The environmental and social impacts of biofuels production: Total Cost Assessment of biomass utilization trials in Japan

L. Laurin[1,*], K.Hayashi[2], S. Uchida[2]

[1]EarthShift, LLC, Kittery, ME, USA
[2]National Agriculture and Food Research Organization, Tsukuba, Ibaraki, Japan
[*]llaurin@earthshift.com

Abstract

Pilot biofuels projects in Japan have allowed a better understanding of the actual land use, processing requirements, and economic impacts of biofuels. Through the use of Total Cost Assessment (TCA), this study looks at the costs and benefits of Japanese investments in biofuels production in order to determine whether the projects are sustainable. Total Cost Assessment allows the enumeration of uncertain events with their concurrent costs and benefits, giving a financial picture of the future of a decision that includes best case, worst case, and most probable ranges of return on investment. The methodology encourages assessment of economic, social and environmental impacts within the same framework, addressing all three pillars of sustainability. This study applies the methodology to two projects: one project focuses on fuel from waste bioproducts, such as animal manure, sludge, and food processing residues; the other focuses on fuel production from crops grown specifically for this purpose.

Keywords: biofuels, Total Cost Assessment, social impacts, Life Cycle Assessment

1. Introduction

For Japan, biofuels offer the potential to reduce dependence on foreign fuels, reduce greenhouse gas emissions, and support domestic farming. The National Food and Agriculture Organization has sponsored a number of pilot projects as feasibility studies, and to provide background information to assess the long term viability of these biofuels. This study uses Total Cost Assessment to investigate two of these projects from the perspective of economic, social, and environmental sustainability.

Any assessment method for biofuels must address certain concerns. First, it must be economically viable for the operator of the plant. If this basic need is not met, adoption of the fuel is unlikely. Stakeholders, such as the local community, affected farmers, and fuel users must be considered. An example in the energy arena is the negative response to wind turbines in some communities simply due to visual impact. Offensive odors, changes in waste treatment costs, and the viability of local farmers may also affect the outcome of the decision. Finally, there should be a political return on investment for Japan in terms of improved fuel security and reduced healthcare costs.

2. Biofuel production techniques

A pilot project located in Kanto produces methane, compost and fertilizer from agricultural wastes. High quality fertilizer and compost are saleable byproducts. New regulations for waste processing require the community to build facilities to handle livestock and food processing waste using either conventional approaches (composting and wastewater treatment) or new techniques such as that being developed in the pilot plant. Livestock farmers and food processors are ultimately unaffected by the decision; they will pay the same for their waste treatment under any scenario. Purchasers of fertilizer may be impacted, depending on the solution chosen.

A second pilot project, located in Hokkaido, produces ethanol from cover and feed crops. Raw materials include sugar beets, potatoes and poor quality winter wheat. Stakeholders include the ethanol plant operators, crop farmers, agricultural cooperatives, automobile drivers, automobile manufacturers, construction companies, gasoline retailers, agricultural machinery manufacturers, sugar and starch companies, and the community.

3. Total Cost Assessment

The Total Cost Assessment (TCA) methodology [1] was created by chemical and pharmaceutical manufacturers (Dow Chemical, Merck, and Monsanto to name a few) under the auspices of the American Institute of Chemical Engineers (AIChE) to take uncertain environmental and health costs into account in decision-making. TCA allows the enumeration of uncertain events with their concurrent costs and benefits, producing a financial picture of the future of a decision that includes best case, worst case, and most probable ranges of return on investment. TCA considers both internal (those borne by the company) and external (those borne by society) costs, to allow decision-makers to evaluate one or both aspects, as is appropriate. This aspect of TCA makes it ideal for use in governmental assessments as well, since it is ultimately governments that must deal with these external costs. Traditional decision-making focuses on direct and indirect costs that appear on the balance sheet; TCA defines three additional cost types: contingent liabilities, and internal and external intangibles (Table 1.)

