**FACULTAD DE ECONOMÍA Y CIENCIAS EMPRESARIALES**

TOPIC: BUSINESS MODEL PROPOSITION BASED ON THE PRODUCTION OF HIGH ADDED VALUE PRODUCTS MADE BY THE REPROCESSING OF WASTED TIRES LOCATED AT THE MAJOR TIRE COMMERCIAL HOUSES IN GUAYAQUIL.

TRABAJO DE TITULACION QUE SE PRESENTA COMO REQUISITO PARA OPTAR EL TÍTULO DE **INGENIERO EN CIENCIAS EMPRESARIALES**

Autor
**Ernesto Nicolás Raad Serrano**

Tutor
**James W. Keeley, PhD**

SAMBORONDÓN, **Enero 2014**

**Acknowledgement**

This work was only possible thanks to Dr. James Keeley, with his constant motivation to do the best possible job even when the light was not seen at the end of the tunnel. His expert guidance and patience allowed me to learn the task of writing a true research paper and allowed me to keep a focus and be confident throughout the writing of this paper.

Uees International Career Program staff, especially Maria Isabel Armijo, was the most the most help possible clearing any doubts and counseling. Also I want to thank Dean Isidro Fierro for his predisposition to always help students on any regards, Dean Mauricio Ramirez for his understanding and help through the process of starting the thesis process. Thanks to the Economia staff specially to Miss. Elba for her unconditional patience.

Finally I want to thanks my father who has taught me everything I know about rubber and his support through the elaboration of this paper. I want to thank my grandmother Leonor and Uncle Jorge, without them anything of this was possible.

One final thanks to Ing. Wohlgemuth, for dedicating time to clear any doubts regarding data without asking anything in return.

**General Index**


1. Chapter 1 .......... 2
1.1 Background .......... 2
1.2 General Objective .......... 2
1.4 Problem Description .......... 3
1.5 Delimitation .......... 3
1.6 Justification .......... 3
2. Chapter 2 .......... 6
2.1 Reference Framework .......... 6
2.1.1 United States Success in Waste Tire Management .......... 6
2.1.2 Moulded Rubber Industry in US .......... 8
2.2.3 West Australia Waste Tires Management Project .......... 9
2.2.4 Free Rider Regulation .......... 11
2.2.5 Passenger Tire producers in Australia .......... 11
2.2.6 Reuse of tires in West Australia .......... 11
2.3 Theoretical Framework .......... 12
2.3.1 History and use or rubber .......... 12
2.3.2Reclaimed Rubber .......... 15
2.3.3 Types of Rubber .......... 15
2.4 Legal Framework .......... 17
3. Chapter 3 .......... 19
3.1 Methodology .......... 19
3.2 Conceptual Framework. .......... 20
4. Chapter 4 .......... 21
4.1 Industry Description - Tire Shredding Industry .......... 21
4.2 Molded and extruded Rubber Industry .......... 22
4.3 Ecuador’s Macroeconomical Overview .......... 23
4.3.1 Sector Data .......... 23
4.4 Competitive Analysis .......... 24
4.5 Technical Advantage and Filler Efficiency .......... 25
4.6 Production Process Advantage .......... 27
4.7 Market Advantage .......... 28

4.8 Porter's (1979) Five forces Industrial Analysis ........ 28
4.8 Potential Customers ........ 29
4.9 Operations Plan ........ 31
4.11 Machinery Required. ........ 32
4.12 Production Process ........ 40
Company Organizational Structure ........ 44
4.13 Human Resources ........ 45
4.15 Main financial ratios. ........ 57
5. Chapter 5 ........ 59
5.1 Conclusion ........ 59
5.2 Recommendations ........ 60
6. 6 .- References ........ 61
7. 7.- Annexes ........ 64

**Tables Index**


Table 1 US wasted tire market 2005-2007 ........ 7
Table 2 US. Destination of ground rubber powder. ........ 7
Table 3 Value of the molded rubber industry in the US ........ 8
Table 4 Natural natural rubber consumption char ........ 13
Table 5 History of Natural and SB Rubber Consumption. (Approximate numbers). ........ 14
Table 6 Approximate available tires in Ecuador ........ 23
Table 7 *Rubber coating and flooring.. Date 5/2012 – 5/2013* Advalorem: 25%; FONDINA: 0,5% ; IVA: 12% ........ 24
Table 8*, Rubber Gaskets. Date 9/2011 – 9/2012* Advalorem:15% ........ 25
Table 9 Cracker line ........ 35
Table 10 Technical properties ........ 38
Table 11Shredding Capacity. ........ 40
Table 12 Powder Production. ........ 41
Table 13 Devulcanization capacity ........ 41
Table 14 Mixing Capacity. ........ 42
Table 15 Base formula for rubber mats. ........ 42
Table 16 vulcanization capacity. ........ 43
Table 17 Sector Minimum Wage for Tire and other rubber made industries. ........ 45
Table 18Direct Labor Cost Detail. ........ 46
Table 19 Cost of raw materials in formula ........ 47
Table 20Indirect Labor Costs Detail ........ 48
Table 21 Detailed Plant Indirect Costs. ........ 49
Table 22 Detailed Cost per Kilogram ........ 49
Table 23 Initial investment composition. ........ 50
Table 24 Projected Production Overview ........ 51
Table 25 Raw Material inventory efficiency in years (US Dollars). ........ 51
Table 26 Finished Products inventory in years. (US Dollars). ........ 51
Table 27 Sales efficiency projection in years (US Dollars). ........ 52
Table 28 Cost per unit projection in years. (US Dollars). ........ 52
Table 29 Expenses projections in years. (US Dollars). ........ 53
Table 30 Company Income Statement ........ 53
Table 31 Company Balance Sheet. ........ 54
Table 32 Cash flow statement ........ 56
Table 33 Net Present Value and Internal Rate of Return. ........ 57

**Figures Index**

Figure 1 Loop cutter, cuts the tire in order to take away the bead wires .. 32
Figure 2 Loop press: takes the bead wires away. (Figure # 2)................. 33
Figure 3 Bar cutter: cut the tire into bars. (Figure # 3).............................. 33
Figure 4 Block cut the rubber bar into blocks. (Figure # 4) ...................... 34
Figures 5 Cracker Line.......................................................................... 35
Figure 6 Rubber reclaiming machine. ..................................................... 38
Figure 7 Therman Oil Boiler.................................................................... 39
Figure 8 Large rubber mixer.................................................................... 39
Figure 9 Vulcanization Press 1.30 x 1.20 500 tons. ................................ 39

## Abstract

This research couples the necessity of recycling tires in Ecuador along with the opportunity of starting a waste tire recycling businesses in Guayaquil, Ecuador, South America.

The research takes into account various international solutions to the problem of used tires, specifically highlighting the legislation and macro structure of the waste tire industry in Australia and USA. The industry structure of molded rubber in which benefits from a macro waste tire recycling project will allow for the potential of Ecuadorian expertise.

The current Ecuadorian situation on tire recycling is reviewed in this paper. The Ecuadorian government is moving forward into making the country suitable for having a sustainable tire recycling industry. Legislation has been approved supporting future recycling projects but it is still only the foundation stage.

This paper also analyzes the current situation of the waste tire recycling environment in Guayaquil concluding that it is still in a developing stage.

Finally, the research proposes a waste tire recycling business dedicated to the shredding of scrap tires and devulcanization of scrap tire powder. Using the devulcanized powder as 80% of the raw material needed for the final product, the production process meets a relative low cost, suitable quality solution. The final product is rubber mats for the cow owners mainly in Manta, Ecuador.

The business project considers and includes the recycling legislation foundation to affirm a complete government guarantee on free of cost supply of waste tires all year round as Environmental Manager as end of life waste tire consumers.

The proposed business project concludes that with proper regulation, a waste tire devulcanization plant in Guayaquil can be economically feasible and sustainable over time. It will even attract significant capital to invest on the industry because of its potential profitability which will allow for increased employment and international recognition as a enviro-friendly country.

## Introduction

Tires represent the single biggest use of synthetic and natural rubber worldwide. In Ecuador, around two million waste tires are generated annually (INVEC, 2012). These used tires appear to have no certain destination. In Guayaquil, which represents 30% of the total waste tires generation, it's not possible to bury them. The Municipality doesn't count waste tires as landfill material since tires naturally decreases the life a landfill.

Recycling tires in Ecuador has always been difficult since there is a lack of information on how many tires are waiting to be recycled or actually where are they. Written records are not kept regarding the transport of waste tires. The job required locating, collecting and transporting to the potential recycling factory would have high costs. Currently there is not a process to recycle or track waste tires; there are no tire recycling companies in Guayaquil.

On 2013 The Ecuadorian Government approved the "Acuerdo Ministerial 020" which is a set of laws and regulations which has the intention of making viable a waste tire recycling industry.

The highlight of the law is that it states that the authorized recycling companies will have for free the tires in order to be destroyed, transformed or end the life of the waste tire as it is. This sole detail makes devulcanizing processes extremely profitable since it eliminates any logistics problems and most of the raw materials would have no cost making the company profitable.

Thanks to this governmental initiative, everyday there are more and more investors interested in tire recycling businesses. In Samborondon, the first tire recycling plant in the history of Guayas is being built. The author was part of the construction of it (see annex #18). Although the resulting product of that recycling plant is going to be rubber powder to be mixed with char to build roads.

This paper proposes a higher added value product which partially returns the vulcanized state of the tire rubber to a vulcanizable state again. This enables the possibility to mold the materials into new, durable products.

## Chapter 1

### 1.1 Background

Guayaquil is gradually transforming from a dirty city with no sense of city planning to a clean, self regulating city. Part of the transformation is the new recycling culture that was born due to a private entrepreneur who made recycling a profitable business. This private company works mainly with traditional recyclable materials such as plastic wastes and paper wastes. It has a positive impact in the environment, tons of plastic and paper wastes have been collected and used since this initiative. The steel waste is collected and reused by steel companies like Andec and others.

The waste that has no certain destination for recycling ends-up as waste tires. Tires which cannot be retreaded anymore are lying in dump fields and some many of them in Guayaquil's shanty areas. This has been the situation for wasted tires since the use of cars; thousands of tons of wasted tires have accumulated through the pass of the decades.

### 1.2 General Objective

To develop a business model proposition based on the production of high added value products made by the reprocessing of wasted tires located at the major tire commercial houses in Guayaquil.

### 1.3 Specific Objectives

1- To analyze the main wasted tire disposal mechanisms used by the major tire stores in Guayaquil.

2- Establish a production model in which the reclaimed wasted tire rubber gains value by modifying its chemical composition.

3- Develop a business model focused in logistic planning, storage strategies and commercialization of wasted tire reclaimed rubber products.

## 1.4 Problem Description

In Guayaquil, Ecuador, South America there are dump areas where vast numbers of used (waste) tires have accumulated. The Municipality of Guayaquil has tried to bury some of them but still they aren't able to bury them all. Because rubber does not biodegrade naturally, burying them creates additional burdens on local municipalities. Annually in Ecuador around 2.4 million wasted tires are generated (Ministerio de Industrias y Productividad MIPRO, 2012). These tires have no use and have no official destination. This solid waste is one of the most difficult to recycle because its former duty required top quality. Its physical form is also a problem for its storage.

Today in 2013 the large distributors of retail tires are the biggest wasted tire disposers in Guayaquil. The Government approved a waste control regulation which prohibits the dumping of tires (Mipro, 2012). The regulation is affecting the tire distributors because piling wasted tires in warehouses is expensive. With time, prohibition of disposing wasted tires to landfills is going to be unsustainable. The piled wasted tires in warehouses need to be used somehow. There have been a few attempts to start a wasted tire recycling business but all have failed. These attempts failed because the business plans proposed were based on low margin, low added value products, resulting in weak business models. This situation resulted on a systematic lack of interest from investors. Not enough investors are whiling to use resources to research other possibilities regarding wasted tire processing businesses.

## 1.5 Delimitation

This work encompasses the current wasted tire recycling scenario in Guayaquil. This work also presents basic knowledge in rubber processing.

## 1.6 Justification

There are two main environmental impacts caused by wasted tires that must be taken into account. The first one is with nature itself; although tires take more than a hundred years to completely decompose and disappear, the process damages the soil. When tires are left in dump areas their erosion can liberate particles to the soil like sulfur (Environmental Protection Agency, 2007). These particles are toxic to plants and other living creatures.

The second environmental impact can affect directly humans. When tires are dump in huge quantities, hills of wasted tires results. In these wasted tires hills new ecosystems appears. These ecosystems are actually incorporated by living creatures considered dangerous for humans. For example rats, depending on the race, can become reproductive within five weeks. Rats don't have breed seasons neither recognize incest so reproduction can occur within members of the same breed. Six rats can become a family of sixty members in around twelve weeks (New Zealand, 2006).

Although these ecosystems do count on other predators like cats and large birds, the protective nature of wasted tires hills gives the rats a huge protective advantage. Other dangerous creatures are snakes, scorpions, cockroaches and others. They all have the protective advantage of the tires. Although one insect in particular is the most dangerous of them all is the mosquito.

Generally speaking, Ecuador has a suitable climate for the reproduction of mosquitoes. The Coast and East has tropical climate and naturally water deposits for the mosquitoes to breed. The problem especially in the Coast and in Guayas is that in many places wasted tires are just lying in the ground. Some other populations are near the dump sites. Mosquitoes can breed all year round thanks to tires. When rain falls naturally water will accumulate in certain places of the soil so mosquitoes and other living beings can reproduce. Shortly after the rain stops, the water evaporates and naturally decreasing the mosquito breeding possibility. When rain falls over the hills of waste tires, water will accumulate inside the tires and stay there long after the rain season had ended leading to unnatural mosquito overpopulation.

Harbach maintains (2008) Mosquito is a word from which insects of the Culicidae family are generally called, especially the ones in the Anophelinae family. There are over 2000 types of mosquitoes all around the world (Harbach, 2008). Mosquitoes are generally considered dangerous to humans.

In Ecuador there are three main types of mosquitoes, the Anopheles, Aedes Aegypti and the Culex Pipiens (Ministerio de Salud Publica, 2012). The most dangerous ones are particularly the Aedes Aegypti and the Anopheles. The Aegypti is the responsible of transmitting the yellow fever disease and the dengue disease (Romero, 2007).

In 2012 Ecuador reported having over 16.300 cases of dengue followed by 260 serious cases and 22 deaths. Up until week 26 of 2013 in Ecuador, MSP reports 9.503 cases of dengue with 9 deaths (MSP. 2013). . Although Ecuador has reduced the cases of Malaria and its mortality through proper fumigation, preventive education and improved medical care, reducing the possible number of mosquitoes breed could be a important step into further reducing infection cases since eradication is directly related to the number of possible infected Anopheles on the areas. Culex Pipiens is not a major threat and is rather a big nuisance since they reproduce even faster and in large numbers can leave dozens of rashes and stitches to exposed humans (Romero, 2007)

The Ecuadorian State already passed a law where it states that is illegal to dump tires. The law is easily applied inside the city of Guayaquil but is not completely safe to affirm that in rural areas of the province enough control is possible.

The approval of the law is an important step in resolving the problem, but the law by itself won't resolve the tire issue. The city is heading to a critical point where there is no place for tires anymore. With said situation, another possibility is being analyzed for the use of the wasted tires which is burning them for energy. This, however, creates another set of hazards.

