A BUSINESS OPPORTUNITY STUDY ON RECOVERY OF FUEL OIL, CARBON BLACK AND STEELFROM USED TYRES

BY

GEBRU AYEHUBZU ALAMREW

ADDIS ABABA UNIVERSITY

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A Business Opportunity Study on Recovery of Fuel Oil,CarbonBlack and Steel from Used Tyres

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By

Gebru Ayehubzu Alamrew

Advisor

Mohammed Seid, PhD

Department of Management

College of Business and Economics

Addis Ababa University

May 2014

Addis Ababa

Addis Ababa University

School of Graduate Studies

College of Business and Economics

Department of Management

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Approved by Board of Examiners

1. ____________________ ____________ ________________________
Advisor Signature Date

2. ____________________ ____________ ________________________
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3. ____________________ ____________ ________________________
External Examiner Signature Date

DECLARATION

I hereby declare that the thesis entitled "**A Business Opportunity Study on Recovery of Fuel Oil, Carbon Black and Steel from Used Tyres**" is my original work and has not been submitted by anyone for any degree in any university. All the materials used for the study have been duly acknowledged.

Gebru Ayehubzu Alamrew	___________	___________
Name	*Signature*	*Date*

ADVISOR'S APPROVAL

This is to certify that Gebru Ayehubzu Alamrew has completed his thesis entitled "**A Business Opportunity Study on Recovery of Fuel Oil, Carbon Black and Steel from Used Tyres**" successfully. The thesis, done under my supervision, is the original effort of the candidate and all materials usedhave been duly acknowledged. It is recommended that thethesis be placed before the examiners for evaluation.

Mohammed Seid (PhD) ___________ ___________

Name *Signature* *Date*

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ABSTRACT

The purpose and scope of this study is to introduce used tyre pyrolysis business and provide general information on the project. Tyre pyrolysis is a process carried out in the absence of oxygen to recover fuel oil, gases, carbon char and steel from used tyres. The study is based on data gathered from pertinent secondary and primary sources, and certain assumptions. In the study, it is found that about 40,000 tons of scrap tyres are generated annually in Ethiopia currently, out of which about 6,000 tons per year are estimated to be available for pyrolysis project. The envisaged project will have adequate market for its products. A plant with 12 tons per day capacity with technology from China is selected. The best location for the project is in the outskirts of Addis Ababa or Oromia towns around Addis. The total investment cost of the project is estimated at Birr 12.6 million. The financial analysis shows that the project is viable in all measures of profitability analysis: The simple rate of return on total investment at full capacity operation is 52%; the payback period is 3.6 years including the construction period; the net present value (NPV) over the total investment, calculated at 12.5% discount rate, is positive (i.e., Birr 19,447,413); the internal rate of return (IRR) over the total investment is 43%; and annual cash surplus starts in the second year and continues to grow. The result of sensitivity analysis shows that the project is primarily sensitive to fuel oil sales price, and also to scrap tyre acquisition cost on secondary level. The feasibility of the project becomes marginal if the steel has no sales, and the project ceases to be feasible if both carbon black pellet and steel do not have market. This is in conformity with the findings in the literature. The project possesses wide range of benefits such as generation of social surplus and employment, import substitution and contribution to the transfer of technology. In addition, the project greatly contributes to the environmental protection effort by cleaning waste tyres, reducing the health and fire hazards and avoiding release of chemicals that harm the environment by open burning. Hence, the project is worth implementing, and it is recommended that interested parties should prepare a detailed feasibility study and start the project soon to get the first mover advantages.

Key Words: *Scrap Tyre Management, Scrap Tyre Pyrolysis, Project Feasibility Study, Tyre Pyrolysis Oil, Carbon Black/Char*.

CHAPTER 1: INTRODUCTION

This chapter provides the study background and presents statement of the problem, the objectives, significance, scope and limitation of the study, and organization of the report.

1.1 Background of the Study

The automobile industry is the largest consumer of rubber, about 65% being used for tyres alone (Ahmed, van de Klundert & Lardinois, 1996). The average tyre last for about 50,000km before it is likely to require replacement (Rice, 2002). Then it has to be replaced and disposed off, making used tyres one of the very familiar solid wastes.

Globally, about 1.5 billion waste tyres are generated annually (Ware, Shukla, Kushvah, & Desai, 2013; and Makitan, 2010). In addition to the annual continuous flow of waste tyres, billions of tyres are already stocked in piles. When tyres are disposed of, they have lost only a small percentage of their original mass, indicating that used tyres are essentially the same in physical and chemical properties to that of new tyres. Hence, scrap tyres present both an environmental challenge and a resource opportunity.

The environmental challenges come from the property of the tyres themselves. Tyres are designed to be abrasive, load carrying and indestructible made to high quality standards. These distinctive properties that ensure safe travel and long service life make scrap tyre disposal a difficult task. Rubber, the major component of tyre, is non-biodegradable material. In addition to being unpleasant, tyre piles are breeding grounds for mosquitoes and rats, and they are susceptible to fire hazards. Uncontrolled open-air burning of tyres releases potentially hazardous chemicals that affect the ground, surface of water and the air (Secretariat of the Basel Convention (SBC)/UNEP, 2002).

Globally, the effort for solving waste tyre problems through market-based value-adding waste tyre management options is as old as tyre itself. These include reusing, de-vulcanization, mechanical and thermal (including pyrolysis) processing. Disposal options such as land filling and stockpiling are also practiced[1]. Study on resource recovery and development of

[1] Land filling is banned in the European Union and many other countries.

scrap tyre pyrolysis technology has been going on in the USA, Japan, and Europe for long. Recently, other countries mainly China and India are also producing scrap tyre pyrolysis plant equipment for affordable price.

Tyre pyrolysis is a thermal process carried out in the absence of oxygen for producing oil, carbon char/black and gases from used tyres and recovering the steel wires in the tyre. This presents an opportunity to consider scrap tyre pyrolysis as a business.

However, tyre pyrolysis had not been the leading option globally for used tyre management and at the same time be a viable business opportunity because of problems related to scrap tyre acquisition costs and products marketability, quality and prices. The viability also varied from country to country.

In Ethiopia, the amount of waste tyres generated is expected to grow with the increase in the vehicle fleet in the country. So, what to do with this increasingly available resource? The environmental challenges are obvious, and the quantity of waste tyres generated may justify studying value-added economical exploitation. Hence, it is intended in this study to look at scrap tyre pyrolysis from the perspective of business opportunity.

1.2 Statement of the Problem

The situation of waste tyres either as a resource opportunity or as an environmental problem is not studied well in Ethiopia. Some of the current applications of scrap tyres include: making of rubber-based items, construction applications (e.g., retaining walls), burning as fuel, burning for the steel and cutting for the nylon cord, and other uses. However, a considerable amount of used tyres are piled up in the shops of tyre repairers and traders, compounds of organizations and individuals.

It is observed that the current practices of utilizing used tyres in Ethiopia do not result in higher value-added products and are not environment-friendly. The current applications do not take full advantage of the potential value-added recovery for energy and materials from scrap tyres. Introduction into the country of environmentally safe and feasible new tyre recycling technologies are needed.

Hence, given the availability of used tyres, appropriate technology and demand for the oil as fuel, carbon char (to replace coal or firewood) and steel in Ethiopia, pyrolysis offers the opportunity to recover value-added products and at the same time solve sustainably the potential waste tyre environmental and health problems. But the challenges generally attributed to tyre pyrolysis such as product marketability and price, scrap tyre availability and costs and profitability issues are not explored yet, and deserve studying in respect of the local conditions in Ethiopia.

Hence, the study questions are:

- What is the feasibility of recovering fuel oil, carbon char and steel wire from used tyres in Ethiopia currently?
- What national socio-economic benefits are obtained from the project?
- What incentives & supports are needed to achieve a sustainable operation, if any?

1.3 Objectives of the Study

1.3.1 General Objective

The general objective is to assess the viability of establishing a scrap tyre pyrolysis plant that creates demand for waste tyres, adds value and develops markets for the products.

1.3.2 Specific Objectives

The specific objectives are to:

i. assess the market potential for scrap tyre pyrolysis products
ii. estimate total quantity of waste tyres generated and available for the project
iii. determine plant capacity, location, technology and its sources, and estimate project engineering requirements and implementation activities
iv. determine the plant organization and human resource requirements
v. conduct financial analysis by determining all costs, and
vi. assess socio-economic benefits of the project.

1.4 Significance of the Study

This study is an attempt to preliminarily investigate the profitability of scrap tyre pyrolysis project and to make findings known for business development by potential investors. The results from this study can thus be used to initiate a detailed feasibility study.

Ethiopia annually imports thousands of tons of fuel oil, coal and steel raw materials (including scrap steel) which consume a significant percent of its export earnings. Moreover, huge amounts of firewood are consumed every year which is a cause to deforestation. Thus, the study provides an insight into a potentially viable means of recovering value-added products from waste tyres to substitute these products.

The pyrolysis solution option will result in an approach that addresses sustainably the potential environmental and health problems due to waste tyres. Hence, it will be of interest to agencies concerned with waste management and environmental protection.

Moreover, the project, when implemented, is expected to contribute nationally to the transfer of knowledge and technology, and development of a new industry, and creation of new jobs in the chain of waste tyre collection, transportation, processing and products marketing, and national value addition.

1.5 Scope and Limitations of the Study

The scope of work includes a preliminary assessment on marketing, raw material and supplies, location, technical, organizational, financial and socio-economical aspects of a scrap tyre pyrolysis project.

The following are the limitations of the study:

- As laboratory analysis is not conducted in the study to determine the composition of used tyres, and yield and specifications of pyrolysis products, data from reports, the literature and suppliers of equipment are used.
- The study is limited to business profitability analysis and did not deal with environmental or technological aspects of waste tyre management.

- It is likely that whole or pieces of waste tyres and rubber materials are accumulated since tyres/rubbers are first imported into Ethiopia. This amount is not considered in the calculation of waste tyre stock/resource in the study. Analysis is based only on annually generated amount of used tyres.

1.6 Definitions

Pyrolysis. The thermal decomposition of an organic material in absence of oxygen.

Scrap tyre[2]. A tyre that can no longer serves its original intended purpose. The phrases "scrap tyre", "waste tyre", "used tyre", "end-of-life tyre" are used interchangeably in the report to mean scrap tyre.

Scrap tyre pyrolysis. The thermal degradation of scrap tyres at high temperature to produce fuel oil, gas and solid residue (char) with varying yields by weight. Scrap steel is also recovered in the process.

1.7 Organization of the Paper

The paper is organized in five chapters. Beginning with an Introduction in Chapter One, it follows with the Literature Review in the second chapter. Chapter Three addresses the Study Methodology. Chapter Four presents the Analysis and Findings, and the last chapter, Chapter Five, is on Conclusions and Recommendations.

[2] The spelling "tyre" is used throughout the report though "tire" is commonly used specially in the American literature.

CHAPTER 2: LITERATURE REVIEW

In this chapter, a review of literature, study reports and supplier information on scrap tyre problems and their management options, and in particular, scrap tyre pyrolysis is conducted. Application of used tyres in the Ethiopia context is also briefly discussed.

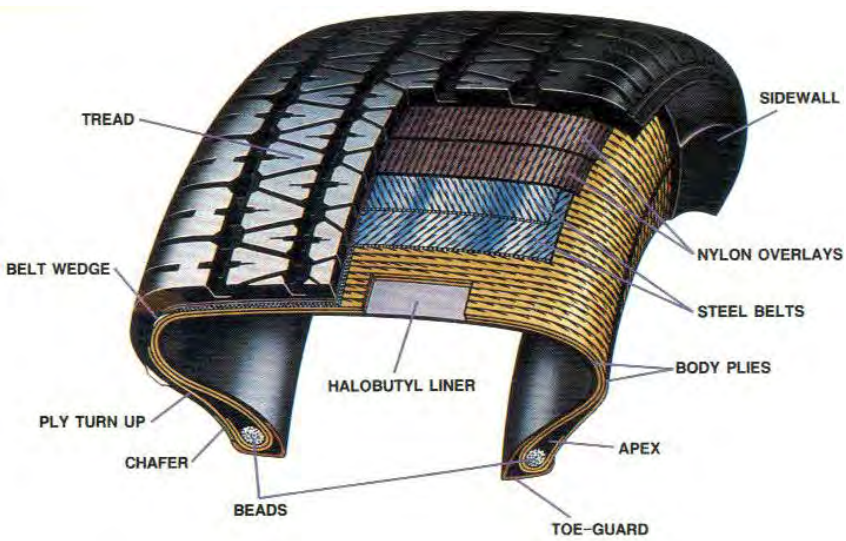
2.1 Problems and Resource Potential of Scrap Tyres

It was predicted that global scrap tyre generation would reach about 18 million tons per annum by year 2012, which is equivalent to above 1.5 billion tyres (Makitan, 2010; Ware, Shukla, Kushvah, & Desai, 2013). In addition, an estimated 4 billion tyres are already heaped globally in stockpiles harming the environment (Buan, 2013). Adding these two, scrap tyres become one of the biggest waste problems in the world which is creating environmental and health impacts.

Tyre fires burn for days resulting in high emissions of toxic gases as well as soil and groundwater pollution caused by the formation and runoff of hydrocarbons. Health impacts, such as the risks of disease and infection, resulting from being a breeding ground for mosquitoes and rats in large tyre stockpiles, are also the other problems (Secretariat of Basel Convention (SBC)/UNEP, 2002). In addition, scattered waste tyres are unpleasant.

Consequently, efforts have been going on to develop appropriate scrap tyre management options, including the search for new technologies which could recover valuable resources from tyres. The resource recovery solution comes from the content of tyres themselves. Tyres contain a number of components that can be recovered for various uses that makes recovery potentially economical. A typical tyre is about 45-48% rubber (both natural and synthetic), about 22% carbon black and silica, 15-25% metal, as well as textiles, zinc oxide, sulfur and additives (Ondrey, 2011). A sectional view (showing recoverable components) of a typical tyre is shown in Figure 2.1.

However, there had been economical and non-economical barriers for increased scrap tyre utilization: high costs or limited revenues; lack of technical information or concerns regarding the quality of products or processes; reluctance of consumers and processors to employ new approaches; and concerns on health and safety, environmental issues, laws and regulations (US Environmental Protection Agency (EPA), 1993).



