

Mobile App for the Logistics and Management of Waste Electric and Electronic Equipment (WEEE)

Luis Alejandro Turriago Romero¹, Andres Esteban Galindo González¹, Andres David Ochoa Moreno¹, Nicolas David Valencia Reina¹, Carlos Andres Montoya Marentes¹, Juan Steban Sánchez Ramírez¹, Paula Fernanda Moreno Aconcha¹, Alberto Uribe Jongbloed^{1,*}

¹ Facultad de Ingeniería; Universidad EAN, Bogotá, D.C., Colombia, 110221

auribejo@universidadean.edu.co

* Author to whom correspondence should be addressed

1. ABSTRACT

The purpose of the paper is to provide a proposed solution to the problem of logistics for WEEE within the Colombian territory. For this, a methodology will be exposed, which will be based on a mobile application that facilitates the process of collection, storage, treatment and final disposal, involving the relationship between the producer, user and manager, to have a control of the real-time follow-up of the WEEE available. All these studies were developed taking into account the law 1672 of 2013, Colombian regulations established for the integral management or WEEE, in addition to the European Directive 2012/19, Annex II, for the classification of the Waste Electrical and Electronic Equipment.

2. INTRODUCTION

The waste of electrical and electronic devices has been a global problem in recent years as it does not have an efficient logistics for its collection, storage, treatment and final disposal, that is, its integral management plan. "Most people throw them into the trash at the end of their useful life without considering that a huge amount of polluting materials such as copper, aluminum, iron and petroleum products are being thrown away." (El Tiempo, 2015), is a general occurrence. Users determine -by different factors- whether an electric/electronic piece of equipment will be a waste and decide its final disposal, but the manufacturers and the State have not made a large enough effort to publicize the policies and management procedures this waste. The United Nations Environmental Programme (UNEP), has been developing reports to determine the amount - in tons per year - of electrical and electronic waste (PNUMA, 2013) that humanity has generated. We must not forget the impacts that these waste produce to the environment if they are not treated properly, without an appropriate management and treatment strategy.

The UNESCO Regional Science Office for Latin America and the Caribbean (Oficina Regional de Ciencia para América Latina y el Caribe) in a 2012 electronic book (UNESCO, 2012), calls the United States and China the largest producers and generators of WEEE in the world; USA produces about 10 million tons of "electronic garbage" annually and China produces 11.1 million tons per annum. It is also specified that the world, annually, is producing around 49 million tons of WEEE and it is projected to increase by 33% by 2017, that is, humanity will generate annually, around 65.4 million tons of WEEE, equivalent to 200 Empire State buildings in NY, USA. In Latin America, Mexico and Brazil lead the list

of countries generating WEEE, Brazil (1.4 million tons) and Mexico (1 million) (Landini, 2015). As the global market for electronic equipment grows exponentially, so does the problem of disposal of such materials once they become obsolete and their users deem them waste.(Bhutta, Omar, & Yang, 2011). We understand well that the problem exists, for that reason we want to give an integral solution to the management of this waste starting with a proposed logistic technological advance in the form of a mobile application.

It is expected that by the implementation of the application within the Colombian territory, its citizens will have a tool to guide them to manage WEEE without affecting the environment, involving the user, the manager and the producer of the electrical or electronic equipment which is proposed to manage. The logistics of delivery, collection, storage, treatment and final disposal, can be monitored by interested parties to know, in real time, what is being done with the waste and its possible future. This will strengthen better relations between the end user and the manufacturers/sellers and, in turn, generate a source of employment represented in the companies that are dedicated to the different activities of the logistics chain; collection, storage, treatment or final disposal. It is hoped that we Colombians can adopt this to our culture, to set an example to the world and to be able to handle in a clear, efficient and effective way the management process of an Electrical and Electronic Waste.

a. LEGAL FRAMEWORK

In Colombia there is a relatively recent regulatory framework whose fundamental purpose is, among others, to lay the foundations for the management of waste electrical and electronic equipment that, if not managed properly, would have a negative impact on the environment and society. This regulatory framework is composed of laws, decrees and resolutions that give importance to the proper handling of these materials in order to mitigate the potential impacts, since every day there is an increase in their production (Ministerio del Medio Ambiente, 2017). Our proposal is an application that will allow us to classify and identify these devices so that they can be collected and treated appropriately or use or dispose of them.