There are two negative situations regarding this plan. The first one is of economical aspect. In Ecuador, an attempt from private companies to sell tire crumbs to the cement companies is virtually impossible because of subsidized fuel. The government could create a system where is the cement companies could cease from fuel subsidize but that could create conflicts and unwanted economic situations for the cement companies. Also by force of the law the Government could make the tire crumbs part of the cement kilns energy source. This solution is economically inefficient since double subsidies would result, the fuel subsidy and now the tire industry subsidy because for cement kilns burning petrol based fuels is more efficient.

The second problem with burning wasted tires is that one environmental hazard is replaced by another. When tires are burned as fuel in form of crumbs, more toxins are liberated into the air. Carrasco, Bredin and Heitz (1994) states that after burning tire crumbs in conjunction with coal the following toxic elements increased in air discharge. It increases Carbon Dioxide 37%, Sulfur Dioxide 24%, Hydrochloric Acid 48%, Lead 339%, Chrome 100% emissions. The inhalation of these gases is considered harmful to humans.

Mager (1998) sustains that inhalation of lead may result in lung retention of 15% of the material. Some of the lead deposits in the lower part of the lungs. It may be absorbed by the blood vessels into the blood plasma. This may result in lead deposit in the body that may last for weeks and with extreme exposure up until years. Lead intoxication produces several neurological illnesses, problems related to the central nervous system and damages kidneys. The other dangerous gas is the Hydrochloric Acid. Mager (1998) states that the molecules damage soft mucous tissue like throat, nose and mouth. Skin rashes can occur in more exposed situations

Although there is no guarantee that these gases will harm certain populations, it is clear that only hoping for it not to occur is not logical. Another negative effect of burning tire crumbs for the same reason described above it may promote the increase in air pollution which is harmful to nature itself.

## Chapter 2

### 2.1 Reference Framework

Although the first people to use rubber in Ecuador were the natives from the Amazonas hundreds of years ago, it was not until 1930 when Mr. José Filometor Cuesta Tapia started producing shoes with rubber soles. In 1938 the brand Venus was officially registered. Plasticaucho Industrial now a day has expanded its market into the production and commercialization of EVA products (Plasticaucho Industrial, 2013).

In 1957 Ecuadorian Rubber Company, known as Erco, was founded. In 1962 Erco produced the first tire. In 1972 Erco was forced to change the company name to "Compañia Ecuatoriana del Caucho". Erco Company owns rubber plantations located mainly in Santo Domingo but also is supplied of synthetic rubber from imports (Cedillo, 2007).

These two companies are considered the biggest rubber related companies in Ecuador. The rest of the rubber market is spread over many small artisans, who produce in scarce quantities rubber products.

#### 2.1.1 United States Success in Waste Tire Management

The US started to confront heavily the waste tire problem since the ninety's decade. Every state has its own system to manage the solid waste. The systems depends heavily on government intervention in form of subsidizes. For example, wasted tire logistics are funded with a tax addition to the purchase of a new tire. The Government works directly with tire commercial houses and retread plants to manage the systems. The Government monitories the movement and tracks all tires that are disposed. The illegal dump of tires is nearly if not completely eradicated. The following table from Rubber Manufacturers Association (RMA) (2012) shows the average wasted tire figures of the US from 2005 to 2009.

**Table 1 US wasted tire market 2005-2007**

| **Market or Disposition.** | 2005 | 2007 | 2009 |
|---|---|---|---|
| Tire-Derived Fuel | 2144.6 | 2484.36 | 2084.75 |
| Ground Rubber | 552.51 | 789.09 | 1354.17 |
| Land Disposed | 590.81 | 593.98 | 653.38 |
| Used Tires | n/a | n/a | 371.25 |
| Civil Engineering | 639.99 | 561.56 | 284.92 |
| Reclamation Projects | UNK | 132.58 | 130 |
| Exported | 111.99 | 102.08 | 102.1 |
| Baled tires/Market | UNK | UNK | 27.76 |
| Electric Arc Furnance | 18.88 | 27.14 | 27.1 |
| Baled/not market | 42.22 | 9.31 | 15.57 |
| Agricultural | 47.59 | 7.13 | 7.1 |
| Punched/Stamped | 100.51 | 1.85 | 1.9 |
| Total to Market | 3616.11 | 4105.79 | 4391.05 |
| Generated | 4410.73 | 4595.72 | 5170.5 |
| % to market utilized | 82% | 89.3% | 84.9% |
| % Managed including baled and landfilled tires) | 96.3% | 102.5% | 97.9% |

Source: Rubber Manufacturers Association, 2011

It is important to point out that tired derivate fuels is the biggest destination for waste tires with a mean 40.3% annual destination (RMA, 2011). In United States might be cost efficient to use tire derived fuels as a source of energy since oil base fuels prices have been steadily raising through years in consequence of crude oil commodity inflation. The number two largest destination is ground rubber with a mean 26.2%. Ground rubber is the shredding of tires into rubber crumbs or powder. The ground rubber market for 2005, 2007 and 2009 was divided as follow (RMA, 2011).

US ground rubber market, approximate. This data is not linked to the entering waste tires in the market, is linked to ground rubber consumption in end of use market.

**Table 2 US. Destination of ground rubber powder.**

| Market | 2005 | 2007 | 2009 |
|---|---|---|---|
| Molded/extruded products | 225 | 400 | 500 |

| | | | |
|---|---|---|---|
| Sports Surfacing<br>Asphalt | 250<br>120 | 300<br>100 | 400<br>150 |
| Automotive | 100 | 125 | 175 |
| Export | 30 | 100 | 115 |
| Play Grounds | 25 | 100 | 320 |

Source: Rubber Manufacturers Association, 2011. Elaboration by the Author.

The United States have been decreasing its stock piled waste tires at a high rate since 1990. It has decreased from one billion tires in 1990 to 111.15 million tires in 2010.

### 2.1.2 Moulded Rubber Industry in US

Industry value of shipment is defined by the US Government (2007) as "Includes the total sales, shipments, receipts, revenue, or business done by domestic establishments (excludes foreign subsidiaries) within the scope of the economic census." Table #3 will show the financial value of the molded rubber industry in the US on 2007:

**Table 3 Value of the molded rubber industry in the US**

| Description | Establishments | Value of Shipments (x1000) | Value of Shipments % of US | Value of Shipments per Capita | Annual Payroll (x1000) | Paid Employees |
|---|---|---|---|---|---|---|
| United States | 784 | 8,662,810 | 100 | 29 | 1,345,920 | 35,121 |
| Ohio | 76 | 976,648 | 11.27 | 85 | 143,522 | 4,005 |
| California | 112 | 796,846 | 9.2 | 22 | 138,945 | 3,735 |
| Pennsylvania | 30 | 575,708 | 6.65 | 46 | 72,897 | 1,624 |
| Tennessee | 27 | 477,597 | 5.51 | 77 | 76,582 | 1,864 |
| Georgia | 31 | 419,361 | 4.84 | 44 | 71,793 | 1,970 |
| North Carolina | 25 | 377,862 | 4.36 | 42 | 56,617 | 1,471 |
| New Jersey | 20 | 223,868 | 2.58 | 26 | 50,298 | 1,160 |
| Illinois | 25 | 209,402 | 2.42 | 16 | 42,137 | 1,044 |
| Massachusetts | 23 | 186,031 | 2.15 | 29 | 44,421 | 983 |
| Texas | 46 | 180,226 | 2.08 | 8 | 42,935 | 1,430 |
| Indiana | 35 | 179,548 | 2.07 | 28 | 36,919 | 1,060 |
| Michigan | 25 | 174,768 | 2.02 | 17 | 41,328 | 991 |
| Alabama | 16 | 146,570 | 1.69 | 32 | 20,101 | 694 |
| Connecticut | 11 | 145,850 | 1.68 | 42 | 28,670 | 649 |
| Minnesota | 27 | 129,729 | 1.50 | 25 | 29,219 | 735 |
| Florida | 21 | 111,218 | 1.28 | 6 | 31,715 | 789 |
| West Virginia | 5 | 99,392 | 1.15 | 55 | 14,052 | 369 |
| Missouri | 16 | 89,340 | 1.03 | 15 | 18.936 | 544 |
| Oregon | 14 | 61,622 | 0.71 | 17 | 10,088 | 352 |
| Washington | 6 | 30,301 | 0.35 | 5 | 7,092 | 163 |
| Oklahoma | 10 | 14,640 | 0.17 | 5 | D | (100-249) |
| All other States (15) | 183 | 3,056,283 | 35.28 | D | 367,653 | 9,489 |

Source: United State Census Bureau Data elaboration by the Author, 2013

In the above chart, the molded rubber industry in USA is explained. By doing some simple calculations the mean revenue per establishment in USA is about 8 million dollars in 2007. In 2012 the total US revenue for molded rubber industry was of 18 billion dollars and number of businesses on the industry was on 1093 and there is no dominant company in the market, this means that the market share is well distributed (IBIS,2013).

The mean is around 16 million dollars of revenue per business. This can be confidently taken into account since the same report holds that the market is well distributed and there are no big leaders on the industry. US molded rubber industry is taken as an example because of the lack of official information about other countries in the region similar to Ecuador. Although the US is the biggest economy in the world, it has all the elements of a matured waste tire recycling system and a molded rubber industry which benefits from it. In Ecuador, this is not the case, where a molded rubber industry is almost inexistent.

### 2.2.3 West Australia Waste Tires Management Project

Ecuador is planning to implement legislation to build a waste tire management system similar to West Australian's current system.

The waste tire management project that the WA government wants to apply has three main elements. These elements are the people living in the area, the private owners of companies and the government agencies. Each one of these has specific duties in order to comply with the goal set which is the complete exploitation of wasted tire landfills.

The project initiated back in 2001 when the Environment Protection and Heritage Council or EPHC officially started to gather information of the wasted tire situation so proper policies could be applied. After much information gathering and study was made, the EPHC concluded that if the project was to be successful, the problem solving should spin over three main points.

First of all, tire commercial houses should retain by will the disposed tires that they get for changing tires to customers. They would retain the wasted tires because of a economic stimulus which will be paid by tire recycling companies.

Secondly, a small tax should be charged to the buyer of new tires in any fashion, importation, retail sale or manufacturing. The money collected from this tax will be invested in any activity that involves converting wasted tires into end of use products like moulded goods, rubber derivative fuels between others.

Third, a control system based in certificates and documentation so that the activity can be measured. This said, the Government and the private sector came to an agreement. A non profit organization was to be founded. This organization was going to be in charge of managing the program. The name of the non profit company is Producer Responsibility Organization or PRO. The company is funded by the tire tax. Private companies intending to become members of the organization will have to sign a pact in where the obligations of each stakeholder are specified. The headquarters of the organization is to be elected by the participants of the pact

PRO is going to be the vehicle from which the compensation and tax collection plan is going to flow. PRO is given the power to collect the taxes related to the commercialization of new tires. With the resources gathered from said tax, the organization is going to manage the compensations to different companies who do something positive with wasted tires. Companies which transform wasted tires to any other physical form will be eligible for compensation. Importers who manage to export wasted tires to other companies abroad that will use the tires for end of use products will be grant a reimbursement of the tire tax paid for importation of new tires.

The economic compensations given by the PRO to manufacturing companies which uses wasted tires as raw material is calculated in function of costs. PRO takes into account the costs involved in the manufacturing of their products. These include cost of classifying, cleaning and grounding tires. Other costs like administrative, maintenance and other non operating costs are not taken into account. Surprisingly costs involving logistics of accruing the wasted tires are neither taken into account.
.

Specifically, the elements eligible for such compensations are as follows:

Companies which primary manufactures end of use goods using wasted tires as raw materials. For example a rubber carpet manufacturer who pays to a tire recycling company the rubber crumbs it gets for grinding tires and uses them as raw material for the rubber carpet production is eligible for payments.

The tire crumbs producer will be eligible for payments if the company can prove that in fact wasted tires were used in the process and those tires do no longer exist.

Payments will be made to companies which uses whole wasted tires as energy. Larger payments in accordance to costs will be made to companies which uses as fuel wasted tires previously treated. This means that the rubber was separated from the metal parts and the fabrics, because burning rubber crumbs is less air polluting than burning whole tires. This encourages companies to use tires as energy as described rather than using whole tires.

Activities regarding construction: If a company is going to use wasted tires as construction materials, or for companies that use rubber crumbs as raw materials for any type of manufacturing. And, finally, any person or institution that promotes consciousness on tire recycling and environmental friendly culture.

### 2.2.4 Free Rider Regulation

Importing new tires is going to be prohibited. Only companies or persons subscribes in PRO will be able to manage any importation tire importation business. Regulations regarding penalization of fraud made to the PRO are made.

### 2.2.5 Passenger Tire producers in Australia

There are two big producers and importers of this tire type in Australia, South Pacific Tyres and Bridgestone Australia Limited. Southe Pacific Tyres not only produces tires but they import them. They are the biggest importers of tires in Australia. These companies use tire crumbs as raw material for the production of new tires, although the percentages in the formulation are really small since quality in tires is very important, can be a life or death matter.

### 2.2.6 Reuse of tires in West Australia

In 2005, only 20% of the passenger tires were retreaded in WA. Truck tires only were retreaded in average 100.000 tires annually. The government of Australia saw this not as a problem solution, but rather just as a prolongation of wasted tire dumping. Tires can be retreaded a specific amount of times depending on the type and the method of retreading.

Net statistics of tire destination in WA is: 49% of tires are buried, 34% are transformed, 5% are dumped and 3% are used for civil engineering like dock defenses (Matthews, 2005).

In WA there are companies which dedicates to the business of management of wasted tires. Companies like Tyre Waste WA that has the business of baling tires. Lately the company has been experiencing financial problems since it is expensive to go house to house recollecting tires in towns. The company tried to stay in the dumping area to get tires, yet the government had to step in to subsidize the company in order to keep it operating. Baling is extremely necessary on industrialized countries because their wasted tire generation is extensive and baling make tires much more easily to manipulate.

There are other companies like TyreCycle which have grown thanks to the systemized attention that the population and the government have paid to the tire problem. Here is a table showing information about tire recycling in Australia.

Australia can be an example of how can the governments and the private sector can ally to tackle one of the most difficult environmental problems on the planet which is wasted tires. Australia in a few years with the correct regulation for their scenario could manage to make important progress. Ecuador is already creating regulations that will help the creation of these businesses.

## 2.3 Theoretical Framework

### 2.3.1 History and use or rubber

Natural rubber can be defined as a polymer of isoprene atoms bonded by esther chains which forms a spiral molecular body. The Royal Spanish Academy (RAE in Spanish, n.d), which is the official institution which defines words in Spanish, defines rubber as: “Latex produced by several intertropical Euphorbiaceae and Moraceae that after coagulated, is a very elastic, waterproof mass, and has many applications in industry.”

The first document written about rubber was made by Prieto Martínez d’Anghiera in 1521. He mentioned in his writings a dark material which could be molded and was waterproof. Later other authors including Antonio de Herrera y Trodesillas mention an item used by natives in the Americas. The item was a dark play ball which natives obtained from trees substances. Grann wrote about the same material natives used where now a day is Honduras. The natives used it to make clothes, not just as balls.

The first scientific document regarding rubber was developed by Charles Marie de La Condamine, a French scientist sent by the French Crown to the Americas to study the equatorial line. The scientist traveled to what is now the Republic of Ecuador in 1735 where many samples got collected for French universities to study. One of those materials was rubber which the scientist described as a dark bouncy material that was used by the natives of Esmeraldas to make torches and clothing. La Condamine also noted that the tree from where the natives got the resin for rubber was also found in the Amazonas, where the natives called it “cahutchu”. These natives used rubber to make impermeable boats. With La Condamine’s work, Freneau discovered in French Guyana, the same trees which La Condamine described on his paper. Freneau defined the tree as “ Hevea Guyanensis”

This discovery gave the French science community interest in the subject, leading to a massive increase in scientific missions to tropical lands searching for materials alike. In 1765 Coffigny extracted similar resins from trees in Madagascar and in Assam, the scientist Whoxbourgh discovered the “Ficus Elastica”. In 1772 Priestley discovered that this resin could erase pencil from paper. This is when rubber got its name, because people started using it to "rub" the paper with it to clear pencil writings (Vidal, 1963).