Source: Carmichael, Gesley, Li and Windsor, 2007

Figure 2.1 Cross-sectional diagram of a standard vehicle tyre

According to Klein, Archer, Whiting and Schwager, (2004), the most important application options of scrap tyres include:

- Reuse (whole tyres): Retread, export, marine use (sea walls, reefs), civils (entertainment, landfill engineering)
- Thermal treatment: Incineration (heat/power), co-combustion (heat), gasification (heat/power), microwave (heat/power and value-added products), plasma (slag), and pyrolysis (heat/power and value-added products)
- Mechanical processing: Shredding (civils and co-combustion), granulation/crumbing (road building, sport surfaces, consumer items) and grinding (consumer items)
- De-vulcanization (reclaimed rubber)

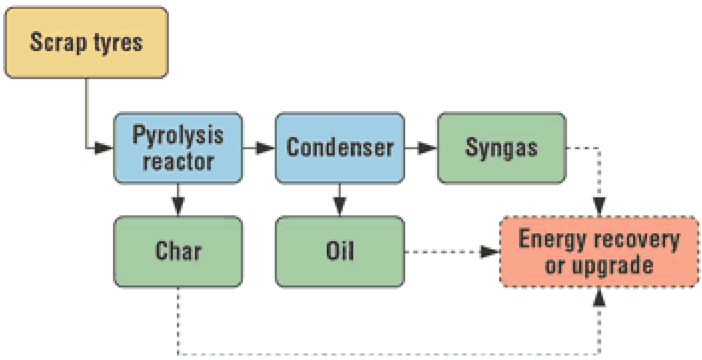
Application of used tyres varies widely from country to country. For example, in Japan, about 62% of used tyres in 2010 were used as an alternative fuel in various industries. Only 10% of the tyres were recycled for reclaimed and powdered rubber. In the U.S., about 76% of the 300 million tyres generated annually are recycled, with tyre derived fuel accounting for about half in 2010. In the European Union, where land-filling of post-consumer tyres is banned (1999/31/EC – The Landfill Directive), material recycling using a variety of treatments and technologies has grown to more than 36% of postconsumer tyres (Ondrey, 2011).

2.2 Scrap Tyre Pyrolysis

Only few of the scrap tyre utilization options are commercially established, and others are still either at the pilot or bench scale (Klein *et.al,* 2004), and most are investment intensive and are not without environmental concerns. In addition, the demand for materials and energy surpasses them. Hence, pyrolysis is emerging as a more efficient way to utilize the resources in scrap tyres compared to the other options.

From pyrolysis of scrap tyres, four products are obtained: oil, carbon char, fuel gas and steel wire. Typical product yield ranges are oil: 40-45%, carbon char: 30-35%, gas: 10-15% and steel 10-15% of waste tyres pyrolysed at a temperature range of 430-600^{0}C (Fels and Pegg, 2009; Bhatt & Patel, 2012; CalRecovery, 1995).

Tyre pyrolysis oil and char can be further processed to more valuable products (e.g. higher value chemicals) with additional processing and high technology and investment costs. However, the proposed applications in this study are for energy and steel recovery (the primary products) as shown in Figure 2.2.



Source: SBC, 2010. Material recovery from char (i.e., steel output) not shown.

Figure 2.2 Tyre pyrolysis scheme for energy recovery

Scrap tyre pyrolysis technology is currently receiving more attention and the technology is being developed by many companies in the US, Europe, and particularly in China and India for reasonable cost. Pyrolysis projects are increasing, and a number of developers have indicated they are receiving more orders to build plants (Klein *et.al,* 2004).

Pyrolysis is preferable because of the following reasons[3]:

- It recycles 100% of the waste tyres. All valuable materials are extracted.
- It produces four valuable products out of waste tyres with no effect on the environment. They are "green" products.
- There exists a huge and increasing demand for the products.
- It delivers clean steel after processing than other technologies.
- The plants need very minor maintenance in comparison with other applications that use heavy shredding machines.

However, scrap tyre pyrolysis, researched since the mid 1970s (Luck, 2004), had not been the leading technology option for the use of scrap tyres in the past because of problems related to products (specifically the carbon char) marketability, quality, and prices (Dodds *et.al*, 1983). As a result, many projects in various parts of the world have failed. The success of waste tyre pyrolysis mainly depended on used tyre acquisition costs and the ability to find viable value-added outlets for the products (Klein *et.al,* 2004).

2.3 Practices of Recycling Scrap Tyres in Ethiopia

In Ethiopia, tyre recycling is an old informal sector business. The main applications include reusing, open burning and retreading. The technique of sandal shoe making introduced by an Italian is said to have started in Asmara in 1928 (Abraham, 2010). Reuse applications (shoes, straps, stool and chair seats, ceiling dividers, animal feeding troughs, carrier straps (*mechagna*), etc.) are providing various items that are substitute to products produced in factories which are beyond reach to customers. Nylon cords pulled out of bias tyres are used for making musical instruments and sewing shoes, bags, etc.

The activity provides employment and income to many citizens. However, according to recyclers, the demand for the products is decreasing nowadays mainly due to modernization and the change in the living condition of the people, particularly the urban dwellers.

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[3] Based on one of the equipment manufacturers brochure from: www.pyrosyn.com.

Radial tyres are more difficult to cut and are not usable for reuse as bias tyres. Hence, radial tyres are burned to obtain the steel wires or for energy sources such as asphalt melting and stone mining, or are used for septic tank retaining wall construction or are lying idle in various places. The steel wires are sold to scrap dealers for recycling, for making egg containers, fence, etc. The pieces leftover from recycled tyres and smaller tyres of both types are sold to road contractors to be used as fuel to melt asphalt.

Retreading of tyres extends the life of tyres. But it will have little effect on the amount of scrap tyres generated as the retreated tyres will later join the scrap tyre pool. Ethiopian Roads Authority, Tyre Retreading Industry Addis Ababa PLC (TRIA), and Ethiopian Tire and Rubber Economy Plant PLC are engaged in tyre retreading (Abraham, 2010).

However, not disregarding the possible health and environmental impacts, the current applications are not effective and do not consume the bulk of scrap tyres, and other value-adding uses can still be studied and practiced. As a case in point, Abraham (2010) had studied the use of scrap tyres as a partial replacement for coarse aggregates in concrete.

Laws and regulations are expected to be issued by the Government as environmental problems become severe and experiences are taken from other countries that aid value-adding uses. Articles on prohibition of importation of used tyres are included in the Solid Waste Management Proclamation No. 513/2007. In addition, the new Ministry is working on a draft regulation to comply with the Basel Convention[4].

2.4 The Study Components and Model

The pre-investment phase of an industrial project consists of several stages: Opportunity, pre-feasibility and feasibility studies and project appraisal & investment decision. Prefeasibility study involves a preliminary assessment on the components of a study. Figure 2.3 indicates the interrelationship between the main components to be covered in the prefeasibility study which is an iterative process.

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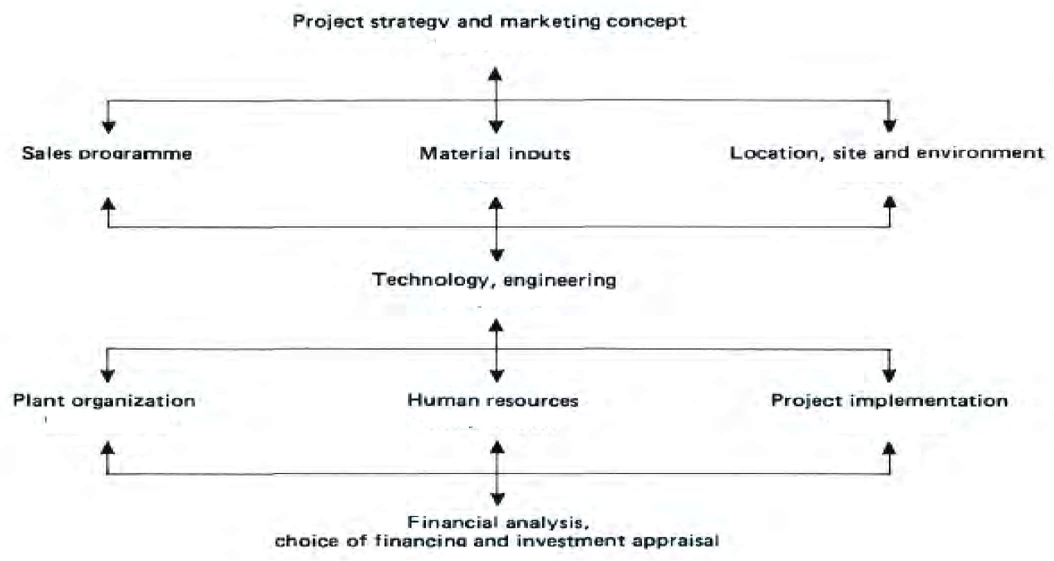
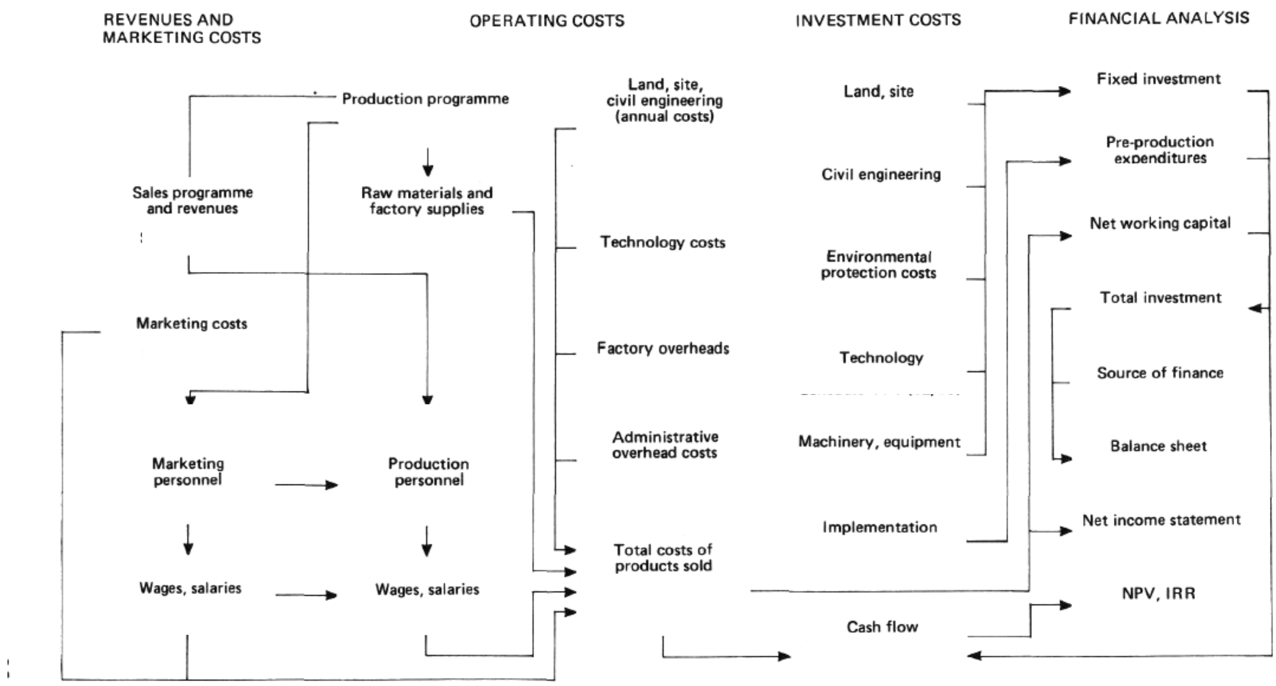
[4] Discussion with a Department Head in the Federal EPA. Ethiopia is a signatory to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.



Source: Behrens and Hawranek, 1991

Figure 2.3 Interrelationship between the components of the study

Figure 2.4 shows the flow of data and the linkage of the various study components, to be used as a model for collection of data and subsequent financial analysis.



Source: Behrens and Hawranek, 1991

Figure 2.4 Information flow chart for the preparation of industrial feasibility studies

2.5 Financial Feasibility Analysis

2.5.1 Conducting Financial Feasibility Analysis

For investors to engage in a new investment project, the project has to be financially viable. Invested capital must show the potential to generate an economic return to investors at least equal to that available from other similarly risky investments, i.e., the return on investment needs to be equal or higher. Estimates of the cost of operating a plant, as well as expected income generated, are therefore essential in determining the financial feasibility.

Financial feasibility analysis is an analytical tool used to evaluate the economic viability of an investment. It consists of evaluating the financial condition and operating performance of the investment and forecasting its future condition and performance. Feasibility study is conducted before proceeding with the development of a business idea, and that also applies for financial feasibility analysis.

Financial feasibility analysis is conducted by developing a base case financial plan and assessing the sensitivity of the profitability of the project, and the projected return, on the investor's equity to various unforeseen events.

2.5.2 Criteria for Financial Feasibility

The financial feasibility analysis comprises investment profitability analysis and financial analysis. Investment profitability analysis is an assessment of the potential earning power of the resources committed to the project. On the other hand, financial analysis takes into consideration the financial features of the project to ensure that the disposable finances permit the smooth implementation and operation of the project (UNIDO, 1986).

2.5.2.1 Investment Profitability Analysis

Different methods are used as a basis on which to assess the investment profitability of a project: Simple or static methods (simple rate of return and pay-back period), and discounted or dynamic methods (net present value and internal rate of return).

The simple rate of return is the ratio of the annual net profit on capital. This rate could be computed either on total investment, on equity or on net worth. When the simple rate of return is higher than the rate of interest, the project is considered as good from this point of view though the decision depends on the minimum rate set by the investor(s).

The payback is the period required to recover the original investment outlay through the accumulated net cash flows earned by the project. Interest and depreciation are added back onto the net profit after tax to calculate the payback period. If the payback period is shorter than the cut-off payback period established by the investor, the project is acceptable and vice versa.

The net present value (NPV) of a project is the value obtained by discounting, at a constant interest rate and separately for each year, the differences of all annual cash outflows and inflows accruing throughout the life of a project. The NPVs obtained for the years of the project life (including construction periods) are added to obtain the project NPV. The NPV rule is that all investments where NPV>0 will be accepted. The advantages of the NPV rule are that it considers the time value of money and risk associated with an investment, thereby evaluating each investment on common ground.

The discounting rate or cut-off rate is equal to the actual rate of interest on long-term loan (i.e., the interest rate (cost of capital) paid by the borrower). In other words, the discount rate is the minimum rate of return, below which the entrepreneurs would consider that it does not pay for them to invest (Behrens and Hawranek, 1991).

The internal rate of return (IRR) is the discount rate at which the present value of cash inflows is equal to the present value of cash outflows. In other words, it is the discount rate for which the present value of the net receipts from the project is equal to the present value of the investment, and the NPV is zero. The IRR rule states that a project will be accepted if its IRR is greater than the minimum acceptable rate of return.

2.5.2.2 Liquidity and Capital Structure Analysis

Liquidity analysis aims at ensuring the flow of cash through the construction, running-in and operation periods of the project.

The capital structure analysis is carried out to make sure that each type of investment is covered by a suitable type of finance.

A combination of equity capital and loan sufficient to meet the fund requirements, both in terms of initial capital investment and working capital needs, is made available. From the profitability point of view, equity owners may prefer high debt-equity ratios, since such ratios give leverage to equity capital and allow equity owners to control projects even with a small amount of equity capital. The smaller the equity capital, the higher the income per unit share. However, due to the financial risk with the increasing debt balance, it is also in the interest of the shareholders to establish a sound balance between risk and loan capital.

2.5.2.3 Financial and Efficiency Ratios

In financial analysis, a number of ratios are calculated to evaluate the financial position and the strengths and weakness of the project. The most important financial and efficiency ratios are calculated using the year-end figures from the balance sheet, net income and cash flow statements and other relevant data over the analysis period. Hence, the results can be used to compare the project with industry standards and with other projects of the investor for investment decision.

