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Chapter X. Florida Agricultural Energy Consumption Model Results[1]

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INTRODUCTION

Florida's agriculture is highly important to the economy of the state. It is very diverse in terms of number and types of commodities produced. The production systems for many of these commodities are quite energy intensive due to such factors as poor soil fertility, high pest pressures, irrigation of a large portion of the cultivated acreage, and large acreages of fruits, vegetables and ornamentals.

The Florida Agricultural Energy Consumption Model was developed to address a lack of adequate knowledge of the amounts of energy required by Florida agricultural production. Prior to the development of this model, data on quantities of energy commodities (diesel fuel, gasoline, electricity, etc.) consumed were fragmentary and sporadic. Data on the indirect energy (energy required to provide fertilizers, pesticides, labor, etc.) requirements were very deficient. In general, information is inadequate about where energy is used in agricultural production and where it can be better managed for greater efficiency. Better and more timely data is needed for two reasons: 1) In the event of an energy shortage we need to know how best to allocate available fossil fuel energy resources within the agricultural industry to maintain adequate production of food and other agricultural commodities, and 2) By identifying the agricultural production systems that consume the most energy and in what forms, we can focus our efforts on making those systems more energy efficient in order to achieve greater energy savings.

This report details the results of a computer-based spreadsheet model of Florida agricultural energy consumption, the Florida Agricultural Energy Consumption Model. A detailed description of the model, titled *Florida Agricultural Energy Consumption Model, Presentation And Verification*, is available from the senior author.

DESCRIPTION OF MODEL

The objective for the project which led to the development of the model was to develop an accounting mechanism to provide energy consumption data for Florida agricultural production systems on an annual basis. The outcome is a computer-based spreadsheet model of Florida agricultural energy

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consumption, the Florida Agricultural Energy Consumption Model (FAECM).

The scope of the model is limited to agricultural production. It does not extend beyond the "farm gate" into other agribusiness industries, such as food processing, despite the fact that with some large farm operations, processing is part of the same enterprise. By its nature, however, in including the indirect energy for agricultural production the model does extend backwards to include the energy required to provide inputs such as fertilizers, pesticides and machinery.

Process analysis, one of the conventional methods for performing energy analyses, was used in developing the model. The networks, processes or activities required to make a final product are identified and each process of the networks is analyzed for energy inputs and energy or material outputs. Each identified input is then assigned an energy value, depending on the system boundary of the energy analysis.

Existing production cost budgets, representing typical production processes that constitute complete agricultural production systems, were obtained for approximately 50 of Florida's most important agricultural commodities. These budgets were evaluated from an energy analysis point of view, and the quantities or monetary costs of all inputs were transformed to energy requirements. All production budget inputs were categorized into five energy commodities and twelve other inputs, to transform the commodity production budgets into commodity energy budgets.

The concept of energy sequestered in goods and services was used to determining the total primary energy requirements of those inputs in the form of services, fertilizer, chemicals and other non-fuel materials. Primary energy is the total energy, both direct or heat energy and indirect or other energy that is sequestered or embodied in a product or service. Some of the primary energy required for Florida agricultural production is expended outside Florida, at locations where industries manufacture some of the inputs required, for example. The concepts of both heat generated (direct or thermal energy) and sequestered energy were applied to energy commodities; diesel, gasoline, lubricants, LPG, and electricity.

The scope of the indirect energy inputs included in the model exceeds that of many other agricultural energy analyses. The category "other costs" includes all other costs not included in any of the other sixteen input categories. For example, supplies such as containers, twine, fencing materials, and paint are included. Capital costs for buildings, machinery and irrigation systems are included. Repair and maintenance costs are included. Land rental, taxes and fees, and custom services may be included. All these inputs in the "other costs" category require the expenditure of energy.

Agricultural commodity energy requirements as specified in the commodity energy budgets were multiplied by annual production levels (number of acres or head of livestock) for their respective commodities to calculate statewide totals for the 17 categories of energy-requiring inputs. Minor commodities' production levels were included in the totals also. Totals were determined for both direct or thermal energy and total primary energy, for both individual commodities and for statewide annual agricultural production requirements.

The model was verified by making comparisons with four years of Agricultural Census data for energy commodity consumption. The model predicts somewhat higher energy consumption than is reflected by Agricultural Census data for direct energy consumption. This may perhaps be due to farmers' using lower input levels than indicated by the production budgets, as well as possible underreporting by the Agricultural Censuses.

