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LaWEEEda

Latin American-European network on waste electrical and electronic equipment research, development and analyses

D 4.3 Report on the newly developed CPD educational material

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University of Natural Resources and Life Sciences, Vienna

European Partners:

Hamburg University of Technology

University of Northampton

Latin-American Partners:

Local Coordination in Brazil:

UFRJ

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1. Introduction

Within course of the project “Latin America-European network on Waste Electrical and Electronic Equipment, research, development and analysis” (LaWEEEda) modern and high quality modules, courses and educational products will be developed. These educational products are especially tailored for Nicaragua and Brazil and include both academic education and continuing professional development (CPD) training courses in the area of WEEE management and related entrepreneurial skills.

This report focuses on the newly developed CPD educational material. This comprises following elements:

- **Dismantling videos**: videos demonstrating and explaining the sequence of dismantling for a number of different e-waste products practical
- **Dismantling training**: specifically for practitioners it is important to understand the sequence of dismantling and the output materials from this treatment step
- **Plant layout design**: the participants learn to plan and design processes in the recycling of e-waste products
- **Entrepreneurship**: beside technical knowledge other skills in non-technical areas like cost calculation and business plan development are of importance. Training in these fields is given in connection with the practical dismantling training.

2. Dismantling videos

The dismantling videos have been developed with a particular purpose of providing better educational basis for manual dismantling of WEEE. The videos have several unique advantages compared to the material currently available. First, the practical dismantling is carried out by experienced professionals from the D.R.Z. recycling company in Vienna, Austria. Second, the dismantling videos will follow specific dismantling depths described in the StEP Tool, ranging from depollution, over standard dismantling up to in-depth dismantling of particularly valuable components.

Developed for 5 types of e-waste; selected to demonstrate the wider range of products (from PC, relatively simple) to printers (more complex appliance); refrigerator included although this requires specific technology and is not accessible by simple manual dismantling; PC, laptop, printer, CRT, refrigerator;

Within the scope of the dismantling videos, following devices are dismantled:

- Personal computer
- Laptop
- Cathode Ray Tube - television set
- Multifunctional printer / scanner, and
- Refrigerator

Features: for each product type the typical sequence of dismantling is shown, intertitles explain the work step, spoken text is given additionally; all videos are available in three languages: English, Spanish, Portuguese.

The videos contain between two and three dismantling levels, where each further step represents more in-depth dismantling procedure. After the dismantling sequences the resulting output materials are shown and explained (see Fig. 1 and Fig. 2). This can be used as an interface to a next step, where the economic value of the output materials and / or the related hazards of the materials can be demonstrated (see Fig. 3).

Training purpose of the dismantling videos – before practical training, the videos can be used to demonstrate the work sequence; can also be used for distance learning

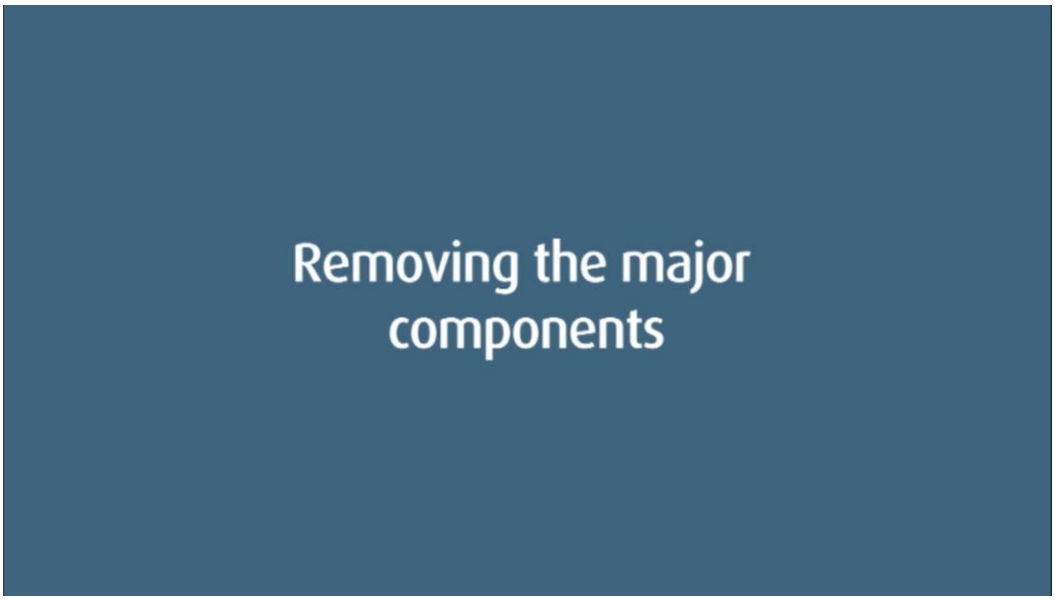

Fig. 1: An example of the dismantling segment title (Screenshot from the dismantling video)

