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BEE – BIOMASS ECONOMIC EVALUATION: A MODEL FOR THE ECONOMIC ANALYSIS OF ENERGY CROPS PRODUCTION

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ABSTRACT: The extend use of biomass based energy contributes to less environmental deterioration, increased energy self sufficiency, improved balance of payment levels and increased job opportunities in the agricultural sector. However, the whole of the bioenergy chain is novel and costs and benefits have not yet been settled. In the agricultural production phase, new plants and production and harvesting methods are being tested today with substantial learning effect on costs. Models such as BEE are useful because they can explore the economic possibilities and financial viability of different crops under different economic, soil and climatic conditions and offer the opportunity of "what if" and sensitivity analyses. A cost and financial analysis model also provides the basis of feasibility studies, which always precede decisions for investments such as ones required for bioenergy chains.
Keywords: bio-energy financing, costs, energy crops

1. INTRODUCTION

This paper presents BEE (Biomass Economic Evaluation), a technical and economic model for cost and financial analysis of biomass cultivation (http://www.bee.aua.gr). In particular, it describes the methodology and preliminary results of the model. BEE was developed by the Laboratory of Agribusiness Management, Agricultural University of Athens, in the framework of the EC project "Bioenergy Chains of Perennial Crops in South Europe", No: ENK6-CT-2001-00524.

The EU's White Paper (Energy for the future: Renewable Sources of Energy) strategic objective demands the increase of the contribution of renewable energy sources to 12% of the EU gross inland primary energy consumption, by the year 2010 [1]. In particular, it records that biomass contribution in 1997, for EU15, was accounting for about 3% of total inland energy consumption, which equals to 44.8 Mtoe (Million tons of oil equivalent). According to the particular scenario, of the White Paper, on biomass, the additional contribution of *bioenergy* in 2010 is set up to 90 Mtoe (equal to 8,5% of projected total energy consumption in this year), of which energy crops account for 45 Mtoe. In this respect, energy from biomass crops is regarded as a significant potential contributor towards the reduction of fossil fuel usage.

BEE can analyse a wide range of perennial energy crops such as Giant Reed, Switchgrass, Miscanthus and Cardoon, as well as a variety of annual crops, for example Rapeseed and Sunflower. It uses common financial analysis methodologies, adapted for the case of agricultural projects. The model has already been used to analyse the annual cost of several perennial energy crops in Greece and other South European Countries.

2 METHODOLOGY

The economic analysis of energy crops production consists of cost analysis and analysis of financial statements of the agricultural production enterprises. Full and detailed economic analysis gives the researcher the opportunity, not only to identify cost and financial results of the project, but also to perform sensitivity analysis and "what if" investigation by modifying any of the primary data. The researcher may examine the farmer's position "with" and "without" the project and he may compare the profitability of conventional vs. biomass crops.

2.1 Cost analysis

In practice, most Farm Accounts do not identify the full cost of agricultural production, probably due to lack of consensus and data on imputed costs, such as family labour, own land, etc. For economic analysis, these items should be estimated at their opportunity cost in order to identify net income attributed to the project.

The proposed methodology in the context of the computerised model presented in this paper, demands the decomposition of the project into a number of *operations* or *activities*[1] which sufficiently describe all requirements for plant instalment, cultivation and harvesting activities. Each operation is characterised by its *timing* (both duration per hectare and seasonality within each year) and its needs for *land*, *labour*, *equipment* and *materials*. Seasonality is important if peak labour, machinery and water needs have to be identified. Fuel consumption depends upon operation and machinery used and can easily be estimated if required.

All cost items are firstly measured in physical quantities, for example land area, man and machine hours, fuel needs, raw material volumes, etc. This provides a cost measurement system independent of prices of resources and therefore stable through time in the short and medium run. The required quantities of factors of production and raw materials are then multiplied by their corresponding prices in order to calculate total cost in value terms.

Mechanical equipment may be hired if own machinery is insufficient or non existent. When hired, its cost is equal to the rent paid provided that there is a market for rental; the cost of own equipment is the sum of depreciation, interest, maintenance, insurance, labour and fuel.

