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【Research Note】

Simulation on Feasibility of Palm Oil Plantation with R&D and Manufacturing of Polyhydroxyalkanoates in South Sulawesi

DJAMAN Fitriwati

Abstract: This research evaluates, by simulation, the feasibility of a palm oil plantation company to which R&D and manufacturing of Polyhydroxyalkanotes (PHA) are integrated at a site in South Sulawesi. The feasibility is evaluated by Net Present Value (NPV) and Internal Rate of Return (IRR). The production scale of the plantation is assumed to be 10,000 hectares with a capacity of 30 ton/hour fresh fruit bunches. Saturated fatty acids from Palm Kernel Oil are used as a feedstock of microorganisms to produce PHA. It is assumed that no break-through can be obtained from R&D, whose cost is possibly offset by an operation of a power station using a biomass from the plantation with 1,000 MW electrical energy potential. In accordance with an economic life of the plant, the entire cash flow of the company for 9 years is computed under an uncertainty of CPO price in the international market and a risk that an export of PHA would be taxed by the Indonesian Government in the future. The results show that expected NPVs are positive and the expected IRRs are greater than 1. So that this business model feasible.

Keyword: Polyhydroxyalkanoates, Net Present Value, Internal Rate of Return.

1. Overview

This research is aimed to analyze the feasibility of integrating a palm oil plantation with R&D and manufacturing of Polyhidroxyalkanoates at one location in South Sulawesi by simulation. The business model developed in the previous research of the author is used with one modification that a power generation from biomass using Palm Oil Mill Effluent (POME) is introduced in order to offset a potential loss from R&D since it is assumed that no break-through can be obtained from R&D. Analysis uses Net Present Value (NPV) and Interest Rate of Return (IRR) to characterize the feasibility of the project. The results of calculation show that NPV values are positive and IRR value are large than one. From these results this business can be considered to be feasible.

Polyhidroxyalkanoates (PHA) is a microbial storage polyester synthesized naturally by many types of bacteria and PHA is completly biodegradable in nature. The exploration of inexpensive agricultural products as fermentative substrates for PHA production in a large scale will become profitable, if it is carried out at location where a constant supply of carbon sources such as palm oil is readily available. (Sudesh (2013). According to Akiyama et al. (2003), plant oil have an edge over other conventional and well known carbon feedstocks such as sugars in term of price competitiveness and ability to produce higher yield of PHA. However there is no research that evaluates the feasibility of an integration of palm oil plantation with R&D and manufacturing of Polyhydroxyalkanoates in one location by simulation.

Global palm oil production is dominated by Indonesia and Malaysia. Currently, Indonesia is the largest producer and exporter of palm oil worldwide, and most of Crude Palm Oil (CPO) produced is exported in an unprocessed form. Oil palm plantations spread across several provinces which are located on the island of Sumatra, Kalimantan, Java, Sulawesi and Papua. Malaysian government has an extensive support for downstream of palm oil industries, especially in bioplastics known as polyhydroxyalkanoates (PHA). According to Thompson et al. (2009), the global demand for bio-plastics is estimated at 0.36 million tonnes, which is equivalent to 0.2% of the annual petrochemical plastic production. Currently, majority of PHA is produced from plant sugar, which can be easily obtained from sugar cane, corn sugar, and sugar beet, making it an ideal raw material for PHA. Considerable amount of PHA is also produced from plant or vegetable oils such as soybean oil, palm oil, and corn oil. According to Sudesh (2013), high price and few application are the two major restraints for the PHA market. Generally, the cost of production for biodegradable plastics such as PHA is 20% to 80% higher than that for conventional plastics. This is primarily due to the high polymerization cost of biodegradable plastics as most of the processes are still in developmental stage. A production of PHA is at its initial stage of technology cycle and has not yet achieved an economy of scale. The market for PHA is at a stage with a high capacity but a low consumption. Most of the producers of PHA are into R&D for increasing the applications and decreasing the production cost.

