Decision Factors for E-waste in Northern Mexico: to Waste or Trade

by

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ABSTRACT

Electronic waste is a concern, because of the increasing volume of materials being disposed of. There are economical, social and environmental implications derived from these materials. For example, the international trade of used computers creates jobs, but the recovery from valuable materials is technically challenging and currently there are environmental and health problems derived from inappropriate recycling practices. Forecasting the flows of used computers and e-waste materials supports the prevention of environmental impacts. The nature of these material flows is complex. There are technological geographical and cultural factors that affect how users purchase, store or dispose of their equipment. The result of these dynamics is a change in the composition and volume of these flows. Collectors are affected by these factors.

In northern Mexico, there is an international flow of new and used computers between Mexico and the United States and an internal flow of materials and products among Mexican cities. In order to understand the behavior of these flows a field study was carried out in 8 different Mexican cities. Stake holders were interviewed and through a structured analysis the system and relevant stakeholders were expressed as Data Flow Diagrams in order; to understand the critical parts from the system. The results show that Mexican cities have important qualitative differences. For example, location and size define the availability of resources to manage e-waste. Decisions to dispose a computer depend on international factors such as the price of new computers, but also on regional factors such as the cost to repair them.

Decisions to store a computer depend on external factors such as markets, but also internal factors such as how users perceive the value of old equipment. E-waste collection depends on the value of e-waste, but also on costs to collect and extract value from them. Therefore, a general policy base on how E-waste is managed at a big city might not be the most efficient for a small one. More over combining strengths from different cities might overcome respective weaknesses and create new opportunities; this integration can be stimulated by designing policies that consider diversity.

To my beloved parents: Elena Ayub and Jesus Estrada, and my brother Juan Antonio for their continuous support to my dreams.

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PREFACE

My interest on the environmental field started more than 30 years ago, at the forest range, called Sierra Tarahumara, while observing the long lines of trucks carrying the wealth from minerals and lumber out of the Canyons and Mountain ranges, but leaving misery behind.

The materials extracted from forest ranges and mines are converted into products that are sold at the markets. Farmers and artisans carry their products from their rural villages to the nearest town. New products are created around the world. People get together at local markets to buy their needs and their dreams according with their acquisitive power.

A complex system allows humans to extract materials from natural ecosystems and create different products. Some of these products are closely related with human basic needs like, food, and shelter and some of them are technological products like computers, cell phones and automobiles. At the center from all these activities lies the challenge to satisfy the needs from more than 7000 million humans and their descendants, but also to create the conditions to allow the survival from millions of other species whose lives are connected with the sustainability of life on earth in ways that are still not completely understood.

The thread that connects the materials from natural ecosystems and products consumed by people is easy to see in some of them. For example, the use of feathers in women hats in the late 1800s and the use of rhino horns in the traditional Chinese medicine have a direct effect on the conservation of

animal species. On the other hand, the oil spills and the change from forest land to agricultural land also have a clear connection with the environment. However, there is a ubiquitous connection between natural ecosystems and the production, consumption and disposal of products.

The wastes released by human society are as complex as the social and technological systems that create the products that originate them. The massive quantities of waste generated by the increasing human population surpass the natural ecosystems capacity to process them. The technological change creates new products and these new products may include new chemical compounds and new materials. The ways these new products are created, used and disposed create new kind of wastes that natural systems may not be equipped to process.

The problems I care the most, were not address by the academia in an integrated way, until the emergence of interdisciplinary environmental fields, like Earth Systems Engineering and Management, a field lead by my Advisor Braden Allenby.

Earth Systems Engineering and Management, (ESEM) is a discipline that acknowledges that natural ecosystems are profoundly shaped by human systems; therefore it is necessary to design these human systems rationally and ethically (Allenby, 2005)

For example, automated electronic systems increase production and reduce labor. The reduction of jobs, reduce the consumers. Producers require the continuous consumption from their products in order to survive. The purchase power from the people determine the market size for a product;

therefore, producers have only two options either decrease prices to gain new consumers, or promote the continuous change of their products in their consumer base.

One of the visible effects from these complex interactions can be seen in the increasing quantity of electrical and electronic products that are disposed of. Disposed electrical and electronic products are commonly known as E-waste.

There are valuable metals like gold and cooper in E-waste' materials. E-waste also contains toxic materials. Recycle E-waste requires special care in order to avoid release, these materials in the process. Nonetheless, the value in materials from E-waste is a powerful incentive for people to recycle them, even without the proper care. For example, wires are burn to recover cooper. This method causes the release of dioxins from flame retardants on wires' insulation into the environment. The problems from these types of recycling methods have been widely documented by research and by the media. For example, the exposure to toxic metals in recycling towns like Guiyu China was found to be the cause of the elevated lead levels in the blood of children (Huo, Peng, Zheng, Qui, & Piao, 2007).

However, solutions about E-waste issues required a vision beyond the problems derived from the inappropriate disposal of materials. For example in the case of computers it was shown by the work from Professor Eric Williams that the waste derived from them is not only in the materials and the environmental impacts from their disposal, but in the vast energy resources about 6400 MJ required to produce a computer that is going to be

quickly disposed (Williams, 2004). Used computers also have important social and economical impacts. For example, the trade of used computers in developing countries is a more powerful incentive than the trade of their materials to be recycled. Used computers trade creates jobs and allows access to technology to low income population (Kahhat, 2009).

In developing countries, in addition to the commerce of used computers, there is a continuous growth in the consumption of new computers. It has been forecast that the generation of e-waste in developing countries will surpass that of developed countries (Yu, Willliams, Ju, & Yang, 2010).

Developing countries are different that developed countries in terms of economical, social and cultural characteristics. However, there are regions of the world where there is a mix between both, that create unique conditions. For example, there are cities growing at accelerated rate at the U.S-Mexico border like Tijuana, and Juarez. These Mexican cities together with US cities like San Diego and El Paso are bi-national urban metropolis with unique characteristics (Herzog, 1991).

Cities and towns that are located at less than 200 miles from the US-Mexico border like Tijuana and Juarez have special characteristics in regards the flow of materials and people because at this distance it is possible for people to travel in less than one day between Mexico and the United States. There is a continuous flow of people and products at the border crossings from border cities. Every hour 20,000 people from Mexico enter into the

United States and the equivalents of 34,000 million dollars of products are trade (del Castillo, et al., 2007).

Cities like Tijuana, Nogales, Juarez and Chihuahua are big manufacturing centers of new electronic products like T.V s, cell phones computers and other electrical appliances that are assembled in Mexico and sold in the United States.

However, in addition of the trade of new products between Mexico and the United States, there is a dynamic commerce of used products. Mexican people buy used products like appliances, computers, and other electronics at the United States. Used electronics are refurbish and sold in Mexico.

New policies and regulations are in the process to be enacted in Mexico and the United States. However, it is possible that these regulations and policies that serve well to solve the problems base on the experience from others regions of the world, might not be the best solution to manage E-waste in all Mexican cities. For example, the Mexican cities near the U.S borders that are highly integrated with cities at the United States. At the same time it is possible that new answers can be found in the complex systems created by informal merchants, refurbishers, scavengers, and other stakeholders from these cities.

The information from these stakeholders is scarce; because most of their activities are carry out at informal markets, also called flea markets. However, some of these flea markets like "La Chaveña" (figure 1) in the city of Juarez has been continuously operating for more than 30 years. Flea

markets like "La Villa" in Tijuana assembled more than five thousand vendors every Sunday. Flea markets are common at cities near the border.

Figure 1 Used electronics' shops at La Chaveña Juarez Mexico. Photo Jesus Estrada 2009

In addition to flea-markets, there are also formal refurbishers, which repair computers and provide computers and services to small entrepreneurs. In cities like Juarez and Nogales there are collectors that combine their expertise managing E-waste from international companies to provide service to dispose electronics to the public. At every city there are collectors, which are also known as scavengers that take materials out of the waste stream. The work from this people save natural resources that otherwise will have to be take from natural ecosystems.

This research intention is to give a voice to these stakeholders, and provide new information, so better decisions can be made.

Chapter 1

INTRODUCTION AND BACKGROUND INFORMATION

1.1 Introduction

The truck that carries wastes from the city arrives and it discharges their load at the land fill. Women and men start looking for valuable materials. For Pedro, the leader of the materials collectors this has been his way of life for more than 20 years. For people like him (See figure 2), a computer monitor, a T.V or other electronics is a treasure. Because these products contain valuables metals like cooper.

Figure 2 The Search for Valuables at the Landfill. Photo Jesus Estrada 2009

People like Pedro are the last line of defense to prevent valuable resources end buried on a landfill.

It is the potential value any object may have, the incentive to take it out of the waste stream. How materials are required by the market determines the way materials are handled. For example, if cooper is the only valuable item that can be trade, people will do whatever it takes to take the cooper out. If the condition to trade the materials is that materials have to be

clean, people will keep the materials clean, wash them if it is possible or waste these materials when they are unrecoverable for them. If value can be found in the extraction of a component from a product, for example a hard disk drive from a PC, great care is taking to make the extraction successful.

Material collectors, also known as Scavengers, in the landfills are the last part of a lifecycle that includes: the raw materials extraction, the supply chain to transport materials and transformed into products, the distribution of the products to the markets, the users which buy the products, use them and discard them. Finally the collection of the discarded products and their final disposal (figure 3).These stakeholders does not operate in a vacuum, but are part o a socio-technical system (Odum & Barret, 2005) that includes systems like Internet, radio stations, T.V networks, and comunication

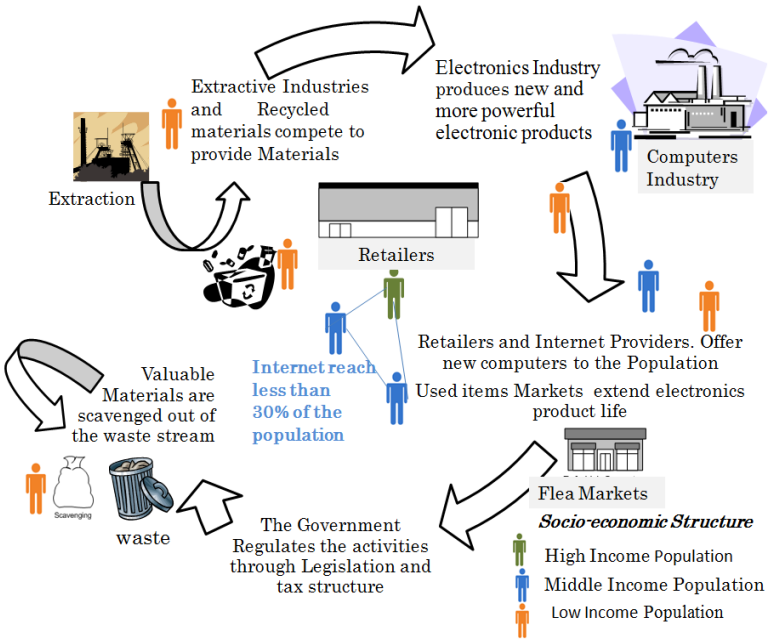

Figure 3 Computers' Life Cycle and Technology and Social Structure in Mexico. (This figure is a fusion from life cycle figures, Socio-economic Structure and Internet Access that are shown in the correct proportions according with statistics from INEGI).

These complex systems are shaped by cultural, social and economical factors in human societies. Figure 3 shows the life cycle from computers in Mexico including internet and the social structure. The social structure is represented as 10 persons. The socio-economic level from these persons is represented by colors to reflect the socio-economic structure in Mexico. It also can be seen how many of these persons are connected to the internet represented by the lines that connect them.

The figure shows that the fate from a computer once it is discarded by its first user depends on factors which shape the decisions from stakeholders. For example if the product is in working condition or it can be repair, the product is used again. Re-use is feasible only if there is a market for used items. These markets are represented in the figure by flea markets. If a computer cannot be repair there is another possibility and this is to extract components from it. This is only possible if these components can be trade. Finally when there is no possibility to repair or extract any component in working condition, there are two possible final possibilities: materials are recycled, if there is a market for them, or they are disposed as waste.

There are factors that shape the decision to waste or trade. As it can be seen in figure 3 recycled materials have to compete in the markets with virgin materials from the mining industry. The market for used parts from computers exists as long as the used models remain in operation.

The socio-economical structure from societies (see figure 3) is also a factor which defines the market for new and used computers. In Mexico only

Figure 4 New computers Sale through credit at a Retail Store in Tijuana. (Photo credit Jesus Estrada. Jan 2011)

3 out of 10 homes have a computer. New computers' market is the high income population. New computers (figure 4) through credit programs compete with used computers in the middle income population segment.

However, half of the population income is so low in Mexico that it is defined as poverty. This largest segment of the population has access to computers from leasing them at small internet cafes (figure 5).

Figure 5 Internet Service to Low Income Population, lease Internet by minutes. (Photo Credit Jesus Estrada (Jan 2011).

Internet cafes lease the service to internet. In figure 5 a cyber shop in Tijuana lease 15 minutes of internet for the equivalent in US dollars of 25 cents. These stores also provide the service to print documents and receive and send fax. Most of the equipments available at these stores are used computers. It is important to point out that e-waste is not formed only for the waste produced by computers disposal, but for many different products at different moments from their lifecycle. In addition Technology creates new products and change the existing ones; therefore, these are variables that change the characteristics from e-waste (see table 1).

Table 1 Variable as factors that cause Change on the Characteristics from E-waste

Variable	Comment.	Example
1- Moment in the lifecycle when e-waste was generated?	E-waste can be generated at different stages at the lifecycle. The lifecycle can be divided into three different stages: 1-The production phase 2-The use phase and 3-When the product is repair, disposed or recycled.	Production phase:. In the production of electronics some of the material is waste e.g. for not meeting quality criteria. This material is called scrap. In the use phase waste is generated. E.g. printer cartridges, batteries, change of CRT monitors to LCD screens. In the third phase. E-waste is generated as part of the product or the complete product is disposed
2- Products that originate E-waste	Environmental impacts from the products are different.	Refrigerators use more energy during their use. Computers use more energy in their production e.g. to manufacture processors There are also environmental impacts derived from the materials and how they are disposed.
3-Technological change	E-waste stream composition is changing	Changes in materials: e.g. Change in solder. Reduction of the content of valuable

	according with the technological changes in the electrical and electronic products	materials e.g. gold. New Products: Digital displays, Net book , Tablets , Cell Phones New Materials: The use of nanotechnology to produce new materials.

Because these variables, there is not a general solution to manage e-waste that fit to all of them. Table 2 shows an example of a more detailed analysis about how electronic products characteristics have different environmental and social impacts.

Table 2 Environmental and Social Factors from Three Electronic Products in Mexico.

Product	Environmental Factors	Social Factors
Refrigerators	Refrigerators energy use is higher in their use phase than when they are manufactured. The use of refrigerant gases like Freon damages the Ozone layer.	Refrigerators are a central piece for families in order to preserve food. The electrical companies benefit from the change to more energy efficient refrigerators.
Television	Old T.Vs screen have Cathode Ray Tubes and CRT's contain lead. Lead is a toxic metal for human health. Lead is no longer part of the components in the new flat screen technologies like LCD and Plasma flat screens.	The substitution of lead in products reduces the demand of lead. A reduced demand from a lead makes difficult to recycle the existing products that contain lead because there is no need for lead, so it is not possible to trade them...
Computers	Computers energy use is higher during manufacture of the processors. In addition lack of appropriate technology to recover the metals. e.g. burning wires releases harmful substances to the environment.	Computers are the main vehicle from Information and Communication Technologies (ICT), like Internet.

Refrigerators, T.Vs and computers in table 2, are interesting to discuss because they can serve an example about how factors like markets

technological change, and the environmental requirements create different conditions for the disposal from these products.

A refrigerator in Mexico is a case in which technological change and market forces were aligned with environmental requirements. Technological change makes refrigerators more energy efficient. From the Environmental point of view, there was a need to change the refrigerant gasses like Freon. Freon gasses and other CFCs (Chlorofluorocarbons) destroy the ozone layer that protects earth from ultraviolet radiation. In order to solve this problem, a worldwide agreement takes place at Montreal to eliminate the use of CFCs. This agreement is called the Montreal protocol.

Base on the Montreal Protocol, the Federal Electricity Commission (CFE) which is the National electricity company in Mexico creates a program named "*Cambia a tu viejo por uno nuevo*" (see figure 6) Viejo in Mexican culture is also a common word to name the husband; therefore the phrase could be also understand as the joke:"change your old husband for a new one". This program allows Mexican families to change their old refrigerator at an authorized recycling center. The way this program works is as follows:

Figure 6 Refrigerators Recycling Campaign (Recycling Center in Chihuahua (Photo Jesus Estrada. Jun 2011)

Families take their old refrigerator to the recycling center. The recycling center gives them a coupon. This coupon is used to buy a new refrigerator at any store without any payment because it is finance by the national electrical company CFE. Later families pay their new refrigerator through their electricity bill. The program creates a huge market that benefit retailers, producers, and saves energy.

Like Refrigerators, T.Vs in Mexico has a history or technological change and their interaction with social and cultural factors. This makes T.V a good case of study about how the socio-economical factors, technological change and legislation interact to define the opportunities to trade or waste old equipments. The first T.V appliances in Mexico were made of vacuum tubes. They were expensive. They were black and white T.Vs and they usually were built into elegant wood frames. Many of these T.Vs remain at Mexican homes because their value as part of the families memories.

Vacuum tubes were substituted by transistors and this make T.Vs cheaper. However the most powerful factor to dispose the old equipments came from a new functionality on T.Vs. For example, the change from black and white to color T.Vs. makes used black and white T.Vs available to low income families. A huge network of repair shops was build in order to maintain this old T.Vs. In addition supply chain networks for spare parts have to be established and this generates thousands of small shops.

However, new technology is not always enough to promote the change. For example, high definition T.Vs does not represent any advantages because the lack of programs transmitted in this technology. New programs available

in high definition make these new functionalities relevant and these factors allow new flat screen T.Vs enter into the market. Finally legislation is another factor that promotes change. For example, legislation in Mexico is forcing the change from analogical signal to digital. A change, called the digital blackout. However, in many towns and cities people do not perceive any advantages. The argument of the possibility to have more channels is irrelevant for places where only three channels can be seen. For the poorest families that still use the old black and white T.V technology this may represent the end of their possibilities to watch T.V.

