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MULTI SCENARIO CASE STUDY OF A FUEL PELLET MANUFACTURING OPERATION UTILIZING COTTON WASTE

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Abstract

The investigation for utilizing cotton processing waste or byproducts as the raw material for manufacturing fuel pellets has continued with the assistance from the USDA. The goal of this project was to develop an economic model to validate the cost feasibility for establishing a fuel pellet operation using cotton gin byproducts. The objectives required a complete and comprehensive analysis of marketing, transportation and manufacturing aspects. The results concluded within the confines of the analysis that manufacturing fuel pellets from cotton byproducts is a feasible operation. Crystal Ball 2000 simulation software, optimizing for Return on Investment (ROI), resulted in the selection of a two-shift 12hr work scenario with a 15,000 tons production capability. This yielded a payback period less than one year and ROI over 100%.

Introduction

The purpose of this project was to validate the economic feasibility for establishing a pellet manufacturing facility, where the pellets are manufactured utilizing cotton gin waste. Pellets made from cotton byproducts have been shown to burn comparably to pellets made from traditional sources. The wholesale pricing points for premium grade wood pellets range from $2.00 to $3.00 per 40 pound bag of finished product. These pricing points were used for baseline comparisons in the analysis.

It is estimated that enough gin waste is generated each year to support a cotton gin waste fuel pellet operation. In a typical year, such as 2002, Texas alone harvested 4,153,866 bales of upland cotton (USDA, 2002), which is estimated to have produced 750,000 tons of waste from the ginning process.

The project analysis focuses on a single pellet operation in a central location that is surrounded by a substantial number of cotton gins. The objectives were to create an economic model and conduct an economic analysis from marketing, transportation, and manufacturing aspects and then analyze the feasibility of this type of manufacturing operation. The following are among the activities that were accomplished to meet the objectives of this project:

1. Determination of acceptability of cotton gin waste fuel pellets in the current market
2. Determination of distribution areas
3. Determination of the appropriate selling price
4. Determination of the most economical mode of transportation for finished products
5. Determination of physical description and layout of the facilities
6. Development of a comprehensive cost system that was used to determine machine and labor compliments required.

Materials and Methods

The project was conducted by dividing requirements into the following task categories: Fabrication & Testing Fuel Pellets, Materials, Equipment & Manufacturing, Transportation, Economic Model and Simulation, and Analysis. The methods used to complete the obligations within each task category are described in the following sections.

Fabrication and Testing Fuel Pellets

Fuel pellet samples made from cotton gin byproducts samples were fabricated at the USDA-ARS Gin Laboratory in Lubbock, Texas. Procedures included common analytical methods and standardized ASTM procedures. Six types of pellets were manufactured using three different processing treatments (varying amounts of a gelatinized polysaccharide) and two types of raw material. The patented USDA COBY process was used to manufacture the pellets. The pellets were then sent to two different laboratories to test heating values, ash content, and bulk densities. Results indicated that the heating values (dry basis) were within 10% of the premium grade wood pellet. The ash contents of the pellets were approximately 3 to 7% higher than the premium grade wood pellet, which is an item that needs to be addressed in order to promote use of pellets in residential pellet stoves. Three out of the six pellet types met the bulk density standard of 40 lb/ft^3 set by the Residential Pellet Fuel Standards.

Materials

To determine the availability of raw material, an evaluation was performed investigating the location and the production capacities of the cotton gins near the proposed facility. Thirty-four gins were identified and their locations mapped to estimate the driving distances. Production capacities for each gin were calculated based on the average production of cotton bales per county between the years 2000 and 2002.

Three different target production rates were considered in this study: 5,000, 10,000, and 15,000 ton/year. The raw material required to meet these target rates were calculated considering that 80 % of the raw material is usable for the pellet production. Based on this estimate it was determined that the amount of material needed for each production rate could be supplied from cotton gins within a 10 mile radius from the proposed facility.

Equipment and Manufacturing

Identification of the specific equipment and costs required for building and running the pellet manufacturing process was a critical objective of this task. An analysis of the required equipment and costs was conducted utilizing quotes from venders and published information. The information was compiled to produce a schema of the process, a process flow diagram, a detailed list of all machinery and their parameters, and measured layout of the manufacturing facility.

