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Departamento de Ambiente e Ordenamento

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Potencial de poupança de energia das práticas de gestão de resíduos eletrónicos: um estudo de caso da América Latina

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Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Sistemas Energéticos Sustentáveis, realizada sob a orientação científica da Doutora Mara Teresa da Silva Madaleno, Professora Auxiliar no Departamento de Economia, Gestão, Engenharia Industrial e Turismo da Universidade de Aveiro e co-orientação científica da Doutora Kerstin Kuchta, Professora da Universidade Técnica de Hamburgo.

Dedico este trabalho à minha família pelo incansável apoio.

o júri

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agradecimentos

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palavras-chave

Gestão de resíduo eletrónico; potencial de poupança de energia; América Latina.

resumo

Em virtude da geração sem precedentes de equipamentos eletroeletrónicos a nível mundial, o setor de gerenciamento de resíduos eletrónicos tem emergido como uma oportunidade de recuperar recursos na forma de materiais e energia. Nesse contexto, a América Latina apresenta um grande potencial para melhoria de suas práticas de gestão nos próximos anos. Os estudos atuais sobre resíduo eletrónico na América Latina ainda são escassos e a maioria dos países enfrenta desafios para instituir um sistema eficaz de gerenciamento. Dessa forma, a presente dissertação tem como principal objetivo explorar o impacto energético das atividades relacionadas à reciclagem de resíduos eletrónicos, e também propor uma metodologia para avaliar o desempenho dos sistemas de gestão de resíduo eletrónico na região.

Com relação à avaliação energética, a poupança de energia foi estimada utilizando o modelo WARM, desenvolvido pela agência ambiental norte americana, sendo comparados dois cenários diferentes de gestão, a disposição em aterro e a reciclagem. De acordo com os resultados, um total de 19.871 GJ de energia poderia ser poupada se todos os países estudados atingissem a taxa de reciclagem estimada para a América Latina em 2016. O estudo também contemplou o cálculo das emissões de gases do efeito estufa evitadas, e um benefício ambiental de 1.569.139 Mt de dióxido de carbono equivalente foi estimado.

Referente à avaliação dos sistemas de gestão de resíduo eletrónico, os países estudados apresentaram diferentes níveis de gerenciamento, e etapas importantes foram identificadas para explorar todos os potenciais benefícios energéticos e ambientais estimados. Nesse sentido, além de estabelecer uma estrutura regulatória sólida, promover uma cooperação mais estreita entre os países demonstrou ser de extrema importância para o desenvolvimento dos sistemas de gestão de resíduos eletrónicos e intercâmbio de informações relevantes em termos de competências técnicas, políticas públicas, entre outros aspectos.

keywords

E-waste management; Energy savings potential; Latin America.

abstract

In view of the unprecedented generation of EEE worldwide, the management sector of e-waste is emerging as an opportunity to exploit resources in the form of both materials and energy. Within this context, LATAM has great potential to improve its e-waste management practices in the coming years. Current studies regarding e-waste in LATAM is still scarce and the majority of countries face challenges in setting up an effective e-waste management system. Therefore, the present dissertation aims to explore the energy impact of e-waste recycling activities, and also propose a methodology to evaluate the performance of e-waste management systems within the region.

Concerning the energy assessment, the energy saving was calculated using EPA's WARM tool throughout the comparison of two different e-waste management scenarios, i.e. landfilling and recycling. The results show that a total of 19,871 GJ of energy could be saved if all countries studied achieved the recycling rate estimated for LATAM in 2016. The avoided GHG emissions were also calculated, and an environmental benefit of 1,569,139 Mt of carbon dioxide equivalent reduction was estimated.

With regard of e-waste management assessment, the countries studied present different levels of e-waste management, and some key steps have been identified to explore all the energetic and environmental potential benefits estimated. In this regard, in addition to establishing a sound regulatory framework, fostering closer cooperation between countries has proven to be extremely important for the development of e-waste management systems, and exchange of relevant information in terms of technical skills, public policies, among others aspects.

TABLE OF CONTENTS

List of Figures

List of Tables

List of Abbreviations and Acronyms

CPI	Corruption Perception Index
CRI	Country Risk Index
EC	European Commission
EEE	Electrical and Electronic Equipment
EPA	United States Environmental Protection Agency
EPR	Extended Producer Responsibility
EU	European Union
GDP	Gross Domestic Product
GNI	Gross National Income
GTAI	Germany Trade & Invest
GSMA	Global System for Mobile Communications Association
HDI	Human Development Index
ITC	International Trade Center
LATAM	Latin America
LFG	Landfill Gas
MSW	Municipal Solid Waste
OECD	Organization for Economic Co-operation and Development
POP	Persistent Organic Pollutant
StEP	Solving the E-waste Problem
UN	United Nations
UNEP	United Nations Environmental Programme
WARM	Waste Reduction Model
WEEE	Waste of Electrical and Electronic Equipment
WHO	World Health Organization

CHAPTER 1

1. Introduction

1.1. Background and motivation

Started in the late 1970s, the digital revolution was marked by the impact of information and communication technology (ITC) on social and economic development, leading to an intensive production of electrical and electronic equipments (EEE), and therefore an unprecedented generation of electronic waste (e-waste): one of the fastest growing waste streams in the world [1].

This trend has presented a challenge for the e-waste management sector worldwide, and the increasing of emerging economies joining the global information society together with a high rate of obsolescence of EEE, represent serious environmental and health issues [2].

Within this context, particular attention should be given to Latin America (LATAM). According to the latest Global E-waste Monitor Report [3], the global quantity of e-waste generated in 2016 was around 44.7 million metric tonnes (Mt), or 6.1 kg per inhabitant, of which 9.4% was originated in LATAM. In addition, the region also presents a volume of e-waste per capita higher than the world average, equivalent to 7.1 kg per inhabitant, and the expected growth rate indicates that the amount of e-waste generated will increase up to twice as fast as the global trends [4].

Requirements for e-waste sector are relatively new in LATAM, and the lack of an effective national regulation in the majority of countries requires a holistic analysis in order to promote the development and improvement of e-waste management practices [4], [5].

In order to meet the growing issue of e-waste in LATAM, an efficient e-waste management is needed, and the region still face significant challenges to treat e-waste in an environmentally sound manner.

The generation of waste represents a loss of resources in the form of both materials and energy, and a frequently overlooked benefit of e-waste management is the energy savings through more efficient practices, a win-win scenario for energy consumption reduction and resource conservation [6].

Once inside the waste stream, each stage of an EEE life cycle has energy impacts: from acquisition of supplies used in the manufacture process to use and disposal by consumers [7].

E-waste management practices, such as recycling, has a potential for contributing to reduce these impacts by lowering the demand for primary raw materials and also the energy inputs from resources extraction and processing activities, thereby saving energy. Since greenhouse gases (GHG) are generally related to energy consumption, avoided emissions of the carbon dioxide are also observed [8].

According to the '*Study on the Energy Saving Potential of Increasing Resource Efficiency'* elaborated by the European Commission (EC), within the waste management sector, markets for recyclables can offer opportunities for increased efficiency and energy savings. As these markets become more mature, with stable prices and easy access to recyclers, businesses and consumers gain an economic incentive for collecting more waste for recycling [6].

To exploit the full benefits of e-waste recycling efforts, LATAM countries need to improve their e-waste management systems by adapting pre- and, to some extent, end-processing technologies to their own needs. For this purpose, a technology transfer and knowledge exchange are required [9].

In this regard, the United Nations Environment Programme (UNEP) identifies areas that pose challenges for a successful transfer of sustainable technologies and economic models of e-waste management, particularly in emerging economies: policy and legislation, technology and skills, business and financing, the strong influence of the informal sector, and low skills and awareness. Each area can prevail in a weaker or stronger degree in developing countries in general, and a better comprehension of these scenarios could help to achieve energy savings through improved e-waste management practices [10].

1.2. General objectives

This thesis aims to estimate the energy saving potential of e-waste recycling process of LATAM countries, and assess their e-waste management systems in order to identify the main aspects towards their improvement.

To achieve this purpose, this work applies the EPA's Waste Reduction Model (WARM) to estimate the energy impacts of e-waste recycling process, and proposes a methodology to assess and compare different e-waste management scenarios.

1.3. Research questions

Two main research questions were formulated:

RQ-1: What is the overall energy impact of e-waste recycling activities?

RQ-2: What are the major strengths and weaknesses of LATAM's e-waste management systems?

The main contribution of this research is to propose a methodology to quantify the energy savings potential of additional e-waste recycling efforts and qualitatively assess different e-waste management systems in LATAM.

Particularly in emerging economies, such as the majority of LATAM countries, the current state of knowledge regarding e-waste is still scarce and this study intends to fill this gap by presenting an energy analysis related to improved e-waste recycling practices. Furthermore, through the assessment of different countries, the present work also intends to promote the benchmarking of e-waste policies and methods within LATAM in order to identify the main areas that should be the focus of potential interventions.

1.4. Document structure

This thesis is structured in six major chapters. Chapter 1 provides the context, motivation, and main objectives and expected contributions of this work. At

Chapter 2, the state of the art is presented, exploring the e-waste concept and its management as a challenging topic for energy savings. This section also includes the life cycle approach through an energy consumption perspective. The general methodology adopted is described in Chapter 3, including the main assumptions adopted in the model, and the comparative analysis proposed to assess different e-waste management scenarios. At Chapter 4, the results are presented, and in Chapter 5 the model outputs are discussed, and the main barriers for improved e-waste management are explored. At last, Chapter 6 summarizes the main conclusions and limitations of this thesis.

CHAPTER 2

2. Literature review

2.1. What is e-waste?

Globally referred to as waste of electrical and electronic equipment (WEEE), or e-waste for short, a standard definition of electronic waste has not been acknowledged so far. Several countries drafted their own definition, interpretation and usage of the term, resulting in different but similar concepts of e-waste. These differences of what constitutes e-waste have the potential to create disparities in both the quantification of e-waste generation and the identification of e-waste flows, and a precise definition is one of the key issues that need to be addressed on an international level [9].

While there is no general agreement on this question, the foundation of most definitions reported in regulations, policies and guidelines rely on the references listed in Table 1.

Table 1: Definitions of e-waste.

Reference	Definition
EU WEEE Directive [11]	Electrical or electronic equipment which is waste within the meaning of Article 1(a) Directive 75/442/EEC[1], including all components, sub-assemblies and consumables which are part of the product at the time of discarding.
Basel Convention [12]	Electrical or electronic equipment which is (i) disposed of or is (ii) intended to be disposed of or is (iii) required to be disposed of by the provisions of national law, including all components, sub-assemblies and consumables which are part of the equipment at time the equipment becomes waste.
StEP [13]	Term used to cover items of all types of electrical and electronic equipment and its parts that have been discarded by the owner as waste without the intention of reuse.
OECD [14]	Electrical and electronic equipment that is no longer suitable for use or that the last owner has discarded with the view of its disposal.
EPA [15]	Used electronics that are nearing the end of their useful life, and are discarded, donated or given to a recycler.

Source: Own elaboration based over the literature review.

[1] Directive 75/442/EEC, Article 1(a) defines 'waste' as "any substance or object which the holder (i) discards or (ii) intends or is (iii) required to discard".

Distinctive methodologies have been developed in order to classify e-waste streams. The most widely accepted classification is based on the European Union (EU) directives, in particular Directive 2002/96/EU (the WEEE Directive), and Directive 2012/19/EU (the new WEEE Directive).

Launched in 2002, the first EU WEEE Directive focuses on waste prevention by improving the environmental performance of all operators involved in the life cycle of EEE [11]. Therefore, to lay the foundations for further development of collection schemes, 10 categories of e-waste have been identified. This classification was applicable in the EU until August 2018, when the recast of the original directive became effective. Within the new EU WEEE Directive, the previously scope will be extended to a so-called open scope with 6 revised categories of e-waste. Figure 1 illustrates the relationship between the old and new EU classifications.

Classified as hazardous due to the presence of highly toxic substances such as heavy metals and persistent organic pollutants (POPs), e-waste also contains items of economic value such as precious metals like silver, gold, platinum and palladium, and non-ferrous metals like copper and aluminum, making it a “tradable commodity” in terms of its potential for material recovery [16].

The presence of worthwhile material in e-waste has attracted the recycling and refurbishing sectors, becoming a business opportunity with potential to create new employment and contribute to economic growth [3]. When handled with minimal technical, occupational, and environmental standards, e-waste can offer a valuable source of raw materials that can re-enter the market for reuse or/and to power other processes [17]. In this regard, the composition of e-waste provides a good indication of the reuse and recycling market potential, playing an important role for the developing of e-waste management strategies [18].

The composition of e-waste is very diverse and differs across product lines and categories. It contains more than 1000 different substances and elements that vary according to the type of EEE, the model, manufacturer and production date [19].

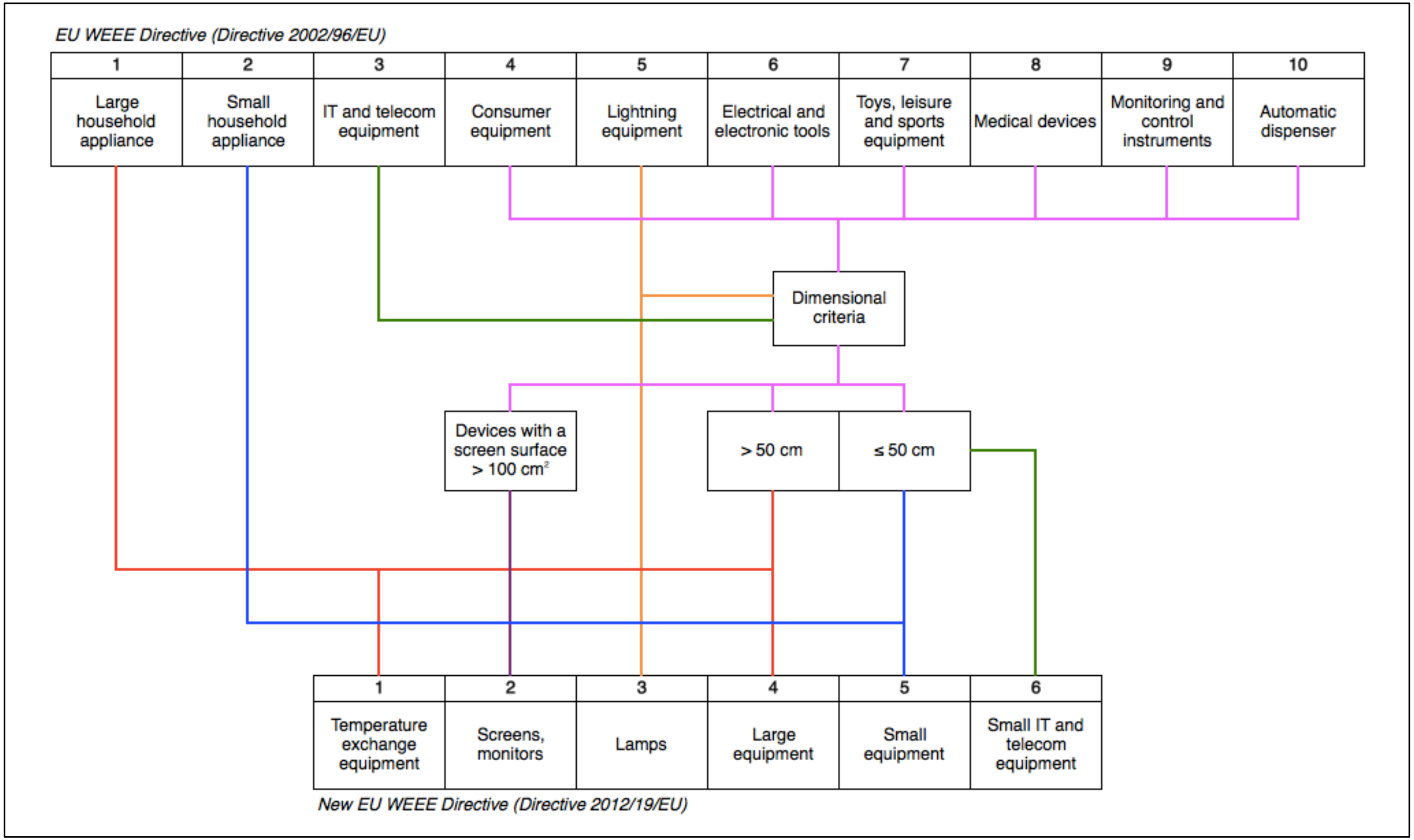

Figure 1: Relationship between old and new e-waste categories.
Source: Adapted from [20].

Generally it consists of ferrous and non-ferrous metals, plastics, glass, wood and plywood, printed board circuits, concrete and ceramics, rubber and others items. In terms of composition by weight, iron and steel comprises approximately 50% of e-waste, followed by plastics (21%), non-ferrous metals (13%), and other constituents [21]. Figure 2 presents the estimated composition of e-waste.

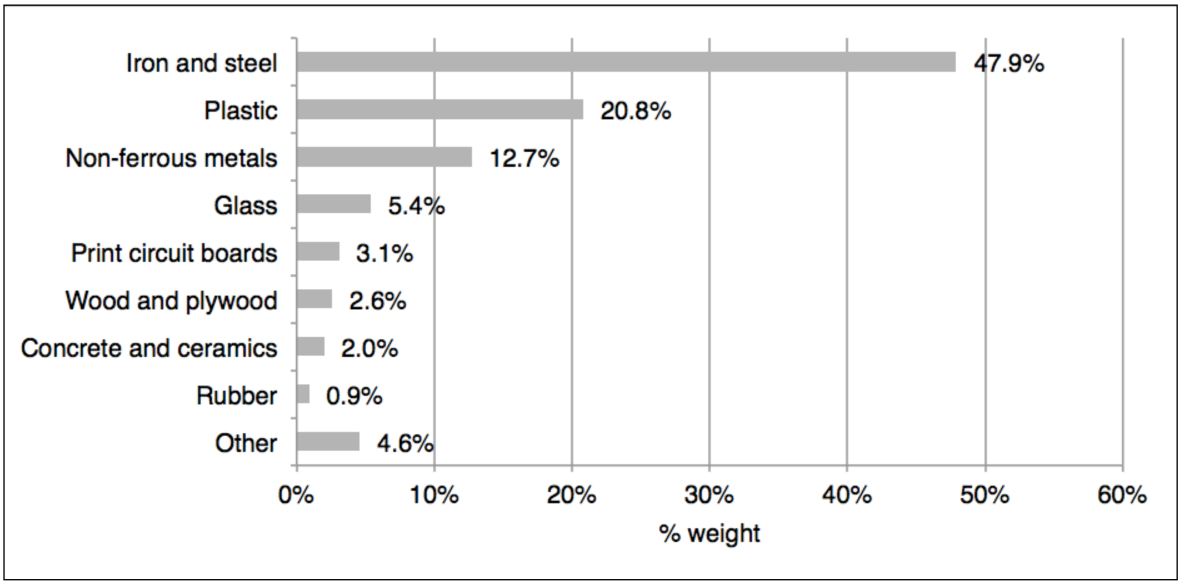

Figure 2: Estimate composition of e-waste.
Source: Adapted from [22].

The technological progress together with social, geographic and cultural factors, including the pressure on manufacturers to reduce or eliminate the potential environmental contaminants in their products, has been responsible for the changing composition of e-waste, and an efficient e-waste management is necessary in order to keep the pace with these changes, particularly in LATAM countries [9].

2.1.1. E-waste management

E-waste management is developed either formally or informally. The formal sector is characterized by the activities under the requirement of national e-waste legislation, in which e-waste is collected by designated organizations, producers, and/or the government to be treated properly. In countries with developed waste management laws, e-waste is also collected by individual waste dealers or companies and then traded through various channels. Possible destinations include recycling facilities and exportation to developing countries [23].

In contrast, the informal sector involves a significant number of self-employed individuals who are engaged in the collection and recycling of e-waste without any legal framework. This usually happens at the household level where e-waste can be either bought directly from consumers or collected from normal dustbins. In this scenario, products are mostly recycled through substandard methods, in poor conditions, manually, and frequently without any protection measures [3].

Informal sector plays a crucial role in e-waste collection and recycling practices across developing countries, where these activities are usually the main income source of low-income populations. For that matter, the key issue is to integrate the informal sector with the formal sector and raise the awareness among both consumers and e-waste recyclers, in order to develop an e-waste management system that meets the environmental, safety and social needs [24].

It is clear that the future of e-waste management, particularly in developing countries, depends not only on the effectiveness of local government authorities working with recycling operators but also on community participation, together with national, regional and global initiatives [9].

