DESIGN OF A BIODIESEL PRODUCTION FROM ALGAE PLANT

PART 4. ECONOMIC SUMMARY

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INTRODUCTION

The project undertaken in this report corresponds to a vision of the future of renewable energy and more specifically to the production of biofuels. The idea we start with is a biodiesel production plant with the capacity to meet 10% of demand for the biodiesel Catalonia planned for the coming years. The biodiesel will be produced from algae because its production capacity is much higher than other crop species used in the production of biodiesel like corn.

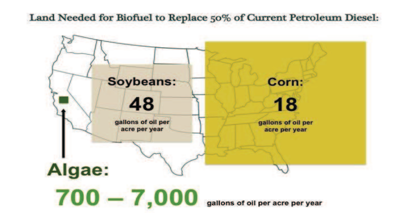

Figure 1. Comparison of the land needed to replace 50% of current petroleum diesel in the U.S. with different types of crops. Source: *U.S. Department of Energy.*

The structure of our plant is divided into three parts:

1. **Carbon absorption** infrastructure for capturing carbon that algae consume to grow up.
2. **Upstream** consists of a serie of reactors scaled to produce enough concentration of algae to produce subsequent extension in the sea bag photobioreactors.
3. **Downstream** that consist of separate biomass from algae oils and then, through a process of transesterification, to obtain biofuel.

FUEL TODAY

The oil refining model of extensive fractionation in order to extract value from every last drop of the barrel of oil must be adapted and adopted for biofuel refineries [1]. Oil currently benefits from a relatively low raw material price (an advantage that is slowly being eroded), but oil-derived products also benefit from highly efficient, integrated processes that minimize capital and operating costs. Unless biorefineries adopt the same approach of extensive fractionation and effective process integration, they will fail to achieve competitive operation.

Catalonia Reference	€/L	€/Kg	$/kg
Gasoline (taxes included)	1.52	2.23	2.90
Diesel (taxes included)	1.342	1.58	2.06
Gasoline	0.751	1.10	1.44
Diesel	0.765	0.90	1.17

Table 1. Catalonia fuel price references with and without taxes. The monetary change is 1€=1.30US$. Source: *Information sheet of the cost of the energy n. 443, 15th of January of 2013 (Catalan Institute of Energy, Department of Labor and Industry of the Government of Catalonia).*

The objective of the current work was to develop process simulation tools by which to evaluate the potential of biofuel production from algae.

MARKET OF THE PRODUCT

The Catalan Institute of Energy, the Department of Labor and the Industry of the Government of Catalonia expect that the use of biodiesel in 2015 will be of 741 KTN, 15% of total diesel distributed in Catalonia [2]. Our aim would be to produce 10% of the forecast consumption of biodiesel, the 10% of the 15% expected (74.100 tons per year of production). However, the real production of our plant reaches only to produce about 17 Kton per year (a 24.2% of the desired productivity).

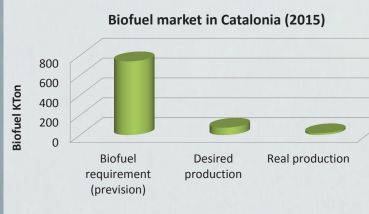

Figure 2. Prospective biofuel requirement and desired production versus the real production of our plant. Source: *Energy Plan 2006-2015 (Catalan Institute of Energy, Department of Labor and Industry of the Government of Catalonia).*

EXECUTIVE SUMMARY

The summary of the whole project concludes that its viability with the actual situation is not possible since the price obtained for our product highly exceeds the current market price of the fuel without government subventions. As mentioned on the Market of the product section, the annual output of our plant was 17 KTon/year (13 batches). We could not achieve the stated goal, reaching only 24.2% of the desired production.

EXECUTIVE SUMMARY		
Total Capital Investment	571,536,370	$
Capital Investment Charged to this Project	611,543,915	$
Operating Cost	167,535,397	$/yr
Production Rate	17,937,985.86	kg/yr
Unit Production Cost	9.34	$/kg
Total Revenues	236,399,220	$/yr
Gross Margin	29.13	%
Return On Investment	8.83	%
Payback Time	11.33	years
IRR (After Taxes)	6.70	%
NPV (at 7.0% Interest)	496,546,450	$

Table 2. Executive Summary of the project assuming we can sell the biofuel at the unit production cost in the market due to government subventions.

CAPITAL COST ESTIMATION

SuperPro Designer we used as the basis of the process does not fit with the plant model that we have designed. For this reason the calculation has been made manually using the program economical statistic parameters [3].

Cost of the Major Equipment

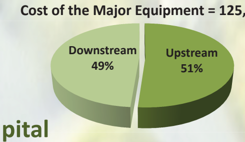

Figure 3. Comparison of the cost of the major equipment between upstream and downstream sections. Upstream includes the cost of the photobioreactors and the carbon absorption.

