent ($133 million) compared to without the tax credit at the 40 million ton biomass supply level with capital mobile. The federal production tax credit for renewable energy generation would increase the value of output of the electric power sector by 0.11 percent ($27 million) compared to the base level, and by 0.45 percent ($103 million) compared to no tax credit. The 100 percent biomass feedstock subsidy increased output of the forestry sector by 79 percent ($3.21 billion), the electric power sector by 5.8 percent ($1.33 billion), and the wood products manufacturing sector by 0.61 percent ($48 million) compared to the base level. It would also increase the output of these sectors compared to without the subsidy at the maximum biomass supply, by 9.9 percent ($404 million), 6.0 percent ($1.39 billion), and 1.1 percent ($84 million), respectively.

Figure 3. Changes in industry output value, by sector, for 40 million tons biomass supply to electric power in Florida under the mobile capital scenario.

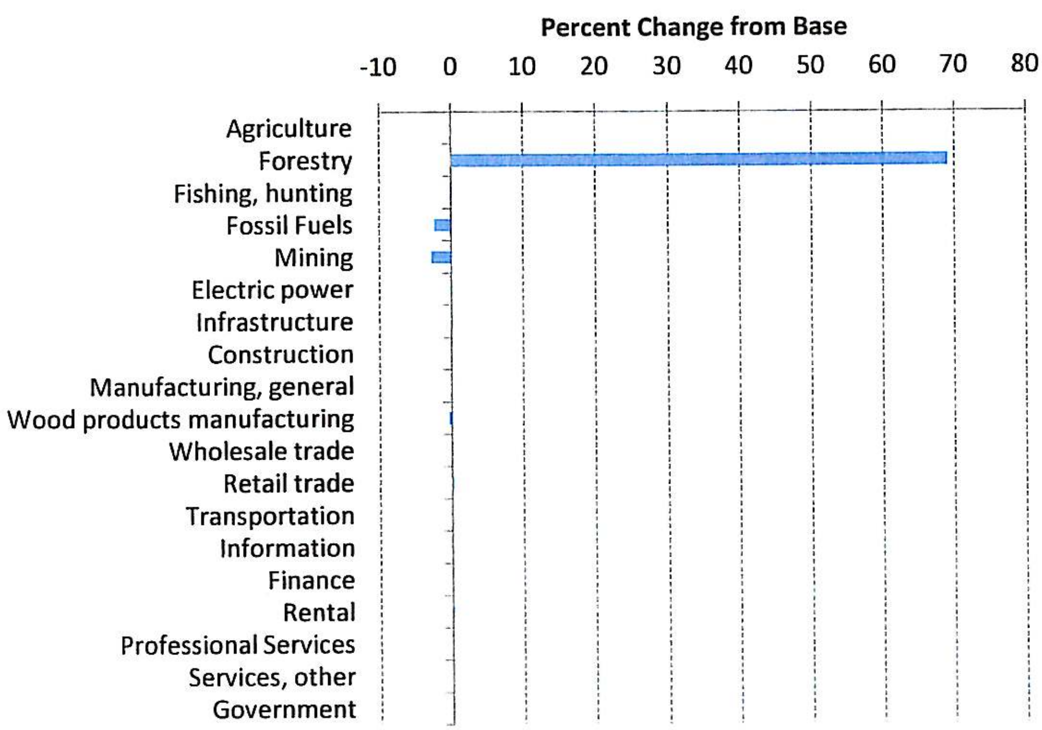
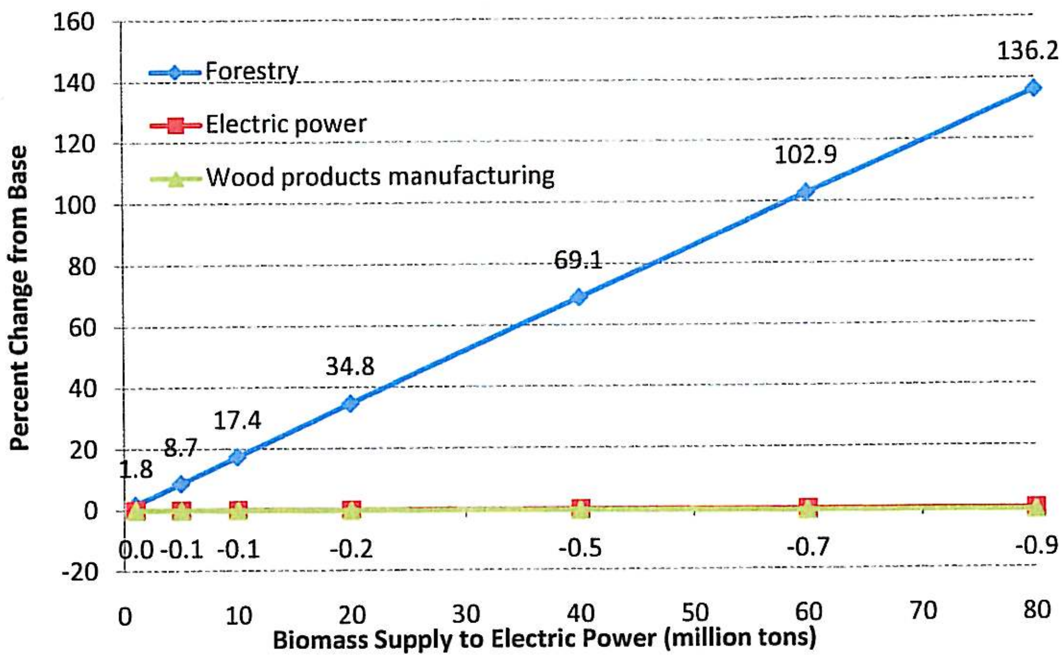


Figure 4. Changes in output value of forestry, wood manufacturing and electric power sectors in Florida from increased biomass supply (mobile capital scenario).

