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POTENTIAL APPLICATIONS OF ELECTRON ACCELERATORS IN MALAYSIA

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Introduction

Currently, there are about 800 electron accelerators operating world-wide mostly in industrialized countries and used for industrial purposes. About 35% of them are in Japan. This tells us the importance of this machine in industrial and manufacturing processes.

The basic premise of the application of electron accelerators, or electron beam machines (EBMs), is the bombardment of materials with lots of electrons of certain energies, the intensity of which is measured in terms of the magnitude of the electron beam current. It is the effects of this interaction that we are after. Thus, research and technology development (R&TD) in EB processing generally centers around studying this effect on different industrial materials and finding formulations which when bombarded by electrons produce desired properties, such as better durability, better finishing, better heat resistance, or even better appearance, hence enhancing the value-addedness of the materials and making them suitable in specific applications. Some of these properties can be achieved by alternative or conventional technologies, for example heat and chemical treatments. But these alternatives can be less attractive for several reasons including cost-effectiveness, process efficiency and throughput, ease of operation, technology and material supply dependencies on external factors, and more importantly, environmental considerations.

Basically, electron accelerator is a device in which electrons are generated, accelerated in vacuum to attain certain velocity (energy), and let out through a thin window. The higher the energy of the electrons coming out of the machine, the deeper they can travel in the product while inducing crosslinking or breakdown in polymer chain and eliminate micro-organisms. EBMs are available in the market from several manufacturers. Generally, they are categorized according to energies: high energy in the range of 5 to 10 MV, medium in the range of 1 to 5 MV, and low energy between 150 to 900 kV.

Some Applications Of Electron Accelerators

The effects that are induced by the interactions of electrons depends on the electron energy and the doses. These effects are exploited commercially in various processes, some of which are:

- high energy EBM (up to 10 MV) - sterilization, pasteurization, decontamination, disinfection of medical products, cosmetics, pharmaceutical, agro-industrial waste, sludge and food;

- medium energy EBM (1 to 5 MV) - crosslinking of wire and cable and insulation, PE tubing, heat-shrinkable tubes and films, polymer composite materials, plastic molded products, foam and foam products, prevulcanization of tire, vulcanization of natural rubber latex;

- low energy EBM (700 to 900 kV) - treatment of flue gases for removal of NOx and SOx from coal burning plants;

- also low energy EBM (200 to 500 kV) - curing of surface coatings, printing ink, adhesives, laminated products, conformal coating, photoresist.

Advantages

To appreciate the attractiveness of electron beam processing it is appropriate to present here a qualitative description of its advantages. These advantages are generally true for radiation processing technology using for example gamma radiation. EB processing requires less energy compared to thermal-based processes. Thermal-based processes need a longer period of stabilization that is governed by the heat capacity and thermal time constant of the plant. In addition, attainment of uniformity in temperature distribution calls for fairly extensive engineering on the room set up, insulation, and air distribution system. This increases the space required for the plant.

The depth of interaction or penetrability of electron beam affords better product homogeneity. This also gives rise to shorter processing time and hence higher process throughput. Complete conversion of wet resin to solid eliminates solvent evaporation, thus reduces the potential for polluting the environment. Since very little heat is generated by the process, EB processing is also known as "cold" process. This is especially desirable for treating heat sensitive products such as papers, plastic films, and "natural products."

In comparison with gamma radiation plants, EBM is much easier and perhaps cheaper to maintain. It does not require reactor-produced radioisotopes such as cobalt-60; it can be turned on-off, thus require no plant activity inventory management; less complication in handling and transportation because no shielding is required; transportation of machine needs only to be done once; and offer some degree of freedom from regular dependency on external suppliers (radiation source as in cobalt-60 plant). Electron beams, however, have shallower penetration compared to gamma radiation from a Co-60 source.

Electron Beam Processing In Malaysia

The beginning of electron beam processing in Malaysia is the commissioning of a medium energy (ALURTRON) and a low energy (CURETRON) EBMs at UTN in 1991. These facilities, made available through UTN-JICA Cooperation, open up new opportunities for research and development in radiation processing technology in Malaysia. With these additions, UTN has already equipped itself with three of the major commercially viable radiation sources: neutrons from a research reactor; gamma from SINAGAMA, a 1.5 MCi gamma irradiation plant; and electrons from the EBMs. Much have been gained in terms of expertise, skills, and experience in the design, installation, operation, maintenance, dosimetry, laboratory set-up and facility development in the process. And much more to be gained as the industry warms up to this technology.

In order to bring the benefit of this technology to the Malaysian industry, several research and technology development activities geared in that direction have already been established and running smoothly using the EBMs. One such activities is crosslinking of wire and cable insulation using ALURTRON. A wire and cable under beam handling system (WUBHS) has been designed and is currently in the process of fabrication. This facility is expected to be ready late this year. Some wire and cable companies have already indicated their interests to participate in this activity. Research using the CURETRON centers around its applications for curing of surface coatings, in particular for coating of wood and non-wood substrates, printing ink, pressure sensitive adhesives, and abrasive papers. Related to these activities is the development of resins from oil palm and liquid natural rubber.

Conclusion

Indeed, radiation technology offers exciting years ahead for UTN. But this excitement can be meaningful only when the technology is put to work outside the laboratory, that is with the industry, where wealth and prosperity can be generated. Radiation processing

technology, however, demands fairly high capital outlay whereas the Malaysian industry is dominated to some extent by small to medium scale enterprises. This actually is an advantage, for big enterprises usually have been fairly well-established and might not be very receptive to changing to new ways and new technology. To facilitate technology transfer process several instruments of collaborations can be used including research cooperation by which facilities, research and technology development costs, and other resources can be shared. In this manner, risks can be minimized. Infact, UTN is known to have carried out a few projects right up to commercial scale operation to demonstrate project feasibility.

ECONOMIC CONSIDERATION OF ELECTRON BEAM PROCESSING OF OIL PALM WASTES - PRODUCTION OF RUMINANT FEED FROM EMPTY FRUIT BUNCH.

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Abstract

The economics of electron beam processing are discussed in terms of capital and materials expense. Specific information is presented on Unit Production Cost (UPC), economic and financial feasibility of the project on production of ruminant feed from Empty Fruit Bunch (EFB).

INTRODUCTION

The ruminant sector of livestock industry in Malaysia is not well developed . The current beef production is only 24% self-sufficiency(1). The shortage in beef, mutton and milk is being met by imports. The poor development performance in this sector is mainly due to basic dependency of the industry on imported feed ingredients, and consequently impedes the improvement in production cost as the price rises. Raw materials cost normally constitutes about 95% of cost of feed production (2). Growing domestic pressure on shortage of labour, technological capability and marketing network pose further problems to the industry.