Although the practical uses of rubber up until that point were limited. It wasn't until Mister Goodyear accidentally discovered vulcanization in 1839. Goodyear was on his lab when suddenly he dropped sulfur and rubber on a hot pan. The next day Goodyear saw that the rubber had different properties than normal rubber. Later he made more research and patented the discovery. Years later with this new method, the uses of rubber increased exponentially. So did the research for new formulas and processes (Vidal, 1963).

In early 20th century, rubber as raw material was tied to the supply provided by natives in tropical lands such as Central and South America, Brazil, Antilles and Africa. Thanks to Goodyear's discovery, the demand for natural rubber increased rapidly making the prices of raw natural rubber to soar. The British Empire had plans to fix this problem. The British Crown sent Mr. Hooker to Brazil with the mission to get seed samples from the *Hevea* tree. In those years, the Brazilian Government prohibited the exportation of *Hevea* seeds. Either way Hook managed to get samples with the consent of the Brazilian Government after several attempts. With these samples, the British Empire was able to build their own plantations in Asia, mainly in Malaysia.

Malaysia became so important in natural rubber production that today's quotation for natural rubber uses the acronym of SMR which stands for Standard Malaysian Rubber. The British Empire received a huge advantage over other countries in the matter of accessing to rubber. Thanks to this, the Brits formed a very important part on the further development of the rubber industry (Vidal, 1963).

**Table 4 Natural natural rubber consumption char**

| Years | Metric Tones (x1000) | Years | Metric Tons(x1000) |
|---|---|---|---|
| 1860 | 1 | 1941 | 1.594 |
| 1875 | 9 | 1944 | 1.020 |
| 1890 | 30.75 | 1945 | 1.055 |
| 1895 | 33.97 | 1946 | 835 |
| 1900 | 49.18 | 1947 | 942 |
| 1905 | 65.72 | 1948 | 1.110 |
| 1910 | 95 | 1949 | 1.437 |
| 1915 | 155 | 1950 | 1.670 |
| 1920 | 295 | 1951 | 1.495 |
| 1925 | 525 | 1955 | 2.930 |

| | | | |
|---|---|---|---|
| 1930 | 825 | 1956 | 3.000 |
| 1935 | 873 | 1957 | 3.160 |
| 1937 | 1135 | 1959 | 3.350 |
| 1940 | 1392 | 1960 | 3.515 |

Source: Tratado Moderno del Caucho (Vidal, 1963). Elaboration by the Author, 2013.

Natural rubber became indispensable for the world powers. Many objects were made by rubber in the 20's which were important for industrial progress. With the introduction of the rubber to the automotor industry in late 19$^{th}$ century and fully adopted in early 20's countries started to look for an alternative for natural rubber. Germany which didn't had an ease access to natural rubber discovered that a rubber like product could be made from petrol derivates. German government funded research projects on this matter. The German scientists discovered that they could emulsify styrene monomers and butadiene monomers into a styrene-butadiene copolymer. This discovery quickly brought the attention of the world. A lot of research started to increase the quality and the usage of this new synthetic rubber.

The United States in 1940 created The Rubber Reserve Company to stock pile natural rubber and to start research on Styrene Butadiene Rubber. In 1945 the US Styrene Butadiene Rubber production was 820,000 tons (Bayer,1970). From this point on, further investigation in synthetic rubbers continued resulting in the creation of hundreds of types of synthetics rubbers which exist in the present day, each one with unique features.

**Table 5 History of Natural and SB Rubber Consumption. (Approximate numbers).**

***(Years 2000 – 2012). X1000***

| Years | Natural Rubber | Styrene-Butadiene | Total Metric Tons |
|---|---|---|---|
| 1970 | 2990 | 5635 | 8625 |
| 1980 | 3760 | 8785 | 12545 |
| 1990 | 5165 | 9581 | 14746 |
| 2000 | 7378 | 10745 | 18123 |
| 2007 | 9719 | 13154 | 22873 |
| 2008 | 10175 | 12703 | 22878 |

| | | | |
|---|---|---|---|
| 2009 | 9330 | 12213 | 21543 |
| 2010 | 10806 | 14046 | 24852 |
| 2011 | 10981 | 14942 | 25932 |
| 2012 | 10942 | 14945 | 25869 |

Source: Malaysian Government, The Rubber Economist Ltd (2013), “Tratado Moderno de las Industrias del Caucho”, (1963). Elaboration by the Author.

#### 2.3.2Reclaimed Rubber

Soachin as stated in Vidal’s work (1963) defines reclaimed rubber as the result of treating vulcanized rubber with regeneration agents in conjunction with heat, oxygen and mechanical work resulting in a sulfur cross linking rupture. It can be formulated, manufactured and vulcanized as virgin rubber.

#### 2.3.3 Types of Rubber

Main types of rubbers (Vanderbilt, 1978):

Natural Rubber, Styrene – Butadiene Rubber, Synthetc Polyisoprene, Polybutadiene Rubbers, Butyl Rubber, Bromobutyl Rubber. Chlorobutyl Rubber. Neoprene Rubbers, Ethylene Propylene Rubbers. Acronitrile Rubbers, Polyacrylic Rubbers Silicone Elastomers.

Natural rubber is the material that comes from the trees, mainly the Hevea Brasiliensis. Synthetic rubbers are the ones which derive from oil refinement. Although natural rubber fits in only one category, there are many types and qualities in the category. The most widely used type is the SMR (Standard Malaysian Rubber).

Natural rubber is mainly made by refined latex. Latex is the substance that runs inside the rubber tree. Producers make incisions on the tree’s bark and tie a container at more or less the medium part of the tree so that the latex that comes out of the incisions fall into the container. More or so five hours after all the latex in the individual containers are purred on bigger containers. Formic acid is then added to the latex on the big containers and then left sit until the next day at PH5. The formic acid has a coagulating effect on the latex making it thicker and less liquid.

This coagulated latex is taken into mastication mills, after a day the latex is more thicken than before. This almost solid substance is grinded into tiny balls which are washed with water, this washed balls are deposited in rectangular baskets with even more tiny holes to drain the water off. The new rubber pellets are then pressed and heated with hot air to achieve complete dry in rectangular molds. The finished product is a rubber skim block of about 35 kg of natural rubber (Vanderbilt, 1978)

### 2.3.4 Tire Recycling Methods

Pirolisis Is a tire recycling method characterized for the effect of decomposing the tire material using extreme heat and pressure. Temperatures can reach up to 500 degrees Celsius. The material basically is introduced into a chamber where heat is build up via oil combustion, induced electricity or microwave while $CO_2$ is pumped in to create the pressure. After a period of time, the tire material is decomposed into three main components: Pirolisis Gas, Oil and Carbon (Wójtowicz, Serio, 1996).

The Pirolisis Gas conforms 10 to 30 percent of the process first yield. This is the result of the chemical unbinding of tire material caused by the extreme heat. In most cases these gases are composed by hydrogen, carbon dioxide, carbon monoxide, methane, ethane and butadiene. These gases can be processed with other elements to produce higher quality combustible gases like propene, propane and butane (Wójtowicz, Serio, 1996).

The oil is the result of the brake down of former tire components. Although this oil which comes from the result of pirolisis is somewhat of less quality than virgin oils, they can be still used as fuel. Also, these oils can be processes in ovens with hot air to be converted into industrial materials like black pigment for coloring.

Carbon is the residue of the majority of the solids of the wasted tire like the fabric and the rubber load components. This carbon has no use unless it is processed. The residual carbon is introduced on a chamber where by the decomposition of volatile molecules and activation from Carbon Monoxide, the material is activated molecularly. This product is called activated carbon black. Activated carbon black can be used on the production of new tires. The typical rubber compound for tire uses as much as 40 parts by weight per batch. Almost 40% of the total weight of the rubber compound is activated carbon black (Wójtowicz, Serio, 1996).

2.3.5 Ambient Temperature Method

There is the possibility to recycle wasted tires mechanically. The objective of this process is to tear apart the waste tires into small crumbs by using mechanical force. At the same time, the rubber crumbs will be separated from the fabric and metal residues.

2.3.6 Cryogenic Method.

The tires are introduced in chambers were temperatures as low as minus 80 degrees Celsius are reached. Liquid nitrogen is used to get these lows temperatures. The tires are then introduced in crushing mills depending on how small the particles are wanted (NASA Spinoff, 2011).

## 2.4 Legal Framework

Environmental Codification Law 2004.

Article 2.Environmental management is bind to principles of recycling and reuse of wastes, use of alternative technologies.

Chapter I Air Pollution Prevention, Article 2. It is considered air pollutant the act of burning of wastes in open space.

Chapter III: Prevention and Control of Soil Contamination. Article 14. Any juridical and natural person that uses wastes should be subjected to correspondent regulations.

Public Health Law 2006.
Second Book. Health and Environmental Safety

Ecuadorian Constitution (2008).

Article 14, The Government guarantees Ecuadorian citizens the right to live in a healthy environment. It is of the Government's interest to preserve ecosystems and any aspect of a clean environment.

Article 15, The Government will support any private or public environment preserving initiative.

Article 397. Environmental management policies will be applied for all juridical and natural persons in the territory including the State. This is the State's obligation.

Article 415, the Autonomous Decentralized Governments (GAD) will develop recycling projects for solid and liquid wastes.

Code of Territorial Organization, Autonomy and Decentralization. (2010)

Article 55. It is of exclusive competence of the Autonomous Decentralized Government to provide solid waste management.

Article 431.The the Autonomous Decentralized Government will establish pertinent regulation regarding waste management.

Article 137. The public service of waste management will be commanded by the Autonomous Decentralized Governments with its respective norms.

Acuerdo Ministerial No.20. Regulations regarding the Waste Tire Management Plan

## Chapter 3

### 3.1 Methodology

The methodology employed in this particular research is based on a descriptive research design. The research applies various combinations of a quasi-experimental research design methodology based on the tenets published by Campbell & Stanley (1963) but relies primarily on secondary data collection, illustration, survey, analysis and dissemination as delineated by Glass & Hopkins (1984); and which only contain one variable as exemplified and illustrated by the research of Borg & Gall (1989). The primary purpose of this research is to report and validate findings (Krathwohl, 1993) in order to develop the business proposition as postulated by the general objective of this study.

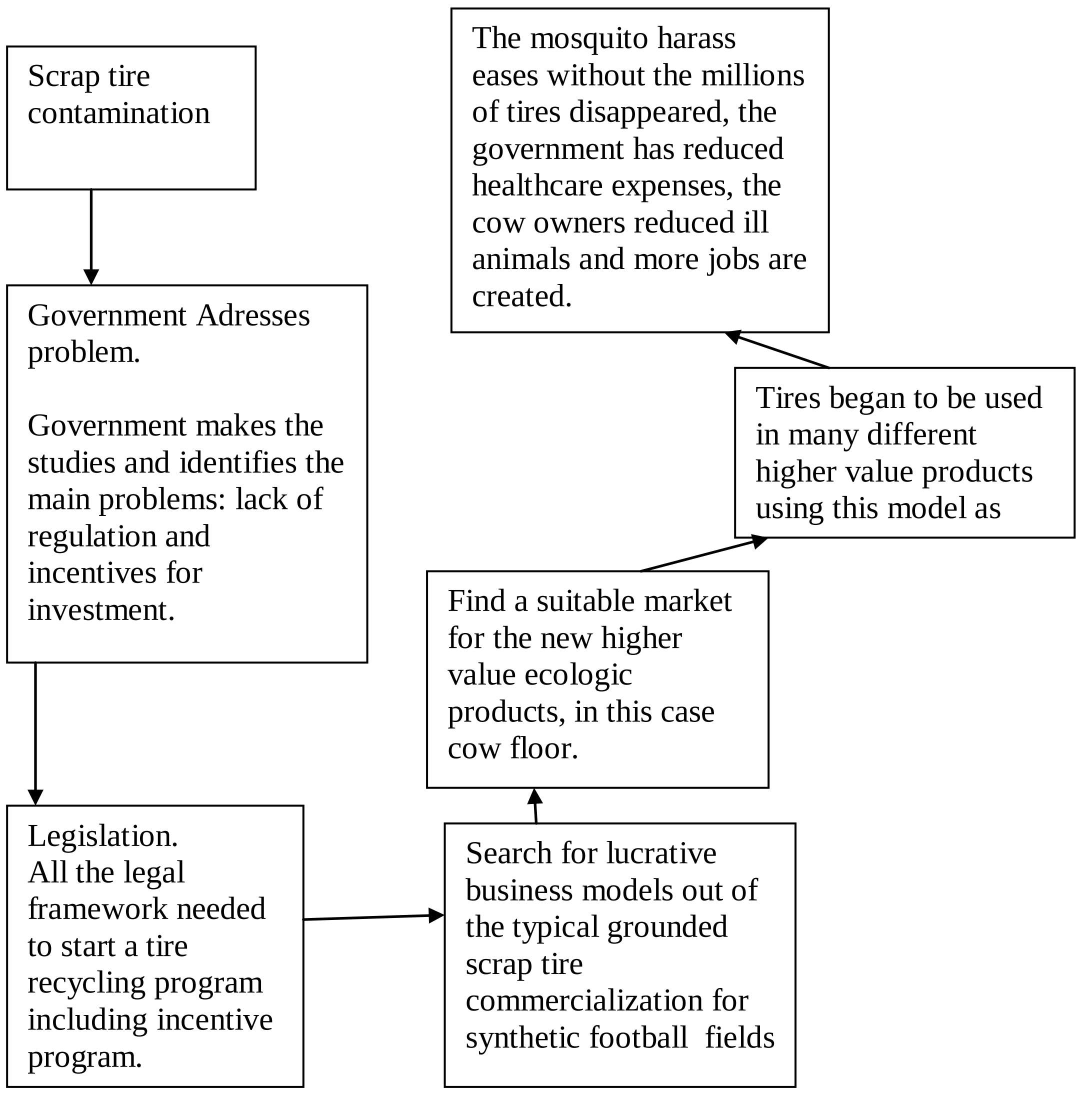
Secondary information is gleaned via texts, technical papers, and scientific experiments, regarding general rubber industry information on production process, trials over rubber quality, production process and recycling. Government and international organization statistics related to data, surveys and trials concerning environmental issues about tires, cattle care and cattle flooring impacts are also used in this study.

In order to analyze the main wasted tire disposal mechanisms used by existing tire retailers in Guayaquil (Specific Objective 1), the author performed visits to seven well known tire commercial stores in Guayaquil. The commercials are Antonio Pino Ycaza, Jackie Brobor, Julio Guerra Accini, Local Amazonas, Importadora Andina, Zeta Llantas.

The methodology has allowed for the analysis of the current Australian, US and Chinese production model of reclaimed tire manufacture and mold rubber industry (Specific Objective 2); the paper takes as an example the Australian waste tire recycling macro system. This means that details over which role has the private and the public sector on the recycling system, along with the regarding regulations and its impacts. The US molded rubber industry is considered for illustrative purposes on the structure of the molded rubber industry as a follow up of recycling the tires. The production model nevertheless is gathered from Chinese models based on efficiency with relative low machinery technology which binds perfectly with the Ecuadorian industry panorama.

