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Mass Balance as Green Economic and Sustainable Management in WEEE Sector

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Abstract

This study investigates the treatment procedures of the Large House Hold Appliance to describe the production of secondary raw material within the Waste of Electric and Electronic Equipment (WEEE) sector in step with the Circular Economy model. Drawing on the modern accounting system, the project developed a perspective, which highlights accounting technologies (i.e. Environmental Accounting, sustainable performance indicators, Mass Balance) as new adaptive management tools for sustainable firms. The theoretical arguments shown by a longitudinal case study proposes a conceptual framework of the e-waste manage within treatment plants in the Sicilian context. The results demonstrate a percentage analysis by waste fraction of all materials recovered which can be re-use. Then, the recognition of critical raw materials identifies the end of west in implementing a competitive advantage for business growth.

Keywords: Type your keywords here, separated by semicolons ;

1. Introduction

This experimental investigation executes research of the key factors that are focused on the Environmental Accounting and on accounting and reporting tools of environmental [1] concerns too.

Since the 1990s empirical studies rotated around the connection between accounting and sustainability to perceive how accounting technologies can handle the issues and the evolution of sustainable development. This study

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considers a general framework which takes care of translating into practice the environmental phenomena, on the one hand, acting through procedures and planes to protect, restore and manage [2] the environmental conditions and ecological components, on the other. This framework underlies the prevention of unethical behaviours and the pervasiveness of wrong practices in so far as it follows crushing effect. So it's clear to see, in an international or in a national sphere, how becomes a shared feeling the term which identify "Environmental Accounting". In this sense, a resolute and positive judgment of legitimacy reformation and firm reputation are one as well as the other significant and crucial traits to restore or carry on the relationship on the basis of which business entities may draw sustainable resources and support from their environment [3].

At the micro-economic level, Environmental Accounting does not have a unique denotation, however the fundamental concept at the base of itself pivots on a specific discipline used into several settings. Therefore, it is a new protocol which provides to identify and quantify the interchange between environmental and economic systems. Moreover, this theoretical scheme represents a pragmatic approach able to take into account natural stock flows and its changes in observing the consequences of human acts on environment [4]. The main theme of sustainable accounting procedures is necessary to get together regulatory interventions and key environmental indicators with the aim to attribute an economic value to the natural components both at the micro-economic (business unit) and macro-economic (country-system) level. In this perspective Environmental Accounting is a paradigm which measuring in space and time management efficiency: sustainability should be implemented into organizational processes for economic and moral reasons [5]. Sure enough, from the managerial attitude the implementation of Environmental Accounting's framework may only attain a real positive influence if it supports sustainable development-oriented of an entrepreneurial entity in changing, and if it minimizes the adoption of natural resources [6]. Thus, the aim of the present study is to perform an analysis of an entrepreneurial entity, such as FG S.r.l., which is the Sicilian benchmark entrepreneurship in the sector of Waste of Electric and Electronic Equipment. In particular, the activity of FG S.r.l. is devoted, according to the Italian legislation transposing the EU Directive in Legislative Decree of March 14, 2014, n. 49 (known as "RAEE Decree"), to the selection and treatments of WEEE from which Recycling Secondary Raw Materials and reporting into mass and environmental balance its outputs. The paper is structured into different parts: Section 1 presents WEEE problems; section 2 explains the material and methods which can be summarized into the main tool object of this study, called Mass Balance; Section 3 explains and describes the case study of FG S.r.l., its story and its production cycle; Section 4 is focused on empirical phases of the Mass Balance's implementation at the firm's level; Section 5 argues about results and variable measurements; Section 6 outlines the final considerations for the sector and, lastly, in Section 7 there are some references which shows lists author bibliographies.

2. Hazardous Wastes from Electronic Recovery

Disposed electronic products can cause health concerns because they contain a wide spectrum of hazardous materials, ranging from lead, phosphorus, cadmium, chromium and barium to mercury. The list of human health risks resulting from improper contact with these materials includes breathing difficulties, coughing, choking, respiratory irritation, pneumonitis, tremors, neuropsychiatric problems, convulsions, comas and even death. Hence, health risks associated with improperly managing and disposing of these toxic substances are significant, if not deadly, and the legislated prevention of their disposal seems to establish logical environmental policy. However, electronic products, in general, are affected not only by the variety of new and pending regulations, but also by their rapid technological obsolescence. Consequently, the European Union (EU) has recently approved an electronic recovery directive applicable to all EU member states, requiring the recovery of a significant proportion of electronic products [7]. As the responsibility for the disposal of spent products increasingly shifts back to the manufacturers, companies have been forced to incorporate these take-back requirements into their strategic planning processes and product design strategies [8-10].