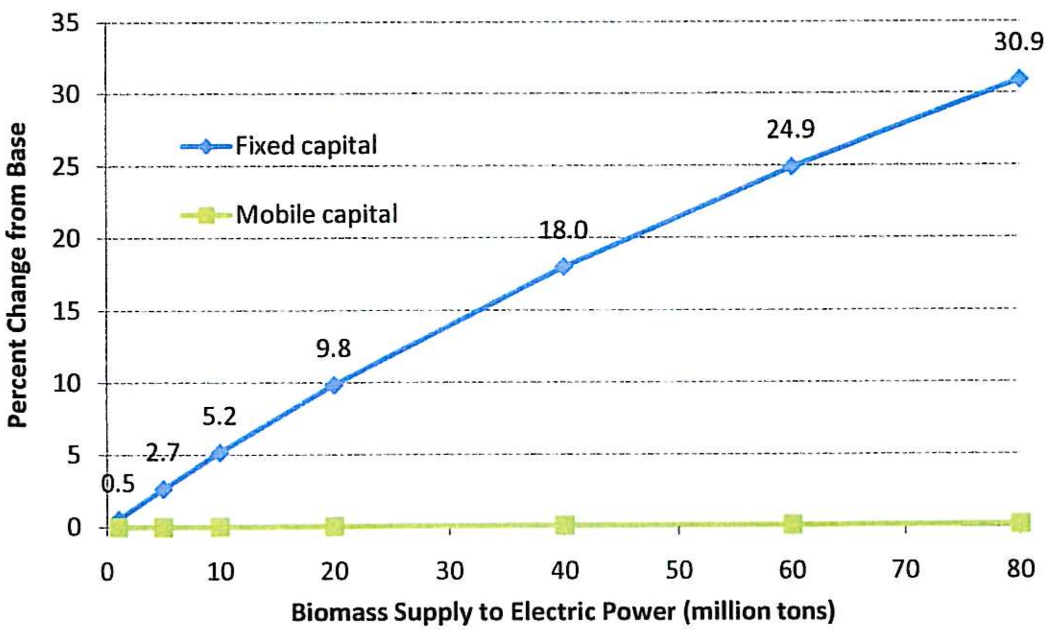


Effects on Commodity Prices

Changes in commodity prices resulting from increases in biomass supplied by forestry for electric power generation are shown in Table 9. These values represent a composite of domestic (Florida) and imported commodity prices. Prices for all commodities in the base year were normalized to a value of one. As with GDP and commodity output changes discussed already, the price changes were linear and proportional to biomass supply levels. The largest price change was an increase of nearly 18 percent for forestry commodities at the 40 million ton biomass supply level under the fixed capital scenario (Figure 5). However, prices for forestry commodities increased by only 0.07 percent under the mobile capital scenario, when additional capital investment is allowed to increase industry capacity in response to greater demand. At the maximum biomass supply level of 80 million tons, with fixed capital, prices for forestry commodities would increase by 30.9 percent. At the 40 million ton biomass supply level, prices for electric power increased by about 0.5 percent, while prices for manufactured wood products increased by 0.40 percent under fixed capital and by 0.03 percent when capital is mobile.

When the CGE model was modified to disaggregate timber production and logging/forestry support services, much larger price effects were observed, with composite prices for timber increasing by 42 percent, prices for logging/support services increasing by 143 percent, and prices for manufactured wood products increasing by 2.4 percent, under the scenario with 40 million tons biomass supply and fixed capital. The price response was greater for logging/support services than for timber production in this case because logging is the direct supplier to the electric power sector and timber production becomes an indirect input. When the model was further modified to restrict imports of timber and logging/support services, prices for forestry products increased by 150 percent, prices for logging/support services increased by 280 percent, and prices for manufactured wood products increased by 4.6 percent.

Figure 5. Changes in composite price for forest commodities from increased biomass supply for electric power.



The state renewable energy production tax credit for electric power would reduce electricity prices by 0.64 percent compared to the base level, and by 1.18 percent compared to without the subsidy for 40 million tons of biomass supplied, with mobile capital, while the federal renewable energy production tax credit would reduce electricity prices by 0.75 percent compared to the base level, and by 1.29 percent compared to without the subsidy. The 100 percent biomass feedstock subsidy would reduce increase forestry commodity prices by 0.26 percent and reduce electricity prices by 7.4 percent compared to the base level. When compared to the situation without this subsidy at the maximum biomass supply level, the subsidy would increase prices for forestry commodities by 0.19 percent and decrease electricity prices by 7.97 percent.

Effects on Commodity Imports

Changes in the quantity of imported commodities resulting from increased use of biomass for electric power generation are shown in Table 10. To meet a supply of 40 million tons of woody biomass, imports of forestry commodities increased by about 119 percent ($104 million) under the fixed capital scenario and by 69 percent ($61 million) under the mobile capital scenario. Presumably, these imports would mainly come from the adjoining states of Georgia and Alabama. Importantly, imports of fossil fuels would decrease by up to 2.5 percent ($1.14 billion), and foreign imports of fossil fuels would be reduced by 2.3 percent ($138 million). These changes represent a significant reduction of leakage from the state economy.

The state and federal renewable energy production tax credit would slightly lessen the change in imports of fossil fuels, by 0.12 percent ($55 million) and 0.16 percent ($73 million), respectively, compared to without the subsidy at the 40 million ton biomass supply level. The 100 percent biomass feedstock subsidy would actually increase imports of fossil fuels by 0.26 ($122 million) percent compared to the base level, and by 2.6 percent ($1.21 billion) compared to no subsidy at the 40 million ton biomass supply level.