RESULTS AND DISCUSSION

Overall Results

Florida production agriculture currently requires annually about 36.7 trillion Btu's of direct energy and about 103.0 trillion Btu's of indirect energy, or 139.7 trillion Btu's of total primary energy. Agriculture is one of Florida's most important industries. It is very important to Florida's economy that agriculture be adequately considered and, if necessary, protected in the event of sharply increased energy costs or decreased energy availability. The model does not address location within Florida or time during the year that agricultural needs energy or energy-requiring inputs; these factors must also be considered in such an eventuality.

Trends Over Time

The model has been applied to the most recent four Agricultural Census years (1974, 1978, 1982, and 1987) as well as to 1990. During this 16 year period from 1974 to 1990, Florida agriculture's total cultivated acreage has remained relatively constant. However, there have occurred rather severe changes in production levels of individual commodities, as well as a trend toward commodities whose production systems are more intensive. Total direct energy requirements as determined by the model have remained relatively constant, varying about 10 percent; 1990's direct energy requirements for Florida production agriculture at 36.7 trillion Btu's are only 1 percent below 1974's. Total primary energy requirements have decreased about 17 percent from 1974, and about 20 percent from 1978's amount. This decrease appears to be due primarily to increased energy efficiency of the input category, "other costs", represented by the average of goods and services in the Gross National Product as well as decreased energy requirements of producing nitrogen fertilizer and providing agricultural labor.

Note that the model is responding primarily to changes in production levels of individual commodities. The model is not responding to real changes in improved agricultural production practices and technology that have also occurred. It is likely that improved agricultural technology and energy conservation practices have also resulted in improved energy efficiency that the model does not exhibit.

The change of largest magnitude in direct energy requirements since 1974 is the decrease in diesel fuel requirements, although the greatest percentage change is the more than doubling of LP gas requirements due to increased foliage plant production. Changes in indirect energy inputs from 1974 to 1990 listed in decreasing order of magnitude of energy requirements include 1) decreased energy requirements for "other costs" due to increased energy efficiency of industrial production; 2) decreased nitrogen energy requirements due mainly to increased energy efficiency of nitrogen fertilizer manufacture; 3) decreased labor energy requirements due to decreased energy embodied per unit of labor; 4) increased energy requirements for salt and minerals and veterinary services and medicines due to increased livestock production; and 5) increased fungicide energy requirements due to increased production of a number of different crops.

Commodity Energy Budgets

For many agricultural commodities, diesel fuel is the energy commodity which consumes the most direct or heat energy. For most commodities, the category "other costs" represents the largest percentage of total primary energy inputs. The relative importance of the 17 inputs in terms of total energy requirements, as well as the magnitudes of the total direct and total primary energy requirements, vary greatly with commodity.

The total energy inputs to Florida agriculture show a significant degree of stability or resistance to change; they do not vary greatly from year to year and are not easily or quickly changed. This appears to be due to the magnitude and variety of Florida's agriculture. Although not all of the 17 input categories are used in producing each commodity, all 17 input categories are vitally important to Florida agriculture. Some substitutions can and do occur among these input categories as relative costs vary over time and as technology changes, but extensive or sudden shifts are unlikely to occur except in response to extreme changes in cost, availability of inputs or improvements in technology. "Other costs" includes capital costs, which represent capital investments that are replaced only over a number of years and that to a large degree determine the nature of the production systems.

Energy Commodity Input Requirements

Florida agricultural production currently requires 168.5 million gallons of diesel fuel annually, 51.8 million gallons of gasoline, 14.4 million gallons of lubricants, 32.5 million gallons of LP gas, and 378.9 million kilowatt hours of electricity. Florida agriculture depends vitally on diesel fuel, as diesel provides about two thirds of the direct energy requirements for Florida agricultural production. Liquid fuels are universally and widely used in industrialized agriculture, and will not easily be replaced. Ultimately, it may be necessary to restrict other uses of these liquid fuels in order to supply agriculture's needs. The infrastructure to supply, deliver and use these direct energy commodities is in place, is functioning satisfactorily, and is not easily or quickly modified.