Malaysia has a large quantity of oil palm by-products from oil extraction process of palm oil industry. The major by-products are Empty Fruit Bunch (EFB), Palm Press Fibre (PPF), Palm Kernel Cake (PKC), Palm Oil Mill Effluent (POME), Oil Palm Trunk (OPT) and Oil Palm Frond (OPF). The use of these by-products in ruminant feeding system has been widely reported. It is estimated that 2.3 million tonnes(mt) of EFB, 1.03 mt of PKC, 2.2 mt of PPF 0.6 mt of POME, 1.32 mt of OPT and 17.2 mt of OPF were available as feed in 1990 (3). Efficient and adequate utilisation of these by-products as feed could meet the demand of feed deficit in the country. The utilisation of by-products would also provide the livestock industry a greater certainty in the supply of feed resources, hence the industry would be less affected by a wide price fluctuation of imported feed ingredients.

Through radiation and fermentation processes, ruminant feed can be produced from oil palm EFB. This process accomplishes that pasteurised empty fruit bunch is amenable by fermentation to produce ruminant feed. The product contains 10% protein and low in fibre. In the total system of this technology, irradiation is considered as an integral part of the production system. Irradiation and fermentation conditions, treatment volume, of EFB using electron beam are discussed. The conceptual design of this facility consists of flow diagram, composition and configuration of the process, is briefly described.

Two main objectives of this paper are, to evaluate the production cost; and the economic feasibility of the project at the maximum treatment capacity of accelerator. The maximum treatment capacity of 10 MeV electron accelerator on EFB is 300,000 tonnes per year (t/y). In EFB-based diets, the fermented EFB is used as a major composition in feed formulation. The economic and financial feasibility of the project with a production volume of 30,000 t/y is

specifically discussed and compared with projects of the same capacity. There are indications that irradiation can be accomplished at a competitive cost when production volume exceeding 100,000 t/y

METHODOLOGY

The Unit Production Cost (UPC) is computed based on total operation cost per unit product (RM/Kg). In order to establish operation costs, the construction or capital cost is initially estimated (Appendix 1). The price and quality of raw materials used in the formulation is shown in Appendix 2. Total operation costs consist of utility , material, labour, amortisation and maintenance, and for each product are shown in Appendices 3 - 5. The economic and financial feasibility of the project are examined using capital budgeting analysis (4). The cash flow projection for all product are presented in Appendices 6 - 11.

Capital budgeting utilises Discounted Cash Flow analysis (DCF) to derive investment criteria such as Net Present Value (NPV), Internal Rate of Return (IRR), Net Benefit Cost Ratio (B/C) and Payback Period (PBP) to make accept or reject decision of a project. All computations are performed in Lotus 123 spread sheet.

Major Assumption:

1. The project useful life is 10 years and discounted at the rate of 10%. The effect of taxation is ignored .

2. There are three facilities of the same production capacity. Each facility operates on ten acres of land with maximum production capacity of 300,000 t/y . The cost of land is RM 14 per square metre. In another consideration, the similar facilities are assumed to operate at maximum production capacity of 30,000 t/y that then allowed a comparison be made with a known conventional technology of the same production capacity. Following reduction in production capacity, there is a substantial reduction in total capital cost due to reduction in areas, hence, cost of land, civil and building.

3. The revenue is computed based on the projected production as follows:

(i). The projected productions of each facility are 30,000 t/y, 60,000 t/y, 105,000 t/y, 180,000 t/y, 240,000 t/y and 300,000 t/y for the rest of useful life of the project. The sale prices for each product are as follows: Fermented EFB, RM 110/ tonne; Beef Cattle Pellets, RM 370/tonne and Dairy Cattle Pellets, RM 430 /tonne.

(ii). Facilities with maximum capacity of 30,000 t/y starts out with 22,500 t/y for the first two years and then increases its production to 30,000 t/y throughout the rest of useful life of that projects. The sale prices for each product are as follows: Fermented EFB, RM 170/ tonne; Beef Cattle Pellets, RM 420/tonne and Dairy Cattle Pellets, RM 480 /tonne.

4. Each facility that produced a type of product is considered as an independent project. Independent projects are projects whose cash flows are independent of one another.

5. Economic indicators derived from discounted cash flows projections are considered with and without borrowing. In the 50% borrowing, payment of the principle and interest are further discounted.

RESULTS AND DISCUSSION

Project Cost and Financing

The items which made up the investment and their costs for the project are shown in Appendices 6 - 11. In the initial year, the total invesments (capital, labour and contingency for the first year) required for the projects are about RM 11.1million (fermented EFB pellets) RM 11.9 million (beef cattle pellets) RM 12 million (dairy cattle pellets), which made up of approximately 97 % capital and 3% operation cost for fermented EFB production; and 90% to 10% for others. The percentage capital cost remain the same for the FEFB and declined to 87 % in others as the maximum production capacity lowered to 30,000 t/y.

Further scrutiny of operational costs shows that material cost represents 85-95% of the total operating cost except for FEFB which is only 58%.

Unit Production Cost (UPC)

The percentage of raw materials used for each product is different according to the nutritional requirement. At maximum production volume, the cost of raw materials constitute more than 95 % of the total operation cost, similar to the conventional technology. The UPC calculated for the first six years of the projected production volume (30,000 - 300,000 t/y) are summerised in Table 1. The UPC for producing these products are as follows: fermented EFB pellets, RM 0.08 - 0.12/kg; beef cattle pellets,RM 0.31 - 0.35/kg; and dairy cattle pellets, RM 0.37- 0.41/kg. The lowest prices achieved at production volume between 105,000 t/y - 180,000 t/y , and the prices do not change upon increasing the production volume.

Economic and Financial Indicators.

(a) Production capacity of 300,000 t/y

Table 2a shows the NPV for all products are positive, thus, production of the three types of feeds are feasible. The highest NPV is RM 20.7 million for dairy cattle pellets, comparable to beef cattle pellets and FEFB pellets has the lowest NPV. The IRR for dairy cattle pellets is 32.2%, comparable to beef cattle pellets and FEFB pellets. Since the discount rate of this project is 10% , the IRR of this project are expected to earn more than the cost of capital needed to finance them. The B/C ratios for all products are between 1.6 - 1.9 shows that this process is feasible but low profitability. The payback periods for all products are 5 years; indicating that the initial invesment can be recouped at the end of this time frame and consistent with IRR values. The selling prices of RM 0.43/kg. (dairy cattle pellets), RM 0.37/kg (beef cattle pellets) and RM0.11/kg (FEFB pellets) are attractive and comparable with the price of currently available feeds resources such as rice bran (RM 0.42/kg), PKC (RM 0.27/kg), wheat bran (RM 0.38/kg) etc.