Effects on Labor Demand

Changes in labor demands resulting from increased use of woody biomass for electric power in Florida are shown in Table 11. This information can be understood as representing the total value of wages, salaries and benefits paid to employees, and is a proxy for employment demand or number of jobs. For the 40 million ton biomass supply level with mobile capital, employment demand would increase by 72.5 percent ($1.43 billion) in the forestry sector, decrease by 0.47 percent in wood products manufacturing, and decrease by 0.58 percent for the electric power sector. Payments to all employees would be increase by $1.61 billion, but this represents just a 0.29 percent increase from the base level of $406 billion.

Effects on State Government Revenues

Changes in state government revenues from sales, property and excise taxes are shown in Figure 6. At the 40 million ton biomass supply level, state government revenues would increase by 0.06 percent, or $108 million with mobile capital, and by 0.04 percent or $66 million with fixed capital. At the maximum biomass supply level of 80 million tons, state government revenues would increase by 0.12 percent ($212 million) or 0.07 percent ($131 million), respectively.

For 40 million tons of biomass supplied, the state renewable energy production tax credit for electric power would reduce state government revenues by 0.08 to 0.05 percent ($142 to $89 million), for fixed or mobile capital, respectively, compared to the base level (Figure 7). In contrast, the federal renewable energy production tax credit would increase state government revenues by 0.05 to 0.08 percent ($86 to $140 million). The federal tax credit would also increase state government revenues by 0.01 to 0.02 percent ($21 to $32 million) above that for 40 million tons of biomass without the tax credit. The federal biomass feedstock subsidy for 100 percent of delivered fuel costs would increase state revenues by 0.10 to 0.18 percent ($174 to $330 million) compared to the base level, and by 0.06 to 0.12 percent ($222 million) compared to the situation without the subsidy.

Figure 6. Changes in Florida (state) government revenues from increased biomass supply for electric power.

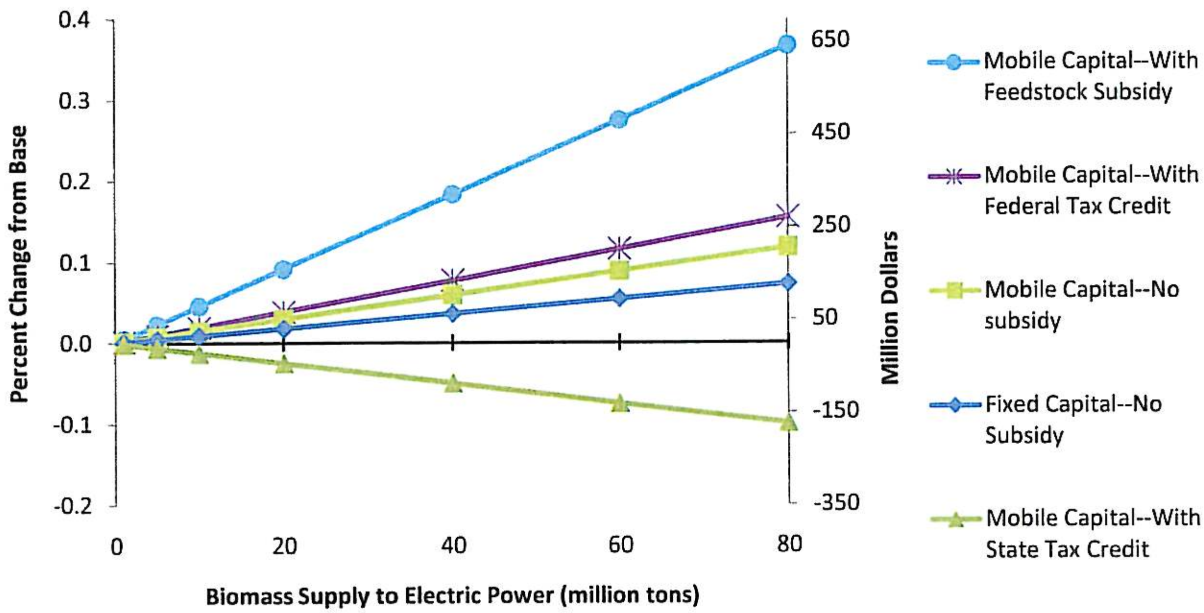


Figure 7. Changes in Florida (state) government revenues due to subsidies for 40 million tons biomass supply to electric power generation.