Land is an essential factor of agricultural production and in most cases a major cost item. The cost of agricultural products may be significantly increased if

[1] ABC (Activity Based Costing) analysis.

planted on high cost land and vice versa. Therefore, land cost must be carefully estimated in all agricultural projects. If there is a fairly competitive market for land, one may assume that its rent adequately reflects its real cost. However, if there is no market, the cost of land is not easily identifiable. In such cases one needs to estimate its opportunity cost as expressed by the net economic output of current land use.

Labour is usually provided by the farmer and his family, but it may also be hired, especially during peak labour demand, e.g. at planting or harvesting times. Hired labour in most cases has a market specified rate, which can be used in the analysis. Imputed labour cost should be principally evaluated at its opportunity cost, i.e. the amount of income forgone for shifting family labour from current activity due to the needs and requirements of the project.

When there is no market for a comodity, the opportunity cost of the relevant factor or production should be used to estimate the cost of inputs. Opportunity costs should, in general reflect implicitly market values. For example, produced expandable inputs should be valued at the cost of purchasing the input from off-farm. Similarly, capital services provided by the owners of a given enterprise should be valued at the cost of obtaining these services from an alternative source in an arm's length market transaction [2].

2.2 Annual equivalent cost

When overall plant cost estimation is required, inspecting individual annual costs is of little use because some operations are not performed regularly and uniformly year after year and therefore, annual costs may differ through time over the plantation life. Additionally, the productivity of the plantation may differ from year to year. For example, the cultivation of perennial energy crops is characterised with high cost for the establishment year and lower annual costs for the rest of its productive life. They are also characterized of low yield at the beginning of their productive life and increased productivity in later years.

Consequently, cost estimation could be carried out either for every individual year or for a typical year when the crop reaches its maturity. The first approach leads to results that are not very useful and are difficult to use for comparison among plantations. On the other hand, the second approach is not taking into account the establishment (initial investment) cost, which usually is a substantial cost element.

From the economist's point of view, the overall approach is to estimate the average cost over the whole economic life of the crop, which allows direct comparisons among different crops. This approach should include the initial investment cost and should also take into account the time value of money. In such cases, the overall cost estimates should be calculated as *annual equivalent costs,* i.e. costs that express lifetime averages incorporating the time value of money [3]. To calculate the annual equivalent cost, the present value of all costs over the useful life of the plantation is transformed into an equivalent annuity with the payment of which is equal to the annual equivalent cost for the same period.

Given a discount rate (d) and the plantation useful life (n),

$$Annual\,Equivalent\,Cost = \frac{PV \times d}{1-(1+d)^{-n}}$$

where

$$PV = \sum_{t=0}^{n} TC_t \times (1+d)^{-t}$$

and TC_t is Total Cost of plantation in year t, *year zero being the investment year.*

2.3 Financial analysis

Financial analysis is concerned with the measurement of performance against set targets on every aspect of the project. It identifies the *efficiency of use of resources* and provides the tools of improving overall performance. It also measures the effectiveness of management in mobilising the factors of production for the achievement of financial goals and supports the search for improved approaches.

Financial analysis of biomass production requires three easily identifiable steps. The first is *Farm Income Analysis*, based on Balance Sheet and Profit & Loss items. This is based on an opening Balance Sheet and Farm Budgets projecting income and expenses for the following years. The second step consists of the estimation of future Balance Sheets based on Farm Income forecasts and on assumptions regarding the timing of receipts and payments [4]. This step identifies *project related future Cash Flows*, which can be achieved either directly (based on timed receipts from sales minus payments for purchases and expenses) or indirectly (based on income before depreciation plus changes in Working Capital). The third step is *Farm Investment Analysis* utilises Cash Flows from step two to estimate the attractiveness of the project, by comparing future net inflows against initial investment requirements [3], [5], [6], [7].

Subsidies are sometimes granted in order to support current agricultural policies. These are temporal cash injections, influencing production decisions, but external to the financial mechanism and identity of production. However, subsidies are scrutinising the real economic characteristics of production and impair the most important financial indices. It is important to isolate the effect of subsidies by entering these amounts at the bottom of Income Statements, in spite of common practice which requires subsidies to be added to income from sales in order to calculate total income.

Cash flows are based on product sales and sales terms, possible subsidies and production expenses (fixed and variable) including overheads most of which are not paid "cash". Average *inventory-, receivables-* and *payables- days* need to be supplied for the estimation of cash flows.