Here is a brief overview of the main regulations that govern the process:

- **Law 1672 of 2013**, *“by which it establishes the guidelines for the adoption of a public policy of integral management of waste electrical and electronic equipment (WEEE), and other provisions are dictated”*; Its purpose is to establish the guidelines for the public policy of integral management of the WEEE generated in the national territory. It is important to take this law as a reference, since it dictates the responsibilities and obligations of each of the participants in the WEEE chain, from its production to the management carried out (Congreso de la República, 2013).

- **Decree 2324 of 2000** *“by means of which Decree 1130 of 1999 is modified and the organisms and entities that will be in charge of the implementation and development of the Programs of the Agenda of Connectivity are established, in particular, of the "Computers to Educate" Program and other provisions are established for the same purposes”*; it is taken into account for the present project, since it has as purpose the collection and reconditioning of equipment discharged

with the intent of distributing them in educational institutions (Presidencia de la República & Ministerio de Comunicaciones, 2000).

- **Decree 4741 of 2005**, *“which partially regulates the prevention and management of waste or hazardous waste generated within the framework of integral management”*; Its purpose is to prevent the generation of waste or hazardous waste, as well as regulate the management of such waste, in order to protect human health and the environment. It is important because WEEE is classified as hazardous waste, therefore the decree is considered as framework for the proper management of it (Ministerio del Ambiente y Desarrollo Sostenible, 2005).

- **Resolution 1297 of 2010** *“by which the Selective Collection and Environmental Management Systems for Waste from Batteries and / or Accumulators are established and other provisions are adopted”*; it is considered as it seeks to implement the systems of selective collection and environmental management of waste batteries and / or accumulators, in addition to the obligations of producers, suppliers, consumers and municipal and environmental authorities and final disposal (Ministerio de Ambiente Vivienda y Desarrollo Territorial, 2010a).

- **Resolution 1511 of 2010**, *“which establishes the Selective Collection and Environmental Waste Management Systems for Bulbs and other provisions are adopted”*; It is important because this resolution aims to implement selective collection systems and environmental management of light bulbs waste, in addition to the obligations of producers, suppliers, consumers and municipal and environmental authorities and final disposal (Ministerio de Ambiente Vivienda y Desarrollo Territorial, 2010b).

- **Resolution 1512 of 2010**, *“which establishes Selective Collection Systems and Environmental Management of Computer and / or Peripheral Waste and other provisions are adopted”*; it is taken into account since the systems of selective collection and waste management of computers and / or peripherals are mentioned, in addition to the obligations of producers, suppliers, consumers and municipal and environmental authorities and final disposal (Ministerio de Ambiente Vivienda y Desarrollo Territorial, 2010c).

b. PROBLEM STATEMENT (NEED FOR THE APP)

The need to create the current proposed solution application arises from the inadequate management that is given to electrical and electronic equipment at the end of its useful life, due to the lack of information and interest on the part of users.

As an indication for the need for the creation of a helpful tool, a small informal survey was conducted among people related to the University¹ in order to know the management they usually give their electrical and electronic devices, obtaining the following results:

¹ Students, their families and immediate Friends and acquaintances. There were 51 answers in all

As can be seen in figure No. 1, most of the population knows what the waste of electrical and electronic equipment is, however 27.5% (a bit more than a fourth of the surveyed population) does not know this information, a large percentage.

