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Discarding Flow Proposition for Hospital Electric and Electronic Equipment

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ABSTRACT

This work proposes a project establishing a staged workflow to ensure any electric or electronic equipment used in a hospital environment that is being discarded would be subject to all possible reuse of its equipment and components through to the manufacturing of new equipment. The workflow would apply to all the electronic equipment used in the hospital (i.e., biomedical, electro-mechanical, computer, refrigeration, air conditioning). This appropriate discarding workflow would address socio-environmental as well as economic/financial concerns.

Keywords – *Discarding, Electronic Equipment, Hospital, Socio-environmental.*

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INTRODUCTION

Technological progress has brought benefits to society but has also resulted in increasing levels of waste which has worried organizations and environmentalists. The environmental damage involved in the disposal of electronic waste is very relevant. The production process to make these components involves the expenditure of natural resources, burning of fossil fuels and increased solid, liquid, and gas pollution emission (including Greenhouse Gas Emissions – GEE).[1]

In the assembly of electronic equipment various component are used that have other constituent heavy metals, such as mercury (used in thermostats, sensors, relays, and switches); lead (used in printed circuit board welding); cadmium (used in printed circuit boards, SMD resistor chips, semi-conductors, and infra-red detectors), and PVC stabilizers (such as the silicon used in the manufacturing of microprocessors and halogenated substances like polyvinyl chloride [PVC] etc.).[2] Other materials often used are iron and steel, used in cabinets and frames; glass, used in screens and counters; plastics, used in cabinets, cable coatings, and printed circuit as well as rubber. These substances when disposed of inadequately can cause ground, water, and air contamination in addition to having an accumulative effect in all trophic levels that can bring harm to human health.[1] Research shows that the residue from electronics manufacturing has a direct relation to 22 types of diseases. Physical and chemical effects observed include headache, nausea, impaired vision, respiratory and pulmonary problems, hearing loss, nervous tension, and hypertension. Chronic conditions as allergies, bronchitis, teratogenic effects, cancers, organ damage, central nervous system issues are affected by heavy metal exposure and have cumulative effects.[2] Table 1 outlines some relevant toxic substances and notes their uses in electric and electronic equipment (EEE) and their effects on health.[3]

TABLE 1. Relevant Toxic Substances, Its Uses in Electric and Electronic Equipment and Its Effects in Health

Substance	Uses	Health Effects
Arsenic	Semi-conductors, alloys, and transistors	Carcinogenic and gene-altering
Beryllium	Copper alloys, mechanical arts, connectors and springs	Skin sensitization, emphysema and fibrosis in the lungs, carcinogenic
Cadmium	Printed circuit boards, chip resistors, semi-conductors and infra-red detectors, batteries, switches, fluorescent materials	Damage to kidneys, liver, pancreas, increased blood pressure, carcinogenic and gene-altering
Lead	Printed circuit boards welding, glass, cathode ray tubes, welding, and lamp glass	Damage to the nervous, endocrine, circulatory, urinary, digestive and skeletal systems (it is the most toxic of the elements)
Copper	Present in several components	Liver damage
Hexavalent Chromium and Chromium VI	Decorative surfaces, pigments and covers, stainless steel	Irritations in the nose, throat, lungs (cancer), muscles, eye, skin, and liver damage
Mercury	Thermostats, switch sensors, data transmission systems, telecommunications, cellphones, flourescent lamps and batteries	Damage to the brain, central nervous system and kidneys, reproductive problems
PBB and PBDE	Printed circuit boards, components like connectors, plastic covers and TV cables and home appliances	Damage to the endocrine system
Aluminum	Computer structures and connections	One of the factors for Alzheimer's disease
Nickel	Computer docking structures	Genetic mutation