Table 2b shows that, in the case of 50 % capital borrowing the NPV of the project declined to RM 13.5 million (dairy cattle pellets) and RM 10 million (beef cattle pellets and FEFB pellets) due to additional cash outflows for repayment of capital. The IRR also declined to about 20 %

for all and consistent with the payback period of 6 years. The B/C ratios also reduced to about 1, indicating the project is still feasible but low profitability.

(b) Production capacity of 30,000 t/v

The facility with 30,000 t/y production capacity capacity is considered as a small or medium size industry. When this technology applied to animal feed industry with this size of operation, the NPV, IRR , B/C and PBP are shown in Table 3a. The industry worth about RM 6-7 million with IRR about 30%, low profitability and the initial capital can be recouped at the end of fourth year, except FEFB pellets production takes only 3 years. In general, the feasibility of this projects are comparable with the production of silage in MARDI except that NPV for silage worth RM 16.7 million. The selling prices of RM 0.43/kg. (dairy cattle pellets), RM 0.37/kg (beef cattle pellets) and RM0.11/kg (FEFB pellets) are also attractive

Table 2b shows that, in the case of 50 % capital borrowing the NPV of the project declined and not feasible.

CONCLUSION

The cost of production per unit is minimum at production of more than 100,000 t/y. Using 3 MeV electron accelerator the production capacity at 300,000 t/y indicated that the project is feasible and competitive. In view of enormous potential market for animal feed in Malaysia, this technology offers an efficient process needed for future expansion of livestock industry.

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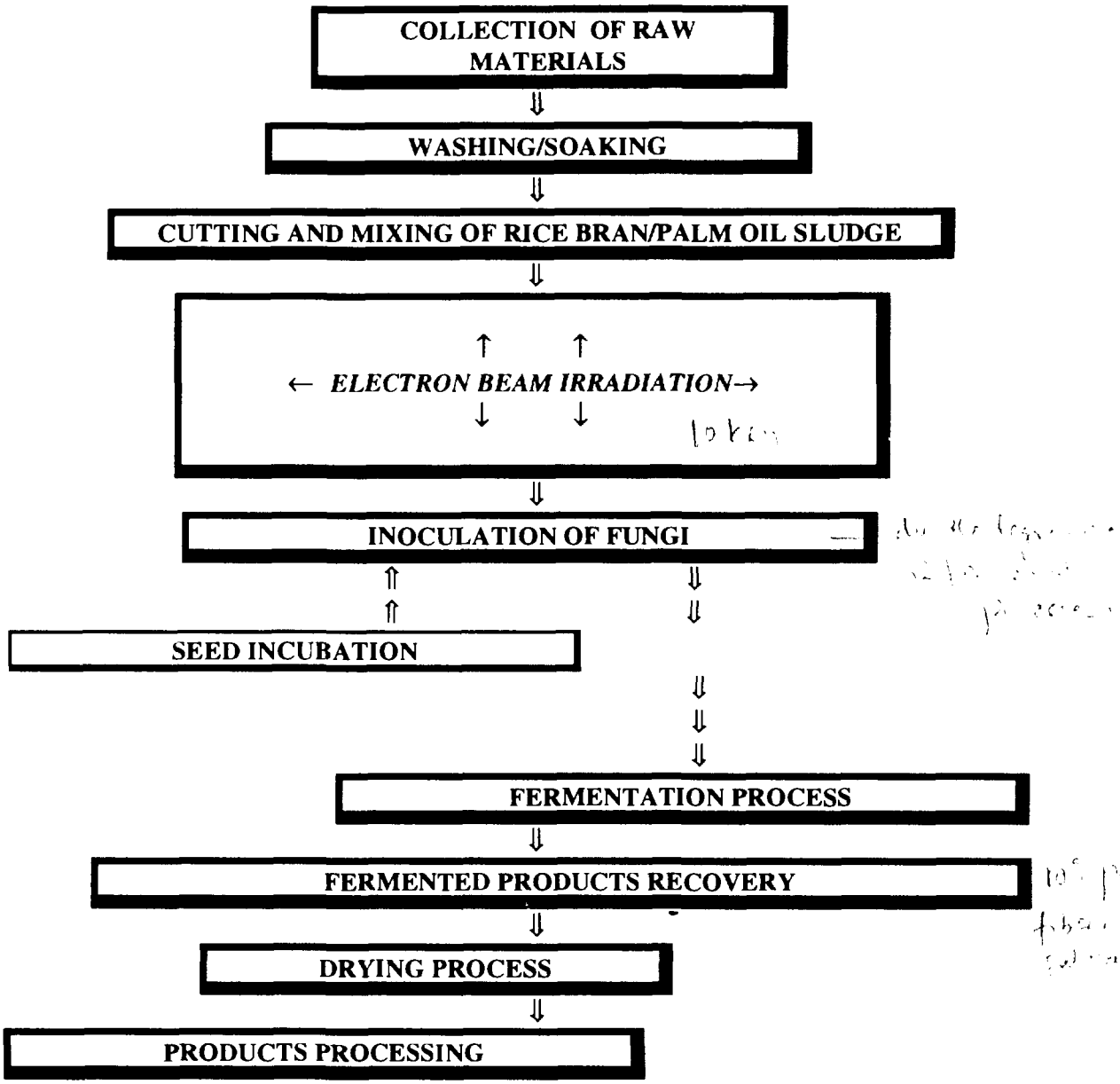

Fig. 1. / RADIATION-FERMENTATION PROCESS FLOW CHART

Table 1. The relation between Unit Price (UP) of feeds with the volume of production

Production volume(kg)	30,000,000.00	60,000,000.00	105,000,000.00	180,000,000.00	240,000,000.00	300,000,000.00
Total Operation cost(RM)						
Fermented empty fruit bunch	3,624,040.00	5,918,740.00	9,360,790.00	15,097,540.00	19,686,940.00	24,276,340.00
Dairy cattle pallet	12,263,620.00	23,197,900.00	39,599,320.00	66,935,020.00	88,803,580.00	110,672,140.00
Beef cattle pallet	10,644,040.00	19,958,740.00	33,930,790.00	57,217,540.00	75,846,940.00	94,476,340.00
Unit Price (RM)						
Fermented empty fruit bunch	0.12	0.10	0.09	0.08	0.08	0.08
Dairy cattle pallet	0.41	0.39	0.38	0.37	0.37	0.37
Beef cattle pallet	0.35	0.33	0.32	0.32	0.32	0.31

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Table 2a. NPV, IRR, B/C and PBP for Fermented EFB, EFB-Based Beef and Dairy Cattle Pallets. Max imum Production Capacity 300,000 t/y.