A process schema was developed to graphically depict the sequence of sub-processes throughout the pellet operation. Three process schemas were created. Each presented the operation for one of three process scenarios that differ in equipment compliments. Scenario 1 uses two extruders, Scenario 2 uses 6 extruders, and Scenario 3 uses no extruders. A process flow diagram was created to evaluate the design of the process schemas.

A comprehensive list of the equipment and equipment parameters was created based on an analysis of quotes and bids from venders along with costs published from previous projects. The purpose of the equipment list was to determine equipment compatibility, electrical consumption, purchase costs, and facility dimensions. A layout was created for the pellet facility to determine the required size and the costs of constructing the facility for each scenario. See Figure 1 for the Process Flow Diagram developed to assist in developing the facility layouts. Figure 2 is an example of one of the layouts developed for this project. Major considerations for constructing the layouts included compatible orientations of each piece of machinery and necessary clearances between machinery.

Transportation

Two different transportation costs were analyzed for this project.

1. The costs of transferring raw material from cotton gins to the manufacturing facility.
2. The transportation costs for shipping the final product.

Transportation costs for raw material were based on the driving distance per trip. The rate was set at $100 for driving distances less then 50 miles to the storage site or $2 per mile for driving distances over 50 miles from the storage site. The total cost of transporting the required raw material was based on the number of trips required to meet the target production capacity.

In general, most finished product transportation would be FOB the manufacturing facility and therefore not considered in the basic manufacturing economic analysis. In this case, the current markets for fuel pellets are remote to the manufacturing facility. The remoteness of the market influences the finish product transportation cost to the consumer and therefore affects the feasibility of the project as a whole. For the final analysis finished product shipping cost will not be included in the economic model and all finished product shipping will be considered FOB the manufacturing plant.

Three destinations were considered in the evaluation of transportation costs for shipping final product: Albuquerque, New Mexico, Oklahoma City, Oklahoma, and Tyler, Texas. These destinations were selected based on market potential and transportation feasibility. An investigation of inter-modal transportation determined that truck was the recommended means of commercial transportations to these destinations. The costs of truck transportation are as follows: Albuquerque ($2.2/mi), Oklahoma City ($1.25/ mi), and Tyler ($1.25/mi). A cost analysis allocating various combinations of the three destinations revealed that two options offer the greatest cost advantages these are: (1) transporting only to Oklahoma City and (2) transporting 1/8 to Albuquerque, 3/4 to Oklahoma City, and 1/8 to Tyler.

Economic Model and Simulation Analysis

The methods used to develop the cost system for this project are broken into three tasks. These include (1) creating the database and formula spreadsheets, (2) setting up and running the economic simulation, and (3) creating and analyzing financial analysis reports. The following will describe the methods used complete these tasks.

The economic model created for this project is complex and includes many interdependent variables. The assumptions and limitations are presented below:

1. No cost of capital (interest) was applied.
2. No machine down time was applied.
3. A project life of 15 years was used to compute Internal Rate of Return with no salvage value included.
4. All finished product was sold during the season.

The model calculated the financial feasibility of operating the pellet manufacturing facility by varying target production capacities, process scenarios, and work shifts is shown at the Table 1.

MS Excel was used to develop the spreadsheets and Crystal Ball 2000 was used as the simulation software. The model was set up in nine main work sheets: Inputs, Production Process, Labor, Utilities, Transportation, Depreciation Schedule, Proforma International System (IS), and Metrics. Statistical distributions were assigned to some independent variables based on the data generating process combined with expert knowledge in the area. For instance, Normal distribution was selected as the best fit to some independent variables. Each work sheet includes organized data and formulas that are linked to each other. These work sheets are described below.

Inputs

The Inputs worksheet contains most of the data obtained from the previous analyses. It includes specific data related to raw material, labor, utilities, finished product, and revenue.

Production Process

The Production Process work sheet calculates the following for each of the three process scenarios: required working days, capital investment, electricity consumption, production capacity, etc. Installation costs were also included in this work sheet and were estimated to be 21.5 % of the capital investment. This amount was suggested by expert consultation and was in accordance with Humphreys, K. K. and P. Wellman (1996). The installation costs included both material and labor costs for instruments, electrical, piping, painting, and miscellaneous.