Computers share some of the characteristics from T.Vs. In recent times, the problems derived from computer disposal through informal recycling practices gain the attention of the media. For example, CRT monitors are smashed to take the cooper out of them. These types of recycling methods release the harmful lead content from monitors (Torzewski, 2009). Although the damages to human health and to the environment derived from these practices are undisputable. Informal recycling is not the same that bad recycling. Informal recyclers are the result from a socio-economical structure which made difficult for them to formalize their activities (Mead & Morrison, 1996). Bad recycling, on the other hand are practices promoted by factors derived from complex systems.

What are these factors and how they affect the decisions from different stakeholders is the objective from this research. Eight different cities about 200 miles from the US-Mexico border were selected base on their characteristics to gain firsthand knowledge about the way e-waste is

perceived and managed by stakeholders (see chapter 3). Because there are a great variety of products that generate e-waste, computers were selected in order to provide a more deep analysis about the decision factors to waste or trade.

Factors to waste or trade a computer impact at various levels from the Micro-level in which individuals, like computer buyers and scavengers take decisions. To the Macro-level, where Institutions like governments made legislations in order to prevent and solve the problems derived from the overall operation of the system. Between the Micro and the Macro level, there is a Meso-level (Sveding & Liljenstro□m, 2005). It is at the Meso-level where stakeholders like producers, retailers, and recyclers shape e-waste systems at local level. However, these systems are in continuous evolution. For example, at international level there are trends like technological change and new legislations. At the micro-level individuals purchase and dispose their computers. The aggregated actions from individuals at the micro-level and the macro-level trends impact how stakeholders the Meso-level manage e-waste and computers disposal.

At Individual level, stakeholders are profoundly influenced by factors like culture and geography. Although, there has been extensive research about e-waste systems in the Macro-level, there is a need to understand how different cities and cultures adapt to the emergent phenomenon of E-waste.

This study uses structural analysis and tools from Lean Manufacture (See chapter 3) in order to understand the system from a bottom to the top approach with an emphasis on the cultural and geographical differences from

cities located at one of the most dynamic regions of the world. The cities located near the U.S-Mexico border. Second it analyzes how these differences interact with factors like legislation (Chapter 4), and culture (Chapter 5).

Finally with the use of deep interviews, and structural analysis it was possible to build a systems model through Data Flow Diagrams about the factors that shape the behavior from E-waste systems at Mexican cities near the U.S Mexico border (Chapter 6).

Chapter 2

STATEMENT OF THE PROBLEM AND RESEARCH QUESTIONS

2.1 Types of E-waste using the concept of *"muda" from* the Toyota System or Lean Manufacture.

The concept of waste is subjective, what is waste for an individual, in a particular time and place is not waste at all for another individual or for the same individual in different time and place. Waste is a very important concept in management and industrial engineering. For example the scientific management created by Frederick Taylor has the purpose to reduce the waste of labor. Henry Ford creates the assembly line in order to avoid waste of time (Montgomery, 1989). The automotive industry evolved from the times of Ford and today one of the most advanced manufacturing systems to reduce waste is The Toyota system also known as Lean manufacturing in the west. Japanese in the Toyota System developed an extraordinary concept for waste: "*Muda".* Muda means any human activity which absorbs resources but creates not value (Womack & Jones, 1996)

If we analyze computers e-waste through the concept of Muda, *E-muda* could be defined as: All activities in the life cycle from a computer that absorb resources but do not create value. According with this concept, in the life cycle from computers, waste can take several forms; therefore there are several types of e- waste. 7 of these types of waste have been identified in Table 3. This list does not pretend to be exhaustive because according with Lean manufacturing, the process to find new types of waste is a continuous one.

Table 3 Types of Waste a Computer may generate in its Lifecycle

1.	A computers disposed on a landfill absorbs the resource of space.
2.	Inappropriate recycling from a computer absorbs environmental resources, such as air quality, clean water and human health.
3.	There are valuable materials in the computer that are wasted, when a computer is land filled or recycled through inappropriate methods
4.	There is waste when a computer is store, while at the same time there are people with no access to computer technology.
5.	There is waste when there is a need to dispose a complete computer, because the high cost to repair and service a single component from it.
6.	There is waste, when a new computer is bought, to substitute a complete functional old one, but the new computer does not offer any relevant new functionality.
7.	There is waste, when microprocessors that required huge amounts of energy to be made, are quickly disposed.

2.2. Background Information about waste from Computers in Mexico

In Mexico, the problem of the waste generated by computers will not be perceived in the same way in all the cities and towns because of the enormous diversity in them. In big cities the most urgent problem is a type 1 to 3 problem. How to dispose E-waste materials, but there are other cities that their main problem is a type 4 problem (access to computers). This diversity can be clearly seen if we review the available statistics about computer ownership in Mexico. These statistics are available through national surveys made by the National Institute of Information and Geography (INEGI). INEGI is a government agency with the purpose to generate the statistical information about Mexico.

Figure 7 was design according with data from INEGI about computer ownership percentage at Mexican homes. It can be seen that in states like

Nuevo Leon, up to 45% of all homes have at least one computer, but states like Puebla, and Oaxaca at the southwest have less than 19% of homes with at least one computer. This variability on computer access at Mexican homes is also present among different cities from the same state. Because of these differences some cities may perceive the problem of E-waste from computers as a type 4 waste (lack of access) instead of a type 1, how to dispose the generated waste.

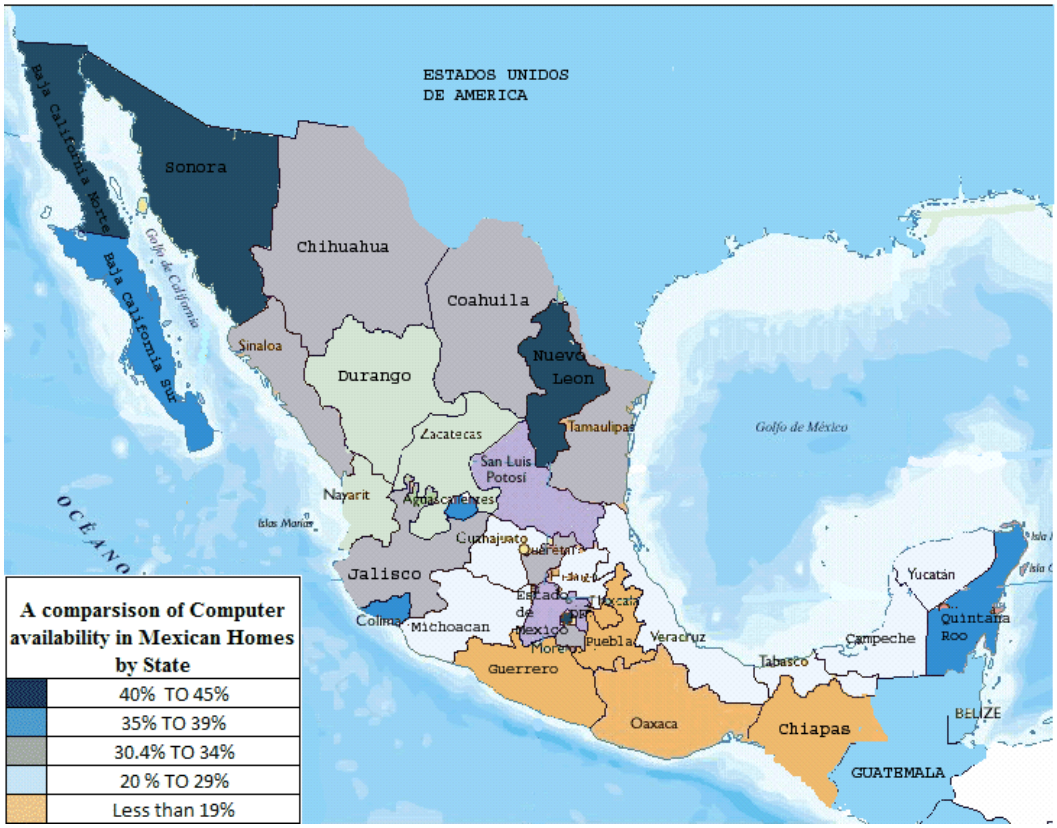

Figure 7 Computer' Availability in Mexican Homes by State. (Map created with Information from INEGI.

However, computers are not only use at homes, but their main applications have been implemented in business. The National Institute of Information in Mexico INEGI, made an economic census from companies in Mexico and these companies are classified according with the number of

employees. According with the last census in 2008 there were 2,118,138 companies in Mexico. Figure 8 shows the stratification from these companies and the access to computers in the particular segment. For example, 70.48% of all companies in Mexico have less than 2 employees, but access to computers in them is less than 4%. On the other hand companies with

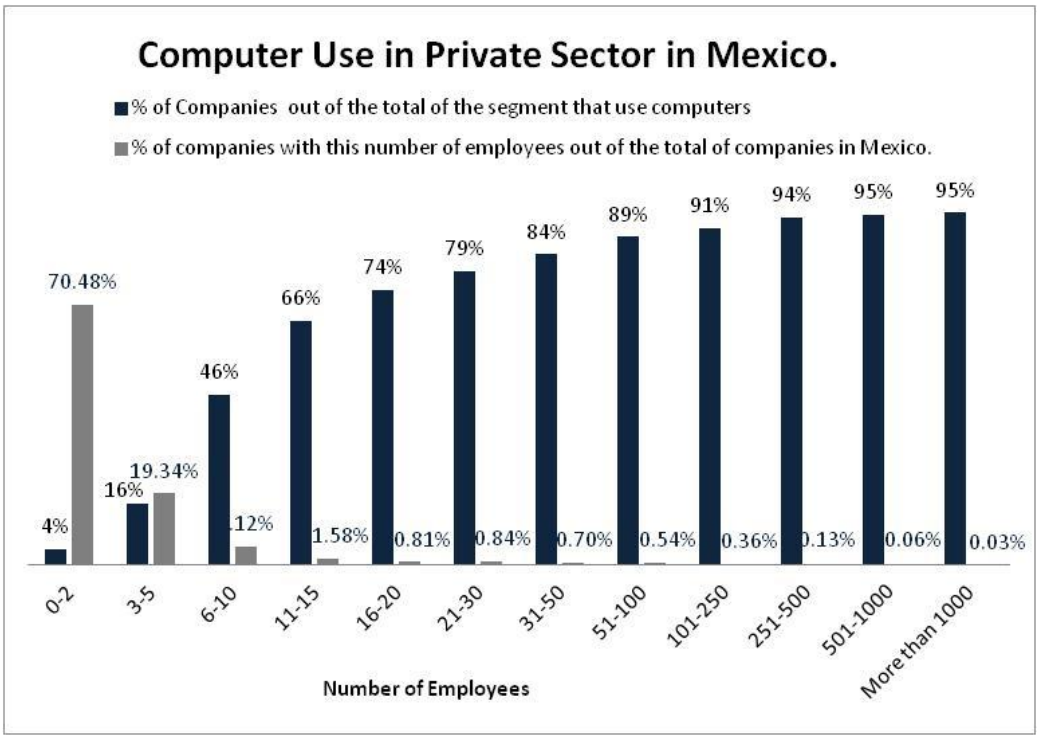

Figure 8 Computers in Mexican Companies (Data source INEGI)

More than 1000 employees have complete access to computers, but they are only about 0.03% of all companies in Mexico. Therefore, for big companies the problem to manage the waste derived from their computers is very different than the problems faced by small companies. Figure 7 and 8 shows the status of computer availability in Mexican homes and private companies in Mexico, but these figures represent only a photograph about the situation in a

particular time because computer technologies are evolving. Figure 9 shows how computers ownership in Mexican homes has grown in recent years.

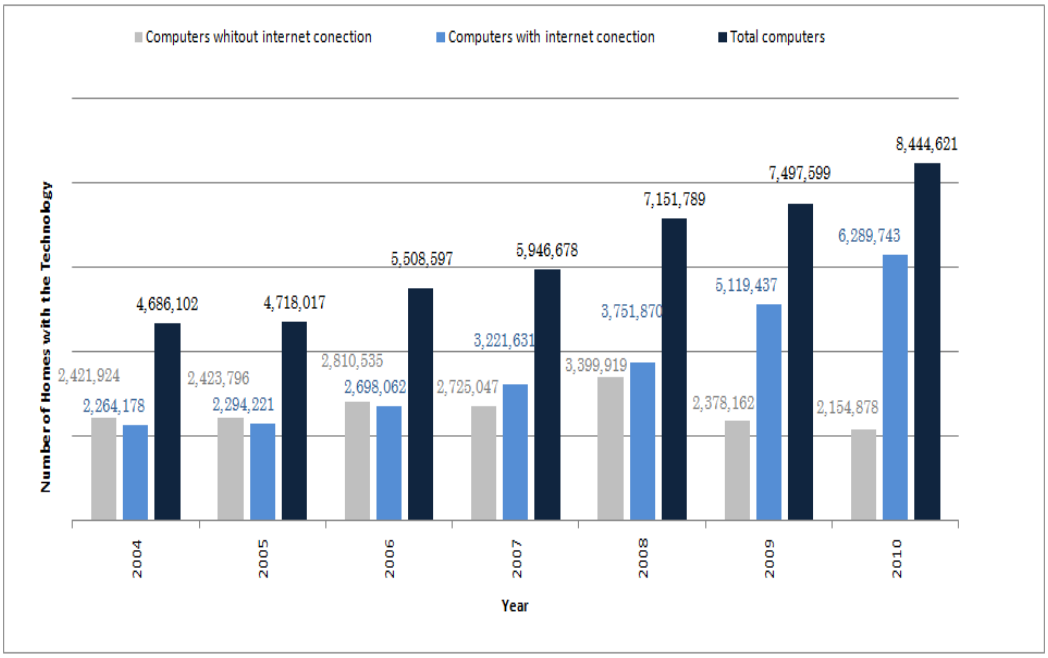

Figure 9 Computers Growth in Mexican Homes (Source INEGI).

In 6 years from 2004 to 2010 access to internet in Mexican homes had a threefold growth. This growth of computers in Mexican homes, may be important, in absolute terms, but if this growth is compared with other electronics products see figure 10, it can be seen that is still far behind from other well established electronic products like T.Vs and its growth is behind the growth from emerging electronic products like cell phones. Figure 10 shows how the E-waste derived from T.Vs that has up to 95% presence in Mexican homes will be more important in terms of their size. At the same time the waste derived from disposed cell phones, is going to increase faster than computers. Therefore, there is a need to design a strategy for them because they have special characteristics. For example their size makes easy

to dispose them inside the common waste. How computers 'waste is managed could provide some answers about how to manage T.Vs and cell phones waste.

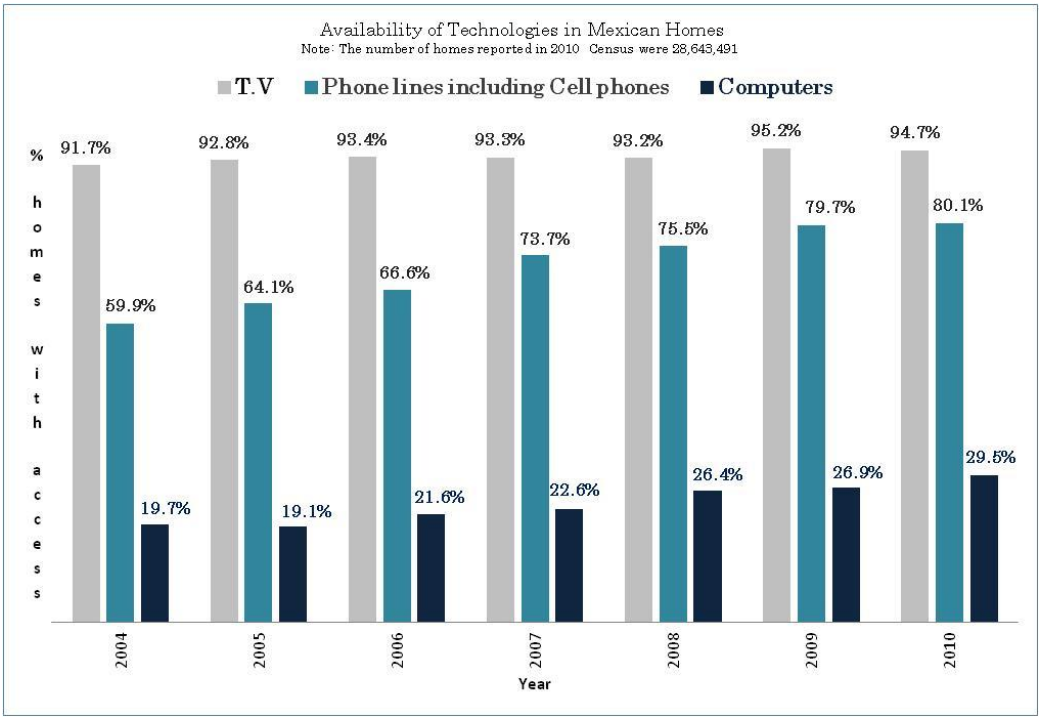

Figure 10 The Evolution from Electronic Products in Mexican Homes. (Data Source INEGI)

2.3 Statement of the Problem and research questions.

The waste derived from computers, can take many forms see table 3. For example waste can be defined as type 1, type 2 or type 3. (Type 1: space to dispose them on a landfill, Type 2 inappropriate recycling or type 3 valuable materials loss). A way to estimate the environmental impacts that result from computers disposal is to calculate the flow of used computers. According with a study made by the Instituto Politecnico Nacional (National Polytechnic Institute) the annual generation of e-waste in Mexico is about 270.000 metric tons (Moguel, Diagnostico de Basura Electronica en Mexico(Electronic waste diagnostic in Mexico, 2007), but there are not

detailed statistics about how many of these e-waste is caused by the disposal of computers. The flow of used computers can be estimated through a materials flow analysis and according with a study made by Arizona State for the Commission for the Environmental Cooperation of North America, the estimated flow of used computers in Mexico is between 230,000 and 2.2 million used computers Thee enormous variability is caused by the characteristics of Mexico because not all computers are connected to the internet (Kahhat, Williams, & Podury, 2011).