Requirements for Other Inputs

Florida agricultural production requires annually 732.2 million pounds of nitrogen, 320.4 million pounds of phosphate, 759.5 million pounds of potash, 4.39 million pounds of herbicides, 12.85 million pounds of insecticides, 9.00 million pounds of fungicides, 15.88 million pounds of other pesticides, 1353 million pounds of other chemicals (this is mainly lime), 6.58 million dollars of salt and other minerals for livestock, 50.16 million dollars of veterinary services and medicines, 217.0 million hours of labor and 2.918 billion dollars of other costs. All these quantities of inputs are being supplied satisfactorily. Future changes in production levels of individual commodities will force adjustments in input levels.

Direct and Indirect Energy Requirements

The difference between Florida agricultural production's total annual primary energy requirement of 36.7 trillion Btu's and the total annual direct or heat energy requirement of 139.7 trillion Btu's is the total annual indirect energy requirement of 103.0 trillion Btu's. Direct energy is currently 27 percent of the total and indirect energy is 73 percent of the total. The energy commodities (the direct energy inputs) are the highly visible energy requirements for agriculture. In contrast, the indirect energy requirements are the less visible or hidden, and often unrecognized, energy requirements. The indirect energy component is almost three times the direct energy component. The indirect energy requirement is no less important or necessary than the direct. Policy and decision makers, agricultural leaders, and others must realize the importance of indirect as well as direct energy requirements to Florida agriculture.

About 64.2 percent of the total direct or heat energy inputs for Florida agriculture is currently (1990) accounted for by diesel fuel, followed in order by gasoline (17.8 percent), LP gas (8.5 percent), lubricants (6.0 percent) and electricity (3.5 percent). The largest percentage of the total primary energy input for Florida agriculture is represented by "other costs" (31.1 percent), followed by diesel fuel (20.5 percent), nitrogen (16.7 percent), labor (8.5 percent), gasoline (5.7 percent), electricity (3.6 percent), potash (3.2 percent), and LP gas (2.7 percent). The categories of lubricants, phosphorus, herbicides, insecticides, fungicides, other pesticides, other chemicals, salt and minerals, and veterinary services and medicines each represent no more than two percent and together sum to about eight percent of the total primary energy requirement for Florida agriculture. This latter group of inputs is no less vital to Florida agriculture, but the inputs representing the larger percentages of direct and total primary energy inputs are where the greatest potential reductions in energy requirements exist.

Energy Consumption by Commodities and Commodity Groupings

Commodities requiring the most direct energy are, in order of magnitude from largest toward smallest, oranges, grapefruit (includes other citrus and miscellaneous tropical fruits), ornamental plants, foliage plants, beef, broilers, layers, tomatoes (includes okra), corn and watermelons (includes cantaloupes). These top ten commodities account for almost 84 percent of the direct energy consumption of Florida agricultural production.

Commodities requiring the most total primary energy are, in order, oranges, beef, foliage plants, dairy, horses, grapefruit (includes other citrus and miscellaneous tropical fruits), ornamental plants, layers, tomatoes (includes okra) and broilers. These top ten commodities account for 77 percent of the total primary energy consumption of Florida agricultural production (Table 1).

Commodities requiring the most fertilizer primary energy are, in order, beef (beef production is treated as combined with pasture, some of which is fertilized), oranges, ornamental plants, grapefruit (includes other citrus and miscellaneous tropical fruits), corn, foliage plants, sweet corn, bahia grass, tomatoes and sod. These top ten commodities account for over 79 percent of the primary energy consumption for fertilizers for Florida agricultural production. Energy conservation in the form of appropriate fertilizer application practices can focus on these commodities for greatest impact.

Commodities requiring the most primary energy for chemicals are, in order, beef, oranges, grapefruit (includes other citrus and miscellaneous tropical fruits), tomatoes (includes okra), ornamental plants, foliage plants, peanuts, bell peppers (includes hot peppers), dairy and cucumbers (includes miscellaneous vegetables). These ten commodities account for over 85 percent of the primary energy consumption for chemicals for Florida agricultural production.

Commodities requiring the most primary energy for labor are, in order, foliage plants, ornamental plants, horses, beef, bell peppers (includes hot peppers), oranges, tomatoes (includes okra), dairy, sweet corn and cucumbers (includes miscellaneous vegetables). These top ten commodities account for over 81 percent of the primary energy consumption for labor used in Florida agricultural production. Mechanization of some of the operations involved in the production of these, and other, commodities may affect (either increase or decrease) total energy requirements.