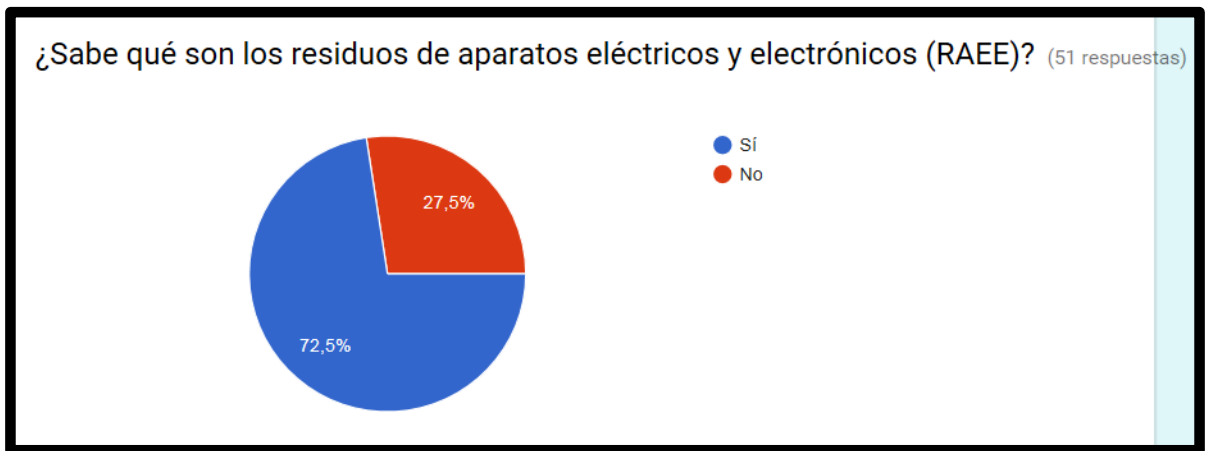


Figure No. 1 Do you know what WEEE are (Waste Electronic and Electric Equipment)?

Figure No. 2 shows that, although most of the population does not know what WEEE are, among them the majority (64,7%) does not know what to do with them, so it was decided to ask an open question in order to know the management that people provide to their WEEE.

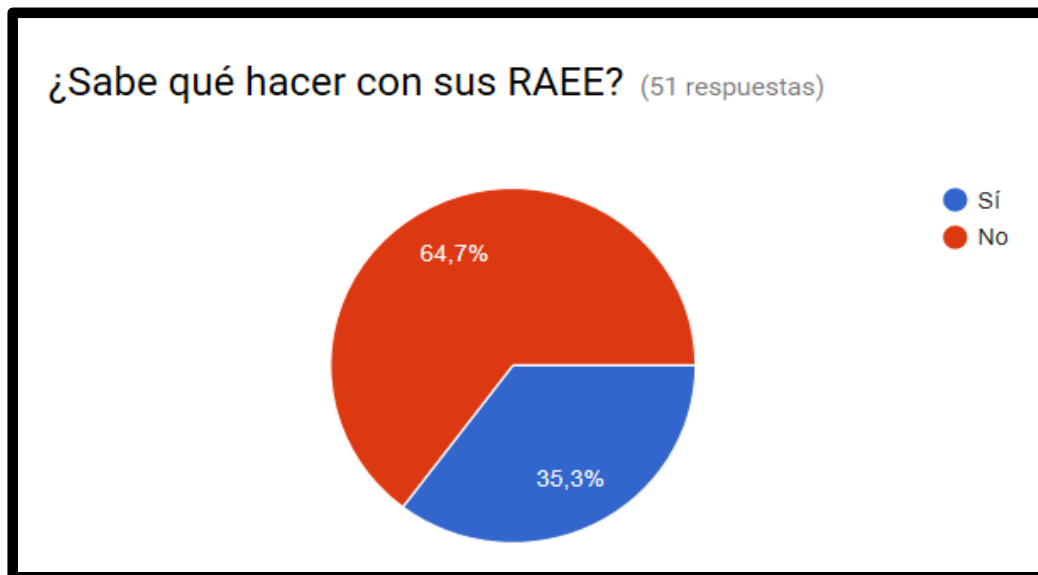


Figure No. 2 Do you know what to do with your WEEE?

In the question: Normally, what do you do with electrical and electronic equipment that you no longer use?; The option was given to be an open question, where the most common answers were:

- Throw them away.
- Leave them anywhere in the house.

- Absolutely nothing.
- Leave them on the street.
- Give them to an informal recycler.

Only 15.6% of the people surveyed responded that they take them to specialized places to carry out special collection/disposal.

The data shown in Figures No. 3 and No. 4 were obtained taking into account that both computers and cell phones are the main electronic devices used today and considering that they are within the Electronic and Electric Equipment with the shortest lifespan.