This article argues that there is an enormous diversity in Mexico and this diversity impacts the materials flows. This diversity is present in geographical, economical and social terms and can be seen in the following factors:

- The high income population in Mexico is very similar to their counterparts in other places of the world, but the middle income and low income segments in Mexico are very different in cultural and economical terms; therefore their decisions are different.
- Towns are different than industrial cities in Mexico.
- Cities that are very close to the United States have in addition to the flow of computers from Mexico, the flow of used and new computers from the United States.
- Technology and materials from ICT technologies are evolving; therefore, it is possible that some of the new technologies may be easy to adapt by low income population triggering the disposal from one particular electronic product instead of another.

Used computers have also important social considerations, which need to be evaluated. For example, there are numerous small entrepreneurs in Mexico (see figure 8), who will benefit from used computers availability. In addition the cost to renew a computer in relation with the income in Mexico make the decision to dispose for low income users very different than in the developed countries.

Finally, although there are not environmental and health problems reported in the literature (A waste type 2) in Mexico. The size of Mexico makes possible that informal recycling could take place at a small scale in small towns or poor suburbs from big cities; therefore, in order to prevent these problem a better understanding from this diversity is required and this is the objective from this research.

2.4 Thesis Statement.

The waste derived from computers is the result of a complex system with a dynamic nature. The flow of used computers changes according with factors that drive its evolution. One of the most important factors is legislation, but there are other factors which either promotes or deterrent the decision to waste or trade computers and their materials; therefore they ultimately control the flow of computer waste.

What are these factors and how they affect the decisions from different stakeholders is the objective from this research. Eight different cities about 200 miles from the US-Mexico border were selected base on their characteristics (see chapter 3).

Although the solution proposed to understand the flows of used computers and computer waste will not provide a numerical answer, it will provide an important piece or information for policy makers and future legislation because according with an Earth Systems Engineering and Management principle, before proposing any potential solutions to the system." The system including relevant stakeholders may be understood as a whole" (Allenby, 2005 pg 186).

Chapter 3

METHODS

3.1 Field, Studies location and criteria to select the cities.

The available statistics about computer ownership in Mexican homes show that there are enormous differences in computer ownership among the different states (figure 7). Most of small companies in Mexico do not have computers (figure8). In addition to these two internal sources of variation at the US-Mexico border through the different ports of entries there is a recorded daily movement of almost half a million people from Mexico visiting the United States (del Castillo, et al., 2007). This movement of people

City	State	Type of city
Tijuana	Baja California Norte	Border City
Rosarito	Baja California Norte	Touristical city
Nogales	Sonora	Border City
Hermosillo	Sonora	State capital
Cuahtemoc	Chihuahua	Agricultural city
Juarez	Chihuahua	Border city
Chihuahua	Chihuahua	State capital
Monterrey	Nuevo Leon	Industrial city

Figure 11 Field Studies about E-waste in Mexico

suggests that in cities that are near enough to the United States to allow the movement of people and goods on daily basis, there is going to be a more

complex flow of used computers, and e-waste than in other parts of Mexico. Therefore, in order to understand these flows of computers and e-waste, field studies were performed at 8 different cities in the north of Mexico. Figure 11 shows the location of the cities, where the field studies were made and some of their most important characteristics.

At figure 11, the first city at the North east is Tijuana. There are two main reasons to include Tijuana. The first is that the activities of used computers shops in Tijuana will have a strong influence from the e-waste legislation from California. The second reason is that Tijuana is the largest border city and together with San Diego, it can be considered as trans-frontier metropolis (Herzog, 1991). A transfrontier Metropolis is an urban city that despite being at two different countries is an integrated urban sprawl that faces common problems and share common resources. The Tijuana and San Diego area have a growing population that at present accounts for more than 5 million.

At the south of Tijuana there is a small town called Rosarito. Small towns like Rosarito are common near big cities. The reason to include Rosarito in the field study is to understand the influence from big urban centers at small towns and how this relationship is reflected on the e-waste stakeholders.

The next two cities that are shown from left to right in figure 11 are two cities located at the State of Sonora. The first city at the north is the city of Nogales, a Mexican city at the border with Nogales Arizona. Nogales is a border city, and its main economic activity is carry out by international

manufacturing companies. These companies assemble a variety of products in Mexico that are exported to the United States market. Hermosillo on the other hand is the capital of the state of Sonora. The reason to include these two different cities is to contrast how their differences impact e-waste management and used computers flows.

According with the information in computers ownership (figure 7), Sonora and Baja California Norte are two states with similar computer ownership, but the state of Chihuahua, have less computer ownership despite being a border state and having one of the largest border cities, Juarez. In the state of Chihuahua field studies were made at three different cities: Juarez, Chihuahua and Cuauhtémoc.

The reason to select the city of Chihuahua is because it is the capital and the second largest city in the state. The reason to include Cuauhtémoc is that it is a small city which main economic activity is agriculture. These two cities in the state of Chihuahua provide a way to contrast how small cities like Cuauhtémoc and capital cities like Chihuahua are managing e-waste as compared with a border city like Juarez.

Finally, the field studies include the city of Monterrey at the state of Nuevo Leon. Monterrey is the third most important city in Mexico in terms of population and it is the second because of its economic impact. Monterrey have an economy base on Mexican national industries, so stakeholders from Monterrey could provide a good example of how e-waste is perceived and managed differently in relationship with the other cities.

In sum field studies include three different states, and 8 different cities with diverse characteristics. The objective is to include diversity as part of the research. A summary of the criteria to select these cities and their main characteristics is shown in Table 4.

Table 4 Criteria to Select the Cities, to make the Field Studies

City	Main Characteristic	Reason for choosing the city
Tijuana	Border city	To understand The impact from California legislation.
Juarez	Border city	To understand The impact from informal commerce
Nogales	Border city	To contrast a small border city with large border cities
Hermosillo	State capital	To understand the role of the government
Chihuahua	State capital	To contrast the role of Chihuahua government
Cuauhtémoc	Small city	To understand the impact of E-waste in agricultural cities.
Rosarito	Small city	To understand the computers flows at touristic cities
Monterrey	Industrial City	To understand e-waste in a large industrial Mexican city.

The matrix from different cities with different characteristics provides a wide array from different communities and this design allow comparing factors such geography, culture and population. The wide scope from field studies main goal is to understand how this diversity impacts on how stakeholders manage E-waste.

The inherent problem of widening the scope on a research is to sacrifice the grade of detail. However, it is possible to overcome this limitation with a careful selection of the type of interviews. It was the selection from the interviews methods, the factor that allow collecting more information in qualitative terms.

3.2 Interview methods.

There are two general categories of interviews: Structured and unstructured. The former is use to test a theory, while the later is use to understand the behavior (Denzin & Linconln, 2000). Because the objective from this research is to understand the complex behavior of multiple stakeholders, unstructured interviews were used. The method for a deep/unstructured interview has the following sequence (Wengraf ,2001, pg 84): Central Research Question (CRQ) → Theory Question (TQ) →Interview Question (IQ) Accordingly:

Table 5 Research Questions, frame for the Interviews.

CRQ- What are the factors that drive the flows from used Computers and e-waste?	TQ1-Characteristics from the equipment/waste.
TQ2-Characteristics from their market	TQ3-Fate of their waste/geographical location.
TQ4-Perceived trends on their customers/activities.	TQ5-Main problems faced in their daily activities.

Deep unstructured interviews provide information about how stakeholders are managing e-waste. In addition because of these stakeholders are in contact with individual users, they could also provide information about them. The main reason to use an unstructured interview approach is that at the present state of the knowledge about e-waste at the Mexican cities near the U.S border it is still not possible to test a theory. According with an ESEM approach there is a need to be able to understand the system and relevant stakeholders as a whole (Allenby, 2005).

Unstructured interviews allow stakeholders to provide qualitative information about how they perceive e-waste.

3.3 Analysis Methods.

Deep unstructured interviews provide information about how stakeholders at different cities are managing e-waste and used computers. In order to transform these data into information and create a model to understand the system and relevant stakeholders a technique called structured analysis were used. Structured Analysis is a method used in computer science to create a model of "the real world" using a data flow diagram (DFD) (Yourdon, 1986).

A DFD is graphical representation of the Information flow and they can also be used to represent the flow of activities in a process. DFD can be also used to show decision processes and the flow of information. DFD became a useful tool to represent the decisions that control the flow of materials and information in factories, so they are widely used by industrial engineers. In the same way that a DFD can represent the flow from materials on a factory it can represent the flow of used computers and e-waste materials at the communities.

The method to accomplish this goal is to follow the flow of materials from one stake holder to the next. For example a repair shop, provides information about, who collects its waste. E-waste collectors provide information about the sources from their materials and where the collected materials are either recycled or shipped. Step by step this method builds the DFD.

Information levels (Micro-level Meso-level and Macro level)

The information provided by stakeholders such as scavengers, refurbishers and computer recyclers can be transformed into a DFD. However, this information can be build at several levels. For example the information from refurbishers about their customers can be used to build a decision flow chart about how individual computer users decide if a computer can be waste or trade (Figure 22). This particular DFD will reflect how the system is performing at micro-level.

The information from stakeholders can also be used to build a DFD at a higher level for example at the level of companies and other corporate stakeholders such as schools or government agencies. This new DFD is going to reflect the system at a Meso-level scale. Finally with the information about legislations, laws and aggregated data a DFD can be built at a Macro-level.

In sum a DFD at the smaller level of analysis is called Micro-level and in this paper is referred to describe the individual decisions. The biggest level of analysis at aggregated properties is called Macro-level. Macro-level is often the level in which more statistics are available. Macro level corresponds with the material flows between nations. Recently there has been an increase interest to understand the relationship that connects the Micro-level to the Macro-level. This level of analysis has been called Meso-level (Yourdon, 1986) (Sveding & Liljenstro□m, 2005).

The method used through this research, use the information provided by individual stakeholders to build a DFD at the micro level. The next step, following a bottom up approach is to build a DFD at the Meso-level. Finally

the macro-level is review in terms of factors such as culture, technology and geography.

The structured analysis requires that the flow of information or materials can be expressed according with a systems theory in terms of command controls. Command controls define a decisions according with an open or closed status. This is translated by finding the moments that define the status from computers accordingly. In other words decisions which define what is going to be the status from the material. In order to accomplish this goal, it was necessary to develop an analysis of the decision moments that define the flow from materials. Because these decision moments are caused by several factors, they could be analyze through Ishikawa diagrams.

Method to analyze the decision factors (The Ishikawa Diagram)

Ishikawa diagrams are named after Kaoru Ishikawa, who starts using them since the 1960s to identify factors causing an overall effect or a quality problem (Ishikawa, 1990). They are also known as fishbone diagrams because its form resembles that of a fish. The main objective from this form is to reflect the interaction and the connections between causes and the overall effect. In order to provide an ordered arrangement, these causes are grouped base on their characteristics. For example, the six M method, which is used in manufacturing, provides an order in the diagram according with the following general causes: Machinery, methods, men, manpower, Mother Nature (environment) and management. The five S methods, which is used in services means: surroundings, suppliers, systems, skills, and safety. There

are other ways to classify the causes, but its main objective is to fit the purpose from the analysis.

In the present research, the objective is to understand the factors that drive the materials flows from used computers into e-waste. These factors were arranged base on three important moments that define the generation and the flow from used computers and their waste.

The first decision that generates either e-waste or a used computer is the decision to purchase a computer. The second decision is to store or dispose a computer and the third decision is the decision to collect this computer either to re-sell or recycle. For each of these decisions, factors were identified base on the information from the interviews. These factors were grouped into two general categories: promoters and deterrents.

Promoters are those factors which move forward the decision, while deterrent are those that held the present condition. For example promoters are factors which make the user to purchase a new computer, and deterrents are factors which make the user to keep their present computer.

Types of stakeholders and the variable nature from the e-waste materials that come from computers.

The decisions to purchase a new computer and replace the old one .are decisions take by two types of stakeholders: corporate and individuals.

Corporate users are schools, government agencies and private companies that decide to dispose all their equipments or at least part of them. According with the size of the company the quantities from disposed equipments can be considerable large but their characteristics are usually

uniform. Individuals on the other hand replace one computer at a time, but the increased personal use from computers could produce large quantities of equipments that require being disposed. However, the characteristics from these equipments are not uniform.

As result from these two types of stakeholders, the equipments that are available to trade have different characteristics, and their disposition is going to be different. There are three possible dispositions for a computer and their materials. The first one is that computers are trade as used computers. The second is that computers can also be trade as spare parts. These parts are used to repair and refurbish used computers; therefore most of these parts will perform the same function. A third option is that computers are trade, in order to extract valuable materials in them, so materials can be recycled. Finally materials that have no value are disposed as waste.

Computers end of life or Computers end of use.

This diversity creates the need to clarify some of the terms, like Computers' end of life or computers end of use, Computers recycling or computer refurbishing. It also creates the need to clarify some of the stakeholder's names. The distinction between the end of life or end of use makes all the difference in terms of how materials are managed. Used computers are trade by multiple stakeholders, to be use as computers; the end of life on the other hand is often made in order to save valuable materials. Table 6 shows a glossary of some of the terms as they are used in this paper.

Table 6 Glossary of Terms

Computers end of life.	The final phase in the life from a computer. When the equipment is no longer used as a computer.
Computers end of use.	It is the phase when a computer is replaced by its user, but is still completely functional.
Computer refurbishing	When a computer is repair, clean and its software update, so it can be re-used
Parts recycling	When a computer is dismantle to re-use its parts
Computer recycling	When a computer is dismantle for their materials.

3.4 From field studies to decision factors a summary of methods.

In sum, the first part from this research involves a literature review about e-waste in Mexico. The review from available statistics show the need to have a more deep knowledge about the flows from used computers and E-waste materials at cities near the US-Mexico border this part is reflected in the first two chapters.

The next set of methods involves field studies and these studies require defining criteria to select cities. The criterion to select cities involves four characteristics. First selected cities have to be located at less than 200 miles from the U.S-Mexico border; second there is a need to include the largest border cities in Mexico Juarez and Tijuana. Three there is a need to include capital cities from three different states to test the influence form state governments and four there is a need to include small cities that could provide a contrast with the large cities.

The method to obtain the information from the field studies were unstructured interviews. Unstructured interviews provide more qualitative data about how stakeholders perceive e-waste and their particular problems.

The method to analyze the information used two main tools. The first one was taken from the system theory: the DFD which allow creating models from the system, in order to understand how stakeholders are related. The second method was the Ishikawa diagram, which allows understanding the factors that drive the E-waste and the used computers flows.

Chapter 4

E-WASTE LEGAL FRAMEWORK AT BOTH SIDES OF THE BORDER

One of the most important factors for E-waste management is the law. Legal structures can be seen as instruments used by the society to create new entities and regulate human affairs. In affluent societies, the laws about waste disposal were created because the growth in quantity and complexity of the goods that have to be disposed and because of the environmental consequences from the disposal from them.

Low income societies perceive waste as what is left with no further value. E-waste materials have value. It is this value that creates the emergence of their global commerce. The international commerce creates new environmental threats, Therefore; the need of legislation at international level. The largest international agreement which regulates the movement from electronic waste until today is The Basel Convention. The Basel Convention agreement was enacted in 1992. The Basel Convention is an agreement which objectives are: the environmentally sound disposal from hazardous waste and to avoid the movement of hazardous waste into countries, which do not have the capacity to dispose this kind of waste. The main instrument to reach these objectives is the right of a country to refuse waste. The country of origin from the waste provides a written notice about the materials which it intends to move. After that notice, the country of destination has up to 60 days to issue a written approval or refuse the movement.

The Basel Convention also forbids the shipment from hazardous waste below the parallel 60, and recently it includes a disposition that forbids OCDE countries to export e-waste to non OECD countries. E-Waste is included among the materials that are subject to the convention because of their materials content.

However, the most influential legislation about electronic waste is the European WEEE directive. The WEEE directive has served as a model for other countries to enact a similar legislation see Appendix B. An important principle behind the WEEE directive is the principle of Extended Producer Responsibility (EPR).

4.1 Important Concepts applied on the E-waste laws.

Extended producer responsibility is a concept that establishes that producers are responsible for the waste generated by their products through their whole life cycle. It was presented by Thomas Lindhqvist for the first time in 1990 (Lindhqvist & Kudgreen.1990). The EPR goal is to provide the incentive for producers to reduce the environmental impact of their products through their life cycle (Lindhqvist 1992).

EPR have five elements: Liability, Economic responsibility, physical responsibility and informative responsibility. Liability is the responsibility for proven environmental damages and it is defined by legislation. Economic responsibility means the producer cover part of the expenses caused by the final disposal of the product. Physical responsibility is when the manufacturer is involved in the physical management of the products and their effects and finally informative responsibility means that the producer

must share the information in regards any environmental concern about its products.

In order to implement these five elements, there is a need to define, which the producer is and what the retailers' responsibility is, in other words how to implement a system to collect the waste. Systems to collect waste are called take back systems.

Take back systems

Legislation defines how users can dispose their products and establish the collection system. There are several forms to organize this collection .For example, retailers responsibility can be organized base o sale rule, representative rule and local authority rule. Sale rule means that retailers must accept a product when they sold a similar product. Representative rule establishes that a retailer must accept regardless the brand any item of the same kind, for example a dishwasher's vendor should accept any dishwasher. Local authority rule in the other hand establishes that local authorities must accept any item that is not covered by the other two rules.

4.2 Mexican Legislation about E-waste.

Mexico is member of the Basil Convention and the North American Free Trade Agreement (NAFTA) with the United States and Canada. In addition to International laws there is a federal law which defines e-waste as waste with especial handling; therefore, each state have to regulate it on their own legislations. The body of laws in relation with e-waste can be seen in figure 12.

