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05-00: Economics of Bioenergy

05-00-01 Components of Bioenergy Projects

Bioenergy projects can be considered to be different to many other renewable energy projects as careful consideration has to be given to the entire energy system (fuel supply, fuel processing, energy conversion, residue management etc) to ensure that the project is financially viable. In the majority of cases the fuel or raw material has to be harvested or gathered, transported and processed before being converted into energy. In addition, there are typically end products which have to be disposed of or utilised in another way e.g. ash from a combustion process. It is therefore important that a systems approach is taken when considering the financial viability of bioenergy system.

The approach taken in the following chapters therefore will be to consider the elements to be considered in the fuel/raw material component of the system and then the cost for the bioenergy plant. Where relevant, case studies will be presented. It is important to note that costs for labour, taxes, land etc will vary considerably from country to country with Europe and therefore an approach of presenting percentage breakdowns of the relevant components will be taken.

Firstly however the basics of financial appraisal will be introduced.

05-00-02 Financial Appraisal – the theory

Financial appraisal of a potential project is an important skill to develop. The more thorough your own appraisal of your project, the more likely you are to convince a lender or funder to give you money. To produce a cash flow statement for the proposed project you will require information on Initial Costs, including Capital Expenditure, Annual Costs and Debt Payments, Periodic Costs, Savings or Income and Funding Sources. Producing a cash flow statement is vital to allow completion of Financial Appraisal tools such as simple payback, Internal Rate of Return (IRR) and Net Present Value (NPV).

05-00-02a: Income and Expenditure

Initial and Capital Expenditure Costs could include the following:

- Feasibility studies
- Development costs (e.g. Power Purchase Agreement (PPA) & planning permissions)
- Engineering costs (e.g. design)
- Development contributions
- Renewable energy equipment
- Balance of plant (e.g. civil works, grid)
- Miscellaneous (including contingencies).

For most renewable energy systems the capital costs are significant and are the most important component in any calculation.

05-00-02b: Annual Costs

Annual Costs can be divided into operation & maintenance (O&M) costs, fuel and electricity costs and debt payments. In many cases these costs have to be spread over the life time of the project e.g. 25 years and the costs need to be covered every year from the annual income.

- O&M costs include land lease, insurance, operation, maintenance (parts & labour), community contribution and administrative costs. O&M costs are spread over the length of the project lifetime.
- Fuel and electricity costs for some renewable energy projects can be significant. For bioenergy projects, the cost of fuel can be a major component of the annual costs (e.g. purchase of wood chips) and a bioenergy plant may have a significant electricity demand (e.g. for operation of augers, pumps).
- Debt Payments will reflect your decision as to what percentage of initial costs will be funded by equity and what percentage by debt. Your debt payments will depend on the debt interest rate and the term of the debt.

Hint:
In Microsoft Excel, the 'PMT' standard spreadsheet function calculates the payment for a loan based on constant payments and a constant interest rate. In this case it is assumed that payments are made annually, at the end of the year and do not include any bank fees.

The following formula returns the annual payment on a €200,000 loan at an annual rate of eight percent that you must pay off in ten years:
PMT (0.08, 10, 200000) = -$29,805

Periodic costs are costs that recur on a predictable cycle, for example fire bricks for a wood-fuelled heating system (refractory insulation).

05-00-02c: Determining Savings Or Income

Savings or Income include both the avoided costs of energy purchase where heat / electricity / fuel are used to self-supply, and income earned from selling heat / electricity / fuel to a third party. In most cases you will be comparing the savings from using a bioenergy system to that of the existing system or a default system e.g. wood heating being compared to oil heating or AD CHP to oil heating and electricity supply from the grid. It is important therefore to have a good knowledge of the baseline system which you are comparing against so that your results are valid.