Feeds	NPV (RM 1)	IRR	B/C	PBP (years)
Fermented EFB Pallet (RM0.11/kg)	17,148,542	0.2918	1.58	5
Beef Cattle Pallet (RM 0.37/kg)	20,096,539	0.3164	1.86	5
Dairy Cattle Pallet (RM0.43/kg)	20,794,307	0.3220	1.92	5

Table 2b. NPV, IRR, B/C and PBP for Fermented EFB, EFB-Based Beef and Dairy Cattle Pallets. Max imum Production Capacity 300,000 t/y.

Feeds	NPV (RM 1) [+Capital Repayment[1]]	IRR [+Capital Repayment[1]]	B/C [+Capital Repayment[1]]	PBP (years) [+Capital Repayment[1]]
Fermented EFB	10,384,958	0.1847	- 1	6
Beef Cattle Pallet	11,733,795	0.2053	1.08	6
Dairy Cattle Pallet	13,506,711	0.2285	1.25	6

[1]Repayment for 50% Borrowing at 12% interest rate+50% Equity

Table3a. NPV, IRR, B/C and PBP for Fermented EFB, EFB-Based Beef and Dairy Cattle Pallets. Max imum Production Capacity 30,000 t/y.

Feeds	NPV (RM 1)	IRR	B/C	PBP (years)
Fermented EFB Pallet (RM 0.17/kg)	7,657,810	0.3394	1.32	3
Beef Cattle Pallet (RM 0.42/kg)	6,390,039	0.3042	1.10	4
Dairy Cattle Pallet (RM 0.48/kg)	6,495,469	0.3072	1.12	4
OPF Silage[5]	16,746,010	0.3568		3-4

[5]Oil Palm Silage(OPS) from Livestock Research Division, MARDI

Table 3b. NPV, IRR, B/C and PBP for Fermented EFB, EFB-Based Beef and Dairy Cattle Pallets. Max imum Production Capacity 30,000 t/y.

Feeds	NPV (RM 1) [+Capital Repayment [1]]	IRR [+Capital Repayment[1]]	B/C [+Capital Repayment[1]]	PBP (years) [+Capital Repayment[1]]
Fermented EFB Pallet	3,991,959	0.2114	0.69	6
Beef Cattle Pallet	2,404,852	0.1676	0.24	6
Dairy Cattle Pallet	2,436,609	0.1682	0.42	6

[1]Repayment for 50% Borrowing at 12% interest rate+50% Equity

Appendix 1. Construction cost

ITEM			30,000t/y (RM 1000)	300,000t/y (RM 1000)
Machinery Facility				
Water washing process				
Water pump			40	150
Cutting and mixing process				
Capacity	50 (t/h)	(5 units)	201	750
Irradiation process			4,013	5,241
Seeds incubation process				
Incubators	40,000	(l/unit), (60 units)	81	300
compressors		(6 units)	7	24
Molasses tank:	100,000	(l/unit)	27	100
Fermentation process				
Forklift	2,000	(kg/unit)	32	120
Recovery of fermented products				
Automatic loader		(2 unit)	22	80
Shreder			27	100
Drying process				
High pressure steam dryer			80	300
Products processing				
Pallet machine			134	500
Packaging machine			7	25
Installation and piping			214	800
MACHINERY			**4,884**	**8,490**
Electrical facility				
Power supply			400	400
Control panel			31	117
Installation and cabling			24	89
ELECTRICITY			**455**	**605**
Raw material yard			5	20
Water cell	(5 units)		54	200
Drain pond	(2 units)		21	80
Irradiation building			60	300
Building for incubation				
seed incubation			56	210
Ware house				
Fermentation			91	340
Product recovery			5	17
Dryer			3	11
Product processing			8	28
Storage			4	14
Land			138	515
CIVIL AND BUILDING			**464**	**1,735**
TOTAL COST			**5,803**	**10,830**

Appendix 2. Price and Quality of Raw Materials

RAW MATERIALS	Dry metter	Price RM/kg	% TDN	% Protein	% Ca	% P
(Empty Fruit Bunch)<100%	89.30%	0.10	80.00	10.00	0.02	0.28
(Rice bran)<5%	92.00%	0.42	66.00	10.00	0.07	1.62
(Seed media/molasses) <8%	80.00%	0.30	74.60	1.60	1.12	0.70
(Fermentation containers)						
(Urea) <2.46%	99.00%	1	0	285	0	0
(Soya bean meal/brewers grain) <10%	89.00%	0.88	81.00	43.00	0.36	0.75
(Dried Palm Oil Mill Effluent) <10%	91.20%	0.14	70.00	11.50	0.45	0.50
(Palm Kernal Cake) <20%	92.70%	0.27	84.00	15.20	0.02	0.06
(Limestone powder) <2%	100.00%	0	0	0	34	0
(Salt) <0.32%	100.00%	0	0	0	0	0
(Dicalcium phosphate) <0.32%	100.00%	1	0	0	27	19
(Viphosmine)<5%	100.00%	2	0	2	2	

Source: Livestock Research Division, MARDI, Serdang.

Appendix 3. Operation cost for production of fermented empty fruit bunch

Item	30,000 t/y	60,000 t/y	105,000 t/y	180,000 t/y	240,000 t/y	300,000 t/y
UTILITY COST(>10%TC)	108,300	216,600	379,050	649,800	866,400	1,083,000
(Electricity)	70,937	141,873	248,278	425,619	567,492	709,365
(Fuel)	34,115	68,229	119,401	204,687	272,916	341,145
(Water)	3,249	6,498	11,372	19,494	25,992	32,490
MATERIAL COST	2,114,400	4,228,800	7,400,400	12,686,400	16,915,200	21,144,000
(Empty Fruit Bunch)<100%	900,000	1,800,000	3,150,000	5,400,000	7,200,000	9,000,000
(Rice bran)<5%*	630,000	1,260,000	2,205,000	3,780,000	5,040,000	6,300,000
(Seed media/molasses) <8%*	230,400	460,800	806,400	1,382,400	1,843,200	2,304,000
(Fermentation containers)	300,000	600,000	1,050,000	1,800,000	2,400,000	3,000,000
(Limestone powder) <2%*	54,000	108,000	189,000	324,000	432,000	540,000
LABOR COST	72,000	144,000	252,000	432,000	576,000	720,000
AMORTIZATION COST	1,130,520	1,130,520	1,130,520	1,130,520	1,130,520	1,130,520
MAINTENANCE COST	198,820	198,820	198,820	198,820	198,820	198,820
TOTAL	3,624,040	5,918,740	9,360,790	15,097,540	19,686,940	24,276,340