PBB = POLYBROMINATED BIPHENYL; PBDE = POLYBROMINATED DIPHENYL ETHER

The residue from the disposal of EEE becomes a technological, social, and environmental problem and its proportions are growing larger. That is why it is necessary to develop environmental management planning to reduce their negative effects. Only in 2010, was a law approved regulating the Solid Residue National Policy (law 12.305) defining, among other issues, reverse logistics and the manufacturer's responsibilities for the lifecycle of products. Still, in said law, there was, for the first time, the incentive to develop recycling sectors, the select and providing technical training to staff that work in recycling, as well as encouraging environmental and business management systems including programs like the 3Rs (reduce, reuse, and recycle), aimed at the improvement of productive processes, a reduction in residue exploitation, and recovery and energy reuse.[1]

The Federal Law n. 12.305 of 02/08/2010, establishing the Solid Residue National Policy defined in article 33 that:

> "Are required to structure and implement reverse logistics systems, by returning products after use by the consumer, independently of the public service of urban cleaning and solid waste management, manufacturers, importers, distributors and traders of: ... VI - electro-electronic products and their components."[4]
>
> "The electro-electronic equipment is small and large and includes all the computing, sound, video, telephony, ventilators, exhaust fans, and other devices equipped, in general, with electronic controls or using electric activation."[4]

For the residue from EEE (REEE) it can be considered the is an annual generation rate of 2.6 kg per capita, based on academic works and trace estimates.[1,4] REEE comes from outdated electric and electronic equipment that is selected for disposal, including all the consumable components,

subcategories and materials needed to function. In general terms, the composition of the present materials in REEEs is characterized by the high presence of metal (ferrous and non-ferrous), glass, and plastic. Televisions, computers, and monitors present, on average, 49% in metal weight, 33% in plastic weight, 12% in cathode ray tubes, and 6% other material. In studies performed it was found that printed circuit boards – PCI must be considered as dangerous residue and be disposed of in appropriate places mainly due to the presence of lead and cadmium. Therefore, recycling those materials present in the REEE through the shared socio-environmental responsibility in which manufacturers, importers, public power, and consumers are responsible can aid in environmental protection and demonstrate to present and future generations that is the most viable option. EEE is made of a variety of high commercial value material that can be recycled.[5] With the right action on the appropriate environmental management of this residue, value can be added to what, until then, was considered "waste."

To attenuate this issue there are several residue disposal avenues such as landfills and incineration although recycling is the best and most efficient. As the toxic substances can be found in bigger concentration than they were in nature, the recycling of this residue provides the recovery of toxic substances as well as reducing the exploitation of natural resources. The environmental management of solid waste is a set of activities aiming to reduce or eliminate the damage that these can cause in the environment. Also, as well as being a source of material for other technology manufacturing and generating jobs, material recycling offers great savings to organizations and shows a positive corporate image to the consumer market (an example of "Green Marketing"). The separation and destination of unwanted electronics promote residue reduction, the reuse and recycling of raw material, generate income, and promote social inclusion and the reduction of waste in landfills and helps mitigate environmental degradation from incorrect disposal.[1]

For EEE, the suggested control approaches are: general data and description, generation, collection and transport, destination and final disposal, costs, competence, and responsibilities, needs and deficiencies, relevant initiatives, applicable legislation and applicable standards. There is also the suggestion about the unity of residue processing, such as guidelines, the strategies, the quantitative goals and the programs and actions.[4] Table 2 highlights the categories of the REEEs, by the European Parliament, through the directive 2002/96/CE.[6]

TABLE 2. Categories of Electric and Electronic Equipment Residue

Category	Examples
1. Large home Appliances	Refrigerators, washing machines, dishwashers, stoves, microwaves, vacuums
2. Small house home appliances	Toasters, electric knives, hairdryers
3. Computing and telecommunications equipment	Desktop computer, laptop computer, printer
4. Consumer equipment	Cellphone and telephone, Television equipment, DVD devices
5. Lighting equipment	Fluorescent lamps
6. Electronic Tools (except consumer equipment)	Saws, sewing machines, lawnmowers
7. Toys, sports and leisure equipment	Video games, slot machines, sports equipment
8. Medical equipment (except the implanted and infected products)	Nuclear medicine equipment, radiology, cardiology, dialysis
9. Control and monitoring instruments	Thermostats, smoke detectors
10. Automatic distributors	Dispensers of money, beverages, and solid products