In the future, the prices of PHA will come down with increase of its production. R&D is to ensure that the new products developed are more versatile and more competitive in the production cost than those already available. Lower prices and more versatility of PHA will boost its demand in future. The biocompatibility and biodegradability of PHA have evoked its potential use in applications such as medical tissue engginering, packaging as well as cosmetics and skin cares (Mauclaire et al.(2010), Sudesh et al. (2007), Valappi et al (2007)).

According to Sudesh (2013), a succesfull large scale production of PHA is largely determined by the constant supply of cheap fermentative substrates. Also, the operational cost involved in the production needs to be controlled and reduced. Waste disposals from palm oil mill and the amount of energy needed for PHA production are major concerns in this cost.

The development of palm oil based PHA is a big challenge for the downstream of palm oil industry in Indonesia. On account of feedstock availability, Indonesia is well positioned as a major global producer of palm oil. As a late-comer, South Sulawesi must have a competitive advantage in palm oil industries in the international market with a development of palm oil products with high added values. Therefore, an integration of palm oil plantation with R&D and manufacturing of PHA in the same area of South Sulawesi should be carried out. This research assumes that a business model for the integration of palm oil plantation with R&D and manufacturing of PHA made in my previous research is introduced to South Sulawesi. In Fitriwati (2014), 5 steps are complied for the set-up andexpansion of R&D, along with schedule and stages in building a palm oil company. For the latter, three plans, a plan for plantation, a plan for financing the business and a plan for manufacturing are made. This article analyzes the feasibility of the business model under the assumption that no break through will be made by R&D. To offset the R&D cost potentially, the business model is expanded by introducing a biomass power plant which produces electricity by using Palm Oil Mill Effluent (POME) as its fuel. This ensures not only that an energy for the production of CPO and PHA is supplied, but also that the common problems such as environmental degradation by an introduction of new industries in local communities are avoided. The electricity not used for the operation of the company is sold commercially in order to add a source of revenue to the company.

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2. Investment Analysis of Integrated Palm Oil Plantation

2.1. Fundamentals of Analysis

In this subsection, basic assumptions on the production of Fresh Fruit Bunch (FFB) are given for the calculation of economic evaluation on the level of production. A wide range of input prices are also given, which must be paid for the investment for plants, plant maintanance cost, the cost for harvesting of FFB and production of CPO and Kernel Palm Oil (KPO). It is assumed that an area for the palm oil plantation development is derived from converted agricultural land, and its size is assumed to be 10,000 ha. The cost to obtain The Right of Cultivation (HGU) is US$156297.41. Both a palm oil mill and an R&D laboratory are built nearby the palm oil plantation. Palm oil trees start to produce FFB in 2.5 years after they are planted, and the full production of FFB becomes available after 5 years. 5 years. In this business, it is assumed that planting begins in the second year. After planting, FFB is harvested at the age of 2 years, assuming a use of superior and good quality seeds. Seeds of age 6 months are assumed to be used because in this age the plant or seeds will be safe from the pigs and other animal. To get a high quality of FFB, company will give fertilizer of seeds and plant for 3 times in a year. In the full production of FFB, the CPO extraction rate is 24% and KPO extraction rate is 5%. KPO is used as a main carbon sources for producing PHA. The company starts to operate in 2018, and continues to operate until 2026. CPO price fluctuates under an uncertainty related to the condition of demand and supply as an edible oil. However, the time-series data of CPO prices in the international market, which is used for estimating this fluctuation, indicates that there was a biofuel bubble in 2007-2012. By eliminating the effect of the bubble from the historical data of CPO price and extracting the trend and the up-down uncertainty in the adjusted historical data of CPO price, a binomial uncertainty of CPO price is modelled for 2018-2026. PHA price is assumed to be stationary at US$ 6,000/ton, unless its export is taxed by the Indonesian government. It is assumed that the Indonesian government taxes on the export of PHA only when CPO price moves up in the binomial uncertainty. It is also assumed that the conditional probability that PHA is taxed is 10%. The table below shows the CPO export tax rate in Indonesia. The tax rate for PHA is assumed to be 7.5%, which is the tax rate for downstream industries of CPO products

Table Ⅰ. CPO Tax Rate

CPO TAX RATE (Percent)								
<750	>750-800	>800-850	>1000-1050	>1050-1100	>1100-1150	>1150-1200	>1200-1250	>1250
0	7.5	9	15	16.5	18	19.5	21	22.5

Sources: (Ministry of Finance of Republic Indonesia, study the significanceof export duties on downstream oil industry)

The uncertainty of CPO price and PHA price is represented by an event tree, where each economic state is characterized by a vector of CPO price and PHA price. It has 81 economics states in total. The interest rate is assumed to be 10%.