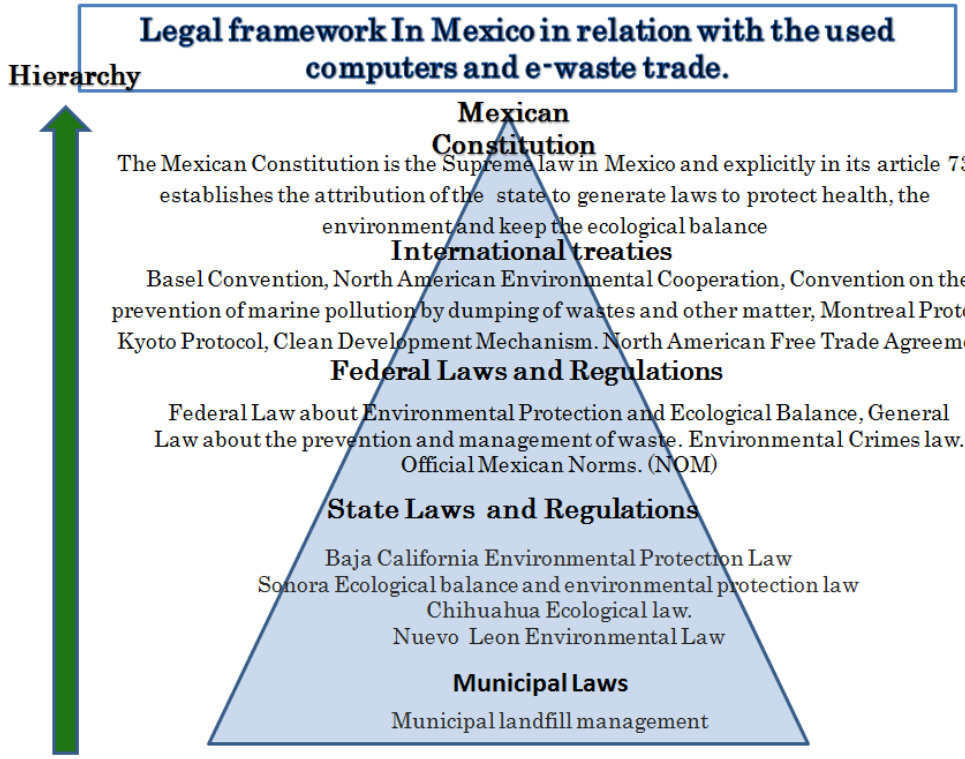

Figure 12 Hierarchy of Legal Framework from Environmental Laws in Mexico

There are three important legal frames to review in Mexico in regards used computers and electronic waste flows between Mexico and the United States: 1-Environmental laws, 2-Commercial laws, and 3-Technical Norms.

Environmental Laws

The main environmental law in regards E-waste in Mexico is the federal law: "*Ley General Para la Prevencion y Gestion Integral de los residuos*" (LGPGIR). (General Law made to prevent and manage Wastes). This law classifies E-waste as a waste with a special handling and it leaves the responsibility to the States to create the provisions to control and manage e-waste. However, Mexican Congress is working on a new legislation on E-waste.

Commercial laws

Customs laws control which products can be imported and this defines how new and used computers can be imported into Mexico. The Customs laws in Mexico have four categories in which a product or material can be legally imported into Mexico. These categories are called "*Regimen Aduanero*" and according with these four categories, there are different requirements in order to import materials and products into Mexico (see figure 13). Personal

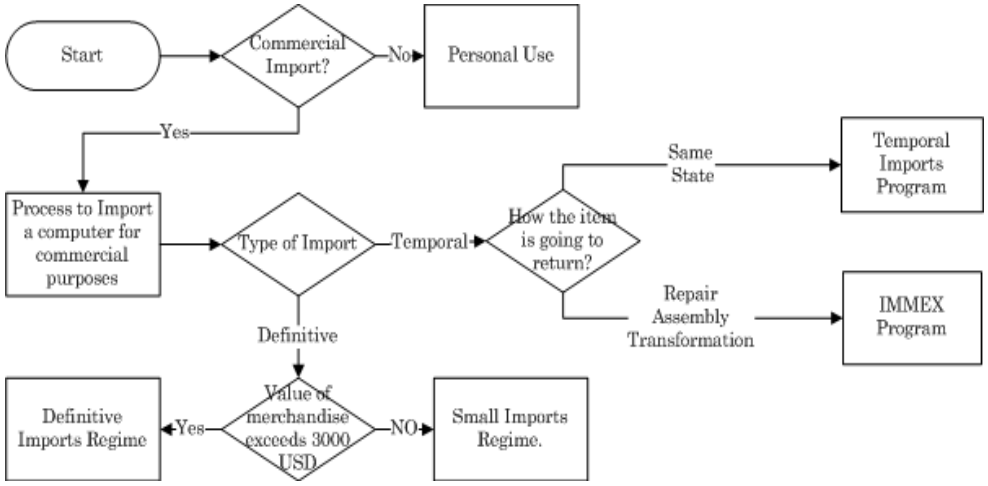

Figure 13 Decision Chart to define Customs Regime

used computers like laptops are free to import as part of the travelers luggage. It is possible also to freely import merchandise up to 300 USD . If the merchandise value is more than 300 USD, but less than 3000 USD, the merchandise is handle through the small Imports regime. The small imports regime, does not require to hire a customs broker to import a product. The customs oficial directly, either defines the fee to import the merchandise or denied the entry of them. The general procedure to import any merchandise into Mexico can be seen in figure 14 and the documents neccesary to import a computer can be senn in figure 15.

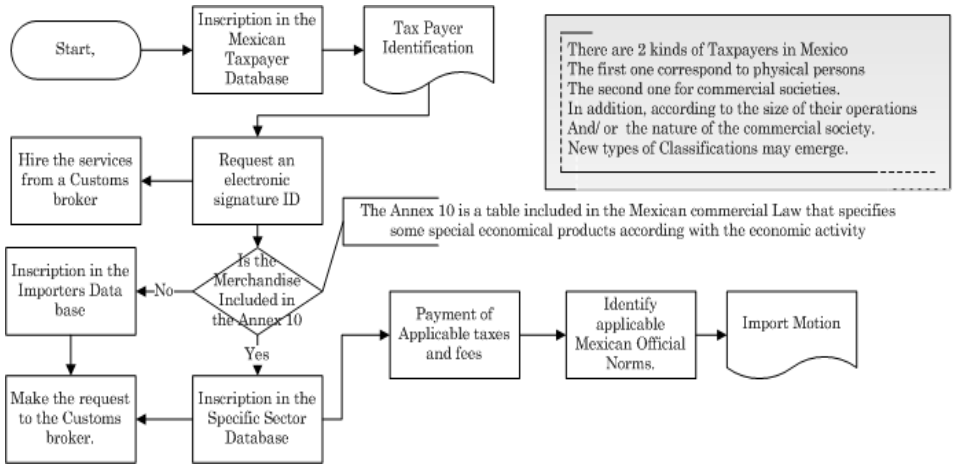

Figure 14 General Procedure to import merchandise into Mexico

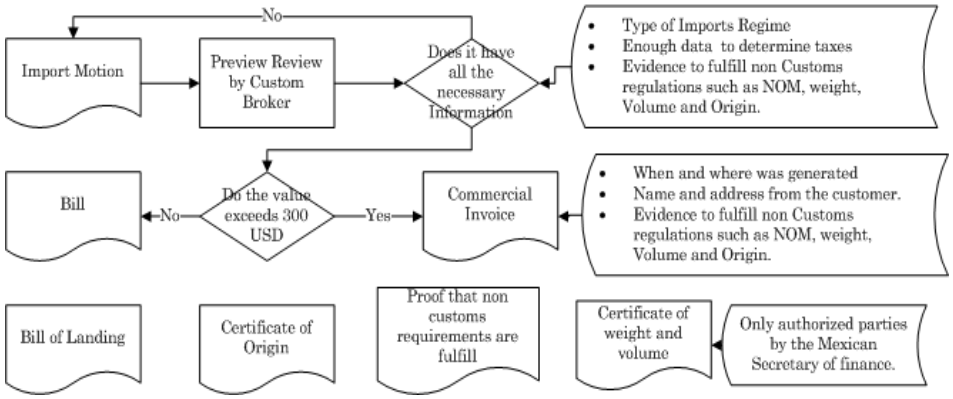

Figure 15 Documents required for importing products into Mexico.

The North American Free Trade Agreement (NAFTA) enacted in 1994 in their fraction 84.71 established a 10 year period to allow used Computers to be imported into Mexico. It was until 2004 when used computers could be legally imported into Mexico. There are two important requirements that used computers must have in order to be imported into Mexico. The first one is that used computers should be made in USA or Canada, otherwise they cannot be imported free of taxes, Second they need to comply with the applicable Official Mexican Norms (NOM)

Technical Norms.

The Official Mexican Norms (NOMs) are technical and specific requirements. They have the purpose to protect Mexican Consumers, from health risks, or environmental risks derived from the characteristics of the products. Table 5 shows the relevant NOMs in regards e-waste.

Table 7 Summary of Relevant NOM in regards E-waste

Official Mexican Norm	Scope	Objective
NOM-052-SEMARNAT-2005 "*Caracteristicas, Procedimiento, Identificacion y Clasificacion de Residuos Peligrosos*"[Procedures for identification and classification of dangerous waste].	These norm applies to electronic components, solvents used for electronic boards cleaning and for waste derived from the electronic process.(NOM-052)	This norms establishes the maximum toxic levels for instance, lead content , and other metals such as arsenic, barium, cadmium, mercury, silver and selenium
NOM-019-SCFI-1998 Equipo de Procesamiento de Datos [Data process' equipment]	This norm applies to any computer and/or electronic communication device	The objective from this standard is the safety and security from computer' users
NOM-024-SCFI-1998 Etiquetado de Productos Electrónicos y Electrodomésticos. [Labeling of electronic products and household appliances].	These norms applies to all computer and their parts well as other electronic devices	This norm controls the information that is require to label electronics products
There is a projected NOM already approved by the technical group in 2010. This Norms defines the criteria, elements and procedures for special waste handling.	It applies to products, which require a special handling at the end of its useful life.	It will provide the Criteria for handling of products such as refrigerators, AC, washers, microwaves, computers, cell phones, (CTR). Plasma screen, Liquid Cristal, Audio and video devices and printers

4.4 United States Legislation

The United States does not ratify the Basel Convention, but the related federal law in regards waste is: The Resource Conservation and Recovery Act (RCRA) that governs the disposal of solid waste and hazardous waste. According with this law some materials from computers are considered hazardous for example, CRT tubes. There is not a federal law about e-waste, but a new legislation the bill HR6252 the Responsible Electronics Recycling Act is in the process to be discussed.

Although there is still no legislation about E-waste in the United States at federal level, 20 States have enacted laws about e-waste. The most important for the used computers flows at Mexican cities near the United States are from the Border States because these state laws define the availability of equipments for Mexican merchants.

Two states at the U.S-Mexico border have enacted legislation in regards e-waste: California and Texas. A summary of the main characteristics from these laws can be seen in table 8. Table 8 shows how Authorities, Producers or Retailers interact in the law.

Authorities are the governments or local authorities' bodies that have the responsibility to manage the program. Producers or retailers refer to the companies that manufacture and sell computers and finally consumers are the individuals that purchase a computer or other electronic equipment. As a result from these laws there is an active commerce or used computers However, legislation is not the only factor that drives the flows of used computers, but certainly is the most important

Table 8 Summary of U.S Border States' Legislation about E-waste

Legislation	Authorities	Producer/Retailers	Consumer
California E-Waste Recycling Act was passed by legislature in 2003	The fee is collected by the State of California. And it is charge at the moment of the purchase.		Beginning January 1 2009 covered electronics devices sold in California are subject to recycling fees in the following amounts: 8 USD for each electronic Device with a screen size less than 15 inches measured diagonally. 16 USD for a device with more than 15 inches but less than 35 inches and 25 USD with a screen greater of equal to 35 inches measured diagonally.
Texas computer equipment Recycling Law. House Bill 2714. Enacted 2007.Effective Date: January 1 2008 Enforcement Date January 1 2009	Texas Commission on Environmental Quality must develop a consumer education program to make consumers aware of the need to recycle end of life computer equipment	Retailers cannot sell computer products to consumers unless the manufacturer has filed a recovery plan and has properly branded its products.Retailers are responsible for determining if the manufacturers whose product they sell is in full compliance with law Manufactures can design the most cost effective and innovative recycling programs based upon their business models.	Consumers are urged to take advantage of the free recycling programs provided by manufacturers under this law: No Charge to consumer either at the time of purchase or at time of disposal.

Chapter 5

FROM THE MACRO LEVEL TO THE MICRO LEVEL A SYSTEM ANALYIS OF THE E-WASTE SYSTEM IN SELECTED CITIES.

5.1 The cultural factor in cities near the U.S-Mexico Border.

Today Mexico is an urban country. In 2010 at national level 78% of the population lives in cities according with the Census. In the northern states the urban population is between 85% and 94%.Northern states represent about 17 % of all the population in Mexico, but they generate up to 25% of Mexico GDP.

Historically northern cities in Mexico born as a mining towns and agriculture in them were a subsidiary activity. At the end of the Nineteenth Century the "*Haciendas*" (big agricultural enterprises), became the place where most of the population lived and work. In 1910 poor peasants from the Haciendas rebelled and the Mexican civil war started. The railroads system, which was planned to promote the development for the country serve to move the armies. The civil war takes almost a decade, and when the civil war ends the Haciendas system was dismantled, but peasants remain poor. In 1942 at the same time that the United States sent their soldiers to World War II, a peaceful army of Mexican peasants enter into the United States as part of the Bracero program to support the United States production (El movimiento 2006). Almost five million Mexicans were part of the program until 1964 when it officially ends.

Mexican cities near the U.S-Mexico border grew up as a crossroads, from Braceros that returned from the United States and new immigrants seeking to enter into the United States. The massive return from *"Braceros*" at the end of the *"bracero"* program, promote the growth from border cities and the need to create new jobs for them. In order to create jobs, in 1960 the first industrial parks to host Maquiladoras were created.

"*Maquiladoras"* are international manufacturing companies that import parts into Mexico and use Mexican labor to assemble products that are returned to be consumed in the U.S market. There are also "Maquiladoras" that make sub-assemblies that are ship to U.S factories, where the final product is made and ship from there to the entire world. It was the increasing pressure faced by American companies to compete with international companies with lower labor costs and the need to create jobs at the border, the factors that create the conditions in Mexico and the United States that promote the growth from the Maquiladoras in Mexico (Medina, 2011). The General Agreement for Tariff and Trade, in 1980s and later the North American Free Trade Agreement in 1990s, accelerate the development from the *"Maquiladora*" industry. The high demand for workers at the "*Maquiladoras*" increases the urban growth in border cities. For example, the availability of jobs in Juarez allows workers to move from plant to plant in search of better work conditions. In order to reduce this mobility the "Maquiladoras" start a program to recruit workers from all over Mexico. As a result the population from Juarez grew from 700 000 inhabitants to more than 1,300,000.

Border cities, were not the only cities in the north of Mexico, who benefit from the deployment from "*Maquiladoras* ". In order to support the development from other cities, the Federal and local governments in Mexico invest to modernize the highway infrastructure (See figure 16) and this makes other cities near the U.S border attractive places for "*Maquiladoras"*.

Capital cities like Hermosillo and Chihuahua, which are about 200

Figure 16 Road to the city of Cuauhtémoc. (Photo Jesus Estrada)

miles from the U.S-Mexico border, were the first to be connected with modern highways, but as more cities became connected, cities like Cuauhtémoc with a more stable workforce became a competitive option.

"*Maquiladoras*" became the largest employer in border cities like Tijuana, Juarez and Nogales. They are the second employer after the government in capital cities like Hermosillo and Chihuahua and they have an increasing presence at small cities like Cuauhtémoc.

Electronics is an important sector from the Maquiladora industry. For example 30 millions T.V sets are assembled in Baja California every year (Moguel, Diagnostico de Basura Electronica en Mexico, 2007). Foxconn, a

larger manufacturer of electronics, assembles cell phones in Chihuahua and is going to assemble computers on a new massive complex of about 240 hectares in the city of Juarez (Ampliara 2011). There are others electronics, products assembled in Mexico. For example, Altec electronics manufacture car auto stereos, Scientific Atlanta manufacture cable decoders; Philips manufacture T.Vs; Acer and Tantung manufacture PC monitors. In addition there are numerous plants that manufacture electronic parts that are ship to the United States where, final assemblies are made. There are up to 200 plants in Baja California Norte, 98 plants in Chihuahua and 49 in the state of Nuevo Leon that manufacture electronics or their subassemblies according with data from the Manufacture and Exporters Association.

Finally, it is important to point out that among the cities, where the field studies take place the city of Monterrey have some unique characteristics derived from their development. Monterrey develops a strong industrial base because the small foundry build to supply cans to its beer industry experience a huge growth derived from the steel demand at the WW II (Mares, 1976). Today Monterrey is the third largest city in Mexico and home base from some of the biggest international Mexican companies.

There are three characteristics derived from the historical evolution in northern cities in Mexico which are important for this research.

1. The high connection these cities have with American cities.
2. There is a knowledge base in the population about how to assemble electronics derived from the experience from workers at the electronics industries.

3. There is a knowledge base about the value from metals derived from the mining operations that have been part of the history from the northern cities.

Economic activities and immigration have shaped the culture at cities near the U.S-Mexico border. However, there has been a continuous change in technology. For example, the Moore Law establishes that the capacity from integrated circuits doubles each two years (Moore 1965). The exponential growth in many technologies has been argued to be a proof that human civilization may reach a point which is called singularity. Technological Singularity is an idea coined by I J. Good about how supercomputers may overcome human intelligence. Kurtwell and Vinge predict that no later than 2030, humans will have the capacity to create super human intelligences.

The changes in integrated circuits are present in methods and materials to manufacture electronics products; therefore, at the same time that new methods to assemble the last computers models are implemented in "Maquiladoras", Mexican merchants buy the old versions from them at used stores or from recyclers in the U.S. These equipments are refurbish and sold in Mexico

5.2 Macro-level Analysis about E-waste in Mexico

There are not detailed information about the kind of processors and other characteristics from the equipments that are imported into Mexico. A traditional macro-level analysis to correctly quantify the flows of E-waste will demand vast resources to make surveys at different cities and at different population segments to correctly quantify the E-waste generation among

cities that have very different characteristics. However, base on data from the interviews made to stakeholders at cities near the US-Mexico border it was possible to build a DFD that shows the information flows to import used computers and export new computers and e-waste to the United States. Figure 17, shows a general view from the E-waste system as described by recyclers and refurbishers in the cities, where the field studies were made.