The paramount objective in the practice of industrial ecology and sustainable manufacturing is to create an industrial ecosystem in which all discarded, returned or otherwise spent products become the raw material inputs for new products. In an idyllic closed-loop industrial ecosystem, the raw material input requirements of the manufacturing processes are exactly balanced by the waste supplied from the discarded products. The motivation behind reusing 'post-consumer' waste as an input for new production is environmentally and ecologically pure, and the initiative for undertaking an industrial ecology approach represents sound policy. However, the enforced introduction of these well intentioned industrial ecology practices can subsequently create very negative, unintended environmental consequences, particularly for electronic products. Numerous non-electronic products such as vehicle tires represent ideal candidates for enforced product take-back schemes, since their stable, predictable and relatively benign waste streams are readily conducive to managed industrial ecosystems. Conversely, many electronic products are not suitable for end of- life industrial eco-system practices, since they contain materials that engender considerable public health concerns, are in the declining-market stage of their lifecycles and are considerably threatened by technological obsolescence. The waste recovery from televisions illustrates a prime example of the negative attributes arising from the new electronic anti-dumping and take-back regulations, with the cathode ray tube (CRT) encapsulating many of the challenges posed in establishing such industrial eco-systems. CRTs provide the viewing portion of most existing television monitors and contain significant quantities of identified hazardous materials – primarily lead. The disposal of CRTs has become controlled within the United States [11-15] and the European Union through the passage of extremely stringent legislation. the best of environmental and ecological intentions established by regulations for the remanufacturing and reprocessing of electronic consumer goods becomes egregiously misplaced when all of the targeted practitioners of the industrial ecology directives have absolutely no propensity to engage in the re-use of the resultant waste materials.

The demand for recycled materials and the potential new regulatory framework are contributing to industrial scaling-up and increased interest among companies in investing in WEEE processing. In various European in WEEE recycling system, consumers either pay to return waste appliances or return them free of charge. Recycling companies can generate revenue from selling refurbished appliances, components and recycled raw materials, as well as charging fees to producers or consumers [16]. New regulatory approaches can have long-term implications for financial, environmental and social sustainability beyond the initial intentions of their designers. Similarly, a lack of attention to the issues of sustainability may result in a new policy unable to effect the desired change in practice and behaviour. Darby et al. (2004) recommend, for example, increased efforts to include all relevant stakeholders and consumers in WEEE recycling systems. Raising awareness among collectors, recyclers and consumers of the potential dangers of recycling and dumping old and broken appliances can contribute to building new attitudes toward WEEE [17].

3. Materials and methods

Usually the recycling of WEEE provides the recovery of precious elements, which can be reused as secondary raw materials: however, this involves the adoption of authentic treatment processes to accomplish specific standard dispositions [18]. The environmental account is based on input-outputs considering component lifetimes which experiences from the WEEE area say is not so easy to verify: today, WEEE sector is collected in a way that gives the major variety of sub-products derived by the fractions recovered [19]. The present survey is based on qualitative-longitudinal analysis of FG S.r.l.'s case study obtained by primary data collection methods based on data set implementation (mass balance) and secondary data information such as research projects, non-written documents acquired from conferences and meeting and written documents obtained from reports and correspondences. This empirical research, selected on the mass Balance's principle for the Large House Hold Appliances, emphasize three main reasons researched into the Circular Economy overview:

– Examined company, FG, is one of the most important entrepreneurial entities in manage WEEE, operating in respect of environmental and quality certifications. Instead, in accordance with the normative standards laws on environmental protection the company has permissions for the processing, storage and the transport of special hazardous waste and non-hazardous waste [20]: ISO 14001 (Environmental Management System) – ISO 9001 (Quality Management) and the European accreditation WEELABEX standard treatment (WEELABEX organization confirm the protocol for FG since 21th September 2015 until 20th September 2017, Certificate N. 14-0016);
– – Enterprise represents a business unit with a flexible vision created by a collaborative asset;
– – Widespread idea thanks to the correct treatment of the WEEE from which FG becomes into Secondary Raw Materials adopting a pro-active internal model which identifies secondary raw materials [21], and their

respective qualities in additional raising a co-operation strategy based on a relevant internal and collaborative staff control in using Best Available Technologies in its plant.