Appendix 4. Operation cost for production of beef cattle feed

Item	30,000t/y	60,000 t/y	105,000 t/y	180,000 t/y	240,000 t/y	300,000 t/y
UTILITY COST(>10%TC)	108,300	216,600	379,050	649,800	866,400	1,083,000
(Electricity)	70,937	141,873	248,278	425,619	567,492	709,365
(Fuel)	34,115	68,229	119,401	204,687	272,916	341,145
(Water)	3,249	6,498	11,372	19,494	25,992	32,490
MATERIAL COST	9,134,400	18,268,800	31,970,400	54,806,400	73,075,200	91,344,000
(Empty Fruit Bunch)<51%	459,000	918,000	1,606,500	2,754,000	3,672,000	4,590,000
(Rice bran)<5%	630,000	1,260,000	2,205,000	3,780,000	5,040,000	6,300,000
(Seed media/molasses) <10%	288,000	576,000	1,008,000	1,728,000	2,304,000	2,880,000
(Fermentation containers)	300,000	600,000	1,050,000	1,800,000	2,400,000	3,000,000
(Urea) <3%	522,000	1,044,000	1,827,000	3,132,000	4,176,000	5,220,000
(Soya bean meal/brewers grain) <40%						
(Dried Palm Oil Mill Effluent) <10%	420,000	840,000	1,470,000	2,520,000	3,360,000	4,200,000
(Palm Kernal Cake) <22%	1,782,000	3,564,000	6,237,000	10,692,000	14,256,000	17,820,000
(Limestone	135,000	270,000	472,500	810,000	1,080,000	1,350,000
(Salt) <5%	278,400	556,800	974,400	1,670,400	2,227,200	2,784,000
(Dicalcium phosphate) <5%	1,470,000	2,940,000	5,145,000	8,820,000	11,760,000	14,700,000
(Viphosmine)	2,850,000	5,700,000	9,975,000	17,100,000	22,800,000	28,500,000
LABOR COST	72,000	144,000	252,000	432,000	576,000	720,000
AMORTIZATION COST	1,130,520	1,130,520	1,130,520	1,130,520	1,130,520	1,130,520
MAINTENANCE COST	198,820	198,820	198,820	198,820	198,820	198,820
TOTAL	10,644,040	19,958,740	33,930,790	57,217,540	75,846,940	94,476,340

Appendix 5. Operation cost for production of dairy cattle feed

Item	30,000t/y	60,000 t/y	105,000 t/y	180,000 t/y	240,000 t/y	300,000 t/y
UTILITY COST(>10%TC)	108,300	216,600	379,050	649,800	866,400	1,083,000
(Electricity)	70,937	141,873	248,278	425,619	567,492	709,365
(Fuel)	34,115	68,229	119,401	204,687	272,916	341,145
(Water)	3,249	6,498	11,372	19,494	25,992	32,490
MATERIAL COST	10,753,980	21,507,960	37,638,930	64,523,880	86,031,840	107,539,800
(Empty Fruit Bunch)<42%	378,000	756,000	1,323,000	2,268,000	3,024,000	3,780,000
(Rice bran)<5%	630,000	1,260,000	2,205,000	3,780,000	5,040,000	6,300,000
(Seed media/molasses) <8%	230,400	460,800	806,400	1,382,400	1,843,200	2,304,000
(Fermentation containers)	300,000	600,000	1,050,000	1,800,000	2,400,000	3,000,000
(Urea) <2.46%	428,040	856,080	1,498,140	2,568,240	3,424,320	4,280,400
(Soya bean meal/brewers grain) <10%	2,640,000	5,280,000	9,240,000	15,840,000	21,120,000	26,400,000
(Dried Palm Oil Mill Effluent) <10%	420,000	840,000	1,470,000	2,520,000	3,360,000	4,200,000
(Palm Kernal Cake) <20%	1,620,000	3,240,000	5,670,000	9,720,000	12,960,000	16,200,000
(Limestone powder) <1.4%	38,340	76,680	134,190	230,040	306,720	383,400
(Salt) <0.32%	278,400	556,800	974,400	1,670,400	2,227,200	2,784,000
(Dicalcium phosphate) <0.32%	940,800	1,881,600	3,292,800	5,644,800	7,526,400	9,408,000
(Visphomine minerals) <5%	2,850,000	5,700,000	9,975,000	17,100,000	22,800,000	28,500,000
LABOR COST	72,000	144,000	252,000	432,000	576,000	720,000
AMORTIZATION COST	1,130,520	1,130,520	1,130,520	1,130,520	1,130,520	1,130,520
MAINTENANCE COST	198,820	198,820	198,820	198,820	198,820	198,820
TOTAL	12,263,620	23,197,900	39,599,320	66,935,020	88,803,580	110,672,140