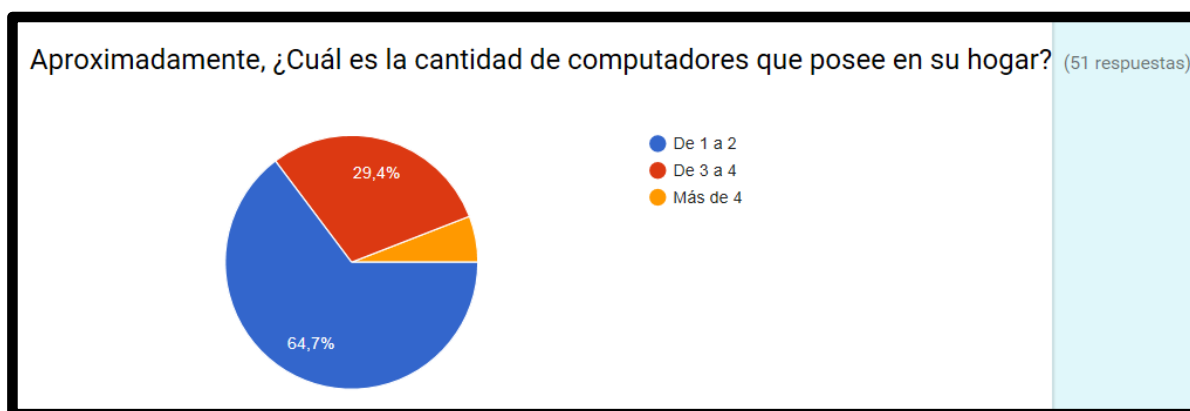


Figure No. 3 Approximately, How many computers do you have at home?

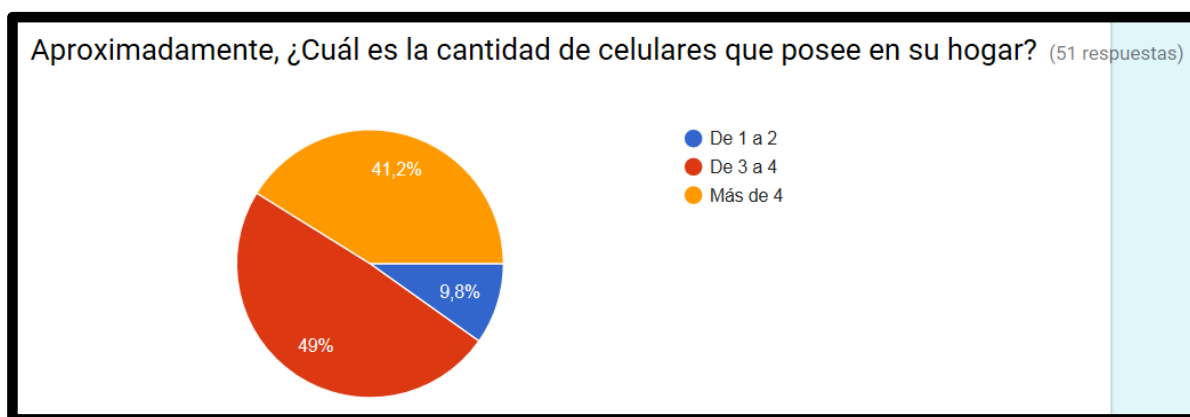


Figure No. 4 Approximately, How many cellphones do you have at home?

A curious result was obtained when people were asked if an incentive should be given in exchange for an electrical or electronic device that they no longer use, only 6 people answered “no”, which is what the law says it should be done, considering that these, when they become waste, they are also classified as hazardous waste, so having them in possession is our responsibility to deliver them to an authorized manager without expecting anything in return. However, it is our belief that this approach should be given a second thought, because there is no better way to accustom a community to a behavior than to give incentives, at least initially.

c. GENERAL DESCRIPTION OF THE APP's PROCEDURES

The application will be developed for mobile devices, with the aim that it can read QR codes. The programming of this code will be given by the categorization of annex II of directive 19 of 2012 (DIRECTIVE 2012/19 / EU OF THE EUROPEAN PARLIAMENT AND OF THE EUROPEAN COUNCIL); In addition, the model of the electrical or electronic device, its brand, serial number and other data relevant to the system will be considered.

It is considered as an electrical or electronic device that needs electrical current or electromagnetic fields to operate, whose nominal voltage must not exceed 1000 V in alternating current and 1500 V in direct current. WEEE refers to such devices at the time when the owner decides that it is no longer useful or that it is obsolete.

REGISTRATION INFORMATION

The registration for each one of those involved must be through a mobile device, after downloading the application.

- For the user, at the time of downloading the application, an access icon registered under your email is created, this way you will have access to this app. When you consider that any device of your property becomes a WEEE, you must scan the respective code of the device to send the information to the managers.