Income for a bioenergy project can come from a number of sources. Examples include:

- Sale of heat from a biomass plant to a client or via district heating system
- Sale of electricity from power plant. This is typically sale of electricity into the National Grid. In many countries the sale of electricity is done via a Power Purchase Agreement (PPA). The PPA is made with a utility and normally guarantees the price per kWh of electricity sold for a particular period. The range of prices paid for electricity from a biomass plant varies considerably from country to country and you will need to check the national policy in this regard.
- Sale of electricity and heat from a Combined Heat and Power plant
- Sale of biofuels for transportation
- Sale of by-products e.g. digestate from an Anaerobic Digestion (AD) Plant
- Income from gate fees charged for raw materials e.g. fish waste into an AD Plant
- Carbon Credits generated from avoided CO_2 emissions. In some countries projects can generate sell the carbon savings from the project into the Carbon Trading system. Carbon is traded on the markets with considerable ranges in prices (€1 to €30/Tonne CO_2)

Examples of savings could include:

- Avoided cost of fossil fuel purchases as heat is now supplied from biomass plant
- Avoided cost of waste disposal as waste is now used as raw material in biofuel production
- Avoided cost of artificial fertiliser which is now replaced with digestate from AD plant
- Avoided cost of electricity purchase from the grid as CHP plant supplies on site demand.

05-00-02d: Cash Flow Statement

Knowing your income and expenditure, it is possible to produce a cash flow statement that brings all of the above information together. This summarises the figures over the length of the project lifetime e.g 25 years. A simple cashflow statement might look like this

Year	**0**	**1**	**2**	**3**	**.....**	**25**
Equity investment	**37 197**					
O&M:		3 960	3 960	3 960		3 960
Inflation:		79	160	242		2 537
Total O&M		**4 039**	**4 120**	**4 202**	**.....**	**6 497**
Fuel/electricity:		21 665	21 665	21 665		21 665
Inflation:		433	875	1,326		13,879
Total fuel/elec.		**22 098**	**22 540**	**22 991**	**.....**	**35 544**
Debt payments		**22 174**	**22 174**	**22 174**	**.....**	
Periodic costs:						
Inflation:		Periodic costs occur only in years 7, 14 and 21				
Total periodic costs						
Total costs	**37 197**	**48 311**	**48 834**	**49 367**	**.....**	**42 041**
Savings:	0	126 224	126 224	126 224		126 224
Inflation:	0	2 524	5 099	7 726		80 860
Total saving (“*income*”)	**0**	**128 748**	**131 323**	**133 950**		**207 084**
Income less expenses	**-37 197**	**80 437**	**82 490**	**84 583**	**.....**	**165 043**
NPV	**1 003 664**					
IRR	**219 %**					

Example of a Cash Flow Calculation

05-00-03: Financial Appraisal methods: Tools (Payback, NPV, IRR)

Financial Appraisal tools such as Payback, Net Present Value (NPV) and Internal Rate of Return (IRR) will facilitate decision making and provide an assessment of whether an investment is worthwhile. These figures are important to be able to present to decision makers e.g. local authorities, funding agencies, banks etc so that they can be assured that the project is viable and worthwhile supporting or investing in. Appraisals can be done in 'real' terms (inflation not included) and in 'nominal' terms (inflation included).

05-00-03a: Payback Period

Payback period is the simplest appraisal approach, but it has disadvantages. It calculates the number of years to recover the initial cost. The payback period equals initial costs divided by net annual savings, calculated below.

Payback = Initial Costs / Net Annual Savings

Year	**0**	**1**
O&M costs		3 960
Fuel/electricity costs		21 665
Total costs		**25 625**
Savings on cost of oil	**0**	126 224
Cash flow or Net Annual Savings		**100 599**
Initial Costs	**185 984**	
Simple Payback Time	185 984/100 599	1.85 years

05-00-03b: Net Present Value

In practice, using Payback Period as an appraisal tool can be too simplistic. For example, Payback Period does not consider cashflows after the end of the simple payback time. It also ignores the differences in the value of money over time. These differences in value can be due to a number of factors including inflation, the level of risks in a project and society's 'time preference' for receiving money, goods and services now rather than later.

Net Present Value (NPV) applies an appropriate discount rate to a series of future payments (negative values) and income (positive values) with the starting investment designated in the 'zero year'. Applying the discount rate converts all costs and benefits to 'present values'.

Choosing the discount rate is important as it is a significant variable in the analysis. Some firms will have a weighted average cost of capital (after tax). This can be increased to allow take account of risk into the future. A variable discount rate with higher rates applied to cash flows occurring further along the time span might be used to reflect the yield curve premium for long-term debt.

Another approach to choosing the discount rate factor is to decide the rate which the capital needed for the project could return if invested in an alternative venture. If, for example, the capital required for Project A can earn five percent elsewhere, use this discount rate in the NPV calculation to allow a direct comparison to be made between Project A and the alternative.