Project evaluation or *Investment Appraisal* is based on project related Cash Flows. By applying Discounted Cash Flow methods, it compares the present value of the benefit from future inflows against the cost of the investment required. There is a large number of net investment criteria and huge amount of bibliography on the subject [3], [5], [6], [7]. For practical reasons at least three indices must be estimated, namely, *Net Present Value, Internal Rate of Return* and *Payback Period.* The choice of appropriate discount rate is a complex task, but very important for the appraisal. Good financial accounting textbooks explain the job in detail [8].

Systematic Risk is usually handled by some kind of agricultural insurance, but it is more difficult to defend against Unsystematic Risk, especially in the agricultural production sector, which is in general less informed than industry and commerce. Discount rates may be increased appropriately in order to express anticipated risk levels.

For project evaluation purposes involving alternative use of the same land, the cost of land can be excluded, since it is a common cost item in both the "with" and "without" the project situations. Under special circumstances, when farmers are partners in agricultural cooperatives, it is possible to contribute to the Balance Sheet with e.g. the use of their land, in which case the cost of land may be regarded as the return on their contribution to the project.

2.4 Input data

The economic analysis of energy crop production consists of the cost and revenue analysis of all agricultural production stages. Full economic analysis of biomass production requires the use of detailed and reliable technical and economic data that concern agricultural production and sales.

The agricultural data is categorised as following:

- *General financial data* that concern a region or the whole country, for example currency, borrowing rates, discount rate etc.
- *Agricultural project data*, such as total occupied land, cultivated land etc.
- *Crops details*, such as economic life, yields and other data concerning every individual crop.
- *Production factors databases* about agricultural land, equipment, labour and raw materials.
- *Operations details* that conclude operation timing and needs.

3 BEE (BIOAMASS ECONOMIC EVALUATION) - BRIEF MODEL DESCRIPTION

BEE is a model, developed by the Laboratory of Agribusiness Management, Agricultural University of Athens, in order to perform full economic analysis of energy crops production. The model is composed by two main modules that may operate independently. The cost analysis module performs cost estimation of biomass cultivation, both by activity and by input factor of production. The financial module performs financial analysis, in the form of industrial accounting and investment appraisal, based on estimated future balance sheets, financial results and expected cash-flows.

The model may analyse annual and/or perennial energy crops. It can also be used to analyse a single plantation or combination of crops.

Some of BEE features are the following:

- It is a standard MS Win XP application with internet support (http://www.bee.aua.gr).
- It performs detailed monthly monitoring of operation needs (labour, raw materials, and machinery including fuel consumption) and activity levels.
- The model carries out full economic analysis by agricultural operation/activity (Activity Based Costing) and by factor of production. The estimated cost is reported by ton, by hectare, etc.
- BEE performs full financial analysis in standard accounting form. The model creates all principal financial statements (Balance Sheets, Income Statements and Statements of Cash Flows) for every crop and for the whole project.
- BEE identifies all relevant cash flow of each crop in order to evaluate projects incorporating more than one crop.
- The model has easy to understand input forms and reports. It may also extract input data and reports to MS office applications (MS Excel and MS Word).

4 COST ANALYSIS OF ARUNDO AND MISCANTHUS

BEE has been used for the cost analysis *of Arundo donax* L. (Giant Reed) and *Miscanthus x gigantheus*. The data used was a refinement of (a) actual data collected from project "Bioenergy chains[2]" experimental fields in Northern Greece, (b) research data collected from earlier work in Greece and the literature (e.g. [9] and [10]), as well as (c) data from other sources (experts, agricultural engineers, agricultural economists, agricultural organisations etc).

4.1 Cost of production of *Arundo donax* L.

The economic analysis of Giant Reed was based on the experience of cultivation of a 9 ha field, established in March 2002 in northern Greece (Xanthi). The economic life of Giant Reed is anticipated to 15 years. The crop starts to produce one year after establishment (first year of its economic life). The dry yield of the first production year is about 2 tons of dry biomass per hectare. Giant Reed reaches full productivity about four years after establishment, where yield is about 19 tons per hectare. The life-span average yield of the crop was calculated at 15.6 dry tons/ha/yr.

According to the analysis, the total production **cost of Arundo per cultivated hectare** is about **1,200 €** and the **cost per dry ton** is **77 €**.