Appendix 6. Cash Flow Projection for Production of Fermented EFB Pallets

PRODUCTION (TON/YEAR)		30,000	60,000	105,000	180,000	240,000	300,000	300,000	300,000	300,000	300,000
Year	0	1	2	3	4	5	6	7	8	9	10
CASH INFLOW	RM	RM	RM	RM	RM	RM	RM	RM	RM	RM	RM
Revenue											
Fermented EFB Pallets	RM110/TON	3,300,000	6,600,000	11,550,000	19,800,000	26,400,000	33,000,000	33,000,000	33,000,000	33,000,000	33,000,000
TOTAL CASH INFLOW		3,300,000	6,600,000	11,550,000	19,800,000	26,400,000	33,000,000	33,000,000	33,000,000	33,000,000	33,000,000
CASH OUT FLOW											
CAPITAL COST											
Land	515,000										
Machinery	3,249,000										
Electricity	605,000										
Civil and building	1,220,000										
Irradiator	5,241,000										
TOTAL CAPITAL COST	10,830,000										
OPERATING COST											
Total Utility Cost		108,300	216,600	379,050	649,800	866,400	1,083,000	1,083,000	1,083,000	1,083,000	1,083,000
Total Material Cost		2,114,400	4,228,800	7,400,400	12,686,400	16,915,200	21,144,000	21,144,000	21,144,000	21,144,000	21,144,000
Labour		72,000	144,000	252,000	432,000	576,000	720,000	720,000	720,000	720,000	720,000
Maintenance		198,820	198,820	198,820	198,820	198,820	198,820	198,820	198,820	198,820	198,820
Miscellaneous (10% O.C)		249,352	478,822	823,027	1,396,702	1,855,642	2,314,582	2,314,582	2,314,582	2,314,582	2,314,582
TOTAL OPERATING COST		2,742,872	5,267,042	9,053,297	15,363,722	20,412,062	25,460,402	25,460,402	25,460,402	25,460,402	25,460,402
TOTAL CASH OUTFLOW	10,830,000	2,742,872	5,267,042	9,053,297	15,363,722	20,412,062	25,460,402	25,460,402	25,460,402	25,460,402	25,460,402
NET CASH INFLOW	(10,830,000)	557,128	1,332,958	2,496,703	4,436,278	5,987,938	7,539,598	7,539,598	7,539,598	7,539,598	7,539,598
ACC. NET CASH BALANCE	(10,830,000)	(10,272,872)	(8,939,914)	(6,443,211)	(2,006,933)	3,981,005	11,520,603	19,060,201	26,599,799	34,139,397	41,678,995
NPV	17,148,542										
IRR	0.2918										
Pay Back Period (years)	5										
B/C	1.58										
FINANCED BY;											
Equity %	50	5,575,676									
Borrowing %	50	5,575,676	(period 5 years,	interest 12%)							
TOTAL(CAP+L1+CON.1)		11,151,352									
REPAYMENT OF LOAN											
Principle		1,115,135	1,115,135	1,115,135	1,115,135	1,115,135					
Interest		669,081	669,081	669,081	669,081	669,081					
TOTAL REPAYMENT		1,784,216	1,784,216	1,784,216	1,784,216	1,784,216					
NET CASH INFLOW	(10,830,000)	(1,227,088)	(451,258)	712,487	2,652,062	4,203,722	7,539,598	7,539,598	7,539,598	7,539,598	7,539,598
ACC. NET CASH BAL.	(10,830,000)	(12,057,088)	(12,508,347)	(11,795,860)	(9,143,798)	(4,940,077)	2,599,521	10,139,119	17,678,717	25,218,315	32,757,913
NPV (+CAP PAYMENT)	10,384,958										
IRR (+CAP PAYMENT)	0.18472										
Pay Back period (years)	6										
B/C	0.96										

Appendix 7. Cash Flow Projection for Production of Beef Cattle Pallets

PRODUCTION (TON/YEAR)		30,000	60,000	105,000	180,000	240,000	300,000	300,000	300,000	300,000	300,000
Year	0	1	2	3	4	5	6	7	8	9	10
CASH INFLOW	RM	RM	RM	RM	RM	RM	RM	RM	RM	RM	RM
Revenue - Beef cattle pallet	RM 370/TON	11,100,000	22,200,000	38,850,000	66,600,000	88,800,000	111,000,000	111,000,000	111,000,000	111,000,000	111,000,000
TOTAL CASH INFLOW		11,100,000	22,800,000	38,850,000	66,600,000	88,800,000	111,000,000	111,000,000	111,000,000	111,000,000	111,000,000
CASH OUT FLOW											
CAPITAL COST											
Land	515,000										
Machinery	3,249,000										
Electricity	605,000										
Civil and building	1,220,000										
Irradiator	5,241,000										
TOTAL CAPITAL COST	10,830,000										
OPERATING COST											
Total Utility Cost		108,300	216,600	379,050	649,800	866,400	1,083,000	1,083,000	1,083,000	1,083,000	1,083,000
Total Material Cost		9,134,400	18,268,800	31,970,400	54,806,400	73,075,200	91,344,000	91,344,000	91,344,000	91,344,000	91,344,000
Labour		72,000	144,000	252,000	432,000	576,000	720,000	720,000	720,000	720,000	720,000
Maintenance		198,820	198,820	198,820	198,820	198,820	198,820	198,820	198,820	198,820	198,820
Miscellaneous (10% O.C)		951,352	1,882,822	3,280,027	5,608,702	7,471,642	9,334,582	9,334,582	9,334,582	9,334,582	9,334,582
TOTAL OPERATING COST		10,464,872	20,711,042	36,080,297	61,695,722	82,188,062	102,680,402	102,680,402	102,680,402	102,680,402	102,680,402
TOTAL CASH OUTFLOW	10,830,000	10,464,872	20,711,042	36,080,297	61,695,722	82,188,062	102,680,402	102,680,402	102,680,402	102,680,402	102,680,402
NET CASH INFLOW	(10,830,000)	635,128	1,488,958	2,769,703	4,904,278	6,611,938	8,319,598	8,319,598	8,319,598	8,319,598	8,319,598
ACC. NET CASH BALANCE	(10,830,000)	(10,194,872)	(8,705,914)	(5,936,211)	(1,031,933)	5,580,005	13,899,603	22,219,201	30,538,799	38,858,397	47,177,995
NPV	20,096,539										
IRR	0.3164										
Pay Back Period (years)	5										
B/C	1.86										

FINANCED BY;											
Equity %	50	5,926,676									
Borrowing %	50	5,926,676	(period	5 years;	interest 12%)						
TOTAL(CAP+L1+CON.1)		11,853,352									
REPAYMENT OF LOAN											
Principle		1,185,335	1,185,335	1,185,335	1,185,335	1,185,335					
Interest		711,201	711,201	711,201	711,201	711,201					
TOTAL REPAYMENT		1,896,536	1,896,536	1,896,536	1,896,536	1,896,536					
NET CASH INFLOW	(10,830,000)	(1,261,408)	(407,578)	837,167	3,007,742	4,715,402	8,319,598	8,319,598	8,319,598	8,319,598	8,319,598
ACCUMULATED CASH BAL.	(10,830,000)	(12,091,408)	(12,498,987)	(11,625,820)	(8,618,078)	(3,902,677)	4,416,921	12,736,519	21,056,117	29,375,715	37,695,313
NPV (+CAP PAYMENT)	11,733,795										
IRR (+CAP PAYMENT)	0.2053										
Pay Back period (years)	6										
B/C	1.08										