The company or companies in charge of the management must register in the same way when downloading the application and have up-to-date the respective licenses, in this way it will be able to receive the location of a WEEE when the user registers it, to make the collection. additionally, this registry will facilitate communication with the following manager, in this case the collection center from which its capacity must be known and the time that each of the waste may be in it. Once the collection stage is completed, the WEEE will be taken to the manager number 2 (corresponding to treatment), who at the time of registration must specify the types of treatment that can be done to the WEEE. For the manager number 3, in charge of the final disposal, in his registry must appear registered the suitable places for such disposal.

Finally, each producer / manufacturer must register with his name and the type of equipment he manufactures, so that when giving due provision to each WEEE, the last signal is sent indicating that the process has been successful.

Table No. 1 Main roles for the use of the App

APPLICATION INFORMATION	
<i>PARTICIPANTS</i>	<i>INFORMATION</i>
<i>User</i>	<i>SCAN (with return info)</i>

	<i>In this first scan, the producer / manufacturer and collection manager will obtain the location of the waste. As return information, the user may have the information of the collection manager (s) who will be in charge of the logistics of the waste..</i>
<i>Managers (The following Managers must be registered within the App)</i>	
<p><i>Manager 1: Collection Center</i></p> <p><i>Registration information: This manager must provide the location of the collection center, capacity and contact center. (See Section ...)</i></p> <p><i>TRANSPORTATION</i></p>	<p><i>SCAN</i></p> <p><i>This second scan will give the producer / manufacturer the information of the collection manager and what products are being collected. In this way, the producer / manufacturer may have a database of what products are being declared as waste..</i></p>
<p><i>Manager 2: Treatment</i></p> <p><i>Registration information: This manager must provide his contact information, location and description of the treatments he performs</i></p>	<p><i>SCAN</i></p> <p><i>This third scan will give the producer information about the products that are in the treatment stage, how many are in the treatment process and how many have already completed the process.</i></p>
<p><i>Manager 3: Final Disposal</i></p> <p><i>Registration information: This manager must provide the site location, restrictions (if any), capacity and contact.</i></p>	<p><i>SCAN (alternate)</i></p> <p><i>This scan is alternate to the one of treatment, it will give the information to the producer of the state of disposal of the product</i></p>
<i>PRODUCER/MANUFACTURER (Must be registered within the App)</i>	

<i>Producer/Manufacturer</i>	<i>It receives information generated from the Scan made by the different managers. It has Supervision quality, with a say of what can or should be done with the materials subject to treatment or final disposal.</i>
------------------------------	--

TARGET POPULATION

The application is aimed at the management of electrical and electronic equipment from its production and distribution to the final disposal, in order to facilitate the management thereof, once its useful life has ended. The main participant involved in the application will be the user who owns the waste of electrical and electronic equipment who will send the first signal to begin the correct management of said waste.

PLACE

It is understood as the space-time location of the generated WEEE.

FUNCTIONALITY OF THE APP

Participants:

- User
- Managers
- Collection.
- Treatment
- Final disposal
- Producer/manufacturer

It is important to keep in mind that each of the participants must be previously registered in the application.

The function of the present application is to manage the waste of electrical and electronic equipment, in such a way that once any Electrical or Electronic Device is purchased by a user, at the place of purchase it is suggested to download the application so that, at the moment Upon completion of its useful life, said user knows what must be done to contribute to the proper management of WEEE. To know how to arrange them, each device will have a code according to the categories described in the EU Directive 19/2012.

- User.

The user will be responsible for ensuring that their electrical or electronic device is registered through the application and then, when the device ends its useful life, the user must send this

information through the application to inform the managers in what area is located and in what classification is the WEEE.

- Collection Managers.

Managers should be responsible for the collection of electrical and electronic equipment when users decide that these are no longer useful, after making such collection should take them to a collection center that meets the characteristics and licenses to have the WEEE.

- Storage Managers.

The storage center, in addition to storing the WEEE carried by the collection managers, must also report the capacity it has for each of the electrical and electronic devices mentioned in the 10 categories and what is the maximum time they can remain in said collection.

- Treatment Managers.

Before the time allowed in the collection center is met, the WEEE must be brought to treatment in accordance with its components. It must be taken into account that to carry out different treatments for WEEE, considering also its hazardous characteristics specified by law, it must have the respective license and generate a database in the application.

- Final disposition.

Once the appropriate treatment has been carried out, they must be brought to final disposal, for this it is also necessary to have a database in the application and the respective environmental license.

- Transportation Considerations.

There are several instances (User-Collection) (Collection-Disposition) (Collection-Treatment). The first can be done by the user himself and leave their devices in the collection center. The other two instances must be done using authorized transports.