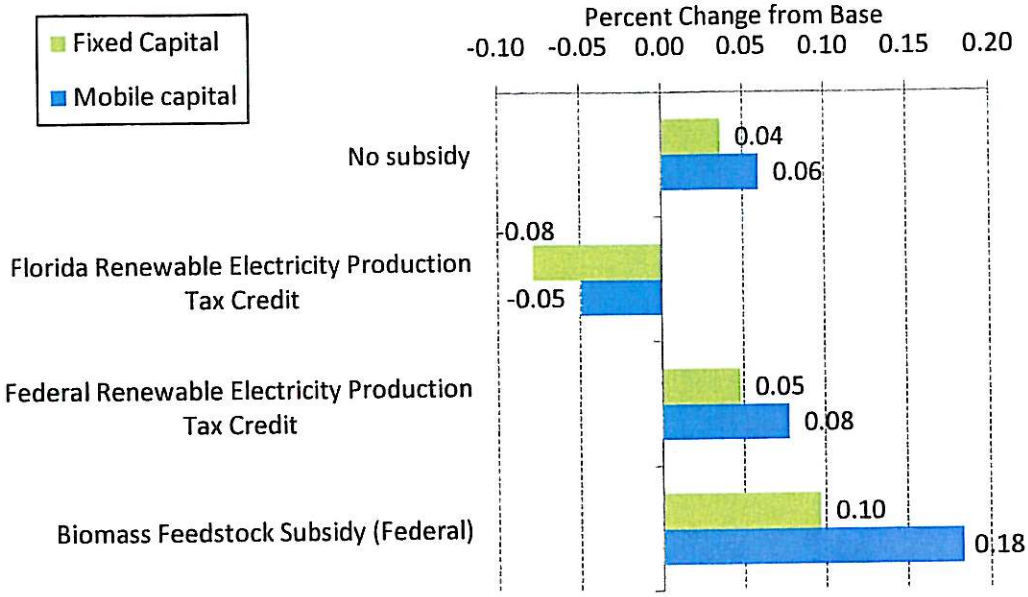


Table 8. Changes in value of output for major economic sectors from increased use of woody biomass for electric power generation in Florida.

Sector	Base (Million $)	Capital Fixed							Capital Mobile						
		Change In Biomass Supply To Electric Power Sector (Million Tons)													
		1	5	10	20	40	60	80	1	5	10	20	40	60	80
		Percentage Change from Base													
Agriculture	7,967.8	-0.04	-0.18	-0.34	-0.65	-1.20	-1.66	-2.06	0.00	-0.02	-0.03	-0.07	-0.13	-0.20	-0.26
Forestry	4,066.8	1.21	6.09	12.32	25.11	51.69	79.12	106.96	1.75	8.74	17.44	34.76	69.05	102.87	136.23
Fishing, Hunting	455.9	0.00	0.00	0.00	0.00	0.00	0.01	0.01	-0.01	-0.03	-0.05	-0.10	-0.20	-0.29	-0.39
Fossil Fuels	6,717.5	-0.03	-0.16	-0.32	-0.66	-1.34	-2.05	-2.78	-0.06	-0.31	-0.61	-1.22	-2.43	-3.62	-4.80
Mining	1,364.1	0.00	0.00	0.00	-0.01	-0.02	-0.04	-0.06	-0.08	-0.38	-0.75	-1.49	-2.93	-4.31	-5.65
Electric Power	23,027.4	0.00	-0.02	-0.05	-0.12	-0.33	-0.62	-0.96	-0.01	-0.03	-0.06	-0.12	-0.25	-0.37	-0.49
Infrastructure	3,139.4	0.00	0.01	0.01	0.02	0.05	0.08	0.11	0.00	0.02	0.04	0.08	0.15	0.22	0.29
Construction	107,325.9	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.00	0.00	0.01	0.02	0.04	0.05	0.07
Manufacturing, General	117,454.1	0.00	-0.01	-0.02	-0.05	-0.09	-0.13	-0.18	0.00	-0.01	-0.03	-0.06	-0.11	-0.17	-0.23
Wood Products Manufacturing	7,825.0	-0.21	-1.02	-1.98	-3.74	-6.73	-9.20	-11.29	-0.01	-0.06	-0.12	-0.23	-0.46	-0.69	-0.91
Wholesale Trade	65,266.3	0.00	0.00	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.02	0.03	0.06	0.12	0.19	0.25
Retail Trade	78,805.1	0.00	0.01	0.02	0.03	0.07	0.10	0.14	0.00	0.02	0.04	0.08	0.16	0.23	0.31
Transportation	43,824.9	0.00	-0.01	-0.01	-0.02	-0.03	-0.04	-0.05	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Information	44,176.7	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	-0.02	-0.03	-0.06	-0.13	-0.19	-0.25
Finance	170,182.9	0.00	0.00	0.00	0.01	0.02	0.03	0.03	0.00	0.00	-0.01	-0.02	-0.03	-0.05	-0.06
Rental	77,368.4	0.00	0.01	0.01	0.03	0.06	0.09	0.12	0.00	0.02	0.04	0.07	0.14	0.21	0.28
Professional Services	113,200.1	0.00	0.00	-0.01	-0.01	-0.02	-0.02	-0.03	0.00	0.00	0.00	0.01	0.01	0.02	0.02
Services, Other	277,352.2	0.00	0.01	0.01	0.02	0.05	0.07	0.09	0.00	0.01	0.03	0.05	0.11	0.16	0.21
Government	102,266.1	0.00	0.00	0.01	0.01	0.03	0.04	0.06	0.00	0.01	0.01	0.03	0.06	0.09	0.12

Table 9. Changes in composite commodity prices from increased use of woody biomass for electric power generation in Florida.

Sector	Capital Fixed							Capital Mobile						
	Change in Biomass Supply to Electric Power Sector (million tons)													
	1	5	10	20	40	60	80	1	5	10	20	40	60	80
	Percentage Change from Base													
Agriculture	0.01	0.04	0.08	0.15	0.28	0.39	0.49	0.00	0.01	0.02	0.05	0.09	0.14	0.18
Forestry	0.54	2.65	5.17	9.84	17.99	24.92	30.92	0.00	0.01	0.02	0.04	0.07	0.11	0.15
Fishing, Hunting	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.01	0.03	0.05	0.08	0.11
Fossil Fuels	0.00	-0.01	-0.02	-0.03	-0.07	-0.10	-0.14	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.08	0.12	0.15
Electric Power	0.00	0.02	0.06	0.16	0.51	0.99	1.60	0.01	0.07	0.13	0.27	0.54	0.81	1.08
Infrastructure	0.00	0.00	0.01	0.02	0.06	0.10	0.16	0.00	0.01	0.02	0.03	0.06	0.09	0.12
Construction	0.00	0.00	0.01	0.01	0.02	0.03	0.04	0.00	0.01	0.01	0.02	0.05	0.07	0.09
Manufacturing, General	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.00	0.00	0.01	0.01	0.02	0.03	0.05
Wood Products Manufacturing	0.01	0.06	0.12	0.22	0.40	0.56	0.69	0.00	0.00	0.01	0.01	0.03	0.04	0.05
Wholesale Trade	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.00	0.01	0.02	0.03	0.06	0.09	0.12
Retail Trade	0.00	0.00	0.00	0.01	0.02	0.04	0.05	0.00	0.01	0.01	0.03	0.05	0.08	0.10
Transportation	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	0.00	0.01	0.01	0.03	0.05	0.07	0.10
Information	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.00	0.01	0.01	0.03	0.06	0.09	0.11
Finance	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.00	0.01	0.02	0.04	0.08	0.12	0.16
Rental	0.00	0.01	0.01	0.03	0.06	0.09	0.12	0.00	0.01	0.03	0.06	0.11	0.17	0.22
Professional Services	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.03	0.05	0.07	0.10
Services, Other	0.00	0.00	0.00	0.01	0.02	0.03	0.05	0.00	0.01	0.01	0.03	0.05	0.08	0.10
Government	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.02	0.03