2.2. Financial Constituents of Palm Oil Plantation Investment

All costs and revenues for the company are specified as flows at each economic state. This means that the company owns no asset. The figures for inflow and outflow are drawn from a standard case of a large-scale palm oil plantations (10,000 ha) over the life activities. Yearly revenue from the sales of CPO becomes positive in the 5th year of operation and is realized in full scale from the 7th year. The production of PHA starts in the 5th year in full scale.

2.2.1. Outflow

Table 2 shows fixed cost and variable cost for operation of this business model. The mill capacity is assumed to be 30 tonnes of FFB per hour. For the land use HGU for 10,000 hectares with 26-year lifespan is assumed to be obtained. Company builds housing for workers, main office, warehouse, R&D laboratory, building for manufacturing PHA, mill and other facilities, whose construction begins in the second year. Most of the buildings must be built before harvest FFB, production of CPO and manufacturing of PHA which starts in the 5th year. The company will use the local port in South Sulawesi which is nearby the palm oil plantation, and CPO and PHA will be transported from there to the Maloy port in East Kalimantan, which is an international port to export palm oil product to the international market. There are two systems in CPO shipping cost for export, Free on Board (FOB) and Cost Insurance and Freight (CIF). In this business, a use of the FOB system is assumed. FOB is a shipping term that the exporter delivers CPO products to the exporting port on its cost and the importer should bears all cost and risk of loss and damage of palm oil products after that.

Table 2. Outflow (fixed cost and variable cost)

No	Description	Year	Amount (US$)
I	FIXED COST		
A	Costs of getting HGU for 10,000 ha (beginning)	1th	156,297.41
B	IPO (Initial Public Offering) Cost		
1	Legal fee	2nd	1,263,000

2	Accounting fee	2nd	550,000
3	Other expense	2nd	850,000
C	**Investment Cost**		
1	Land Clearing (Rp 500,000 / US$ 43.10)/ha	1th	431,034.84
2	Seedling (Rp 5,200,000/ha) 7-12 month	2nd	4,481,758.62
3	Planting palm oil	2nd	2,500,000
D	**Construction Cost**		
1	Building	2nd-7th	3,951,897.21
2	CPO Mill Investment of 30 ton/hour (Rp 300 billion) (machinery and equiptment)	4th	25,862,069.00
3	Bridge (US$ 87 /ha)	4th	870,000
4	Power Plant Station investment (capacity 1,0215MW)	4th	3,120,000.00
III	**VARIABLE COST**		
A	**Maintainances Cost**		
1	Maintainance Cost of Mill &Machinery	4th-9th	100,000
2	Maintainance Cost of Plant US$170.08/ha	2nd-9th	1,700,800
3	Cost of spraying againts weeds US$86.20/ha	2nd-9th	862,000
4	Cost of cutting leaves US$50/ha	3th-9th	500,000
5	Total generation cost and maintanance of power plant= US$58.26	5th-9th	50,289.50
6	Fertilizer =130 kg/ha (x3 in a year)	2nd-9th	5,603,448.27
B	**R&D Cost of PHA**		
1	First phase of research of R&D (US$ 0.9 million)	3th	900,000
2	Manufacturing process of PHA (US$ 6.7 million)	5th-9th	6,700,000
3	Researcher wages (7 researcher)	3th-9th	12.068.97
B	**Harvesting (US$180/ha/year)**	5th-9th	1,800,000
C	**Transportation**		
1	Transportation Cost for FFB to mill (US$15/ton)	5th-9th	4770000
2	Transportation Cost of CPO from mill to Port US$30/ton, assuming the distance from mill to be 50 km)	5th-9th	630000
3	Transportation cost of PHA from mill to port US 15/ton	5th-9th	94500
4	Transportation Cost of CPO using a tangker from nearby port to the Maloy port East Kalimantan (approximately US70/Ton	5th-9th	9800000
5	Transportation Cost of PHA using a tangker from nearby port to the Maloy port East Kalimantan (approximately US 35/ton)	5th-9th	220500
D	**Labor Cost**	2nd-9th	591,939.66
E	**Depreciation**	2nd-9th	520,849
F	**Insurance**	2nd-9th	13,388,710