Hint
In Microsoft Excel the NPV standard spreadsheet function calculates the net present value of a cash flow statement. The NPV formula would be written in Excel as:

= Year 0 Net Cash Flow + NPV (Discount Rate, Sum of Year 1 to 25 Net Cash flows)

This NPV figure should then be compared to that of other investment options to help decide on a particular course of action. Sensitivity analysis is advisable to determine which parameters have the greatest impact on the NPV. The selection of the appropriate discount rate is complex and expert advice should be sought.

If...	It means...	Then...
NPV > 0	the investment would add value to the firm	the project may be accepted
NPV < 0	the investment would subtract value from the firm	the project should be rejected
NPV = 0	the investment would neither gain nor lose value for the firm	We should be indifferent in the decision whether to accept or reject the project. This project adds no monetary value. Decision should be based on other criteria, e.g. strategic positioning or other factors not explicitly included in the calculation.

05-00-03c: Internal Rate of Return

Internal Rate of Return (IRR) is closely related to NPV in that IRR is the discount rate that meets the condition NPV=0. In other words IRR is the discount rate with which the discounted net income of the project is equal to the starting investment. Options with higher IRRs are generally better but NPV and other analyses should also be used to supplement the IRR approach.

An advantage of IRR as an appraisal tool is that (unlike in NPV analysis) a specific discount rate does not have to be chosen. A disadvantage of IRR is that analysis of a project whose cashflow changes from negative to positive more than once over the project's lifetime can return multiple IRR values, thus hindering decision making.

05-00-03d: Costs and Pricing Strategies

The range of scenarios in which a bioenergy project can be developed is significant. Some projects will be stand alone development on a green field site where costs or income do not have to be apportioned out to different areas or business units.

However, there are many cases where a bioenergy project is an additional business development for an existing enterprise or business. A farmer decides to start producing straw briquettes using his existing material, a biomass DH plant develops into a biomass CHP plant or a sawmill develops a wood pelleting plant. Where such a situation occurs consideration needs to be given to how the costs and income are split between the different units of the business.

Taking the example of the sawmill starting to produce wood pellets. It is likely that the pellet production plant will be designed provide heat to the sawmill for timber drying and the plant will avoid costs associated with disposing of waste which is now converted into pellets. The costs associated with the development of the pellet plant could be split to reflect the portion of the costs relevant to the 'core' sawmill business and the 'new' pellet business. Similarly the farmer or farmers cooperative which invest in new harvesting machinery to maximise straw harvesting should consider whether the full cost of the new equipment should be applied to the briquettes enterprise or some applied to the farming enterprise.

For initial analysis splitting cost or income can be ignored but as the project proceeds further into financial analysis this issue should be considered.

05-00-04: Financial Appraisal tools

There are a wide variety of tools available which can be used for assessing bioenergy projects. One which has international appeal is the RETScreen model developed by Natural Resources Canada. It is available at www.retscreen.net and can be used to complete a pre-feasibility analysis of a particular project.

Other tools may be available in your own country. Check your National Energy Agency or National Bioenergy Association.

05-00-05: The Bankers View

The following are key points extracted from a presentation by Tom Bruton, Bioxl, Ireland. These notes were developed based on output from by Deutshe Bank, Paul Batelle, Director Renewable Energy Asset Finance & Leasing. While all bioenergy projects may not be financed using the project finance route the process of considering the issues and risks identified is a valuable one to put your project through.

When analysing biomass projects for credible, capable and creditworthy sponsors, banks will focus on five key areas

- Feedstock supply
- Feedstock storage, transportation, handling and treatment
- Biomass conversion to energy (gas, electricity or heat)
- Construction risks
- Energy offtake contracts

Generally banks will want a minimum of four of these five elements to be fully proven with reference projects demonstrating a first class track record.

Feedstock supply

"With biomass feedstock markets becoming increasingly dynamic, a project's visibility on the availability and pricing of feedstock is essential

- *Long term fixed priced, fixed volume, calorific content assured contracts with investment grade counterparties are one solution*
- *Fully vertically integrated projects which control sufficient land to harvest the required feedstock are also broadly acceptable but may add additional complexity*
- *In some markets, tolling contracts, where price variability in feedstock can be passed through to the energy consumer, may also shelter projects from price risk*

Given the potential evolution of the biomass markets and recent commodity price volatility, these feedstock supply regimes must extend for the entire duration of the financing, if not beyond".