Table 10. Changes in quantity of imports due to increased use of woody biomass for electric power generation in Florida.

Sector	Base (Million $)	Capital Fixed							Capital Mobile						
		Change In Biomass Supply to Electric Power Sector (Million Tons)													
		1	5	10	20	40	60	80	1	5	10	20	40	60	80
		Percentage Change from Base													
Agriculture	3,912.7	0.01	0.06	0.12	0.24	0.45	0.65	0.82	0.01	0.05	0.10	0.21	0.41	0.62	0.82
Forestry	87.9	2.52	12.87	26.37	55.10	118.73	189.18	264.94	1.75	8.76	17.50	34.89	69.36	103.41	137.07
Fishing, Hunting	596.4	0.00	0.00	0.01	0.01	0.03	0.04	0.06	0.00	0.02	0.04	0.08	0.15	0.23	0.30
Fossil Fuels	46,582.0	-0.06	-0.30	-0.60	-1.22	-2.46	-3.71	-4.95	-0.06	-0.30	-0.59	-1.18	-2.34	-3.49	-4.62
Mining	1,601.5	0.00	-0.01	-0.02	-0.04	-0.07	-0.09	-0.12	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01
Electric Power	1,890.1	0.00	0.03	0.07	0.23	0.74	1.49	2.42	0.02	0.11	0.22	0.45	0.90	1.34	1.79
Infrastructure	670.3	0.00	0.01	0.02	0.05	0.12	0.21	0.30	0.01	0.03	0.06	0.11	0.23	0.34	0.44
Construction	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manufacturing, General	182,669.4	0.00	0.00	0.01	0.02	0.04	0.06	0.09	0.00	0.02	0.04	0.08	0.16	0.24	0.32
Wood Products Manufacturing	12,511.4	-0.01	-0.03	-0.06	-0.11	-0.19	-0.25	-0.29	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01
Wholesale Trade	4,846.9	0.00	0.00	-0.01	-0.01	0.00	0.02	0.05	0.01	0.03	0.06	0.12	0.24	0.36	0.48
Retail Trade	5,639.2	0.00	0.01	0.02	0.05	0.10	0.16	0.22	0.01	0.03	0.06	0.12	0.23	0.35	0.46
Transportation	11,428.7	0.00	-0.01	-0.02	-0.03	-0.05	-0.06	-0.07	0.00	0.02	0.04	0.08	0.16	0.23	0.31
Information	26,725.4	0.00	0.01	0.01	0.02	0.05	0.07	0.10	0.00	0.02	0.04	0.07	0.14	0.21	0.28
Finance	56,777.2	0.00	0.01	0.01	0.02	0.05	0.08	0.11	0.01	0.03	0.05	0.10	0.20	0.30	0.39
Rental	1,975.6	0.00	0.02	0.03	0.06	0.13	0.20	0.28	0.01	0.04	0.07	0.14	0.29	0.43	0.57
Professional Services	21,305.1	0.00	0.00	-0.01	-0.01	-0.02	-0.02	-0.02	0.00	0.01	0.03	0.05	0.11	0.16	0.21
Services, Other	38,357.7	0.00	0.01	0.02	0.04	0.09	0.14	0.19	0.01	0.03	0.05	0.11	0.21	0.32	0.42
Government	14,988.6	0.00	0.00	0.01	0.02	0.03	0.05	0.06	0.00	0.01	0.02	0.04	0.09	0.13	0.17

Table 11. Changes in quantity of labor demanded (factor payments) due to increased use of woody biomass for electric power generation in Florida.