Labor

The Labor worksheet calculates direct labor, indirect labor, and labor for hauling raw material. The calculations of these costs depend on each work shift schedule and process scenario due to differences in the number of production days required.

Utilities

The consumption and costs for electricity and fuel are presented in this work sheet. The electricity costs were calculated based on an estimated rate provided by a local electricity company ($0.0511 per kilowatt hour) along with the estimated electricity consumption for the pellet operation. The Utilities work sheet also calculates the fuels costs for propane and diesel fuel that will be used to power the forklift and the module truck for the operation. The rate used for diesel was acquired from an analysis of weekly diesel costs provided by the Energy Information Administration. As for propane, the rate used was based on expert recommendation.

Transportation

The Transportation work sheet calculates the costs for transporting raw material to the storage facility and the costs for shipping final product. Costs in this work sheet mainly depend on target production capacity chosen. The cost rates used were those that were discussed previously.

Depreciation Schedule

This work sheet describes the depreciation schedule for machinery that was confirmed by a Certified Professional Accountant. The schedule used was a Modified Accelerated Cost Recovery System (MACRS) method (Canada, Sullivan, and White, 1996). The depreciation schedule for installation costs was based on a 39-year straight line for a non-residential building.

Proforma IS

This worksheet calculates and displays the following: yearly sales, revenue, cost of goods sold (COGS), gross margin, operating expense, earnings before interest, taxes, depreciation and amortization (EBITDA), earnings before interest and taxes (EBIT), and net income.

Metrics

The Metrics work sheet provides financial measures for further financial analysis. These include: initial investment, annual cash flow and net income, pay-back period analysis, return on investment, internal rate of return. Initial investment contains machines, installation costs, building, and land. The annual net cash flow comes from EBITDA without land cost, although the land cost has been placed in the G&A cost category for the first year's Proforma income statement.

Analysis

The financial analysis report presents the financial performance for the main independent variables: work shifts, target production capacities, and process scenarios. More than 70 combinations were collected and analyzed after running the economic program. Performance was measured by the following financial ratios: payback period, return on investment, and internal rate of return. A break-even analysis was also included.

It is clear from the results of the financial analysis that the economic model validated the cost feasibility for creating a fuel pellet operation utilizing cotton byproducts. The preferred work shift, production capacity, and process scenario for this operation was decided based on the results of the financial analysis. Based on the analysis results, Scenario 3, with a work schedule of 2-12 hour work shifts, and a target production capacity of 15,000 tons generated the highest ROI, the shortest payback period, and the largest net income. The results for the different scenarios are presented in Table 2.

Table 2 reveals that other scenarios also exhibit a reasonable ROI but are not as substantial as the 10,000 and 15,000 tons finished product capacities of Scenario 3. This would also suggest that Scenario 3 ROI would be attractive in years where the harvest is less than optimal and the availability of raw material is limited. This would not be the case for Scenarios 1 and 2 that are only attractive at the maximum production capacity of 15,000 tons per year. This is supported by the break even tons of finished product for each scenario. In Scenario 1 there is a breakeven quantity of 10,727 tons, Scenario 2 has a breakeven quantity of 13,355 tons while Scenario 3 requires 5,784 tons to break even.