Nevertheless, an e-waste management system cannot be merely reduced to the setting up of recycling infrastructure. Taking into account economic and social boundaries conditions are crucial to establish an effective e-waste management structure. Local situations like available investment, economic conditions, local treatment standards, awareness and education of workers and management level of recycling chain should be also considered [25].

In this respect, the UNEP emphasizes that a comprehensive framework considering all issues around policy and legislation, business and financing, and technology and skills is required in order to achieve a sustainable e-waste management system, particularly in emerging countries.

Regarding policy and legislation, the main concerns refer to the presence of specific legal frameworks and conflicting legislations, the priority of the issue at the country level, and uncoordinated enforcement of the law [25]. Policy, laws, regulations related to e-waste management provide an institutional framework for their implementation, increasing the efficiency of recycling operations, easing the identification of markets for recycled material and product reuse, strengthening the formal and organized sector [16].

Concerning business and financing, international cooperation, foreign and local investments, and the development and adoption of new technologies are required to set up the necessary infrastructure for the proper and efficient management of e-waste, particular in emerging countries. Therefore, the main points that should be considered include the accountability and participation of stakeholders, exploitation of workers from disadvantaged communities, and crime and corruption rates [25].

In terms of technology and skills, in addition to the technical competences, the awareness among all actors of the different e-waste sectors is also important in order promote sustainable consumption and production patterns [16]. Thus, additional topics include the existence of environmental, health and safety standards, the influence of informal sector, the status of collection infrastructure, and public awareness [10], [25].

The actors in the e-waste value chain have legal and technological tools as well policy instruments to transform the above-mentioned challenges into opportunities, underlining the need for emerging economies to work together to ensure environmental sustainability for e-waste management.

Information about e-waste management should become a tool that allows governments to lay the foundation for decision-making, in order to identify new alternatives of e-waste treatment and to enable cooperation for research, technology and know-how transfer and sharing. In LATAM context, this information is helpful in creating synergies among countries and with other geographical areas that may face similar challenges [10].

2.1.2. E-waste recycling

An effective e-waste management aims to extend the use and lifespan of materials through recovery or recycling processes, prioritizing repairing and reusing of these materials whenever possible [10].

Within an e-waste recycling chain (Figure 3), the operations intend to maintain or restore as much material as possible that is recovered from e-waste to its original quality in terms of purity and physical and chemical properties. The recovery process involves the removal and decontamination of all potentially toxic compounds, to properly recover valuable materials, and then, safely dispose the toxic parts and non-recyclable residuals [26].

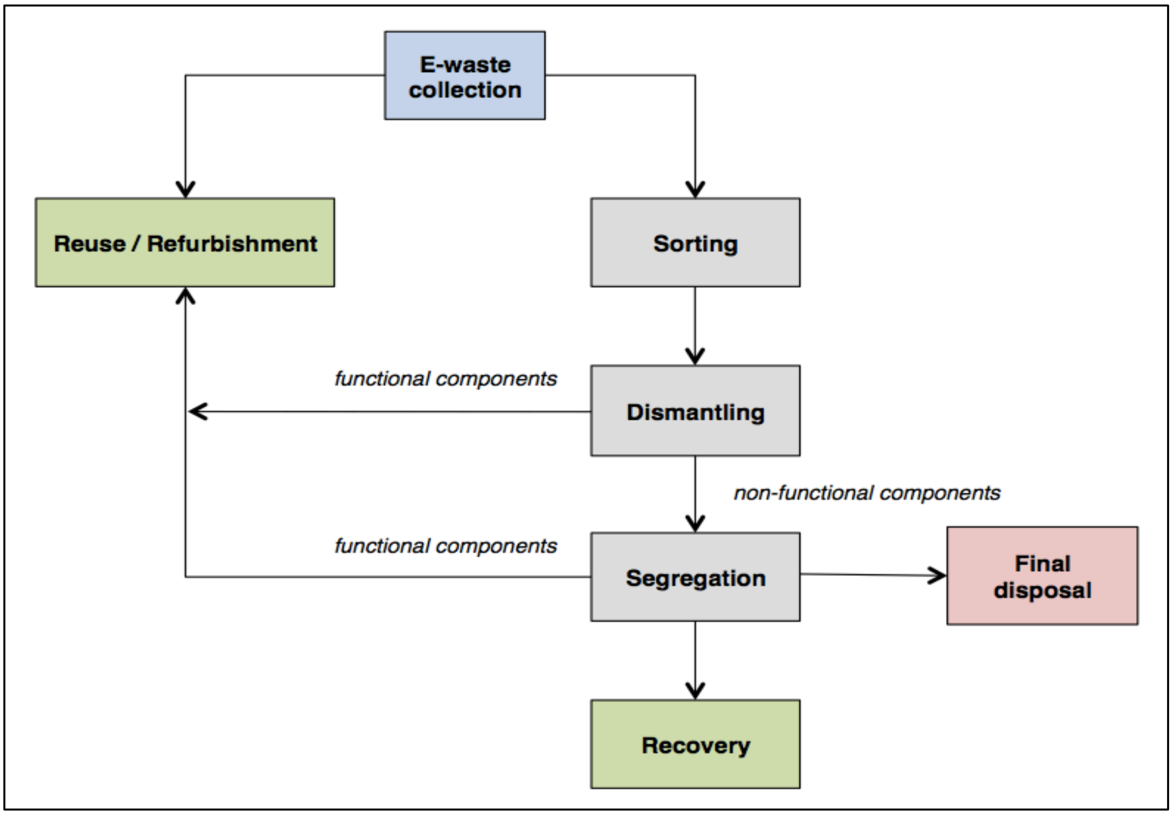

Figure 3: E-waste recycling chain.
Source: Adapted from [27].

The terminology used in the e-waste recycling chain is described in Table 2.

Table 2: Terminology of e-waste recycling chain.

Definitions	
Collection and sorting	The gathering of waste, including the preliminary sorting and preliminary storage of waste, for the purposes of transport to a waste treatment facility.
Dismantling and segregation	Process of breaking of a product or material into its components and segregating them for the convenience of recycling.
Disposal	Any collection, sorting, transport and treatment of waste as well as its storage and tipping above or underground which is not recovery.
Recovery	Any operation that allows utilization of waste by replacing other materials that would otherwise have been used to fulfill a particular function.
Refurbish	Recovery, reclamation and repair of discarded or used electronic devices or components with the intention of resale or reuse.
Reuse	Any operation by which e-waste or components are used for the same purpose for which they were conceived, including the continued use of the equipment or components which are returned to collection points, distributors, recyclers or manufacturers.

Source: [28], [29].

Strong energy savings potential through recycling efforts have been identified within the e-waste management sector. The presence of scarce metals in e-waste requires an energy intensive mining activities, and the recycling sector can play an important role in lowering the pressure on raw materials extraction, resulting in significant reduction of energy consumption.

Through a life cycle approach, energy savings can be estimated as the amount of energy avoided from raw materials acquisition and manufacturing processes caused by waste reduction activities, such as recycling. In addition, since a large portion of GHG emissions is usually related to energy consumption, the carbon dioxide equivalent reduction potential can be also estimated [8].

2.2. Energy implications of e-waste life cycle

Life cycle refers to identifying and quantifying the energy and materials flows of a studied system, which can be a product, a process or an activity [30]. In the case of e-waste, the life cycle process begins at conception of an EEE and completes with the recycle/recovery or disposal of the product and its constituents, when it becomes e-waste (Figure 4) [31].

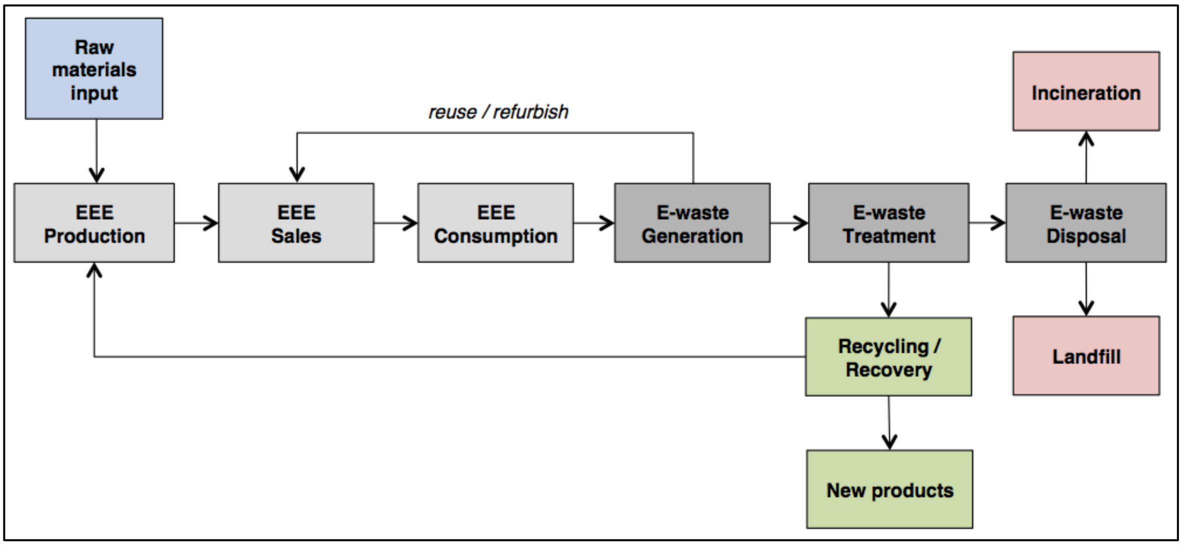

Figure 4: E-waste life cycle.
Source: Adapted from [9].

Each stage of e-waste life cycle has energy impacts. With respect to recycling process, energy savings can occur in close loop or open loop product systems. In the first scenario, end-of-life products are recycled into the same product, and energy benefits result from manufacturing the primary material; in the second, the products of the recycling process are not the same as the inputs. In this scenario, the energy benefits result from the savings associated with the virgin manufacture of the secondary products that the material is recycled into [7].

Energy implications of waste management practices accrue throughout the life cycle, and a product-specific life cycle assessment (LCA) is required to quantify energy savings that could be achievable through improved practices [8].

2.3. Life cycle assessment of e-waste management

LCA is a decision-support tool, which, through its holistic perspective in quantifying environmental impacts, has been demonstrated to provide valuable contributions to identify the potential benefits of improved e-waste management practices [32]. In fact, quite a few scientific literatures with respect to application of

LCA on e-waste management have been recently published [33]. In Europe, much research has been conducted using LCA to evaluate the environmental impacts of end-of-life treatment of e-waste [34]. However, most studies have been conducted in terms of eco-design and product development.

Within this context, the United States Environmental Protection Agency (EPA) Waste Reduction Model (WARM) is a tool designed to help managers and policy-makers understanding and compare the life cycle GHG emissions and energy implications of different waste management practices [35]. By comparing a baseline scenario to an alternate scenario, the model can assess the energy and GHG implications that would occur throughout the material life cycle [7].

To conduct such a comparative analysis, EPA adopted a streamlined application of a LCA. A full LCA is an analytical framework for understanding the material and energy inputs, and the environmental releases associated with the life cycle of a given material. WARM's streamlined LCA is limited to an inventory of energy impacts and GHG emissions of relevant life cycle stages. The model does not consider human health impacts, or air, water, or other environmental impacts [36].

One important difference between WARM and other life cycle analysis is that the model calculates the benefits from a waste generation reference point, rather than a raw materials extraction reference point. Waste generation point refers to the moment that a material is discarded, therefore, the benefits estimated result from the choice of one management path relative to another [37].

To better understand the relationship between materials management and energy use, WARM provides energy factors for five waste management scenarios, i.e. source reduction, recycling, combustion, landfilling, and anaerobic digestion. The total energy estimated by the model is a result of the accumulated energy consumption associated with raw materials acquisition and manufacturing, transportation, and embedded energy [7].

2.4. Solid waste management in Latin America

In order to better understand the e-waste management situation in LATAM, it is first necessary to look the current status of municipal solid waste (MSW) management within the region.

Over time, managing MSW has presented different challenges, and factors such as global change, comprised of population growth, urbanization, and climate change, have also contributed to making MSW management a complex issue. A new positive trend of seeing waste as a resource has been growing in recent years, and this perspective depends not only on the volume of waste, but also on its composition, which is closely tied to the socioeconomic status of the population [38].

LATAM countries have fast growing cities with increasing rates of waste generation, and statistics show some significant differences compared to other regions in the world. On average, the generation of MSW in LATAM is 0.99 kg/capita/day, which keeps LATAM between the Middle East and North Africa, and the Europe and Central Asia rates, with 0.81 and 1.18 kg/capita/day, respectively [39].

Solid waste systems in LATAM are in the process of modernization, and only a few countries have sorting plants and employ recycling as a common practice in their MSW management system. At an urban level, many cities have initiated source-separation programs, and recycling rates are highest for materials such as aluminum, paper, and plastic. Waste collection coverage is at a relatively high level when compared to the global average of 73%. At urban level, about 85% of waste is collected. However, about 69% of waste is disposed of in landfills and dumps [38], [39].

The high percentage of untreated MSW reflects the current performance of separation and segregation practices, which means that a significant space for the informal sector to step into the recycling business has been created [38]. Therefore, population awareness also contributes to collection practices. Most people are neither used to identifying the different waste streams nor to taking each waste stream to the appropriate collection container, which in most cases is missing. In addition, in some cities, the separated material is mixed in the same container by the waste collection truck, invalidating the intent and discouraging further segregation, resulting in a poor performance among voluntary take-back and recycling systems [40].

CHAPTER 3

3. Methodology

This chapter outlines the general methodology adopted in this work. At first, a description of the study case is introduced. Then, the description of the scenarios and main assumptions considered to estimate the energy benefits of e-waste management practices are presented. Finally, the steps adopted to evaluate and compare e-waste management systems are described.

3.1. Description of the case study

This case study included the analysis of fifteen LATAM countries. The regional challenge to treat e-waste in an environmentally sound manner represents an opportunity towards the improvement of e-waste management practices, and also energy savings. Emerging economies, such as the majority of LATAM countries, are those that have more difficult to cope with the fast pace of technological progress worldwide, turning them an interesting case study.

With Brazil and Mexico topping the list of LATAM countries that are progressive growing from emerging to developed economies, the region was impacted by the increasing demand for new and better products and services, specially those related to the technological sector, leading to an outstanding issue in terms of e-waste management [40].

This has driven many governments in LATAM to proactively discuss about regulating the e-waste sector, and since 2000, efforts have been made in this area. According to the ORBIS Compliance's estimate, by 2020, 80% of LATAM countries will have implemented e-waste collection programs covering at least 60% of each country's territory [41].

The general overview of the selected countries is presented in Table 3.

Table 3: General information of selected LATAM countries.

Country	Land area (km^2)	Capital	Other largest cities	Currency
1. Argentina	2,780,400.0	Buenos Aires	Córdoba	Peso
2. Bolivia	1,098,581.0	La Paz	Santa Cruz	Boliviano
3. Brazil	8,515,770.0	Brasília	São Paulo	Real

Table 3 (continued): General information of selected LATAM countries.

	Country	Land area (km^2)	Capital	Other largest cities	Currency
4.	Chile	756,102.0	Santiago	Valparaiso	Chilean Peso
5.	Colombia	1,138,910.0	Bogota	Medellín	Colombian Peso
6.	Costa Rica	51,100.0	San Jose	Puerto Limón	Colón
7.	Ecuador	283,561.0	Quito	Guayaquil	U.S. Dollar
8.	Guatemala	108,889.0	Guatemala City	Mixco	Quetzal
9.	Honduras	112,090.0	Tegucigalpa	San Pedro Sula	Lempira
10.	Mexico	1,964,375.0	Mexico City	Guadalajara	Mexican Peso
11.	Panama	75,420.0	Panama City	San Miguelito	Balboa, U.S. Dollar
12.	Paraguay	406,752.0	Asunción	Ciudad del Este	Guarani
13.	Peru	1,285,216.0	Lima	Arequipa	Nuevo Sol
14.	Uruguay	176,215.0	Montevideo	Salto	Uruguay Peso
15.	Venezuela	912,050.0	Caracas	Maracaibo	Bolivar

Source: [42].

As previously stated, around 4.2 Mt of e-waste was produced in LATAM in 2016 (9.4% of the total amount generated worldwide), and Argentina, Brazil, Colombia, Mexico, and Venezuela accounting for roughly 80% of this total [3].

These figures can be related to the urbanization trends within the region. As seen, LATAM currently houses a couple of megacities (population over 10 million) such as Mexico City, São Paulo, Buenos Aires and Rio de Janeiro. Lima and Bogota are also assumed to have surpassed 10 million. This urbanization trend is creating growing concentrations of people, commerce, and industry, and waste generation is constantly evolving in reaction to the population and economic growth, and industrialization of each country in the region [38].

3.2. Energy savings assessment

Energy savings were estimated using the open source EPA’s WARM tool. The model quantifies the energy impacts associated with waste management practices by applying energy factors related to a given material. Since e-waste composition varies considerably among EEE categories, EPA provides an approved proxy to represent electronic products based on the personal computer energy factors [43].

WARM energy factors are based on a life-cycle analysis, and therefore, to evaluate the energy impacts of different waste management practices, two scenarios are necessary: a baseline scenario that represents current management practices, and an alternative scenario that represents the substitute management practice. Once the management practices are defined, it is possible to calculate the amount of energy consumed or avoided in the baseline and alternative scenarios and then to calculate the difference between both. The result represents the energy consumed or avoided that is attributable to the alternative management scenario [8].

WARM includes source reduction, recycling, landfilling, and combustion pathways for materials management of electronics. In the case of recycling, the model considers an open loop process, meaning that components are recycled into secondary materials [37]. For this study, the analysis consisted in evaluating the energy impact associated with the change in disposal practices from landfilling to recycling.

The energy saving potential was estimated through additional recycling efforts achieved if all LATAM countries studied reach the e-waste recycling rate estimated for the Americas. Since LATAM countries do not have e-waste collection and recycling targets, and mostly of e-waste statistics for the Americas refers to the richest areas of the region (United States and Canada), this study defined the abovementioned rate as a reference.

The latest E-waste Monitor Report [3] reveals that approximately 17% (1.9 Mt) of e-waste was documented to be collected and proper recycled within the Americas. Although the report does not provide an accurate value for e-waste collection and recycling rates, it is estimated that the average e-waste collection rate in LATAM is lower then 3%.

For research purposes, an additional recycling effort of 15% was considered in the analysis. The set of assumptions considered for calculation is described below.

Emissions that occur during transport of materials to the waste management facility are included in the model. Nevertheless, as the variations in transportation distances vary according to each location, the default distance of 20 miles (approx. 32 kilometers) was adopted. The landfill gas (LFG) recovery for energy or flared was not considered in the calculations. Finally, in order to obtain an upper bound estimate, it was considered that the product would have been manufactured from 100% virgin inputs.

3.3. E-waste management assessment

To evaluate and compare the performance of different e-waste management systems, a comprehensive country assessment is required to better understand the local, national and regional conditions.

Following a sequential methodology, in a first step, an extensive research based on the national indicators has been carried out to create a country profile from a macroeconomic perspective. In a second step, the study focused on collecting the available information related to e-waste management, and in determining the number of e-waste recyclers currently operating in each country and their distribution. Then, a set of indicators has been selected according to their relevance and available data in order to evaluate the overall technology transfer performance of countries as a reflection of their improvement ability. As a final step, a comparative analysis was made to verify the current status of e-waste management in LATAM countries to better understand the weaknesses and strengths of their practices, and to encourage their efforts at improving standards.

3.3.1. Macroeconomic factors

Establish a general framework for e-waste management is an important topic to identify the drivers and barriers for collection and recycling activities in developing nations such as the majority of LATAM countries. In this regard, a macroeconomic analysis was conducted to highlight some characteristics of each country as a whole.

The research relied on secondary data and all information has been obtained by sources considered credible and of integrity. General data such as land area, population figures, age structure, and basic economic background, e.g. inflation rate and Gross Domestic Product (GDP), were gathered from the Germany Trade & Invest (GTAI), the economic development agency of the Federal Republic of Germany. Facts about Gross National Income (GNI) and information technology (IT) infrastructure were taken from the World Bank database. Finally, relevant information related to the country waste and e-waste management was collected from local authorities in each country studied and scientific publications.

By developing a macroeconomic framework, the study aimed not only to ease the identification and mapping of waste recycling facilities but also enable a better understanding of the impact of socioeconomic factors in the e-waste management.

3.3.2. E-waste recycling infrastructure

To evaluate the current status of e-waste recycling infrastructure, a survey of all e-waste recycling facilities in operation within a country was carried out. The mapping procedure had the objective to determine the number and distribution of e-waste recycling facilities currently operating in the fifteen LATAM countries studied. Initially, the federal government and environmental local authorities had been contacted in order to verify the existence of a national waste facilities database. In the absence of relevant information, an extensive research was conducted in order to make direct contact with institutions and companies of the waste sector. The selection criterion was based on the premise that at least one of the recycling process stages should be carried out.