Figure No. 5 shows the in the form of a flow chart the general processes and information exchanges between all parties involved.

When starting the operation of the App to facilitate the logistics of WEEE, there will be a direct communication from the Application Manager and the respective representatives of each of the management companies affiliated or registered in the database of the application, in order to keep a continuous record when users give effective use of the app.

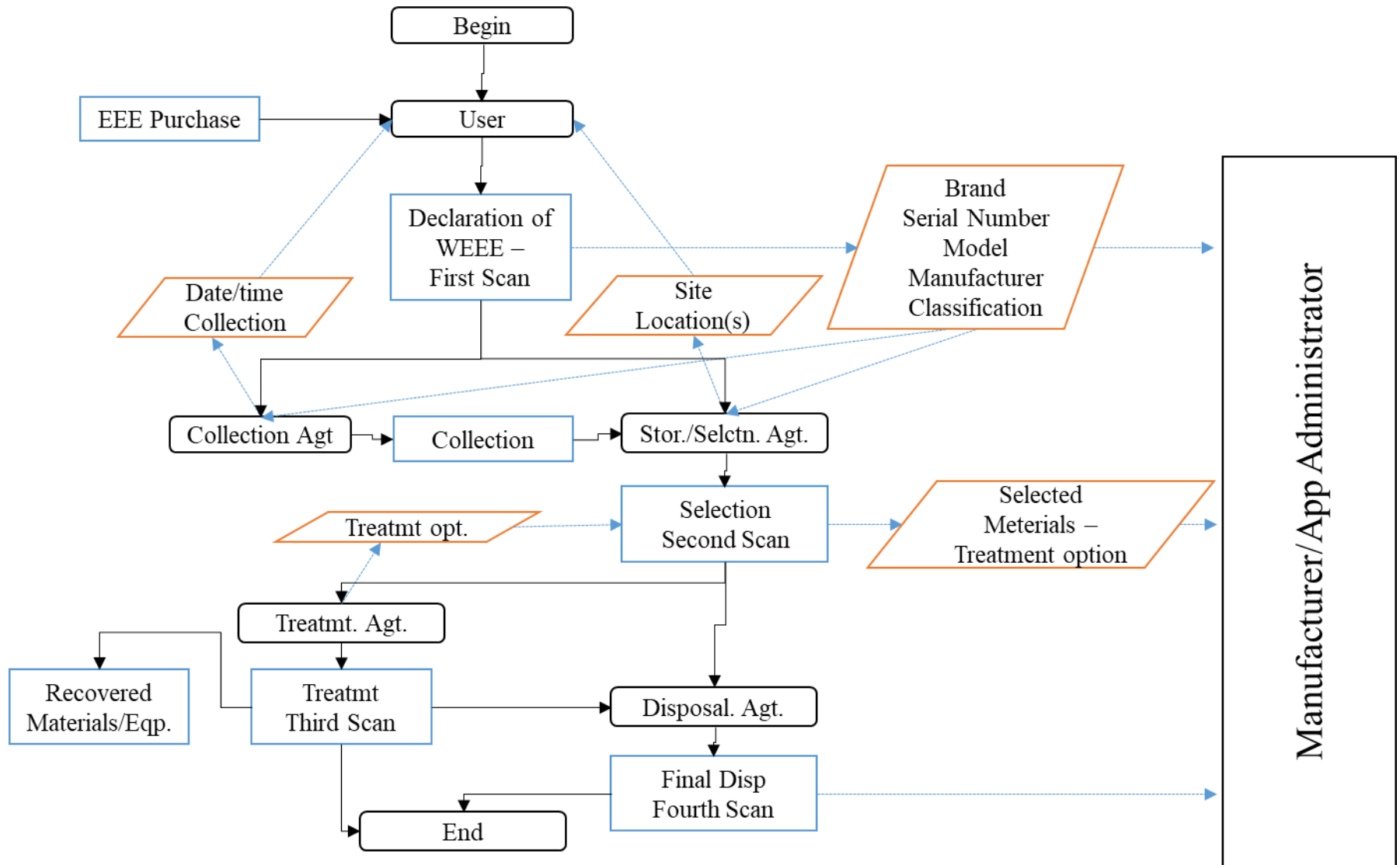


Figure No. 5 General Flow Chart - Sequence of Operation (Dark arrows – Procedures; Blue Arrows Info sharing)

Once the operation of the App to facilitate the logistics of WEEE begins, the main idea is that there will be a direct communication between the administrator of the Application and the respective representatives of each of the affiliated companies in it. Part of the object of the administration of the application is to keep a continuous record of when the users give effective use of the app, that is, when the WEEE declaration occurs, which is when carrying out the first scanning of the QR code of the electronic device.