Table 1. Cost types considered in TCA analysis with a description and examples for each. (Source: AIChE, [1])

Cost Type	***Description***	***Examples***
I. Direct costs (recurring and non-recurring)	Manufacturing site costs	Capital investment, operating and maintenance costs, labor, raw materials, and waste disposal costs
II. Indirect costs (recurring and non-recurring)	Corporate and manufacturing overhead costs; costs not directly allocated to product or process.	Reporting costs, regulatory costs, and monitoring costs
III. Future and contingent liability costs	Potential fines, penalties and future liabilities	Fines and penalties caused by noncompliance; clean-up, personal injury, and property damage lawsuits; natural resource damages; industrial accident costs.
IV. Intangible internal costs	Difficult-to-measure but real costs borne by a company	Cost to promote consumer acceptance; maintaining customer loyalty, worker morale, worker wellness, union relations, corporate image, and community relations.
V. Intangible External costs	Costs borne by society	Effect of operations on housing costs, degradation of habitat, effect of pollution on human health

3. Evaluation of the Biogas Project

During the assessment, a team of experts identified several risks and potential benefits. The first risk was that their would not be enough market for liquid bio-fertilizer. Should this scenario occur, the biogas operator would need to spend additional marketing dollars to increase demand. Similarly, if there was not enough market for the methane, additional marketing effort would be required. Other risks, such as clogging or other damage to equipment, or if animals become diseased and the products cannot be sold are handled on a strictly economic basis that may or may not be included in traditional accounting. Social aspects, such as the the community requiring odor control or limiting expansion due to the odor can also be handled within a strictly economic format. Because each scenario has an uncertainty associated with is, the results will reflect the likelihood of each cost occuring. Some scenarios idenfy potential benefits rather than costs, such as proposed regulation that may enable the sale of methane gas for power production at a higher profit and the potential that the use of the liquid bio-fertilizer would increase farmers' profits.

External intangible costs and benefits are more difficult to assess. By allowing wide ranges of probabilities and costs, these intangibles can be included and their impacts understood from a broad perspective. For example, if the soil analysis and fertilizer design program is not performed (or is ignored) fields may be over fertilized creating environmental burden (eutrophication). The cost of europhication was estimated by the cost to mitigate it: between 200 and 460 yen per kg/nitrogen [2]. By considering a wide range of over application between zero and 50% and the full range of mitigation costs, the model incorporates realistic future uncertainties.

Other external intangibles assessed included these benefits:

- Emissions from biogas vehicles are cleaner than from gasoline vehicles
- No net CO_2 release from biogas combustion (carbon neutral)
- Biogas is a renewable resource that will not deplete fossil fuel stores

A full Life Cycle Assessment [3] of the biogas production process enabled these three benefits to be analyzed.

3.1 Biogas Results

In the case of the biogas plant, the project provides a positive return for all stakeholders. Fig. 1 shows the results of the analysis after 20 years for each major stakeholder. The net present value of the initial investment for all four stakeholders is positive in all possible scenarios. This indicates that even if all the negative scenarios occur, no stakeholder will lose its investment. The colors within the bars show the range of probability, with the mean and median also indicated.

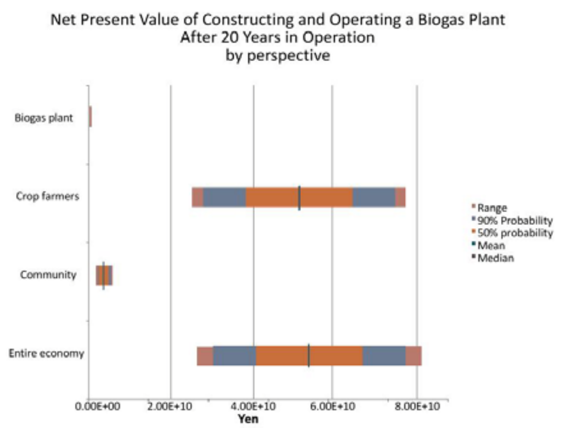

Fig.1: Return on biogas plant investment by stakeholder group.

4. Evaluation of the Bioethanol Project

As in the biogas study, this study was conducted using the expertise of an expert panel. The study analyzes three different options:

1. Bioethanol production is not supported by the government
2. Bioethanol is fully supported, including production and development support as well as subsidies.
3. Bioethanol is supported, but without subsidies for feedstocks.

In this study, the expert panel was less willing to identify actual probabilities or costs, so the analysis started with an estimate of “high”, “medium” and “low” for probability and cost. The biggest concern for the bioethanol plant is raw material costs. If the plant is to be profitable, feedstock costs must decrease to 10-50% of current cost. There are four scenarios under which this might occur:

1. Crops are developed that require so little insecticide, pesticide, and fertilizer that the costs are reduced in the range needed.
2. Crop yields are increased by at least 10%.
3. Cheaper local fertilizers are developed
4. Prices for substandard wheat decrease

Two other risks were identified, the risk that ethanol liquid waste processing costs will rise and the risk that gasoline prices might increase, reducing the use of all vehicle fuels. Counter to the latter point, it is possible that an increase in gasoline prices would increase the use of ethanol. Two opportunities were identified, the potential to make fertilizer or livestock fodder from wastes from the ethanol process. All of these risks and opportunities apply relatively straightforward economic analysis.