Sector	Base (Million $)	Capital Fixed							Capital Mobile						
		Change In Biomass Supply to Electric Power Sector (Million Tons)													
		1	5	10	20	40	60	80	1	5	10	20	40	60	80
		Percentage Change from Base													
Agriculture	1,280.6	-0.13	-0.65	-1.27	-2.41	-4.39	-6.06	-7.49	0.00	-0.02	-0.03	-0.06	-0.13	-0.19	-0.25
Forestry	1,973.6	1.26	6.35	12.85	26.27	54.34	83.51	113.29	1.84	9.17	18.31	36.49	72.48	107.97	142.98
Fishing, Hunting	27.6	0.00	0.00	-0.01	-0.02	-0.03	-0.04	-0.05	0.00	-0.02	-0.05	-0.09	-0.18	-0.27	-0.36
Fossil Fuels	196.3	-0.10	-0.49	-0.99	-1.97	-3.93	-5.87	-7.78	-0.07	-0.37	-0.74	-1.48	-2.94	-4.39	-5.81
Mining	298.7	0.00	0.00	-0.01	-0.02	-0.05	-0.10	-0.16	-0.08	-0.40	-0.79	-1.57	-3.08	-4.54	-5.94
Electric Power	2,454.8	-0.02	-0.15	-0.37	-1.01	-2.95	-5.57	-8.70	-0.01	-0.07	-0.15	-0.29	-0.58	-0.87	-1.16
Infrastructure	186.1	0.00	0.01	0.02	0.06	0.15	0.28	0.42	0.02	0.08	0.15	0.30	0.60	0.89	1.18
Construction	30,469.4	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.02	0.00	0.00	0.01	0.02	0.04	0.05	0.07
Manufacturing, General	21,234.8	0.00	-0.02	-0.04	-0.08	-0.16	-0.24	-0.32	0.00	-0.01	-0.03	-0.05	-0.11	-0.16	-0.21
Wood Products Manufacturing	1,306.9	-0.36	-1.76	-3.39	-6.37	-11.35	-15.39	-18.75	-0.01	-0.06	-0.12	-0.24	-0.47	-0.70	-0.93
Wholesale Trade	23,512.9	0.00	0.00	-0.01	-0.01	-0.02	-0.02	-0.02	0.00	0.01	0.03	0.06	0.12	0.17	0.23
Retail Trade	32,178.8	0.00	0.01	0.02	0.03	0.06	0.09	0.11	0.00	0.02	0.04	0.07	0.14	0.21	0.28
Transportation	11,899.5	0.00	-0.01	-0.01	-0.02	-0.04	-0.05	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Information	11,355.6	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.02	0.00	-0.02	-0.03	-0.06	-0.12	-0.18	-0.24
Finance	35,320.3	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.00	0.00	-0.01	-0.01	-0.03	-0.04	-0.06
Rental	2,292.6	0.00	0.01	0.02	0.04	0.08	0.13	0.17	0.00	0.02	0.04	0.09	0.18	0.26	0.35
Professional Services	43,200.0	0.00	0.00	-0.01	-0.02	-0.03	-0.04	-0.06	0.00	0.00	0.00	0.01	0.02	0.03	0.04
Services, Other	111,126.1	0.00	0.01	0.01	0.02	0.04	0.06	0.07	0.00	0.01	0.03	0.05	0.10	0.15	0.20
Government	75,497.7	0.00	0.00	0.01	0.02	0.04	0.06	0.08	0.00	0.01	0.02	0.04	0.07	0.11	0.14

Conclusions

This study evaluated the potential impacts on the Florida economy resulting from substitution of woody biomass biofuels for fossil fuels used for electric power generation, under the mandates of a Renewable Electricity Standard that would require a minimum percentage of renewable energy sources, state and federal production tax credits, and biomass feedstock subsidies. The analysis was conducted using a computable general equilibrium model coupled to an Input-Output/Social Accounting Matrix representing the structure of the Florida economy in 2007.

The study found that increased biomass use for electric power generation would bring about a modest increase in the Gross Domestic Product of Florida, employment, and state government revenues, while decreasing total imports, particularly for fossil fuels. For a biomass supply level of 40 million tons, with mobile capital assumed, GDP would be increased by 0.32 percent, representing a $2.2 billion addition to Florida's economy. Output of the forestry sector would be increased dramatically, by 69 percent above current levels, to meet new demand for woody biomass fuels, while output of the electric power sector would decrease by up to 0.33 percent as a result of higher costs for biomass replacing fossil fuels. The largest adverse impact of these policies would be a decrease in output of the forest products manufacturing sector by up to 6.7 percent, because of competition and increased prices for forest resources. Prices for forest commodities may increase as much as 18 percent in the short-run due to this resource competition, but would likely be much lower in the long-run if capital is allowed to move freely. The much greater price increases observed when Forestry and Logging/Support Services sectors were disaggregated, and when imports of these commodities were prohibitied are more comparable to results from bioeconomic models such as the Southern Region Timber Supply (SRTS) model used in a companion study (Rossi, Carter and Abt).

Imports of fossil fuels would be decreased by up to 2.5 percent, representing a savings in import purchases of $1.14 billion annually. Employee income would increase by up to $1.61 billion. State government tax revenues would increase by 0.06 percent ($108 million).

The analysis also showed that incentives, such as a state and federal renewable energy production tax credits for electricity generated from biomass equivalent to $0.010 and $0.011 per KWhr respectively, and a 100 percent subsidy to forestry biomass producers, would marginally further increase state GDP and employment. The electricity production tax credit would substantially increase output of the electric power sector, and decrease imports of fossil fuels, while reducing the negative impact of higher electricity prices on all other sectors. However, assuming that the tax credit is unlimited, this state-sponsored incentive would significantly reduce state government revenues by nearly $200 million at the 40 million ton biomass supply level. The federally sponsored renewable production tax credit would not adversely affect state government revenues. The biomass feedstock federal subsidy to forestry producers would dramatically increase both electric-power and forestry commodity output, but would not appreciably affect fossil fuel imports or state government revenues.

In summary, it is concluded that the various policies and incentives for bioenergy development that were examined would have an overall positive impact on the economy of Florida in terms of increased GDP, employment and state government revenues, and decreased imports of fossil fuels. The forestry sector would particularly benefit from increased demand and prices. However, the forest product manufacturing sector would be adversely affected by competition for wood resources and higher prices for material inputs.