As a final product, an interactive database comprising the spatial locations of the recycling facilities was created using the Google Maps platform. The purpose of this database is to create a scope of formal e-waste basic infrastructure and services availability in order to evaluate the presence of relevant technology within the countries.

3.3.3. Technology transfer performance

The availability of e-waste recycling technologies and specialized managers is limited in the majority of the LATAM countries. Therefore, it is important and necessary to identify the challenges involved in the management of e-waste to ensure the transfer of effective technology [10].

In this regard, the evaluation of the technology transfer performance of countries was based on the national regulation framework, and on indicators related to development and business assessment. Data was collected from legislative databases, and reports from the United Nations Development Programme (UNDP), the GTAI, and the global leader in insurance broking and risk management Marsch.

To report the collected data in a comparable way and evaluate the improvement potential of LATAM's e-waste management systems, the indicators were separated in accordance with the following criteria, adapted from the main areas described by the UNEP as challenges for a successful transfer of sustainable technologies [25]. The description of the selected indicators for each criterion is presented in Table 4.

- *Regulation framework:* recycling and reuse activities are directly affected by the availability and implementation of e-waste legislation. The absence of domestic laws may lead to increased informal sector activities, resulting in material losses and uncontrolled trade of e-waste [21];
- *Business attractiveness:* the interest of stakeholders can enable large-scale investments to foster the implementation of new technologies for the recycling and treatment of e-waste;
- *Public awareness:* human development factors, in particular education, are linked to behavior and engagement of people on environmental concerns, e.g. prevention and recycling of waste, contributing to the effectiveness of waste management systems [44].

Table 4: Selected indicators.

Criterion	Indicators
Regulation Framework	i. Ratification of Basel Convention: the Basel Convention establishes a framework of control over the transboundary movements of hazardous wastes, including e-waste. In force since 1992, it places a responsibility on exporting countries to ensure that any hazardous wastes being exported shall be treated in an environmentally sound manner in the importing country, and that the importing country is aware that the hazardous wastes are being imported and which facilities are receiving the materials [45]. ii. Status of national waste legislation: a national waste legislation provides the framework to manage the environmental, health, and safety impacts associated with generation and disposal of waste. It also provides the basis for strong collaboration among stakeholders towards managing waste as a resource. The implementation of a national waste legislation means that all waste, including hazardous waste, will be managed in a way that is consistent with national and/or international obligations for the protection of human health and the environment [46]. iii. Status of national e-waste legislation: a national e-waste legislation provides the technical standards and specifications to manage e-waste streams, including treatment processes and activities such as collection, storage, transportation and dismantling. It may also encourage product design sector to facilitate the recycling, repair, disassembly and reuse of e-waste by introducing the concept of EPR [11]. iv. Extended Producer Responsibility (EPR): EPR is a policy approach under which producers are given a significant responsibility for the treatment or disposal of post-consumer products. It provides incentives to prevent wastes at the source, promote product design for the environment, and support the achievement of public recycling and materials management goals [47].
Business Attractiveness	i. Country Risk Index (CRI): CRI is a composite index of political, economic and operational risks indices over short- and long-term time horizon used to quantify the risks to business conditions within a country. Operational risks include labor market, trade and investment, logistics, and crime and security [48]. ii. Global Competitiveness Index (GCI): GCI measures the economic competitiveness of an economy by assessing the strength of institutions, policies and factors that determine the level of productivity of that economy [48]. iii. Corruption Perception Index (CPI): CPI is a composite index used to measure perceptions of corruption in the public sector of a country. Corruption is defined as an abuse of public position for private gain [48].
Public Awareness	i. Human Development Index (HDI): HDI is a composite index of life expectancy, education and per capita income indicators used to rank countries into four tiers of human development. It can also be used to question national policy choices and stimulate debate about government policy priorities [49]. ii. Illiteracy rate: represents, indirectly, the size of literate population aged 15 years and over. Education level is one of the factors that affect public awareness about waste management impacts [44].

Table 4 (continued): Selected indicators.

Criterion	Indicators
	iii. Tertiary education rate: represents the size of population, based on the ratio of total enrollment, that completed a postsecondary education; tertiary education normally requires, as a minimum condition of admission, the successful completion of education at the secondary level [49].

Source: Own elaboration based over the literature review.

Following the simplified approach suggested by the Solving the E-waste Problem (StEP) initiative for the evaluation of e-waste policies [50], the assessment of collected data was based on a comparative analysis where for each criterion was assigned a value ranging from 0 to 5, with zero the worst and five the best result.

Concerning the non-numerical indicators, namely those related to regulation framework criteria, they had been scored in accordance with the compliance or not of a given requirement, with respective scoring of 1 and 0.

For the quantifiable indicators of the business attractiveness and public awareness criterion, the score was valued according to the classification intervals defined in Table 5, based on the lower and upper bounds of each indicator presented in Figure 5.

In order of best to worst performance, ‘good’ was graded as 2, ‘fair’ as 1, and ‘poor’ as 0.

Table 5: Classification intervals of quantifiable indicators.

Indicators	Range		
	Good	Fair	Poor
Business attractiveness			
Country Risk Index (CRI)	75 - 60	60 - 45	45 - 30
Global Competitiveness Index (GCI)	25 - 60	60 - 85	85 - 130
Corruption Perception Index (CPI)	15 - 70	70 - 125	125 - 180
Public awareness			
Human Development Index (HDI)	0.9 - 0.8	0.8 - 0.7	0.7 - 0.6
Illiteracy rate	0 - 7	7 - 14	14 - 21
School enrollment, tertiary	105 - 70	70 - 35	35 - 0

Source: Own elaboration.

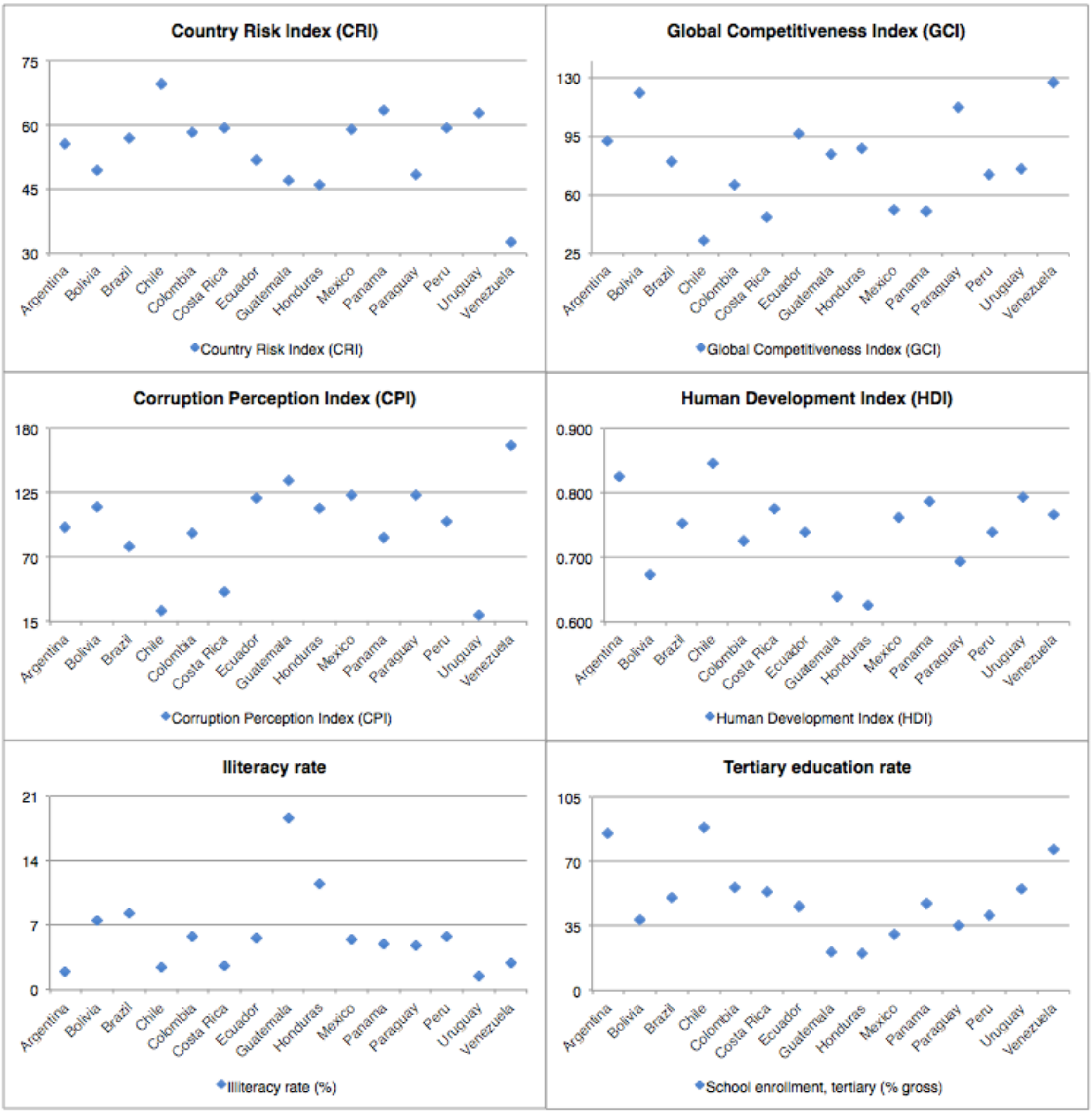

Figure 5: Maximum and minimum values of indicators
Source: Own elaboration.

As noted, the maximum and minimum final score for each criterion differ according with the number of indicators and their respective scoring range, as shown in Table 6. Therefore, in order to put the data on to the 0 to 5 scale previously defined, it was assign the same weight for each indicator and the final score adjusted to a common scale.

Table 6: Final score pontuation for each criterion.

Criterion	Number of indicators	Scoring range	Final score	
			Maximum	Minimum
Regulation framework	4	0 - 1	4	0
Business attractiveness	3	0 - 2	6	0
Public awareness	3	0 - 2	6	0

Source: Own elaboration.

CHAPTER 4

4. Results

This chapter presents an overview of the results for each country studied. Following this, the results are discussed according to the methodology proposed.

4.1. WARM outputs

As previously described, EPA adopted a streamlined application of a LCA limited to an inventory of energy impacts and GHG emissions of relevant life cycle stages from a waste generation reference point, which refers to the moment that a material is discarded. The benefits estimated result from the choice of one management path relative to another. Table 7 shows the model outputs for the management scenarios associated with the change in disposal practices from landfilling to recycling.

Table 7: WARM outputs - energy benefits and GHG emissions.

Country	Tons of e-waste recycled[2]	Energy benefits (GJ)		GHG Emissions ($MTCO_{2eq}$)	
		Landfill	Recycling	Landfill	Recycling
1. Argentina	55,200	15.62	-1,748.99	1,118	-138,226
2. Bolivia	5,400	1.53	-171.10	109	-13,522
3. Brazil	230,100	65.13	-7,290.63	4,661	-576,193
4. Chile	23,850	6.75	-755.68	483	-59,723
5. Colombia	41,250	11.68	-1,306.99	836	-103,294
6. Costa Rica	7,200	2.04	-228.13	146	-18,030
7. Ecuador	13,500	3.82	-427.74	273	-33,805
8. Guatemala	10,050	2.84	-318.43	204	-25,166
9. Honduras	2,850	0.81	-90.30	58	-7,137
10. Mexico	149,700	42.37	-4,743.18	3,032	-374,864
11. Panama	4,950	1.40	-156.84	100	-12,395
12. Paraguay	6,600	1.87	-209.12	134	-16,527
13. Peru	27,300	7.73	-864.99	553	-68,362
14. Uruguay	5,550	1.57	-175.85	112	-13,898
15. Venezuela	38,100	10.78	-1,207.18	772	-95,406
TOTAL	621,600	175.94	-19,695.15	12,590	-1,556,549

Source: Own elaboration.

[2] The value refers to an additional recycling effort of 15% based on e-waste generation estimated for 2016 [3].

4.2. Country profiles

A profile for each country has been elaborated containing all relevant data used in this study and collected externally. The results are presented in Tables 8 to 22.

4.2.1. Argentina

Table 8: Country profile - Argentina.

General Information	Unit	Range	Value
Population, total	million inh.		44.1
Population, density	inh./sq. km		15.9
Population, annual growth	%		0.9
Age structure	%	0-14 years	25%
	%	15-24 years	15%
	%	25-54 years	39%
	%	55-64 years	9%
	%	65+ years	12%
Illiteracy rate (%)	%		1.9%
School enrollment, tertiary (% gross)	% gross		85.7%
Economy	**Unit**		**Value**
Inflation rate	%		26.9
GDP	Billion US$		619.9
GDP/capita	US$ (thousands)		14.1
GNI, PPP	Billion US$		854.8
GNI/capita, PPP	US$ (thousands)		19.5
Income group	-		high
IT infrastructure	**Unit**		**Value**
Mobile phone subscriptions	per 100 people		145.3
Individuals using the internet	% of population		71%
Indexes	**Ranking**	**Range**	**Value**
Human Development Index (HDI)	low-high	0-1	0.827
Country Risk Index (CRI)	low-high	0-100	55.7
Political risk index	low-high	0-100	46.6
Operational risk index	low-high	0-100	65.8
Economic risk index	low-high	0-100	56.7
Global Competitiveness Index (GCI)	low-high	0-137	92
Corruption Perception Index (CPI)	low-high	0-176	95
E-waste management	**Unit**	**Year**	
Amount of EEE put on market, per capita	kg/inh.	2012	8.5
Amount of EEE put on market, total	kilotons (kt)	2012	348.0
E-waste generated in 2016, per capita	kg/inh.	2016	8.4
E-waste generated in 2016, total	kilotons (kt)	2016	368.0
E-waste recycling facilities, total	-	2018	16

Source: Own elaboration based on [42], [48], [49], [51], [52].

4.2.2. Bolivia

Table 9: Country profile - Bolivia.

General Information	Unit	Range	Value
Population, total	million inh.		11.1
Population, density	inh./sq. km		10.1
Population, annual growth	%		1.5
Age structure	%	0-14 years	32%
	%	15-24 years	20%
	%	25-54 years	38%
	%	55-64 years	6%
	%	65+ years	5%
Illiteracy rate (%)	%		7.5%
School enrollment, tertiary (% gross)	% gross		38.4%
Economy	**Unit**		**Value**
Inflation rate	%		3.6
GDP	Billion US$		34.1
GDP/capita	US$ (thousands)		3.1
GNI, PPP	Billion US$		77.4
GNI/capita, PPP	US$ (thousands)		7.1
Income group	-		low-mid
IT infrastructure	**Unit**		**Value**
Mobile phone subscriptions	per 100 people		92.8
Individuals using the internet	% of population		40%
Indexes	**Ranking**	**Range**	**Value**
Human Development Index (HDI)	low-high	0-1	0.674
Country Risk Index (CRI)	low-high	0-100	49.3
Political risk index	low-high	0-100	36.4
Operational risk index	low-high	0-100	51.5
Economic risk index	low-high	0-100	56.5
Global Competitiveness Index (GCI)	low-high	0-137	121
Corruption Perception Index (CPI)	low-high	0-176	113
E-waste management	**Unit**	**Year**	**Value**
Amount of EEE put on market, per capita	kg/inh.	2012	7.6
Amount of EEE put on market, total	kilotons (kt)	2012	82.0
E-waste generated in 2016, per capita	kg/inh.	2016	3.3
E-waste generated in 2016, total	kilotons (kt)	2016	36.0
E-waste recycling facilities, total	-	2018	3

Source: Own elaboration based on [42], [48], [49], [51], [52].

4.2.3. Brazil

Table 10: Country profile - Brazil.

General Information	Unit	Range	Value
Population, total	million inh.		207.7
Population, density	inh./sq. km		24.4
Population, annual growth	%		0.7
Age structure	%	0-14 years	22%
	%	15-24 years	16%
	%	25-54 years	44%
	%	55-64 years	9%
	%	65+ years	8%
Illiteracy rate (%)	%		8.3%
School enrollment, tertiary (% gross)	% gross		50.6%
Economy	**Unit**		**Value**
Inflation rate	%		3.7
GDP	Billion US$		2,081.0
GDP/capita	US$ (thousands)		10.0
GNI, PPP	Billion US$		3,074.7
GNI/capita, PPP	US$ (thousands)		14.8
Income group	-		up-mid
IT infrastructure	**Unit**		**Value**
Mobile phone subscriptions	per 100 people		117.5
Individuals using the internet	% of population		61%
Indexes	**Ranking**	**Range**	**Value**
Human Development Index (HDI)	low-high	0-1	0.754
Country Risk Index (CRI)	low-high	0-100	56.9
Political risk index	low-high	0-100	48.5
Operational risk index	low-high	0-100	57.5
Economic risk index	low-high	0-100	55.6
Global Competitiveness Index (GCI)	low-high	0-137	80
Corruption Perception Index (CPI)	low-high	0-176	79
E-waste management	**Unit**	**Year**	**Value**
Amount of EEE put on market, per capita	kg/inh.	2012	9.3
Amount of EEE put on market, total	kilotons (kt)	2012	1,850.0
E-waste generated in 2016, per capita	kg/inh.	2016	7.4
E-waste generated in 2016, total	kilotons (kt)	2016	1,534.0
E-waste recycling facilities, total	-	2018	134

Source: Own elaboration based on [42], [48], [49], [51], [52].

4.2.4. Chile

Table 11: Country profile - Chile.

General Information	Unit	Range	Value
Population, total	million inh.		18.4
Population, density	inh./sq. km		24.3
Population, annual growth	%		0.8
Age structure	%	0-14 years	20%
	%	15-24 years	15%
	%	25-54 years	43%
	%	55-64 years	11%
	%	65+ years	11%
Illiteracy rate (%)	%		2.5%
School enrollment, tertiary (% gross)	% gross		88.3%
Economy	**Unit**		**Value**
Inflation rate	%		2.3
GDP	Billion US$		263.2
GDP/capita	US$ (thousands)		14.3
GNI, PPP	Billion US$		403.8
GNI/capita, PPP	US$ (thousands)		22.5
Income group	-		high
IT infrastructure	**Unit**		**Value**
Mobile phone subscriptions	per 100 people		130.1
Individuals using the internet	% of population		84%
Indexes	**Ranking**	**Range**	Value
Human Development Index (HDI)	low-high	0-1	0.847
Country Risk Index (CRI)	low-high	0-100	69.7
Political risk index	low-high	0-100	64.8
Operational risk index	low-high	0-100	70.6
Economic risk index	low-high	0-100	67.3
Global Competitiveness Index (GCI)	low-high	0-137	33
Corruption Perception Index (CPI)	low-high	0-176	24
E-waste management	**Unit**	**Year**	**Value**
Amount of EEE put on market, per capita	kg/inh.	2012	11.9
Amount of EEE put on market, total	kilotons (kt)	2012	206.0
E-waste generated in 2016, per capita	kg/inh.	2016	8.7
E-waste generated in 2016, total	kilotons (kt)	2016	159.0
E-waste recycling facilities, total	-	2018	16

Source: Own elaboration based on [42], [48], [49], [51], [52].

4.2.5. Colombia

Table 12: Country profile - Colombia.

General Information	Unit	Range	Value
Population, total	million inh.		49.3
Population, density	inh./sq. km		43.4
Population, annual growth	%		1.0
Age structure	%	0-14 years	24%
	%	15-24 years	17%
	%	25-54 years	42%
	%	55-64 years	9%
	%	65+ years	7%
Illiteracy rate (%)	%		5.8%
School enrollment, tertiary (% gross)	% gross		55.7%
Economy	**Unit**		**Value**
Inflation rate	%		7.5
GDP	Billion US$		282.4
GDP/capita	US$ (thousands)		5.8
GNI, PPP	Billion US$		676.2
GNI/capita, PPP	US$ (thousands)		13.9
Income group	-		up-mid
IT infrastructure	**Unit**		**Value**
Mobile phone subscriptions	per 100 people		120.6
Individuals using the internet	% of population		58%
Indexes	**Ranking**	**Range**	**Value**
Human Development Index (HDI)	low-high	0-1	0.727
Country Risk Index (CRI)	low-high	0-100	58.5
Political risk index	low-high	0-100	48.5
Operational risk index	low-high	0-100	66.5
Economic risk index	low-high	0-100	61.3
Global Competitiveness Index (GCI)	low-high	0-137	66
Corruption Perception Index (CPI)	low-high	0-176	90
E-waste management	**Unit**	**Year**	**Value**
Amount of EEE put on market, per capita	kg/inh.	2012	9.7
Amount of EEE put on market, total	kilotons (kt)	2012	453.0
E-waste generated in 2016, per capita	kg/inh.	2016	5.6
E-waste generated in 2016, total	kilotons (kt)	2016	275.0
E-waste recycling facilities, total	-	2018	35

Source: Own elaboration based on [42], [48], [49], [51], [52].