The team identified several potential externalities that would affect the outcome, including the carbon neutrality of the fuel. The lack of Life Cycle Assessment data in this case precluded a comprehensive analysis of these externalities.

4.1 Bioethanol Results

The results for the bioethanol plant do not show a clear benefit to all parties. Fig. 2 shows the costs and potential benefits of the project plotted by probability and cost. Costs and benefits that lie on the outside of the chart are the most interesting, as they have the potential to have the greatest effect on the profitability of each stakeholder. Only the bioethanol plant has major costs or benefits and there are more potential costs in this area than benefits.

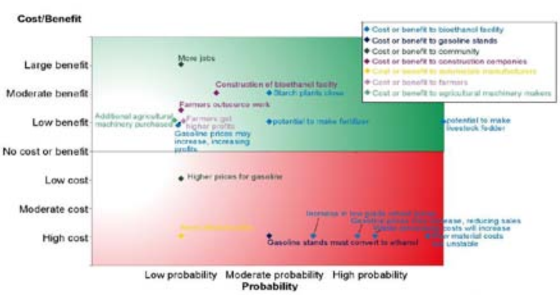

Fig.2: Costs and benefits to all stakeholders plotted by probability and economic value.

Without government subsidies, the bioethanol plant has only about a 50% probability of breaking even after 20 years (see Fig. 3). The known benefits to the community, while positive, are not sufficient to justify subsidizing the plant to enable the operator a reasonable chance to break even.

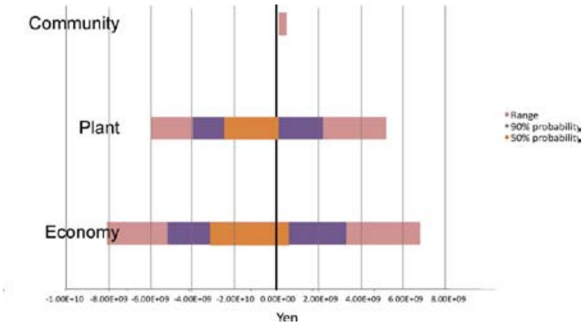

Fig 3: Net present value for each stakeholder after 20 years with no governement subsidies.

5. Conclusions

Within the 20 year time horizon, the results of this study show that under all conditions, the decision to construct the larger biogas plant is a good one. Of all stakeholders, only livestock farmers are unaffected. The biogas plant is poised to be a profitable business. Crop farmers will increase their profitability. The community will be healthier, at lower risk from climate change, have more resources for the future, and will not have to build and operate additional waste processing facilities.

Considering that Total Cost Assessment looks at all three pillars of sustainability, including environmental, social, and economic impacts, it shows the option of building the biogas plant to be the overall more sustainable option under all conditions studied here.

While the bioethanol plant provides a few benefits to society, none of those identified and quantified are substantial. Without government subsidies, the analysis shows the risks involved are substantial enough to jeopardize the plant operator. Without quantified benefits to society, there is little justification for subsidizing feedstock costs.

Initial consideration would suggest that more research needs to be done and better data obtained before a decision to fund ethanol facilities in Hokkaido is implemented. In particular, a full cradle to grave life cycle assessment of the specific bioethanol process should be carried out, along with a traditional risk assessment for both the ethanol and for maintaining status quo. This will better enable quantification of risks and benefits of biobased ethanol. These data will enable a more extensive TCA which will clarify the benefits of future investment.

With the analysis of additional cost types (contingent liabilities, and internal and external intangibles) the TCA method enabled capture of corporate and societal/environmental risks and opportunities and allowed the incorporation of upside and downside risks as well as costs and benefits that are difficult to identify on the bottom line. In effect, TCA provides a comprehensive view of an uncertain future.

6. Acknowledgement

This work was supported in part by the Ministry of Agriculture, Forestry and Fisheries of Japan (Rural Biomass Research Project, BUM-Ca2100).

Special thanks to Dr. Yuyama, Dr. Noda, and their

group members.

7. References

[1] Hunter, J. et al., Total Cost Assessment Methodology, AIChE, 1999

[2] Larsson, M.H., K. Kyllmar, L. Jonasson and H. Johnsson, Estimating Reduction of Nitrogen Leaching from Arable Land and the Related Costs. *AMBIO: A Journal of the Human Environment*, 2005, Vol 34(7): pp. 538–543

[3] Yuyama, Y., National Agricultural Research Center for Kanto Trial, 2009.