Finally, in order to develop a proposal for logistical planning, storage and commercialization of reclaimed rubber product (Specific Objective 3) this research has taken into consideration previous and current practices developed and in use by ANIMAT, this is a Canadian company dedicated to the production of cattle flooring using recycled rubber as raw material for its products. Their targets are the cattle houses where cows suffer hoof lesions due to hardened surfaces. They propose multiple professional services regarding rubber flooring. The paper is going to take into account only the basic rubber flooring as initial product and have all the other services as future product expansion

### 3.2 Conceptual Framework.



## Chapter 4

### 4.1 Industry Description - Tire Shredding Industry

Tires are naturally difficult to manipulate and to store this is because of their circular build and form. Tires are bulky and are geometrically very difficult to stack. Tires are made to last and special care is taken into tire quality since any flaw can cause automobile accidents. Tires must resist extreme conditions, from abrasion resistance to incredible tear strength, and when a vehicle is rolling tires must support all the weight of the car, passengers and any other load against a much harder surface which is the road. When cars need to break suddenly, tires are required to hold all the pressure without bursting.

Normally, the structure of the tires remains in almost perfect state while the part which degrades with the mileage is the tread. When a tread is no longer safe to use which is indicated when the tread forms are erased, there's the possibility to reuse the tire. The old tread is burnished, basically eliminated from the whole tire, and then a primer is added with the cushion gum (Monsanto, 1967). The cushion gum is most of the times natural rubber diluted with solvents and with a really fast vulcanization system. After this, the new tread is placed on the tire and the retreaded tire is put into an autoclave for the tread fixing. When the retreaded tire comes out of the autoclave it is tested with lab machines which exert the tire to see if it is reliable.

The tire retreading process can be done several times, up to three or four times is safe. As the tire gets old, the tire starts to lose important structure features which permit it to be retreaded and safe. It's better to get a new tire rather than risking the tire failing and by consequence having a car accident.

Once the tire reached its end of life time, there's not much to do with it rather than throw it away but, that's well known for not being a viable solution for its environmental problems. For the reasons mentioned, a tire is extremely difficult to change physically. Although this structure only loses relevant strength for road use but in real terms, it is still a very strong structure which is difficult to break. The use of carbon black and steel as reinforces, give wasted tires that hardness when it comes to tear the tire or destroy it. Because of this, tires started to accumulate in all countries so the first non burning method of getting rid of tires was by mechanical shredding.

Mechanical shredding is basically using horse power on machines to shred the tire. There are hundreds of methods of doing so, at the end the result is the same, although some ways are better than other, the result is tire powder. When people started to inquire on the possibility to use the end of life tires, they understood that the tires as they are were not useful, so the classical recycling idea appeared. As any other traditional waste that value can be recovered like aluminum, paper, and plastic and so, the path of wasted tires was onto that way. Machines that could shred tires were created along with the separators to get the most pure possible tire crumbs. The rubber industry discovered that rubber crumbs could add a certain percentage of tire crumbs on their formulations to lower costs but, this degraded the final vulcanized rubber too much (Tripathy, Williams & Farris. 2004). Because of this, tire crumbs were used in very basic rubber formulas like shoe soles and bumpers.

When it was discovered that tire crumbs could be used as rubber compound aggregate, business interest was born for shredding tires.

### 4.2 Molded and extruded Rubber Industry

The molded rubber industry is a versatile industry. With the same machines a company can produce any molded rubber product with only requiring few changes in the production line. Among the common products in this industry are: shoe soles, rubber mats, gaskets, sealants, technical rubber parts for machines, bumpers, toppers, rollers. These can be applied on industrial machinery, auto parts, fishing industry, etc. For example, there can be a company which produces natural rubber gaskets, but a new market opportunity appeared for nitrile rubber gaskets. The company only needs to get new molds for the nitrile sealants and of course, the new raw materials. All other assets stay the same.

The company can also start producing chloroprene rubber products, the only requirements are new molds if needed and new raw materials for the formulation, all other assets stay the same. This is because the most part of the rubber added value comes in the form of formulas rather than in the shape of the product. For example, there can be three identically looking gasket, one is made of natural rubber, another one from chloroprene rubber and the last one from nitrile rubber.

The application of the gasket will be for attaching two tubes which will be submitted to oil and heat. If the owner applies the first gasket made of natural rubber, the item won’t work since natural rubber degrades quickly in presence of heat and oil or any of the two separately. The owner applies the second option which is a chloroprene rubber gasket, which won’t work either since it also degrades in oil and heat. The owner finally tries for the third option, the nitrile rubber gasket. This will work since nitrile rubber resists oil and heat.

This industry must not be confused with tire manufacturing industry which is completely different. Even though in the tire industry rubber is used and few machines are similar, its products require a completely different production process, scientific trials and knowhow (Vidal, 1963). For tire industry it is required unique machines which are investment heavy. These machines cannot be used to produce anything that is not related to the construction of a tire.

### 4.3 Ecuador’s Macroeconomical Overview

The opportunities for doing business in Ecuador started to grow exponentially after the Government of Correa took office. The Government since 2007 started a program to change Ecuador. This program included increasing government investment in the economy. Investments have been made in strategic sectors like clean energy, roads, hospitals, schools, etc. 2011 (Banco Central del Ecuador, 2012)

In Ecuador, the molded rubber industry is underdeveloped. Most of the consumption of rubber molded products is satisfied by imported supply. There is no registered company which manufactures and sells water pipe gaskets or rubber cow beds (Superintedencia de Compañias. 2013).

There are other companies in the molded rubber footwear products, the biggest being Plasticaucho Industrial. This company is located in Ambato, Tungurahua. They started operations in 1931.

#### 4.3.1 Sector Data

In Guayaquil there are no current tire recycling plants. Although, the nearest one is being built in Samborondon. The author visited the tire shredding plan (See Annex 16).

**Table 6 Approximate available tires in Ecuador**

| *Type* | *Quantity* | *Weight* | *Total* | *Rubber* | *Steel* | *Textile* |
|---|---|---|---|---|---|---|
| | *Units* | *Kg/Unit* | *Metric Ton* | *Metric Ton* | *Metric Ton* | *Metric Ton* |
| *Passenger* | *700,000* | *6* | *4,200* | *3,696* | *420* | *84* |
| *Light Truck* | *800,000* | *15* | *12,000* | *10,560* | *1,200* | *240* |
| *Truck* | *500,000* | *50* | *25,000* | *20,000* | *5,000* | *0* |
| TOTAL * | *2´000,000* | - | *41,200* | *34,256* | *6,660* | *324* |
| | | | | | | |

*Guayas Province disposes 35% of this total, mostly from Light Trucks (700.000 tires)
Source: Mipro 2012. Elaboration by the Author.

A construction company is currently venturing on the wasted tire shredding business. They are building the hangar in Samborondon – Ecuador. They bought from China a whole wasted tire shredding plant. The main components of this plant are the crusher and cracker. The other machines are complementary and are attached to the crusher and cracker.

The crusher and cracker are attached one another with transporting bands which have several metal separators using magnets and fabric separators using wind blowers. The wasted tires are feed into the crusher, metal teeth destroys the tires resulting on a batch of rubber large pieces, metal wires and fabrics. These materials are transported automatically through the bands to the cracker. The cracker is responsible of reducing the size of the crushed tire parts, the rubber pieces are now large crumbs which has about 2 cm of area.

The new crumbs pass through a series of magnets and blowers to separate them from metal and fabrics. The company is also acquiring a grinder which will reduce the 2 cm crumbs to 40-50 mesh powder. This powder is suitable to be used as raw material for other products.

This company is planning to use the 40-50 mesh to mix it with tar. As the company is a big contractor of the state to build roads in Ecuador and somewhat in Peru, they would use the powder for their own consumption. They are also planning to produce rubber bricks to use on their own constructions. They don't have plans to sell the finished products to the public but rather to use them on their main activity which is construction.

The plant is going to be installed on a 500 meter square space with three anti vibration floors where the crusher, cracker and grinder is going to be. They have their own generators in case of a blackout. They have a 300 meter square space to stock the wasted tires. The company won't have stocked finished product, all the powder which they get from tire shredding is going to be consumed immediately to produce the bricks or be used as aggregate for road tar. The author actually was part of the installation of the machines (see annex #15)

### 4.4 Competitive Analysis

There are no direct competitors rather than imported goods. Imported goods have several disadvantages. Importing goods require extensive paperwork and have high administrative costs. The rubber beds and the rubber gaskets both have thirty and fifteen percent ad valorem taxes respectively.

**Table 7** *Rubber coating and flooring.. Date 5/2012 – 5/2013* **Advalorem: 25%; FONDINA: 0,5% ; IVA: 12%**

| Subheading Nandina | Description | Tones | FOB DOLAR | CIF DOLAR |
|---|---|---|---|---|
| 4016930000 | Rubber Gaskets and sealers. | 338.35 | 1,064.08 | 1,192.17 |
| Total. | | **338.35** | **1,064.08** | **1,192.17** |

Source Central Bank of Ecuador, 2013. Elaboration by the Author

From April 2012 to April 2013 the country imported 338.35 tons of rubber coatings at a mean price of $3.5 per kilogram. These coatings and flooring are not necessarily used as cow bedding. These represent the total rubber from coating and flooring category and most important it is the price. At $3.5 per kilogram it's unlikely to be cow flooring.

**Table 8***, Rubber Gaskets. Date 9/2011 – 9/2012* **Advalorem:15%**

| Subheading Nandina | Description | Tones | FOB DOLAR | CIF DOLAR |
|---|---|---|---|---|
| 4016930000 | Gaskets. | 1,455.18 | 15,490.20 | 16,787.02 |
| Total. | | **1,455.18** | **15,490.20** | **16,787.02** |

Source: Central Bank of Ecuador, 2013

As seen in Table XX, the total imported rubber gaskets one year ago to date its 1,455 tones. The mean price per kilogram is $11,5. Although the total tons imported represents every type of rubber gasket, from small nitrile rubber sealants for milk pipes to huge natural rubber gaskets for cement water pipes. Sixteen million dollar non competitive market is attractive.

### 4.5 Technical Advantage and Filler Efficiency

The companies that adopt this recycling model will have as main advantage the possibility of producing general usage rubber items at low cost. Because of the Government policies on supporting recycling and ecological projects and the supply of raw materials in form of wasted tires, the job of transforming wasted tires into end life products will be much easier (Ministerio de Ambiente, 2013).

The usage of devulcanized rubber powder as main raw material permits the manufacturing of highly loaded products without sacrificing much quality.

As stated in the Vanderbilt filler guide (N.d). Fillers may reinforce the tear strength of the vulcanized rubber, fillers may not have any tear strength effect or fillers may degrade the tear strength of the vulcanized rubber. Any other production process which greatly lowers the cost of rubber products that doesn't use rubber crumbs will include the following non black fillers, Calcium Carbonate or Kaolin Clay which are the most commonly used. For every one hundred parts of rubber, usually the compound will have fifty or more parts of filler per weight of rubber In filler science, there are four main factors which dictate the quality of filler and its purpose. There is particle size, particle surface area, particle shape and particle surface activity. Although these four factors also determine the compatibility of the fillers to other types of synthetic rubber, for natural rubber, all fillers bind effectively.

Particle size, it's the actual Nm measure of the filler particle. The smaller the particle the more reinforcing it is. This is because more particles can get in between the rubber matrix chains. These particles in between the matrix chains dissipate stressing energy, making the rubber more resistant to tear or break. The opposite happens when the filler particle is bigger than the interchanged rubber matrix particles; it actually creates additional stress, contributing in a faster tearing or braking.

The particle surface area, the bigger the better reinforcement qualities will have. This is because in order to the filler to reinforce the structure of the rubber matrix, it must make deep contact with the particle surface, the more surface there is to make contact, the more attach power it will have.

Particle shape, it's the physical form of the particle. The higher the aspect ratio, the better. Round, circular, square or blocky in shape particles will have a low aspect ratio, platy and needle shape particles will have a higher aspect ratio. Precipitated Silica and carbon black are structures of particles which have a complex construction, making them efficient reinforces.

Surface activity is the polarity of the particles regarding the rubber matrix. The higher the polarity in the particle, the more it will chemically bind to the rubber matrix. Carbon blacks have carboxyl, lactone and quinone which are organic structures that bind perfectly with rubber matrixes. Carbon blacks also have high surface area, small particle size and complex particle shape resulting in the most efficient reinforce. Naturally, non carbon black fillers are not as effective as carbon blacks, but the precipitated silica have its own silanols which binds with rubber matrix.

The nature of rubber fillers is that the more reinforcement properties it has, the higher it will be its cost (Vanderbilt, N.d). This relates to the technical competitive advantage that the company will have since for any other company that uses non black fillers will have to degrade the rubber in order to compete in price, but if the quality is degraded enough, then the company's products will have a quality advantage.

Other manufacturing processes regarding the production of low cost natural rubber products without devulcanized tire crumbs will result in a low cost, low quality product. For example if calcium carbonate is used to reduce cost of the natural rubber product, it will suffer more mpa reduction than a natural rubber product manufactured with devulcanized rubber crumb as filler for reducing cost. The same goes if clay is used as cost reduction filler, the quality properties will drop lower than a devulcanized rubber crumb filled product.

### 4.6 Production Process Advantage

In rubber compounding, each element that is mixed with the rubber matrix has a function in order to give the vulcanized finished product required properties. Companies that produce rubber compounds have to mix in at least six to seven different components. These components are: the rubber, the reinforcing filler, the diluting filler (optional), stearic acid, zinc oxide, accelerant and sulfur. This is the most basic list of components that a rubber compound must have in modern industry. There are thousands of other components that can be added depending in the use, quality, properties that need to be achieved. In an open mixer of thirty five kilograms capacity, the mean time of mixing of the said compound will be at least 25 minutes. On an internal mixes (Banbury) mixing times are reduced to ten minutes with additional five minutes of adding the vulcanization system either in the internal mixer as well or on an open mixer.

This type of rubber compound production process is exposed to many threatening flaws. Rubber compounding is sensitive to ingredient proportions, this means, that if the person in charge of weighting the ingredients for the rubber compound makes a mistake on any of elements, the full batch will have to be discarded since the properties of the rubber will be changed and will not be homogenous regarding other products of the same line.

Traditional rubber compounding companies must be constantly testing the ingredients for the following reason. Rubber compounding ingredients can vary process properties within one brand and another. For example, a company uses Bayer's zinc oxide for the shoe hill production line. The company imports the zinc oxide directly from Germany but that week's shipment was delayed for any reason. Bayer's zinc oxide runs out of stock but is quickly resupplied with Xhing Xao's zinc oxide purchased in the local chemical wholesaler. The production plant was using three Bayer's zinc oxide phr in the shoe hill formula, so now the weighting employee applies the same amount of zinc oxide but this time is from Xhing Xao, the shoe hills started to come out with the center not vulcanized. This is the classical error which traditional rubber compound companies fall into. In the previous example, it resulted that Xhing Xao's zinc oxide was less concentrate, resulting in a softer accelerant activation making the shoe hill to come out of the mold crude. This is why companies have to be careful when replacing brands.

The proposed company that uses recycled tires does not have to engage in having this kind of problems. The core of the vulcanization system will be given by the tires.

### 4.7 Market Advantage

The first to enter the market as a manufacturer of these items will have open door to exploit the market before other competitors start to enter. Most importantly, the Government is offering different benefits to companies which use Made in Ecuador supplies. As potential suppliers for the government, the company will have the positive factor of producing in Ecuadorian territory which is directly preferred by the government and will be in taken in priority against imported goods which is the actually competition.