4.2.6. Costa Rica

Table 13: Country profile - Costa Rica

General Information	Unit	Range	Value
Population, total	million inh.		5.0
Population, density	inh./sq. km		97.2
Population, annual growth	%		1.2
Age structure	%	0-14 years	23%
	%	15-24 years	16%
	%	25-54 years	44%
	%	55-64 years	9%
	%	65+ years	8%
Illiteracy rate (%)	%		2.6%
School enrollment, tertiary (% gross)	% gross		53.6%
Economy	**Unit**		**Value**
Inflation rate	%		0.0
GDP	Billion US$		58.1
GDP/capita	US$ (thousands)		11.8
GNI, PPP	Billion US$		76.5
GNI/capita, PPP	US$ (thousands)		15.8
Income group	-		up-mid
IT infrastructure	**Unit**		**Value**
Mobile phone subscriptions	per 100 people		171.5
Individuals using the internet	% of population		66%
Indexes	**Ranking**	**Range**	**Value**
Human Development Index (HDI)	low-high	0-1	0.776
Country Risk Index (CRI)	low-high	0-100	59.3
Political risk index	low-high	0-100	53.1
Operational risk index	low-high	0-100	61.0
Economic risk index	low-high	0-100	58.8
Global Competitiveness Index (GCI)	low-high	0-137	47
Corruption Perception Index (CPI)	low-high	0-176	41
E-waste management	**Unit**	**Year**	**Value**
Amount of EEE put on market, per capita	kg/inh.	2012	11.0
Amount of EEE put on market, total	kilotons (kt)	2012	51.0
E-waste generated in 2016, per capita	kg/inh.	2016	9.7
E-waste generated in 2016, total	kilotons (kt)	2016	48.0
E-waste recycling facilities, total	-	2018	10

Source: Own elaboration based on [42], [48], [49], [51], [52].

4.2.7. Ecuador

Table 14: Country profile - Ecuador.

General Information	Unit	Range	Value
Population, total	million inh.		16.8
Population, density	inh./sq. km		59.2
Population, annual growth	%		1.3
Age structure	%	0-14 years	27%
	%	15-24 years	18%
	%	25-54 years	40%
	%	55-64 years	8%
	%	65+ years	8%
Illiteracy rate (%)	%		5.6%
School enrollment, tertiary (% gross)	% gross		45.5%
Economy	**Unit**		**Value**
Inflation rate	%		1.7
GDP	Billion US$		97.8
GDP/capita	US$ (thousands)		5.9
GNI, PPP	Billion US$		180.7
GNI/capita, PPP	US$ (thousands)		11.0
Income group	-		up-mid
IT infrastructure	**Unit**		**Value**
Mobile phone subscriptions	per 100 people		84.7
Individuals using the internet	% of population		54%
Indexes	**Ranking**	**Range**	**Value**
Human Development Index (HDI)	low-high	0-1	0.739
Country Risk Index (CRI)	low-high	0-100	51.9
Political risk index	low-high	0-100	47.9
Operational risk index	low-high	0-100	52.5
Economic risk index	low-high	0-100	55.0
Global Competitiveness Index (GCI)	low-high	0-137	97
Corruption Perception Index (CPI)	low-high	0-176	120
E-waste management	**Unit**	**Year**	**Value**
Amount of EEE put on market, per capita	kg/inh.	2012	7.2
Amount of EEE put on market, total	kilotons (kt)	2012	110.0
E-waste generated in 2016, per capita	kg/inh.	2016	5.5
E-waste generated in 2016, total	kilotons (kt)	2016	90.0
E-waste recycling facilities, total	-	2018	7

Source: Own elaboration based on [42], [48], [49], [51], [52].

4.2.8. Guatemala

Table 15: Country profile - Guatemala.

General Information	Unit	Range	Value
Population, total	million inh.		16.9
Population, density	inh./sq. km		155.4
Population, annual growth	%		1.8
Age structure	%	0-14 years	35%
	%	15-24 years	22%
	%	25-54 years	34%
	%	55-64 years	5%
	%	65+ years	5%
Illiteracy rate (%)	%		18.7%
School enrollment, tertiary (% gross)	% gross		21.3%
Economy	**Unit**		**Value**
Inflation rate	%		4.4
GDP	Billion US$		67.5
GDP/capita	US$ (thousands)		4.1
GNI, PPP	Billion US$		128.5
GNI/capita, PPP	US$ (thousands)		7.8
Income group	-		up-mid
IT infrastructure	**Unit**		**Value**
Mobile phone subscriptions	per 100 people		110.1
Individuals using the internet	% of population		35%
Indexes	**Ranking**	**Range**	**Value**
Human Development Index (HDI)	low-high	0-1	0.640
Country Risk Index (CRI)	low-high	0-100	46.9
Political risk index	low-high	0-100	38.2
Operational risk index	low-high	0-100	40.8
Economic risk index	low-high	0-100	58.5
Global Competitiveness Index (GCI)	low-high	0-137	84
Corruption Perception Index (CPI)	low-high	0-176	136
E-waste management	**Unit**	**Year**	**Value**
Amount of EEE put on market, per capita	kg/inh.	2012	5.8
Amount of EEE put on market, total	kilotons (kt)	2012	88.0
E-waste generated in 2016, per capita	kg/inh.	2016	4.0
E-waste generated in 2016, total	kilotons (kt)	2016	67.0
E-waste recycling facilities, total	-	2018	1

Source: Own elaboration based on [42], [48], [49], [51], [52].

4.2.9. Honduras

Table 16: Country profile - Honduras.

General Information	Unit	Range	Value
Population, total	million inh.		8.4
Population, density	inh./sq. km		74.9
Population, annual growth	%		1.7
Age structure	%	0-14 years	34%
	%	15-24 years	21%
	%	25-54 years	36%
	%	55-64 years	5%
	%	65+ years	4%
Illiteracy rate (%)	%		11.5%
School enrollment, tertiary (% gross)	% gross		20.5%
Economy	**Unit**		**Value**
Inflation rate	%		3.2
GDP	Billion US$		20.3
GDP/capita	US$ (thousands)		2.4
GNI, PPP	Billion US$		40.2
GNI/capita, PPP	US$ (thousands)		4.4
Income group	-		low-mid
IT infrastructure	**Unit**		**Value**
Mobile phone subscriptions	per 100 people		86.0
Individuals using the internet	% of population		30%
Indexes	**Ranking**	**Range**	**Value**
Human Development Index (HDI)	low-high	0-1	0.625
Country Risk Index (CRI)	low-high	0-100	45.9
Political risk index	low-high	0-100	37.6
Operational risk index	low-high	0-100	43.5
Economic risk index	low-high	0-100	56.0
Global Competitiveness Index (GCI)	low-high	0-137	88
Corruption Perception Index (CPI)	low-high	0-176	112
E-waste management	**Unit**	**Year**	**Value**
Amount of EEE put on market, per capita	kg/inh.	2012	3.1
Amount of EEE put on market, total	kilotons (kt)	2012	25.0
E-waste generated in 2016, per capita	kg/inh.	2016	2.3
E-waste generated in 2016, total	kilotons (kt)	2016	19.0
E-waste recycling facilities, total	-	2018	3

Source: Own elaboration based on [42], [48], [49], [51], [52].

4.2.10. Mexico

Table 17: Country profile - Mexico.

General Information	Unit	Range	Value
Population, total	million inh.		123.5
Population, density	inh./sq. km		62.9
Population, annual growth	%		1.1
Age structure	%	0-14 years	27%
	%	15-24 years	18%
	%	25-54 years	41%
	%	55-64 years	8%
	%	65+ years	7%
Illiteracy rate (%)	%		5.5%
School enrollment, tertiary (% gross)	% gross		30.8%
Economy	**Unit**		**Value**
Inflation rate	%		2.8
GDP	Billion US$		1,047.0
GDP/capita	US$ (thousands)		8.6
GNI, PPP	Billion US$		2,188.6
GNI/capita, PPP	US$ (thousands)		17.2
Income group	-		up-mid
IT infrastructure	**Unit**		**Value**
Mobile phone subscriptions	per 100 people		87.6
Individuals using the internet	% of population		60%
Indexes	**Ranking**	**Range**	**Value**
Human Development Index (HDI)	low-high	0-1	0.762
Country Risk Index (CRI)	low-high	0-100	59.2
Political risk index	low-high	0-100	51.2
Operational risk index	low-high	0-100	56.9
Economic risk index	low-high	0-100	66.7
Global Competitiveness Index (GCI)	low-high	0-137	51
Corruption Perception Index (CPI)	low-high	0-176	123
E-waste management	**Unit**	**Year**	**Value**
Amount of EEE put on market, per capita	kg/inh.	2012	10.8
Amount of EEE put on market, total	kilotons (kt)	2012	1,241.0
E-waste generated in 2016, per capita	kg/inh.	2016	8.2
E-waste generated in 2016, total	kilotons (kt)	2016	998.0
E-waste recycling facilities, total	-	2018	35

Source: Own elaboration based on [42], [48], [49], [51], [52].

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4.2.11. Panama

Table 18: Country profile - Panama.

General Information	Unit	Range	Value
Population, total	million inh.		4.1
Population, density	inh./sq. km		54.3
Population, annual growth	%		1.3
Age structure	%	0-14 years	26%
	%	15-24 years	17%
	%	25-54 years	40%
	%	55-64 years	8%
	%	65+ years	8%
Illiteracy rate (%)	%		5.0%
School enrollment, tertiary (% gross)	% gross		47.3%
Economy	**Unit**		**Value**
Inflation rate	%		0.7
GDP	Billion US$		55.2
GDP/capita	US$ (thousands)		13.7
GNI, PPP	Billion US$		84.6
GNI/capita, PPP	US$ (thousands)		21.0
Income group	-		high
IT infrastructure	**Unit**		**Value**
Mobile phone subscriptions	per 100 people		127.5
Individuals using the internet	% of population		54%
Indexes	**Ranking**	**Range**	**Value**
Human Development Index (HDI)	low-high	0-1	0.788
Country Risk Index (CRI)	low-high	0-100	63.4
Political risk index	low-high	0-100	56.2
Operational risk index	low-high	0-100	69.8
Economic risk index	low-high	0-100	62.3
Global Competitiveness Index (GCI)	low-high	0-137	50
Corruption Perception Index (CPI)	low-high	0-176	87
E-waste management	**Unit**	**Year**	**Value**
Amount of EEE put on market, per capita	kg/inh.	2012	11.3
Amount of EEE put on market, total	kilotons (kt)	2012	41.0
E-waste generated in 2016, per capita	kg/inh.	2016	8.0
E-waste generated in 2016, total	kilotons (kt)	2016	33.0
E-waste recycling facilities, total	-	2018	3

Source: Own elaboration based on [42], [48], [49], [51], [52].

4.2.12. Paraguay

Table 19: Country profile - Paraguay.

General Information	Unit	Range	Value
Population, total	million inh.		7.0
Population, density	inh./sq. km		17.1
Population, annual growth	%		1.2
Age structure	%	0-14 years	25%
	%	15-24 years	19%
	%	25-54 years	41%
	%	55-64 years	8%
	%	65+ years	7%
Illiteracy rate (%)	%		4.9%
School enrollment, tertiary (% gross)	% gross		35.1%
Economy	**Unit**		**Value**
Inflation rate	%		3.5
GDP	Billion US$		28.8
GDP/capita	US$ (thousands)		4.1
GNI, PPP	Billion US$		60.9
GNI/capita, PPP	US$ (thousands)		9.1
Income group	-		up-mid
IT infrastructure	**Unit**		**Value**
Mobile phone subscriptions	per 100 people		111.4
Individuals using the internet	% of population		53%
Indexes	**Ranking**	**Range**	**Value**
Human Development Index (HDI)	low-high	0-1	0.693
Country Risk Index (CRI)	low-high	0-100	48.5
Political risk index	low-high	0-100	39.4
Operational risk index	low-high	0-100	48.1
Economic risk index	low-high	0-100	52.5
Global Competitiveness Index (GCI)	low-high	0-137	112
Corruption Perception Index (CPI)	low-high	0-176	123
E-waste management	**Unit**	**Year**	**Value**
Amount of EEE put on market, per capita	kg/inh.	2012	10.4
Amount of EEE put on market, total	kilotons (kt)	2012	69.0
E-waste generated in 2016, per capita	kg/inh.	2016	6.4
E-waste generated in 2016, total	kilotons (kt)	2016	44.0
E-waste recycling facilities, total	-	2018	0

Source: Own elaboration based on [42], [48], [49], [51], [52].

4.2.13. Peru

Table 20: Country profile - Peru.

General Information	Unit	Range	Value
Population, total	million inh.		31.8
Population, density	inh./sq. km		24.8
Population, annual growth	%		1.0
Age structure	%	0-14 years	26%
	%	15-24 years	18%
	%	25-54 years	40%
	%	55-64 years	8%
	%	65+ years	7%
Illiteracy rate (%)	%		5.8%
School enrollment, tertiary (% gross)	% gross		40.5%
Economy	**Unit**		**Value**
Inflation rate	%		3.6
GDP	Billion US$		195.3
GDP/capita	US$ (thousands)		6.2
GNI, PPP	Billion US$		396.6
GNI/capita, PPP	US$ (thousands)		12.5
Income group	-		up-mid
IT infrastructure	**Unit**		**Value**
Mobile phone subscriptions	per 100 people		116.2
Individuals using the internet	% of population		45%
Indexes	**Ranking**	**Range**	**Value**
Human Development Index (HDI)	low-high	0-1	0.740
Country Risk Index (CRI)	low-high	0-100	59.3
Political risk index	low-high	0-100	49.9
Operational risk index	low-high	0-100	59.6
Economic risk index	low-high	0-100	66.9
Global Competitiveness Index (GCI)	low-high	0-137	72
Corruption Perception Index (CPI)	low-high	0-176	101
E-waste management	**Unit**	**Year**	**Value**
Amount of EEE put on market, per capita	kg/inh.	2012	8.2
Amount of EEE put on market, total	kilotons (kt)	2012	250.0
E-waste generated in 2016, per capita	kg/inh.	2016	5.8
E-waste generated in 2016, total	kilotons (kt)	2016	182.0
E-waste recycling facilities, total	-	2018	7

Source: Own elaboration based on [42], [48], [49], [51], [52].

4.2.14. Uruguay

Table 21: Country profile - Uruguay.

General Information	Unit	Range	Value
Population, total	million inh.		3.5
Population, density	inh./sq. km		19.8
Population, annual growth	%		0.3
Age structure	%	0-14 years	20%
	%	15-24 years	16%
	%	25-54 years	39%
	%	55-64 years	11%
	%	65+ years	14%
Illiteracy rate (%)	%		1.5%
School enrollment, tertiary (% gross)	% gross		55.6%
Economy	**Unit**		**Value**
Inflation rate	%		6.1
GDP	Billion US$		60.3
GDP/capita	US$ (thousands)		17.3
GNI, PPP	Billion US$		72.6
GNI/capita, PPP	US$ (thousands)		21.1
Income group	-		high
IT infrastructure	**Unit**		**Value**
Mobile phone subscriptions	per 100 people		148.6
Individuals using the internet	% of population		66%
Indexes	**Ranking**	**Range**	**Value**
Human Development Index (HDI)	low-high	0-1	0.795
Country Risk Index (CRI)	low-high	0-100	62.8
Political risk index	low-high	0-100	54.3
Operational risk index	low-high	0-100	71.5
Economic risk index	low-high	0-100	58.8
Global Competitiveness Index (GCI)	low-high	0-137	76
Corruption Perception Index (CPI)	low-high	0-176	21
E-waste management	**Unit**	**Year**	**Value**
Amount of EEE put on market, per capita	kg/inh.	2012	13.4
Amount of EEE put on market, total	kilotons (kt)	2012	45.0
E-waste generated in 2016, per capita	kg/inh.	2016	10.8
E-waste generated in 2016, total	kilotons (kt)	2016	37.0
E-waste recycling facilities, total	-	2018	7

Source: Own elaboration based on [42], [48], [49], [51], [52].

4.2.15. Venezuela

Table 22: Country profile - Venezuela.

General Information	Unit	Range	Value
Population, total	million inh.		31.4
Population, density	inh./sq. km		34.5
Population, annual growth	%		1.2
Age structure	%	0-14 years	27%
	%	15-24 years	17%
	%	25-54 years	41%
	%	55-64 years	8%
	%	65+ years	7%
Illiteracy rate (%)	%		2.9%
School enrollment, tertiary (% gross)	% gross		77.0%
Economy	**Unit**		**Value**
Inflation rate	%		254.4
GDP	Billion US$		236.4
GDP/capita	US$ (thousands)		7.6
GNI, PPP	Billion US$		536.1
GNI/capita, PPP	US$ (thousands)		17.4
Income group	-		up-mid
IT infrastructure	**Unit**		**Value**
Mobile phone subscriptions	per 100 people		87.4
Individuals using the internet	% of population		60%
Indexes	**Ranking**	**Range**	**Value**
Human Development Index (HDI)	low-high	0-1	0.767
Country Risk Index (CRI)	low-high	0-100	32.5
Political risk index	low-high	0-100	29.7
Operational risk index	low-high	0-100	30.6
Economic risk index	low-high	0-100	26.9
Global Competitiveness Index (GCI)	low-high	0-137	127
Corruption Perception Index (CPI)	low-high	0-176	166
E-waste management	**Unit**	**Year**	**Value**
Amount of EEE put on market, per capita	kg/inh.	2012	10.4
Amount of EEE put on market, total	kilotons (kt)	2012	308.0
E-waste generated in 2016, per capita	kg/inh.	2016	8.2
E-waste generated in 2016, total	kilotons (kt)	2016	254.0
E-waste recycling facilities, total	-	2018	6

Source: Own elaboration based on [42], [48], [49], [51], [52].

CHAPTER 5

5. Discussion

In this chapter the main findings are described. Initially, the environmental benefits of recycling e-waste in terms of energy savings and avoided GHG emissions are discussed. Subsequently, a comparative analysis is presented with the aim of gaining a holistic perspective to identify the major strengths and weaknesses of LATAM's e-waste management scenarios.

5.1. Energy savings assessment

As previously described, the EPA's WARM tool was used to calculate the energy savings associated with the change in e-waste disposal practices from landfilling (baseline scenario) to recycling (alternative scenario). The avoided GHG emissions were also estimated.

The estimated environmental impacts were calculated as the difference between baseline and alternative scenarios, where negative values indicate net energy savings or avoided emissions.

Table 23 shows the energy savings and avoided GHG emissions estimated based on the WARM results. Energy is shown in giga-joules (GJ), while GHG emissions in metric tons of carbon dioxide equivalent ($MTCO_{2eq}$).

Table 23: Energy savings and avoided GHG emissions.

Country	Energy savings (GJ)	Avoided GHG emissions ($MTCO_{2eq}$)
1. Argentina	-1,764.61	-139,344
2. Bolivia	-172.63	-13,632
3. Brazil	-7,355.75	-580,854
4. Chile	-762.43	-60,206
5. Colombia	-1,318.67	-104,130
6. Costa Rica	-230.17	-18,175
7. Ecuador	-431.56	-34,079
8. Guatemala	-321.27	-25,370
9. Honduras	-91.11	-7,194

Table 23 (continued): Energy savings and avoided GHG emissions.

Country	Energy savings (GJ)	Avoided GHG emissions ($MTCO_{2eq}$)
10. Mexico	-4,785.56	-377,896
11. Panama	-158.24	-12,496
12. Paraguay	-210.99	-16,661
13. Peru	-872.72	-68,915
14. Uruguay	-177.42	-14,010
15. Venezuela	-1,217.97	-96,178
TOTAL	-19,871.08	-1,569,139

Source: Own elaboration.

According to the model outcomes, considering an additional recycling effort of 15% of the total amount of e-waste sent to landfill, a total of approximately 19,871 GJ of energy savings would be achieved taking into account all the fifteen LATAM countries studied.

As observed, the total energy savings potential from e-waste sector lies within 91.11 in Honduras and 7,355.75 GJ in Brazil. With regard to GHG emissions, the estimated carbon dioxide reduction potential lies between 7,194 to 580,854 Mt.

Although this analysis considered the same ‘recycling performance’ for all countries studied, the model also provides the energy and emissions factors per ton of material, which can be used by organizations to quantify the benefits of waste disposal options and by countries to estimate the national environmental gains related to e-waste management sector.

