TECHNICAL-ECONOMIC AND FINANCIAL ANALYSIS FOR RENEWABLE ENERGY CHAINS: THE CASE OF BIO-ENERGY

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EXTENDED ABSTRACT

We are all familiar with current environmental deterioration and problems due to a large number of factors. Some of the most important pollutants are generated in conventional energy utilisation (fossil primary energy). Additionally, one of the strategic objectives of EU's White Paper on Energy (European Commission 1997) is to increase the contribution of renewable energy sources to 12% of the EU's gross inland energy consumption, by 2010. In this field, biomass based energy is regarded as a significant potential contributor towards the reduction of pollution caused by extended use of fossil fuels. Biomass crops are an important source of energy biomass. In comparison to conventional crops, perennial energy crops have lower input requirements and their cultivating techniques are more environment friendly.

Although today biomass energy does not contribute economically to more than a small fraction of energy requirements, institutional and governmental support can both increase its usage and accelerate cost reduction along the learning curve. Towards such goals, researchers develop models of technical and economic analyses of energy crops production, by adding up production and conversion costs.

In this work we present some methodological aspects of an extended economic model which is being developed. It includes the usual technical-economic analysis and more features such as:

- Detailed monthly monitoring of the various types of labour and machinery used, the amount of energy consumed as well as a detailed amount of all required chemicals
- Full financial analysis in the form typically adapted by industrial accounting today for decision making and the development of strategic plans. This analysis is based on estimated future balance sheets, financial results and expected cash-flows
- Identification of relevant cash-flows for investment appraisal, using the findings of the financial analysis.

It is logical that through rigorous financial analysis of energy crops production and conversion, the model will not only face this option on a practical and pragmatic base, but it will also provide a very useful decision making tool to the investor (state/public or private). The model presented in this paper attempts to bridge the gap between academic research and industrial feasibility and is intended to be used for the preparation of integrated business plans ready to be discussed on financial terms. Need for possible subsidies as well as externalities can be easily identified and added to the basic model results.

It is expected that such models, i.e. models that express actual market reality, can provide a very useful and solid basis or first step to a more elaborate treatment of renewable energy sources (such as for example biomass), aiming at a more intensive effort towards the estimation of the potential of technologies of energy production friendlier to the environment.

Key words: Biomass, Bio-energy, Economic Modelling, Energy Crops, Environment

1. REVIEW OF SOME BIOMASS PRODUCTION-CONVERSION MODELS

In our days, researchers develop and use models for cost estimation and investment appraisal of biomass production and conversion, for the economic analysis of bio-energy production. Some of the existing models perform simple economic analysis of various bio-energy schemes. More specifically, they perform cost estimation by adding up cost elements of biomass production and conversion. Sometimes, they perform limited investment appraisal by calculating some investment indicators, usually Net Present Value (NPV) and Internal Rate of Return (IRR). Many times the user does not have full accessibility on technical and economic parameters of these models. Unfortunately, the simplicity of economic analysis of the models limits their usefulness for the user and especially for the investor (state/public or private).

For an analytical economic analysis of bio-energy production detailed modelling is needed. Most of the times, the user of a bio-energy economic model needs to adjust the techno-economic parameters of the model according to the particular conditions of the examined site. Also, besides cost analysis, the user needs to carry out sensitivity analysis and scenarios investigation of bio-energy projects. For this purpose, an economic model should give the user control over most technical and economic parameters used by the model.

The problem of more detailed models is that they are less friendly for the user. The best way to face this problem is to provide the user with all the needed data and give him the opportunity to intervene and introduce his own data. The more familiar the user is with the problem, the more credible the results of the model will be.

BIOSEM, RECAP, BEAM, BIOCOST, BEAVER, MULTISEES are some economic models, developed by research institutes in Europe and the USA, that carry out cost, technical, environmental and social analysis of bio-energy chains.

BIOSEM (Biomass Socio-economic Multiplier) is a model using socio-economic technique to capture the employment and income effects of bio-energy projects (ETSU 1998). The first step of the programme is to examine the economic viability of feedstock production and conversion process. The financial analysis of the programme is limited and offers to the investor only a basic appraisal approach.

RECAP (Renewable Energy Crop Analysis Programme) analyses all aspects of producing energy from energy crops (Moore 1996). It models all costs involved from energy crop production, harvesting, storage, transport and conversion. The model calculates cash flows and undertakes an investment appraisal by calculating NPV and IRR for both the farmer and the conversion plant operator.