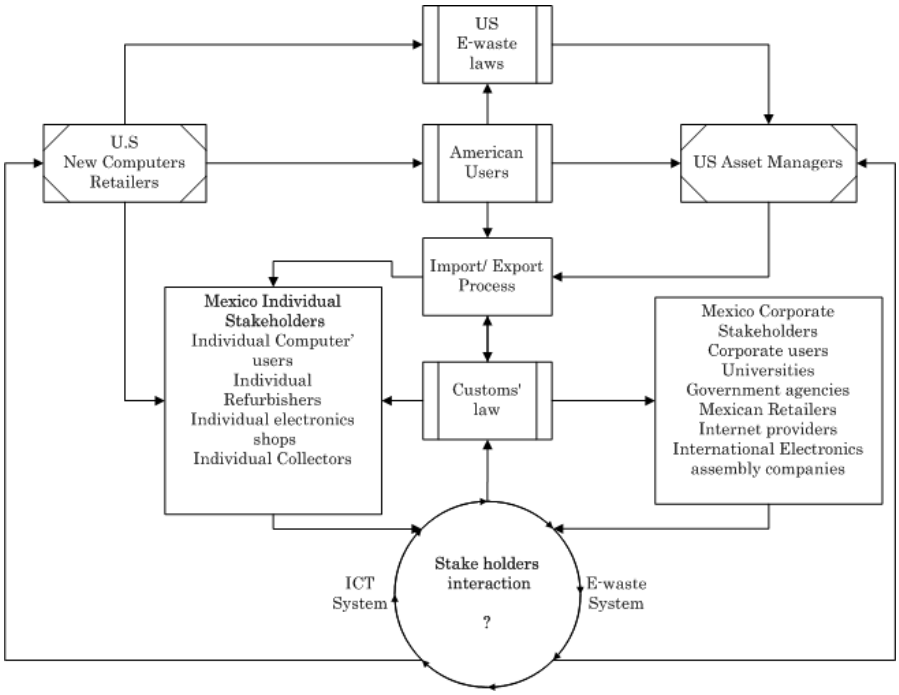

Figure 17 General View from E-waste Stakeholders at the United States Mexico Border

Figure 17 was design according with the information provided by stakeholders in the cities of Tijuana, Juarez and Chihuahua. These stakeholders import computers from the U.S and sell these equipments in Mexico. According with them, E-waste laws at the United States control the availability from used computers. The actions from American users, new computers retailers and Asset Managers at the U.S also depend on the law.

In order to import used computers from the United States into Mexico, there is a process that depends on the customs law. Corporate stakeholders like companies and government institutions, import equipments in quantities that require a customs broker. However individual users can buy and import legally into Mexico one computer. This computer can be either new or used. New computers are purchase from U.S retailers at cities near the Mexican border. Used computers are purchase by Mexican computer merchants, imported refurbish and sold in Mexico. However, there are also computers which enter into Mexico as part of the luggage from Mexicans that live in the United States and bring computers to their relatives in Mexico.

On the other hand there is a flow from brand new equipments assembled in Mexico. International "*Maquiladoras*" assemble electronics and export computers to the United States. These computers can be sold at the United States or exported from the United States to other countries.

The waste derived from the processes to assemble electronics in Mexico must be collected and exported to the United States. This collection is a requirement from the laws that allow "*Maquiladoras"* to operate in Mexico.

There are companies that provide the service to collect these wastes, that are called scrap, and they are export back to the United States according with the law.

At border cities, the companies that collect scrap from "*Maquiladoras*" provide the service to collect e-waste from computers. This waste usually is generated by computers refurbishers but they also receive e-waste from domestic users. Metal collectors provide a similar service collecting e-waste at

small towns. At small towns used computers are commercialized with other electronics at flea markets. At big cities there are specialized used computers refurbishers. At small towns there are repair shops that keep old equipments working. The process from all these stakeholders is shown with a question mark in figure 17 but they are going to be the subject from the Meso-level analysis about E-waste in Mexico.

5.3 Meso-level Analysis about E-waste in Mexico

Figure 18 Metals' recovery from e-waste and prepared for foundries in Monterrey Mexico.(Photo credit Jesus Estrada. Sep 2010)

The structure from the stakeholders that manage E-waste at the US-Mexico border presents great variability. Border cities for example, use scrap collectors to move e-waste to the United States, so it can access the international e-waste market. At cities like Monterrey there are companies that are extracting metals by mechanical processes as a way to recycle them, see figure 18). Materials are ship to foundries in Mexico. There are two sources of e-waste in Monterrey. The first source is the Residential E-waste that is collected through collection points in the city of Monterrey and the second source of e-waste is from companies. Companies' e-waste is directly collected by the recycler.

Capital cities like Chihuahua and Hermosillo have annual collection events to collect e-waste from homes and business. In Chihuahua, the collected e-waste is move and managed by an E-waste collector that is exporting these materials outside of Mexico. In Hermosillo there is a different collector that provides the same service to the government to export e-waste materials out of Mexico.

Border cities like Juarez, Hermosillo and Tijuana collect e-waste through e-waste collectors that serve the Maquiladora industry. In smaller cities e waste is collected by metal collectors. Figure 19 shows the DFD that represents the systems view from the stakeholders that manage E-waste in Mexico and Table 9 shows the explanation of each of them in alphabetical order. Figure 19 is design according with the information from stakeholders. The information about the volume and formality from the operations is a result from the information provided by stakeholders in qualitative terms e.g. most of the materials are moved through a particular channel. This information about the volume of e-waste, and formality present by stakeholders at each operation is also reflected figure 19. There are three important characteristics that are worth to clarify from the Meso-level DFD that is shown on figure 19.

The first is the definition from formality shown by stakeholders which are shown from black very informal to white very formal in figure 19. Formality in the case from stakeholders that managed E-waste is related with the need to be registered by law and adhere to existent rules and regulations (Mead & Morrison, 1996). The informality is derived from two

main components, the first is the lack of specific regulations and the second is derived from the difficulties for informal collectors like scavengers to register and carry out complex bureaucratic regulations.

The second important characteristic from the DFD is that it shows which parts of the systems are enforced by law. For example, scrap from Maquiladoras and CRT's must be collected and regulated by law.

There are three important characteristics from the DFD and these shows show 3 critical decisions in the system:

1. The presence from a CRT collector. Small cities and towns have an increased risk to not dispose CRTs in an environmental sound way because of the lack of presence from these recyclers.
2. The presence from Markets. Most of the system runs of profit; therefore any material that does not have a market is sent to the landfill.
3. The regulation that prohibits landfills to receive materials does not solve the problem of material that was already generated, and it creates the potential scenario from materials being disposed illegally.

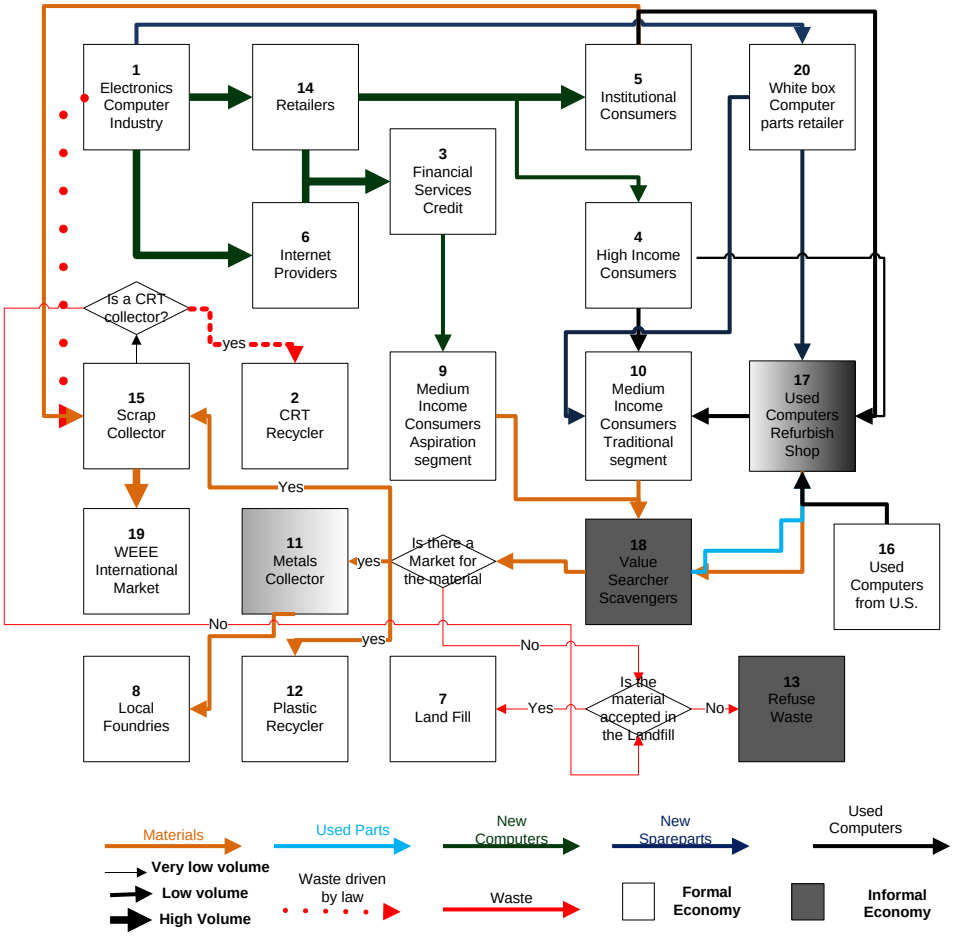

Figure 19 Meso-level Analysis about Stakeholders from the Life-cycle of Computers in Mexico.

Table 9 Stakeholders in the Computer Lifecycle in México (Table is in alphabetical order, to make easy to follow the DFD at Figure 15

1	Electronic Computer Industry	Electronic industry, manufactures computers and their components. Many of these components and computers are assembled in Mexico, but most of them are sold at the U.S
2	CRT & Recycler	Because of the lead included in the CRT monitors this activity is carried out under a license provided by the Mexican Environmental Secretary SEMARNAT
3	Financial Services Credit	Banks, retailers, and internet providers offered credit to consumers to afford new computers.

4	High Income Consumers	These consumers can buy brand new computers without credit. In addition they can buy computers locally or in the United States
5	Institutional Consumers	Corporation, government as computer consumers.
6	Internet Providers	Internet providers offer computers, along with their service through their long term contracts.
7	Landfill Administrators	Depending on the city some landfills are managed by private companies, but others are in charge of municipal authorities. There are some landfill that already ban the electronic waste disposal
8	Local Foundries	Due the long tradition of miner industries in Mexico, Including the steel industry and cooper industry there are several local foundries the biggest in Mexico are located at Monterrey, where there are WEEE recyclers who prepare materials for them (see figure 6)
9	Medium Income Consumers Aspirations Segment	This consumer prefer to buy brand new computers, but the only way they can access this computers is credit
10	Medium Income Consumers Traditional Segment	This consumer prefer to buy the cheapest computer that can be find and do not hesitate to buy a used computer
11	Metal Collector	Also known as "Yonques" their core business is collect metals mainly from automobiles, but there are some like Yonque Phoenix in Juarez, who may take electronics
12	Plastic Recycler	This business buys plastic to scavengers and recycle plastic for the plastic industry. Because of the mix of plastics in the computers design and the need to separate them, and reach scale economy plastic is accumulated by WEEE recyclers (as seen in figure 8)
13	Refuse Waste	When waste, do not hold any value, but there are no suitable places to dispose it there is an increased probability that this waste may be dumped illegally.

14	Retailers	Big commercial retail stores, which sold branded computers, but also small dedicated computer stores. Due the distance to the border, Retailers can be either national or from the United States.
15	Scrap Collector	These businesses provide a service that collects the scrap from the foreign industries established in Mexico to assemble products, but they are also starting to provide the service to collect the domestic e-waste. Some of these business export e-waste to the International market, but there are also some that integrate the materials into the national industries. For example, plastic is used to make hills from shoes, and metals are separated and sold to foundries.
16	Used Computers From United States	Because of the NAFTA, used computers can be bought in the United States imported and sold in Mexico
17	Used Computers refurbishers shop	These kind of business, sometimes assemble and sell new computers, but most of the time refurbish and sell used computers. In addition some provide internet and computer services to the public, through Cyber stores
18	Scavengers	There are several types of scavengers, From the ones that collect waste out of the streets and occasionally collect e-waste, to the ones that specialize on e-waste. In some places the government organizes collection events.
19	WEEE International Market	Demand from the international markets like China, and Europe. .
20	White Box Computer parts retailer	This business sells new spare parts, they are also known as white box computer sellers, because their parts create non branded computers.

The analysis at the Meso-level is important, because at this level the system is affected by factors such as: Technological change and legislation. At the Micro-level the sum from the individual decisions creates a similar effect. There is a considerable body of knowledge about factors that have a great impact at Macro-level, but how the system works at the Micro-level is seldom discussed in the literature.

5.4. Micro-level Analysis about End of Use Collection, Disposal and End of life of Computers.

The Micro-level Analysis is shown as a DFD in figure 20. Figure 20 is formed by three different blocks. The first block at the upper part represents the use phase. The block in the middle represents the refurbish process and the third block show how these two blocks are connected.

Figure 20 starts once a computer is purchase and it enters in its use phase this use phase can be divided into two loops. The first loop is carry out by the first user of the computer. The second is the re-use cycle when the computer is used again by a second, third or fourth user. (The DFD in Figure 20 shows only the second user as an example from the re-use cycle).

The interaction between both cycles is show in the DFD in the form of decisions. These decisions define the fate from a computer into two different cycles. The first is the re-use cycle and the second is the Value deterioration cycle. The re-use cycle is defined by two different controls. The first control works at the user's internal level and is represented in figure 20 as a loop identified as user' evaluation internal process. The second control functions

at an external level and depends on the presence of markets for used computers.

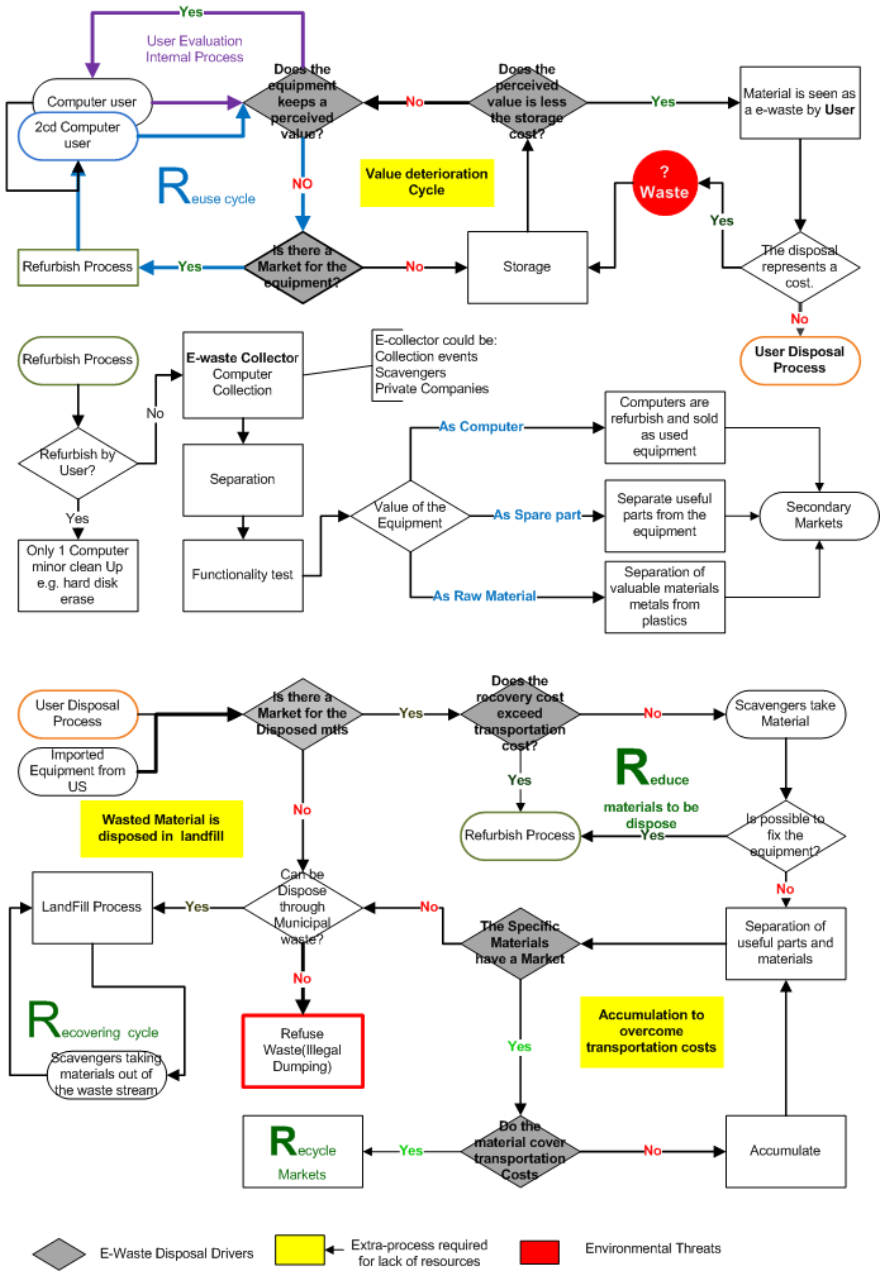

Figure 20 Decision Process From Purchase to Disposal of a Computer in Mexico.

Decisions blocks in figure 20 define two different cycles the first one is the already mentioned re-used cycle and the second cycle is represented in the DFD as a value deterioration cycle.