This highlights the need to consider carefully the fuel supply chain as part of your project and not only look at quantity, but quality of supply. Refer to columns 02, 03 and 04 in this handbook (i.e. chapters 02-00, -01…, 03-00, 03-01… and 04-00, 04-01 etc) for more details.

Feedstock storage, transportation, handling and treatment

"Large scale biomass projects are a logistics management exercise where cost control and feedstock quality can be major challenges

- *Simple logistics systems and contracts can significantly reduce project risk*
- *Oil prices feed into transportation and handling costs and can have a major impact on projects cash flow volatility*
- *Projects involving long distance transportation and complex storage strategies need quality control systems to ensure feedstock quality and delivery schedules*
- *With numerous processes, particularly in vertically integrated projects, capital expenditure and operating and maintenance estimates need to be very well thought through to establish a reliable base case*
- *Counterparties providing logistics services should have a proven track record and be easily replaceable at equivalent service level and costs"*

Many projects fail to put sufficient logistic management controls in place to deal with the safe storage, transportation and management of the fuel supply. Without such control additional cost variability will be introduced into the project e.g. dealing with excessive moisture in wood chip and the cash flow of the project will be impacted.

Biomass conversion to energy (gas, electricity or heat)

"Conversion technologies vary widely in their readiness for project finance

- *In general, for a technology to be suitable for project finance, it needs to already be in full scale commercial operation at reference sites and have a demonstrable and verifiable track record at these sites*
- *Technology suppliers with a strong balance sheet and a proven track record of standing behind their technology (instead of hiding behind their warranty) can be essential*
- *With complex processes involving multiple conversion steps (biomass to gas to power; biomass to pellets to power and heat) proving each step and the combined process can be challenging and requires technology providers to take on interface risk*
- *Ensuring the absence of a "feedstock quality" versus "technology performance" debate is essential"*

The technology that will be used to produce the energy (your income) needs to be proven with evidence that can show that it can meet the demands and requirements for the site/project. Given the significant impact that fuel quality can have on bioenergy conversion technology performance a clear process where the variability of output can be clearly linked to either fuel supply or technology performance is important.

Construction risks

"Bankable projects tend to require lump-sum turnkey date-certain EPC contracts with an investment grade contractor

- *The contractor needs to offer bankable support for timely completion and plant performance in the form of liquidated damages*
- *Multi-contracting with two main contracts, e.g. anaerobic digestion and power plant or boiler and steam turbine, may be possible with good contractors and interface management*
- *As the industry matures and project sizes increase, these challenges can become more manageable attracting larger EPC contractors and system integrators*
- *Insurance providers are emerging with insurance products such as delayed start-up insurance and warranty wraps"*

Larger bioenergy projects are complex construction projects which require significant control of risk and strong project management skills. Ensuring that the construction team have good communication processes in place will be vital to ensure that construction deadlines are achieved.

Energy offtake contracts
"Historically, power and energy projects that have taken unhedged commodity risk such as electricity price risk and biofuel-related price risks have performed poorly for banks
- *Feed-in tariffs have historically offered good certainty*
- *Green certificate systems have attracted investors with views on (and appetite for) future increases in energy prices*
- *Green certificate systems generally need long-term Power Purchase Agreements (PPAs) buying both power produced and certificates*
- *Banks may take small amounts of merchant price risk on projects with guaranteed dispatch and "market plus premium" type feed in tariffs or "price floor and percentage share" PPAs"*

For projects where energy offtake contracts are available banks clearly have a preferences for Power Purchase Agreement (PPA) type contracts which offer certainty and minimise risk. PPA's typically apply to power and CHP systems but there will also be heat supply controls associated with district heating systems.

Green Certificates are a mechanism where a value is assigned to the 'green' value of energy produced from the plant. This can relate to the CO_2 savings relative to a baseline fossil fuel or the average CO_2 emissions from electricity in a particular country. They are normally an additional payment on top of the fixed price agreed via the PPA.

Case Study – AD Plant
"Large scale project with key parameters well addressed
- *Vertically integrated project controlling sufficient land on long term lease and operating in partnership with landowners and regional agencies*
- *100% of feedstock supplied from within 40km of plant and residues go back to the farms*
- *Proven AD technology supplier and gas engine model*
- *Single bankable experienced EPC contract for both AD and power plant*
- *Fixed feed in tariff for a sufficient period to amortise fully the project financing"*