Considering that the Resolution, RCD 16, in 2013, *Manufacturing Good Practices,* defines the responsibilities of the manufacturer to installation stages, according to the item 6.4.1: "Each manufacturer must establish and maintain procedures to the components identification, manufacturing material, intermediate products and finished products during all the storage, production, distribution and installation stages to avoid confusion and to guarantee the correct order fulfilments,"[7] considering that the draft CONAMA Resolution, which regulates the management of waste electrical and electronic equipment in Brazil, suggests "the need to discipline correct

environmental management and disposal of electrical and electronic equipment residue, concerning the collection, reuse, recycling, treatment or final disposal."[8] This work proposes a project establishing a staged workflow that would make sure any electric/electronic equipment used in a hospital environment that is being discarded would be subject to any and all possible reuse of its equipment and components through to the manufacturing of new equipment.

METHOD

With the reference to the proposition of the disposal flow of hospital EEEs were used the researched references, according to what is described below.

Art. 7 of the Resolution, RCD 16, of 2013, about *Manufacturing Good Practices* states:

> "Are obligations: I – From the manufacturers and importers of EEE and its components: (a) adopt technologies or processes of acquisition that take into consideration the "ecodesign," that allows reducing, reusing or recycling the REEE; (b) the REEE management (collect, transport, handling, storage, processing and environmentally appropriate disposal). The manufacturers and importers should be able to choose to fulfil this management either individually, adhering to a collective regime or through a third part; (c) collect the REEE, creating accredited collection points and/or in articulation with its commercialization network, technical assistance and with the public power as the implementation of the necessary structure to guarantee the reverse logistics of this waste and to give them environmentally appropriate destination; (d) to recover, when possible, the REEE in form of new raw material or new products, in its cycle or in other productive cycles; (e) the management of REEE applies to current products and historical passages; (f) to establish collection points for the REEE that are accessible to consumers / users and to provide environmentally adequate disposal for tailings; (g) to articulate the reverse logistics of REEE with its commercialization network and technical assistance; (h) to disclose information on the location and operation of REEE collection points and to promote environmental awareness campaigns to combat inadequate disposal; (i) to ensure that the products and electric and electronic components commercialized in Brazil indicate with emphasis, the following to the consumer, at least in the equipment manual and in the producer's official site or importer on the internet."[8]

And item III of the same draft suggests:

> "III – Of consumers: (a) to adopt practices that make it possible the reduction of its generation; (b) after the use of the product, condition adequately and to deliver of REEE to the dealers/distributors or to destine them to the collection points, according to the information provided by the producer/importer."[8]

The recycling stages of REEEs are similar for and include the steps outlined below.

Disassembly

Done at a sorting center, this stage involves the removal of parts that contain dangerous substances (chlorofluorocarbons, mercury, polychlorinated biphenyl, etc.), parts that contain valuable substances (copper cables, steel, iron, and precious metals). The environmental risk in this stage is from ground contamination by improper storage of REEEs or oil or CFCs leaking from removed parts.

Separation of Ferrous and Non-ferrous Metals, and Plastics

This step is normally performed manually in a sorting center.

Recycling/Recovery of Valuable Material

Items containing ferrous and non-ferrous metals, plastics, and precious metals are sent to specific recycling companies for recovery.

Processing/Disposal of Dangerous Material and Residue

Any remaining non-recovered/recycled material is sent to landfills or industrial landfills for further disposal following the appropriate legislation.[5]

Figure 1 illustrates the sorting scheme for materials present in EEE.[4]

Also described are possible process indicators:

- The number of producers, importers, and dealers for used EEE.
- The number of establishments receiving REEEs.
- The number of agents involved in the waste collection program.