The energy and emissions factors are presented in Table 24.

Table 24: Energy and emissions factors per ton of material

Factors	Unit	Landfill	Recycling
Energy use per ton of material	GJ	0.28	-31.71
GHG emission per ton of material	$MTCO_{2eq}$	0.02	-2.5

Source: Own elaboration.

The results presented in this study demonstrate that the improvement of e-waste management practices can lead not only to a reduction of the total amount of e-waste generated, but also to a significant energy savings and avoided GHG emissions. Nevertheless, some important constraints presented in the e-waste management value-chain and also in the policy framework need to be overcome in order to allow LATAM countries to explore the full environmental benefits of improved e-waste management practices. In this regard, an e-waste management assessment was conducted in order to identify these barriers.

5.2. E-waste management assessment

The analysis presented in the following items has been structured to provide initial benchmarks for national and regional authorities, easing the comparison among the LATAM countries.

5.2.1. General framework

Several trends are driving the generation of e-waste, particularly in developing countries: higher levels of disposable income, urbanization, and industrialization are leading to growing amounts of EEE, and consequently of e-waste.

As presented in Figure 6, the results of the macroeconomic analysis show a strong relationship between the percentage of population using the Internet, and the economic indicators.

GDP and GNI in purchasing power parity (PPP) are measurements of a country’s income that usually reflect, respectively, the standard of living, and the wealth of individuals among the population [49]. In this regard, it was expected that countries with high-income also presented a higher share of the population with Internet access, such as Chile, Argentina, and Uruguay. In contrast, the low-income economies, for instance Honduras, Guatemala, and Bolivia, are those that have the smaller percentage of online population.

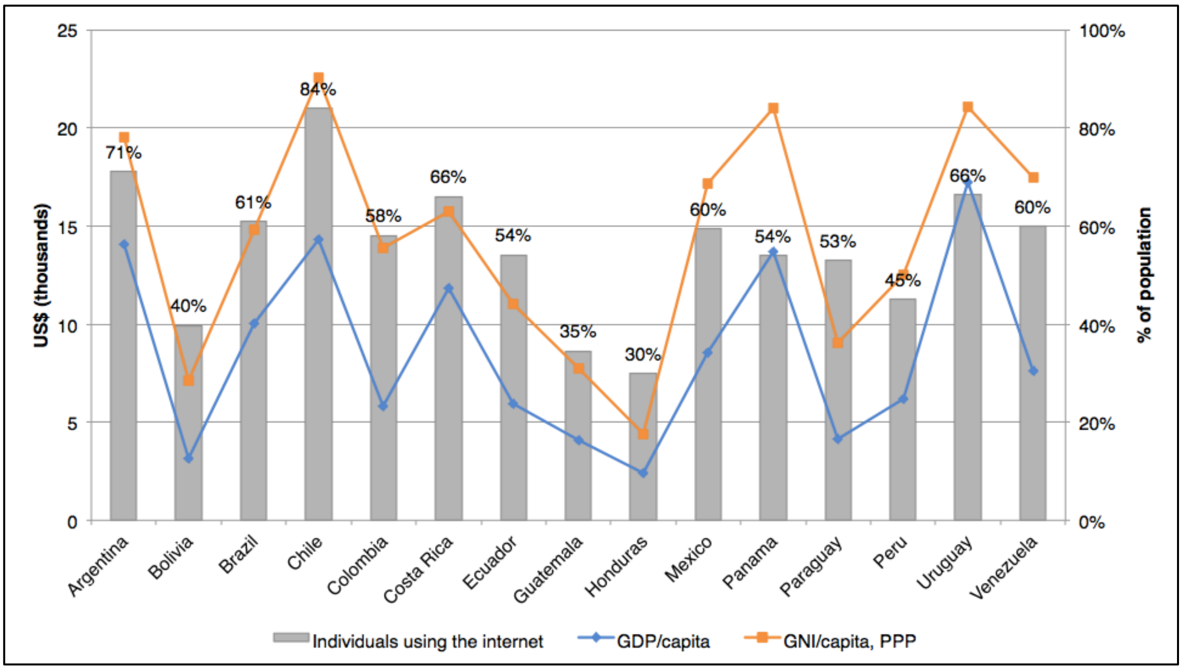

Figure 6: Comparison between internet use, GDP and GNI indicators.

Concerning the inflation rate, this indicator reflects the purchasing power of currency [53], therefore, is expected that countries with the highest inflation rates, such as Argentina and Venezuela, present a lower business attractiveness. In general, economic indicators are directly linked with the overall performance of a country in terms of financing and business because of their effect in costs, trading, and production, among others aspects.

Table 25 shows the main economic indicators for the LATAM countries studied.

Table 25: Economic indicators of LATAM countries.

Country	Inflation rate (%)	GDP per capita (US$)	GNI per capita, PPP (US$)	Income group classification
1. Argentina	26.9	14,062.0	19,500.0	High
2. Bolivia	3.6	3,125.0	7,100.0	Lower-middle
3. Brazil	3.7	10,020.0	14,810.0	Upper-middle
4. Chile	2.3	14,315.0	22,540.0	High
5. Colombia	7.5	5,792.0	13,900.0	Upper-middle
6. Costa Rica	0.0	11,836.0	15,750.0	Upper-middle
7. Ecuador	1.7	5,917.0	11,030.0	Upper-middle
8. Guatemala	4.4	4,070.0	7,750.0	Upper-middle

Table 25 (continued): Economic indicators of LATAM countries.

Country	Inflation rate (%)	GDP per capita (US$)	GNI per capita, PPP (US$)	Income group classification
9. Honduras	3.2	2,406.6	4,410.0	Lower-middle
10. Mexico	2.8	8,562.0	17,160.0	Upper-middle
11. Panama	0.7	13,670.0	20,980.0	High
12. Paraguay	3.5	4,139.0	9,050.0	Upper-middle
13. Peru	3.6	6,204.0	12,480.0	Upper-middle
14. Uruguay	6.1	17,252.0	21,090.0	High
15. Venezuela	254.4	7,620.0	17,440.0	Upper-middle

Source: Adapted from [42].

Furthermore, the age structure of countries (Figure 7) also shows that the low-income economies have a smaller proportion of the population aged 25-to-54, the age group where the number of EEE consumers is expected to be higher [54]. Together with the economic factors, this trend might explain the fact that Bolivia, Guatemala and Honduras have the lowest values of e-waste generated per capita. With respect to the working age population, defined as those aged 15-to-64, the countries presented a very similar share, with an average of 58% of potential workers.

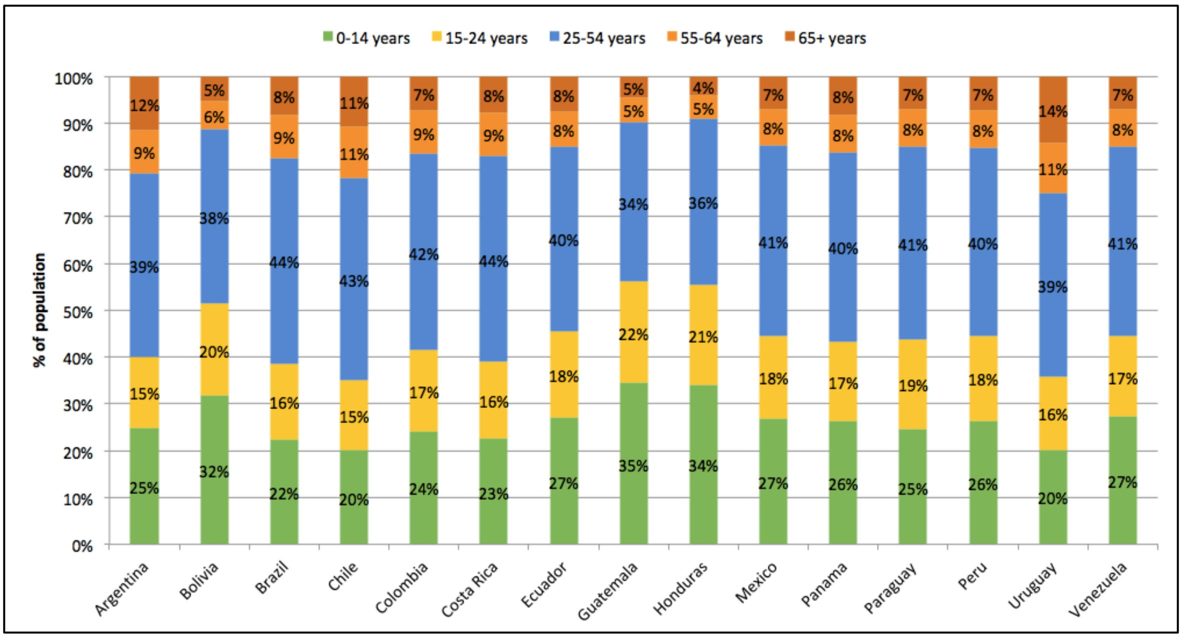

Figure 7: Population age structure.

Regarding the total amount of inhabitants and e-waste generated, the indicators are directly linked: the most populated countries have also the highest quantities of e-waste. As illustrated in Figures 8 and 9, the biggest countries of LATAM, Brazil and Mexico, were also responsible for the largest generation of e-waste in 2016, with 1,534 and 998 kilotons respectively.

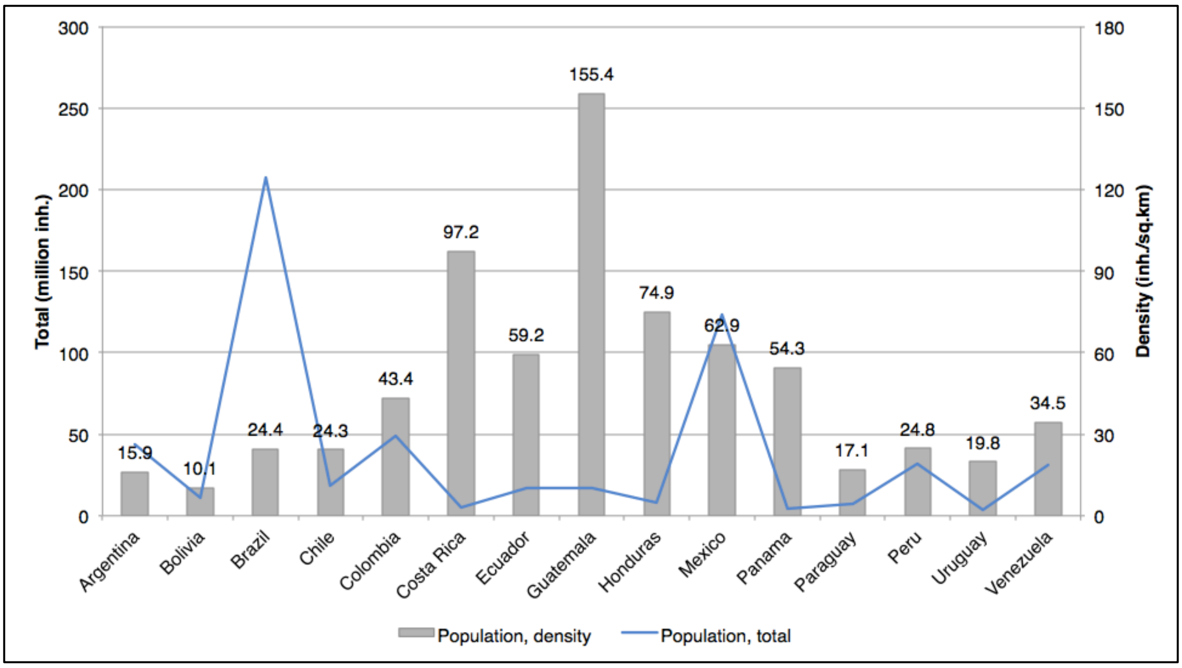

Figure 8: Population in LATAM countries.

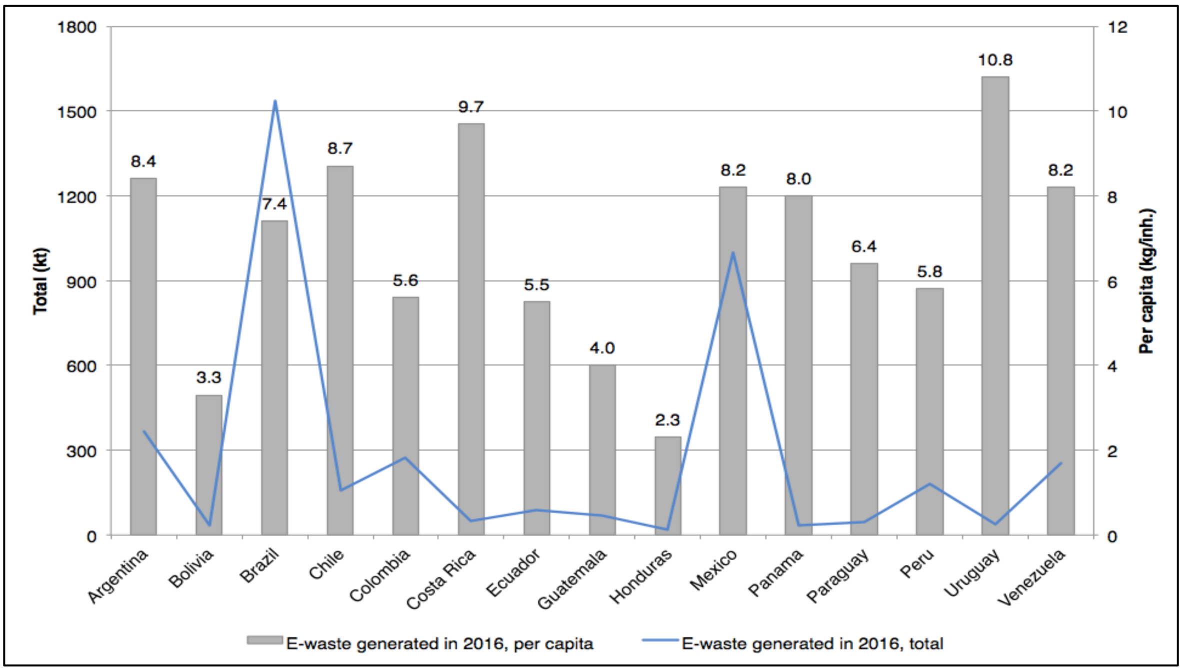

Figure 9: E-waste generated in LATAM countries.

In terms of e-waste generated per capita, Uruguay and Costa Rica presented the highest values of the group. Although the total amount of both countries is well below the average of the others LATAM countries, estimated in 276.3 kilotons, this indicator reflects the environmental pressure of e-waste, indicating that a response to raise consumer awareness and e-waste prevention should be greater within these countries. Overall, the total amount of e-waste generated within the fifteen LATAM countries was of 4,144 kilotons, resulting in an average of 7.2 kg per capita.

It is important to highlight that information related to EEE put on market and e-waste collection rate, was also researched. However, data was outdated and were excluded of the current analysis. The acknowledgment of these limitations aims to encourage countries to collect and diffuse better quality data, especially in LATAM.

5.2.2. E-waste recycling infrastructure

To evaluate the current status of recycling infrastructure within the fifteen LATAM countries, a survey of the existent e-waste operators was performed. As a result, a total of 283 companies were identified (Figure 10).

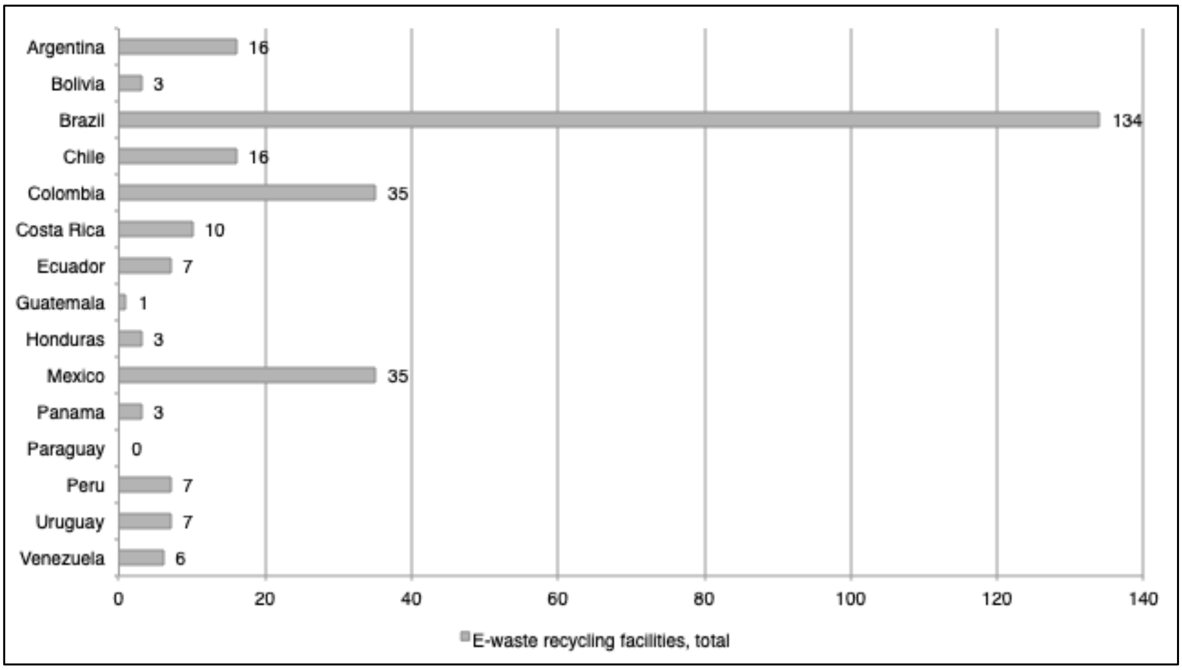

Figure 10: Number of e-waste recycling facilities in LATAM.

Brazil leads the ranking accounting for close to 47% of the total number of recyclers, followed by Colombia and Mexico. In Paraguay, no establishment was recognized as an e-waste recycler; the companies identified were usually related to metal scrap processing or responsible for receiving e-waste for landfilling or incineration.

The number of e-waste recycling facilities currently operating in the fifteen LATAM countries is presented in Figure 11.

Figure 11: E-waste recycling facilities in LATAM.

In terms of geographic distribution, it is noted that the majority of facilities are located primarily in the capitals and cities considered as economic centers. As a result, the e-waste operators are generally concentrated in the central area of the countries, which means that investments in transshipment stations are necessary in order to ensure a proper management of e-waste. Table 26 shows the region of each country with the largest concentration of e-waste recycling facilities.

Table 26: Regions with the higher concentration of e-waste operators in LATAM.

Country	Region	Main States/Provinces	E-waste operators	
			Total	Share
1. Argentina	Center-west	Buenos Aires	13	81%
2. Bolivia	Center	Santa Cruz de La Sierra	2	67%
3. Brazil	Southeast	São Paulo	59	44%
4. Chile	Center	Santiago	14	88%
5. Colombia	Center-west	Bogota	17	49%
6. Costa Rica	Center	San Jose	6	60%
7. Ecuador	North	Quito	4	57%
8. Guatemala	Southeast	Guatemala City	1	100%
9. Honduras	Northwest	San Pedro Sula	3	100%
10. Mexico	Center	Mexico City	12	34%
11. Panama	Center	Panama City	3	100%
12. Paraguay	-	-	-	-
13. Peru	Center	Lima	4	57%
14. Uruguay	South	Montevideo	6	86%
15. Venezuela	North	Caracas	4	80%

Source: Own elaboration.

The list of all facilities identified is presented in Appendix.

In general, the infrastructure of e-waste recycling facilities is mostly linked to the pre-processing activities, relying mainly on manual dismantling to obtain raw materials such as plastics, non-ferrous metals, wires and cables. With the exception of some specific e-waste categories, for instance lamps and batteries, for which there is specialized companies to manage and treat their hazardous content, end-processing or disposal options for the majority of e-waste are still missing in LATAM countries.

In this scenario, e-waste management market offers a strong potential for further improvement, and the development of e-waste recycling industry is expected to grow in the coming years.

5.2.3. Availability and transfer of technology

With regard to the regulation framework, the results show that all LATAM countries assessed are signatories to the Basel Convention and have at least one regulation related to solid waste management or the environmental protection in general.

In terms of specific regulation for e-waste management, only a few countries have policies in force, for instance Brazil, Colombia, Costa Rica, Ecuador and Peru. Concerning the EPR approach, in addition to the mentioned countries, Argentina, Bolivia, Chile, Panama e Paraguay also started the implementation of laws based on the EPR principle.

A summary of the main regulations related to waste and e-waste within the LATAM countries studied are presented in Table 27.

Table 27: Regulation framework.