Fixed Capital

FIXED CAPITAL ESTIMATE SUMMARY	Cost ($)		Cost ($)
Total Plant Direct Cost (TPDC)		**Total Plant Cost (TPC)**	
1. Equipment Purchase	65,435,605	TPDC + TPIC	365,231,813
2. Installation	9,815,341	**Contractor's Fee & Contingency (CFC)**	
3. Process Piping	22,902,462	12. Contractor's fee	18,261,591
4. Instrumentation	26,174,242	13. Contingency	36,523,181
5. Insulation	1,963,068	TOTAL	54,784,772
6. Electrical	6,543,561	**Direct Fixed Capital (DFC)**	
7. Buildings	29,446,022	TPC + CFC	420,016,585
8. Yard Improvement	9,815,341	**Total Capital Investment (TCI)**	
9. Auxiliary Facilities	26,174,242	Start up/Validation cost	21,000,829
10. Port[a]	30,000,000	Working Capital (30 days)[b]	6,791,190
TOTAL	228,269,883	Direct Fixed Capital (DFC)	420,016,585
Total Plant Indirect Cost (TPIC)		Reusable material initial capital[c]	123,727,765
10. Engineering	57,067,471	TOTAL	571,536,370
11. Construction	79,894,459		
TOTAL	136,961,930		

Table 3. Fixed capital estimation. Source: *SuperPro Designer economic parameters.*

a. The cost of the port has been estimated according to the cost of a construction port project in Catalonia. It has been supposed that due to the nature of our project we could ask for an European competitive financial aid (FEDER), 50% of the cost subvention.

b. Covering labor, raw material, utilities and waste treatment cost.

c. Algae bags plus hexane (Reusables section).

OPERATING COST ESTIMATION

Annual operating cost

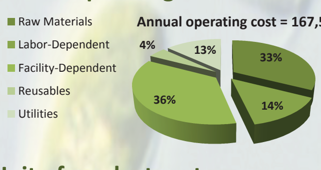

Figure 4. Comparison of the annual operating cost items.

Unit of product cost

UNIT COST - PROCESS SUMMARY	
Operating cost ($)	167,535,397
Total production (Kg)	17,937,986
Cost per Kg biofuel ($/Kg)	9.34

Table 4. Unit cost of the product calculated as the quotient of the operating cost divided by the total production. Source: *SuperPro Designer output production values.*

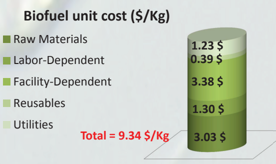

Figure 5. Biofuel unit cost divided into the sections that add up the total cost.

PROFITABILITY ANALYSIS

The cost estimation discussed in the previous section is valuable for economists, engineers and microbiologists because they are concerned with the long-run industry sustainability. Nevertheless, potential investors may be more concerned with the profitability of their investment. Profitability is typically measured by such indicators [4] as payback period, net present value (NPV) and internal rate of return (IRR) extracted of the Cash Flow of the project [5]. This section will analyze the profitability of the biofuel production plant, providing insights to potential investors who might be interested in this technology.

Financing

FINANCING - PROCESS SUMMARY	
Total Capital Investment	571,536,370
Interest (7%)	40,007,546
TOTAL	611,543,915

Table 5. Project financing based on a 7% interest rate bank credit.

Revenues

Revenue	Kg/batch	Kg/year	Cost ($/Kg)	Guany ($)
Biofuel[a]	1379845.07	17937985.86	9.34	167,535,397
Dry biomass[b]	2112100.21	27457302.75	2.00	54,914,605
Glycerol[c]	144309.58	1876024.538	0.70	1,313,217
CO_2[d]	10800000	140400000.5	0.09	12,636,000
			TOTAL	236,399,220

Table 6. Total revenues summary.

a. Biofuel is sold at unit cost price supposing government subventions.

b. Dry biomass is sold at 2$/Kg for animal feed. Source: *Wageningen University and Research Centre. Industrial production of biodiesel feasible within 15 years, researchers predict. ScienceDaily, 13th Aug. 2010.*

c. Glycerol 50-80% of purity is sold for industrial use. Source: *alibaba.com*

d. CO_2 emission cost prediction in 2020 (90 $/ton). Source: *Wilson, R., Luckow, P., Biewald, B., Ackerman, F., Hausman, E., Carbon Dioxide Price Forecast. Synapse Energy Economics, Inc. 4th Oct. 2012.*

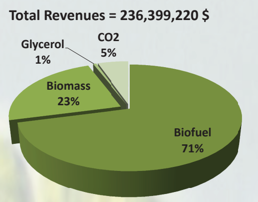

Figure 6. Contribution to the total annual revenues of every item.

Cash flow

As we said before this analysis is based on the idea that we will be able to sell the biofuel at the unit cost price because government subventions. In the figure below is analyzed which would be the result of the Net Present Value of the plant if the selling price of the biofuel changes.

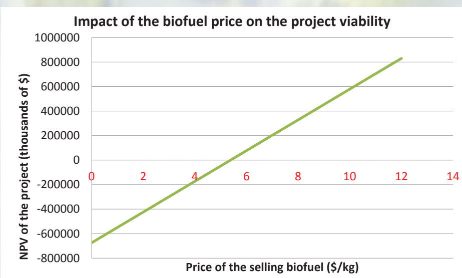

Figure 8. Variation of the NPV of the project at different selling prices of the biofuel. The selling price of the biofuel can be reduced to 5.38-5.39$ to obtain a NPV of 0$, so we could be not so far of the market price of the fuel.

REFERENCES

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