Of course, all economic analyses are based on certain assumptions that are integral to the economic models and data used, and this study is no exception. Firstly, I-O/SAM models assume a fixed relationship between production volume (output) and intermediate inputs estimated based on national averages, however, the CGE modeling approach overcomes some of the limitations of standard Input-Output analysis by allowing substitution of labor and capital resources and changes in commodity prices. Secondly, the I-O/SAM and CGE models used in this study do not explicitly have a time dimension; the impacts are assumed to occur within a relatively short period of a year of less. It is expected that the results under the mobile capital scenarios would hold in the long run, say 10 years or more, while fixed capital would prevail in the short run. Also, these models do not recognize physical or biological capacity constraints on commodity production, such as forest growth. Changes in commodity demand are assumed to be fulfilled from either local or imported sources, in order for the market to reach equilibrium. This is in contrast to bioeconomic models such as the SRTS model which represents forest inventories, growth and harvest removals dynamically over time.

Future studies on the economic impacts of bioenergy development policies may more fully explore other types of incentives, such as investment tax credits, as well as possible trade policy provisions that could mitigate the adverse effects on certain sectors, or the effects of model parameters and closure rules that may better reflect the characteristics of specific industry sectors or commodities

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Appendix Table 1. IMPLAN Social Accounting Matrix for Florida, 2007.

		Activities																
		Agricul-ture	Forestry	Fish-hunt	Fossil-fuel	Mining	Electric	Infra-structure	Const-ruction	Manu-facture	Wood manuf	Whole-sale	Retail	Transpor-tation	Informa-tion	Finance	Renting	Services-prof
Activities	Agriculture																	
	Forestry																	
	Fish-hunt																	
	Fossil-fuel																	
	Mining																	
	Electric																	
	Infrastructure																	
	Construction																	
	Manufacture																	
	Woodmanuf																	
	Wholesale																	
	Retail																	
	Transportation																	
	Information																	
	Finance																	
	Renting																	
	Services-prof																	
	Services																	
	Gov-Other																	
Commodities	Agriculture	567	21	0	1	3	40		265	2,563	1	1	76	1	0	84	12	12
	Forestry	682	417	1			40			63	684		0					3
	Fish-hunt									223			15	1				0
	Fossil-fuel	333	12	16	2,277	110	10,540	7	3,204	3,599	223	676	317	4,363	262	185	74	305
	Mining	6	0		1	59		1	829	610	6	0	0	1	15	9	42	6
	Electric	130	2	0	78	62	0	1	446	1,378	169	382	1071	187	199	1,352	155	447
	Infrastructure	31	0	0	0	0	2		47	59	6	17	35	43	26	83	9	13
	Construction	44	3	1	412	0	173	59	115	537	57	128	324	198	451	1077	2,405	271
	Manufacture	929	202	16	449	78	228	7	25,094	43,810	1062	1969	1811	2,808	2,756	791	1599	2719
	Wood-manuf	59	2	1	14	2	1	0	3,949	2,684	2,010	354	220	91	482	182	323	198
	Wholesale	172	42	4	72	13	19	1	3,503	6,018	546	2,404	885	453	451	168	845	518
	Retail	5	0	0	17	1	1	0	5,354	319	7	78	208	110	16	46	354	45
	Transportation	111	11	4	35	64	220	2	2,042	3,454	363	2,202	1969	4,455	853	667	376	1376
	Information	9	1	0	17	3	15	3	923	1,103	41	556	754	339	9,330	2,111	202	2,843
	Finance	492	20	3	150	43	99	18	2,677	2,080	109	3,212	7,075	3,149	2,498	38,065	15,436	8,384
	Renting	34	4	0	300	26	3	1	1327	884	47	479	421	654	670	433	352	1043
	Services-prof	190	38	65	549	96	218	51	9,345	11,023	454	6,281	5,077	1547	6,362	9,430	2,654	12,322
	Services	50	29	12	92	13	105	13	3,421	2,830	219	3,012	3,089	2,681	3,656	7,497	2,961	7,824
	Gov-Other	2	1	0	17	2	7	2	20	470	64	1,131	715	2,252	641	1414	195	758
Institutions & Trade	Labor	1,328	1421	28	213	298	2,572	193	30,477	21,219	1444	23,514	32,158	11895	11,352	35,304	2,292	43,202
	Capital	2,726	490	265	715	575	7,582	205	13,587	10,929	768	9,528	10,210	5,294	12,273	61729	36,472	18,380
	Ind-Taxes	173	63	23	120	44	2,016	27	731	1,559	58	9,355	12,094	1203	2,318	11276	7,266	1,197
	House-holds																	
	Fed-Gov-Non-																	
	Fed-Gov-Def																	
	Fed-Gov-Inv																	
	St-Gov-non-																	
	St-Gov-edu																	
	St-Gov-Inv																	
	Inventory																	
	Foreign-Trade																	
	Domestic-																	
	Total	8,075	2,783	440	5,529	1491	23,878	591	107,356	117,415	8,337	65,281	78,522	41725	54,613	171904	74,022	101865

1 All values are in millions of U.S. dollars , 2 Household sectors were consolidated to conserve space.

Appendix Table 1 (continued). IMPLAN Social Accounting Matrix for Florida, 2007.