BEAM (Bio-energy Assessment Model) is an Excel spreadsheet model for techno-economic assessment of a) biomass to electricity and b) biomass to ethanol schemes (Robertson 1998). BEAM covers particular types of feedstock, conversion technologies and energy products. It is a typical model for cost analysis but does not perform investment appraisal of bio-energy schemes. The user has only partial intervention facilities on input data.

BIOCOST (Bio-energy Crop Production Cost Model) is an Excel-based programme that can be used to estimate the cost of producing hybrid poplar and switchgrass in seven regions of the United States (Walsh 1996). The model assumes default values for many parameters, such as combinations of machinery, establishment and cultivation techniques, planting densities, etc.

BEAVER (Biomass Economic Appraisal & eValuation ExpeRt) is an investment appraisal system for the economic evaluation of biomass cultivation (Agricultural University of Athens 1996). Its knowledge data bases currently hold detailed information about three biomass crops, namely sweet sorghum, poplar and willow. The model also uses genetic algorithms to identify optimal values for externally determined parameters.

MULTISEES is a multiple criteria decision making tool (GIS-based) for the analysis of integrated bio-energy systems in rural region in Southern Europe (Rozakis 2002). The model covers the integration of four different energy species (*Cynara cardunculus, Miscanthus, Robinia and Eucaliptus*) and analyses four technologies of energy conversion (Fixed bed plus steam turbine, Fluidized bed plus steam turbine, Fluidized bed plus gas turbine and Combined heat and power). The model uses three different categories of default values (fuel parameters, technological parameters and economic parameters) that limit its flexibility.

2. PROJECT APPRAISAL METHODOLOGY

The purpose of the methodology proposed in this text is to encourage agricultural economists to adopt some aspects of financial analysis as it is commonly used in industry and commerce. This will not only improve its effectiveness, but will also facilitate investment decisions, usually based on well established investment appraisal methodologies[1].

The most important objective of financial analysis of bio-energy chains is to *asses the financial impact* of projects on the farmers and enterprises involved, as well as any others who may be affected by the project. This is achieved by analysing all costs and benefits due to the project and by forecasting them into the foreseeable future, in order to project the net financial effect on all actors involved. In most cases financial analyses are based on some form of computerised mathematical modelling for profit and cost calculations and investment appraisal (Gittinger 1984, Drury 2000).

A second equally important objective of financial analysis is the *preparation of financial plans or scenarios*. These financial or business plans are somehow indirectly obtained while in the process of assessing the impact of the project or, to put it another way, they are the means through which project financial assessment is usually made.

Financial analysis is also 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 bio-energy chains 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 (Needles 2002). 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*

[1] The methodology described in this section has being implemented in the AGRICOST model of the Laboratory of Agribusiness Management of the Agricultural University of Athens.

Analysis utilises Cash Flows from step two to estimate the attractiveness of the project, by comparing future inflows against initial investment requirements (Bierman 1993 and Gittinger 1984).

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 financial analysis, these items should be estimated at their opportunity cost and be included in cost analysis, in order to identify net income attributed to the project.

The proposed methodology demands the decomposition of the project into a number of *operations* which sufficiently describe all required jobs 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 requirements for *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.

Mechanical equipment may be hired if own machinery is insufficient or non existent. When hired, its cost is equal to the rent paid; otherwise its cost is the sum of depreciation, maintenance, 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 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. 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.

Labour is usually provided by the farmer and his family, but it may also be hired, especially during peak labour demand, e.g. 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.

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

Cash flows are based on product sales, possible subsidies and production expenses including overheads most of which are not paid “cash”. *Inventory, receivables* and *payables days* need to be supplied for the estimation of cash flows. They are reflected in Balance Sheet items.

Project evaluation or *Investment Appraisal* is based on project related Cash Flows. By applying Discounted Cash Flow methods, it is comparing the present value of the benefit from future inflows against the cost of the investment required. There is a large number of investment criteria and huge amount of bibliography on the subject. 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 (e.g. Dickerson 1995). 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.

3. BRIEF MODEL DESCRIPTION

Based on the above methodology for the economic analysis of bio-energy chains, the Laboratory of Agribusiness Management is developing AGRICOST model, for cost analysis and investment appraisal of annual and/or perennial crop production, specializing on energy crops. The goal of the model is first to estimate the production cost of biomass at farm gate for different locations and secondly to examine the attractiveness of investing the farmer's land in biomass production. It can be used to analyse a single plantation or some combination of crops. Thus, it may analyse a farm with a number of different plantations, or various biomass crops grown in different farms, etc.

The model comprises five different sections combined into one economic module.