The re-use cycle is the process that allows an old computer to be used again as a computer. The value deterioration cycle is formed by the decision to store computers until it is more expensive to store them than their perceived value. Frequently, at the time these computers are disposed by their owners they do not have a market as computers because their technology is very old as compare with new computers.

There is an additional decision in figure 20 and it represents disposal cost. There are not disposal costs for domestic users in Mexico, but this added cost can be higher than storage costs and this will make equipments to be store again. However there is a possibility these equipments might be disposed illegally (Electronic 2009) and this possibility is also represented in figure 20.

Once a computer is disposed by their user the next part of the DFD process depends on the refurbish cycle. This cycle is represented at the center of figure 20 and it reflects: how materials fate is decide according with their characteristics.

Finally the last part in figure 20 connects the user cycles and the refurbish cycle. It is at this part that decisions to waste or trade are represented. The first decision depends on having markets for the materials. If the materials do not have markets they are disposed as waste. However, this search for markets takes place at different steps through the process.

The easiest and more valuable materials are retrieved first from the waste stream. It is at this part of the process that new decision factors such as transportation costs, the availability of disposal sites, and labor costs that allow dismantling materials enter as decision factors.

The combine action from stakeholders such as scavengers, computer refurbishers, collectors and recyclers reduce the quantity of materials that are wasted. Often there is a need to store materials in order to make the trade from these materials possible. The decisions factors are the topic from the next chapter.

Chapter 6

TO WASTE OR TRADE: FACTORS THAT DETERMINE THE END OF LIFE FOR COMPUTERS

The flows of used computers and e-waste from computers are related between them by decision factors. For example a useless machine in one place can be repair and be used again at another place. There is also the possibility this computer may be turn into a source of valuable materials. However, there are technological and social factors that make these decisions more complex. In figure 20 the decisions process are simplified into single questions in order to make the DFD easy to read, but decisions to waste or trade depend on multiple factors.

This chapter purpose is to make the analysis about these factors and how they impact the decisions from stakeholders. Decision factors are important at several levels and to different stakeholders. The same factor impacts different decisions. For their analysis decision factors are grouped into three blocks of decisions.

1. The decision to purchase a new computer and change the old one.
2. The decision to store or not to store an old computer.
3. The decision to collect and trade the computer, its parts or the materials inside them or to waste them.

6.1 Factors to purchase a new computer and change the old one.

The first decision factor that caused the end of life from a computer is when the computer's user decides to purchase a new one. This decision is

based on factors that promote or prevent the action to take place. According with the information from surveys the factors that promote the action to purchase a new computer are: failure, technological obsolescence and fashion. On the other hand, price, attachment and repair costs are factors that prevent this decision to take place. These 6 factors in turn are also the result from multiple factors. Figure 21 shows these six main factors and some of the factors that are related with them.

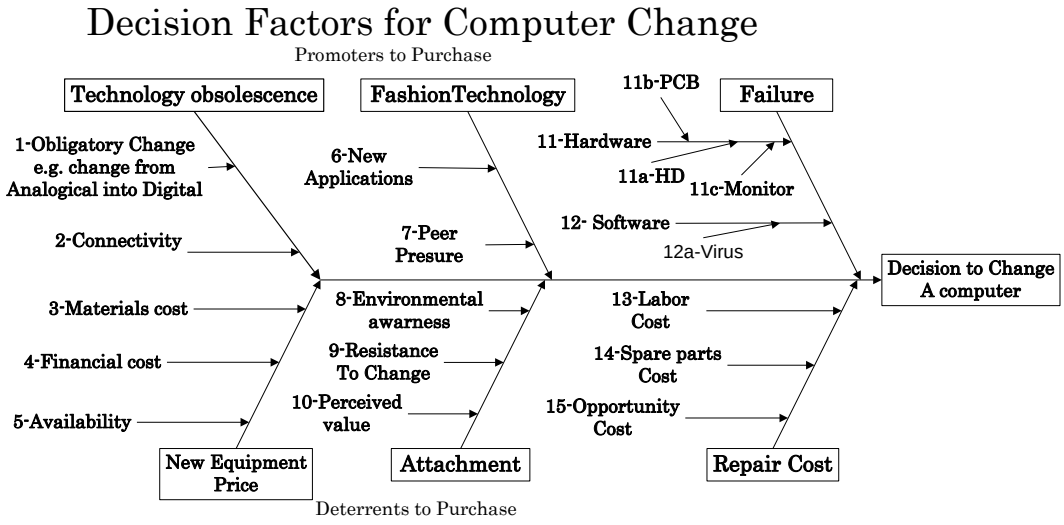

Figure 21 Decision factors to Purchase/Change a computer

Technology Obsolescence

Technological obsolescence is when the benefits from purchasing a new computer minus the incurring costs from this purchase are more than the benefits generated by the present computer (Saleh, 2008). Optimum obsolescence is a concept that proposes that a computer must be change when the benefits from a new computer are higher than the associated costs to replace the old one (Carlaw, 2005).

At the micro-level organizations and individuals change their obsolete equipments, but at the Macro-level complete engineering systems are changed. For example, the changes plan by the government from analogical to digital T.V. A word of caution is required to not take this example as typical. Often engineering changes are caused when new technologies with emerging characteristics displaced old technologies. For example laptops displace desktops because they allow their users the freedom to work from different places. At the same time new technologies do not displace completely the old ones, but can be competing between them.

The impacts from technological change are profound and they have been the subject of analysis from several disciplines. For example, Marx, and later Schumpeter, proposes that in order for new structures, technologies and systems to emerge there is a need to destroy the old ones. This concept is called creative destruction (Marx & Engels, 1848) (Schumpeter, 1943). The analysis of creative destruction in computers is beyond the scope of the present work, but according with surveys the concept of obsolescence in computers is not absolute, but relative to its intended use. For example obsolete computers for a company are totally fine for a computer shop that lease internet service. Some of the reasons for computers to become obsolete according with stakeholders are:

1. Mandatory Changes: for example, a change in engineering standard. E.g. lack of memory to run programs.
2. Connectivity: Computers that cannot be connected to internet or to new devices.

However, computer change is not always trigger by an important change in technology bur result from other factors.

Computer change promoted by fashion.

The purchase from a new computer to change the old one is no always the result from technological change or creative destruction. There are changes that are promoted by cosmetic changes like a new computer color, and more attractive design. A change promoted by these types of factors can be defined as a change promoted by fashion.

At corporate level, quantitative economic analysis is made about the convenience to change equipments, but at individual level, changes by fashion are more common. For example, according with stakeholders that refurbish and sell used computers, teenagers from certain economic level buy new equipments instead of a used one because the pressure among their peers to have the latest equipments.

Computer fails to provide their function.

Finally the most powerful reason to purchase a new computer is that the old one fails to provide their intended function. Failure can be caused either by hardware, or software. Failure derived from Software includes slow internet connections or the lack of capacity from the equipment to support new software applications. Failure derived from hardware includes the failure from components in the computer.

However in the same way that there are factors that promote the purchase from a computer, there are factors that promote the continuous use

from a computer and serve as a deterrent to buy a new one and these factors are: Repair costs, Attachment and New equipment prices

Repair Costs.

Repair costs can serve both ways, as a deterrent or as promoter to purchase new equipments. If the cost to repair is cheaper than the cost to buy a new one, these lower costs become a powerful deterrent to buy a new computer. This is especially important because the differences in the cost to repair a computer in Mexico and the costs to repair them at the United States, makes attractive to import used computers from the United States. These computers are refurbished and trade in Mexico.

The distance between cities at the North of Mexico and cities at South of the United States could provide also benefits for companies that seek to reduce maintenance and repair costs to their computer customers in the United States, but this topic will be further discussed in Chapter 7.

The attachment to computers

Corporate users and individual users, develop attachment to old computers equipments by different reasons. In the case of corporate users, there is the fear that valuable information about the company might be lost or access by people outside the company. In the case of individual users, in addition to the fear of losing valuable information, there are subjective feelings of attachment to old equipments. For example they were a special gift, and they represent a value beyond their practical use. Some factors that can cause attachment to old equipments are: perceived value, resistance to change and environmental awareness. Perceived value is a factor that

impacts the decision to purchase a new computer, but also impacts the decision to store it; therefore, it will be discuss further in section 6.2 (factors to store a computer).

Change resistance.

Attachment to a computer can be derived from the resistance to change from its user. Because computers are technological innovations how user purchase and kept their old equipments is also a reflection of the technology adoption curve. The technology adoption curve proposed by Rogers in 1962 propose that there are five groups: innovators, early adopters, early majority, late majority and laggards (Rogers, 1962)

Innovators are about 2.5% of the population and are the first to adopt new technologies or products. Early Adopters are less tolerant to risk than innovators and they are 13.5 % from the population. Early Majority is 34% from the population and they adopt technology slower than early adopters. Late Majority is about 34% of the population and they are highly conservative. Finally about 16% from the population are classified as laggards which are individuals that are forced to adopt the technology once is has been widely accepted by the majority of the population. Therefore, according with this model 16% from the population will keep their old equipments as long as they can before changing them.

Environmental awareness

There are some individuals that kept their old computer because they know about the environmental impacts from computer disposal. In addition

there are people that do not dispose their equipments and give them to relatives or people that do not have access to computers.

Price of New Computers

This factor is an important deterrent for low income population. Cheaper new devices emerge and they are competing with computers to provide a specific service. For example smart cell phones provide access to internet. Therefore, these equipments will compete directly with used computers.

New computers can be also purchased through credit schemes that allow low income users to purchase them. Income differences also causes that used equipments are perceive different among users. For example, the high cost from a new computer in relation with income increases the time a computer is used. Figure 20 shows the Ishikawa Diagram from changing a computer and Table 10 shows a summary from all the factors to purchase and change a computer.

Table 10 Decision Factors to Change a Computer

Factors	Discussion
Technological Obsolescence	When the equipment start losing functionality with the new technological trends
1-Change on Standard;	A complete shift on technology e.g. digital T.V
2- Connectivity.	The device unable to communicate with some new technologies such as new printers or other devices.
Price of New Equipment	the price of the new equipment in relation with the income level.
3-Material Cost.	The direct cost of the equipment to the customer.
4-Finalcial Cost	The feasibility to overcome the cost of the new equipment through credit.
5-Availability	The availability of the new products in the market.

Fashion Technology	Change derived to keep oneself with the popular new technologies.
6- New applications	Emergent applications, such as new videogames that require new graphics cards, or complete new applications that allow new functionalities
7- Peer pressure	Adoption of technology as result of peer pressure derived from the community
Attachment	The attachment developed from users towards their equipments.
8- Environmental awareness	The decision to not change a computer in order to reduce the consumption of natural resources.
9- Change Resistance	The decision to not change because a complete mastering of the current technology
10- Sentimental value	The attachment derived from other factors other than the objective ones.
Failure	The natural change of the equipment because failure on their components.
11-Hardware	When failure is caused by the hardware part of the equipments
11a-HD	Hard disk failure
11b- PCB	When the failure is caused by the electronic board from the computer.
11C-Monitor	Failure from the monitor. This applies mostly to laptops computers. In the case of desktops only the monitor is disposed.
12-Software	The failure of the computer derived from software e.g. a virus, slow response.
Repair Cost	All the costs derived from trying to repair a computer
13- Labor Cost	The cost derived from technician labor, but also the availability of qualified technicians.
14 Spare parts cost	The cost of spare parts, but also the availability of them.
15-Opportunity cost.	The convenience or feasibility to repair the equipment by the user.

6.2 Factors for Computer Storage or Disposal.

When a new computer is purchase, the old computer is either store or disposed. A stored computer decreases their value according with the time is stored. The more time a computer is stored, there is going to be more new technologies. Users store their computers because of factors. Figure 22 shows a general view of the factors to store or dispose a used computer.

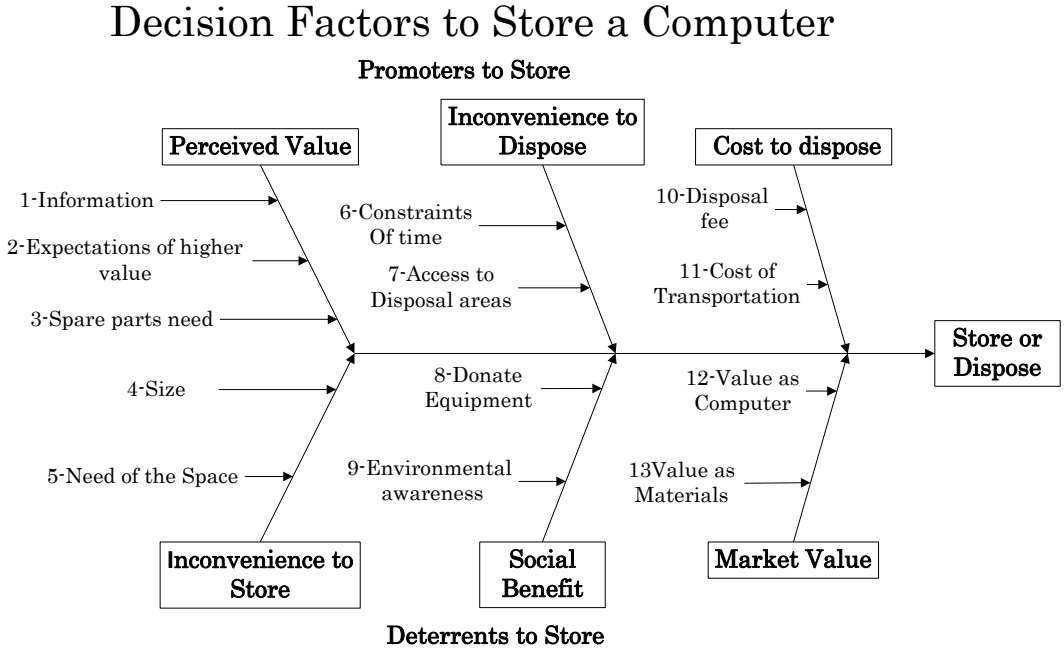

Figure 22 Decision' Factors to Store or Dispose a Computer

Computer´s Perceived Value.

Perceived value is factor that impacts how users purchase, store and dispose their computers. Customer perceived value has been defined as a how customer perceives the benefits and other factors from equipment and its inconveniences or trade offs (Woodruff et al, 1993; Zeithaml et al., 1996; Slater and Narver, 2000; Ulaga and Chacour, 2001; Lapierre, 2000). According with interviews perceive value have a great impact on the decision

to dispose them. The decision to store impacts the collection and later the possibility to, refurbish old computers, so they can be trade. For example, new devices that allow access to internet might be an important deterrent for users to acquire old computers. Used computers are perceived with higher risks of failure, so they are perceived as lower quality. (Snoj, Korda and Mumel, 2004).

Inconvenient to dispose computers

One reason to store a computer according with some stakeholders is that its disposal results inconvenient. This can be caused by two reasons; the first one is the value of the information kept in the device. The second is the difficulties faced to dispose a computer. This difficulties can be caused by geographical or by temporal reasons. A geographical reason for example is that in small towns there are not any places to dispose a computer. Sometimes the problem is that collection points to dispose a computer are far away from users. Finally sometimes collection points are not permanent, but only through some collection events. Therefore users have to store their equipments until there is a collection event. .

Cost to Dispose

The state of California creates a disposal fee, in order to provide a financial structure for the disposal of electronics equipments. There are not disposal fees in Mexico. The possibility for a disposal fee in Mexico was discussed in the interviews. Te result is that in Mexico a disposal fee at the moment that electronic equipment is going to be disposed became a factor

that will make users either to store their equipments or to dispose them illegally to avoid the fee.

Computers disposed as social benefit.

Computers are not always disposed for an economical reason; old computers are giving away as a gift to relatives. Individual users often give their old equipments to relatives and some corporate users give old equipments to schools and other institutions. One important source from computers in Mexico comes from equipments that are provided to their families in Mexico from Mexican people working at the United States.

Inconvenience to Store

In the same way that there are factors that make difficult to dispose computers there are factors that make difficult to store them. It is more difficult for a company to store their old equipments than for an individual user. There is not information about the quantities of computers that are stored at users' homes. New devices are smaller than the old ones; therefore they are easier to store for individual users. This factor is especially important for smaller devices like cell phones. As the user base grows, more materials and resources are stored. Like perceived value, the market value from used computers and their materials is a factor that promotes their disposal, but also their collection or waste and it will be discussed in section 6.3 (Decision' factors for collection or waste).Finally there are other factors that either promote or deterrent the possibility to store, or dispose a computer and this factors are discussed in table 11

Table 11 Decision Factors to Store or Dispose a Computer

Factors	Discussion
Perceived Value	Users measure this in subjective and objective terms as the benefits from their actual equipments compared with the cost to replace them
1-Information	There are two main characteristics from this factor. The first one is the desire to keep the information and the second one the fear that this information might be access by others.
2-Expectation of higher value	Objective scales about used computers prices are not widely available. Therefore, computer is keep because a higher value is attributed to them that the value the market assigns to the equipment.
3- The need of spare parts	When several old computers are kept in small business and households old equipments are kept as a source of spare parts.
Inconvenience to Storage.	For companies this factor is more important than for individual users. because for companies, storage represent an expense
4-Size	Reduction on the size of the equipments favors the storage. Families usually keep their equipments.
5-Need for Space	Users, requires space, regardless the size of the equipment.
Inconvenience to Dispose.	Non economical reasons that act as deterrent for disposal
6- Constraints of time	Collection events take place at specific dates in some cities. If the users miss the date, the equipments are kept until the next collection events.
7-Access to disposal areas.	The areas to dispose the equipment can be a deterrent for users to dispose their equipment because lack of knowledge of where this areas are located.
8-Donate equipment	Frequently, disposition from the equipment is the feasibility to give them to someone from the extended family.
9-Environmental awareness	Campaigns made about the dangers from electronics waste motivate user to dispose their equipments in collections events.
Cost to Dispose	Potential cost to dispose e-waste
10-Disposal fee	Although in some societies a disposal fee serves as a way to control and maintain an e-waste collection system, fees in Mexico may have an opposite effect to promote the storage of the equipments to avoid costs.
11-Cost of Transportation	The cost to transport the equipment to the collection points,

Market Value	The Used computers markets that promote users change their old computer.
12-Value as a Computer	The value of a computer, as a used computer. or as spare parts to be used as a computer.
13-Value as materials	The value of the materials in a computer. e.g. cooper, gold. and so forth

6.3 Factors for Collection and End of Life

As it was already mention the end of use from a computer is not the same that the end of life. There are factors, which define how a computer is disposed of and these factors also define the viability of collection. The most important factor is the possibility to trade a computer or the materials inside them. This possibility s depends on the market value.