Taking into account the information needs, some of the essential characteristics that will be used in the operation of the system are:

- Georeferencing (Space-Time)

The app will have a spatial registry (where they are) of the collection, storage, treatment and final disposal managers. It will record the spatio-temporal location of the WEEE declaration for its correlation with the managers as well as make a spatial-temporal follow-up of the WEEE management process.

- Push notifications.

They will be used to let the participant know (user declarant)

the information necessary for the collection or delivery of the WEEE. They will also be used in the intermediate managers for the transmission of information between them and the administrator of the app or the manufacturers.

- Schedule.

It is necessary to confirm the date of collection of waste electrical and electronic equipment.

Example:

- The application, once scanned the code, will send the information contained in it to the administrator of the App, which will be transmitted to all the managers close to the position of the declarant; these should verify how feasible it is to collect the waste immediately or wait for more notices from the area to arrive. At the same time, the location information of the receiving site of the device will be sent.

- Now, when the waste is in the possession of the manager, said waste should be taken to a collection center, which should provide information to the application in the form of databases, so as to know the capacity of the same, its location and contact updated.

- Once in the collection center, the waste should be brought to treatment according to their respective category, as for the databases in this phase, you should find the description of the different treatments, their location and contact updated, in addition to the respective environmental license to carry out the treatment of WEEE.

- Finally, the disposal of waste electrical and electronic equipment will be made, keeping in the database the description of the final disposition that was given to them, the location where

said disposition was made, the contact and the environmental license to perform this type of procedures.

Costs

The costs of the operation of the system (general management) must be borne by the manufacturers / traders / importers according to the Law; This includes all the costs associated with the presented logistics and the administration of the App itself. It is proposed that the cost be assumed by them according to their market penetration. Some of the costs that could be incurred are:

- Collection fees between User - Collection
- Administrative and storage operation costs
- Freight between storage - treatment
- Administrative and treatment operation costs
- Freight of waste treatment materials
- Freight between storage-disposal
- Administrative and disposal operation costs
- Cost of application management

Financing.

Considering that according to the law 1672 of 2013, Chapter I, Article 3, Literal a) Extended responsibility of the producer, is the duty of the producer of electrical and electronic equipment, throughout the different stages of the life cycle of the product, to ensure the good use that is given to them (as a machine) being its responsibility to contribute to their proper management at the end of their useful life. The App will be paid by the direct manufacturers of electrical and electronic devices, it follows that although users can download the application for free, this cost will be included in the price of the electrical or electronic device.

It can also include advertising within the application as banners, recommendation for other apps, viewing videos, etc; to contribute to the financing of the application administration.

Antecedents to the Idea.

It can be taken as a basic reference to ReciclApp-Birziklapp, whose function is to recognize in which container each waste is deposited and where the clean points are located, some specific containers such as oil, clothing, batteries, among others and the community composting areas in Navarra, Spain. The application only needs to recognize the location and enter the language of your preference (Gestión Ambiental de Navarra S.A., 2017).

Platforms

The application will be available for Android, iOS and Windows Phone with tools such as frameworks that allow the development of the application at the same time in several operating systems.

Advantages and disadvantages.

Table No. 2 gives a brief description of the possible advantages and disadvantages that may arise when putting the APP into operation for the logistics of collection of WEEE.

Table No. 2 Advantages and Disadvantages of the proposed process

Advantages	Disadvantages
<ul style="list-style-type: none"> ● High utilization of this waste. ● Costs would be reduced due to the possible recycling of WEEE. ● Facilitate the logistics of returning WEEE to producers. ● There will be a unified system for the WEEE collection logistics, applicable in any context. 	<ul style="list-style-type: none"> ● It is a subject that is very little addressed and very little knowledge of the general public. ● Large spaces are needed to store the WEEE after its collection. ● Special facilities are needed for treatment and final disposal ● Permits and other legal and environmental hurdles

Final Remarks

As a result of the study conducted with respect to WEEE and its management, it was observed that it is not given the necessary interest and that it needs an adequate management worldwide, therefore, the creation of the application focused on locating the electronic devices when its owner decides that they are no longer useful and provide a more organized logistics to facilitate management by the actors from its production to its final disposal becomes a proposal of manifest utility.