The cost by factor is:

- 10% Labour
- 15% Mechanical equipment
- 25% Raw materials and
- 40% Land

It has to be noted that the cultivation of Arundo is mechanised. About 90% of the labour cost reflects the operators' cost and only 10% represents unskilled labour cost. Expensive irrigated land is necessary for Arundo.

The detailed cost analysis of Giant Reed production (see Table 1) shows that the cost of land is the highest cost element, accounting for about 40% of total cost of production. The high cost of land is due to the fact that Arundo cultivation in Greece requires high rent *irrigated* land.

Among all cultivation operations, planting, including cost of rhizomes is the most demanding and represents about 20% of total cost, although it takes place only once, at the establishment period. Planting cost is so high mainly because of the high cost of arundo rhizomes and because it is a labour intensive operation. Harvesting is performed annually and is a fully mechanised operation. It represents about 10% of total cost.

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[2] Contract No: ENK6-CT-2001-00524

Table 1: Cost of Giant Reed production, performed by own means, break down by major operations*

Operation	**Cost per cultivated ha (€)**	**Cost per dry ton (€)**	**%**
Planting	242	15.50	20%
Irrigation	85	5.42	7%
Fertilisation	68	4.34	6%
Weed control	22	1.43	2%
Harvesting	117	7.47	10%
Other operations	56	3.60	5%
Cost of land	*500*	*32.05*	*42%*
Overheads	*109*	*6.97*	*9%*
Total Cost	**1,198**	**76.78**	**100%**

Total area: 9 ha, Cultivated area: 8,28 ha
**Annual equivalent cost*

4.2 *Miscanthus x giganteus* cost of production

The cost analysis of Miscanthus was base on experimentation of a 5 ha field, established in March 2003, in Northern Greece (Orestiada – Fylakio). The economic life of Miscanthus is also about 15 years. Crop's productivity is low in the first year after establishment, (about 4 tons of dry biomass per hectare). Three years after establishment, the plantation reaches its maximum productivity, which is about 15 dry tons/ha. The overall average yield of Miscanthus (13.1 dry tons/ha/yr) is a little lower than the one of Arundo.

The cost analysis of Miscanthus production has shown that **the cost per cultivated ha of Miscanthus is about 1,200 €**, which is the same as with Arundo. However, **the cost per dry ton** is **91 €**, higher than Arundo, due to lower annual productivity.

The cost distribution of Miscanthus by production factor is similar to Arundo. In particular:

- 10% Labour
- 20% Mechanical equipment
- 20% Raw materials and
- 40% Land

Miscanthus cultivation is also fully mechanised and so 80% of the labour cost reflects the remuneration of machine operators and the rest represents unskilled labour cost.

Like Arundo, the cost analysis of Miscanthus production (see Table 2) shows that the cost of land is the highest cost element and represents a percentage of about 40% of total cost of production. The high cost of land is also explained by the fact that Miscanthus is also cultivated on irrigated land.

Among all operations, irrigation (establishment and annual) is the most costly, with a share of 13% of total production cost. Harvesting accounts for about 10% of total cost, because of need of expensive mechanical equipment. It has been estimated that Miscanthus planting, (unlike Arundo planting), is only a small percentage of total cost (7%). This is because the cost of Miscanthus rhizomes is very much lower than the cost of Arundo rhizomes.

Table 2: Cost of Miscanthus production, performed by own means, break down by major operation*

Operation	**Cost per cultivated ha (€)**	**Cost per dry ton (€)**	**%**
Planting	85	6.50	7%
Irrigation	161	12.24	13%
Fertilisation	68	5.15	6%
Weed control	98	7.46	8%
Harvesting	117	8.87	10%
Other operations	60	4.52	5%
Cost of land	*500*	*38.05*	*42%*
Overheads	*109*	*8.27*	*9%*
Total Cost	**1,197**	**91.06**	**100%**

Total area: 5 ha, Cultivated area: 4,60 ha
**Annual equivalent cost*

5 CONCLUSIONS

BEE has been extensively used for the estimation of costs and returns of various bioenergy plants in Greece and elsewhere. Collection of data required for the model is laborious, but it guaranties to a great extend the validity of economic analysis. The use of BEE is greatly facilitated with the supply of previously collected data stored into BEE data banks. Such data refer to input values, which are more or less common for different locations, soil and climatic conditions, etc., such as cost of equipment, requirements for most of the operations etc.

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