2.5.2.4 Uncertainty Analysis

Uncertainties usually occur, as it is not possible to predict exactly the different variables and the values of benefits and costs exactly. On the hand, one hundred per cent predictability in project analysis may not be needed. Many of the uncertainties are outside the control of analysts; others can be influenced by their assumptions. Break-even and sensitivity analysis are the main methods of uncertainty analysis.

CHAPTER 3: STUDY METHODOLOGY

The study methodology refers to the techniques and procedures used to obtain relevant information and data from various sources, analyze them and report the findings.

3.1 Data Requirement and Sources

The primary purpose of the study is to provide general idea and information on the project including its raw material, marketing, technical and financial aspects. It is an exploratory study in the sense that it is aimed at gaining information for decision-making and/or for further study, and seeking new insights. The study, as a prefeasibility study, is conducted on the basis of information and data available in published form or that can be easily collected or worked out as described by Behrens and Hawranek (1991). Thus, the literature, study reports, import data, supplier information and offers, and other secondary data are the main sources. Some data are also obtained from market assessment. Assumptions, experiences and data in other studies are taken in cases where there are no other sources of information.

All in all, various data required for conducting financial analysis, i.e., quantities and costs related to investment, production/operating and marketing, are collected. The entire national marketing data are collected and analyzed as all required data are obtained from visited/contacted Government and other organizations and also due to the nature of the study. Hence, there was no need for sample data collection from individual user companies. The data collected with respective sources are as summarized in Table 3.1.

3.2 Data Collection

Initially, a preliminary assessment was conducted to identify the overall data requirement and sources of data about the topic; search for and review study documents, supplier information and the literature; and receive inputs from advisor, classmates and professionals in the field.

The next phase of the study focused on collecting relevant qualitative information and quantitative data in hard and soft copies and taking notes during discussions and observations.

Table 3.1 Data Required and Sources

Data	Sources
Yields, and properties of products and scrap tyres	Literature, study and test reports
Import/consumption data of substituted products	Ethiopian Petroleum Supply Enterprise (EPSE), Ethiopian Revenue & Customs Authority (ERCA), Metal Industry Devt. Institute (MIDI), Ethiopian Alternative Energy Devt. & Promotion Center (EAEDPC)
Market prices of products (pyrolysis and substituted)	Oil Libya, ERCA/EPSE/Mugher Cement & GH Gypsum Factory, MIDI/informal sector, Supplier
Quantity of waste tyres	ERCA/Federal Transport Authority (FTA), Horizon-Addis Tyre (HAT)/Central Statistical Agency (CSA)
Quantity and cost of raw material and factory supplies	Ethiopian Investment Agency (EIA)-factor cost data, supplier data & references in the industry
Number and costs of manpower and overheads	Supplier data, CSA, EIA-factor cost, similar studies
Quantity and costs of land and buildings and other civil works	Suppliers, EIA-factor cost data, contractors, industry reference data
Quantity and costs of plant, auxiliary and service machinery and equipment and erection services	Suppliers, local market assessment, industry reference data
Quantity and costs of office equipment, furniture and vehicles	Local market assessment of suppliers
Preproduction and project implementation (cost and quantity)	Local suppliers, related projects
Other factor costs and data for financial analysis	EIA-factor cost, assumptions, industry reference data, and local practices.

This was achieved through communicating all relevant companies and individuals categorized as follows:

- 13 companies visited: ERCA, EPSE, MIDI, EAEDPC, FTA, EIA, Oil Libya, Horizon-Addis Tyre S.C., Anbessa City Bus Service, HGMT Transport, MOENCO, Hagbes, and CB Building Construction.

- Nine companies whose websites and/or databases are accessed: ERCA, CSA, suppliers and plant developers (listed below), EIA, and Horizon-Addis Tyre S.C.
- Five suppliers communicated through email: Divya International (India), Shangqiu RESEM (China), Pyrosyn (India), DGE (Germany) and Xinxiang HREE (China).
- More than 15 individuals contacted: From tyre recyclers at *Merkato* (3), tyre repairers (3), computer and stationery traders (2), EEPCO (1), Ministry of Industry (1), HA Tyre S.C. (2), Mugher Cement (1), Gift Trading (1), and Kirby (UAE based) (1). The criteria for selection included annual amounts of product usage or transaction, knowledge or involvement in the area/business.

3.3 Data Analysis

An outline similar to that recommended by United Nations Industrial Development Organization (UNIDO) for a prefeasibility in the *Manual for the Preparation of Industrial Feasibility Studies* (Behrens and Hawranek, 1991) is used for the content of the topics for analysis. Qualitative analysis is done using models (such as Porter's Five Forces) to generate qualitative information whenever needed. Statistical data are compiled and analyzed using quantitative/descriptive statistical techniques as appropriate. Arithmetic (linear) trend analysis (extrapolation) is used to project growth in demand and other parameters.

Simple or static (rate of return and payback period) and discounted or dynamic (net present value (NPV) and internal rate of return (IRR)) methods of investment profitability analysis are used to assess project feasibility. Cash flow analysis is done to determine project liquidity. Key financial and efficiency ratios are calculated to enable comparison with other projects by investors. Uncertainty analysis is done to identify variables that make the project most sensitive to changes. Then the results of the analysis are interpreted whether they are suitable for investment decision-making or further study. Microsoft Excel program is used for the analysis.

Lastly, preliminary assessments on national socio-economic implications of the project, particularly, on net value added, employment, and benefit distribution effects and other implications of the project are presented.

CHAPTER 4: ANALYSIS AND FINDINGS

In this chapter, all data collected are presented and analyzed in the first parts, following a prefeasibility outline, to organize the data for input to the financial analysis. In the financial analysis part, the assumptions, the costs, the results of the analysis and appraisal, and the socio-economic benefits are presented.

4.1 Project Strategy and Marketing

4.1.1 Descriptions and Applications of the Products

The application of tyre pyrolysis products proposed in this study and potential customers are listed in Table 4.1 below. Quality analysis result of a typical tyre pyrolysis oil as tested by the Entry-Exit Inspection and Quarantine Technology Center of China, and the properties of carbon char are attached in Annex 1 and 2.

Table 4.1 Application of pyrolysis products

Products	Applications	Potential Customers
Tyre pyrolysis oil	Substitute to heavy fuel oil	Firms burning heavy fuel oil
Carbon char pellet	Substitute to coal, coke and firewood as source of heat	Organizations burning solid fuels (coal & commercial biomass fuels)
Steel wire	Recycled as scrap steel	The metal industry
Gases	Fuel (source of heat)	Internally used by the pyrolysis plant

4.1.2 The Industry

4.1.2.1 Overview

Ethiopia expends huge amounts of foreign currency to import fuel and steel products. As per the data from the Ethiopian Petroleum Supply Enterprise (EPSE), in 2004 E.C. alone, nearly

2.0 billion USD (cost and freight basis) is spent to import about 2.0 million tons of petroleum products. This amount was about 64% of the country's export earnings in the same year.[5]

Also, the total steel requirement of the country is estimated to grow at 28% per annum that in 2012/13, about 1,905,021 tons (worth one billion USD with current price) of steel is required. Eighty five percent of these demands are filled by imports (Homma, 2010). In 2007 E.C. (the end of the Growth and Transformation Plan (GTP) period), per capita steel consumption is expected to reach 35kg as per same study.

4.1.2.2 Analysis of competition

From Porter's Five Forces analysis conducted, the following are observed.

i. The threat of substitutes is medium to high. Currently, no used tyre pyrolysis plant exists in Ethiopia, and the company will have no local direct competitors in this regard. However, for fuel oil and carbon char pellet, electricity, imported fuel oils, local and imported coal, all biomass fuels, etc.; and for scrap steel, imported billets and imported/local scrap steel are the established substitute/alternative competing products. Profit and prices are affected by substitutes, and hence, price of the substitute products has to be closely monitored and adjusted.

ii. The threat of new entrants is high. Investors who want to enter to the scrap tyre pyrolysis business are not restricted. The Government may even encourage them to engage in the business from the point of view of import substitution, environmental protection as well as job creation. Hence, new entrants will be attracted to the business once the current project becomes successful. Profit will then be low to the project, and hence, it must take first-mover advantages.

iii. The bargaining power of suppliers is low to medium. A key success factor for the business is reliable supply of scrap tyres. Hence, as suppliers can increase the price of scrap tyre and sell to other applications, having good relation with them and multi-sources of supply is necessary. Raw material supply can be handled by signing long term

[5] Based on Addis Ababa Business Directory 2013/14. In 2011/12, total export earnings was USD 3.11 billion.

contracts with local suppliers. Moreover, strategic partnership particularly with big transport and vehicle service companies must be created.

iv. The bargaining power of buyers is low to medium. Buyers may force down the product prices by buying from competitors. Buyers can influence price of proposed products if they are of higher price and of poor quality. Identification of markets for the materials produced, a very strong product development and aggressive marketing is desirable, especially for the oil and carbon char pellet as the products are new to the market and huge quantities of products are imported annually. Hence, offering low price and good quality products and services is essential.

v. The intensity of rivalry among established firms is low to medium. Low to medium advertising and price wars exist. Market is highly regulated and supply is monopolized by Government especially for oil and coal. Scrap steel market is also controlled.

4.1.3 Supply and Demand

4.1.3.1 Supply

i. **Fuel oil.** Table 4.2 shows the amount and value of light and heavy fuel oils imported for the last five years.

Table 4.2 Import of fuel oil

	Light Fuel Oil (LFO)		Heavy Fuel Oil (HFO)		Total	
Year, E.C.	**Qty, Tons**	**Value, USD (C&F)**	**Qty, Tons**	**Value, USD (C&F)**	**Qty, Tons**	**Value, USD (C&F)**
2001	36,421	17,939,958	116,506	47,844,702	152,927	65,784,660
2002	10,714	5,732,121	100,967	51,626,458	111,681	57,358,579
2003	34,353	21,057,875	97,191	58,981,675	131,544	80,039,550
2004	36,492	27,973,008	107,964	78,957,245	144,456	106,930,253
2005	37,509	25,925,288	131,068	87,313,711	168,577	113,238,999

Source: EPSE

ii. **Coal and commercial biomass fuels.** Import data of coal for cement, gypsum and related industries for the last five years is shown in Table 4.3.

Table 4.3 Coal imported: Amount and cost (Cost, Insurance & Freight)

	2008		2009		2010		2011		2012	
	Qty, Tons	**CIF, Birr**	**Qty, Tons**	**CIF, Birr**	**Qty, Tons**	**CIF, Birr**	**Qty, Tons**	**CIF, Birr**	**Qty, Tons**	**CIF, Birr**
Bituminous coal	-		-	-	-	-	79,220	245,541,182	0	0
Coke					5,000	4,000,000				
Other coal	14,710	26,934,434	24,927	37,834,355	9,000	24,763,185	18,600	62,191,509	282,614	763,485,909
Total	**14,710**	**26,934,434**	**24,927**	**37,834,355**	**14,000**	**28,763,185**	**97,820**	**307,732,691**	**282,614**	**763,485,909**
Av. price, Birr/ton		**1831**		**1517**		**2054**		**3145**		**2700**

Source: ERCA database

With reference to data obtained from the Ethiopian Alternative Energy Development and Promotion Center (EAEDPC), the total commercial services consumption of biomass fuels (for bakeries, etc.) in 2013 is about 1.7 million tons as shown in Table 4.4.

Table 4.4 Commercial consumption of biomass fuels in 2013

Region	**Total Wood, Tons**	**Residues, Tons**	**Dung, Tons**	**Charcoal, Tons**	**Total**
Addis Ababa	400,408	-	-	55,863	456,271
Afar	81,191	-	-	12,199	93,390
Amhara	183,379	-	-	14,204	197,583
Benishangul Gumuz	2,189	-	-	260	2,449
Dire Dawa	51,082	-	-	7,127	58,209
Gambela	4,040	-	-	536	4,576
Harari	29,040	-	-	4,052	33,092
Oromia	273,173	-	-	14,735	287,908
SNNP	180,039	1,166	134	4,514	185,853
Somali	187,531	-	-	27,540	215,071
Tigray	133,094	-	-	24,382	157,476
Total	**1,525,130**	**1,166**	**134**	**165,411**	**1,691,841**

Source: EAEDPC

iii. Scrap steel. Table 4.5 shows the current production of reinforcement bar from recycled steel only, as obtained from the Metal Industry Development Institute (MIDI), with input material conversion efficiency rate of about 98%[6]. The data is actual consumption. However, the installed plant capacity of the basic metal industries is more than one million tons in 2010 (Homma, 2010). Lack of scrap steel is one of the major causes for this low capacity utilization.

Table 4.5 Rebar production from recycled steel (scrap)

Year, E.C.	**Production, Tons**		**Scrap Input, Tons**	**Remark**
	Plan	**Actual**		
2003	582,671	124,874	127,422	
2004	586,112	193,646	197,598	
2005	594,139	176,528	180,131	Based on report for 9 months

Source: Metal Industry Development Institute

4.1.3.2 Projected Demand

A demand projection based on linear regression is used to model growths for fuel oil, imported coal and scrap steel from the data presented earlier. The demand projection for biomass fuel for commercial services application is approximated based on growth rate method using annual growth rate of 2.6% (Boyd, 2007).

As it can be seen from Table 4.6, the projected demand for fuel oil, coal, biomass fuels (commercial application) and scrap steel is big and continues to grow. It is possible to note here that the projected demands are based on actual supply data which are well below the potential demands as many users are working below capacity and due to control of foreign exchange, and other reasons. Moreover, the projection does not include demands of new users. For example, Toussa Steel Factory (a member of Derba MIDROC) alone will import 1.5 million tonnes of scrap metal a year for its plant at Kombolcha when the plant starts operation (Tiret, 2012).

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[6]http://www.worldsteel.org/dms/internetDocumentList/fact-sheets/Fact-sheet_Raw-materials2011/document/Fact%20sheet_Raw%20materials2011.pdf

Table 4.6 Projected demand of fuels and scrap steel

Year	Fuel Oil, Tons	Imported Coal, Tons	Biomass for Commercial, Tons	Scrap Steel, Tons
2013	161,060	269,425	1,691,841	221,093
2014	167,467	330,295	1,735,829	247,447
2015	173,875	391,165	1,780,960	273,802
2016	180,282	452,035	1,827,265	300,156
2017	186,690	512,905	1,874,774	326,511
2018	193,097	573,775	1,923,518	352,865
2019	199,505	634,645	1,973,530	379,220
2020	205,912	695,515	2,024,842	405,574
2021	212,320	756,385	2,077,488	431,929
2022	218,727	817,255	2,131,502	458,283
2023	225,135	878,126	2,186,921	484,638
2024	231,542	938,996	2,243,781	510,992

Source: Own projection

4.1.4 Marketing Strategy

Marketing strategy here refers to the position that the project takes with regard to the marketing mix (pricing, promotion/advertising, product design and distribution).

4.1.4.1 Product/Service

Apart from the variations that may be created by supply of different types of tyres, the products will be of uniform quality. Specially, the oil shall conform to specific standards. The scrap steel is already a good quality material. Carbon char fuel will be in pellets and is of high heat content. Products will be packaged properly to suit transport and customer requirements. Transport services will be offered to important customers.