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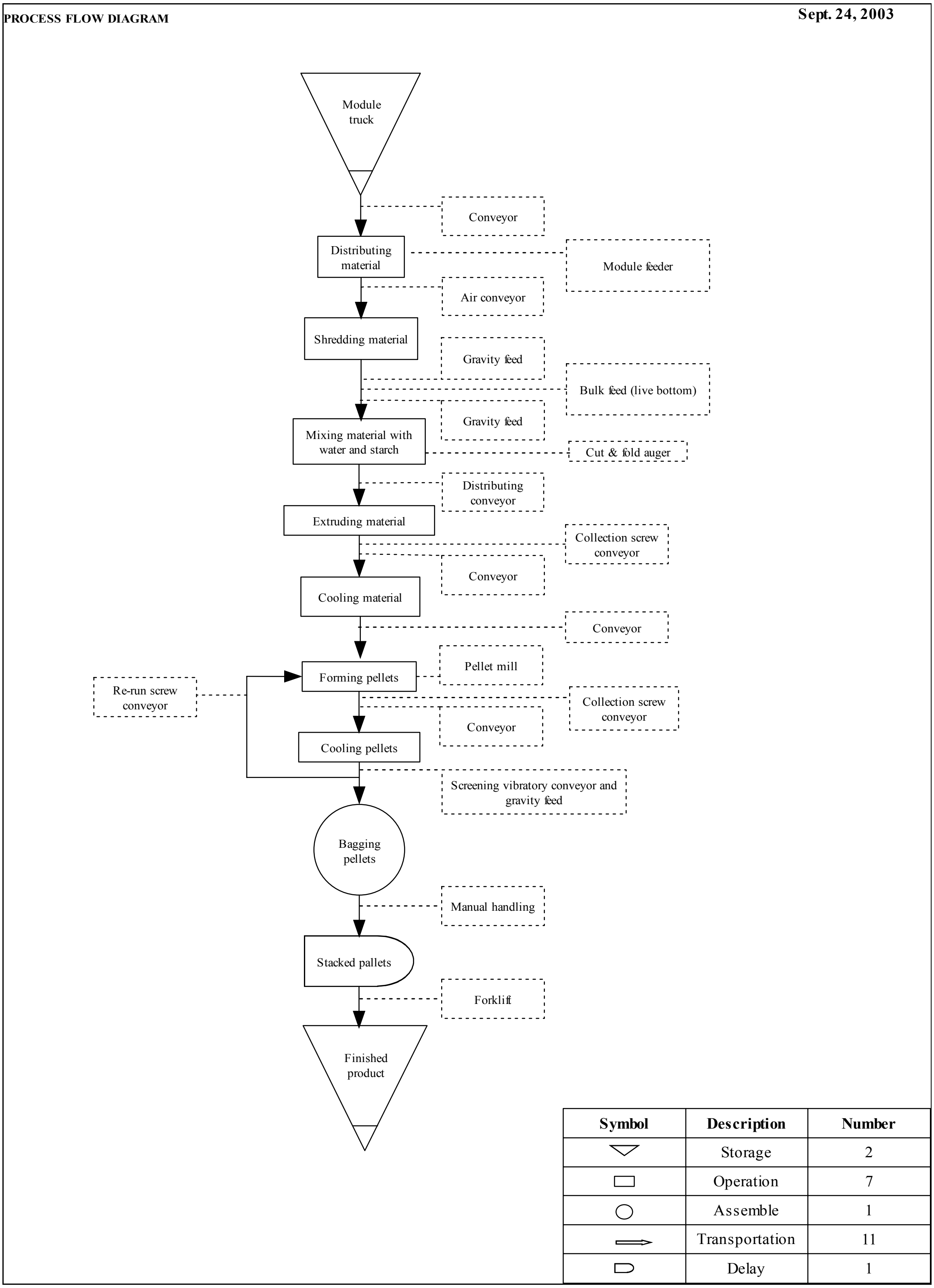

Figure 1. Process flow diagram.