Other companies in the bovine industry might as well prefer made in Ecuador products for their cow mats since the milk producers can be government suppliers as well. Construction companies might find buying recycled Ecuadorian rubber gaskets a good deal since the government is the biggest construction concessioner in the industry.

Porter's five forces analysis is required for any business investing decision. Stoner (1996) points out that Porter's five forces model is essential for a competitive advantage analysis of a company on a specific industry.

### 4.8 Porter's (1979) Five forces Industrial Analysis

Professor Porter from Harvard Business School, stated that there are five main forces that determines the competitive environment of a certain industry or company, these are:

Threats of new entrants. Refers to the possibility or how easy is for other competitors to enter the market. Between the variables regarding this possibility are how quick can they acquire capital, government policies (anti monopoly regulations), nature of the industry, how complex is the products and the learning curve of the industry. This would be beneficial for the country since the market holds enough space for more industries.

Bargaining power of suppliers. This force defines how much influence the suppliers can have with the company in question. For example, how many suppliers are in the market who can satisfy the company's needs. If there are few suppliers of a certain raw material, it is more probable that they get better deals out of their customers, making the life of the company in question a lot harder. On the other hand, if there are many possible suppliers for the raw materials needed, they will compete for better deals and the company in question will have a much more advantageous position. Eigty percent of the raw materials the company will need are going to be guaranteed by the government so that’s an advantage for the company.

.

Bargaining power of customers. It is understood that many times the customer is always right, but that there are certain times where the lack of customer variety give them an overpowered decision making and that might affect negatively the company in question. For example, there are industries which are exclusively dedicated to one customer. That customer has the power to set the price. For example, in Ecuador, if a company offers PetroEcuador supplies exclusively for oil industry, PetroEcuador will have a negotiation power over the supplier, since PetroEcuador is the only customer. The customers would see the final product as a necessity to catch up between the company of their industry rather than an option. Up until more companies enter the same market as the proposed one, the product should be well positioned.

Substitution Risk. This refers as how elastic is the product that the company in question is going to sell. How easy is it replaced by the market. For example on the soda industry, products can be replaced because of price changes. If soda becomes increases in price, the market may switch to consuming juice. On more complex industries, the possibility for a substitution is much more unlikely. For example a company that manufactures satellites, if prices rises, customers may not find a substitution for satellites. Although substitutions not only are for prices but also can happen for fashion changes. For example, people can replace subscriptions to traditional gyms over crossfit gyms because of momentary trending.  Well documented data concludes that the next cheaper option for cow flooring from rubber is concrete, but concrete damages the hoof of the cows, so rubber is a logical option to stay.

Rivalry of the competitors. Analyses in what degree is the market distributed. There might saturate markets, for example the snack industry. There can be are over supply of snack products from different brands fighting to gain customers. This situation might cause profit margins to naturally go down. But there are also other markets like oil industry where there is always an over demand and the fighting is more directed to find oil rather than to sell it. On the proposed business model it would be low, since the market is big enough to have and the supply so underdeveloped that attractive margins can be sustained long.

## 4.8 Potential Customers

The main commercial transactions of the molded rubber industry are made via business to business. The molded rubber manufacturers have as clients other businesses rather than individual consumers. This is because the products are used mainly as replaceable parts for other industries. Between these industries there's the construction industry, soft drinks and milk products manufacturers, agricultural farms, fishing industry, automobile industry. For this project, the company will focus on the construction sector and agricultural farms industries as base potential clients.

These two sectors were chosen because in Ecuador, the government has increased by several billions the construction expenditure and there's a plan to increase four times the access to water for irrigation and the construction of sewers to reduce floods. The government has 16 projects to be finished by 2016 and the total investment is estimated at 2.1 billion dollars (Senagua.2013).

The government is planning on giving concession the construction of the majority of the project. These projects are important to the molded rubber industry since the tubing system requires lots of rubber gaskets, support flooring, among other products. The most important product is the rubber gasket. Every concrete construction that requires assembly needs the support of rubber. The concrete water pipes are no different. Every joint in a concrete pipe needs a rubber gasket to seal the joint.

Traditionally these rubber gaskets were shipped from Colombia or any other country, there are few craftmen who provide certain quantity of these gaskets, but companies don't like too much to buy from them since there aren't any guarantees and normally, the quality of the gaskets barely meats the standards (Citation needed).

. The main potential market for recycled waste tire based products is cow farms, there are several benefits for cow health regarding using rubber mat floor. Lameness in cows reduces significantly the production of milk. The reasons can vary from many sources. Many studies affirms it, Coulon as cited in Warnick, Janssen, Guard & Grohn (2001) study concluded that many of the cows suffering from lameness had decreased production up to 440 kg. Enting as cited in Warnick, Janssen, Guard & Grohn (2001) study affirmed that lame cows produced 3 kg approximately less of milk daily. Lameness in cows are produced by many factors but one part of the cow is the greatest causer of lameness when damaged, the hoof.

Clarkson et al; Green et al; Warnick et al, as cited in Telezheko's work (2007) and Clarkson, as cited in Mulling & Greenhough work (2006) states that hoof damage is the main cause of lameness in cows. Hoof damage can result from almost any situation similar to what can happen to any farm animal, although one element in the cow's environment can passively significantly increase the risk of a cow suffering hoof damage leading to lameness Blowey. 2005, Telezhenko et al., 2009 this element is flooring.

Floor material plays a very important roll on how highly is the cow's propensity to hoof injury. Telezhenko et al. as cited in Norberg's work (2012) states that many modern cow stalls have adopted cement flooring but cows seem to prefer rubber covered floors over cement because of reduced impact in limbs.

There are several studies that conclude that rubber flooring is beneficial for cows hoof health for example Britt et al. on Norberg's work (2012) concluded that rubber flooring increased the steps made by cows daily, decreased the slippery of the floor and increased step confidence of cows over concrete floor.

All this useful information should be use to inform the cattle owners around the country. The Ministry of Environment and the Ministry of Industrialization and Productivity can work together in conjunction with the companies recycling waste tires to introduce the floor mats to the cattle owners. This will benefit the cattle owners having less ill animals, the Ecuadorian Government will save resources helping less ill animals from cattle farmers and the public will enjoy less contamination, all at the same time.

As for Ecuador, there were approximately five point three million cows in 2012. A cow's cubicle is recommended to be 1.20 meters wide and 2. 30 meters long (EFSA, 2009). This means a assumed space of 2,76 square meters for each cow cubicle, The British Standard 5502 as cited in DairyCo technical information recommends a space of 3 square meters for each cow for lying areas. If Manabi is taken as the target market, there were 982.833 cows reported in 2012 (INEC). This is 18% of the total cows in Ecuador and if the company targets the ten percent of said market which is 98.283 cows which is the 1,8% of the total cows in Ecuador, which would need 98.283 x 3 = 294.948 square meters of rubber mats. Each square meter weights 15 kilograms so for the business 294.948 x 15 is 4,4 million kilograms, the maximum capacity of the factory is approximately 691,2 thousand kilograms of finished product annually (see production process section). The company would need 6,3 years of maximum capacity commercialization to meet the 1.8% of the Ecuadorian cattle market. For this reason, concrete water gaskets or any other product can be adopted any time further.

**4.9 Operations Plan**

The product is a 1x1 cow floor rubber mat of 13 mm of thickness. It requires no skill to install, The mats have to be laid on the concrete floor and can be cut in any form necessary. The MPA value of the rubber would be ranging from 8 to 10. The expected lifespan of the floor is six years.

4.10 Provisioning/Supply Plan.

The waste tires are provided by the government which collects the tires that are impossible to retread. This is connected to the retreading norm driven from Ministerio de Ambiente where all the state's vehicles will have to retread the tires until it cannot be retreaded more times. Tire importers and producers will have the obligation to collect and dispose to natural or juridical person that uses any tire recycling method which must be approved by the Government. Guayas generates more than three hundred thousand tires annually; the production model proposed will approximately consume thirty thousand tires annually. This will provide a steady and safe supply of tires to be used as raw material (Mipro, 2012).

The natural rubber is going to be supplied by the local producers from Santo Domingo, an example of a company which produces natural rubber is IMSSA, they have enough capacity to supply all year long. Other possible supplier is Erco tires plantations and natural rubber processing installation.

The accelerants and activators can be supplied by the local wholesalers since the volumes of utilization are relatively low. The local wholesalers are Resiquim, Solvesa. These are companies which whole sale industrial raw materials, they have warehouses in Guayaquil.

The products sold can be transported in any of the four trucks the company would acquire. The company will acquire the Hino City 512 which is a truck that has 3.6 ton cargo capacity. This is suitable for the company selling and distribution objectives since the maximum production of the company are 2.88 tons. The other two trucks can go through the city collecting the tires required to supply the factory. The factory will require around 307 light truck tires which weight 4660 kgs but only 60% of it is rubber so roughly will represent 2764 kgs of rubber supplied daily. That tentative represents only the 16% of the waste tires produced daily by Guayaquil (Mipro, 2012)

As the installation of the product in the cow farms doesn't need any skill, the distribution team can unload the cargo and then go for all the other clients. This is in the case that the client doesn't have any way of transporting the products but is expected that clients for the product being sold count with transportation means like trucks. If not, the company can transport the products but a cost.

## 4.11 Machinery Required.

4.11.1 Tire grinding plant.
- Dismantling line.

**Figure 1 Loop cutter, cuts the tire in order to take away the bead wires**

Source: Baichuan International Co. Ltd

**Figure 2 Loop press: takes the bead wires away. (Figure # 2)**

Source: Baichuan International Co. Ltd

**Figure 3 Bar cutter: cut the tire into bars. (Figure # 3)**

Source: Baichuan International Co. Ltd

**Figure 4 Block cut the rubber bar into blocks. (Figure # 4)**

Source: Baichuan International Co. Ltd

4.11.2 Tire grounding line.

**Table 9 Cracker line**

**Figures 5 Cracker Line**

| | | | |
|---|---|---|---|
| 5 |  | TRE-1012 Double –roller cracker (Grind the rubber lump into rubber powder 20-30mesh) | 1 |
| 6 |  | Assembly units of TRE-1012 Double –roller cracker (including Linear Vibrating sieve, Magnetic metal remover, Antiskid conveyor,) | 1 |
| 7 |  | Exhaust fan | 8 |

| | | | |
|---|---|---|---|
| 8 |  | Feed material collector | 4 |
| 9 |  | TRE-1019 Rubber fine grinder (Grind the 20-30mesh rubber powder into fine rubber powder) | 4 |
| 10 |  | TRE-1022-2 Linear Vibrating sieve (separate the rubber size) | |

| | | | |
|---|---|---|---|
| 11 |  | MC-1000 Dust collector （Including Dust-collect pipe system） (Collecting dust) | |
| 12 | <br> | Conveying pipeline | |
| 13 |  | Electric control system | |

Source: Quingdao Eenor Rubber Machinery Co.
Elaboration: Quingdao Eenor Rubber Machinery Co

4.11.3 Rubber Reclaiming Plant.

**Figure 6 Rubber reclaiming machine.**

Source: Heibei Gold Bangzi Boilers Co. Ltds

**Table 10 Technical properties**

| Content | Parameters |
|---|---|
| Designed Pressure | 2.1 Mpa |
| Working Pressure | 1.8 Mpa |
| Designed Heat | 217 °C |
| Working Heat | 212 °C |
| Active Volume | 6 cm3 |
| Rotate Speed of Blender | 15r/m |
| Jacket Volume | 1.6 m3 |
| Designed Pressure of Jacket | 0.1 Mpa |
| Working Pressure of Jacket | Normal Pressure |
| Jacket Designed Temperature | 300°C |
| Jacket Working Temperature | <300°C |
| Heating Method | Heating Conduction Oil |
| Heat Exchange Area | 15.4 m2 |
| Motor Power | 18.5 Kw |

Elaboration: Author.
Source: Heibei Gold Bangzi Boilers Co. Ltds

**Figure 7 Therman Oil Boiler**

Source: Yangzhou Chenguang Special Equipment Co.,Ltd

Moulded Rubber Area.

**Figure 8 Large rubber mixer.**

Source: Wuxi Jufenglong International Trade Co., Ltd.

**Figure 9 Vulcanization Press 1.30 x 1.20 500 tons.**

### 4.12 Production Process

The production process is taken from the Chinese company “Beijing Oriental Dragon Company”, process which is also described in Vidal’s work (1961). The science behind the process has been studied more than fifty years ago, but today’s machinery and government incentives have made this process viable. The business model is inspired by the company Animat from Canada.

The production involves four main processes. The first one is the conversion of whole waste tires into useable tire powder, the second is to devulcanize the tire powder, the third is to mix the devulcanized powder with virgin natural rubber and the fourth is to vulcanize the rubber compound into the final products.

Step one.

**Table 11Shredding Capacity.**

| **Powder Production** | |
|---|---|
| Hours per shift | kg powder per hour |
| 8 | 300 |
| Total kg/d | 2400 |

Source: Quingdao Eonor Rubber Machinery (2012)

Tires are stored as raw materials in an individual storage room. Every day the tires that are going to be converted are taken out from the tire storage room and are put into the shredding plant.

The first step is to use the loop separator; this machine detaches the sidewall from the tread. Next, the sidewall is taken to the bead wire separator which cuts away the reinforcing steel wire at the edge of the sidewall. The tread is then taken to the strip cutter which transforms the tread into multiple rubber strips. The rubber strips are passed through the block cutter, this machine converts the tread strips into 1-2 inch rubber blocks.

Finally, the blocks are taken to the cracker, which will reduce the blocks to 20 – 30 mesh rubber powder, while the fabrics and steel is separated from the rubber using magnets and air. Once the 20 - 30 mesh powder is collected, it goes to the four pulverizers.

**Table 12 Powder Production.**

| **Powder Production** | |
|---|---|
| Hours per shift | kg powder per hour |
| 8 | 300 |
| Total kg/d | 2400 |

These machines reduces the powder particle size from 10 - 30 to 40 – 60 mesh and some percentage to 80-10- mesh. This is the powder needed to keep with the production process.

Step two, rubber powder devulcanization.

**Table 13** Devulcanization capacity

| **Powder devulcanization (4 hours 600 kg batches for each machine)** | | |
|---|---|---|
| Hours | Batches | |
| | 8 | 1200 |
| | 8 | 1200 |
| Total kg/d | | 2400 |

Source: Heibei Gold Bangzi Boilers (2012)

The 40-60 mesh powder and the reclaiming agents are introduced in the two reclaiming machines, the reclaiming agent should be five parts per weight. The machine must be at 200 °C using hot oil heat from the oil boiler. When the jacket is closed, air pressure is applied, using approximately 1.8 Mpa in order to reclaim the rubber. While the heat and pressure plasticizes the rubber, the reclaiming machine also mixes the reclaiming agent in the whole 4 hour process to get homogenous results. After four hours, the discharge jacket opens and the reclaimed rubber is taken out of the reclaiming machine.

Step three, using the reclaimed rubber as compound material.

**Table 14 Mixing Capacity.**

| **Banbury mixing** | | |
|---|---|---|
| Mixes per hour | Minutes/hour | Time/mix |
| 15 | 60 | 4 |
| Banbury Capacity | Shift Hours | killograms mixed per hour |
| 24 | 8 | 360 |
| killograms mixed per shift | | |
| 2880 | | |

Elaboration by the Author.

The reclaimed rubber is left to cool down. The person in charge of preparing the rubber compound, weights the following formulation, 100 parts of reclaimed rubber, 20 parts of virgin natural rubber, 0.1 parts of zinc oxide and stearic acid, 0.08 parts of MBTS and DPG, 1 part of antioxidant and 0.05 parts of sulfur. This is the base formula that will work for either producing rubber gaskets or cow mats. For a 25 kg rubber compound, following said formula, these will be the quantities.