4.1.4.2 Price and pricing

Most buyers are price sensitive. The proposed products are substitutes for already existing products in the market. Hence, a low price strategy is followed in order to penetrate the market and stay in the business. Availability of the raw material at low cost with appropriate technology will enable the project to produce good quality products with high yield rates, which can reduce production cost. During the study survey, prices of substitute products were collected as shown in the table below, Table 4.7.

Table 4.7 Selling prices of products

Pyrolysis Product	Substituted Product	Unit	Price, Birr	Remark
Tyre pyrolysis oil	Heavy fuel oil (HFO)	Litre	15.15	Oil companies (Addis Ababa retail price)
Carbon char pellet	Coal, imported	kg	2.88	At Djibouti
	Coal, local	kg	2.30	At Yayu, Illubabor
Scrap steel	Collected by MeTEC from Government institutions	kg	10-13	MIDI
	Informal collectors (of low quality)	kg	8-10	Market assessment

Sources: Own assessment

In addition, prices of the envisaged products from the equipment supplier in China were also obtained. The FOB (free-on-board) prices from China port are pyrolysis oil: 750USD/ton, carbon char: 100USD/ton and scrap steel wire: 350 - 400USD/ton[7].

Hence, proposed selling prices (before any taxes) at the gate of the plant in Addis Ababa are as follows: Tyre pyrolysis oil: 10.55 Birr/litre (i.e., 9.60 Birr/kg), carbon black pellet: 2.50 Birr/kg, and scrap steel: 10.00 Birr/kg which are below the imported or local prices.

4.1.4.3 Promotion

A very aggressive market promotion is desirable, as the products are new to the market and the customers have long adapted to the alternative products already available. The promotion strategy will be based on making the right information available to the right target customers. The promotion will also target scrap tyre suppliers, particularly, collectors, post consumer sellers and the general public. These promotions can be done through personal sales, active

[7] E-mail communication with (Sino-American) Shangqiu Ruixin Environmental Specialty Equipment Manufacturing Co., Ltd.

presence at bazaars, exhibitions, sport and societal events and advertising on radio, newspapers, billboards and company brochures, table and wall calendars, etc.

4.1.4.4 Sales and channels of distribution

It is expected that much of the sales of the products will be made in Addis Ababa. Hence, the project can sell the bulk of its products in convenient packages and bales (for the steel) at its premises to most end-users to be more cost-effective. Direct delivery to big consumers can be advantageous, however. In addition, products will be supported through credit sales. It will be designed to have closer relations with, and providing better service to, major users.

4.1.5 Sales Program

As the demand for fuel oil, coal, biomass fuels and scrap steel is huge, this project can substitute only a very small percentage of the demand for the products. However, due to possible challenges in scrap tyre collection, production and marketing and sales, a gradual growth of sales and market penetration is proposed that is in line with the production program (50% in the 1st year, 75% in the 2nd, and 100% in the 3rd year of operation and beyond).

4.2 Raw Material Availability and Supply

4.2.1 Scrap Tyre Generation

The annual scrap tyre generation in the country is estimated from data of imported and locally produced tyres, and imported vehicles.

4.2.1.1 Imported tyres

The import of new tyres as obtained from Ethiopian Revenues and Customs Authority (ERCA) database for the last five years is shown in Table 4.8.

Table 4.8 Import of new tyres

Year	Qty, Ton	No. of Tyres	CIF Value, Birr
2008	26,527	965,974	762,868,937
2009	36,254	37,905	1,370,268,484
2010	31,964	926,505	1,601,944,380
2011	23,234	664,338	1,708,569,190
2012	29,890	864,250	2,421,087,429
Average	**29,574**	**691,794**	**1,572,947,684**

Source: ERCA Database

4.2.1.2 Tyres coming with imported vehicles

As per data calculated from ERCA database about 55,000 new and used vehicles of all types are imported in 2011 (for generation after 2012) with about 207,000 tyres. This generates about 5,485 tons of waste tyres as shown in Annex 3.

4.2.1.3 Local production of tyres

Horizon-Addis Tyre S.C. produces various types of bias tyres: Passenger, light truck, and truck & bus tyres. Data for the last five years is shown in Table 4.9.

Table 4.9 Local tyre production

Year E.C.	Tyres Produced, pcs	Tyres Produced, Tons	Remark
2001	210,374	3,366	
2002	72,939	1,167	
2003	266,494	4,264	
2004	250,000	4,000	
2005	300,000	4,800	Company data[8]

Source: Central Statistical Agency

[8] Horizon-Addis Tyre S.C.'s current production capacity is 400 tons per month at 60% of capacity.

Hence, the latest used tyre generation quantity based on tyre and vehicle import data, and local production is estimated to be about 40,175 (29,890+5,485+4,800) tons.

4.2.2 Projection of Scrap Tyre Generation

The amount of scrap tyres projected to be generated is estimated from the data of imported tyres, local production and growth of imported vehicles. Import of vehicles is currently growing by 8-10% per year (Demiss, 2012). Hence, this figure is considered for projection for tyres with imported vehicles. For others, linear regression is used. Moreover, to determine the amount of scrap tyre that can be available for pyrolysis project, the following assumptions are considered:

i. About 60% of the total tyres are bias tyres[9]. These types of tyres are not considered for pyrolysis in this study and are left to continue for reuse applications. Adding smaller bias tyres (estimated at 5%) which have less usage, the tyres available for pyrolysis will be about 45%.

ii. About 75-80% of the registered vehicles in Ethiopia are found in Addis Ababa[10] (Plate AA, 56% and ET, 15%) and Oromia (OR, 9%) (Demiss, 2012). Hence, 75% the total radial tyres are considered for pyrolysis.

iii. Collection of scrap tyres is assumed not to be easy. At the beginning (i.e., in year 1), the collection rate will be low and expected to be about 45%[11]. This rate will progressively be increased up to 80% (in 2024 and beyond) after the system has been implemented and awareness campaign has had its full effect.

Table 4.10 shows the amount of projected scrap tyre generation available for pyrolysis project. Hence, 6,000 tons per year of scrap tyres can be available for pyrolysis in 2015.

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[9] It is not possible to identify from ERCA database radial and bias tyre types. These estimates are based on the discussion with traders and engineers who have worked in Horizon-Addis Tyre S.C.

[10] Hence, the project location is preliminarily assumed to be in Addis Ababa or its surroundings.

[11] From local experience in PET recycling (33%) and also referring estimation in a similar study in Kenya, 60% and Malaysia, 55%.

Table 4.10 Projected scrap tyre generation, in tons

Year	Imported Tyres	Locally Produced	Imported with Vehicles	Total Tyres	Radial & Small Tyres, 45%	In Addis Ababa Area, 75%	Available for Project
2013	28,244	5,230	5,485	38,958	17,531	13,148	5,194
2014	28,379	5,800	5,924	40,103	18,046	13,535	5,703
2015	**28,515**	**6,370**	**6,398**	**41,283**	**18,577**	**13,933**	**6,262**
2016	28,651	6,940	6,910	42,501	19,125	14,344	6,876
2017	28,787	7,510	7,462	43,759	19,692	14,769	7,552
2018	28,923	8,080	8,059	45,062	20,278	15,209	8,295
2019	29,059	8,650	8,704	46,413	20,886	15,664	9,113
2020	29,195	9,220	9,400	47,816	21,517	16,138	10,015
2021	29,331	9,790	10,152	49,274	22,173	16,630	11,008
2022	29,467	10,361	10,965	50,792	22,856	17,142	12,104
2023	29,603	10,931	11,842	52,375	23,569	17,677	13,313
2024	29,738	11,501	12,789	54,028	24,313	18,235	14,649

Source: Own estimation

4.2.3 Scrap Tyre Collection and Supply System

There are two options for collecting tyres: outsourcing to suppliers and paying at the gate, or collecting and transporting by own crew and transport arrangement (see Table 4.11). However, it is better initially to integrate both options and receive part of the raw material from independent collectors, while also being reliant on own collection activities. Moreover, direct supply agreement with big transport and vehicle service companies can be dealt to secure supply.

4.2.4 Cost of Raw Material - Scrap Tyre

In order to calculate the cost of raw material, it is assumed that scrap tyres will be delivered to the plant by independent suppliers, specifically the informal sector. In order to motivate the informal sector to collect and deliver scrap tyres, a price needs to be paid which is competitive to revenues from open burning and marketing steel. This is very important in that the present collection system can be integrated into the new formal system that ensures scrap tyre supply to the project.

Table 4.11 Scrap tyre collection options

Option	Advantage	Disadvantage
Outsourcing	• Less operational task as collection is handled by collectors • Effective as operation is handled by groups working for their own	• Threat of supply shortage and loss of production • Large quantities of tyres need to be kept on site as contingency and this requires space and may present a fire hazard
Collecting by own crew	• Cost reduction • Security associated with constant provision of scrap tyre	• Huge task • Requires high coordination

Source: Own analysis

For the calculation shown in Table 4.12, an average cost of 8 Birr per kg of steel from scrap tyres is considered, paid to the primary collectors or owners, and for middle men, for collection of tyres from waste pickers or owners and transportation to collection points, 4 Birr per kg is considered, summing up to 12 Birr per kg of scrap steel.

Table 4.12 Cost of scrap tyre

S.No	Item	Calculation	Unit	Passenger Car	Light Truck	Bus/Heavy Truck
1	Weight of scrap tyre		kg	8.3	21	50
2	Percentage of steel		%	16	20	25
3	Weight of steel per tyre	(1)x(2)	kg/tyre	1.33	4.2	12.50
4	Payment to scrap tyre collector for one tyre	8x(3)	Birr/tyre	10.62	33.60	100.00
5	Payment to middle man for one tyre	4x(3)	Birr/tyre	5.31	16.80	50.00
6	Revenue per tyre = cost for tyre acquisition	(4)+(5)	Birr/tyre	15.94	50.40	150.00
7	Average cost of scrap tyres	(6)/(1)	Birr/kg	1.92	2.40	3.00

The above calculated costs (average cost of 2.44 Birr/kg) are higher than the current market prices for radial scrap tyres. In addition, the values are only indications about the cost ranges since scrap tyre prices vary from place to place and are fluctuating. In practice, cost reductions might be possible if individuals or companies from the tyre and transportation sector deliver their scrap tyres directly to the plant at less cost.

The cost of transportation of waste tyres is high. This is due to the bulkiness of tyres, and hence, full loads of scrap tyres can't achieve the maximum weight allowed in any truck load (with specific weight of stacked bulk tyres not exceeding 200kg/m^3). This means additional trips are required, and therefore increasing the transportation cost.

For transporting materials within and around Addis Ababa, the price is 6-10 Birr per quintal. Taking an average of Birr 8 per quintal and density of bulk tyres of 200kg/m^3 (i.e., loads tyres about 1/5 of the paying weight), a ton of tyre (120 tyres) costs 400 Birr. Hence, the transport cost is 3.33 Birr per scrap tyre (i.e., 0.40 Birr per kg). For smaller tyres, the transport cost is about 21% (0.4/1.92) of the cost of scrap tyre.

Hence, adding the transport cost and outsourced weighbridge fee gives Birr 2.85 per kg, as an initial cost of scrap tyre at the gate of the plant. The annual direct raw material requirements for full (third year) capacity operation are presented in Table 4.13.

4.2.5 Factory Supplies

In addition to the main raw material, the project requires various factory supplies. Unit prices for utilities are taken from factor cost data published by the Ethiopian Investment Agency (EIA, 2013).

i. **Electricity.** As per the proforma invoice from the machinery supplier, power requirement for the 12 tons/day tyre pyrolysis plant is 25kW, and for the carbon black pellet unit about 24.5kW. Hence, a total power of about 55kW is required including 10% for lighting and other purposes. A transformer of appropriate capacity will be installed. Hence, 396,000kWh of electrical energy is estimated to be consumed at full operation year. The current unit price is 0.5778 Birr/kWh for this category of power.

ii. Water. Process water requirement, based on the supplier's documents, is about 1500 litres/day. Assuming the same amount for other purposes: toilets, container washing, garden, etc., annual water demand is estimated to $900m^3$. Water cost is Birr $11.60/m^3$.

iii. Initial fuel. Coal, firewood or fuel oil can be used as initial fuel to heat the pyrolysis reactor. Hence, it is assumed that the project uses carbon black pellet it produces for this purpose. As per data from suppliers contacted, daily consumption for coal is about 800-1000kg. Hence, full capacity annual requirement comes about 250,000kg, and the first year consumes 50% and the second year 75% of this amount. These quantities are deducted from sales amounts, and cost for fuel is set zero.

iv. Spare parts. 1-2% of the fixed investment cost is assumed as cost of spare parts (Peters and Timmerhaus, 1991).

v. Maintenance materials. These include materials like lubricants, grease and cleaning materials, etc. The value recommended by Towler and Sinnott (2008) for ordinary chemical plants is 10% of the maintenance and repairs cost.

vi. Packaging materials. The cost of packaging materials which include polyethylene bags, sewing ropes, etc. is estimated at about 2% of the direct material cost.

Table 4.13 Raw material and supplies program at full capacity

S.No	Item	Unit	Cost, Birr/Unit	Quantity per Year	Total Cost, Birr
1	Raw material: Scrap tyres	kg	2.85	3,600,000	10,260,000
2	Packaging materials	LS			205,200
3	Maintenance materials	LS			29,276
4	Electricity	kWh	0.5778	396,000	228,809
5	Water	m^3	11.60	900	10,440
6	Initial fuel (CB pellet)	kg	-	250,000	-
7	Spare parts	LS			142,764

4.3 Technology and Engineering

4.3.1 Plant Capacity and Production Program

Though scrap tyre is available in/around Addis Ababa for up to 20 tons of per day (6,000 tons/year), a medium size plant with 12 tons per day capacity (i.e., 3,600 tons per year) is proposed, based on Chinese technology, in view of the technology absorption capacity, marketing and raw material collection experience, and investment cost. In addition, it is considered that new entrants might share the raw material, and hence, the current potentially available scrap tyres will not be for this project only. However, the plant is envisaged to expand to 24 tons/day by adding a similar unit in later years.

It is planned that the plant works 24 hours/day, 6 days/week for 300 days in a year in three shifts, where the remaining days will be scheduled for maintenance stoppages and Sundays. Accordingly, the following plant capacity is proposed.

Table 4.14 Plant capacity

Description	Unit	Qty
Design capacity	Tons/day	12
Effective working time per day	Hrs	18-24
Number of shifts per day	Shift	3
Working time per year	Days	300
Max production capacity per year (input)	Tons per year	3,600

However, at the initial stage, the plant requires some years to penetrate into scrap tyre collection system and products marketing and to develop skills in production. Therefore, the proposed plant will not be expected to start operation at full capacity. A production and sales target of 50% of the full capacity is assumed in the first year of operation, 75% in the second, and 100% in the third year of operation and beyond. This is based on the suggestion by Behrens and Hawranek (1991) that a target of 40-50% of overall capacity is good for the first year depending on the nature of the industry and local factor conditions.