1. *Input*: Supplies the data required for the analysis.
2. *Detail*: Data transformations and calculations of the necessary magnitudes for economic analysis. Basic cost analysis is performed in volume terms (i.e. man-hours, machine-hours, kilos, litres, etc.)
3. *Cost*: This section calculates cost details, by factor and by activity or operation (volumes x prices = values).
4. *Financial*: Estimates of future Profit and Loss Statements, Balance Sheets, and Cash Flows.
5. *Investment Appraisal*: Incorporates Investment Appraisal analysis and criteria useful for the determination of the attractiveness of the investment.

The required input consists of a number of small external databases and a few information tables that fully describe the biomass production process.

Table *Crops* holds information about all cultivated crops, their average life and selling price. Another table, named *Harvesting Quantities* gives the user the opportunity to record volume of production that usually differs from year to year.

Land records cultivated area that is distinguished in to own and hired area. This database contains also data about purchasing cost and land rent. *Labour* consists of the three labour types (skilled, operator, unskilled) and the hourly and yearly labour cost of each type. The *Raw Materials* table describes all the needed raw materials and their corresponding prices. In the *Fuels* table, the user provides information about the required fuels and their prices. Fuels are recorded separately from other raw materials because this will facilitate the estimation of energy balance.

The *Machines* database provides information about mechanical equipment which is used for the operations of the cultivation. The data consists of the machinery name and description, purchasing cost, average life, average yearly operation, maintenance and depreciation cost, etc. Some of the information is provided by the user and the rest is calculated by the model (e.g. depreciation cost, replacement periods, etc.). It is possible that some pieces of equipment (e.g. plough) may be required only once in the case of perennial crops. However, under the assumptions, (a) that the farmer is cultivating biomass only in a small part of his land and (b) that he allocates to biomass only part of the cost of commonly used machinery it could be assumed that the farm can provide the required machinery at normal cost.

The *Subsidies* table provides information for situations involving subsidies per hectare or per tonne of production or lump sums.

The *Operations* database is separated into a number of necessary operations for every biomass crop under examination. It holds information about the timing and frequency of every operation. Each operation is characterised by its requirements for labour, equipment and raw materials. It also determines if the operation is done with own factors of production or is hired and calculates the total cost of every hired operation.

The model incorporates a table that records *Fuel Consumption* of machinery used, according to the operation performed. This is needed because fuel consumption differs from operation to operation. For example, the tractor's consumption for ploughing is higher than its consumption for spraying. With these data, the model has the ability to estimate total fuel consumption, a very important element for further environmental analysis.

For a complete cost and financial analysis an initial *Balance Sheet* is needed. Also, for the evaluation of the project, its cash flows should be identified. For this reason, a table named *Financial Performance Indices* records the inventory months, the days or months receivable and the days or months payable.

The model carries out all necessary detailed calculations for the economic analysis. Monthly quantities of labour, machinery, raw materials and fuels required for each operation of each crop are estimated in section *Detail*. Total financial cost of production is calculated and distinguished by crop, by operation and by production input. Based on the seasonality of harvesting, the model calculates monthly net sales. All this detail is accessible by the user so he could use any of this for further analysis.

The basic *Cost Analysis* section includes two main tables a) the *Direct Cost by Factor* table that summarises total cost by production input for each year, including the investment year and b) the *Direct Cost by Operation* table that summarises total cost by operation for each year, including the investment year too.

The *Financial Analysis* part of the model includes the *Profit & Losses Account* that summarises Income and Expense in the usual financial form which is common in all businesses today. Given a selling price for each of the crops included, it calculates all lines of Profit & Losses by crop and by year, excluding the investment year which is the year of the establishment of the crops (the cost of which has been included in the opening Balance Sheet). Also, there is a series of monthly Balance Sheets that give the user the opportunity to check the levels of all accounts.

Finally, the model performs *Investment Appraisal* of the project. The *Cash Flow Statement* is the first table of this section. Cash flows are estimated internally based on changes in *Balance Sheet* items after utilising the information supplied by the user regarding inventory days, receivable days and payables days. The basic investment appraisal indices are calculated from the Cash Flows of the project. Cash from operations, from investments and from financing are estimated separately, in order to evaluate the investment with or without the effect of financing (loans and repayment). Except from the basic *Investment Appraisal Indices* (Net Present Value, Internal Rate of Return and Payback Period), a NPV parametric analysis is performed for various interest rates.

The AGRICOST model performs full and detailed economic analysis of energy crop production. It gives the user the opportunity to perform sensitivity analysis and "what if" investigation by modifying any of the primary data. The user may examine the farmer's financial position "with" and "without" the project. He may also compare the production of conventional and biomass crops.

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