**Table 15** Base formula for rubber mats***.***

| Quantity Required: **24kg** | | |
|---|---|---|
| Elements | PPW | KGs |
| Reclaimed | 100 | 19.86 |
| NR | 20 | 3,97 |
| Stearic Acid | 0,10 | 0,02 |
| Zinc Oxide | 0,10 | 0,02 |
| Antioxidant | 0,50 | 0,10 |
| MBTS | 0,05 | 0,01 |
| DPG | 0,05 | 0,01 |
| Sulfur | 0,05 | 0,01 |
| Total | **120,85** | **24 kg** |

Elaboration: Author.
Source: Comercio General e Industrias.

To mix the formula, the operator introduces the above materials at the same time in the Banbury mixer and sets the mixing time to four minutes. In those four minutes, the operator should be weighting the next 24 kg batch. As soon as the timer hits, the operator opens the discharge door and loads the mix in a railroad cart and loads the Banbury with the new batch once more time. The mill operator drives the loaded cart to the mill and places the batch in. The mill operator laminates the mix to a rubber sheet of 2 cm width. The rubber sheets are taken to the hydraulic press station.

Step four, rubber compound vulcanization.

**Table 16 vulcanization capacity.**

| **Vulcanization Press** | **Detail** |
|---|---|
| Slots | 4 |
| Vulcanization time in minutes | 10 |
| Vulcanization per hour | 6 |
| Kgs per vulcanized mat | 15 |
| Kgs per vulcanization cicle (4 slots) | 60 |
| Kgs vulcanized per hour | 360 |
| Kgs in 8 hour shift. | **2880** |

Elaboration: author

The next step is vulcanizing the mix of virgin rubber with accelerated reclaim rubber with the desired form. In this case, the moulds of the desired production must be placed in the vulcanizing press slots. The working temperature of the molds must be around 140°C to 150°C, the heat can be obtained either with hot oil or electric resistance. While the vulcanizing press is heated, the operator must arrange the form of the compound and have it weight in with the objective of accurate mold production.

Once the molds are ready, the operator puts the pieces of rubber compound inside the molds and then the operator press the up button. This will make the press to automatically to perform vertical upward 450 ton pressure to all the six press slots with the loaded molds. The vulcanizing process lasts around five minutes. After the time is done, the press slots automatically go back to the starting position and the operator opens the molds and takes away the vulcanized finished product. Between the four vulcanizing minutes, the operator stets ready the next four units of compound to load the molds. The whole loading, vulcanizing, unloading and reloading takes ten minutes approximately.

Step five

A vulcanized finished product unit of each 50 kg rubber compound batch is taken to the lab to be tested. The vulcanized products are submitted to tensile strength tests. The approved vulcanized finished products are packed and stored.

**Company Organizational Structure**

A one-product rubber company hierarchy can be organized department based (Stoner, Freeman and Gilbert, 1999). In this case, basically the company would account with a general management department, a sales department, financial department, human resources department and production department.

The General Management Department is the head of the organization; it's the responsible of processing the information that inputs all the other departments. The processing of said information means that the department has to use it to plan and execute work tasks of short, medium and long term. In order to achieve this, the GMD has to apply communicational strategies like daily meetings and instant communication channels like telephones, skype, celphones, mail and when needed, person to person communication by physically traveling to speak up any message.

The Financial Department is going to be responsible of all the economical aspects of the company. The department must generate all the financial data related to the company. As well is in charge of managing all the legal obligations regarding declaration of taxes, management of IEES resources outputs and all other aspects. The department is also responsible for generating financial projections and research possible future commodity price changes to provide economic previsions.

The Human Resources Department is in charge of meeting any inquietude that any employee might have. The department is in charge of providing employees all the elements that the Ecuadorian Law states, including scheduling vacations, managing extra hours. As well as managing the enforcing of the company code that must be developed by this department as well for the correct functioning of the company. The department is also in charge of the hiring of employees and the management of possible firing, always in concur with the Ecuadorian Law.

The Sales Department is the responsible of all matters regarding the commercialization of the company's product. The department must generate strategies to capture as much of the target market as quickly as possible before other competitors arise. The sales department must be in synchronization with the Finance Department because the daily input of sales must be registered and processed. The Sales Department also is responsible for any marketing strategy or technique potentially used. With this, the department will also be ahead on delivering the finished products to clients and will attend any customer’s doubts, questions, and all which has to do with post sale service.

The Production Department will be in charge of all the process required to convert waste tires into the finished product. For this to happen, the production department must generate the daily raw material requirements and as well give feedback to the General Management Department regarding the possibilities on potential production milestones. The department will also be responsible for the safety and wellness of all the plant workers regarding the Ecuadorian Law and to be in order with all the relevant governmental authorities such as the firefighters, environmental agencies and other safety supervision agencies.

## 4.13 Human Resources

The company was planned to be composed by 41 employees, 15 of them in plant and 26 in the administrative area. The company has the lowest personal in plant because the machinery can function with mid relative low hand labor. The reason why the majority of the personal is in the administrative area is because of the sales department.
All hiring must be in concordance with the Labor Law of Ecuador, including the 4% hiring of handicapped employees for companies above 22 employees (Ecuadorian State. 2013).

The hiring of direct labor in the production plant should all have minimum high school degree and have metal mechanics knowledge. The Plant supervisors should have college degree at least. This is because the company will rely in having higher quality personal over cheap labor. Table #xx Shows the legal minimum wage for industrial sector on tires and other rubber made industries.

**Table 17 Sector Minimum Wage for Tire and other rubber made industries.**

| Job | Minimum Sectorial Wage |
|---|---|
| Superintendent | 339,72 |
| Plant Chief | 339,72 |
| Industrial Safety Chief | 337,02 |
| Maintenance Chief | 334,32 |
| Production Area Chief | 331,61 |

| | |
|---|---|
| Inspector, Supervisor, Advisor | 330,21 |
| Technical Analyst | 329,99 |
| Machine Operator | 326,72 |
| Machine Supporter | 322,33 |
| Lubricator | 322,33 |
| Specific Sector Production Worker | 318,89 |

Source: Ministry of Labor Relations. Elaboration by the Author, 2013.

As seen on the project's financials, all employees will have salaries above of what the law states as minimum wages for each specific job in the Industrial Sector ( Ministry of Labor Relations, 2013).

4.14 Projected Financial Data

**Table 18 Direct Labor Cost Detail.**

| **Plant Direct Labor** | | |
|---|---|---|
| Shredding | | |
| Job | Quantity | Salaries |
| cortadora de lado | 1 | 450 |
| peladora del rin | 1 | 450 |
| cortadora de rodadura | 1 | 450 |
| cortadora de bloques | 1 | 450 |
| cracker | 1 | 450 |
| patinador | 1 | 450 |
| grinding machines | 1 | 450 |
| total | 7 | 3150 |
| Devulcanizing | | |
| Job | Quantity | Salaries |
| autoclaves | 1 | 450 |
| total | 1 | 450 |
| Mixing | | |
| Job | Quantity | Salaries |
| Banbury | 1 | 450 |

| | | |
|---|---|---|
| Mill | 1 | 450 |
| total | 2 | 900 |
| | | |
| Vulcanizing | | |
| Job | Quantity | Salaries |
| Hydraulic Press Operator | 1 | 450 |
| total | 1 | 450 |
| | | |
| **Total Plant Direct Labor** | **11** | **4950** |

These are the direct operations needed to transform the waste tires into rubber mats. Each station is detailed with the number of operators and roles.

The salaries displayed are superior for the ones stated by the law as minimum wages for the industrial sector. This is because a rubber company should always target for higher quality personal over cheaper labor (See human resources section).

Direct materials

**Table 19 Cost of raw materials in formula**

| | Parts per polymer weight | Dolars/ Kilogram | Dolars per part |
|---|---|---|---|
| Reclaimed | 100,00 | 0,56 | 56 |
| NR | 20,00 | 4 | 80 |
| Stearic Acid | 0,10 | 1,92 | 0,192 |
| Zinc Oxide | 0,10 | 2,5 | 0,25 |
| Antioxidant | 0,50 | 10,33 | 5,165 |
| MBTS | 0,05 | 6 | 0,3 |
| DPG | 0,05 | 12,82 | 0,641 |
| Sulfur | 0,05 | 4,4 | 0,22 |
| Renacit6 | 0,05 | 6,54 | 0,327 |
| Totals | 120,900 | | 143,095 |
| | | | |
| Total Cost Dolars per Kilogram of raw materials | | **1,18** | |

Elaboraiton: Author.

Source: Comercio General e Industrias (2012), Vidal (1963)

The above table shows the cost structure of raw materials in the formula. To get the numbers, first the formula must be created in parts per kilogram of polymer. Then the parts per kilogram of polymer of each ingredient must be multiplied by the dolar cost per kilogram of ingredient, 100 x 0,56 = 65 ; 20 x 4 = 80 and so on. After all the “dollars per part” values are obtained, the total is divided by the total of “Parts per Polymer weight”, 143,095 ÷ 120,900 = 1,18. One point eighteen is the cost per kilogram of raw material for this formula.

Indirect Labor Costs.

**Table 20Indirect Labor Costs Detail**

| **Plant Indirect Labor** | | |
|---|---|---|
| Raw Material, in process Warehouse | | |
| Job | Quantity | Salaries |
| Warehouse keeper | 1 | 600 |
| Total | 1 | 600 |
| | | |
| Finished Products Warehouse | | |
| Job | Quantity | Salaries |
| warehouse keeper finished products | 1 | 600 |
| total | 1 | 600 |
| | | |
| Supervision | | |
| Job | Quantity | Salaries |
| Supervisor | 1 | 700 |
| Total | 1 | 700 |
| | | |
| Product tester. | | |
| Job | Quantity | Salaries |
| Tester | 1 | 600 |
| Total | 1 | 600 |

| | | |
|---|---|---|
| Mantainance | | |
| Job | Quantity | Salaries |
| Mechanical technician #1 | 1 | 500 |
| Mechanical technician #2 | 1 | 500 |
| total | 2 | 1000 |
| | | |
| **Total Indirect Labor** | **7** | **3500** |

Elaboration: Author

These are the jobs that don't directly intervene in the transformation of the raw materials into the finished products, but at all matters are essential for their transformation.

Plant Indirect Costs

**Table 21 Detailed Plant Indirect Costs.**

| **Plant Inderct Costs** | | |
|---|---|---|
| Lease | 3500 | |
| Electric Bill | 3500 | |
| Maintenance materials. | 200 | |
| Water supply | 100 | |
| Security | 400 | |
| Communication | 150 | |
| **Total indirect costs** | | **7850** |

These are the costs that do not intervene directly to the production process but are necessary in order to perform the process correctly. The electric bill if the project is implemented should be counted as direct cost. As it is currently irrelevant to try to convert it to a variable cost, it is appropriate to account it as indirect cost.

Unified Product Cost per Kilogram.

**Table 22  Detailed Cost per Kilogram**

| **Labor Cost calculation** | |
|---|---|
| Direct Labor CPU | 0,09 |

| | |
|---|---|
| Indirect Labor CPU | 0,06 |
| **Total labor cost** | **0,15** |
| | |
| Indirect CPU | |
| **Indirect CPU** | **0,14** |
| | |
| Raw Material Cost Calculation | |
| **Formula cost per kilogram** | **1,18** |
| | |
| Total Cost per Kilogram | **1,47** |

Total Cost of finished product 22,05

Cost per kilogram calculations were perfume dividing the total dollars of each category by the total kilograms of finished vulcanized product in a month then adding each category total together to get the total cost per kilogram. To get the total cost per Unit, which is the finished cow mat unit, the weight in kilograms of the unit is multiplied by the cost per kilogram as follow: 1,47 x 15 = 22,05.

**Table 23 Initial investment composition.**

| | |
|---|---|
| Machinery | |
| Rubber Mill | 20000 |
| Vulcanization Press | 15000 |
| Banbury | 25000 |
| Devulcanization machines | 20000 |
| Shredding Plant | 150000 |
| Oil Boiler | 5000 |
| Total machinery investment | 235000 |
| | |
| Foundations | 20000 |
| | |
| Electric Instalations | 50000 |
| | |
| Vehicles | |
| Truck #1 | 25000 |
| Truck #2 | 25000 |
| Truck #3 | 25000 |
| Loading truck | 10000 |
| Total vehicles | 85000 |
| | |
| Implementation | 15000 |
| | |
| Initial raw material inventory | $ 68.174 |
| | |
| Other administrative investments | 10000 |
| Computers and other depreciables | 15000 |
| Working Capital | 100000 |
| | |
| Total initial investment | $ 598.174 |
| Bank Loan | 553.174 |
| Investor capital | 45.000 |
| | |
| Straight line depreciation | |
| Salvage value (10%) | $ 33.500 |
| Depreciable amount | $ 301.500 |

The prices of the machines are from quotations to the mentioned companies from China. The trucks are the ones presented on by Mavesa. The other less essential values are estimated based on recompilation of different private construction projects.

**Table 24 Projected Production Overview**

| | | | | | |
|---|---|---|---|---|---|
| Annual Finished kg Production (max ) | 691200 | | | | |
| Production Projection | | | | | |
| Production | 1 | 2 | 3 | 4 | 5 |
| Production efficiency | 80% | 84% | 93% | 97% | 97% |
| Kgs produced | 552960 | 580608 | 642816 | 670464 | 670464 |

The plant maximum capacity of kilograms produced based on the quotations and following one eight hours shift is 691.2 thousand kilograms. Although complete efficiency is rarely achieved, the author considered the learning curve for manufacturing by Stewart (1995) which dictates an initial of 80% efficiency with a rather fast scaling increase due to professionalization of hand work involvement.

**Table 25 Raw Material inventory efficiency in years (US Dollars).**

| Raw materials inventory | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Initial raw materials | - | 163618 | 130895 | 57266 | 24543 |
| Purchase of raw materials | 818092 | 654473 | 687197 | 760825 | 818092 |
| Raw materials to production | 654473 | 687197 | 760825 | 793549 | 793549 |
| RM balance to initial RM inventory | 163618 | 130895 | 57266 | 24543 | 49085 |

The raw material efficiency is directly related on how much was produced and how much it was planned to be produced each year. The first year is the purchase of the raw materials planned to satisfy a 100% production efficiency, whilst the hundred percent is not achieved, the remaining materials are stored on inventory. With each year the purchase of raw materials is more efficient on the prediction of production due to the existing historical data.

**Table 26 Finished Products inventory in years. (US Dollars).**

| Finished Products Inventory | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Initial FP Inventory | - | 265669 | 455499 | 640730 | 768927 |
| Production | 885563 | 949152 | 1029058 | 1068310 | 1075100 |
| Production sold | 619894 | 759322 | 843827 | 940113 | 1021345 |
| To inventory | 265669 | 455499 | 640730 | 768927 | 822682 |

As the business model proposed is based on manufacturing, there is also the finished product inventory. This inventory is completely dependent on the production and the sales that year.