Table 4.15 Production program

Description	Unit	Production Year		
	Year	1	2	5-10
Number of effective working times per day	Hrs	18-24	18-24	18-24
Total scrap tyre (input)	Tons	1,800	2,700	3,600
Capacity utilization	%	50	75	100

4.3.2 Technology and Equipment

4.3.2.1 Production process

Scrap tyres are delivered by trucks, weighed and stockpiled. The tyres are then cleaned with compressed air and fed into the pyrolysis reactor. Initial heat is provided by burning carbon black pellet under controlled conditions of temperature and pressure. The process will convert the tyres into oil vapors and gases at operating temperatures of about 450-500^{0}C (CalRecovery, 1995).

Then the vapors/gases are passed through heat exchangers and the vapors are condensed into liquid in the form of oil. The oil is collected in a storage tank. The heat exchangers use water for cooling as a condensing medium and the water is re-circulated through the process. The non-condensing gases are compressed and are used for heating of the reactor in the later stages of the process and the excess gases are burned off separately.

The solid residue (char) that exits the pyrolysis reactor contains carbon black, steel and other materials. The steel is separated and baled for delivery to recyclers. Two types of steel wires are obtained: thick wires found along the rim, and thin wires found elsewhere around the tyre. The carbon char is then sent to a carbon char pellet unit. A simplified waste tyre pyrolysis process flow diagram is shown in Figure 4.1.

The product proportions and characteristics are dependent on the feedstock (scrap tyre) composition and the specific pyrolysis conditions (temperature, residence time, heating rate, pressure) that are applied. In general, lower process temperatures produce more oil and less gas, while higher temperatures tend to create more gas. Also, increasing the pyrolysis temperature would cause damage to the steel due to carbonization or other possible reactions. The scrap steel would be similar to its original quality if the pyrolysis temperature is kept below 600^{0}C (CalRecovery, 1995).

The following average values of yields are assumed in this study: Oil: 42%, carbon char: 32%, steel wire: 12% and gas: 14%. For comparison, the yield of products at a plant in

Shanghai was as follows: Tire Pyrolysis Oil = 45%; Carbon = 35% and Steel = 10% and Gas = 10% (Fels and Pegg, 2009)[12].

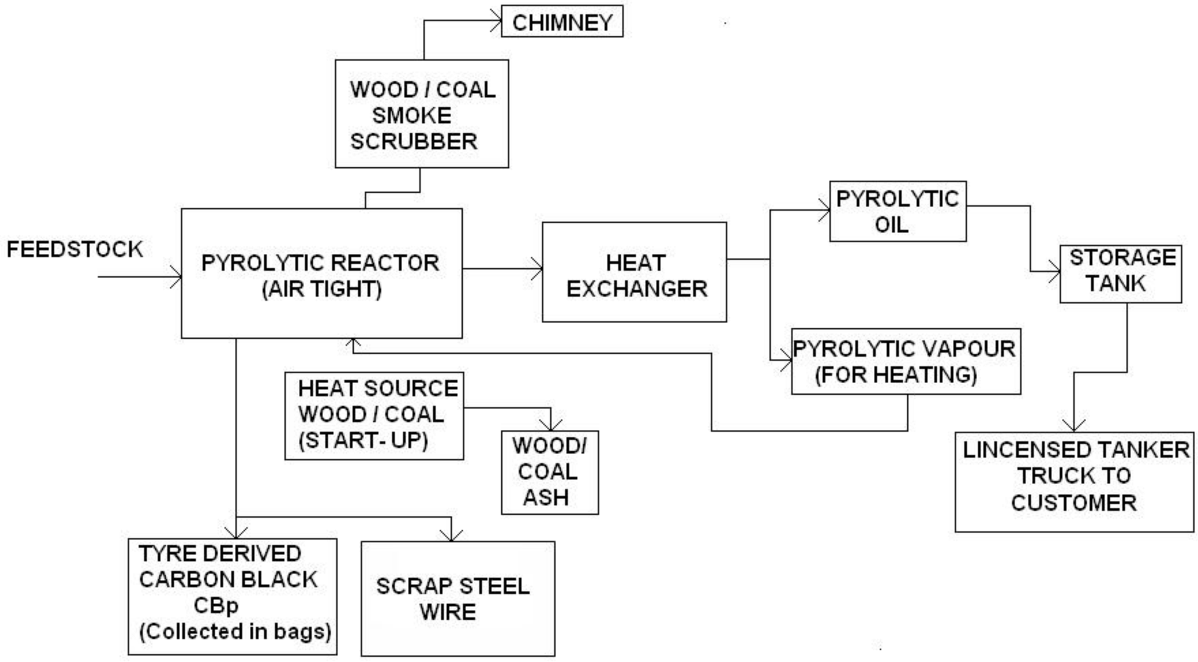

Figure 4.1 Simplified waste tyre pyrolysis process flow diagram

A typical cycle time for waste tyre pyrolysis is shown in Table 4.16.

Table 4.16 Process cycle time

Process	Time, Hours	Remark
Tyre feeding	2 to 3	
Reactor pre-heating	4 to 5	
Pyrolysis process time	6 to 8	at 450 - 500^{0}C
Reactor cooling	2 to 3	
Char and pellet discharging	4 to 5	
Packaging of carbon black pellet, oil, steel	--	Parallel processes
Total	**18 to 24**	

Source: PyroSyn company catalogue

[12] Shanghai Greenman Ecological Economic and Technological Co. Ltd.

4.3.2.2 Plant machinery and equipment

The production equipment for the study is based on the quotation of Shangqiu Ruixin Environmental Specialty Equipment Manufacturing Co., (Sino-American) Ltd. as detailed in Annex 4. A total cost of USD 101,000 FOB Lianyungang port including spare parts worth about 5% of the value of the machinery and equipment is the foreign currency cost of the plant. Hence, total landed cost of equipment adding freight, insurance, bank and port charges and inland transport of 20%, becomes Birr 2.4 million.

The equipment from this supplier is selected because the Company has sold many plants to customers in many countries. It is a joint venture of Chinese and American companies. The technology will be acquired through purchasing, the details of which will be negotiated during ordering.

4.3.2.3 Auxiliary and service equipment

The cost of auxiliary and service equipment, available locally, is estimated to be Birr 790,000 as shown in Table 4.17.

Table 4.17 Cost of auxiliary and service equipment

S.No	Item	Qty	Total Cost, Birr	Remark
1	Utility supply (electric power and water) equipment and installation	LS	220,000	Includes 100kVA local transformer
2	Standby generator, 40kVA	1	400,000	Price from importers
3	Workshop tools and compressor for cleaning tyres and other applications	LS	100,000	
4	Packaging and safety equipment: Bascule, filled bag sewing machine, firefighting equipment, etc.	LS	70,000	
	Total		**790,000**	

Source: Own assessment

4.3.2.4 Cost of installation and commissioning services

Installation costs for equipment are estimated to vary from 25 to 55% of the purchased equipment cost (Peters and Timmerhaus, 1991) for both the imported and locally bought items. The cost of these services is estimated to be Birr 797,500 taking the minimum percentage as the plant is not complex.

Table 4.18 Installation cost

Items	Total, Birr	Remark
Installation cost: including insulation and painting, 25% of purchased equipment	797,500	Includes Birr 324,000 for three supplier technicians (Supplier data): • Fee: USD80 per day for 30 days (Birr 144,000) • Accommodation & allowances: Birr 1,000 per day (Birr 90,000) • Return air ticket: @USD1,500 each (Birr 90,000)
Training	-	Included in the above
Total	**797,500**	

Source: Supplier communication and quotation, and estimates

Hence, the total installed cost of process equipment and auxiliary machinery is estimated at Birr 3,987,500.

4.3.3 Location, Site and Environment

4.3.3.1 Location and Site

The ideal location for establishing the envisaged project, in view of the two major factors, i.e., the availability of the raw material and market for the products, and also other factors, is Addis Ababa, or Oromia towns around Addis Ababa. As transport of scrap tyres is a significant cost to the plant, it is important that the plant be situated in a site that minimizes the overall distance from collection points/main sources of scrap tyres.

The specific site for the plant has not been identified as this is not within the scope of this study, and as it needs detailed data from the supplier. However, an estimated site preparation and development costs for a grass root plant (a complete plant erected on a new site) are included in this analysis.

The land required for the project as per the communication with the supplier is about 1,500-2,000m^2. Considering double capacity plant expansion, an area of 3,000m^2 is proposed to be leased with 1,500m^2 built-up area in the first phase.

4.3.3.2 Cost of land

The envisaged plant will have numerous socio-economic benefits. Therefore, the project is expected to be eligible for support from the Government. In this regard, the project can have three options to get land:

i) Leasing land free of charge as an incentive and construct its own buildings.
ii) Leasing shop floors in an industry zone (but for exporting industry) with lease rates of up to USD2.00/m^2 per year with the necessary buildings constructed (data obtained by communication with investors and officials).
iii) Leasing land with minimum rates (without auction).

The land cost, assuming the third option, is calculated based on Addis Ababa City land lease price, assuming land located in an expansion zone, 2nd grade lease land (minimum lease price 299 Birr/m^2 per year) with width of road 10 to 20m (multiplier of 1.3), gives land lease rate of Birr 388.70/m^2. For industry, period of lease payment is within 20 years (EIA, 2013). Thirty (30%) percent (the minimum is 5%) of total lease payment is planned to be paid initially. The directive by the City Administration requires that the remaining balance be paid periodically/annually with bank compound interest on the unpaid balance. Hence, the total land lease payment becomes Birr 1,166,100 and initial payment is Birr 349,830.

Table 4.19 Cost of land lease

Items	Unit	Unit Cost, Birr	Qty	Total Cost, Birr	Remark
Land lease	m^2	388.70	3,000	1,166,100	
Site preparation & development	LS			-	Included in the cost of buildings and civil works
Total cost				**1,166,100**	

4.3.3.3 Environmental factors and impacts

No specific natural environment conditions are required for the establishment of waste tyre pyrolysis plant. The plant is environment-friendly with little or no harm on the external environment with correct design and operation. Technologies are available to control potential discharges to the environment. Waste water can be treated by the emulsifying unit included in the production equipment. Many of the emissions are negligible or below standards (CalRecovery, 1995; Fels and Pegg, 2009). The excess pyro-gas is completely flared to non-polluting gas and water. However, this has to be confirmed in a separate environmental impact study.

4.3.4 Building and Civil Works

It is proposed that all buildings will be constructed with steel structures since raw materials and products to be stored will not be affected by the variation of temperature and humidity. The shades are light structures the details of which are to be obtained from the supplier considering equipment loads, site conditions, etc. From design data for chemical plants (Peters and Timmerhaus, 1991), assumptions shown in Table 4.20 are considered for the pyrolysis plant to estimate the building and other civil work costs.

The cost of buildings and civil works excluding engineering and supervision and construction expense (considered as project management costs) becomes Birr 2,552,000.

Table 4.20 Cost of buildings and civil works

S.No	Item	Estimate	Cost, Birr	Remark
1	Buildings: Process and auxiliary	50%	1,595,000	Range: 10-70% of equipment cost
2	Service facilities & yard improvements	30%	957,000	Range: 30-100% of equipment cost
3	Engineering and supervision	5%	199,375	Range: 5-30% of cost of installed equipment
4	Construction expense and contractor's fee	6%	239,250	Range: 6-30% of cost of installed equipment

4.3.5 Vehicles and Office Equipment and Furniture

4.3.5.1 Vehicles

One light truck possibly to deliver products to customers and collect tyres, one minibus to be used for transport service, and an automobile for the General Manager will be purchased for smooth operation of the plant. Vehicles cost, assumed to be acquired with duty free privilege, is estimated at Birr 1,600,000.

Table 4.21 Cost of vehicles

S.No	Vehicle	Qty	Unit Price, Birr	Total Price, Birr
1	Truck	1	750,000	750,000
2	Minibus	1	500,000	500,000
3	Automobile	1	300,000	300,000
4	Motorcycle	1	50,000	50,000
	Total			**1,600,000**

Source: Own assessment

4.3.5.2 Office Equipment and Furniture

Office equipment and furniture are estimated to cost Birr 212,000 as listed in Table 4.22.

Table 4.22 Cost of office equipment and furniture

S. No	Items	Unit	Qty	Price per Unit, Birr	Total Price, Birr
1	Computers	pcs	8	10,000	80,000
2	Printers	pcs	2	6,000	12,000
3	Office tables with chairs, shelves, coffee tables, etc.	set	12	10,000	120,000
	Total				212,000

Source: Own assessment

4.4 Organization, Human Resource & Overhead Costs

4.4.1 Organizational Structure

A simple functional organizational structure is proposed for the envisaged plant. A General Manger reporting to owners leads and coordinates the activities of the functional departments with responsibilities described in Table 4.23. The General Manager will also be assisted by an administrative assistant and a legal advisor (on a part-time basis) and other staffs as needed. The owners are responsible for decisions of strategic nature.

Table 4.23 Responsibility of organizational units

Department	Responsibility
Procurement	Supply, transport, storage of inputs
Production	Plant operation, quality control, and maintenance & repair
Marketing	Marketing, sales and distribution of products
Finance	Finance, financial control and accounting
Administration	Human resource and general services

The managers of the departments, with the appropriate qualification and experience, are responsible for the day-to-day activities in their respective units, and report to the General Manager. The right employees will be assigned at all levels.

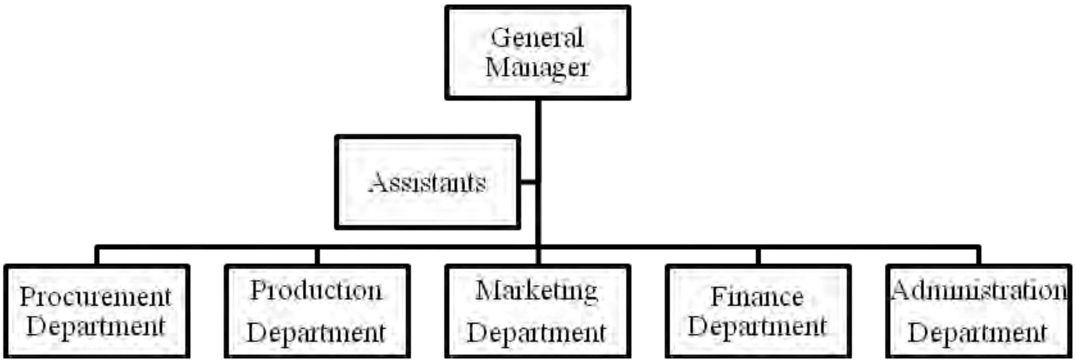

Figure 4.2 Organization chart

4.4.2 Human Resource Requirement and Costs

The equipment supplier recommends about 4-5 direct operating labor under one supervisor per shift for the 12 ton per day plant. All other manpower requirements are determined on the basis of nature of the jobs and experience.

It is assumed that there will be an additional cost of about 25% of the annual salary (based on CSA 2003 EFY data) for related costs and employee benefits (pension contribution, medical, accident, food/drink, bonuses, etc.). Salary is proposed based on the factor cost data published by the Ethiopian Investment Agency (EIA, 2013) and experience in factories of similar size in the country. The manpower required and the proposed gross salary is shown in Table 4.24. The detail manpower requirement and cost is attached (Annex 5).