Country	Legislation	Year	Description
Argentina	*Bill S-104	2017	Minimum requirements for the management of WEEE.
	Resolution 522	2016	National strategy for the sustainable management of special waste.
Bolivia	Law 755	2015	Integrated management of waste.
	Technical Standard NB-69019	2012	Management of WEEE.
	Technical Standard NB-69018	2012	WEEE - definitions and classification.
Brazil	Technical Standard NBR-16156	2013	WEEE - requirements for reverse manufacturing activity.
	Law 12305	2010	Brazilian national policy on solid waste.
Chile	Law 20920	2016	Framework for waste management, extended producer responsibility and recycling promotion.
Colombia	Law 1672	2013	Integrated management of WEEE.
	Resolution 1512	2010	National system for selective collection and management of computer and/or peripherals waste.
Costa Rica	Law 8839	2010	Integrated management of waste.
	Decree 35933	2010	Regulation for the integrated management of electronic waste.
Ecuador	Ministerial AGMT 191	2013	Instructions for the recycling of used mobile phones.
	Ministerial AGMT 190	2013	National policy post consumption of electrical and electronic equipment.
	Ministerial AGMT 161	2012	Regulations for the prevention and control of pollution by hazardous chemical substances, hazardous and special waste.
Guatemala	Government AGMT 341	2013	National policy for the environmentally rational management of chemicals and hazardous waste.
	Government AGMT 111	2005	National policy for the integrated management of waste and solid waste.

Table 27 (continued): Regulation framework.

Country	Legislation	Year	Description
Honduras	Executive AGMT 1567	2010	Regulation for the integrated management of solid waste.
Mexico	NOM-161-SEMARNAT	2011	Establishes the criteria to classify waste of special management.
	NOM-052-SEMARNAT	2005	Establishes the characteristics and procedures to identify, classify, and separate hazardous wastes.
	Official Gazette Tomo DCI 6	2003	General law for the prevention and integrated management of waste.
Panama	Decree 34	2007	National policy for the management of hazardous and non-hazardous waste.
Paraguay	Law 3956	2009	Integrated management of solid waste.
Peru	Decree 1278	2017	Regulation for the integrated management of solid waste.
	Resolution 27-SBN	2013	Proper management of state property classified as WEEE.
	Decree 001-MINAM	2012	National regulation for the use and management of electrical and electronic waste.
	Technical Standard NTP-900.065	2012	WEEE - generation, internal collection, classification and storage.
	Technical Standard NTP-900.064	2012	WEEE - generalities.
	Law 27314	2000	General law of solid waste.
Uruguay	Law 17283	2000	General law of the protection of the environment.
Venezuela	Official Gazette 6017	2010	Integrated management of waste.

* Draft legislation.

Source: [51], [55].

In general, most of regulations cover up-stream as well as down-stream aspects of e-waste management, and refers to EPR principles similar to the European WEEE directives. However, a common aspect of most of these regulations is that key elements and principles are still defined in very general terms. A lack of defined responsibilities in the e-waste management processes represents a significant gap to promote an efficiently e-waste management under formal and controlled processes. In practical terms, for the majority of LATAM countries, e-waste is usually treated as hazard waste under the umbrella of correlated legislation and managed together with solid waste in general.

With respect to business attractiveness and public awareness criterion, the performance outcomes relied on the results of the classifications based on the methodology previously described in Chapter 3. The outputs obtained are presented in Table 28.

Table 28: Outputs of the classification of quantifiable indicators.

Country	Business attractiveness			Public awareness		
	CRI	GCI	CPI	HDI	Literacy	Tertiary education
1. Argentina	Fair	Poor	Fair	Good	Good	Good
2. Bolivia	Fair	Poor	Fair	Poor	Fair	Fair
3. Brazil	Fair	Fair	Fair	Fair	Fair	Fair
4. Chile	Good	Good	Good	Good	Good	Good
5. Colombia	Fair	Fair	Fair	Fair	Good	Fair
6. Costa Rica	Fair	Good	Good	Fair	Good	Fair
7. Ecuador	Fair	Poor	Fair	Fair	Good	Fair
8. Guatemala	Fair	Fair	Poor	Poor	Poor	Poor
9. Honduras	Fair	Poor	Fair	Poor	Fair	Poor
10. Mexico	Fair	Good	Fair	Fair	Good	Poor
11. Panama	Good	Good	Fair	Fair	Good	Fair
12. Paraguay	Fair	Poor	Fair	Poor	Good	Fair
13. Peru	Fair	Fair	Fair	Fair	Good	Fair
14. Uruguay	Good	Fair	Good	Fair	Good	Fair
15. Venezuela	Poor	Poor	Poor	Fair	Good	Good

Source: Own elaboration.

Concerning the business attractiveness, with exception of Chile, Costa Rica, Panama and Uruguay, the majority of LATAM countries are classified as 'fair' or 'poor'. As observed, the lowest scores awarded to Argentina and Venezuela can be linked to the fact that both countries have the highest inflation rates, even thought they are classified as high and upper-middle income countries.

In terms of public awareness, although the levels of literacy rate are relatively good, the levels for tertiary education are classified as fair' or 'poor', indicating the need for additional efforts in the education sector in order to raise general awareness on EEE and e-waste management in some countries.

The result of all performance indicators combined is presented in Figure 12.

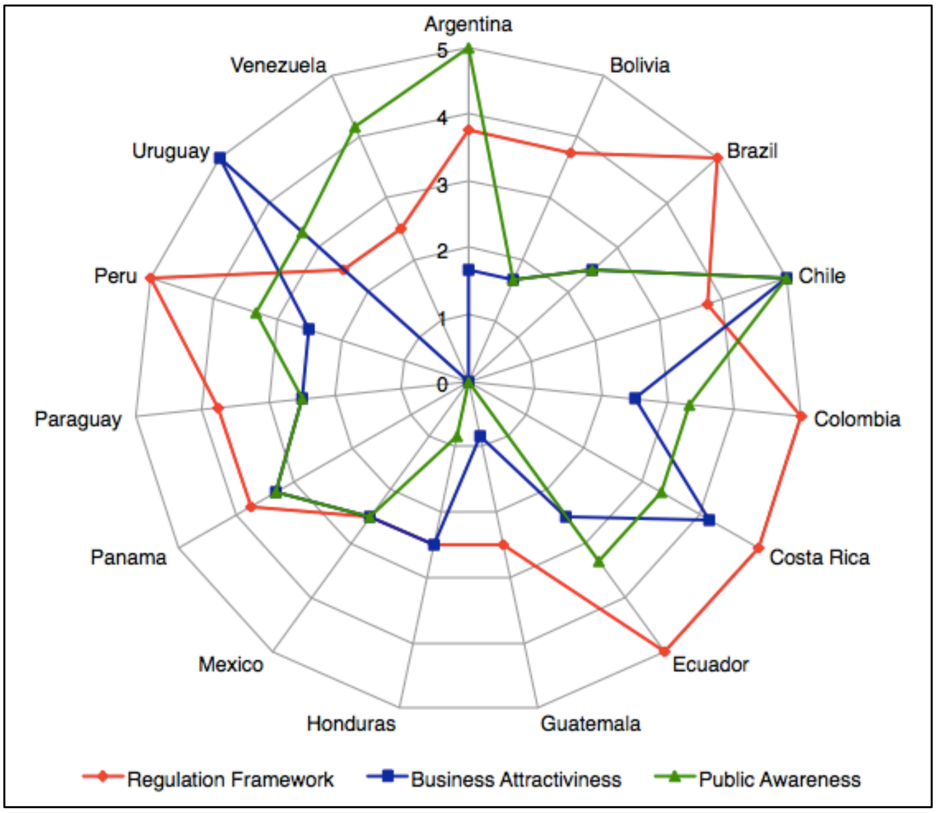

Figure 12: E-waste technology transfer performance of LATAM countries.
Source: Own elaboration.

The final score for each country based on the results of performance indicators is summarized in Table 29.

Table 29: Scoreboard of performance indicators.

	Scoreboard of performance indicators	Argentina	Bolivia	Brazil	Chile	Colombia	Costa Rica	Ecuador	Guatemala	Honduras	Mexico	Panama	Paraguay	Peru	Uruguay	Venezuela
	Regulation Framework															
i	*Ratification on Basel Convention*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ii	*Status of national waste legislation*	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
iii	*Status of national e-waste legislation*	0	0	1	0	1	1	1	0	0	0	0	0	1	0	0
iv	*Extended Producer Responsibility (EPR)*	1	1	1	1	1	1	1	0	0	0	1	1	1	0	0
	FINAL SCORE (ADJUSTED)	4	4	5	4	5	5	5	3	3	3	4	4	5	3	3
	Business Attractiviness															
i	*Country Risk Index (CRI)*	1	1	1	2	1	1	1	1	1	1	2	1	1	2	0
ii	*Global Competitiveness Index (GCI)*	0	0	1	2	1	2	1	0	1	1	1	1	1	2	0
iii	*Corruption Perception Index (CPI)*	1	1	1	2	1	2	1	0	1	1	1	1	1	2	0
	FINAL SCORE (ADJUSTED)	2	2	3	5	3	4	3	1	3	3	3	3	3	5	0
	Public Awareness															
i	*Human Development Index (HDI)*	2	0	1	2	1	1	1	0	0	1	1	0	1	1	1
ii	*Literacy*	2	1	1	2	2	2	2	0	1	2	2	2	2	2	2
iii	*Tertiary education*	2	1	1	2	1	1	1	0	0	0	1	1	1	1	2
	FINAL SCORE (ADJUSTED)	5	2	3	5	3	3	3	0	1	3	3	3	3	3	4

Source: Own elaboration.

As seen, the barriers that need to be addressed towards the improvement of e-waste management practices are different for each country. In the LATAM context, not only a regulation framework needs to be outlined to ensure an effective e-waste management and disposal, but also measures related to public awareness and business attractiveness.

In this regard, the benchmarking of e-waste indicators aims to support country's efforts towards improved e-waste management practices, and therefore, energy savings.

5.3. SWOT analysis

To better understand the main factors associated with improved e-waste management systems in LATAM countries, an analysis based on the strengths, weaknesses, opportunities and threats (SWOT) was carried out. This analysis has been summarized in Table 30.

Table 30: SWOT analysis of e-waste management systems in LATAM.

STRENGTHS	WEAKENESSES
• Existence of a national waste management framework; • Existence of countries with e-waste data and knowledge which might be helpful for benchmarking; • Reduction of e-waste generated through reuse and recycling processes; • Reduction of pollutants and hazardous materials emissions to the environment; • Reduction of raw materials demand through recovery processes; • Increased e-waste collection and recycling rates; • Extended landfill lifetime expectancy due to reduction of e-waste discarded;	• Strong influence of e-waste informal sector; • Poor e-waste recycling infrastructure; • Poor collection schemes; • Lack of information and public awareness; • Absence of recycling and collection targets for e-waste; • Absence of relevant data related to e-waste statistics;

Table 30 (continued): SWOT analysis of e-waste management systems in LATAM

OPPORTUNITIES	THREATS
• Energy savings; • GHG emissions reductions; • Creation of new jobs; • Generation of income from materials sales; • Development of e-waste formal sector; • Transfer of technology; • Exchange of knowledge between countries;	• Lack of an effective and specific national regulation for e-waste; • Low business attractiveness; • High initial investments; • Absence of technology transfer;

Source: Own elaboration.

As the SWOT analysis shows, an effective e-waste management system offers a number of opportunities, including a significant improvement in terms of energy savings. Concerning the strengths, which in this context refer to the ability to achieve an effective e-waste management system, the implementation of a national waste framework represents an important milestone to build up e-waste policies, laws and regulations. In this regard, some LATAM countries have already developed or are in the process of developing a specific legislation for e-waste. Furthermore, e-waste reuse, recycling, and recovering practices would help manufacturers to address their products life cycle issues, in particular those linked to the end-of-life phase. Finally, the overall benefits associated with a better e-waste management (e.g. reduction of e-waste generation, raw materials demand, and pollutants emissions) support the improvement and strengthening of e-waste value chain. However, to explore all potential benefits, some weaknesses and threats need to be overcome.

In this regard, the establishment of an e-waste national regulation is one of the major issues that need to be addressed as a matter of priority. The absence of an effective and specific national legislation for e-waste is a threat that leads to weaknesses, such as the strengthening of informal sector, the lack of recycling and collection targets, poor e-waste database and collection schemes. Thus, to achieve a sustainable management of e-waste in LATAM, a number of key steps have been identified by the World Health Organization (WHO) [10], encompassing the main points described below:

(i) Develop a database to identify the e-waste generation sources and the total amount produced for present and future measurement of technological capacities;

(ii) Perform a detailed and comparable analysis about the situation of e-waste throughout the region to identify the key actors and the applicable social framework, cultural boundaries, technological availability, among other factors;

(iii) Foster closer cooperation between actors and stakeholders in order to facilitate learning from the experiences of other countries, and develop international cooperation and partnerships for sustainable management of e-waste;

(iv) Make further efforts to raise the awareness of e-waste amongst consumers, business and policymakers;

(v) Promote innovation and technology transfer through the assessment of economic implications of e-waste recycling processes, and identification of the mechanisms to measure their implementation progress.

The ongoing development of e-waste management in LATAM is noticeable and appropriate measures need to be taken in the coming years. Therefore, to ensure the establishment of a sustainable management of e-waste, the results of this study should assist in supporting an exchange of information about e-waste between LATAM countries. The acknowledgement of countries' strengths and vulnerabilities would facilitate the identification of priority areas and their mutual cooperation in terms of relevant skills, know-how and technological transfer.

In addition, the review of current practices of e-waste in different countries provides an understanding of e-waste policies, laws, regulations and institutional framework, and will be important in developing a roadmap for setting up an effective e-waste management chain [16].

CHAPTER 6

6. Conclusions

E-waste is a serious problem at both local and global scales. The increase of developing countries joining the global information society coupled with the fast obsolescence of EEE led to an unprecedented growth of e-waste.

In this context, emerging economies, such as the majority of LATAM countries, are those that have more difficult to cope with the fast pace of technological progress worldwide. The hazardous content of e-waste demands an effective management in order to prevent negative environmental and human health impact, contributing not only to resource conservation but also energy savings.

This thesis aimed to estimate the energy saving potential of the e-waste recycling process of LATAM countries. It was also a goal to identify the major strengths and weaknesses of e-waste management processes in order to acknowledge which areas should be the focus of future actions, and also benchmarking procedures and techniques within the region.

The proposed methodology was based on the following approaches: the energy saving potential was calculated using EPA's WARM tool, which considered two e-waste management scenarios to calculate the energy avoided through additional recycling efforts; to evaluate and compare different e-waste management systems, a set of criterion were defined to better understand the overall performance of countries. Three main aspects were considered and combined to carry out such assessment: macroeconomic factors, recycling infrastructure, and technology transfer performance.

Initially, two research questions were formulated. At first, the aim was to quantify the potential of energy saving associated with e-waste recycling process. For this purpose, the amount of e-waste generated in 2016 for all countries was considered. Then, due to the absence of specific e-waste collection and recycling targets in LATAM, the rate estimated for all American countries combined was regarded as a goal to be achieved.

From the analysis performed, it has been concluded that e-waste recycling practices offers a strong potential to energy savings. Considering an additional recycling effort of 15% among all the fifteen LATAM countries studied, a total of

19,871 GJ of energy savings could be achieved. With regard to GHG emissions, an environmental benefit of 1,569,139 Mt of carbon dioxide equivalent reduction was estimated.

The second research question aimed to identify the major factors contributing to overall performance of e-waste management systems with the purpose to reap the full benefits linked to this issue. The results of e-waste management assessment indicate that to exploit these potential benefits some barriers need to be addressed in different stages of e-waste management value chain and also in the regulation framework.

The first point to mention is the lack of reliable data related to e-waste within LATAM countries. This fact poses a challenge to both policy makers and the industry sector that intend to design an e-waste management strategy or make rational investment decisions.

E-waste status and trends is an important step towards addressing the e-waste challenge. Statistics help to assess developments over time, set and calculate targets, and identify best practices of policies. In addition, to support decision makers from industry, governments and other stakeholders to make a better, and more informed decision about their e-waste management, is crucial to minimize its generation, prevent illegal disposal, promote recycling, and create new jobs in the e-waste management sectors.

With regard to regulation framework, the lack of a clear definition of basic principles and responsibilities in the e-waste management results into a strong influence of the informal sector. In this context, although several risks to the environment and human health are identified, the informal sector also provides jobs opportunities for low-income populations in developing countries. For that matter, a key issue is to incorporate informal recyclers into a formal system, creating opportunities in the e-waste recycling business.

Technological advancements are required to meet all the steps for the full recycling of e-waste, and cooperation between countries is necessary in order to promote technological transfer and knowledge exchange. It can also provide guidance for the development of new recycling systems and the improvement of old ones. As verified, the majority of e-waste recycling facilities comprise pre-processing activities, and disposal options are still missing.

The present scenario of LATAM indicates a strong improvement potential of e-waste management practices within the region, and the development of the recycling industry is expected to grow in the coming years. To support this process, the comparative analysis provides a general overview of current status of LATAM's e-waste management systems, giving an insight of which areas should be prioritized in future actions. It also allows countries to benchmark their performance against one another in order to identify and share best e-waste practices.

In conclusion, to achieve the full benefits of an improved e-waste management practice, a joint effort between LATAM countries is necessary to increase e-waste technical standards and solutions. Furthermore, when effective and correctly implemented, an e-waste management system also provides a tangible benefit of energy savings and GHG emissions reduction.

6.1. Limitations

Given the complex nature of e-waste streams and the significant number of countries evaluated, this study was subject to important limitations.

The calculations performed by WARM are an estimate and do not encompass all possible energy savings potentials in e-waste management sector, given the following limitations:

- Although EPA strives to provide high quality energy and GHG emission factors in WARM, there is already some inherent uncertainty within the factors;
- WARM considered a proxy to represent all electronics products based on the personal computer energy factors, adding further uncertainty to calculations due to the differences in the materials life cycle;

- WARM calculations were based on conservative assumptions in order to calculate an upper bound estimate;
- WARM results are based on a hypothetical scenario, which depends on successfully implementing technological and/or behavioral changes in order to achieve the additional recycling effort used in the calculations.

The limitations related to e-waste management assessment refer mostly to data collection, as described below:

- Information collected from authorities, scientific publications, companies, and other different sources was considered credible and of integrity;
- Information related to EEE put on market, and e-waste collection and recycling rates were excluded from the analysis because data was outdated and the information did not cover all countries studied;
- Although an extensive survey of e-waste recycling facilities was performed, the analysis was based on available data and may not include all existent companies within the countries;
- The regulation framework analysis was restricted to national regulations in force; local legislations at municipal level were not evaluated in this study due to lack of available and complete information;
- The classification of quantifiable indicators was based on values obtained for the fifteen countries studied and may not be applicable in another context, since it was possible to infer large differences among countries which should also imply different conclusions at the country individual level.

6.2. Recommendations for future research

This research endeavors to include a holistic view of e-waste management with focus on energy savings, particularly in LATAM countries. Prior to this study, no research or studies had been carried out in terms of energy savings and e-waste management practices in LATAM countries, and this study, aimed to partially fill this gap. However, due to a several limitations previously described, a simplified approach was proposed in order to evaluate and compare the particularities of each country studied.

There are a number of gaps identified within this research and these could turn into benefits in future research. Among these, it should be included a more realist evaluation to extend and further the methodology proposed. In this sense, a particular attention should be given to the following points:

- A smaller scope can provide a more detailed analysis and comparable outputs to local reality;
- The impacts of energy savings and avoided GHG emissions can be followed by an economic evaluation;
- More indicators can be considered for benchmarking e-waste management performance of countries, in order to increase the indicator reliability.