Appendix 8. Cash Flow Projection . . Production of Dairy Cattle Pallets

PRODUCTION TON/YEAR		30,000	60,000	105,000	180,000	240,000	300,000	300,000	300,000	300,000	300,000
Year	0	1	2	3	4	5	6	7	8	9	10
CASH INFLOW	RM	RM	RM	RM	RM	RM	RM	RM	RM	RM	RM
Revenue - Dairy Cattle Pallets	RM 430/TON	12,900,000	25,800,000	45,150,000	77,400,000	103,200,000	129,000,000	129,000,000	129,000,000	129,000,000	129,000,000
TOTAL CASH INFLOW		12,900,000	25,800,000	45,150,000	77,400,000	103,200,000	129,000,000	129,000,000	129,000,000	129,000,000	129,000,000
CASH OUT FLOW											
CAPITAL COST											
Land	515,000										
Machinery	3,249,000										
Electricity	605,000										
Civil and building	1,220,000										
Irradiator	5,241,000										
TOTAL CAPITAL COST	10,830,000										
OPERATING COST											
Total Utility Cost		108,300	216,600	379,050	649,800	866,400	1,083,000	1,083,000	1,083,000	1,083,000	1,083,000
Total Material Cost		10,753,980	21,507,960	37,638,930	64,523,880	86,031,840	107,539,800	107,539,800	107,539,800	107,539,800	107,539,800
Labour		72,000	144,000	252,000	432,000	576,000	720,000	720,000	720,000	720,000	720,000
Maintenance		198,820	198,820	198,820	198,820	198,820	198,820	198,820	198,820	198,820	198,820
Miscellaneous (10% O.C)		1,113,310	2,206,738	3,846,880	6,580,450	8,767,306	10,954,162	10,954,162	10,954,162	10,954,162	10,954,162
TOTAL OPERATING COST		12,246,410	24,274,118	42,315,680	72,384,950	96,440,366	120,495,782	120,495,782	120,495,782	120,495,782	120,495,782
TOTAL CASH OUTFLOW	10,830,000	12,246,410	24,274,118	42,315,680	72,384,950	96,440,366	120,495,782	120,495,782	120,495,782	120,495,782	120,495,782
NET CASH INFLOW	(10,830,000)	653,590	1,525,882	2,834,320	5,015,050	6,759,634	8,504,218	8,504,218	8,504,218	8,504,218	8,504,218
ACC. NET CASH BALANCE	(10,830,000)	(10,176,410)	(8,650,528)	(5,816,208)	(801,158)	5,958,476	14,462,694	22,966,912	31,471,130	39,975,348	48,479,566
NPV	20,794,307										
IRR	0.3220										
Pay Back Period (years)	5										
B/C	1.92										
FINANCED BY;											
Equity %	50	6,007,655									
Borrowing %	50	6,007,655	(period (years) 5;	interest	12.00%)						
TOTAL(CAP+L1+CON.1)		12,015,310									
REPAYMENT OF LOAN											
Principle		1,201,531	1,201,531	1,201,531	1,201,531	1,201,531					
Interest		720,919	720,919	720,919	720,919	720,919					
TOTAL REPAYMENT		1,922,450	1,922,450	1,922,450	1,922,450	1,922,450					
NET CASH INFLOW	(10,830,000)	(1,268,860)	(396,568)	911,870	3,092,600	4,837,184	8,504,218	8,504,218	8,504,218	8,504,218	8,504,218
ACC. NET CASH BAL.	(10,830,000)	(12,098,860)	(12,495,427)	(11,583,557)	(8,490,956)	(3,653,772)	4,850,446	13,354,664	21,858,882	30,363,100	38,867,318
NPV (+CAP PAYMENT)	13,506,711										
IRR (+CAP PAYMENT)	0.2285										
Pay Back period (years)	6										
B/C	1.25										

Appendix 9. Cash Flow Projection for Production of Fermented EFB Pallets (30,000 Capacity)

PRODUCTION (TON/YEAR)		22,500	22,500	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
Year	0	1	2	3	4	5	6	7	8	9	10
CASH INFLOW	RM	RM	RM	RM	RM	RM	RM	RM	RM	RM	RM
Revenue- Fermented EFB Pallets	170/ton	3,825,000	3,825,000	5,100,000	5,100,000	5,100,000	5,100,000	5,100,000	5,100,000	5,100,000	5,100,000
TOTAL CASH INFLOW		3,825,000	3,825,000	5,100,000	5,100,000	5,100,000	5,100,000	5,100,000	5,100,000	5,100,000	5,100,000
CASH OUT FLOW											
CAPITAL COST											
Land	138,000										
Machinery	871,000										
Electricity	455,000										
Civil and building	326,000										
Irradiator	4,013,000										
TOTAL CAPITAL COST	5,803,000										
OPERATING COST											
Total Utility Cost		81,225	81,225	108,300	108,300	108,300	108,300	108,300	108,300	108,300	108,300
Total Material Cost		1,585,800	1,585,800	2,114,400	2,114,400	2,114,400	2,114,400	2,114,400	2,114,400	2,114,400	2,114,400
Labour		54,000	54,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000
Maintenance		149,115	149,115	198,820	198,820	198,820	198,820	198,820	198,820	198,820	198,820
Miscellaneous (10% O.C)		187,014	187,014	249,352	249,352	249,352	249,352	249,352	249,352	249,352	249,352
TOTAL OPERATING COST		2,057,154	2,057,154	2,742,872	2,742,872	2,742,872	2,742,872	2,742,872	2,742,872	2,742,872	2,742,872
TOTAL CASH OUTFLOW	5,803,000	2,057,154	2,057,154	2,742,872	2,742,872	2,742,872	2,742,872	2,742,872	2,742,872	2,742,872	2,742,872
NET CASH INFLOW	(5,803,000)	1,767,846	1,767,846	2,357,128	2,357,128	2,357,128	2,357,128	2,357,128	2,357,128	2,357,128	2,357,128
ACC. NET CASH BALANCE	(5,803,000)	(4,035,154)	(2,267,308)	89,820	2,446,948	4,804,076	7,161,204	9,518,332	11,875,460	14,232,588	16,589,716
NPV	7,657,810										
IRR	0.3394										
pay back period(years)	3										
B/C	1.32										
FINANCED BY;											
Equity %	50	3,022,007									
Borrowing %	50	3,022,007									
TOTAL(CAP+LAB.1+CONTIN.1)		6,044,014									
REPAYMENT OF LOAN	(5 YEARS)										
Principle		604,401	604,401	604,401	604,401	604,401					
Interest (12%)		362,641	362,641	362,641	362,641	362,641					
TOTAL REPAYMENT		967,042	967,042	967,042	967,042	967,042					
NET CASH INFLOW	(5,803,000)	800,804	800,804	1,390,086	1,390,086	1,390,086	2,357,128	2,357,128	2,357,128	2,357,128	2,357,128
ACC. NET CASH BALANCE	(5,803,000)	(5,002,196)	(4,201,392)	(2,811,307)	(1,421,221)	(31,135)	2,325,993	4,683,121	7,040,249	9,397,377	11,754,505
NPV (+CAP PAYMENT)	3,991,959										
IRR (+CAP PAYMENT)	0.21139										
Pay Back period (yrs)	5										
B/C	0.69										

Appendix 10. Cash Flow Projection for Production of Beef Cattle Pallets (30,000 ton capacity)