The managerial, professional and support staff and laborers for the plant can easily be recruited from Addis Ababa and its surroundings. On the job training of key production and maintenance personnel will be conducted by the supplier of the Plant. The training will primarily focus on the production technology, equipment operation and maintenance and troubleshooting. The supplier has stated that training will be given free of charge by its technicians during plant erection.

Table 4.24 Annual manpower requirement and costs

S.No	Category of Manpower	Number of Personnel	Average Annual Salary, Birr
1	Production		
1.1	Direct operating	15	450,000
1.2	Maintenance	5	150,000
1.3	Production supervisory	5	315,000
2	General & administrative	21	873,000
3	Marketing	2	127,500
	Total	**48**	**1,915,500**

4.4.3 Overhead Costs

4.4.3.1 Factory overhead costs

Factory overheads are costs that accrue in conjunction with the production operation and include salaries of plant supervisory personnel, factory supplies (utilities and other supplies) and maintenance, which are determined in the preceding sections. Other cost items (insurance, office supplies) are included in administrative overhead costs.

4.4.3.2 Administrative overhead costs

Costs include salaries, benefits and other services (included in human resource costs), office supplies, communications, insurance, fuel, lubricant and maintenance for vehicles, uniforms, cleaning materials and safety items as shown in Table 4.25.

4.4.3.3 Marketing costs

Total marketing cost items include salaries (included in human resources costs); office supplies, utilities and communication (included in administrative costs); and direct marketing costs (advertising, training, etc.). Recommended value for marketing cost is 2-20% of the total operating cost (Peters and Timmerhaus, 1991) and 2% is considered for this project.

Table 4.25 Administrative overhead costs

S.No	Cost item	Unit	Cost, Birr	Remark
1	Fuel and lubricant (car running)	LS	150,000	Based on number of vehicles
2	Vehicle maintenance and repair	LS	35,000	New vehicles
3	Communications (tele/fax/internet)	LS	76,000	Internet and mobile card costs included
4	Stationery and office supplies	LS	50,000	Similar company data
5	Insurance	LS	95,176	l% of the fixed investment
6	Uniforms, cleaning materials and safety items	LS	33,000	Based on number of workers
7	Miscellaneous expenses, 10%	Ls	40,000	
	Total		**479,176**	

Source: Own estimate

4.4.3.4 Depreciation costs

Depreciation and amortization of preproduction expenditures have been calculated on a linear basis (straight line method) with the following rates applied:

- Building: 5%
- Machinery and equipment: 10%
- Office equipment and furniture: 20%
- Vehicles: 20%
- All pre-production expenditures (capitalized and amortized): 20%

As the plant is not assumed to cease operation at the end of the analysis period, salvage values (from depreciable assets) and residual values (from working capital and land) are not considered as income in the financial analysis. Also, land is leased from Government, and the resulting cash flows from sales of salvaged assets and residual values are far off in the future that they are assumed to have negligible impacts.

4.4.3.5 Financial costs

Financial costs (interests) are incurred from the long-term loan and the leased land. They are shown as a separate item because they have to be excluded when computing the discounted cash flows of the project, but are to be included for financial planning.

4.5 Implementation Planning and Budgeting

4.5.1 Proposed Implementation Schedule

The total time for implementation of the project is estimated to take one year. The erection of the plant, as proposed by the Chinese supplier, will be completed within two to three months. To accomplish the installation within this time, however, buildings and facilities, equipment, tools and machinery and the manpower have to be ready ahead of time. The supplier will send professional technicians for guiding the installation and testing of the plant and training workers. Details (of requirements and schedule) will be provided by the supplier.

4.5.2 Preproduction and Project Implementation Cost

Preproduction and project implementation expenses are incurred before the start of commercial production starting from the date decision to invest is passed. Both local and foreign parties and costs are involved. The total cost is estimated to be Birr 1,168,888 as shown in Table 4.26.

Table 4.26 Pre-production expenditure

S.No.	Cost Item	Cost, Birr	Remark
1	Formation expenditures: Formation costs, office rent, etc.	170,000	Includes office rent for one year
2	Expenditures for preparatory studies	-	By project team
3	Pre-production marketing costs: Printing of brochures, advertising	60,000	
4	Trial runs, start-up and commissioning	-	In the production year
5	Project management: Engineering and supervision, construction fees	438,625	From Section 4.3.4
6	Project management salary	294,000	For project team
7	Travel/supplier company visit	100,000	
8	Contingency, 10%	106,263	
	Total	**1,168,888**	

Source: Own estimate

4.5.3 Investment Incentives

To encourage investment, there is an exemption from income tax for five years for chemical and chemical products industry project in Addis Ababa and Special Zone of Oromia (EIA, 2013). In addition, machinery, vehicles and replacement parts will be imported duty free or at a lower schedule. The level of corporate income tax is 30%.

4.6 Financial Analysis and Investment Appraisal

4.6.1 Total Initial Investment Costs

The total initial fixed investment cost is estimated at Birr 9,517,600 out of which about 24% is in foreign currency. Fixed investment/replacement during plant operation is not considered in this study. Total net working capital requirement, Birr 1,923,553, is calculated based on the expected minimum days of coverage determined for the project as follows.

Table 4.27 Minimum days of coverage

Cost Item	Minimum Days of Coverage
Raw material, local	15 days at delivered cost
Factory supplies, local	15 days at delivered cost
Spare parts in stock, imported	120 days at delivered cost
Finished products	15 days at factory costs plus administration overheads (Behrens & Hawranek, 1991)
Accounts receivable	30 days at costs of the product sold minus depreciation & interests (Behrens & Hawranek, 1991)
Accounts payable	30 days at cost of utilities and salaries and 7 days for scrap tyres
Cash-in-hand	15 days at operating costs less the costs of raw materials, factory supplies (including utilities) and indirect marketing (Behrens and Hawranek, 1991)
Work-in-process	No. of days the process passes at factory cost (1 day in this case)

The total initial investment cost of the project is Birr 12.61 million as detailed in Table 4.28.

Table 4.28 Investment outlay

S.No	Investment Category	Total Investment, Birr
1	Fixed investment costs	
1.1	Leased land	1,166,100
1.2	Buildings and civil works	2,552,000
1.3	Process and auxiliary equipment and machinery, installed	3,987,500
1.4	Vehicles	1,600,000
1.5	Office equipment and furniture	212,000
	Total initial fixed investment	**9,517,600**
2	Pre-production capital expenses, including project management (net of interest)	1,168,888
3	Working capital (including bank borrowing)	1,923,553
	Total initial investment cost	**12,610,041**

4.6.2 Source and Structure of Finance

Considering the local practice for financing projects, it is assumed for the analysis that 70% of the total investment will be financed by long-term loan (finance plus leasehold), and the balance, 30%, will be by equity including the lease advance payment. The loan is expected from a local commercial bank with 12.5% interest rate per annum payable on the outstanding debt balance, repayable in five years with the construction year as grace period. The lease payment will be payable within 20 years.

The structure of financing is projected in Table 4.29 where it shows the accounts payable as short-term finance in excess of the total initial investment amount.

Table 4.29 Structure of financing

Source	Total Inflow, Birr	Remark
1. Equity capital	3,783,012	
2. Long-term loan	8,827,028	
2.1 Commercial banks (incl. working capital)	8,010,758	
2.2 Others (land lease)	816,270	Balance lease amount
Total long-term capital	**12,610,041**	
3. Short-term finance	395,752	
Bank overdraft	-	
Accounts payable	395,752	
Total financial flow	**13,005,793**	

4.6.3 Total Costs of Products Sold

The total cost of products sold in the first year is Birr 10,106,809. The cost grows with increase in production capacity, and at the first year of full capacity (Year 3) operation, it is Birr 15,248,967 and becomes steady at about Birr 14 million in later years. The variable share of the total cost is higher compared with the fixed cost. The major share of the variable cost is the cost of raw material (cost of scrap tyres).

4.6.4 Revenues

The revenues for the project are incomes earned from sales of tyre pyrolysis oil, carbon char pellet and scrap steel. It is planned that revenue of Birr 10,545,100 will be generated in the first year of operation and sales will grow with growth of production. At full capacity (Year 3 & above), revenue is Birr 21 million.

In the analysis, inflation or price escalation is not considered. It is carried out with constant market prices assuming that all prices of inputs and outputs will change at the same rate during the analysis period. The prices for each product sold are net of taxes. All of the products are assumed to be completely sold annually and over the life of the project.

4.6.5 Profitability Analysis

4.6.5.1 Investment profitability analysis

i. **Simple or annual rate of return.** Table 4.30 shows the simple rates of return for Year 3 and for Year 6, after the expiry of tax holidays. The ratios at other years are shown in the Net Income Statement (Annex 6).

Table 4.30 Simple rates of return in percent

Ratio	Year 3	Year 6
$\frac{\text{Net profit}}{\text{Equity capital}}$	154	130
$\frac{\text{Net profit + Interest}}{\text{Total investment}}$	52	40
$\frac{\text{Net profit}}{\text{Total net worth}}$	79	19

Net profit is positive starting from the first year, i.e., Birr 438,291. The net profit to equity ratio increases from 11.6% at Year 1 to a maximum of 166% at Year 5 and stays at 130% onwards. The return on total investment is positive from the first year, at 11.7% and it increases to 52% up to Year 5 and remains at about 40% onwards. These ratios of the project show the effectiveness of the production program in generating profit throughout the operation period.

Since the simple rate of return is higher than the rate of interest (excluding the first year), the project is considered good from this point of view though the decision depends on the minimum rate set by the investors.

ii. **Payback period.** For the envisaged project, the payback period is 3.6 years including the construction period, i.e., the plant must be in operation for 2.6 years for the initial investment to be recovered.

iii. **Net present value.** The net present value for the project over the total investment, calculated at 12.5% discount rate, is positive, i.e., Birr 19,447,413 (seen in Annex 7). Hence, the project is acceptable seen from positive NPV criterion.

iv. **Internal rate of return.** The IRR for the project over total investment is 43%, which has a 30% spread over the required discount rate. The investment proposal is acceptable since the IRR is greater than the cut-off rate (the cost of capital plus any margin for risk), which is the lowest acceptable interest rate for the invested capital.

4.6.5.2 Financial Analysis

i. **Liquidity analysis.** In the cash flow statement, the construction year shows a positive value by the amount of the working capital. The first year shows a cash deficit of Birr 790,996, but the cumulative cash flow is positive because of the coverage by the working capital. Annual cash surplus starts in the second year. Then the cash flow grows reaching a steady value of about Birr 5.4 million in the fourth year and beyond. Therefore, the requirement of liquidity is covered by the working capital and cumulated cash.

The project's annual cash balance is positive starting from the second year means that the project is able not only to meet all the cash outflows, but also to produce surplus in the remaining years of its operating period. Therefore, the envisaged project is considered to have good liquidity of resources. The detailed Cash Flow Statement for Financial Planning is attached (Annex 8).

As dividend distributions are a matter for corporate finance policy, the present analysis does not consider dividend payments. Therefore, the entire surplus is cumulated over the years of the investment planning horizon. The total cumulated cash increases from Birr 1.13 million in Year 1 to Birr 46.52 million Year 10.

ii. **Capital structure analysis.** At the start of the project, the debt-equity ratio is 70:30 but gradually decreases as debt is serviced. Other ratios over the years are presented with the projected Balance Sheet attached in Annex 9.

4.6.5.3 Financial and Efficiency Ratios

The most important financial and efficiency ratios are calculated using the year-end figures from the balance sheet, net income and cash flow statements and other relevant data over the analysis period and are shown in Annex 10[13]. Hence, the results can be used to compare the project with other projects of the investor for investment decision.

4.6.5.4 Uncertainty Analysis

The two main methods of uncertainty analysis, break-even and sensitivity analysis, are presented here.

i. **Break-even analysis.** The break-even point (BEP) of the project expressed in sales revenue is Birr 9,028,691, or 43% of the installed production capacity at the third year of operation. The project's break-even point is relatively low (due to a high variable cost rate), which is an indication of a low risk of carrying on losses and a high chance of earning profit. The variable margin to total income of the project is 48%.

   Sensitivity analysis is conducted to check the impact of changes in unit fuel oil sales price, variable production cost and fixed production cost (including depreciation) on the base case of the break-even point (as a percentage of capacity utilization) is shown in Table 4.31.

Table 4.31 Sensitivity on break-even point

Item	BEP1 (+15%)	BEP2 (-15%)	Remark
Change in unit selling price of fuel oil	35%	54%	Wide variation
Change in variable production cost	51%	37%	
Change in fixed production cost	49%	36%	

[13] Profitability ratios are already described in the profitability analysis.

The break-even point is highly sensitive to change in unit selling price, and also to the change in variable production cost (mainly cost of scrap tyre).

ii. **Sensitivity Analysis.** Sensitivity analysis (at +/-15% of base values) is performed on variables related to sales revenue (sales price of oil and byproducts), cost of production (cost of scrap tyres) and investment cost as shown in Table 4.32.

Table 4.32 Results of sensitivity analysis

Variables	Variation	IRR	NPV	Return on Equity	Net Profit Margin
Base Values	-	43%	19,447,413	154%	28%
Sales Price – Oil	15%	56%	28,813,412	212%	34%
	-15%	29%	10,081,415	97%	19%
Sales of Byproducts – Steel	No sales	14%	864,083	40%	9%
	15%	47%	22,234,913	172%	30%
	-15%	39%	16,659,914	137%	25%
Sales of Byproducts – Carbon Black Pellet	No sales	29%	9,747,087	95%	19%
	15%	45%	20902462	163%	29%
	-15%	41%	17,992,364	145%	27%
Sales of both Carbon Black & Steel	**No sales**	**-8%**	**(8,836,243)**	**-19%**	**-5%**
Cost of Inputs – Scrap Tyres	15%	33%	12,365,377	110%	20%
	-15%	53%	26,529,450	201%	35%
Investment Cost	15%	38%	17,683,873	130%	26%
	-15%	50%	21,210,954	186%	29%

As can be observed from the table, the result of the analysis shows that most of the predicted variables (IRR, NPV, return on equity, net profit) levels are reasonably good and provide some flexibility at least within +/- 15% range. For the variables to affect the base case projections, the changes need to be sustained over the whole life of the project with no feedback possible to compensate for the increased/decreased variables.

The envisaged project is primarily sensitive to fuel oil sales price, and also to scrap tyre cost on secondary level. If one of the byproducts do not have market, the project can still become viable. However, the project ceases to be feasible if both carbon black pellet and steel wire do not have market. This is in conformity with the findings in the literature.