**Table 27 Sales efficiency projection in years (US Dollars).**

| Sale Plan | | | | | |
|---|---|---|---|---|---|
| Sale efficiency | 70% | 80% | 82% | 88% | 95% |
| Kgs sold | 387072 | 464486 | 527109 | 590008 | 636941 |
| Sale Price | 3,5 | 3,5 | 3,5 | 3,5 | 3,6 |
| Income | 1354752 | 1625702 | 1844882 | 2065029 | 2292987 |

The sale efficiency is estimated based on the lack of competitors and the recommended pre introduction (see recommendations section) of the product before initiating the project. Also a decisive factor is The fact that the price of the vulcanized rubber is considered low since in today rubber market of Guayaquil. The company “Cauchera Duran” has prices per kilogram for unvulcanized rubber ranging from $4 up to $10. Artisans buy this rubber to vulcanize it into rubber items to be commercialized at a price 100% higher. This means that on the market, kilograms of technical rubber parts are sold at 8 dollars up 20 dollars per kilogram while the proposed product would be sold vulcanized at $3.5, a four point five dollar difference from the cheapest kilogram of vulcanized items. Meaning a attractive situation for customers.

**Table 28 Cost per unit projection in years. (US Dollars).**

| Cost Per Unit Projection | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Direct Labor | 59400 | 61776 | 61776 | 61776 | 61776 |
| IESS Direct Labor | 20790 | 21622 | 21622 | 21622 | 21622 |
| Indirect Labor | 42000 | 43680 | 45427 | 47244 | 49134 |

| | | | | | |
|---|---|---|---|---|---|
| IESS Inderct lb | 14700 | 36910 | 37521 | 38157 | 38819 |
| Indirect Costs | 94200 | 97968 | 101887 | 105962 | 110201 |
| CPU Direct Labor | 0,15 | 0,14 | 0,13 | 0,12 | 0,12 |
| CPU Indirect Labor | 0,10 | 0,14 | 0,13 | 0,13 | 0,13 |
| CPU Indirect Costs | 0,17 | 0,17 | 0,16 | 0,16 | 0,16 |
| CPU Raw Materials | 1,18 | 1,18 | 1,18 | 1,18 | 1,18 |
| total cpu | 1,60 | 1,63 | 1,60 | 1,59 | 1,60 |

The costs are all the outflows related to the production of the items. On the cost structures are also considered the legal benefits, insurance and vacations for each employee. The second year the total cost per unit increases due to the increase in salaries but a not so high production efficiency, although the third year the cost is reduced and the fourth year is reduced even more. The fifth year the cost increases again because the company would need to increase production investment to meet the annual increase in salaries.

**Table 29 Expenses projections in years. (US Dollars).**

| Expenses Projection | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Office Managers | 108000 | 112320 | 116813 | 121485 | 126345 |
| Admin support jobs | 19200 | 19968 | 20767 | 21597 | 22461 |
| Sale Staff | 92160 | 95846 | 99680 | 103667 | 107814 |
| Other function Staff | 22200 | 23088 | 24012 | 24972 | 25971 |
| IESS/other | 84546 | 87928 | 91445 | 95103 | 98907 |
| Other admin expenses | 34632 | 34632 | 34632 | 34632 | 34632 |
| Depreciation (Office) | | | | | |
| Total Expenses Projection | 360738 | 373782 | 387348 | 401457 | 416130 |

These are the outflows not related to the production. These are the administrative salaries, food supply, between other detailed on the above table. These values are input on the income statement to determine margins.

**Table 30 Company Income Statement**

| Income Statement | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| Net Sales | $ 1.354.752 | $ 1.625.702 | $ 1.844.882 | $ 2.065.029 | $ 2.292.987 |
| COGS | $ 619.894 | $ 759.322 | $ 843.827 | $ 940.113 | $ 1.021.345 |
| Gross Margin | $ 734.858 | $ 866.381 | $ 1.001.055 | $ 1.124.916 | $ 1.271.642 |
| Operating Expenses | | | | | |
| Salaries | $ 241.560 | $ 251.222 | $ 261.271 | $ 271.722 | $ 282.591 |
| EBIDT | $ 493.298 | $ 615.158 | $ 739.783 | $ 853.194 | $ 989.051 |
| Other expenses | | | | | |
| Depreciation | $ 60.300 | $ 60.300 | $ 60.300 | $ 60.300 | $ 60.300 |
| Other adming expenses | $ 34.632 | $ 34.632 | $ 34.632 | $ 34.632 | $ 34.632 |
| Interest | $ 66.381 | $ 55.932 | $ 44.229 | $ 31.122 | $ 16.442 |
| EBIT, workers | $ 331.985 | $ 464.294 | $ 600.622 | $ 727.140 | $ 877.677 |
| - 15% Workers | $ 49.798 | $ 69.644 | $ 90.093 | $ 109.071 | $ 131.652 |
| Total EB income tax | $ 282.187 | $ 394.650 | $ 510.529 | $ 618.069 | $ 746.026 |
| -22% Income Tax | $ 62.081 | $ 86.823 | $ 112.316 | $ 135.975 | $ 164.126 |
| EB legal reserve | $ 220.106 | $ 307.827 | $ 398.213 | $ 482.094 | $ 581.900 |
| 10% Legal Reserve | $ 22.011 | $ 30.783 | $ 39.821 | $ 48.209 | $ 58.190 |
| Net Income | $ 198.095 | $ 277.044 | $ 358.391 | $ 433.885 | $ 523.710 |
| Income Margin | 15% | 17% | 19% | 21% | 23% |

The gross margin averages at 53%, this is because the 80% of the raw material has extreme low cost. This 80% is the devulcanized scrap tire powder, the scrap tires should be provided for free following the Ecuadorian law. Although having this high gross margin, the sell effort and the staff behind the pursue of clients reduces the margin significantly to just 38% in average on EBIT. Leaving just the presented income margins presented on the table. As the production learning curve stabilizes and the market positioning establishes within the years, the margins are widen up.

**Table 31** Company Balance Sheet.

| Balance | | | | | | |
|---|---|---|---|---|---|---|
| Years | 0 | 1 | 2 | 3 | 4 | 5 |
| Current Assets | | | | | | |
| Cash | $ 100.000 | $ 94.406 | $ 32.816 | $ 34.319 | $ 41.494 | $ 81.938 |
| Account recievables | $ 0 | $ 56.448 | $ 67.738 | $ 76.870 | $ 86.043 | $ 95.541 |
| Inventory FG | | $ 265.669 | $ 455.499 | $ 640.730 | $ 768.927 | $ 822.682 |
| Inventory RM | $ 68.174 | $ 163.618 | $ 130.895 | $ 57.266 | $ 24.543 | $ 49.085 |
| Total C Assets | $ 168.174 | $ 580.141 | $ 686.948 | $ 809.185 | $ 921.007 | 1.049.246 |
| | | | | | | |
| Fixed Assets | | | | | | |
| Machinery and electric systems | $ 285.000 | $ 285.000 | $ 285.000 | $ 285.000 | $ 285.000 | $ 285.000 |
| Vehicles | $ 85.000 | $ 85.000 | $ 85.000 | $ 85.000 | $ 85.000 | $ 85.000 |
| Foundations | $ 20.000 | $ 20.000 | $ 20.000 | $ 20.000 | $ 20.000 | $ 20.000 |
| Computers and other depreciables | $ 15.000 | $ 15.000 | $ 15.000 | $ 15.000 | $ 15.000 | $ 15.000 |
| Administrative Investments | $ 10.000 | $ 10.000 | $ 10.000 | $ 10.000 | $ 10.000 | $ 10.000 |
| Structural investments | $ 15.000 | $ 15.000 | $ 15.000 | $ 15.000 | $ 15.000 | $ 15.000 |
| (-) Depreciation | | ($ 60.300) | ($120.600) | ($ 180.900) | ($ 241.200) | ($ 301.500) |
| Total Fixed Assets | $ 430.000 | $ 369.700 | $ 309.400 | $ 249.100 | $ 188.800 | $ 128.500 |
| | | | | | | |
| Total Assets | $ 598.174 | $ 949.841 | $ 996.348 | 1.058.285 | 1.109.807 | 1.177.746 |
| | | | | | | |
| Liabilities. | | | | | | |
| Short Term Liabilities | | | | | | |
| Salaries | | $ 28.580 | $ 29.723 | $ 30.706 | $ 31.729 | $ 32.792 |
| IESS/social benefits | | $ 10.003 | $ 12.205 | $ 12.549 | $ 12.907 | $ 13.279 |
| 15% workers | | $ 49.798 | $ 69.644 | $ 90.093 | $ 109.071 | $ 131.652 |
| income tax | | $ 62.081 | $ 86.823 | $ 112.316 | $ 135.975 | $ 164.126 |
| Suppliers | 0 | $ 68.174 | $ 54.539 | $ 57.266 | $ 63.402 | $ 68.174 |
| | | | | | | |
| Long Term Liabilities | 553.174 | 466.099 | $ 368.575 | $ 259.348 | $ 137.014 | 0 |
| Total liabilities | 553.174 | 684.735 | $ 621.510 | $ 562.280 | $ 490.098 | $ 410.022 |
| | | | | | | |
| Owners Equity | | | | | | |
| Capital | $ 45.000 | $ 45.000 | $ 45.000 | $ 45.000 | $ 45.000 | $ 45.000 |
| Legal Reserves | | $ 22.011 | $ 22.500 | $ 22.500 | $ 22.500 | $ 22.500 |
| Optional reserve | | | $ 30.293 | $ 70.115 | $ 118.324 | $ 176.514 |
| Net icome | | 198.095 | $ 277.044 | $ 358.391 | $ 433.885 | $ 523.710 |
| total owner's equity | $ 45.000 | 265.106 | $ 374.838 | $ 496.006 | $ 619.709 | $ 767.724 |
| | | | | | | |
| OE + Liabilities = Assets | 598.174 | 949.841 | $ 996.348 | 1.058.285 | 1.109.807 | 1.177.746 |

At year zero, the machines are being imported, the warehouse where the machines are going to be placed is being enabled. The antisismic foundations where the machines are going to be placed are being build. The offices and all other infrastructure investment are being made. Up until the machines arrive, the installation begins.

When all the components are set up, the testing start with a reduced number of workers. Up until the year 1, all the necessary plant and administrative labor force is hired and the production begins. It's important to note out that on the five year periods there are no new machinery acquirements. By the fifth year, the planned cost per kilogram starts to increase

This is because the supposed maximum real capacity reaches its peak while real salaries keep increasing resulting on a higher labor cost that the machinery can't mitigate by higher production. This can be resolved by making new investments on equipment and production processes starting the 6$^{th}$ year. The required cash for these investments to take place can be found ad the Optional Reserves, which is the amount of 10% legal reserve after it crosses the maximum Legal reserve amount decided by the Ecuadorian law which is half the amount of the subscribed capital.

The company should be able to pay out every next year the accumulated income as a form of dividends to the investors. Government supported businesses may have this advantage due to low cost raw materials, increasing that way the desire for potential new investors to invest on the industry.

**Table 32** Cash flow statement

| Cash Flow Statement | | | | | | |
|---|---|---|---|---|---|---|
| Operational Activities | 0 | 1 | 2 | 3 | 4 | 5 |
| Cash received from clients | | 1298304 | 1614413 | 1835749 | 2055856 | 2283489 |
| Paid to suppliers and employees | 68174 | 1150442 | 1262370 | 1316923 | 1424518 | 1519729 |
| Loan paiment | | 66381 | 55932 | 44229 | 31122 | 16442 |
| Income tax | | | 62081 | 86823 | 112316 | 135975 |
| Total cash balance by operational act | 68174 | 81481 | 234029 | 387774 | 487900 | 611343 |
| | | | | | | |
| Cash flow from investment activities | - 430000 | 0 | 0 | 0 | 0 | |
| Total cash balance from Investment act | - 430000 | 0 | 0 | 0 | 0 | |
| | | | | | | |
| Cashflow from finance activites | | | | | | |
| Long term liabilities paiments | 553174 | 87075 | 97524 | 109227 | 122334 | 137014 |
| Capital | 45000 | | | | | |
| Dividends Paid | | | 198095 | 277044 | 358391 | 433885 |
| Total cash balance from finance act | 598174 | 87075 | 295619 | 386271 | 480725 | 570899 |
| | | | | | | |
| Total cash flow from year | 100000 | -5594 | -61590 | 1503 | 7175 | 40444 |
| Cash at beginning of year | 0 | 100000 | 94406 | 32816 | 34319 | 41494 |
| Net cash balance | 100000 | 94406 | 32816 | 34319 | 41494 | 81938 |

The company's cash flow statement at simple view might show weakness on the final cash balance but it isn't for the following reason. After year two, when the cash seems to slump, the biggest outflow of cash apart from operating activities, is the dividend payment. Meaning that most of the excess cash can be safely paid to investors.

This situation can vary, when in execution, the company might change the rate or the amount which the administration gives out as dividends depending on the real situation.

This represents the advantage on having the government aid on handing the scrap tires for free, cash flow is necessary on any company and by having this advantage, the business is viable

. So this way for the whole industry it means even more security to invest. Without this the supply chain can gain too much power. This is that if there is no possibility on regulating the supply for scrap tires, potential suppliers can actually take advantage of the situation and impose inconvenient prices for the tire unit, this could lead to a dangerous cost increase that might put in danger the whole industry.

## 4.15 Main financial ratios.

**Table 33 Net Present Value and Internal Rate of Return.**

| PV | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| | -598174 | 280406 | 368127 | 458513 | 542394 | 642200 |
| Discount | 0,15 | | | | | |
| NPV | 743388 | | | | | |
| IRR | 58% | | | | | |

This is the most represents the real value of the business. The value of the investment is 598.174 dollars, while the maximum cash generating on the worst case scenario is just 7% more of that value.

Although if all the cash flows are add up the business would represent a net present value of $743387 in five years period against the initial outflow. The internal rate of return would be of 58% on average. This is because the majority of the raw materials are provided for free thanks to the Ecuadorian Government.

It is important to state that it is not really free since the resources from required to get the scrap tires stored and transported throughout the city will come from a tax that is going to be charged to new tire buyers on all the tire commercial houses in Guayaquil and all of the country.

This is how the recycling industry works on the majority of industrialized countries like USA and Australia which has been successful on the reduction of scrap tire generation and stockpiling through years. Most importantly is the dangers that will be reduced associated with the accumulation of scrap tires.

**Chapter 5**

## 5.1 Conclusion

1.- The main tire commercial houses in Guayaquil has a moderate level of uncertainty on what to do with the disposal tires. These companies are storing the scrap tires on roofed warehouses. This temporary solution has high costs to these companies and is unsustainable. Sooner than later this system wont be viable and the jobs of the people who work on those companies are going to be in danger.

2.- The chemical process which would add the most value to the finished products using scrap tire powder is the reclamaition process. This process uses heat, oxygen and chemicals like mercaptans to break the previously sulfur bonds on the rubber matrix from the powder. This process allows to use the reclaimed rubber as the main raw material for finished products depending on their use and quality necessity. The ratio would be of eighty percent reclaimed rubber and twenty percent of virgin materials in order to significantly increase the quality while at the same time having a reasonable low cost.

3.- The business model proposed is a integrated industry between the actual recycling of the scrap tires and a rubber mixing and molding plant. This last process is the key in which the final product gains substantial higher value than traditional recycling business models. Through the research for the paper, it was found that the logistics for receiving the scrap tires would run by the Government account since this is essential for any tire recycling business model to be profitable. The study also found that, accounting the government aid, with the process given to the scrap tire powder, the cost of production are substantially lower than using traditional rubber production processes. While on the market vulcanized rubber is sold at a mean price of eight dollars per kilogram . The final price of a vulcanized item using this business model could safely be three point five dollars per kilogram. Four point five dollars cheaper than the average price.

## 5.2 Recommendations

1.- The closest businesses to the tire recycling industry are the retreading plants and the tire retail sale houses. These businesses are mentioned on the new law and have their own responsibilities on the upcoming national plan to develop a scrap tire recycling industry. These industries can be the backbone on collecting true data about the scrap tire generation. When a consumer buy new tires, normally the retail store stays with the old tires, these should be sent to the tire retreading plants to be classified between scrap and reusable tires.