Market Value

Figure 23 Electronic Components at a Landfill in Chihuahua Mexico photo Credit: Jesus Angel Estrada Ayub

Market value like perceived value is an important factor that impacts the decisions to purchase, to store and to collect a computer. It is the market value that keeps computers out of the landfill. However, materials with less value such as plastics and part of electronics toys can be easily found in landfills (see figure 23).

Waste in this sense can be seen as the failure from the socio-technological system to extract value from these materials. There are three potential markets for a computer that is going to be disposed by their firs user::

1. The market for used computers.
2. The market for spare parts for used computers.
3. The market for the materials in the computers.

Marker for Used Computers

From information derived from interviews. The market value for a used computer is related with the feasibility to be connected to internet, and to support some software. At flea markets used equipments with a Pentium III have a price between 200 USD and 300 USD. The window of opportunity to trade a used computer decreases with the time.

Nonetheless, used computers are trade because of the enormous diversity in Mexican society. Used computers trade is growing. Information about the flows of used computers trade is scarce because a huge part of this trade is carry out by informal markets and between individuals' users.

The diversity on Mexican society makes difficult to estimate correctly the obsolete computer stock. In the U.S for example it is possible to model the obsolete computer stock base on sales and known statistics at aggregated data and then extrapolate this characteristics into regions in which this information is not known. (Light et al 2006). This approach can lead to serious overestimation of the obsolete computer stocks in Mexico. For example if stocks are modeled base on computer ownership in a city like Monterrey (computer ownership is up to 50%) and extrapolate to a city like

Cuauhtémoc because computer availability is different.. Nonetheless used computer trade is a dynamic activity in all Mexican cities near the border. For example, at the time from the interviews in the flea market of la Villa, 3 used equipments were trade in approximately one hour. In addition to the trade of complete computers, at this places there is a trade of its parts.

Market for Computers as spare parts

The demand for spare parts for used computers is closely related with the computers models that are currently being used. Once a particular model is discarded the market for this particular parts ends. The market for parts depends on the size of the city.

Figure 24 Used Computer and other Used Electronics Flea market in Cuauhtémoc. Photo Jesus Estrada 2010

Specialized computer stores are more common in big cities than in small ones. At big cities this specialized computer stores collect used computers to dismantle them and they are able to trade computers parts. On the other hand, small cities combine used computers with other used electronics because only through this diversification they are able to manage their inventory costs. (See figure 24).

Computers disassembly has an interesting part that has seldom discuss: even the more difficult parts to extract are take from computers and trade. However there are parts like CRTs which are extremely difficult because of their characteristics. For example their lead content (Hill, 2008) and they have been control by Mexican laws to provide an appropriate disposal for them.

The market for used parts could be boost if new applications for old parts are developed. In addition repair service in Mexico by Computers Manufacturers to their customers in the U.S is an opportunity which has not been developed.

Materials inside computers and their Markets..

When computers and their components cannot be trade and used for their intended function they still retain value according with the materials that are contain in them. The value from materials creates the incentive to collect computers.

Metals.

The biggest incentive to collect computers is their metal content. (Oswald & Reller, 2011). The value of E-waste as a source of metals has been extensively reported in literature (Hageluken 2005; Xiang et al, 2006). However the lack of e-waste at landfills, from the cities in which this research take place could be either a consequence from the value from metals, but also from legislation because there are some landfills that banned e-waste.

Plastics and other material in Computers

According with recyclers in Monterrey it is difficult to recycle CRT's, and this is in line with the literature (Torzewsky,2009). There are also great difficulties to recycle plastics in computers due its variability and the need of specialized equipment to recycle them.

Figure 25 The Problem of Plastics from Computers. Photo Jesus Estrada

Often Plastics are take out from computers and stored to make feasible to recycle them later. (See figure 25).Despite the emergent research about how to recycle plastics (Qu, Williams & Grant, 2006). The problem also involves solving the logistic problem to transport materials which are less valuable than metals. The feasibility of collection depends also on the costs to recycle materials. These costs can be classified into three types:

1. Process Costs. 2-Transportation costs and 3-Labor Costs

Labor and Transportation costs are self explanatory, but process costs deserve further discussion. The process to change a disposed computer into an item that can be trade requires an expense on resources, such as energy or materials. This can be as simple as materials to clean a computer.

There are costs to store large quantities of computers in order to be recycled. This computer first have to be sorted into two parts: computers to be dismantled for materials and computers to be refurbish and sold as used

computers. In addition there are indirect costs, like energy and taxes that are part of the overall costs of these simple operations.

However, the costs to recycle the materials from computers can be as complex as the costs that are carry out by the operation of processes like the ones from Umicore, a metallurgy complex at Belgium. The technology in these kinds of facilities is able to recover more precious metals with stringent environmental controls. There are also costs derived from the patents developed in the technology to recycle metals. This type of technology is more developed in the mining industry and it is unknown for the computer industry. There are advanced methods like bioleaching (Acevedo, 2002) which is currently used on mining operations that might be viable option to recover metals from E-waste.

There are different stakeholders in the systems to process e-waste in cities in Mexico. At small cities there are only metal collectors. In big cities there are collectors of PC boards and collector of plastics. Metal collectors receive any kind of metals, like cooper, and iron, but especially at small towns they also collect computers. PC board collectors are specialized collectors that collect the electronic boards from computer in order to export them. Finally plastic recyclers, collect plastics, but the demand for plastics from computers is still limited. Figure 26 show the Ishikawa diagram from the decision factors to collect or waste and table 12 is a summary from all the factors that were already discussed.

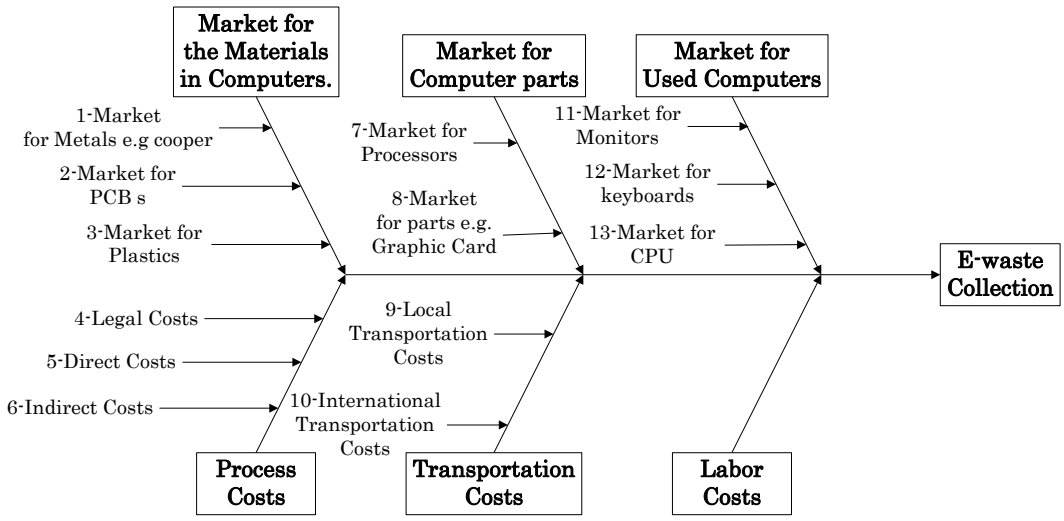

Figure 26 Decision factors to collect or Dispose as Waste

Table 12 Factors to Collect or Dispose as Waste

Factors	Discussion
Market Materials	The market for the materials inside the computers
1-Market for Metals.	Market for cooper in wires and tin in the cabinets and Precious Metals on PC boards
2-Market for PCB	When PCB's are not processed inside the country, but sent them out to be processed at China or Europe.
3-Market for plastics	The market to recycled plastics from computers parts.
Process Cost	There is a large pool of costs which are incurred in the activities to process and recycle a computer. The costs that appear here are just a simplification of them.
4- Legal Costs	Costs for software licenses, Payment of new emerging patents for metal treatment.
5- Direct Costs	All those costs directly related for the activity for example energy to grind metals
6-Indirect Costs	Those costs that are not directly related with the activity, but are necessary to carry out the activity For example, storage costs,
Market for Computer Parts	The markets for computer as spare parts.
7- Market for processors	Some Mexican recyclers due their manual ability are able to take out the processors to use them in other applications.

8- Market for Computer Parts	The market for the parts of computer that can be disassembled to updated or repair a computer for example the graphics card or memory rams
Transportation Costs	The cost to transport a material. It can be expressed in monetary or energy terms.
9- Local Transportation	The transportation costs to collect and concentrate the e-waste from a city or a particular area.
10-International Transportation	The transportation cost to move the materials to the international market
Market for used Computers	Used computers are valuable depending on their age. In addition some major parts of a computer are also trade.
11- Market for Monitors	The market for CTR monitors has been reduced as new flat screen monitors make their entrance into the market.
12- Market for keyboards	The quality from some of the keyboards once are refurbished is about the same of new keyboards.
13- Market for CPU	The market for used desktops computers. or used Laptops

Chapter 7

CONCLUSIONS

7.1 Qualitative Analysis of E-waste Flows at Selected Cities.

Diversity in natural ecosystems allows the efficient recycling from materials and other resources. Human societies are also diverse and cities near the U.S-Mexico border are an example from this diversity. Table 13 shows an analysis about how Mexican cities near the U.S-Mexico border are managing E-waste.

Table 13 Comparative Analysis from Cities at the North of Mexico

Type of City	Example	Strengths	Weaknesses
Industrial City	Monterrey	Materials recyclers have the presence from materials markets in Mexico High volume insures scale economy	Increase waste derived from a major disposal culture
Border City	Tijuana, Juarez, Nogales	Access to the border allow to import used computers and export e-waste through International electronic assembly companies,	The materials recycling facilities depend on international markets to dispose materials
Political Center	Hermosillo, Chihuahua	Institutional management and strong policies action to manage e-waste	Monopolies on e-waste management.
Agricultural small town	Cuauhtémoc, Rosarito	Strong re-use culture	Less advanced landfills

Cities like Tijuana, Juarez, and Monterrey, have the advantage of their size, which provide them with enough materials to trade. Cities like Juarez and Tijuana in addition to its size are border cities that are completely connected with the United States and have the presence from international electronic assembled companies. It is this presence from international electronics industries in these cities that have create in them the following important characteristics:

1. Electronics products and parts are highly appreciated
2. The companies that manage scrap from "*maquiladora*s" also manage domestic e-waste.

Monterrey, in addition to be highly connected with the United States like Juarez and Tijuana is also the third largest city in Mexico and an important industrial hub. E-waste in the case of Monterrey can be trade through national commercial channels. For example, plastic is frequently sent to a flip flops' factory at other city in Mexico. Cities like Chihuahua and Hermosillo have the advantage of being the political center from their states. Policies are implemented first in this type of cities. It is the small cities like Cuauhtémoc that have the greater potential for inappropriate disposal for three factors:

1. The need for income at rural communities
2. The lack of resources to appropriate disposal e-waste
3. The lack of resources to enforce any proposed legislation.

Table 14 shows the different strategies take by cities to collect and dispose their e-waste

Table 14 Strategies to Manage E-waste at Selected Cities

City	Collection strategy	Disposal Strategy
Monterrey	Curb collection systems and E-waste collection events	Integrated supply Chain to dismantle and dispose materials
Chihuahua	Collection events	Export e-waste through one e-waste collector
Tijuana	Collection through metals collectors	Export through e-waste international companies.
Rosarito	Collection points through Metal recyclers	The small city integrates its systems to the largest Metropolitan area of Tijuana.
Juarez	Collection through specialized collectors	Export through companies that serve international companies.
Nogales	Collectors from Manufacturing companies	International manufacturing companies, through their specialized environmental department build the infrastructure to export e-waste
Hermosillo	Collection events sponsored by State government	Export e-waste through, environmental e-waste collectors from international manufacturing companies.
Cuauhtémoc	Repair shops	E-waste is collected by informal recyclers and dispose to metal recyclers

7.2 Decision Factors to Trade or Waste Computers in Selected Cities.

The collection of E-waste produced by computers has two main drivers: Used Computer trade and Materials from Computers. The first one is caused by the enormous need from computers. The flows of used computers in Mexico, like the flows of used T.Vs from Japan into Philippines (Yoshida & Treason, 2010) and the flow of used computers from the U.S into Peru

(Kahhat & Williams 2008) have important benefits in this cities in terms of jobs created from their commerce and because they provide access to the technology. The value from used computers in Mexico is a better driver to avoid the inappropriate disposal than the value as E-waste materials. This is an important difference with Asia, where E-waste is the value because of its materials (Terazono, et al, 2006).

End of life for Computer Waste in Selected Cities.

The behavior of the E-waste flows at the cities where the field studies take place is characterized by two different flows: The first one is formed by used items from the United States into Mexico and the second one is formed by e-waste materials from Mexico. The disposal of computers waste in Mexico once they no longer can be used in border cities is exported to the United States and to China. Used computers are imported into Mexico from the U:S by thousands of small merchants and some of them trade computers at flea markets in Mexico, but they are also trade by small shops.

- The role of the flea markets to mobilize used items in addition to its importance in economic terms has a beneficial environmental impact that deserves further study. Flea markets are complex phenomena. For example, La Chaveña in Juarez has more than 30 years of history. Flea markets in Tijuana are massive. For example, the flea market of la Villa is a gathering from 5000 vendors.
- The flow of e-waste from Mexico to the United States is formed by scrap residues produced by international manufacturing companies.

These companies take domestic e-waste out of the waste flows in Mexico and use their commercial channels to export e-waste out of Mexico. The waste that is exported to United States and from there it is managed by U.S companies.

There are factors that are important for stakeholders in Mexico. For example technology, transportation costs, attachment from users and value of e-waste. Technology is important, because as new and cheaper computers and other devices like tablets or smart phones enter into the market, the old computers cannot be trade because the consumers have access to new products and the price difference from a new tablet with a used computer is not important enough for some consumers so they prefer to buy a new item rather than a used one.. Nonetheless low income consumers have access to computer from stores with used computers, but this is changing as competition among cyber stores is triggering the need on then for having better equipments, so nee computers displace old computers.

Transportation cost is important because transportation of e-waste from small towns to big cities may not be economically attractive because their quantities are small. This characteristic is a threat to small towns, and it is at this kind of places that landfills are less developed.

Attachment from users to their old equipments, make them to store computers for a long time. This is an important factor because the time these equipments are store decreases the possibility to trade them when they are finally disposed. The value of e-waste is very important. If the value from e-waste decreases this cause then that the feasibility from the collection

systems decreases. There are two factors that will make the value from e-waste decrease.

The first one is the continuous quest to reduce cost in the materials from products as a way to produce cheaper products. If each generation contains less valuable materials this will make the waste derived from them reduce its value by weight.

The Second factor is that increasing quantities of e-waste materials at developing countries will lead to a reduction in the overall value of the e-waste because there is going to be more e-waste available at locations near the recyclers sites; therefore, e-waste transported from places that are far away from recyclers will reach this markets at a higher costs because the increase on transportations costs and this can be derived from the rise on the cost of energy.

There is a need to increase the resilience from e-waste systems in Mexico because at its present stage all the system depends on the value from e-waste materials from countries outside of Mexico. Therefore, the system is extremely vulnerable to international changes in the value of materials.

One important factor to reduce this vulnerability is the development of new applications for the old equipments and their components. A value created for recycled components will make the collection and the recycling of computers' e-waste more resilient to changes on the e-waste materials value.

New applications for computer components will also increase the window of opportunity to sell used computers and their parts because now,

the value from computers parts decreases with the feasibility to commercialize the correspondent computer model.

Used computers today have only two potential states to be commercialized. The first one is to commercialize them as used computers; the second one is to commercialize them as materials. However, in recent time new applications for old processors have been developed, for example IPADs, and E-readers so it is clear that new applications for the old processors will be a valuable alternative for extending processors life. The value from old processors as computer power that can be used in multiple applications may increase the potential to develop new products and new business models to manage e-waste at the cities near the U.S-Mexico border and the distance between integrated circuits producers, designers and assemblers is an interesting opportunity that has not been explored.

New policies to address how to manage e-waste in Mexico must take into consideration local conditions because cities differ in their characteristics. For instance, while a market oriented policy (Dreher, & Pulver, 2008) works best for big cities like Monterrey it is important to take into consideration that small towns might not have the required volumes to make their e-waste commercially attractive; therefore a policy that allows a strong regulation might be better

Developing appropriate solutions according with the conditions at cities and towns may increase the benefits from used computers and the e-waste materials from them. There is a need to develop strategies to manage e-waste from new products like cell phones. Also there is a large pool of waste

derived from products that have strong presence at Mexican homes like T.Vs. Therefore, it is important to develop strategies to address these types of wastes because of their volume. For example cell phone are increasingly use by low income population and rural communities, but cell phones presents a risk for improper disposal due their size, which allows them to be included into the domestic waste. In the field studies at landfills plastics parts from old cell phones were found at landfills. There are also electronic parts from old toys which often end in the common waste. The relative low value from this type of materials makes them difficult to recycle in a system that is value driven.

7.3 Future Research

The cities and towns from the north of Mexico and the South of the United States have a common heritage. These cities born as result from the appetite from valuable metals like gold and silver, demanded by the economical system from the human society of past centuries (The search from El Dorado, The Gold Rush). Some mining towns succeed in becoming important cities, but other´s decay and became ghost towns. Today, new technology in mining operations is able extract minerals from more poor concentrations and this opens the possibility for old mining sites and new ones. This mining sites are often locates in places which are part of forest ranges and other ecosystems that have a value seldom acknowledge by the economic system. .