4.7 National Economic and Social Benefits

The envisaged project possesses wide range of benefits that promote socio-economic goals of the country. Some of the benefits are described below.

i. **Net value added**. As net value added shows positive (i.e., Birr 77,636,570), it is a good sign for proceeding further with the project. The project generates at years 3 and 6 social surpluses of Birr 8,707,183 and Birr 9,303,361 respectively over and above wages and, therefore, passes the absolute efficiency test. The analysis is attached in Annex 11.

ii. **Employment effect**. The total, direct and indirect employment effect is 11, 4 and 35 jobs respectively per million Birr investment for the first phase of the project. Hence, the project creates total job opportunities for at least 178 citizens out of which 139 are unskilled and 39 are skilled as shown in Annex 12.

iii. **Distribution effect**. The distribution effect among social groups for the sixth year shows that wage earners, profit earners and the Government are expected to receive respectively 21%, 53% and 25% of the value added generated by the project. A portion of the value added (2%) is expected to remain in the project (Annex 13).

iv. **Other benefits**. The project brings with it a lot of benefits such as import substitution, contribution to the transfer of technology and development of local skills and capabilities. Moreover, the project greatly contributes to the environmental protection effort by cleaning waste tyres, and reducing the health and fire hazards, avoiding release of chemicals that harm the environment by open burning.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

In this chapter, conclusions will be drawn in respect of the study questions and objectives, and recommendations for further study and action will be presented.

5.1 Conclusions

In this study, a preliminary investigation on the feasibility of establishing a scrap tyre pyrolysis plant has been carried out. Marketing, raw material and supplies, technological and engineering, organization and management aspects, and financial commitments and rewards of the project have been assessed. The result of the study, based on data & assumptions considered in the analysis, is summarized as follows.

- The potential demand for tyre pyrolysis oil, carbon char pellet, and scrap steel is so big and growing that the project will have no problem of sales; strategy of cost leadership (low sales prices) is possible to achieve and maintain.
- Currently, scrap tyre for pyrolysis is adequately available at about 6,000 tons per year, and generation is increasing; scrap tyre could be acquired by own collection and transport means or by outsourcing it.
- A plant of 3,600 tons/year capacity is selected. Analysis is based on technology from a supplier in China. As the technology is not so complex, it can easily be transferred and operated with local manpower. Project implementation is relatively simple and can be completed within one year. The best project location for the plant is in the outskirts of Addis Ababa. The plant will operate in a safe and environmentally non-polluting manner.
- The project has been evaluated using various appraisal methods and is found feasible. NPV on total capital is positive at 12.5% discount rate and the IRR is 43%. The project profitability is primarily sensitive to the selling price of fuel oil followed by cost of scrap tyres. The project ceases to be feasible if both carbon black pellet and scrap steel do not have market, which is in conformity with findings in the literature.
- The project creates various economic and social benefits: it generates social surplus and employment; contributes to import substitution effort and transfer of technical know-how; and helps in reducing the environmental & health impacts of waste tyres.

5.2 Recommendations

The preliminary study shows that the project is financially feasible and socio-economically acceptable and, hence, it is worth further studying and implementing. However, for investors who are interested to engage in the project based on this study, the following are recommended:

- Conducting a detailed feasibility study based on specific technology of a selected supplier, specific site by getting the feedback of potential scrap tyre suppliers and buyers of the products.
- Conducting a study on environmental impact of the project (a requirement too).
- Starting the project early to take first-mover advantages.

Moreover, as waste tyre management is a public concern, and to reduce possible risks that might face it, the project deserves the following supports from the Government:

- Granting land without auction for the pyrolysis plant.
- Allowing use of spaces for scrap tyre sorting/collection in various parts of the city.
- Facilitating awareness creation and organizing the youth to collect scrap tyres.
- Setting up a framework for collection, processing and disposal of used tyres.
- Financing further studies on scrap tyre pyrolysis.
- Subsidizing the cost of scrap tyre transport by charging fees on tyre importers and producers, as practiced in other countries.

The following issues need further study and research in view of the local conditions.

- Experimental or laboratory study to ascertain yields and tyre composition data.
- Study on techniques to upgrade product quality of tyre oil and carbon char.
- Study on optimum operating conditions to maximize the yield of high value products.

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ANNEXES

ANNEX 1. PROPERTIES OF CHAR

Properties of tyre derived pyrolysis chars

	Temperature of Pyrolysis (°C)					
	450	475	500	525	560	600
Proximate analysis						
(Wt% as received)						
Moisture content	0.5	0.4	0.4	0.4	0.3	0.4
Volatiles	3.0	2.7	2.8	2.8	2.6	2.3
Ash content	11.7	11.6	11.9	12.4	12.3	12.1
Ultimate analysis						
(Wt% dry ash-free)						
Carbon	93.3	94.8	90.6	95.0	94.6	95.9
Hydrogen	1.1	0.9	0.9	1.1	0.8	0.8
Nitrogen	0.7	0.7	0.7	0.9	0.9	1.1
Gross CV (MJ kg^{-1})	30.5	30.7	30.5	30.0	30.6	30.2
Sulphur content (wt%)	2.4	2.6	2.3	2.6	2.4	2.3
Toluene discoloration (% transmission)	93.9	98.2	99.6	99.9	100.0	100.0

Source: Carmichael, Gesley, Li, and Windsor (2007)

ANNEX 3. TYRES COMING WITH IMPORTED VEHICLES IN 2010

S.No	Vehicle Type	No. of Imported Vehicles	No. of Tyres per Vehicle	Total No. of Tyres	Weight, kg/Tyre	Period of Tyre Use, Years	Total Weight of Waste Tyres, Ton	Total No. of Waste Tyres
1	Automobile							
	<=1800cc	7,987	4	31,948	10	2	160	15,974
	< 2500	2,143	4	8,572	10	2	43	4,286
	>= 2500cc	1,627	4	6,508	10	2	33	3,254
2	Dry cargo			-				-
	< =5 ton	5,232	6	31,392	25	0.5	1,570	15,696
	5 - 20 ton	1565	10	15,650	50	0.5	1,565	7,825
	> 20 ton	18	10	180	50	0.5	18	90
	Others	23	6	138	25	1	3	69
3	Bus							
	< 15 Passengers	8,234	6	49,404	25	1	1,235	24,702
	>=15 Passengers	534	6	3,204	50	1	160	1,602
4	Trailer	854	6	5,124	50	0.5	512	2,562
5	Motorcycles	25,255	2	50,510	5	1.5	168	25,255
6	Three wheelers	1,509	3	4,527	6	1.5	18	2,264
	Total	**54,981**		**207,157**			**5,485**	**103,579**

Source: Based on ERCA database

ANNEX 4. LIST OF PLANT MACHINERY AND EQUIPMENT

S.No	Item	Specification	Qty
A	**Pyrolysis Plant**		
1	Reactor (square door)	D2800xL6600mm	1
2	Gas sub-package with tower	D900xL1500mm	1
3	Catalyst chamber	D325xL2200mm	1
4	Horizontal water spray condenser	D133xL6000mm	16
5	Residual oil tank	D700xL1260mm	1
6	Pyrolysis oil tank	D1200xL3000mm	1
7	Tail gas device		3
8	Anti-back fire device	D700xL1260mm	2
9	Atomization strong tower	D950xL4000mm	1
10	Draught fan		1
11	Chimney	D325xL10000mm	1
12	Link pipes		Many
13	Soft tube carbon black discharging machine		1
14	Electrical cabinet		1
15	Waste water treatment: Emulsifying machine		1
16	Carbon black pellet machine		1
B	**Carbon Black Pellet Machine**	HQ-500 (1-1.2 t/hr)	1 set
C	**Emulsifying Machine**	3-4m^3/hr	1
17	Primary spare parts, 5%		LS

ANNEX 12. EMPLOYMENT EFFECT

Location of Effect	Number of New Job Opportunities			Capital Invested, Birr
	No. of Unskilled Workers	No. of Skilled Workers	Total	
Within the project	9	39	48	12,610,041
Input-supplying projects	130	-	130	3,750,000
Output-using projects	-	-	-	-
Total	**139**	**39**	**178**	**16,360,041**

ANNEX 13. DISTRIBUTION EFFECT

Benefit Item	Value, Birr	Distribution
1. Gross domestic value added	9,829,711	
Annual depreciation	526,350	
2. Net domestic value added	9,303,361	
Repatriated payments	0	
3. Net national value added	**9,303,361**	
4. Wage earners	**1,915,500**	**21%**
4.1 Wages	1,915,500	
4.2 Fringe benefits		
5. Profit earners	**4,936,324**	**53%**
5.1 Net profits-dividends to domestic shareholders	4,936,324	
5.2 Interest on domestic private capital		
5.3 Rent received by domestic private owners		
5.4 Fringe benefits		
6. Government	**2,303,776**	**25%**
6.1 Taxes paid to the treasury	2,115,567	
6.2 Interest on loans from public banks	0	
6.3 Profits-dividends to state-owned shares	0	
6.4 Rent and insurance charges received by the state	188,208	
7. Undistributed	**147,761**	**2%**

ANNEX 5 MANPOWER REQUIREMENT

S.No	Position	Required No.	Monthly Salary per Head, Birr	Monthly Salary, Birr	Annual Basic Salary	Annual Salary with 25% Benefits	Category
1	**General Manager's Office**	**3**		**16,000**	**192,000**	**240,000**	Gen & Admin
1.1	General Manager	1	10,000	10,000	120,000	150,000	
1.1.1	Administrative Assistant	1	3,000	3,000	36,000	45,000	
1.1.2	Legal Advisor	1	3,000	3,000	36,000	45,000	
2	**Production Department**	**25**		**61,000**	**732,000**	**915,000**	
2.1	Manager	1	7,000	7,000	84,000	105,000	Supervisory
2.1.1	Production clerk	1	2,000	2,000	24,000	30,000	Supervisory
2.1.2	Shift leaders	3	4,000	12,000	144,000	180,000	Supervisory
2.1.3	Operators (2 skilled)	15	2,000	30,000	360,000	450,000	Operating
2.1.4	Mechanics	3	2,000	6,000	72,000	90,000	Maintenan
2.1.5	Electricians	2	2,000	4,000	48,000	60,000	Maintenan
3	**Marketing Department**	**2**		**8,500**	**102,000**	**127,500**	
3.1	Manager	1	6,500	6,500	78,000	97,500	Marketing
3.1.1	Salespersons	1	2,000	2,000	24,000	30,000	Marketing
4	**Procurement Department**	**4**		**11,000**	**132,000**	**165,000**	Gen & Admin
4.1	Manager	1	6,000	6,000	72,000	90,000	
4.1.1	Purchaser	1	2,000	2,000	24,000	30,000	
4.1.2	Storekeepers	2	1,500	3,000	36,000	45,000	
5	**Finance Department**	**3**		**12,000**	**144,000**	**180,000**	Gen & Admin
5.1	Manager	1	6,500	6,500	78,000	97,500	
5.1.1	Accountant	1	4,000	4,000	48,000	60,000	
5.1.2	Cashier/accountant	1	1,500	1,500	18,000	22,500	
6	**Administration**	**11**		**19,200**	**230,400**	**288,000**	Gen & Admin
6.1	Manager	1	6,000	6,000	72,000	90,000	
6.1.1	Personnel Clerk	1	1,500	1,500	18,000	22,500	
6.1.2	Driver, Truck	1	1,800	1,800	21,600	27,000	
6.1.3	Assistant Driver, Truck	1	1,200	1,200	14,400	18,000	
6.1.4	Driver, Minibus	1	1,500	1,500	18,000	22,500	
6.1.5	Motorcyclists/Postman	1	1,200	1,200	14,400	18,000	
6.1.6	Security Guards	4	1,200	4,800	57,600	72,000	
6.1.7	Cleaner/Messenger	1	1,200	1,200	14,400	18,000	
	Total salary	**48**		**127,700**	**1,532,400**		
	Benefits, 25%				**383,100**		
	Total salary and benefits					**1,915,500**	

S.No	Category of manpower	Number of personnel	Average annual wages
1	Production		
1.1	Direct	15	450,000
1.2	Maintenance	5	150,000
2	Supervisory	5	315,000
3	General & Admin	21	873,000
4	Marketing	2	127,500
	Total	**48**	**1,915,500**

Benefits: Pension contribution, medical, accident, food/drink, bonuses 25%

Project Office: During construction: 4 staff		Fin and Admin Head	78,000
Project Manger	120,000	Engineer	60,000
Secretary	36,000	Total	**294,000**

ANNEX 6 NET INCOME STATEMENT

	Production									
Year	1	2	3	4	5	6	7	8	9	10
Capacity utilization (%)	50	75	100	100	100	100	100	100	100	100
1. Total income	10545100	15817650	21090200	21090200	21090200	21090200	21090200	21090200	21090200	21090200
Sales revenue	10545100	15817650	21090200	21090200	21090200	21090200	21090200	21090200	21090200	21090200
Other income										
2. Less variable costs	5485004.7	8176820.94	10876489.2	10876489	10876489.2	10876489.2	10876489.2	10876489.2	10876489.2	10876489.2
Material	5130000	7695000	10260000	10260000	10260000	10260000	10260000	10260000	10260000	10260000
Personnel (salaries, wages)										
Marketing (except personnel)										
Other variable costs	355004.7	481820.94	616489.2	616489.2	616489.2	616489.2	616489.2	616489.2	616489.2	616489.2
VARIABLE MARGIN	5060095.3	7640829.06	10213710.8	10213711	10213710.8	10213710.8	10213710.8	10213710.8	10213710.8	10213710.8
(in % of total income)	47.99%	48.31%	48.43%	48.43%	48.43%	48.43%	48.43%	48.43%	48.43%	48.43%
3. Less fixed costs	3587876.22	3638428.451	3688702.856	3684491.4	3679722.376	3068786.953	3068738.607	3068683.86	3068621.863	3068551.657
Material	384000	384000	384000	384000	384000	384000	384000	384000	384000	384000
Personnel (salaries, wages)	1915500	1915500	1915500	1915500	1915500	1915500	1915500	1915500	1915500	1915500
Marketing (except personnel)	70672.72043	121224.9513	171499.3559	167287.95	162518.8762	147760.9531	147712.6074	147657.8599	147595.8629	147525.6566
Depreciation	1122527.5	1122527.5	1122527.5	1122527.5	1122527.5	526350	526350	526350	526350	526350
Other fixed costs	95176	95176	95176	95176	95176	95176	95176	95176	95176	95176
OPERATIONAL MARGIN	1472219.08	4002400.609	6525007.944	6529219.4	6533988.424	7144923.847	7144972.193	7145026.94	7145088.937	7145159.143
(in % of total income)	13.96%	25.30%	30.94%	30.96%	30.98%	33.88%	33.88%	33.88%	33.88%	33.88%
4. Less costs of finance/interest	1033927.821	869723.1271	683775.0964	473204.56	234751.1113	93032.45451	90615.16792	87877.79381	84777.94743	81267.63166
GROSS PROFIT	438291.2582	3132677.482	5841232.848	6056014.8	6299237.313	7051891.392	7054357.025	7057149.146	7060310.99	7063891.512
5. Less allowances										
TAXABLE PROFIT	438291.2582	3132677.482	5841232.848	6056014.8	6299237.313	7051891.392	7054357.025	7057149.146	7060310.99	7063891.512
6. Income (corporate) tax, 30%	0	0	0	0	0	2115567.418	2116307.107	2117144.744	2118093.297	2119167.454
NET PROFIT	438291.2582	3132677.482	5841232.848	6056014.8	6299237.313	4936323.975	4938049.917	4940004.402	4942217.693	4944724.058
7. Dividends payable										
RETAINED PROFIT	438291.2582	3132677.482	5841232.848	6056014.8	6299237.313	4936323.975	4938049.917	4940004.402	4942217.693	4944724.058
RATIOS (%)										
Gross profit/sales	4.16%	19.80%	27.70%	28.71%	29.87%	33.44%	33.45%	33.46%	33.48%	33.49%
Net profit after tax/sales	4.16%	19.80%	27.70%	28.71%	29.87%	23.41%	23.41%	23.42%	23.43%	23.45%
Net profit/equity capital	11.59%	82.81%	154.41%	160.08%	166.51%	130.49%	130.53%	130.58%	130.64%	130.71%
Net profit + interest/investment	11.67%	31.74%	51.74%	51.78%	51.82%	39.88%	39.88%	39.87%	39.87%	39.86%
Net profit/Net worth	11.59%	74.21%	79.43%	45.90%	32.72%	19.32%	16.20%	13.95%	12.24%	10.91%