- The percentage of employment and income generated.
- The quantity of generated residue and the estimate of the amount of waste that is no longer being sent to landfills.[5]

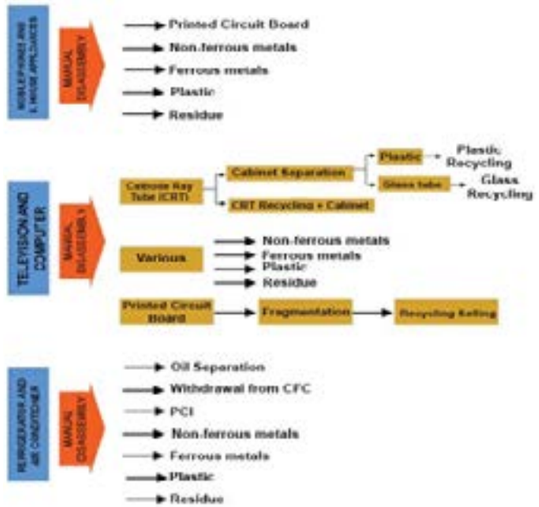

FIGURE 1. Sorting scheme for material present in electric and electronic equipment.

The implementation of a plan for the disposal of EEE makes it possible to improve environmental conditions, encourages future generations to continue the process of environmental education, and generates the potential for increased employment and income. Establishing an evaluation and monitoring program is of great importance to help identify the stages that need correction and to continuously improve the process. The monitoring must evaluate all the stages from environmental education to final disposal. The results found by monitoring must be available to those involved in the work. The implementation of monitoring activities also needs a preestablished selection of indicators to simply illustrate the functioning of the plan.[5]

RESULTS

Based on our results and shown in Figure 2 we have a proposed flow for discarding hospital EEE.

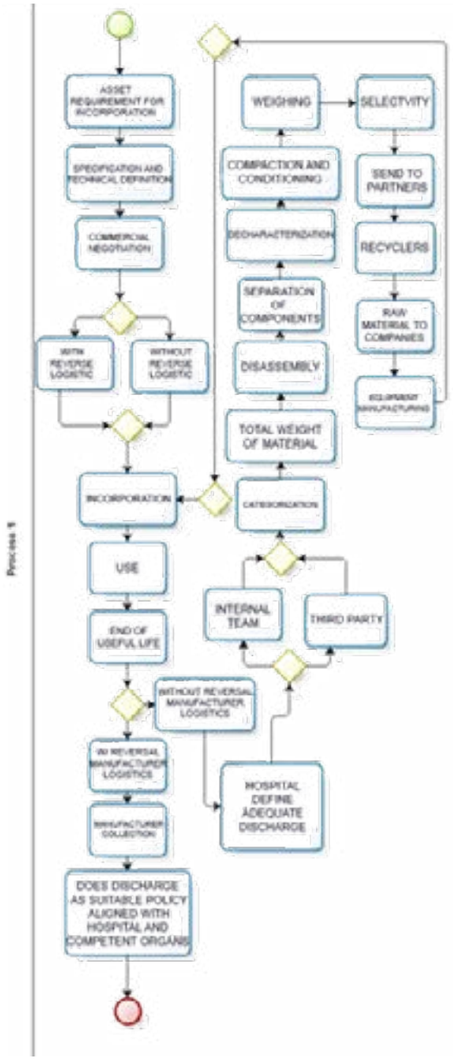

FIGURE 2. Proposed flow for discarding hospital electric and electronic equipment. Adapted from Meta-recycling.[1]

DISCUSSION

There are some points worth taking into consideration to clarify the process of defining and executing the management plan for disposal of hospital EEEs:

- Local issues
- Use of dedicated personnel (own or outsourced)
- Partners to conduct the external stages
- Internal policies as well as any relevant municipal, state, or federal guidelines

This project should be continuously evolving in the hospital and include the involvement of various departments such as environmental management, patrimony management, and accounting in addition to hospital and clinical engineering. This is important so that after well-defined and detailed stages are in place the results can be taken to the hospital's directors for analysis and validation.

CONCLUSION

The reality demonstrates the need for definition by standardization, detailing, and validation of the EEEs flow disposal. The proper disposal management of the components of EEEs can eliminate potential environmental damage and be a source of material for other applications. There is also the possibility to generate new jobs and create potential saving for health organizations. Hospitals can contribute considerably in this issue by instituting the right processes in handling and disposal of EEEs.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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