3. REFERENCES

- Bhutta, M. K. S., Omar, A., & Yang, X. (2011). Electronic Waste: A Growing Concern in Today's Environment. *Economics Research International*, 2011, 1–8.
<https://doi.org/10.1155/2011/474230>
- Congreso de la República. Ley 1672 de 2013 “por la cual se establecen los lineamientos para la adopción de una política pública de gestión integral de residuos de aparatos eléctricos y electrónicos (RAEE), y se dictan otras disposiciones” (2013). Diario Oficial N°48.856, República de Colombia, Bogotá D.C, 19 de Julio, 2013.
- El Tiempo. (2015). ¿A dónde llevar la basura electrónica? Retrieved November 4, 2017,

from <http://www.eltiempo.com/estilo-de-vida/ciencia/a-donde-llevar-la-basura-electronica/15879599>

Gestión Ambiental de Navarra S.A. (2017). ReciclApp-Birziklapp. Aplicación para dispositivos móviles sobre reciclaje de residuos domésticos. Retrieved August 11, 2017, from http://www.ganasa.es/areas/calidad-ambiental/app_movil1.aspx

Landini, P. (2015). Argentina, Brasil y México están entre los 40 países que más basura electrónica generan. Retrieved August 9, 2017, from <http://www.equidad.org/noticias-y-novedades/487-raee-mundial>

Ministerio de Ambiente Vivienda y Desarrollo Territorial. Resolución 1297 de 2010 “Por la cual se establecen los Sistemas de Recolección Selectiva y Gestión Ambiental de Residuos de Pilas y/o Acumuladores y se adoptan otras disposiciones”. 2010 § (2010). Diario Oficial 47.769 de julio 13 de 2010.

Ministerio de Ambiente Vivienda y Desarrollo Territorial. Resolución 1511 de 2010 “Por la cual se establecen los Sistemas de Recolección Selectiva y Gestión Ambiental de Residuos de Bombillas y se adoptan otras disposiciones.” 2010 § (2010). Diario Oficial 47.797 de Agosto 10 de 2010.

Ministerio de Ambiente Vivienda y Desarrollo Territorial. Resolución 1512 de 2010 “Por la cual se establecen los Sistemas de Recolección Selectiva y Gestión Ambiental e Residuos de Computadores y/o Periféricos y se adoptan otras disposiciones.” (2010). Diario Oficial 47.797 de Agosto 10 de 2010.

Ministerio del Ambiente y Desarrollo Sostenible. (2005). Decreto 4741 de 2005 “Por el cual se reglamenta parcialmente la prevención y el manejo de los residuos o desechos peligrosos generados en el marco de la gestión integral.” Diario Oficial 46137. Retrieved from <http://www.minambiente.gov.co/index.php/bosques-biodiversidad-y-servicios-ecosistematicos/normativa/decretos#decretos>

Ministerio del Medio Ambiente. (2017). *Política Nacional para la Gestión Integral de Residuos de Aparatos Eléctricos y Electrónicos*. Bogotá D.C. Retrieved from http://www.minambiente.gov.co/images/AsuntosambientalesySectorialyUrbana/pdf/e-book_rae_/Politica_RAEE.pdf

PNUMA. (2013). *El PNUMA en América Latina y el Caribe Boletín Nov-Dic 2013*. Retrieved from [http://apps.unep.org/redirect.php?file=/publications/pmtdocuments/-UNEP in Latin America and the Caribbean-2013Newsletter_November-December2013.sp.pdf](http://apps.unep.org/redirect.php?file=/publications/pmtdocuments/-UNEP%20in%20Latin%20America%20and%20the%20Caribbean-2013Newsletter_November-December2013.sp.pdf)

Presidencia de la República, & Ministerio de Comunicaciones. Decreto 2324 de 2000 "Por medio del cual se modifica el Decreto 1130 de 1999 y se establecen los organismos y entidades que estarán a cargo de la implantación y desarrollo de los Programas de la Agenda de Conectividad, en especial, del Programa "Computado, 2000 § (2000). Diario Oficial No 44.228, del 15 de noviembre de 2000.

UNESCO. (2012). *Los residuos electrónicos: Un desafío para la Sociedad del Conocimiento en América Latina y el Caribe*.