Total cash flow from operations (net income after taxes + depreciation)	1560818.758	4255204.982	6963760.348	7178542.3	7421764.813	5462673.975	5464399.917	5466354.402	5468567.693	5471074.058

ANNEX 7 **DISCOUNTED CASH FLOW - TOTAL CAPITAL INVESTED** Rate 12.5%

	Construction	Production									
	0	1	2	3	4	5	6	7	8	9	10
TOTAL CASH INFLOW	0	10545100	15817650	21090200	21090200	21090200	21090200	21090200	21090200	21090200	21090200
1. Inflow operation											
Sales revenue		10545100	15817650	21090200	21090200	21090200	21090200	21090200	21090200	21090200	21090200
2. Other income											
TOTAL CASH OUTFLOW	10686487.5	9062101.7	11096804.85	13850386.33	13438277.67	13433485.37	15533878.66	15535182.9	15535965.52	15536851.78	15537855.38
3. Increase in fixed assets		0	0	0	0	0	0	0	0	0	0
Fixed investments	9517600										
Pre-production expenditures (net of interest paid)	1168887.5										
4. Increase in net working capital		1111748.28	404082.96	407721.78	-175.48	-198.71	-614.91	-2.01	-2.28	-2.58	-2.93
5. Operating costs		7752180.70	10443996.94	13143665.20	13143665.20	13143665.20	13143665.20	13143665.20	13143665.20	13143665.20	13143665.20
6. Marketing costs		198172.72	248724.95	298999.36	294787.95	290018.88	275260.95	275212.61	275157.86	275095.86	275025.66
7. Corporate tax paid		0.00	0.00	0.00	0.00	0.00	2115567.42	2116307.11	2117144.74	2118093.30	2119167.45
NET CASH FLOW	-10686487.5	1482998.30	4720845.15	7239813.67	7651922.33	7656714.63	5556321.34	5555017.10	5554234.48	5553348.22	5552344.62
CUMULATIVE NET CASH FLOW	-10686487.5	-9203489.20	-4482644.05	2757169.62	10409091.95	18065806.59	23622127.93	29177145.03	34731379.51	40284727.73	45837072.35
Net present value (at 12.5%)	1.0000	0.8889	0.7901	0.7023	0.6243	0.5549	0.4933	0.4385	0.3897	0.3464	0.3079
Net cash flow net present value	-10686487.5	1318220.71	3730050.49	5084752.54	4777057.44	4248932.67	2740767.65	2435666.05	2164731.47	1923898.72	1709823.13
Cumulative net present value	-10686487.5	-8180879.29	-3541842.21	1936448.35	6498344.86	10025239.21	11652091.40	12793080.63	13536358.69	13956217.55	14115349.85
NET PRESENT VALUE (at 12.5%)	19447413.37										
INTERNAL RATE OF RETURN, %	43.16%										
NPV ratio	1.81981342										

ANNEX 8 CASH FLOW FOR FINANCIAL PLANNING

	Construction	Production									
		1	2	3	4	5	6	7	8	9	10
TOTAL CASH INFLOW	12610040.51	10823710.98	15876190.82	21148800.31	21090200	21090200	21090200	21090200	21090200	21090200	21090200
1. Inflow funds/financing											
Total equity	3783012.153										
Total long-term loans	8827028.357										
Total short-term finance/payable		278610.975	58540.82	58600.305	0	0	0	0	0	0	0
2. Inflow operation											
Sales revenue		10545100	15817650	21090200	21090200	21090200	21090200	21090200	21090200	21090200	21090200
3. Other income											
TOTAL CASH OUTFLOW	10686487.5	11614706.93	13429339.92	16182980.89	15712271.92	15707479.62	15645166.35	15646470.59	15647253.22	15648139.47	15649143.08
4. Increase in fixed assets											
Fixed investments	9517600										
Pre-production expenditures (net of ir	1168887.5										
5. Increase in current assets		1390359.254	462623.7753	466322.0804	-175.4754448	-198.7112095	-614.913464	-2.014405487	-2.281145098	-2.583205312	-2.925263146
6. Operating costs		7752180.7	10443996.94	13143665.2	13143665.2	13143665.2	13143665.2	13143665.2	13143665.2	13143665.2	13143665.2
7. Marketing costs		198172.7204	248724.9513	298999.3559	294787.9453	290018.8762	275260.9531	275212.6074	275157.8599	275095.8629	275025.6566
8. Corporate tax paid		0	0	0	0	0	2115567.418	2116307.107	2117144.744	2118093.297	2119167.454
9. Interest paid		1033927.821	869723.1271	683775.0964	473204.5626	234751.1113	93032.45451	90615.16792	87877.79381	84777.94743	81267.63166
10. Loan repayments		1240066.433	1404271.127	1590219.158	1800789.691	2039243.143	18255.23907	20672.52566	23409.89977	26509.74615	30020.06193
11. Dividends paid											
SURPLUS (DEFICIT)	1923553.01	-790995.9536	2446850.899	4965819.415	5377928.076	5382720.381	5445033.649	5443729.406	5442946.784	5442060.53	5441056.922
CUMULATIVE CASH BALANCE	1923553.01	1132557.056	3579407.956	8545227.37	13923155.45	19305875.83	24750909.48	30194638.88	35637585.67	41079646.2	46520703.12
	Avg cash flow	4459715.011									
		Pback	2.82754402								

ANNEX 9 PROJECTED BALANCE SHEET

	Construction	Production									
		1	2	3	4	5	6	7	8	9	10
TOTAL ASSETS	12610040.51	12086876.31	13873823.49	18183437.48	22438662.58	26698656.75	31616725.49	36534102.88	41450697.38	46366405.33	51281109.32
1. Total current assets	1923553.01	2522916.31	5432390.99	10864532.48	16242285.08	21624806.75	27069225.49	32512952.88	37955897.38	43397955.33	48839009.32
Inventory on materials & supplies	0.00	289991.00	405899.80	524188.00	524188.00	524188.00	524188.00	524188.00	524188.00	524188.00	524188.00
Work in progress	0.00	17777.79	25255.06	32754.14	32754.14	32754.14	32754.14	32754.14	32754.14	32754.14	32754.14
Finished products in stock	0.00	323007.53	435166.54	547652.72	547652.72	547652.72	547652.72	547652.72	547652.72	547652.72	547652.72
Accounts receivable	0.00	662529.45	891060.16	1120222.05	1119871.10	1119473.67	1118243.85	1118239.82	1118235.25	1118230.09	1118224.24
Cash-in-hand	0.00	97053.48	95601.47	94488.21	94663.69	94862.40	95477.31	95479.32	95481.61	95484.19	95487.11
Cash surplus, finance available	1923553.01	1132557.06	3579407.96	8545227.37	13923155.45	19305875.83	24750909.48	30194638.88	35637585.67	41079646.20	46520703.12
2. Total fixed assets, net of depreciation	10686487.50	9563960.00	8441432.50	7318905.00	6196377.50	5073850.00	4547500.00	4021150.00	3494800.00	2968450.00	2442100.00
Fixed investment	9517600.00	9517600.00	9517600.00	9517600.00	9517600.00	9517600.00	9517600.00	9517600.00	9517600.00	9517600.00	9517600.00
Construction in progress											
Pre-production expenditures	1168887.50	1168887.50	1168887.50	1168887.50	1168887.50	1168887.50	1168887.50	1168887.50	1168887.50	1168887.50	1168887.50
Less accumulated depreciation	0.00	1122527.50	2245055.00	3367582.50	4490110.00	5612637.50	6138987.50	6665337.50	7191687.50	7718037.50	8244387.50
3. Accumulated losses brought forward											
4. Loss in current year											
TOTAL LIABILITIES	12610040.51	12086876.31	13873823.49	18183437.48	22438662.58	26698656.75	31616725.49	36534102.88	41450697.38	46366405.33	51281109.33
5. Total current liabilities	0.00	278610.98	337151.80	395752.10	395752.10	395752.10	395752.10	395752.10	395752.10	395752.10	395752.10
Accounts payable	0.00	278610.98	337151.80	395752.10	395752.10	395752.10	395752.10	395752.10	395752.10	395752.10	395752.10
Bank overdraft											
6. Total long-term debt	8827028.36	7586961.93	6182690.80	4592471.64	2791681.95	752438.81	734183.57	713511.04	690101.14	663591.40	633571.34
Loan	8010758.36	6780494.89	5387324.80	3809676.63	2023122.53	0.00	0.00	0.00	0.00	0.00	0.00
Lease	816270.00	806467.04	795366.00	782795.01	768559.42	752438.81	734183.57	713511.04	690101.14	663591.40	633571.34
7. Total equity capital	3783012.15	3783012.15	3783012.15	3783012.15	3783012.15	3783012.15	3783012.15	3783012.15	3783012.15	3783012.15	3783012.15
Ordinary capital	3783012.15	3783012.15	3783012.15	3783012.15	3783012.15	3783012.15	3783012.15	3783012.15	3783012.15	3783012.15	3783012.15
8. Retained profit brought forward		0.00	438291.26	3570968.74	9412201.59	15468216.38	21767453.69	26703777.67	31641827.58	36581831.99	41524049.68
9. Net profit after tax	0.00	438291.26	3132677.48	5841232.85	6056014.79	6299237.31	4936323.97	4938049.92	4940004.40	4942217.69	4944724.06
Dividends payable											
Retained profit	0.00	438291.26	3132677.48	5841232.85	6056014.79	6299237.31	4936323.97	4938049.92	4940004.40	4942217.69	4944724.06
Net worth	3783012.15	4221303.41	7353980.89	13195213.74	19251228.53	25550465.84	30486789.82	35424839.74	40364844.14	45307061.83	50251785.89
RATIOS (%)											
Equity/total liabilities	30.00%	31.30%	27.27%	20.80%	16.86%	14.17%	11.97%	10.35%	9.13%	8.16%	7.38%
Long-term debt/net worth	233.33%	179.73%	84.07%	34.80%	14.50%	2.94%	2.41%	2.01%	1.71%	1.46%	1.26%
Current assets/current liabilities		9.06	16.11	27.45	41.04	54.64	68.40	82.15	95.91	109.66	123.41

ANNEX 10 FINANCIAL AND EFFICIENCY RATIOS

Ratio	Construction	Production									
	0	1	2	3	4	5	6	7	8	9	10
Financial ratios											
Long-term debt to equity ratio	2.33	2.01	1.63	1.21	0.74	0.20	0.19	0.19	0.18	0.18	0.17
Long-term debt to net-worth ratio	2.33	1.80	0.84	0.35	0.15	0.03	0.02	0.02	0.02	0.01	0.01
Current ratio		9.06	16.11	27.45	41.04	54.64	68.40	82.15	95.91	109.66	123.41
Quick ratio		6.79	13.54	24.66	38.25	51.85	65.61	79.36	93.12	106.87	120.62
Long-term debt to service coverage		3.34	2.72	2.02	1.23	0.33	6.60	6.41	6.20	5.96	5.69
Debtors to creditors ratio		3.86	5.04	6.15	6.15	6.15	6.14	6.14	6.14	6.14	6.14
Efficiency ratios											
Output to capital ratio		0.84	1.25	1.67	1.67	1.67	1.67	1.67	1.67	1.67	1.67
Net present value ratio		1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82	1.82
Relation between personnel employed and investment											
Investment to total cost of personnel		6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.58	6.58
Efficiency of personnel employed		219689.58	329534.38	439379.17	439379.17	439379.17	439379.17	439379.17	439379.17	439379.17	439379.17
Turnover of inventories		31.29	29.15	27.84	27.45	27.01	25.63	25.63	25.62	25.62	25.61

ANNEX 11 INTEGRATED VALUE ADDED ANALYSIS

	Construction	Production Year									
Item		1	2	3	4	5	6	7	8	9	10
1. Value of output	0	10545100	15817650	21090200	21090200	21090200	21090200	21090200	21090200	21090200	21090200
1.1 Domestically marketed (import substitution): oil	0	7257600	10886400	14515200	14515200	14515200	14515200	14515200	14515200	14515200	14515200
1.2 Infrastructural services: CB pellet	0	1127500	1691250	2255000	2255000	2255000	2255000	2255000	2255000	2255000	2255000
1.3 Domestically marketed: scrap steel	0	2160000	3240000	4320000	4320000	4320000	4320000	4320000	4320000	4320000	4320000
1.4 Exports											
2. Value of material inputs	12610040.51	5869004.7	8560820.94	11260489.2	11260489.2	11260489.2	11260489.2	11260489.2	11260489.2	11260489.2	11260489.2
2.1 Investments	12610040.51										
2.1.1 Imported	2234000										
2.1.2 Domestically procured	10376040.51										
2.2 Current material inputs	0	5869004.7	8560820.94	11260489.2	11260489.2	11260489.2	11260489.2	11260489.2	11260489.2	11260489.2	11260489.2
2.2.1 Imported		107073	121349.4	142764	142764	142764	142764	142764	142764	142764	142764
2.2.2 Domestically procured		5642307.3	8260034.94	10878476.4	10878476.4	10878476.4	10878476.4	10878476.4	10878476.4	10878476.4	10878476.4
2.2.3 Infrastructural services		119624.4	179436.6	239248.8	239248.8	239248.8	239248.8	239248.8	239248.8	239248.8	239248.8
3. Net domestic value added (1-2)	-12610040.51	4676095.3	7256829.06	9829710.8	9829710.8	9829710.8	9829710.8	9829710.8	9829710.8	9829710.8	9829710.8
4. Repatriated payments	0	0	0	0	0	0	0	0	0	0	0
4.1 Wages	0										
4.2 Profits	0										
4.3 Interest	0										
4.4 Others (royalties, insurance and reinsurance etc)	0										
5. Net national value added (3-4)	-12610040.51	4676095.3	7256829.06	9829710.8	9829710.8	9829710.8	9829710.8	9829710.8	9829710.8	9829710.8	9829710.8
5.1 Wages		1915500	1915500	1915500	1915500	1915500	1915500	1915500	1915500	1915500	1915500
5.2 Social surplus (5-5.1)		2760595.3	5341329.06	7914210.8	7914210.8	7914210.8	7914210.8	7914210.8	7914210.8	7914210.8	7914210.8
Total value added	77960570.25										
Absolute efficiency, Es		3553567.8	6134301.56	8707183.3	8707183.3	8707183.3	9303360.8	9303360.8	9303360.8	9303360.8	9303360.8