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Appendix

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Argentina	*Buenos Aires*	*Buenos Aires*	*Cooperativa La Toma Del Sur*	*www.facebook.com/cooperativa-la-toma-del-sur-272124996167396/* *cooplatomadelsur03@yahoo.com.ar*
Argentina	*Buenos Aires*	*Buenos Aires*	*Deposito Esteban Echeverria*	*www.scrapservice.com/sec_contactos.asp* *sidchb@siderca.com*
Argentina	*Buenos Aires*	*Buenos Aires*	*Deposito Miguelete*	*www.scrapservice.com/sec_contactos.asp* *sidchb@siderca.com*
Argentina	*Buenos Aires*	*Buenos Aires*	*Deposito San Miguel*	*www.scrapservice.com/sec_contactos.asp* *sidchb@siderca.com*
Argentina	*Buenos Aires*	*Buenos Aires*	*Deposito San Nicolas*	*www.scrapservice.com/sec_contactos.asp* *sidchb@siderca.com*
Argentina	*Buenos Aires*	*Buenos Aires*	*Equidad Fundacion Compania Social*	*www.equidad.org* *info@equidad.org*
Argentina	*Buenos Aires*	*Buenos Aires*	*Industrias Dalafer SA*	*www.dalafer.com.ar* *info@dalafer.com*
Argentina	*Buenos Aires*	*Buenos Aires*	*Reciclaje Electronico Esquinazo*	*www.facebook.com/reciclajeelectronicoecologicosocial/*
Argentina	*Buenos Aires*	*Buenos Aires*	*Reciclando Suenos*	*www.facebook.com/ottoeklix/* *trabajadoressociales@hotmail.com*
Argentina	*Buenos Aires*	*Buenos Aires*	*Rezagos*	*www.rezagos.com* *info@rezagos.com*
Argentina	*Buenos Aires*	*Buenos Aires*	*Scrap Service SA*	*www.scrapservice.com/sec_contactos.asp* *sidchb@siderca.com*
Argentina	*Buenos Aires*	*Buenos Aires*	*Silkers SA*	*www.silkers.com.ar* *info@silkers.com.ar*
Argentina	*Cordoba*	*Cordoba*	*3R Ambiental*	*www.3rambiental.com.ar* *info@3rambiental.com.ar*
Argentina	*Cordoba*	*Cordoba*	*Deposito Cordoba*	*www.scrapservice.com/sec_contactos.asp* *sidchb@siderca.com*
Argentina	*Mendoza*	*Mendoza*	*Reciclarg Recycling Technology*	*www.reciclarg.com/sitio/* *info@reciclarg.com*
Bolivia	*La Paz*	*La Paz*	*Raee Recicla*	*www.facebook.com/pg/raeerecicla/about/?ref=page_internal* *raee.recicla@gmail.com*

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Bolivia	*Santa Cruz*	*Santa Cruz de La Sierra*	*Fundare Centro Raee*	*www.ensulugar.com* *fundareraee@cainco.org.bo*
Brazil	*Alagoas*	*Maceio*	*Bio Digital Reciclagem de Resíduos Eletrônicos*	*www.biodigital-al.com.br/index.php* *atendimento@biodigital-al.com.br*
Brazil	*Amazonas*	*Manaus*	*Descarte Correto Gestão de Resíduos Tecnológicos*	*www.descartecorreto.com.br* *contato@descartecorreto.com.br*
Brazil	*Bahia*	*Camaçari*	*Ecoti Logística Reversa*	*www.ecoti.com.br* *ecoti@ecoti.com.br*
Brazil	*Bahia*	*Feira de Santana*	*Ecoba Logística Reversa de Eletroeletrônicos*	*www.ecoba.eco.br/site/* *suporte@ecoba.eco.br*
Brazil	*Bahia*	*Salvador*	*JJ Lixo Eletrônico*	*www.facebook.com/lixodigitalsalvador/* *joandroaraujo@gmail.com*
Brazil	*Bahia*	*Salvador*	*Recicle Logística Reversa de Eletroeletrônicos*	*www.reciclelogisticareversa.com.br* *contato@reciclelogisticareversa.com.br*
Brazil	*Bahia*	*Salvador*	*Sucatex do Brasil*	*www.sucatex.eco.br* *elderass@hotmail.com*
Brazil	*Ceará*	*Fortaleza*	*Ecoletas Ambiental*	*www.ecoletas.com.br* *ecoletas@ecoletas.com.br*
Brazil	*Distrito Federal*	*Brasília*	*Zero Impacto E-Reciclagem*	*www.zeroimpacto.com.br* *contato@zeroimpacto.com.br*
Brazil	*Espírito Santo*	*Linhares*	*ES Ambiental*	*www.esambiental.com.br* *contato@esambiental.com.br*
Brazil	*Goiás*	*Goiânia*	*Sucata Eletrônica Goiânia*	*www.sucataeletronicagoiania.com.br* *atendimento@sucataeletronica.com.br*
Brazil	*Goiás*	*Valparaíso de Goiás*	*Estação de Metarreciclagem*	*www.facebook.com/estacaodemetarreciclagem/*
Brazil	*Maranhão*	*São Luís*	*GRD Gestão em Resíduos Tecnológicos*	*www.gervasreciclagemdigital.com.br* *comercial@gervasreciclagemdigital.com.br*
Brazil	*Mato Grosso*	*Cuiabá*	*Ecodescarte Reciclagem de Eletrônicos*	*www.ecodescarte.com* *contato@ecodescarte.com*

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Brazil	*Minas Gerais*	*Belo Horizonte*	*Reciclar Minas*	*www.reciclarminas.com.br* *contato@reciclarminas.com.br*
Brazil	*Minas Gerais*	*Belo Horizonte*	*SOS Green Gestão de Descarte de Eletrônico*	*www.sosgreen.16mb.com* *fernando_caiafa@yahoo.com.br*
Brazil	*Minas Gerais*	*Betim*	*E-Mile Descarte de Eletrônicos*	*www.emile.net.br* *emile@emile.net.br*
Brazil	*Minas Gerais*	*Contagem*	*MR Recicla*	*www.mgrecicla.com* *contato@mgrecicla.com*
Brazil	*Minas Gerais*	*Duque de Caxias*	*E-Ambiental*	*www.eambiental.eco.br* *eambiental89@gmail.com*
Brazil	*Minas Gerais*	*Uberlândia*	*Codel Reciclagem*	*www.codelreciclagem.com.br* *contato@codelreciclagem.com.br*
Brazil	*Minas Gerais*	*Varginha*	*Ecobrasil Reciclagem de Eletrônicos*	*www.ecobrasil.net* *coleta@ecobrasil.net*
Brazil	*Paraíba*	*Conde*	*Ecobras*	*www.reciclagemecobras.com.br/site/* *contato@reciclagemecobras.com.br*
Brazil	*Paraíba*	*João Pessoa*	*Tech Five Gestão de Resíduos Eletroeletrônicos*	*www.techfive.com.br* *comercial@techfive.com.br*
Brazil	*Paraná*	*Colombo*	*Reciclatech*	*www.reciclatech.com.br/Modulos/Inicio/inicio.asp* *reciclatech@reciclatech.com.br?ref=1*
Brazil	*Paraná*	*Curitiba*	*Bulbox*	*www.bulbox.com.br* *contato@bulbox.com.br*
Brazil	*Paraná*	*Curitiba*	*Essencis Sul - UVS Curitiba*	*www.essencis.com.br/logistica-reversa* *essencis@essencis.com.br*
Brazil	*Paraná*	*Curitiba*	*Ester Reciclagem Ambiental*	*www.esterambiental.com.br*
Brazil	*Paraná*	*Curitiba*	*Hamarec*	*www.hamarec.com.br* *contato@hamarec.com.br*
Brazil	*Paraná*	*Curitiba*	*Mega Reciclagem*	*www.megareciclagem.com.br/site/* *mega@megareciclagem.com.br*
Brazil	*Paraná*	*Curitiba*	*Parcs Resíduo Eletrônico*	*www.parcs.com.br* *parcs@parcs.com.br*

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Brazil	*Paraná*	*Curitiba*	*Rafan do Brasil*	*www.rafandobrasil.com.br* *administrativo@rafandobrasil.com.br*
Brazil	*Paraná*	*Curitiba*	*Recicla E-Waste Company Brasil*	*www.reciclaeletronicos.com.br* *contato@reciclaeletronicos.com.br*
Brazil	*Paraná*	*Curitiba*	*Sete Ambiental Logística Reversa*	*www.seteambiental.com.br* *vendas@seteambiental.com.br*
Brazil	*Paraná*	*Foz do Iguaçu*	*Krefta Tecnologia em Serviços*	*www.krefta.com.br* *irmaoskrefta@gmail.com*
Brazil	*Paraná*	*Jacarezinho*	*Dallon Metais*	*www.dallon.com.br/metais/* *metais@dallon.com.br*
Brazil	*Paraná*	*Londrina*	*ONG E-letro Recuperação de Eletrônicos*	*www.e-lixolondrina.blogspot.com* *social@elixo.org.br*
Brazil	*Paraná*	*São José dos Pinhais*	*Ambserv Tratamento de Resíduos*	*www.ambserv.com.br* *ambserv@ambserv.com.br*
Brazil	*Paraná*	*Tamanara*	*Tamanara Tecnologia Ambiental*	*www.tamaranatecnologia.com.br* *falecom@tamaranatecnologia.com.br*
Brazil	*Rio de Janeiro*	*Duque de Caxias*	*Info Ambiental Coletor Tecnológico*	*www.ecoletaambiental.com.br*
Brazil	*Rio de Janeiro*	*Duque de Caxias*	*Prorecicle Ambiental*	*www.prorecicle.com.br* *contato@prorecicle.com.br*
Brazil	*Rio de Janeiro*	*Duque de Caxias*	*São Lourenço Ambiental*	*www.saolourencoambiental.com.br* *contato@saolourencoambiental.com.br*
Brazil	*Rio de Janeiro*	*Niterói*	*Coopertroni*	*www.facebook.com/coopertronic.eletronicos*
Brazil	*Rio de Janeiro*	*Pinheiral*	*Ecotronic Comércio e Manufatura Reversa*	*www.ecotronicbr.com* *contato@ecotronicbr.com*
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Brazil	*Rio de Janeiro*	*Rio de Janeiro*	*Descarte Rápido*	*www.descarterapido.com*
Brazil	*Rio de Janeiro*	*Rio de Janeiro*	*E-Lixo-RJ*	*www.e-lixo-rj.com.br* *contato@e-lixo-rj.com.br*
Brazil	*Rio de Janeiro*	*Rio de Janeiro*	*Zyklus Reciclagem e Manutenção de Eletrônicos*	*www.zyklus.com.br* *contato@zyklus.com.br*
Brazil	*Rio Grande do Norte*	*Natal*	*EVS Reciclagem Digital*	*www.facebook.com/EVS-Reciclagem-Digital-1412360425740054/*

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Brazil	*Rio Grande do Norte*	*São Gonçalo do Amarante*	*Ecoativa Gestão de Resíduos*	*www.ecoativarecicla.com.br* *contato@ecoativarecicla.com.br*
Brazil	*Rio Grande do Sul*	*Alvorada*	*JG Recicla Gestão de Resíduos Eletrônicos*	*www.jgrecicla.com.br* *atendimento@jgrecicla.com.br*
Brazil	*Rio Grande do Sul*	*Cachoeirinha*	*Trade Recycle*	*www.traderecycle.com.br* *comercial@traderecycle.com.br*
Brazil	*Rio Grande do Sul*	*Caxias do Sul*	*Ambe Gerenciamento de Resíduos*	*www.ambe.com.br* *ambe@ambe.com.br*
Brazil	*Rio Grande do Sul*	*Horizontina*	*Natusomos Lixo Eletrônico*	*www.natusomos.com.br* *natusomos@natusomos.com.br*
Brazil	*Rio Grande do Sul*	*Novo Hamburgo*	*Reverse Gestão de Resíduos*	*www.reverseresiduos.com.br* *contato@reverseresiduos.com.br*
Brazil	*Rio Grande do Sul*	*Paraí*	*Recicla Gestão de Resíduos*	*www.recicla.rs* *comercial@recicla.rs*
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Brazil	*Rio Grande do Sul*	*Porto Alegre*	*Apliquim Brasil Recicle*	*www.apliquimbrasilrecicle.com.br* *descontaminacao@brasilrecicle.com.br*
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Brazil	*Rio Grande do Sul*	*Porto Alegre*	*RS Recicla*	*www.rsrecicla.com.br* *contato@rsrecicla.com.br*
Brazil	*Rio Grande do Sul*	*São Leopoldo*	*E-Sucata*	*www.e-sucata.com/home* *comercial@e-sucata.com*
Brazil	*Rio Grande do Sul*	*São Leopoldo*	*Usina de Resíduos Pavani*	*www.usinapavani.com.br* *contato@usinapavani.com.br*

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Brazil	*Santa Catarina*	*Blumenau*	*Reciclean Reciclagem de Aparelhos Eletrônicos*	*www.recicleanblumenau.webnode.com.br* *contato@reciclean.eco.br*
Brazil	*Santa Catarina*	*Chapecó*	*Rec Reciclagem de Eletrônicos Chapecó*	*www.recchapeco.com.br* *reciclagemdeeletronicoschapeco@bol.com.br*
Brazil	*Santa Catarina*	*Indaial*	*Apliquim Brasil Recicle*	*www.apliquimbrasilrecicle.com.br* *descontaminacao@brasilrecicle.com.br*
Brazil	*Santa Catarina*	*Itajaí*	*Reciclavale*	*www.reciclavaleitajai.webnode.com* *reciclavaleitj@bol.com.br*
Brazil	*Santa Catarina*	*Joaçaba*	*Alpha Digital*	*www.alphadigital.eco.br* *venda@alphadigital.eco.br*
Brazil	*Santa Catarina*	*Joinville*	*Reset Descarte Tecnológico*	*www.resetdescarte.com.br* *eduardo@resetdescarte.com.br*
Brazil	*Santa Catarina*	*Palhoça*	*WEEE.DO Logística Reversa de Eletroeletrônicos*	*www.weee.do/site/* *contato@weee.do*
Brazil	*São Paulo*	*Americana*	*Ecológica Soluções Ambientais*	*www.ecologicaambiental.com* *contato@ecologicaambiental.com*
Brazil	*São Paulo*	*Bauru*	*Witzler Recicla*	*www.witzlerrecicla.com.br* *recicla@witzler.com.br*
Brazil	*São Paulo*	*Cabreúva*	*Reciclagem Brasil / By Word Reciclagem*	*www.reciclagembrasil.com.br* *contato@reciclagembrasil.com.br*
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Brazil	*São Paulo*	*Campinas*	*Eco Vallore Gestão e Valorização Ambiental*	*www.ecovallore.com.br* *contato@ecovallore.com.br*
Brazil	*São Paulo*	*Campinas*	*Belmont Trading Brazil*	*www.belmont-trading.com/brazil/pt-br/* *info.hq@belmont-trading.com*
Brazil	*São Paulo*	*Diadema*	*Recicle Digital*	*www.recicledigital.com.br* *recicledigital@gmail.com*

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Brazil	*São Paulo*	*Guarulhos*	*Umicore Brasil*	*www.umicore.com.br/pt/*
Brazil	*São Paulo*	*Guarulhos*	*Vida Trans Ambiental*	*www.vidatrans.com.br* *atendimento@vidatrans.com.br*
Brazil	*São Paulo*	*Indaiatuba*	*ERS do Brasil*	*www.ersdobrasil.com.br* *br.frontdesk@ers-international.com*
Brazil	*São Paulo*	*Indaiatuba*	*Re-Teck Comercial Exportadora e LogíStica Reversa Ltda.*	*www.re-teck.com* *info_br@re-teck.com*
Brazil	*São Paulo*	*Jaboticabal*	*Recicla Bytes*	*www.reciclabytes.com.br* *contato@reciclabytes.com.br*
Brazil	*São Paulo*	*Jundiaí*	*GAG Reciclagem de Eletrônicos*	*www.reciclagag.com.br/#inicio* *contato@reciclagag.com.br*
Brazil	*São Paulo*	*Jundiaí*	*Naturalis Brasil*	*www.naturalisbrasil.com.br* *contato@naturalisbrasil.com.br*
Brazil	*São Paulo*	*Jundiaí*	*RBI Informática*	*www.rbijundiai.com.br* *contato@rbijundiai.com.br*
Brazil	*São Paulo*	*Limeira*	*Recicla Lâmpadas*	*www.reciclalampadas.com.br* *info@reciclalampadas.com.br*
Brazil	*São Paulo*	*Mauá*	*Vertas*	*www.vertas.com.br* *vertas@vertas.com.br*
Brazil	*São Paulo*	*Mococa*	*Led Reciclagem*	*www.ledreciclagem.com.br* *reciclagemled@hotmail.com*
Brazil	*São Paulo*	*Nova Odessa*	*Descarte Certo / Grupo Ambipar*	*www.descartecerto.com.br/index.php* *contato@grupoambipar.com.br*
Brazil	*São Paulo*	*Osasco*	*Tramppo*	*www.tramppo.com.br* *supvendas@tramppo.com.br*
Brazil	*São Paulo*	*Osasco*	*Cintitec*	*www.cintitec.com* *cintitec@cintitec.com*
Brazil	*São Paulo*	*Paulínia*	*Apliquim Brasil Recicle*	*www.apliquimbrasilrecicle.com.br* *descontaminacao@brasilrecicle.com.br*
Brazil	*São Paulo*	*Salto*	*Ecoprocessos*	*www.ecoprocessos.com.br* *contato@ecoprocessos.com.br*
Brazil	*São Paulo*	*Santo André*	*Hequipel*	*www.hequipel.com.br* *comercial@hequipel.com.br*

Country	State/Province	Municipality	Company	Contact
Brazil	*São Paulo*	*Santo André*	*Reciclagem Certa*	*www.reciclagemcerta.com.br* *contato@reciclagemcerta.com.br*
Brazil	*São Paulo*	*Santo André*	*Stock33 Soluções Ambientais*	*www.stock33.com.br* *contato@stock33.com.br*
Brazil	*São Paulo*	*São Bernardo do Campo*	*Interamerican Gerenciamento Ambiental*	*www.interamerican.com.br* *intersbc@terra.com.br*
Brazil	*São Paulo*	*São Bernardo do Campo*	*Recycare Sucata Digital*	*www.recycare.com.br* *atendimento@recycare.com.br*
Brazil	*São Paulo*	*São José dos Campos*	*ARL Vale Comércio e Reciclagem De EletroeletrôNicos*	*ctbsaojose@uol.com.br*
Brazil	*São Paulo*	*São José dos Campos*	*Bulbless Reciclagem de Lâmpadas*	*www.bulbless.com.br/index.php* *contato@bulbless.com.br*
Brazil	*São Paulo*	*São José dos Campos*	*Gm&Clog Soluções de Logística Reversa e Reciclagem*	*www.gmclog.com.br/site/* *atendimento@gmclog.com.br*
Brazil	*São Paulo*	*São José dos Campos*	*Tech Five Gestão de Resíduos Eletroeletrônicos*	*www.techfive.com.br* *comercial@techfive.com.br*
Brazil	*São Paulo*	*São Paulo*	*3E Reciclagem*	*www.treise.com.br* *eee@treise.com.br*
Brazil	*São Paulo*	*São Paulo*	*486 Reciclagem Eletrônica*	*www.486reciclagem.com.br* *contato@486reciclagem.com.br*
Brazil	*São Paulo*	*São Paulo*	*Coopermiti*	*www.coopermiti.com.br* *contato@coopermiti.com.br*
Brazil	*São Paulo*	*São Paulo*	*Descarte de Lixo Eletrônico*	*www.descarte-de-lixo-eletronico.business.site*
Brazil	*São Paulo*	*São Paulo*	*Eco Computadores*	*www.ecocomputadores.com* *contato@ecocomputadores.com*
Brazil	*São Paulo*	*São Paulo*	*Eco-Cel Reciclagem Sustentável*	*www.eco-cel.com* *contato@eco-cel.com*
Brazil	*São Paulo*	*São Paulo*	*Ecobraz*	*www.ecobraz.org.br* *contato@ecobraz.org.br*
Brazil	*São Paulo*	*São Paulo*	*Global Reciclagem*	*www.globalreciclagem.com.br* *contato@globalreciclagem.com.br*
Brazil	*São Paulo*	*São Paulo*	*Grava Sucata de Informática e Eletrônico*	*www.sucatadeinformatica.com.br* *contato@sucatadeinformatica.com.br*

Country	State/Province	Municipality	Company	Contact
Brazil	*São Paulo*	*São Paulo*	*Green Company CO2*	*www.greencompanyco2.com.br* *comercial@greencompanyco2.com.br*
Brazil	*São Paulo*	*São Paulo*	*JC Logística Reversa*	*www.jclogisticareversa.com.br* *contato@jclogisticareversa.com.br*
Brazil	*São Paulo*	*São Paulo*	*Loop Logística Reversa*	*www.looplog.com.br* *contato@looplog.com.br*
Brazil	*São Paulo*	*São Paulo*	*Lorene Importação e Exportação*	*www.lorene.com.br* *comercial@lorene.com.br*
Brazil	*São Paulo*	*São Paulo*	*Reciclo Descarte de Eletrônicos*	*www.reciclometais.com.br* *contato@gruporeciclo.com.br*
Brazil	*São Paulo*	*São Paulo*	*Recomércio*	*www.recomercio.com.br* *contato@recomercio.com.br*
Brazil	*São Paulo*	*São Paulo*	*Reversee Soluções em Tecnologia Reversa*	*www.reversee.com.br* *atendimento@reversee.com.br*
Brazil	*São Paulo*	*São Paulo*	*Royal Metais*	*www.royalmetais.com.br* *contato@royalmetais.com.br*
Brazil	*São Paulo*	*São Paulo*	*San Lien Gestão de Resíduos*	*www.sanlien.com.br* *formulario@sanlien.com.br*
Brazil	*São Paulo*	*São Paulo*	*Silcon Ambiental Ltda.*	*www.silcon.com.br* *comercial@silcon.com.br*
Brazil	*São Paulo*	*São Paulo*	*Sir Company Soluções Ambientais*	*www.sircompany.com.br* *contato@sircompany.com.br*
Brazil	*São Paulo*	*São Paulo*	*Tech Eco*	*www.techeco.com.br* *contato@techeco.com.br*
Brazil	*São Paulo*	*São Paulo*	*WN Recicla*	*www.wnrecicla.com.br* *contato@wnrecicla.com.br*
Brazil	*São Paulo*	*Sorocaba*	*Estre / Resicontrol*	*www.estre.com.br* *comercial@estre.com.br*
Brazil	*São Paulo*	*Sorocaba*	*Salmeron*	*www.gruposalmeron.com.br* *contato@gruposalmeron.com.br*
Brazil	*São Paulo*	*Sorocaba*	*Sinctronics*	*www.sinctronics.com.br* *sinctronics@sinctronics.com.br*