2 .2.2. Inflow

Inflow consists of revenues from the sales of CPO, PHA products and excess biomass electricity to PLN (state electricity company). Sales revenue is strongly influenced by capability of the mill' s production and sales prices. Production of palm oil and kernel oil depends on plant/mill capacity, yield levels of palm oil, kernel yield and supply of raw materials. The average of CPO extraction rate is 24 % and the average of KPO extraction rate is 5% for 26 years lifespan of palm oil plantation. It is assumed that company start harvesting FFB in the 5^{th} year by 14 ton per hectare, CPO extraction rate is 15% and KPO extraction rate is 4.5% in that year. In the 6th year, palm oil trees produce 23 ton of FFB per hectare. CPO extraction rate is 17% and KPO extraction rate is 4.6%. In the 7th year, the production of FFB is 28 ton per hectare. CPO extraction rate is 19% and KPO extraction rate is 4.9% .In the 8th year, the production of FFB is 30.5 ton per hectare. CPO extraction rate is 21% and KPO extraction rate is 5%. In the 9th year, the production of FFB is 31.8 ton per hectare. CPO extraction rate is 23% and KPO extraction rate is 5%. The extraction rate of PHA from KPO is about 90 %, or 1 ton of KPO is converted to 0.9 ton of PHA.

2 .3. Method and Evaluation

The feasibility of the palm oil plantation integrated with R&D and manufacturing of PHA in South Sulawesi is evaluated by Net Present Value (NPV), Internal Rate of Return (IRR). The business is financially viable in expactation if the NPV and IRR is large than 1, it is means that the investment would add value to the firm.

3. Result and Conclusions

Results of calculation using the interest rate 10% are shown in the table 3

Table 3 . CPO and PHA Price, NPV and IRR in Each Economic States

2018	A			
	CPO PRICE	PHA PRICE	NPV	IRR
1	800.860732	6000	40,285,843.23	68.59123303
2019	B			
	CPO	PHA	NPV	IRR
2	821.468085	6000	22,487,201.37	1.11430142
3	821.468085	5550	142,895,036.20	7.080834074
4	766.331632	6000	62,852,961.89	3.11453362
2020	C			
	CPO	PHA	NPV	IRR
5	840.915338	6000	83,781,134.66	3.475177703
6	840.915338	5550	212,155,401.30	8.800044584
7	800.941282	6000	80,726,094.37	3.348456957
8	800.941282	5550	139,328,133.50	5.77922494
9	744.067379	6000	106,763,777.70	4.428480245
2021	D			
	CPO	PHA	NPV	IRR
10	859.202491	6000	116,419,004.40	2.189938468