2.- It is important to note out that any investor willing to enter the tire recycling market, must do proper research beforehand and use all government aids as possible. In the case of the proposed business, investors, before even buying the machinery, should plan ahead their real requirements in order to the business to be successful. The most important part of this is safeguarding the market. On this particular situation, investors should seek government aid to enter in contact with possible future clients, for example via the “Asociacion Nacional de Ganaderos” in conjunction with “Ministerio de Industrias y Productividad”. Investors and government can help spread the selling object’s benefits for cow owners, they can get information about how many they are, where they are and how to contact them, this should be done even before buying the machines. This must be done so that when the factory is installed, the target market already knows about the features of the product and the selling effort is reduced dramatically.

3.- There should be and organization similar to Puerto Limpio in Guayaquil with the objective of managing the scrap tire logistics. Preferably the organization can be private and acting as a Government client to ensure the most efficient service seeking profit. The logistic organization would be the responsible of collecting the scrap tires from the retreading plants and store them in stockpiling centers. Once this is achieved, the private sector will be interest in using those stockpiled tires since they would get them relatively for free, on their doors and most importantly, they will know where are they, how many there are and how many are generated. The classic scrap tire problem of lack of information would be over and the private sector will be motivated to invest in recycling industry.

## 6 .- References.

Cedillo. L. María José. (2007). Análisis y Mejoramiento de Método de Retoque de Llantas Radiales en la Compañía Ecuatoriana Del Caucho S.A [Analysis and Improvement of The Radial Tire Milling Method in Compañía Ecuatoriana Del Caucho S.A]. Retrieved:http://dspace.ups.edu.ec/bitstream/123456789/967/5/Capitulo_1.pdf

DairyCo (2013). Technical Information. Cow Behaviour and Confort. United Kingdom. Retrieved: June 5, 2013, from: http://www.dairyco.org.uk/technical-information/buildings/housing/cow-behaviour-and-comfort/

Ecuador, INEC (2011). Encuesta de Superficie y Producción Agropecuaria Continua. [Agricultural Surface and Production Survey.] Quito, Ecuador.

Ecuador, INEC (2011). Encuesta de Superficie y Producción Agropecuaria Continua. Existencia de ganado en Manabi. [Agricultural Surface and Production Survey. Cattle presence in Manabi] Quito, Ecuador.

Ecuador, INVEC (2012). Proyecto de Ley para gestión de neumáticos desechados. Cuenca, Ecuador.

Ecuador, Ministerio de Ambiente (2013). Acuerdo Ministerial No.020

Ecuador. Ministerio de Industrias y Productividad (2012). Bosquejo de datos estadísticos. Llantas.

Ecuador. Ministerio de Industrias y Productividad (2012). Programas y Servicios. Reúsa Llanta. [Programs and Services. Reuse Tires] Retrieved from: http://www.industrias.gob.ec/reusa-llanta/

Ecuador. Ministerio de Salud Publica (2013). Epidemiological billboard #26. Retrieved from: http://www.salud.gob.ec/boletin-epidemiologico-no-26-de-la-situacion-de-dengue-en-el-ecuador-2013/

Ecuador. Secretaria Nacional del Agua. (2013). En entrevista para El Ciudadano: Megaproyectos de Senagua prevendrán inundaciones en el país. [In an Interview for “El Ciudadano”: Senagua’s Megaprojects will prevent floods]. Quito, Ecuador. Retrieved May 16, 2013, from: http://www.agua.gob.ec/en-entrevista-para-el-ciudadanomegaproyectos-de-senagua-prevendran-inundaciones-en-el-pais/

Ecuador. (2013). Codigo Laboral.

European Food Safety Authority, (2009). Effects of farming systems on dairy cow welfare and disease.

IBISWorld. 2013. Rubber Product Manufacturing in the US : Market Research Report. Industry Statistics and Market Size. California. USA Retrieved May 18, 2013 from: http://www.ibisworld.com/industry/default.aspx?indid=529

Harbach R. (2008). Mosquito Taxonomi Inventory. Culicidae. Retrieved June 10 from: http://mosquito-taxonomic-inventory.info/simpletaxonomy/term/6045

ICI Formulation Manual (1965). Rubber Reclaiming Agent. Manchester, England.

United Nations, International Labour Office, Mager J. Stellman (1998). Encyclopedia of Occupational Health and Safety. Geneva, Switzerland.

Matthews M. (2005). Used Tyre Recycling Industry Triple Bottom Line Analysis. West Australia.

Monsanto Chemical. (1967). Monsanto Auxiliary Products for Rubber Industry. State Louis, Minnesota. USA.

Mulling, C. Greenough, P. (2006). Applied Physiopathology Of The Foot. Nice, France

New Zealand. Department of Conservation. (2006). Introduced Rodents. Rodents Facts. Christchurch.

Norberg, P (2012). Effects of rubber alley flooring on cow locomotion and welfare. Uppsala, Sweden.

Pacuar. Elena. (2013, Janyuary 7). El dengue no dio tregua en el país durante el 2012 [Dengue disease in 2012 didn´t gave a brake] . El Comercio. Quito, Ecuador. Retrieved from: http://www.elcomercio.ec/pais/dengue-Ecuador-tregua-pais-salud_0_842915715.html

Plasticaucho Industrial (2013). Our Company. History review. Retrieved from: http://www.plasticaucho.com.ec/index.php/nuestra-empresa/resena-historica.html

Romero C. Raul (2007). Microbiology and Human Parasitology. Etiological Bases of Infectious and Parasitic Diseases. Chapter VI. Prasitology. 3rd Edition. Mexico.

Romero C. Raul (2007). Microbiology and Human Parasitology. Etiological Bases of Infectious and Parasitic Diseases. Chapter VI. Prasitology. 3rd Edition. Mexico.

Rubber Manufacturers Association (2011). U.S Scrap Tire Management Summary 2005-2009. 2009 US Scrap Tire Generation. Washington D.C.

Rubber Manufacturers Association (2011). U.S Scrap Tire Management Summary 2005-2009. 2009 U.S Scrap Tire Disposition. Washington D.C.

Rubber Manufacturers Association (2011). U.S Scrap Tire Management Summary 2005-2009. 2005-2009 Ground Rubber Market Distribution. Washington D.C.

R.T Vanderbilt Rubber Book (1978). Reclaimed Rubber. Connecticut, USA

R.T Vanderbilt Rubber Book (1978). Production Process. Machinery. USA. Connecticut. USA

R.T Vanderbilt Rubber Book (1978). Production Methods and Equipments. Rubber Mixing Equipments. Connecticut, USA.

R.T Vanderbilt (n.d.). *Rubber: Mineral Fillers, Non-Black Fillers for Rubber*. Retrieved May 10, 2013, from http://www.rtvanderbilt.com/vnews/RubberProductGuide.pdf

R.T Vanderbilt (n.d.). *Rubber: Mineral Fillers, Non-Black Fillers for Rubber*. Page 30. Retrieved May 10, 2013, from http://www.rtvanderbilt.com/vnews/RubberProductGuide.pdf

Stewart. R. Wyskida R.M. Johannes .J . (1995). Cost Estimator's Reference Manual, 2nd Edition. New York, USA

Stoner J, Freeman E & Gilbert D (1996). Management. Strategic Management and Planning. Corporate Strategy Content. "Five forces" of the Corporate Strategy. Pp 300-302.

Telezheko, E (2007). Effect of Flooring System on Locomotion Comfort in Dairy Cows. Sakara, Sweden.

Tripathy, A. R., Williams, D. E., & Ferris, R. J. (2004). *Rubber Plasticizers From Degraded/Devulcanized Scrap Rubber: A Method of Recycling Waste Rubber* (44,7 ). Polymer Engineering and Science.

USA. Environmental Protection Agency (2007). Scrap Tires. Health and Evironmental Concerns.

USA. NASA Spinoff. (2011). Tire Recycling. Environment and Waste Management. Retrieved from: http://spinoff.nasa.gov/spinoff1997/er4.html

Vidal. M. De Cacer. Tratado Moderno de las Industrias del Caucho. Historia del Caucho. [Modern Rubber Industry Lecture. History of Rubber.]Barcelona, Spain.

Warnick,L. Janssen, D. Guard, L. & Grohn, Y (2001). The Effect of Lameness on Milk Production in Dairy Cows. New York, USA.

Western Australia Department of Environment. (2006). Submission to Productivity Commission Enquiry into Waste Generation and Resource Efficiency.

## 7.- Annexes

Company list of
Loan Amortization
Annex #11

| | | | | |
|---|---|---|---|---|
| Capital | $ | 553.174 | | |
| Interest | | 12% | | |
| T | | 5 | | |
| Years | | Capital | Interest | paiment |
| | 1 | $ 87.075 | $ 66.381 | $ 153.456 |
| | 2 | $ 97.524 | $ 55.932 | $ 153.456 |
| | 3 | $ 109.227 | $ 44.229 | $ 153.456 |
| | 4 | $ 122.334 | $ 31.122 | $ 153.456 |
| | 5 | $ 137.014 | $ 16.442 | $ 153.456 |
| | | $ 553.174 | $ 214.105 | $ 767.280 |

Composition of Company representing monthly outflows. Annex #12

| | | |
|---|---|---|
| **Plant Direct Labor** | | |
| | | |
| Shredding | | |
| Job | Quantity | Salaries |
| Sides cutter | 1 | 450 |
| Rin cutter | 1 | 450 |
| Tread cutter | 1 | 450 |
| Block cutter | 1 | 450 |
| Cracker | 1 | 450 |
| Handyman | 1 | 450 |
| Grinding machines | 1 | 450 |
| total | **7** | 3150 |
| Devulcanizing | - | |
| Job | Quantity | Salaries |
| autoclaves | 1 | 450 |
| total | **1** | 450 |
| | | |
| Mixing | | |
| Job | Quantity | Salaries |
| Banbury | 1 | 450 |
| Mill | 1 | 450 |
| total | **2** | 900 |
| | | |
| Vulcanizing | | |
| Job | Quantity | Salaries |
| Hydraulic Press | 1 | 450 |
| total | **1** | 450 |
| | | |
| **Total Plant Direct Labor** | **11** | **4950,00** |

**Plant Indirect Labor**

| | | | |
|---|---|---|---|
| Raw Material, in process Warehouse | | | |
| Job | Quantity | Salaries | |
| Warehouse keeper | 1 | | 600 |
| Total | **1** | | 600 |
| | | | |
| Finished Products Warehouse | | | |
| Job | Quantity | Salaries | |
| warehouse keeper finished products | 1 | | 600 |
| total | **1** | | 600 |
| | | | |
| Supervision | | | |
| Job | Quantity | Salaries | |
| Supervisor | 1 | | 700 |
| Total | **1** | | 700 |
| | | | |
| Product tester. | | | |
| Job | Quantity | Salaries | |
| Tester | 1 | | 600 |
| Total | **1** | | 600 |
| | | | |
| Mantainance | | | |
| Job | Quantity | Salaries | |
| Mechanical technician #1 | 1 | | 500 |
| Mechanical technician #2 | 1 | | 500 |
| total | **2** | | 1000 |
| | | | |
| **Total Indirect Labor** | **6** | | **3500** |
| | | | |
| **Total Plant Labor** | **17** | | **8450** |
| **Plant Inderct Costs** | | | |
| Lease | 3500 | | |
| electric bill | 3500 | | |
| maintenance material | 200 | | |
| water | 100 | | |
| security and insurance | 400 | | |
| communication | 150 | | |
| **total indirect costs** | | | **7850** |

Annex #13 Production Capacities.

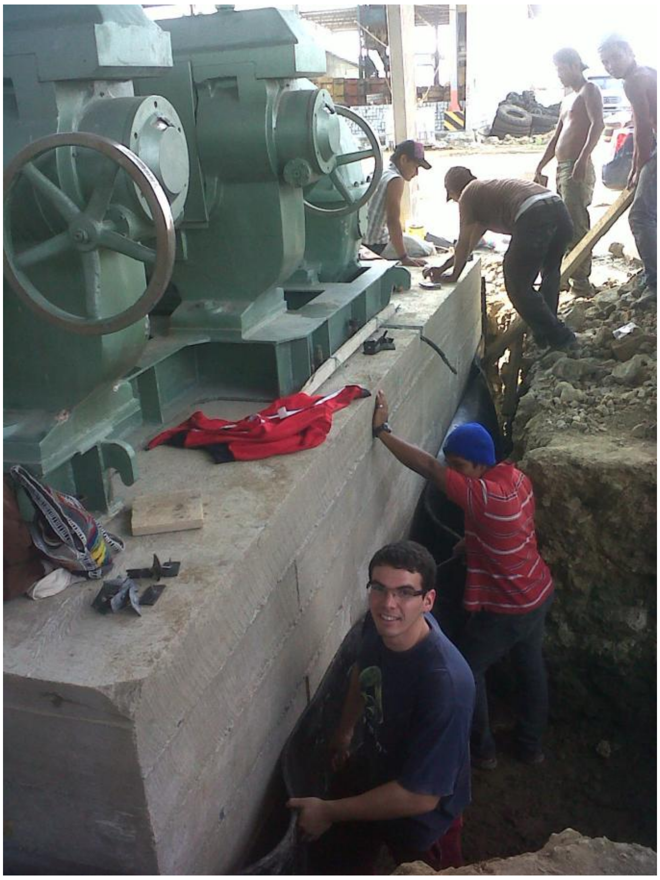
| Max Capacity Production | Tons |
|---|---|
| Daily Production | 2880 |
| Monthly total kg Production | 57600 |
| Yearly total kg production | 691200 |

Annex#14 Non Production Expenses

| | |
|---|---|
| **Non production Expenses** | |
| Office Managers | |
| General Manager | 3000 |
| Operations Manager | 1500 |
| Sales Manager | 1500 |
| Financial Manager | 1500 |
| Human Resources Manager | 1500 |
| Total office managers | 9000 |
| Administrative Support Jobs | |
| Secretary #1 | 400 |
| Secretary #2 | 400 |
| Secretary #3 | 400 |
| Secretary #4 | 400 |
| Total admin sup jobs | 1600 |
| Sale Staff | |
| Seller #1 | 500 |
| Seller #2 | 500 |
| Seller #3 | 500 |
| Seller #4 | 500 |
| Seller #5 | 500 |
| Seller support #1 | 400 |
| Seller support #2 | 400 |
| Seller support #3 | 400 |
| Instalation support #1 | 400 |
| Instalation support #2 | 400 |
| Instalation support#3 | 400 |
| Truck driver #1 | 500 |
| Truck driver #2 | 500 |
| Truck driver #3 | 500 |
| Total sale stall | 6400 |
| Other function Staff | |
| Office Guard | 500 |
| Plant Guard | 500 |
| Office Janitor | 400 |
| Handyman | 450 |
| Total non production expenses salarie: | 1850 |
| | |
| Total non production salaries | 18850 |

| | |
|---|---|
| Other Admin Costs. | |
| Office Rent | 700 |
| Company Staff Food | 1386 |
| Office Supplies | 200 |
| Sale requirements | 200 |
| Cleaning supplies | 100 |
| Utilities | 100 |
| Comunications | 200 |
| Total other admin costs | 2886 |
| | |
| Total non production expenses | 21736 |

Annex #16 Author's experiences on scrap tire shredding equipment plant installation.



Annex #17Author provided antisismic rubber for the machine foundation.

Annex #18  Author with finished antisismic rubber installation job.