Instead, the company in its activity provides a combined approach founded on annual data collection (for the 2016) derived by the material flows entering as input and leaving as output into the plant. Mechanism of Legal compliance and proactive management of some environmental concerns have influence on the use of environmental performance indicators. Peculiarly, environmental performance indicators are adopted for waste management, environmental resources, air emission and water use cost reduction. Empirical studies have shown that considerable companies make investments in sustainability management and external report to intensify visibility and to inform stakeholders [22]. In this sense, accounting and reporting tools for the analysis of environmental and social issues can be catalogued under the extensive logical intuition within sustainability accounting [23]. Environmental indicators are essential tools for tracking environmental progress, supporting policy evaluation, strategies and performance, and informing the array of stakeholders too [24]. The important implication, which should be relevant for this project is to demonstrate the expectations and evaluations for an environmental firm in being a product of economic and ecological confluences, including the attribution of environmental responsible behaviour. The objective is to achieve a sustainable value and a better understanding of the quality and quantity output, whereby peculiar component within the WEEE given a new role of sustainability in firms. Moreover, The key approach in developing this perspective is draw on an adaptive management tool, which the present firm adopts in its processes to implement WEEE management and observe technological progress over time too. By considering the connection between the industrial and the environmental dimensions, the implemented model importing data from Excel Spread sheets shows in a percentage analysis the critical secondary materials obtained.

4. Case study: FG S.r.l.

FG S.r.l. is the most considerable Sicilian family unit Appliance Recovery and Recycle organization and is today's clear leader in the sector of Waste of Electric and Electronic Equipment. The story of the firm is based on a steady improvement about environmental performances, from one hand, magnifying the recovery of secondary raw and, from the other, reducing environmental risk. Founded in the 1974, by the entrepreneur Failla Giovanni, and operational since the 2008, in Waste of Electric and Electronic equipment, actually, FG Ltd. is a family-controlled company in with Failla Salvatore is the sole director and his brothers, Francesco and Massimo, are associates. FG is Headquartered in Belpasso (CT), covering an area of over 19.000 m2, (of which over 6.500 m2) and 5.000 m2 expanding, and employing 60 workers. The family-run company operates with individual and with companies and public bodies too, holding the following standards: ISO14001–ISO 9001–ADR – BAT. The establishment has been equipped with complete processing plants for the treatment of potentially polluting materials and for maximum reuse of recyclable raw materials. WEEE is handled differently by the Disposal Facilities according to the 5 Groupings: R1 (cooling & freezing equipment) Refrigerators, air-conditioners, freezers, etc; R2 (large household appliances) Washing machines, dishwashers, extraction bonnet, etc; R3 (TVs & monitors) Televisions and CRT, LCD or plasma screens, etc; R4 Small household appliances Mobile phones, computers, electronic toys, lighting equipment, etc.; R5 Light Sources Low energy light bulbs, neon light bulbs, etc. the plants of FG S.r.l are the following: R 1: Disassemble and drainage system of raw materials which correspond to the R1. Step 1 – Removal of different detachable components (glass, cables, condensers) in big bags; Step 2 – Degassing/drainage of the cooling circuits which is (in 8-10 minutes) tapped and exhausted by grippers and drill heads: separating recovery of pentane, CFCs and Oils; Step 3 – Disassembly and security area in which the compressor is separated from the pump head/motor, so the remaining oil is decanted into a recovery container; Step 4 A. Crushing primary area in which, residual CFC/pentane's components injected in the polyurethane part, have been recovered. Immediately after, the machine screening and separating ferrous pieces from non-magnetic materials carried on conveyors vibrating feeders, achieving an output ready for the steelworks. Step 5 B. crushing secondary area: screening and separating the pure foam from material stream and metal separating regain aluminium, copper and plastics collected. R2: waste treatment plant of non-hazardous White goods by chipping or grinding Cathode Ray Tube: manual disassembly of R3 (TVs & Monitors) and R4 (Small household appliances) groups; Bulky waste: processing techniques of woody or metallic waste (mattress, sofa, furniture, etc), by crashing, separating ferrous pieces and selecting.