11	859.202491	5550	387,200,490.70	7.283563825
12	821.547285	6000	104,288,805.30	1.961759317
13	821.547285	5550	222,784,410.90	4.190760381
14	766.412182	6000	127,219,581.50	2.393106321
15	766.412182	5550	152,617,767.50	2.870867359
16	720.645726	6000	175,732,769.40	3.305679804
2022	E			
	CPO	PHA	NPV	IRR
17	892.071991	6000	203,129,374.10	5.1865376
18	892.071991	5550	252,751,691.20	6.453552844
19	840.993188	6000	183,315,653.40	4.680630426
20	840.993188	5550	231,645,790.60	5.914652216
21	801.021832	6000	175,822,876.40	4.489316051
22	801.021832	5550	391,410,242.60	9.993945728
23	744.149279	6000	221,617,055.90	5.658586793
24	744.149279	5550	224,357,113.70	5.728549164
25	740.49646	6000	312,972,127.90	7.991171716
2023	F			
	CPO	PHA	NPV	IRR
26	908.618994	6000	233,825,663	4.744109749
27	908.618994	5550	279,378,587.70	5.668337104
28	859.278991	6000	198,201,017.80	4.021318143
29	859.278991	5550	249,142,025.20	5.054864789
30	821.626485	6000	191,373,786.70	3.882799841
31	821.626485	5550	237,127,667.40	4.81110441
32	766.492732	6000	183,272,132.40	3.718424655
33	766.492732	5550	272,098,230.20	5.520625281
34	720.728976	6000	302,348,954.10	6.134384918
35	720.728976	5550	196,224,638.60	3.981219209
36	701.91646	6000	415,202,440.90	8.424079386
2024	G			
	CPO	PHA		
37	957.810991	6000	218,443,422.20	4.081976804

38	957.810991	5550	328,527,282.40	6.139075889
39	892.148491	6000	210,355,627.40	3.930842975
40	892.148491	5550	185,594,529.40	3.468140887
41	841.071038	6000	201,121,121.90	3.758280959
42	841.071038	5550	291,094,327.20	5.439579179
43	801.102382	6000	136,380,442.50	2.548494238
44	801.102382	5550	324,046,761.60	6.055349944
45	744.231179	6000	182,925,258.10	3.418261136
46	744.231179	5550	182,730,227.30	3.414616663
47	740.58646	6000	447,532,952.90	8.362893761
48	740.58646	5550	178,483,831.70	3.335265735
49	663.33646	6000	174,465,532.10	3.260177157
2025	**H**			
	CPO	**PHA**	**NPV**	**IRR**
50	938.2327	6000	172,180,491.20	3.135437737
51	938.2327	5550	164,334,781.30	2.992565948
52	908.694144	6000	168,430,493.40	3.067149602
53	908.694144	5550	160,494,290.40	2.922629916
54	859.355491	6000	162,683,085.10	2.962488261
55	859.355491	5550	104,535,266.40	1.903606018
56	821.705685	6000	157,410,271.70	2.866469381
57	821.705685	5550	149,816,293.30	2.728181666
58	766.573282	6000	150,848,757.20	2.74698302
59	766.573282	5550	143,121,910.10	2.606275744
60	720.812226	6000	145,918,286.50	2.657198262
61	720.812226	5550	138,002,373	2.513048052
62	702.00646	6000	142,281,485.90	2.590971469
63	702.00646	5550	134,353,482.30	2.446601096
64	624.75646	6000	132,454,021.90	2.412011579
2026	**I**			
	CPO	**PHA**	**NPV**	**IRR**
65	951.299403	6000	99,216,882.84	1.761521432
66	951.299403	5550	92,061,882.84	1.634489767

67	924.079697	6000	97,226,033.53	1.726175394
68	924.079697	5550	90,071,033.53	1.599143729
69	892.224991	6000	94,896,180.32	1.684810595
70	892.224991	5550	87,741,180.32	1.55777893
71	841.148888	6000	91,160,474.14	1.618485931
72	841.148888	5550	84,720,974.14	1.504157432
73	801.182932	6000	88,237,364.10	1.566588302
74	801.182932	5550	81,797,864.10	1.452259803
75	744.313079	6000	84,077,903.05	1.492740186
76	744.313079	5550	77,638,403.05	1.378411688
77	740.67646	6000	83,811,920.76	1.48801787
78	740.67646	5550	77,372,420.76	1.373689371
79	663.42646	6000	78,161,855.76	1.387705198
80	663.42646	5550	71,722,355.76	1.2733767
81	586.17646	6000	72,511,790.76	1.287392527

Source: Result of Analisys.

The results of this simulation show that expected NPVs are positive and the expected IRRs are greater than 1 for all economic states. So that this business model is feasible.

4. Remarks

In the next future research, I will conducting the field study in South Sulawesi to introduce polyhydroxyalkanotes using palm oil as a carbon sources by conducting symposium to know the response of local community in the proposed area of palm oil industries.

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