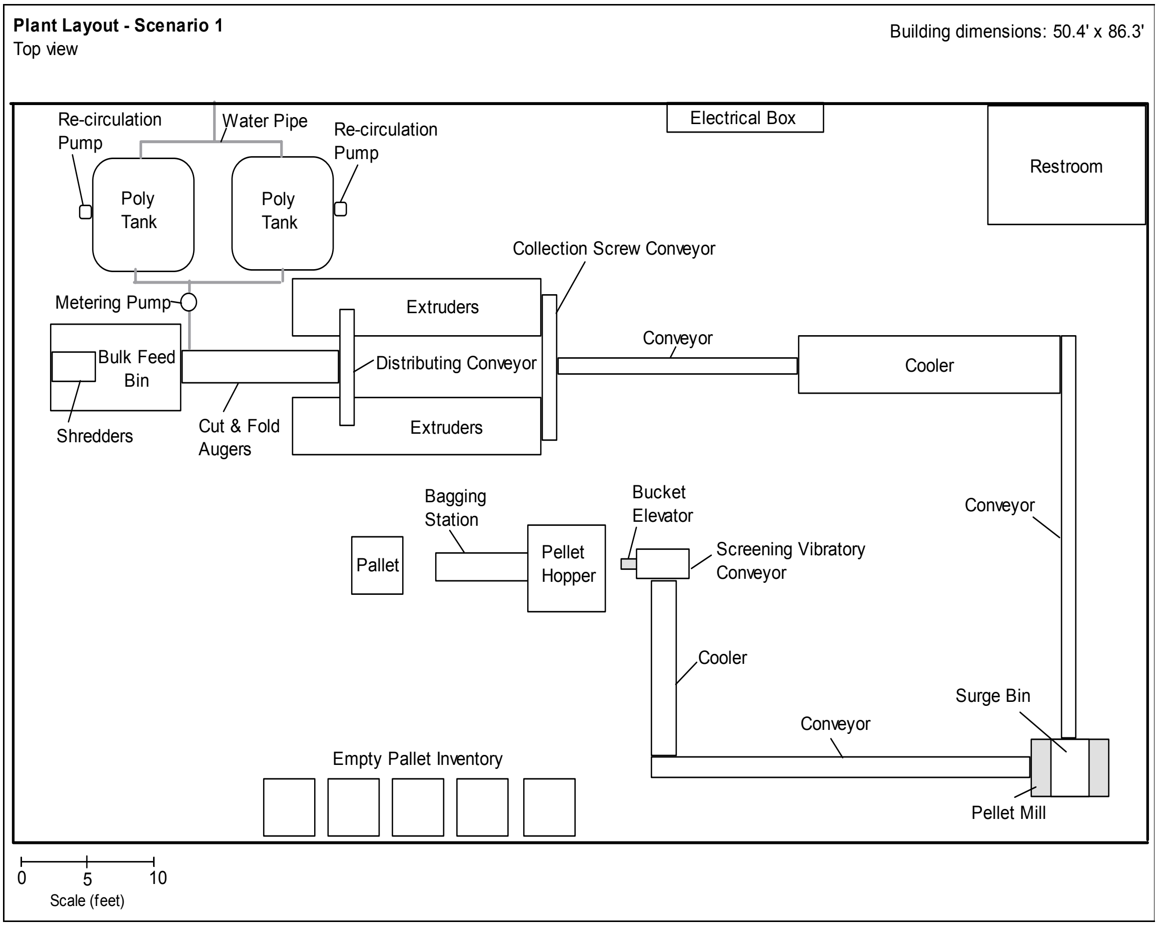

Figure 2. Equipment layout for scenario #1.

Table 1. Levels of target production capacities, process scenarios, and work shift schedules.

Main Variables	Levels of Variables
Target production capacities	
	5,000 tons/hr
	10,000 tons/hr
	15,000 tons/hr
Process scenarios	
	Scenario 1 (2 extruders)
	Scenario 2 (6 extruders)
	Scenario 3 (no extruders)
Work shift schedules (5 days/wk)	
	1 shift 12 hours
	2 shifts 12 hours
	2 shifts 8 hours
	3 shifts 8 hours

Table 2. Results of the financial analysis for a 2 shift 12 hour work schedule including process scenarios and target production capacities.

Shifts /day	Process Scenario	Finished Product (tons/yr)	Days Required	Net Income - without land costs	EBITDA - without land costs	Break Even (tons)	Pay Back Period (years)	Return on Invest-ment	Internal Rate of Return
		5,000	49.0	($248,899.57)	($132,005.05)	-	N/A	N/A	N/A
	1	10,000	97.0	($32,417.36)	$84,477.17	-	10.73	9.32%	4.51%
		15,000	146.0	$186,351.59	$303,246.12	10,727.28	2.99	33.45%	32.98%
		5,000	61.0	($329,766.13)	($189,905.45)	-	N/A	N/A	N/A
2	2	10,000	122.0	($133,840.57)	$6,020.12	-	177.29	0.56%	N/A
		15,000	182.0	$65,658.85	$205,519.53	13,354.51	5.19	19.26%	17.55%
		5,000	50.0	($40,351.02)	$18,945.35	-	26.58	3.76%	-6.42%
	3	10,000	100.0	$218,285.89	$277,582.26	5,783.82	1.81	55.13%	55.05%
		15,000	150.0	$479,107.41	$538,403.78	-	0.94	106.92%	106.92%