Although the largest portion of both direct and total Florida agricultural energy requirements are accounted for by only a small number of commodities, Florida produces a large number of other agricultural commodities. These other commodities too require considerable quantities of energy. It is obvious that those commodities named in the above five paragraphs, however, should be the ones on which efforts should be directed to achieve the greatest decreases in energy consumption in Florida agricultural production.

Fruit crops is the commodity grouping that requires the largest portion of the direct energy -- over 43 percent. Livestock requires the largest portion of the indirect energy requirements, over 42 percent, as well as the largest portion of the total primary energy required, at 35 percent. These commodity groupings would appear to be the ones whose common operations should receive the most attention in order to improve energy efficiencies and decrease energy consumption.

Production Per Unit of Energy Consumption

Energy productivity is the quantity of product obtained from the production system per unit of energy consumed. Energy productivities are not useful for comparing commodities; commodities differ considerably in their nature and value as well as in their production systems. Energy productivities can be used, however, to compare the energy efficiencies of proposed production systems for a specific commodity with its current production system. The fact that commodities that are similar (for example, grains) demonstrate energy productivities that are similar is an interesting coincidence that probably has a rational basis.

IMPLICATIONS

One way FAECM can be used is to play "what if" games, or simulation of specific hypothetical scenarios. These may take the nature of sensitivity analyses, in which a particular adjustment of some parameter is made and the consequences are examined. For example, a specified reduction in sugarcane acreage due to increased sugar imports or a required reduction in water pollution might be modeled to determine its impact on the statewide energy input requirements for sugarcane.

As Florida's human population continues to increase, pressures on agriculture may result in decreased production of certain commodities, such as certain agronomic crops. But increased demand from increased population may also lead to increased production of other commodities, such as ornamentals. The model can be used to estimate the impacts on agricultural energy requirements due to any predicted production level changes.

If the effects of the proposed Free Trade Agreement with Mexico act, the US GATT proposal, etc. on Florida agricultural production can be predicted, resultant changes in Florida agricultural production energy requirements could easily be estimated using this model. Predicted changes in production levels can be entered into the model to determine the estimated changes in energy requirements.

Increases in temperatures due to global warming, increased carbon dioxide, etc. can have effects upon the quantities and yields of various commodities that are produced in Florida. If the effects on production levels and/or yields can be predicted, the effects upon statewide energy requirements can also be predicted by using this model.

Most of the original production budgets upon which the model was based were dated in the late 1980's, and therefore reflect technology used during those years. Production technology changes may reflect newly available technology, changing relative costs of inputs, new pest pressures, etc. The production budgets and energy budgets can readily be updated to reflect current, anticipated or proposed production technology. The model will then provide the production energy requirements using the new production technology.

Commodities whose production requires large quantities of energy, either direct or indirect, will, in the future as energy becomes more expensive relative to other inputs, be more likely to suffer production decreases. Such production decreases will be less likely for highly-valued commodities that can withstand price increases to cover increased costs. Commodities that produce net energy and exhibit very large energy productivities, such as grass, sorghum and sugarcane, may be candidates for renewable energy sources and therefore also be candidates for increased production.

SUMMARY

A Florida Agricultural Energy Consumption Model has been developed. It is a useful accounting methodology for quantifying the direct as well as the total primary energy requirements for Florida agricultural production. It responds to crop acreages and number of head of livestock in determining the energy consumption within seventeen categories of inputs.

Table 1. Total Primary Energy Requirements for Florida Agricultural Commodities, 1990.

Ranking	Commodity	Energy (Trillion Btu)[1]	Percent	Cumulative Percent
1	Oranges	19.7	15.99	15.99
2	Beef	14.0	11.35	27.34
3	FolPlant	10.7	8.70	36.04
4	Dairy	10.5	8.51	44.55
5	Horse	10.4	8.46	53.00
6	Grapefruit	9.3	7.52	60.52
7	OrnPlant	8.8	7.10	67.62
8	Layers	4.4	3.56	71.18
9	Tomato	4.1	3.30	74.48
10	Broiler	3.9	3.19	77.67
11	CornGrain	2.3	1.89	79.56
12	SweetCorn	2.2	1.78	81.34
13	Cucumber	2.0	1.65	83.00
14	Watermelon	1.4	1.13	84.12
15	BellPepper	1.3	1.09	85.22
	Next 27 Crops	17.8	14.48	99.70

[1]There are approximately 125,000 Btu in one gallon of gasoline.