However, these same metals and other materials are available in larger quantities in the flow of wastes generated by cities with their growing

urban population. This creates an urban mine, which on contrary with the old mines will never be exhausted. What are the implications for countries that base their wealth on raw materials extraction, when for example, the value from a pristine forest, for human leisure and as reservoir of biodiversity will be more precious than the minerals underneath. Mining and materials recycling can use the same technology, but mining operations are able to prorate their environmental costs to the future while recycling must address these costs immediately. However, once these systems mature, in the future, the environmental and economical consequences could be problematic for places that will have to invest to mitigate the environmental problems left when the source of wealth derived from mining operation fades.

The possibility to retrofit the ancient mining towns and installations to treat e-waste compare with the present course of opening new mining operations as a way of development is a worth venue of research.

Nonetheless, the value of computers as a source of valuable materials still does not solve the waste derived from the energy demanded to make processors that are disposed, and do not address the complex social and economical dimension from the used computer trade and the lack of access to technology. Old computers and their processors can find new applications. For example, saving energy or providing services to elderly. In order to make this possible there is a need to made research on how to dismantle and extract parts from computers that can be an option to create work for poor communities that today are recycling the best they could under the present conditions, but with the support from new applications and the appropriate

markets development will prevent them from performing operations that are dangerous for their health and for the environment.

E-waste management has been focus on how to manage e-waste in the context of a city or town with similar characteristics. Cities near the U.S-Mexico border have the opportunity to combine their strenghts to create more effective ways to manage E-waste. New solutions with a partnership among Mexican cities and U.S cities will get the benefit of increased diversity.

The possibility to create Sustainable Closed Loops (Quarigasi et al, 2010) between cities at the south of the U:S and the north of Mexico could generate new opportunities to create jobs and find the ways of development for cities that because of their geographical proximity share a common future.

Finally human systems are complex and proposed solutions may take into account this complexity. For example the creation from Maquiladoras at the border cities creates an autocatalytic system that promotes the growth and creates new problems. Therefore proposed scenarios must be tested. Computer simulation could be an economically and feasible way to perform this kind of test; therefore, the factors and the data presented in this work could serve as a base to build a models for computer simulation to test scenarios and generate data so better decisions can be made. In this sense the importance from this research is that it leaves a complex system in a language that can be understood by computer scientist to create virtual reality to test scenarios and could serve as a bridge to social scientist to test the proposed models. .

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APPENDIX A

FIELD RESEARCH BITACORA

City	Stakeholders	Quantity	Dates	Activity
Tijuana	Electronics retailers	3	Feb/12/2011	Electronics retailer sell parts to computers refurbishers
Tijuana	Computer refurbishers	1	Feb /12/2011	Import and refurbish used computer from the U.S, and sells to business in Mexico
Tijuana	Street Sellers	3	Feb/13/2011	Informal Street Sellers, Used Computers, assembled desktops and Laptops.
Tijuana	Internet leasing	2	Feb/12/2011	Sells internet time and computer services to students. In addition sells used computers.
Juarez	Used Computer Shops	2	Aug/5/2010	Imports and Sells used computers from the U. S
Juarez	Computer Refurbishers	6	Aug//6/2010	Used electronic devices from "La Chaveña" . the biggest hub of used items
Juarez	Electronic Waste Recyclers	3	Aug/5/2010	Provide services to international manufacturing companies, but also collect domestic waste
Juarez	Metals recyclers	2	Aug/7/2010	Metals recyclers, accept computer scrap upon request.
Nogales	Electronic waste recycler	1	Feb/04/2011	Provides the service to international manufacturing companies of collecting their scrap
Hermosillo	Academics	2	Feb/03/2011 to	The University of Sonora, is leading an e-waste collecting program through all the state. However, according with mineral and metallurgy specialists there
Hermosillo	Repair Shop	1	Feb/04/2011	Computers repair Shop

Chihuahua	Computer collector and refurbish equipment	1	Jul/27/2010	Collects used computers, sell parts and refurbished equipment.
Chihuahua	Land fill scavengers	7	Jul/26/2010	Scavengers, working in Chihuahua land fill and street collectors.
Chihuahua	Land fill operators	2	Jul/27/2010	Municipal officials in charge of the landfill
Chihuahua	Metals recycler	1	Jul/25/2010	Collects used electronics equipment and recycle Metals.
Chihuahua	Paper mill and Cardboard recycler	2	Jul/28/2010	Paper Recycler, Buys used paper and cardboard collected by Scavengers
Chihuahua	Electronic Retailers	3	Jul/28/2010	Sell electronic parts, including computer spare parts.
Chihuahua	New computer parts stores	2	Jul/29/2010	Sellers of computer parts, which are assembled by users, "White box computers"
Cuauhtémoc	Landfill Operator	1	Aug/12/2010	Municipal official in charge of the landfill
Cuauhtémoc.	Informal shops	2	Aug/12/2010	Used computers and laptops are sell among the other used products.
Rosarito	Materials Recyclers	3	Feb/13/2011	Materials recyclers main target are metals.
Rosarito	Computer refurbishers	1	Feb/13/2011	The core business is the leasing from Internet time to Students.
Monterrey	Computers Recycler	1	Jan/21/2011	Its main activity is transforming the materials from computers into a more useful form for foundries and plastic recyclers.
Monterrey	Computer refurbishers	1	Jan/21/2011	Collect old computers, mainly for re-use purposes.

APPENDIX B

E-WASTE LEGISLATION AROUND THE WORLD.

Country	Legislation	Authorities	Producer/Retailers	Consumer
Australia	Voluntary schemes are in process Main projects are: The Major Appliances Materials Project. The Computers and Peripherals Material Projects and Electrical and Electronics Infrastructure Facilitation	Environment ministers in Australia are considering a plan to impose a $18.75 USD on the sale of new T.Vs The collected funds will be used to develop and operate a nationwide recycling scheme	Australian Mobile Telecommunications Association (AMTA) is responsible to recycling mobile telephones	
Austria	The Ordinance on Waste Prevention, Collection and Treatment of Waste Electrical and Electronic equipment (WEEE Ordinance) entered into force on April 2005	Authorities keep a record of manufacturers, Environmental Ministry responsible, but may transfer task to a qualified legal entity There is a guarantee that could apply to producers. either they participate in the system or their bank account is blocked.	Manufacturers should Producers pay a flat rate to communes that includes financing for containers, building changes required by the treatment ordinance and information to consumers	Waste equipment from private households can be returned at collection points A visible fee is allowed for historical waste No fee is allowed for new waste.
Belgium	The VLAREA Ordinance goes beyond the WEEE Directive e.g by requiring collection of	Local municipalities organize collection points	Producers are charged for using these sites. Retailers offer 1:1 take back Recupel manages a	Visible fee. Allowed until 2011 or 2013 for large

	7kg		producer scheme for recovery of browns and white goods. Historic WEEE financed according with market share	appliances
Canada	Saskatchewan Environmental and Protection Act.	SWEEP is governed by a board of directors including three representatives from electronics companies, two representatives from the Retail council of Canada, two representatives from Saskatchewan-based business Collection	SWEEP (Saskatchewan waste electrical and electronics program was established by 21 private sector electronics companies since 2006. It has a disassembly manufacturing facility and 71 SARCAN recycling deposit sites	Environmental Handling fees This fees are paid at the moment of the purchase of new equipment and are not refundable. The current fees at the moment are Desktop Computers 10 USD Notebook Computers 5 USD Computers monitors 12 USD

	Alberta(Alberta 2010)	Collection sites are administered by municipalities	Companies that supply electronics must register with the government There are 6 registered dismantlers in Alberta,	Electronics recycling operations is finance by a fee paid at the moment of purchase. by the customer. Corporate users need to contact dismantlers directly in order to proceed their waste
	Ontario	Waste Diversion Act, Municipalities collect WEEE at collecting places in landfills	Producer and retailers must register, report and pay fees to operate the program across Ontario	A fee is no defined as part of consumer duties, Most WEEE can be disposed as part of the purchase of new equipment, but a fee is not forbidden by

				law.
	British Columbia (British 2010)	Returned it electronics program is a wide province program	Producer have to pay for the program.	Consumer can deliver their electronics free of charge.
	Quebec,	electronic recycling law is still under development	Some OEM have implemented take back systems	
China	Draft The Management Regulation on the Recycling of Used Household Electronics Products and Electronics	Recycling system is largely unorganized, but there is a state run collection system in Beijing for waste with 1800 collection points and approximately 3600 employees All WEEE collected is sent to southeast China mainly the provinces of Guang Dong and Zhe Jiang, where the actual refinery process take place.	Beijing has a semi-organized collection network, There are approximately 5000 individual collectors. Top State owned electronics manufacturers Haier and Hisense set up a centre for recycling old and useles household appliances.	
Chile (Chile 2010)	T.V s equipment break with the earthquake	Municipal collection for the E-waste	Take back systems to replace broken appliances has been organized by some retailers.	

Cyprus	Regulation 68-2004 transposing the RoHs and WEEE directive was approved by the parliament on 30 July 2004	There is a National register, managed by the Statistical Service and the Environment Service of the Ministry of Environment Municipalities are not obliged to collect.	Producers have to register and organize and finance a separate collection.	
Czech Republic	The Waste Act Amendment 7/2005	Municipal collection	Producer may use municipal collection or set up own collection Producer must provide containers for municipal collection Producer responsible for WEEE post 13 2005.	1:1 tale back at retailers is mandatory. Replacemen t purchases finance the WEEE, pre August 13 2005. Visible fee for large appliances to be determined.
Denmark	An Amendment of the Waste Management Act was approved by Parliament in May 2005	Local government must ensure adequate coverage for free municipal collection points	Retailers accept on 1 on 1 basis Historic WEEE collective financing based on Market Share.	End user is responsible, unless a replacement purchase is made.
Ecuador	A recycling e-waste	Recycling campaign	Telefonica Porta	

	campaign started with the endorsement of private Institution as part of their social responsibility	started with cell phones	provide containers in parts of the University Porta and Fundacion Natura made this program since 2006	
Estonia	Expected WEEE directive to be transposed	Control registar for producer with the Environment Information Centre	Producer 100% responsible for financing separate collection systems from Households Marking to show full producer address	
Finland	Act 452/2004 Amending the 1993 Waste Act was adopted by Parliament	The Pirkanmaa Regional Environmental centre will run the nationwide producer registration system for Producer Responsibility	Producers are responsible for organizing and financing the collection of WEEE from households. Retailers must teither take back WEEE on a 1:1 basis or indicate to the consumer an alternative reception	
France	A new WEEE Decree will transpose the WEEE and RoHS Directives, Several sub Decrees to regulate detailed provisions and preparation	If communes collect waste, a coordinating organization of producers to install a separate collection system	For WEEE not collected by communes producers to install a separate collection system Retailers to take back at least free of charge on a 1:1 basis, may	Visible fee only allowed for historical WEEE, Will be mandatory for large WEEE

			delegate to 3rd party Historic and new waste responsibility is proportionate to equipment placed in the market.	appliances
Germany	Draft WEEE Law ElektroG	Municipalities to operate and finance collection points for free of charge take-back.	Producers to provide containers for six collection categories Producer responsibility proportional to market share	
Greece	Presidential Decree 117 of 5 March 2004 transposes the directives and applies the provisions of Waste Law no 2939/2001	Municipal collection points to be set up. It will be forbidden to collect e-waste with other household wast	Retailers to take back WEEE free of Charge on a 1:1 basis Historic waste will be paid as you go basis according to current market share.	
Hungary	Government decree 264/2004	The product fee Act levies a waste tax on EEE from January 2005	Producer to bear all costs including collection costs Producers participating in a collective system are exempt from the product fee	
Ireland	Three sets of regulations: Waste Management act. Implementation	Each local authority will be obliged to maintain a register of all retailers of	Producers must meet their obligations through a collective scheme	

	arrangement to WEE Directive and Implementation arrangement to RoHS Directive	EEE in its functional area. Accept WEEE free of charge from members of the public and registered retailers. who take back household WEEE on a one for one basis	Retailers will be obliged to take back at least free of charge household WEEE on a one for one basis	
Italy	Draft legislative decree on WEEE	Tax financing municipal collection, centers to accept WEEE from retailers and consumers	Producer to finance from collection centers onwards Retailers to accept one and one take back from consumers.	
Japan	Japanese law for household appliance recycling	Collection of used products can be done through municipalities and retailers. In rural areas without major appliances retailers collection is provided by local government of AEHA (The Association for electric Homes Appliances)	The law requires industry to establish a recovery and recycling system for used products. Manufacturers are obligated to finance the recycling of their own products	Finance through end-users fees, However the law imposes an old for new requirement on Japanese retailers. A T.V fee is 11 Euro, Refrigerators are 30 to 38 Euro and Washing

				Machines 16 to 22 Euro
Latvia	WEEE directive transposed in Several text: Law on Waste Management, Amendment to the Natural resource tax law, Cabinet of Minister regulations 624,736,923 and Draft on National Registers, Revision of the National Waste Management Plan 2003-2012	Tax amount has not been defined yet Industry reject an initial propolsal to have a flat weight based tax for all EEE categories.	Producers are responsible for collection. Those who comply individually or collectively will be exempt from a new tax on EEE	Separate collection form Households.
Lithuania	Draft law and the Amendment of the Law on Waste Management	Municipalities to run collection centers	Unless producer runs their own collection center they must accept conditions of municipalities	1:1 take back at retailers mandatory on all sizes
Luxemburg	Draft WEEE regulation published on January 2005	Municipalities maintain collection	Historic waste base on current market share. Producer have a responsibility for WEEE placed on the Market post 13 August 2005. Producer responsible for pre-13 Aug 2005 if replacement or purchase otherwise	Retailers will continue to offer 1:1 take back free of charge.

			end User Responsibility	
Malta	The Eco-Contribution Act	Charge importers a tax on WEEE. In addition WEEE is collected by WasteServ a company established by the government in 2003	Historic waste base on current market share	
Netherlands	WEEE Management Regulations State Secretary for Housing, Spatial Planning and the Environment on July 19 2004	Municipal authorities shall bear responsibility for the separate collection of waste electrical and electronic equipment	When supplying a new product a distributor shall at least free of charge, take back a similar item of waste electrical and electronic equipment from a private household. A producer shall ensure that any waste electrical and electronic equipment originally produced by him other than waste electrical and electronic equipment form private households is separately collected.	Every Municipal authority shall provide sufficient opportunity for final holders and distributors to return waste from private households at least free of charge. Visible fee allowed until 2011 for large appliances.

Poland	The WEE Directive will be transposed through an Act requiring Parliamentary aproval	Local authorities to provide collection points	Producer to finance separate collection of an amount equal to 90% of what is place on the market.	Visible Fee for historic waste, set by the producer or collective organization
Portugal	Decree Law 2030/2004	Municipal collection points,	Distributors will be obliged to take back WEEE free of charge on a 1:1 basis Historic waste shall be funded by producer according to their market share	
Slovakia	Amendment of the Waste Act of 2001		A Recycling Fund was set up and manufacturers are obliged to pay a product fee, Which is used for financing relevant recycling activities and the development of infrastructure. Manufacturers that develop their own recycling infrastructure get an exemption this way.	Visible fee allowed until 2013 for large appliances
Slovenia	WEEE Ordinance.		Retailers are obliged to pay eco product fee for goods put on the	An Ecofee Decree introduces

			market	fees payable at the point of sale for the 10 EEE categories.
Spain	Royal Decree 208/2005	Local authorities will be responsible for collecting WEEE form households and storing it until is collected for sorting and treatment by producers or their collective organization	Producer will bear the cost of the collection, treatment and final disposal of the item.	The consumer may return the WEEE to a distributor from when they are buying a equivalent product, or may drop off at an authorized location in most cases at no cost.
Sweden	WEEE directive in Sweden	Municipalities are allowed to make their own decisions regarding of the waste collection system. Consequently it may vary between different municipalities	Swedish Collection system is originally based on an agreement between a producer organization, El Krestsen representing producer of electronic products established that local	

		depending on the different conditions. Size of population, geographic, size, types of housing, types of business and operation	authorities of the municipalities of Sweden will bear the cost of the collection of electric waste and El Kretsen will bear all other costs. Companies manufacturing and selling or importing any products included by the WEEE Directive must register with the Swedish EPA.	
United Kingdom	The Environment Agency is the leading public body responsible for protecting and improving the environment in England and Wales, and the Scottish Environment Protection Agency protects Scotland's environment	In England and Wales: Since 1 July 2007 Household owners, start seeing information in shops that sell electrical goods about how the shop is going to take back WEE. They must either offer in store take back or be part of the Distributor Take back Scheme	Scotland: Duty of care. Business are responsible that its wasted electronic equipment is isolated from the waste stream and disposed appropriately	When the customer buys a new electronic product alike for a like purchase. the shop must take back the old one at no cost. Shops can take back goods in store or at

		the nearest drop off point. Electronic waste treatment is financed with the purchase of new electronic equipment

BIOGRAPHICAL SKETCH

Jesús Ángel. Estrada Ayub was born in Chihuahua Mexico in 1969. He holds a B.S in Industrial Engineering from the Instituto Tecnologico de Chihuahua II and a M.A. from the Universidad Autonoma de Chihuahua.

He combines his professional experience between the Academia and Industry. Some of his professional accomplishments are:

Re-engineering from the Supply Chain Management from United Technologies Automotive Operations in Chihuahua

Design and Re-engineering from operations base on Lean Manufacturing. In charge of the quality process approval called PSO for Chrysler at the first automotive injection molding plant in Chihuahua.

Lead and design the first ISO9000 quality system for education in Chihuahua that attained ISO9000. Lead and train from the first operators of Sheet Metal Assembly to support the Aerospace Industry deployment in Chihuahua.

In addition to these professional activities he has developed an intense activity as professor at University level. In 2005 he was awarded professor of the generation from their Students.

In 2008 he was recipient of the Fulbright Garcia Robles Scholarship to carry out PhD studies at the Civil & Environmental and Sustainability Engineering School at Arizona State University. In 2010 in the Boston Seminar from Lab to Market he was awarded the Second Place for an Environmental Project to support the deployment from solar energy for cooking at rural communities.

His main research interests are Industrial Ecology and Earth Engineering systems and Management and Sustainable Development from poor communities.