PRODUCTION (TON/YEAR)		22,500	22,500	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
Year	0	1	2	3	4	5	6	7	8	9	10
CASH INFLOW	RM	RM	RM	RM	RM	RM	RM	RM	RM	RM	RM
Revenue											
Beef cattle Pallets	420/ton	9,450,000	9,450,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000
TOTAL CASH INFLOW		9,450,000	9,450,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000	12,600,000
CASH OUT FLOW											
CAPITAL COST											
Land	138,000										
Machinery	871,000										
Electricity	455,000										
Civil and building	326,000										
Irradiator	4,013,000										
TOTAL CAPITAL COST	5,803,000										
OPERATING COST											
Total Utility Cost		81,225	81,225	108,300	108,300	108,300	108,300	108,300	108,300	108,300	108,300
Total Material Cost		6,850,800	6,850,800	9,134,400	9,134,400	9,134,400	9,134,400	9,134,400	9,134,400	9,134,400	9,134,400
Labour		54,000	54,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000
Maintenance		149,115	149,115	198,820	198,820	198,820	198,820	198,820	198,820	198,820	198,820
Miscellaneous (10% O.C)		713,514	713,514	951,352	951,352	951,352	951,352	951,352	951,352	951,352	951,352
TOTAL OPERATING COST		7,848,654	7,848,654	10,464,872	10,464,872	10,464,872	10,464,872	10,464,872	10,464,872	10,464,872	10,464,872
TOTAL CASH OUTFLOW	5,803,000	7,848,654	7,848,654	10,464,872	10,464,872	10,464,872	10,464,872	10,464,872	10,464,872	10,464,872	10,464,872
NET CASH INFLOW	(5,803,000)	1,601,346	1,601,346	2,135,128	2,135,128	2,135,128	2,135,128	2,135,128	2,135,128	2,135,128	2,135,128
ACC. NET CASH BALANCE	(5,803,000)	(4,201,654)	(2,600,308)	(465,180)	1,669,948	3,805,076	5,940,204	8,075,332	10,210,460	12,345,588	14,480,716
NPV	6,390,039										
IRR	0.3042										
Pay back period(years)	4										
B/C	1.10										
FINANCED BY:											
Equity %	50	3,285,257									
Borrowing %	50	3,285,257									
TOTAL(CAP+LAB.1+CONTIN.1)		6,570,514									
REPAYMENT OF LOAN	(int. 12%; 5 yrs)										
Principle		657,051	657,051	657,051	657,051	657,051					
Interest		394,231	394,231	394,231	394,231	394,231					
TOTAL REPAYMENT		1,051,282	1,051,282	1,051,282	1,051,282	1,051,282					
NET CASH INFLOW	(5,803,000)	550,064	550,064	1,083,846	1,083,846	1,083,846	2,135,128	2,135,128	2,135,128	2,135,128	2,135,128
ACC. NET CASH BALANCE	(5,803,000)	(5,252,936)	(4,702,872)	(3,619,027)	(2,535,181)	(1,451,335)	683,793	2,818,921	4,954,049	7,089,177	9,224,305
NPV (+CAP PAYMENT)	2,404,852										
IRR (+CAP PAYMENT)	0.16761										
Pay Back period (yrs)	6										
B/C	0.41										

Appendix 11. Cash Flow Projection for Production of Dairy attle Pallets (30,000 ton cap.)

Production (ton/year)		22,500	22,500	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
Year	0	1	2	3	4	5	6	7	8	9	10
CASH INFLOW											
Revenue-Dairy Cattle Pallets	480/ton	10,800,000	10,800,000	14,400,000	14,400,000	14,400,000	14,400,000	14,400,000	14,400,000	14,400,000	14,400,000
TOTAL CASH INFLOW		10,800,000	10,800,000	14,400,000	14,400,000	14,400,000	14,400,000	14,400,000	14,400,000	14,400,000	14,400,000
CASH OUT FLOW											
CAPITAL COST											
Land	138,000										
Machinery	871,000										
Electricity	455,000										
Civil and building	326,000										
Irradiator	4,013,000										
TOTAL CAPITAL COST	5,803,000										
OPERATING COST											
Total Utility Cost		81,225	81,225	108,300	108,300	108,300	108,300	108,300	108,300	108,300	108,300
Total Material Cost		8,065,485	8,065,485	10,753,980	10,753,980	10,753,980	10,753,980	10,753,980	10,753,980	10,753,980	10,753,980
Labour		54,000	54,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000
Maintenance		149,115	149,115	198,820	198,820	198,820	198,820	198,820	198,820	198,820	198,820
Miscellaneous (10% O.C)		834,983	834,983	1,113,310	1,113,310	1,113,310	1,113,310	1,113,310	1,113,310	1,113,310	1,113,310
TOTAL OPERATING COST		9,184,808	9,184,808	12,246,410	12,246,410	12,246,410	12,246,410	12,246,410	12,246,410	12,246,410	12,246,410
TOTAL CASH OUTFLOW	5,803,000	9,184,808	9,184,808	12,246,410	12,246,410	12,246,410	12,246,410	12,246,410	12,246,410	12,246,410	12,246,410
NET CASH INFLOW	(5,803,000)	1,615,193	1,615,193	2,153,590	2,153,590	2,153,590	2,153,590	2,153,590	2,153,590	2,153,590	2,153,590
ACC. NET CASH BALANCE	(5,803,000)	(4,187,808)	(2,572,615)	(419,025)	1,734,565	3,888,155	6,041,745	8,195,335	10,348,925	12,502,515	14,656,105
NPV	6,495,469										
IRR	0.3072										
pay back period(years)	4										
B/C	1.12										
FINANCED BY:											
Equity %	50	3,345,991									
Borrowing %	50	3,345,991									
TOTAL(CAP+LAB.1+C.1)		6,691,983									
REPAYMENT OF LOAN (5 yrs)											
Principle		669,198	669,198	669,198	669,198	669,198					
Interest (12%)		401,519	401,519	401,519	401,519	401,519					
TOTAL REPAYMENT		1,070,717	1,070,717	1,070,717	1,070,717	1,070,717					
NET CASH INFLOW	(5,803,000)	544,475	544,475	1,082,873	1,082,873	1,082,873	2,153,590	2,153,590	2,153,590	2,153,590	2,153,590
ACC. NET CASH BALANCE	(5,803,000)	(5,258,525)	(4,714,049)	(3,631,177)	(2,548,304)	(1,465,431)	688,159	2,841,749	4,995,339	7,148,929	9,302,519
NPV (+CAP PAYMENT)	2,436,609										
IRR (+CAP PAYMENT)	0.16822										
Pay Back period (yrs)	6										
B/C	0.42										

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