5. Experimental

The following two figures depict a method for the recycling of all materials recovered by the electronic equipment waste treatment procedures. The secondary raw materials are expressed by the percentage analysis of fractions resulting from the sorting, dismantling and recycling processes of Large House Hold Appliances. From the collected data perceived after the treatment phases result many elements which can be re-use as new resources minimizing the deposed materials destined to incineration or land filling. An overview of the system is shown in the following fluent charts:

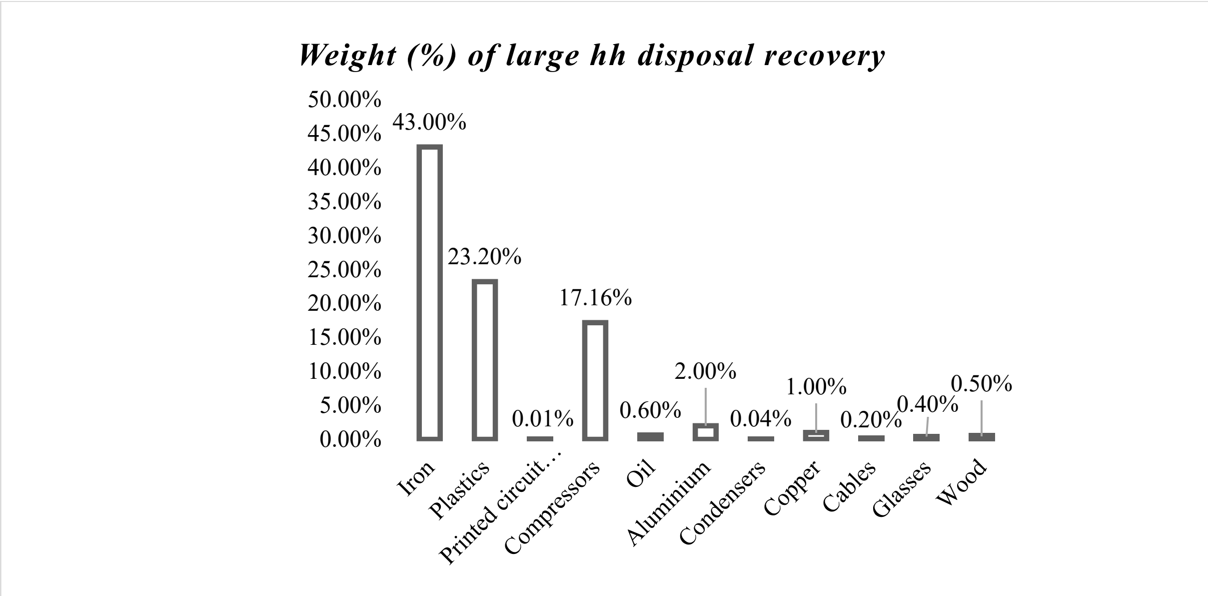

Figure 1 -Weight (%) of Large HH Recovery

Figure 1 -Weight (%) of Large HH Recovery - shown a lot of components such as: Iron (EWC 19.12.02) for 43.00%; Plastics (EWC 19.12.04) for 23.00%; Compressors (EWC 16.02.16) for 5.40%; Aluminium (EWC 19.12.03) for 2.00%; Copper (EWC 19.12.03) for 1.00%. However, many elements don't exceed the unit value such as: Oil (CER 13.02.08) for 0.60%; Wood (EWC 19.12.07) for 0.50%; Glasses (EWC 19.12.05) for 0.40%; Cables (EWC 17.04.11) for 0.20%; Condensers (EWC 16.02.09) for 0.04%; Printed circuit boards (EWC 16.02.16) for 0.01%.

The company recovery 100% of Iron, Plastics, Printed circuits board, compressors, Aluminium, Copper, Woods and Cables, instead, the firm recycling 95.00% of Oil and 93% of plastic and glasses.