		Activities		Commodities														
		Services	Gov-Other	Agriculture	Forestry	Fish-hunt	Fossil-fuel	Mining	Electric	Infra-structure	Construction	Manufacture	Wood manuf.	Whole-sale	Retail	Transportation	Information	Finance
Activities	Agriculture			7,978	71													
	Forestry				2,783													
	Fish-hunt					440												
	Fossil-fuel						5,414	0	77			38						
	Mining						7	1298				186						
	Electric						914		22,741	224								
	Infrastructure									517								
	Construction										107,356							
	Manufacture						38	64				116,405	86					
	Woodmanuf											126	8,203					
	Wholesale													65,281				
	Retail														78,522			
	Transportation															41725		
	Information																44,040	
	Finance																	168,628
	Renting																	
	Services-prof																32	
	Services																	704
	Gov-Other						510		866	2,404					266	2,096	17	827
Commodities	Agriculture	204	0															
	Forestry	0																
	Fish-hunt	228	0															
	Fossil-fuel	3,129	1638															
	Mining	45	33															
	Electric	2,909	114															
	Infrastructure	340	92															
	Construction	859	617															
	Manufacture	21,081	1,182															
	Wood-manuf	1529	31															
	Wholesale	3,435	244															
	Retail	672	1															
	Transportation	3,028	361															
	Information	4,448	109															
	Finance	22,371	974															
	Renting	1548	15															
	Services-prof	19,714	900															
	Services	19,237	661															
	Gov-Other	2,342	145															
Institutions & Trade	Labor	111,050	75,557															
	Capital	33,787	12,347															
	Ind-Taxes	8,398																
	House-holds																	
	Fed-Gov-Non-			37	4													
	Fed-Gov-Def																	
	Fed-Gov-Inv																	
	St-Gov-non-edu			19	103	15				58							75	
	St-Gov-edu																	
	St-Gov-Inv																	
	Inventory			12			26	0				659	2			6	8	
	Foreign-Trade			478	0	314	6,208	123	8			46,520	1467			570	154	598
	Domestic-			3,419	41	282	42,872	1,479	2,025	695		136,147	11,069	4,850	5,640	10,869	26,569	56,175
	Total	260,356	95,022	11,944	3,002	1,052	55,987	2,965	25,717	3,897	107,356	300,081	20,828	70,132	84,428	55,266	70,894	226,932

[1] All values are in millions of U.S. dollars , [2] Household sectors were consolidated to conserve space.

Appendix Table 1 (continued). IMPLAN Social Accounting Matrix for Florida, 2007.

		Commodities				Institutions and Trade													
		Renting	Services-prof	Services	Gov-Other	Labor	Capital	Indirect-Taxes	House-holds	Fed-gov-NonDef	Fed-gov-Def	Fed-gov-Inv	St-gov-NonEdu	St-gov-Edu	St-gov-Inv	Inventory	Foreign-Trade	Dom-Trade	Total
Activities	Agriculture			25															8,075
	Forestry																		2,783
	Fish-hunt																		440
	Fossil-fuel																		5,529
	Mining																		1,491
	Electric																		23,878
	Infrastructure				75														591
	Construction																		107,356
	Manufacture		735	25	62														117,415
	Woodmanuf				8														8,337
	Wholesale																		65,281
	Retail																		78,522
	Transportation																		41,725
	Information		10,508	65															54,613
	Finance	3,276																	171,904
	Renting	74,022																	74,022
	Services-prof		101774	59															101865
	Services	66	155	259,396	35														260,356
	Gov-Other			629	87,408														95,022
Commodities	Agriculture								3,306	8	0		63	11		10	751	3,855	11,946
	Forestry								31				42			1	71	1728	3,629
	Fish-hunt								409				4	1		0	22	149	1052
	Fossil-fuel								18,246	61	327		1,563	345		239	95	1374	53,515
	Mining								8	2			48			51	119	1045	2,965
	Electric								8,424	22	142		417	91			42	6,880	24,980
	Infrastructure								2,606	13	33		297	63			4	0	3,825
	Construction								0	120	358	819	1649	143	15,236	73,284	5	7,998	107,356
	Manufacture								96,185	305	4,525	3,381	4,937	985	2,115	13,550	17,274	48,249	300,086
	Wood-manuf								1,754	46	15	0	765	222		342	735	4,328	20,828
	Wholesale								26,117	63	309	127	1,160	252	330	4,625	5,338	12,021	70,132
	Retail								66,590	0	0		1	10		1895		8,705	84,428
	Transportation								14,581	98	689	47	871	417	71	750	5,704	10,452	55,266
	Information								23,029	385	779	107	2,282	760	119	1697	784	18,147	70,895
	Finance								62,297	223	20		2,336	59		4,838	1683	48,627	226,932
	Renting								64,659	10	26		270	40			2,262	3,831	79,340
	Services-prof								8,815	1,199	4,921	1018	3,677	901	355	6,704	1620	19,006	134,530
	Services								182,414	426	1,791		6,109	1029			346	66,173	315,635
	Gov-Other								10,627	6,136	18,049		19,811	36,276	187	165	13,935	1888	117,256
Institutions & Trade	Labor																		405,518
	Capital																		237,864
	Ind-Taxes																		57,920
	House-holds				8,557	358,994	106,714		24,759	10,147			13,346			202,522	0	5,593	830,632
	Fed-Gov-Non-				365	46,086	1,704	5,443	77,858							48,644	0	0	180,140
	Fed-Gov-Def									31983						0			31983
	Fed-Gov-Inv				19					5,481							0		5,500
	St-Gov-non-edu		44	17,072	394	764	-231	52,478	4,318	19,599						25,068	0	0	19,776
	St-Gov-edu				244								41,359						41,603
	St-Gov-Inv												13,420			0			13,420
	Inventory				5,111	-325	161,189			2,137		0	336			17,597	23,178	64,657	404,636
	Foreign-Trade	1	84	29	11,956		344		3,556	1,678	0	0	0	0	0	0	3,354		77,442
	Domestic-	1,974	21230	38,335	3,022		-31,855		0	0	0	0	0	0	0	0			334,837
	Total	79,340	134,530	315,635	117,256	405,518	237,864	57,920	830,632	180,140	31983	5,500	19,776	41,603	13,420	401989	77,442	334,837	5,650,074

Note: all values are in millions of U.S. dollars; household sectors were consolidated to conserve space.