Country	State/Province	Municipality	Company	Contact
Brazil	*São Paulo*	*Taboão da Serra*	*SAR do Brasil*	*www.sardobrasil.com.br* *sac@sardobrasil.com.br*
Brazil	*Sergipe*	*Aracaju*	*Eco TI Logística Reversa*	*www.ecoti.com.br* *ecoti@ecoti.com.br*
Brazil	*Tocantins*	*Palmas*	*Recicle Tocantins*	*www.recicletocantins.blogspot.com* *hardsis.to@pop.com.br*
Chile	*Antofagasta*	*Calama*	*Recimat*	*www.recimat.cl* *comunicaciones@recimat.cl*
Chile	*Nuble*	*Chillan Viejo*	*Chile Recicla*	*www.chilerecicla.com* *info@chilerecicla.com*
Chile	*Region Metropolitana*	*Santiago*	*Codec Reciclaje Computacional*	*www.codec.cl* *info@codec.cl*
Chile	*Region Metropolitana*	*Santiago*	*Debaja*	*www.debaja.cl* *contacto@debaja.cl*
Chile	*Region Metropolitana*	*Santiago*	*Degraf*	*www.degraf.cl* *electronicos@degraf.cl*
Chile	*Region Metropolitana*	*Santiago*	*Exportaciones Emanuel*	*www.exportacionesemanuelspa.cl* *contacto@exportacionesemanuelspa.cl*
Chile	*Region Metropolitana*	*Santiago*	*Fundacion Chilenter*	*www.chilenter.com* *contacto@chilenter.cl*
Chile	*Region Metropolitana*	*Santiago*	*Hidronor*	*www.hidronor.cl* *contacto@hidronor.cl*
Chile	*Region Metropolitana*	*Santiago*	*LG Electronics Inc Chile Ltda*	-
Chile	*Region Metropolitana*	*Santiago*	*Manejo de Residuos Solidos Industriales SA (Marsin SA)*	*www.comec.cl/index.php* *ventas@comec.cl*
Chile	*Region Metropolitana*	*Santiago*	*Midas Chile*	*www.midaschile.cl* *contacto@midaschile.cl*
Chile	*Region Metropolitana*	*Santiago*	*Procesadora de Metales SA*	-
Chile	*Region Metropolitana*	*Santiago*	*Reciclajes de Chile Ltda*	-

Country	State/Province	Municipality	Company	Contact
Chile	*Region Metropolitana*	*Santiago*	*Recycla Chile*	*www.recycla.cl* *info@recycla.cl*
Chile	*Region Metropolitana*	*Santiago*	*Recytech Services*	*www.recytech.cl/* *gerencia@recytech.cl*
Chile	*Region Metropolitana*	*Santiago*	*Tecnorecicla*	*www.tecnorecicla.cl*
Colombia	*Atlantico*	*Barranquilla*	*Ecoeficiencia Barranquilla*	*www.ecoeficiencia.com.co* *contacto@ecoeficiencia.com.co*
Colombia	*Atlantico*	*Barranquilla*	*Gecoraee*	*www.gecoraee.com* *info@gecoraee.com*
Colombia	*Atlantico*	*Barranquilla*	*Lito Ltd Barranquilla*	*www.litoltda.com* *erika.suarez@litoltda.com*
Colombia	*Atlantico*	*Barranquilla*	*Megaserviciosplus Barranquilla*	*www.megaserviciosplus.com* *gerenciacomercial@megaserviciosplus.com*
Colombia	*Distrito Capital*	*Bogota*	*Asei Sas y Biologicos y Contaminados Sas Esp*	*www.asei.com.co/index.php?r=site/contacto&sec=7* *info@biologicos.net*
Colombia	*Distrito Capital*	*Bogota*	*Belmont Trading Colombia*	*www.belmont-trading.com/location/colombia/* *info.hq@belmont-trading.com*
Colombia	*Distrito Capital*	*Bogota*	*Centro Nacional de Aprovechamiento de Residuos Electronicos*	*www.computadoresparaeducar.gov.co/es/contactanos/tramites-y-servicios* *info@cpe.gov.co*
Colombia	*Distrito Capital*	*Bogota*	*CI Recyclabes Sas Bogota*	*www.recyclables.com.co* *bogota@recyclables.com*
Colombia	*Distrito Capital*	*Bogota*	*Click on Green*	*www.clickongreen.com* *maria@clickongreen.com*
Colombia	*Distrito Capital*	*Bogota*	*Ecocomputo*	*www.ecocomputo.com*
Colombia	*Distrito Capital*	*Bogota*	*Ecoeficiencia Bogota*	*www.ecoeficiencia.com.co* *contacto@ecoeficiencia.com.co*
Colombia	*Distrito Capital*	*Bogota*	*Gaia Vitare Bogota*	*www.gaiavitare.com/site/* *servicioalcliente@gaiavitare.com*
Colombia	*Distrito Capital*	*Bogota*	*Jacobs International Sas*	*www.jacobsi.com/blog/cometa/* *info@jacobsi.com*

Country	State/Province	Municipality	Company	Contact
Colombia	*Distrito Capital*	*Bogota*	*Lasea Soluciones*	*www.laseasoluciones.com* *comercial@laseasoluciones.com*
Colombia	*Distrito Capital*	*Bogota*	*Lito Ltd Bogota*	*www.litoltda.com* *erika.suarez@litoltda.com*
Colombia	*Distrito Capital*	*Bogota*	*Megaserviciosplus Bogota*	*www.megaserviciosplus.com* *gerenciacomercial@megaserviciosplus.com*
Colombia	*Distrito Capital*	*Bogota*	*Mejoriamento Global SA*	*www.mejoramientoglobal.com* *info@mejoramientoglobalsas.com*
Colombia	*Distrito Capital*	*Bogota*	*Ocade Sas*	*www.ocade.net* *gerencia@ocade.net*
Colombia	*Distrito Capital*	*Bogota*	*Orinoco*	*www.orinocol.com*
Colombia	*Distrito Capital*	*Bogota*	*Planeta Verde Gestion Integral de Residuos*	*www.planetaverdegir.com/index.html* *comercial@planetaverde.com.co*
Colombia	*Distrito Capital*	*Bogota*	*WEEE Global*	*www.weee.global* *info@weee.global*
Colombia	*Santander*	*Bucaramanga*	*Ecoeficiencia Bucaramanga*	*www.ecoeficiencia.com.co* *contacto@ecoeficiencia.com.co*
Colombia	*Santander*	*Bucaramanga*	*Lito Ltd Bucaramanga*	*www.litoltda.com* *erika.suarez@litoltda.com*
Colombia	*Valle Del Cauca*	*Cali*	*Ecoeficiencia Cali*	*www.ecoeficiencia.com.co* *contacto@ecoeficiencia.com.co*
Colombia	*Valle Del Cauca*	*Cali*	*Gaia Vitare Cali*	*www.gaiavitare.com/site/* *dirsuroccidente@gaiavitare.com*
Colombia	*Valle Del Cauca*	*Cali*	*Hometal Recycling Sas*	*www.facebook.com/pg/hometalrecycling/about/?ref=page_internal* *info@hometalrecycling.com.co*
Colombia	*Valle Del Cauca*	*Cali*	*Lito Ltd Cali*	*www.litoltda.com* *erika.suarez@litoltda.com*
Colombia	*Valle Del Cauca*	*Cali*	*Raoc*	*www.raoc.com.co*
Colombia	*Bolivar*	*Cartagena*	*CI Recyclabes Sas Cartagena*	*www.recyclables.com.co* *administracion@recyclables.com*
Colombia	*Antioquia*	*Medellin*	*Asei Sas y Biologicos y Contaminados Sas Esp*	*www.asei.com.co/index.php?r=site/contacto&sec=7* *info@asei.com.co*

Country	**State/Province**	**Municipality**	**Company**	**Contact**
Colombia	*Antioquia*	*Medellin*	*Ecoeficiencia Medellin*	*www.ecoeficiencia.com.co* *contacto@ecoeficiencia.com.co*
Colombia	*Antioquia*	*Medellin*	*Ecycling Sas*	*www.ecyclingcolombia.com/* *info@ecyclingcolombia.com*
Colombia	*Antioquia*	*Medellin*	*Gaia Vitare Medellin*	*www.gaiavitare.com/site/* *dircentro-occidente@gaiavitare.com*
Colombia	*Antioquia*	*Medellin*	*Lito Ltd Medellin*	*www.litoltda.com* *erika.suarez@litoltda.com*
Colombia	*Antioquia*	*Medellin*	*Reverse Logistics Group America*	*www.latam.rlgamericas.com* *colombia@rlgamericas.com*
Costa Rica	*Alajuela*	*Alajuela*	*Multiservicios Ecologicos*	*www.multiserviciosecologicos.com* *multiservicios@multiecocr.com*
Costa Rica	*Alajuela*	*Alajuela*	*Valu Shred Costa Rica*	*www.valushred.com* *valushredcostarica@valushred.com*
Costa Rica	*Cartago*	*Cartago*	*Fortech*	*www.fortech.cr* *info@fortech.cr*
Costa Rica	*Cartago*	*Cartago*	*GEEP Global Costa Rica*	*www.geepglobal.com* *info@geepglobal.com*
Costa Rica	*San Jose*	*San Jose*	*Recicladora Capri*	*www.recicladoracapri.webs.com* *recicladoracapri@hotmail.com*
Costa Rica	*San Jose*	*San Jose*	*Remecsa*	*www.remecsacr.com* *info@remecsacr.com*
Costa Rica	*San Jose*	*San Jose*	*Servicios Ecologicos Mbb SA*	*www.reciclajecr.com* *info@reciclajecr.com*
Costa Rica	*San Jose*	*San Jose*	*Solirsa Soluciones Integrales en Reciclaje SA*	*www.solirsa.com* *info@solirsa.com*
Costa Rica	*San Jose*	*San Jose*	*Wastech Costa Rica*	*www.wastechcr.com* *info@wastechcr.com*
Costa Rica	*San Jose*	*San Jose*	*Zubre SA*	*www.zubre.com* *info@zubre.com*
Ecuador	*El Oro*	*Machala*	*Intercia Machala*	*www.intercia.com* *intercia@intercia.com*

Country	State/Province	Municipality	Company	Contact
Ecuador	*Guayas*	*Guayaquil*	*Intercia Guayaquil*	*www.intercia.com* *intercia@intercia.com*
Ecuador	*Manabi*	*Montecristi*	*Intercia Montecristi*	*www.intercia.com* *intercia@intercia.com*
Ecuador	*Pichincha*	*Quito*	*Intercia Quito*	*www.intercia.com* *intercia@intercia.com*
Ecuador	*Pichincha*	*Quito*	*Plusambiente SA*	*www.plusambiente.com/index.html* *comercial@plusambiente.com*
Ecuador	*Pichincha*	*Quito*	*Reciclametal*	*www.reciclametal.com* *info@reciclametal.com*
Ecuador	*Pichincha*	*Quito*	*Vertmond*	*www.vertmonde.com/index.html* *vertmonde.ec@gmail.com*
Guatemala	*Guatemala*	*Ciudad de Guatemala*	*Recelca*	*www.recelca.com* *info@recelca.com*
Honduras	*Cortes*	*San Pedro Sula*	*Invema Group*	*www.invemagroup.com* *info@invemagroup.com*
Honduras	*Cortes*	*San Pedro Sula*	*Recacel Recicladora Centroamericana SA*	*www.facebook.com/Recacel/* *informacion@recacel.com*
Honduras	*Cortes*	*San Pedro Sula*	*Recycle Honduras*	*www.facebook.com/recyclehonduras/* *ventas@recyclehonduras.com*
Mexico	*Aguascalientes*	*Aguascalientes*	*Redisa Ambiental*	*www.redisaambiental.com* *contacto@redisaambiental.com*
Mexico	*Baja California*	*Mexicali*	*Recycling Synergy*	*www.resyn.mx* *contacto@resyn.mx*
Mexico	*Baja California*	*Tijuana*	*Glezco Tijuana*	*www.glezcocorp.com.mx* *webmaster@glezcocorp.com.mx*
Mexico	*Distrito Capital*	*Ciudad de Mexico*	*Proambi Reciclaje de Electronicos*	*www.proambi.com* *clientes@proambi.com*
Mexico	*Distrito Federal*	*Ciudad de Mexico*	*Centro de Reciclaje Recupera Del Valle*	*www.recuperamexico.com* *recicla@recuperamexico.com*
Mexico	*Distrito Federal*	*Ciudad de Mexico*	*Centro de Reciclaje Recupera Mixcoac*	*www.recuperamexico.com* *recicla@recuperamexico.com*

Country	State/Province	Municipality	Company	Contact
Mexico	*Distrito Federal*	*Ciudad de Mexico*	*Centro de Reciclaje Recupera San Pedro de Los Pinos*	*www.recuperamexico.com* *recicla@recuperamexico.com*
Mexico	*Distrito Federal*	*Ciudad de Mexico*	*Centro de Reciclaje Recupera Tacubaya*	*www.recuperamexico.com* *recicla@recuperamexico.com*
Mexico	*Distrito Federal*	*Ciudad de Mexico*	*Ecoazteca Recicladora*	*www.reciclaje-de-electronicos.com.mx*
Mexico	*Distrito Federal*	*Ciudad de Mexico*	*Recall International*	*www.recallinternacional.com* *cygoca@yahoo.com.mx*
Mexico	*Distrito Federal*	*Ciudad de Mexico*	*Recicladora Electronica*	*www.recicladoraelectronica.com/index.html* *info@recicladoraelectronica.com*
Mexico	*Distrito Federal*	*Ciudad de Mexico*	*Recicmx*	*www.recicmx.com* *contacto@recicmx.com*
Mexico	*Distrito Federal*	*Ciudad de Mexico*	*Recyel Electronics Recycling*	*www.recyel.com* *contacto@recyel.com*
Mexico	*Distrito Federal*	*Ciudad de Mexico*	*Refcupera Centros de Reciclaje*	*www.recuperamexico.com* *recicla@recuperamexico.com*
Mexico	*Distrito Federal*	*Ciudad de Mexico*	*The Ewaste Group*	*www.theewaste.com* *info@theewaste.com*
Mexico	*Jalisco*	*Guadalajara*	*Belmont Trading Mexico*	*www.belmont-trading.com/mexico/* *info.hq@belmont-trading.com*
Mexico	*Jalisco*	*Guadalajara*	*IRE Ingenieria en Reciclaje Especializado*	*www.chatarraelectronic.com* *ire_reciclaje@hotmail.com*
Mexico	*Jalisco*	*Guadalajara*	*Mac Grupo Ecologico*	*www.gemac.com.mx* *info@gemac.com.mx*
Mexico	*Jalisco*	*Guadalajara*	*Natura Recovery Solutions*	*www.naturarecovery.com/index.html* *info@naturarecovery.com*
Mexico	*Jalisco*	*Guadalajara*	*Reciclatronic*	*www.reciclatronic.com.mx* *hola@rericlatronic.com.mx*
Mexico	*Jalisco*	*Tlaquepaque*	*Glezco Guadalajara*	*www.glezcocorp.com.mx* *webmaster@glezcocorp.com.mx*
Mexico	*Mexico*	*Ecapetec de Morelos*	*Wsilver Recycling - Mexico City Consolidation Center*	*www.wsilverrecycling.com/index.html* *customerservice@wsilver.com*
Mexico	*Mexico*	*Toluca*	*Reciclatronica*	*www.reciclatronica.com* *contacto@reciclatronica.com*

Country	State/Province	Municipality	Company	Contact
Mexico	*Nuevo Leon*	*Apodaca*	*Glezco Monterrrey*	*www.glezcocorp.com.mx* *webmaster@glezcocorp.com.mx*
Mexico	*Nuevo Leon*	*Apodaca*	*Morphos Recycling*	*www.morphosrecycling.com* *atnclientes@morphosrecycling.com*
Mexico	*Nuevo Leon*	*Apodaca*	*Wsilver Recycling - Monterrey Consolidation Center*	*www.wsilverrecycling.com/index.html* *customerservice@wsilver.com*
Mexico	*Nuevo Leon*	*Apodaca*	*Wsilver Recycling - Steel Yard and Public Scale*	*www.wsilverrecycling.com/index.html* *customerservice@wsilver.com*
Mexico	*Nuevo Leon*	*Guadalupe*	*Venymex*	*www.intereciclaje.com/perfiles/?386* *venymex.ventas@gmail.com*
Mexico	*Nuevo Leon*	*Juarez*	*Corporacion de Valores Reciclados - Cvr Mexico*	*www.cvrmexico.com* *reciclaje@cvrmexico.com*
Mexico	*Nuevo Leon*	*Monterrey*	*Laptronics*	*www.facebook.com/laptronics.mx/* *laptronics_ventas@hotmail.com*
Mexico	*Nuevo Leon*	*Monterrey*	*RCE Reciclaje de Cable y Electronica*	*www.reciclaje-electronico.com* *servicio@reciclaje-electronico.com*
Mexico	*Nuevo Leon*	*Monterrey*	*Techemet Technical, Chemical and Metallurgical Group*	*www.techemetmx.com*
Mexico	*Queretaro*	*Queretaro*	*Remsa Recicla Electronicos Mexico*	*www.reciclaelectronicos.com* *recicla@reciclaelectronicos.com*
Mexico	*San Luis Potosi*	*San Luis Potosi*	*Incycle Eletronics Mexico*	*www.incycle.mx* *info@incycle.mx*
Mexico	*San Luis Potosi*	*San Luis Potosi*	*Mundo Rojo*	*www.mundorojo.com.mx/english.html* *contacto@mundorojo.com.mx*
Panama	*Panamá*	*Ciudad de Panama*	*Recicla Panama*	*www.reciclapanama.net* *comercial@reciclapanama.net*
Panama	*Panamá*	*Ciudad de Panama*	*Recimax Recycling Services SA*	*www.recimax.net* *info@recimax.net*
Panama	*Panamá*	*Ciudad de Panama*	*Renuevo Panama*	*www.facebook.com/RenuevoPanama/* *info@renuevopanama.com*
Peru	*Callao*	*Callao*	*Perurecicla*	*www.perurecicla.net/sidebsp/* *contacto@perurecicla.net*

Country	State/Province	Municipality	Company	Contact
Peru	*Coronel Portillo*	*Pucallpa*	*Grupo Brunner Pucallpa*	*www.brunner.com.pe* *comercial@brunner.com.pe*
Peru	*Lima*	*Lima*	*Akstarcom*	*www.akstarcom.com/index.htm* *ventas@akstarcom.com*
Peru	*Lima*	*Lima*	*Comimtel Recycling*	*www.comimtel.com* *info@comimtel.com*
Peru	*Lima*	*Lima*	*Grupo Brunner Lima*	*www.brunner.com.pe* *comercial@brunner.com.pe*
Peru	*Lima*	*Lima*	*San Antonio Recycling*	*www.sar.pe* *info@sar.pe*
Peru	*Maynas*	*Iquitos*	*Grupo Brunner Iquitos*	*www.brunner.com.pe* *comercial@brunner.com.pe*
Uruguay	*Maldonado*	*Maldonado*	*Werba Reciclando Metales Maldonado*	*www.werbasa.com/es/* *fabio@werbasa.com*
Uruguay	*Montevideo*	*Montevideo*	*Antel Integra*	*www.antel.com.uy/institucional/antel-integra* *antelintegra@antel.com.uy*
Uruguay	*Montevideo*	*Montevideo*	*Crecoel*	*www.crecoel.com* *crecoel@gmail.com*
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