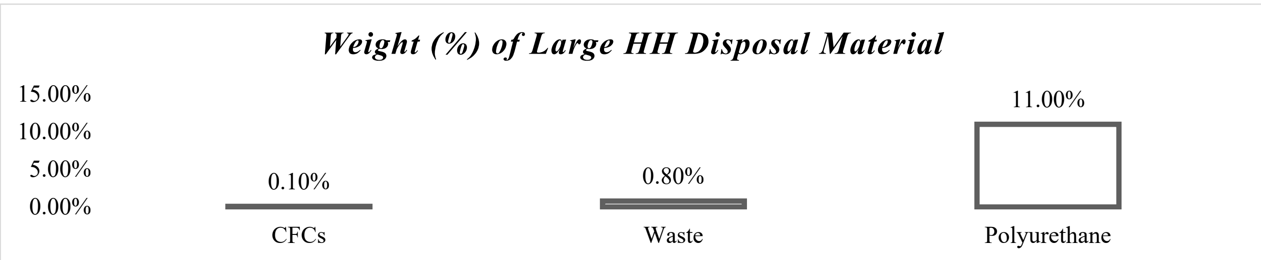

Figure 2 - Weight (%) of Large HH Disposal Material

Figure 2 - Weight (%) of Large HH Disposal Material - depicts the materials disposed and their quantitative. There are CFCs (EWC 14.06.01) for 0.10%; Waste (EWC 19.12.12) for 0.80% and, lastly, Polyurethane for 11.00%. According to FG S.r.l. the amount of WEEE recycled are 88.10%, instead disposed materials are 11.10%.

5. Results and discussion

This article uses the Mass Balance approach to describe how the environmental strategy of FG S.r.l. are rooted in an assessment which can affect the ecological side of the organization. The e-Waste Mass Balance of Large House Hold Appliances is expressed by the following Table 1 – Mass Balance of large House Hold:

Table 1 – The Mass Balance of Large House Hold

E.W.C. Code	Recovered Materials	Recovery Percentage
19.12.02	Iron	43.00%
19.12.04	Plastic	23.20%
16.02.16	Compressors	17.16%
19.12.12	Polyurethane	11.00%
19.12.03	Alumin	2.00%
19.12.03	Copper	1.00%

Table 1 - The Mass Balance of Large House Hold – shows the percentage points for the different range of materials found in e-waste of Large HH. This analysis underlines categories of secondary raw materials such us Iron which represents the higher value (43.00%), to follow Plastic (23.20%), indeed, the precious non-ferrous materials such as Aluminium by weight representing 2.00% and Copper that represents1.00%.

Looking at the minimum recovery targets applicable until 14 August 2018 to the categories listed in the Annex II (WEEE Directive – n. 49/2014) falling within category 1 (Large House Hold Appliance) provided for e-waste referred to the present list the 85% shall be recovered. The treatment operations carried out by the Mass Balance of FG are in accordance with the normative standards for 88.10%. Furthermore, this result shows how the firm is leader in the Large HH treatment: sure enough, using the best available techniques FG ensures a proper treatment which highlights a rise of 3.00%. The empirical analysis here developed attests that the firm have been working towards sustainability efforts. This responsibility effort reveals a positive opportunity, not only for the firm's reputation as an environmentally efficient system, but also, to demonstrate how the company is able to achieve a competitive advantage in monitoring and controlling its environmental, economic and social issues: relevant data could support strategy decisions to develop a sensible perspective in evaluating alternative sources for the future research.

6. Conclusions

The model presented here provides insight into how Mass Balance approach arises at the level of the individual firm within the linkage between economic and environmental dimensions. Even though much consideration has been given in various streams of the organizational literature, an attention has been given to the implemented study. It is important to consider through public documents, reports and articles the possibility to demonstrate that companies, often, are not interested to modify their behaviours and their business strategies. This lack of interest demonstrates how the economic entities are reluctant to use environmental accounting systems. Therefore, companies are involved in a business model that actually penalize them because, from the one hand, the recovery of Mass Balance outputs decreases in the last years, on the other, the recognition of the proper treatment regards compliance mechanism to respect the minimum targets requested by law. Italian treatment plants reflect a reality which is one of the best in the

European context, but it is necessary the implementation of a revision of the rules by which Public Hand supports the sector's programs and gives the smart tools to the companies [24]. The actual status depicts by WEE sector is not represented by the turning point of the Circular Economy strategy in its immaterial dimension: moving from this perspective, concerning a critical theme in the productive assets and in the way to do business, it will be necessary to create a distance from the cultural relativism to catch the tangible essence of the e-waste sector [25].

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