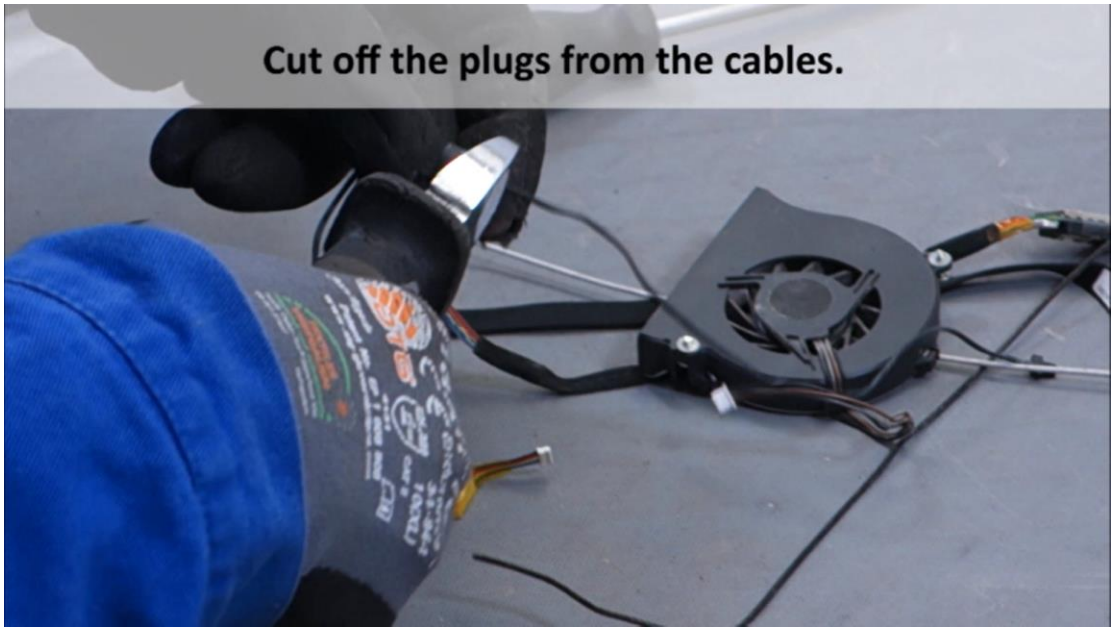

Fig. 2: Description of the particular assignment (Screenshots from the dismantling video)

Fig. 3: An example of the resulting materials after manual dismantling

3. Practical training for dismantling

The practical dismantling module, provided within CPD courses will focus on the main WEEE categories according to the European WEEE-Directive. Each module can be selected separately, so that interested participants can get the knowledge in terms of their field of interest. The practical dismantling modules are offering the possibility to be rewarded with ECTS points as well. To each partner university it is recommended to consider this option to provide extra incentives to take part in the courses. Each specific lecture (dismantling course for a specific WEEE category) is designed for 7 hours, i.e. one day. It is intended to provide a half day course on theoretical background and a half day for practical dismantling exercises in the LaWEEEda training centres (see **Fehler! Verweisquelle konnte nicht gefunden werden.**).

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Table 1 - Content of practical dismantling courses

Lecture number	Chapter	Main Content	Workload in teaching hours per semester
3.1	Screens and monitors	Laptops and notebooks, CRT displays, LCD displays	15
3.2	Small IT and tele-communication equipment	Printers and multifunction printers, personal computers	20
		Total:	**35**

Fig. 4: Impressions from the dismantling workshop in Rio de Janeiro (Brazil)

Fig. 5: Impressions from the workshop in Panama City (Panama)

Fig. 6: Dismantling of CRT devices – dismantling workshop in Panama City (Panama)

The learning outcomes for the practical dismantling courses (Module 3: lectures 3.1 to 3.5)) are related to the issue, that successfully completing participants should be in a future position to:

- Understand the sequence of practical dismantling and depolluting of a specific WEEE;
- Get to know the specific tools that are needed for dismantling and depolluting;
- Know the valuable parts and the hazardous parts / components of a specific WEEE;
- Understand the proper storage of WEEE and the components after dismantling / depollution
- Are aware of all necessary occupational health and safety measures for all depolluting and dismantling sequences of a specific WEEE.

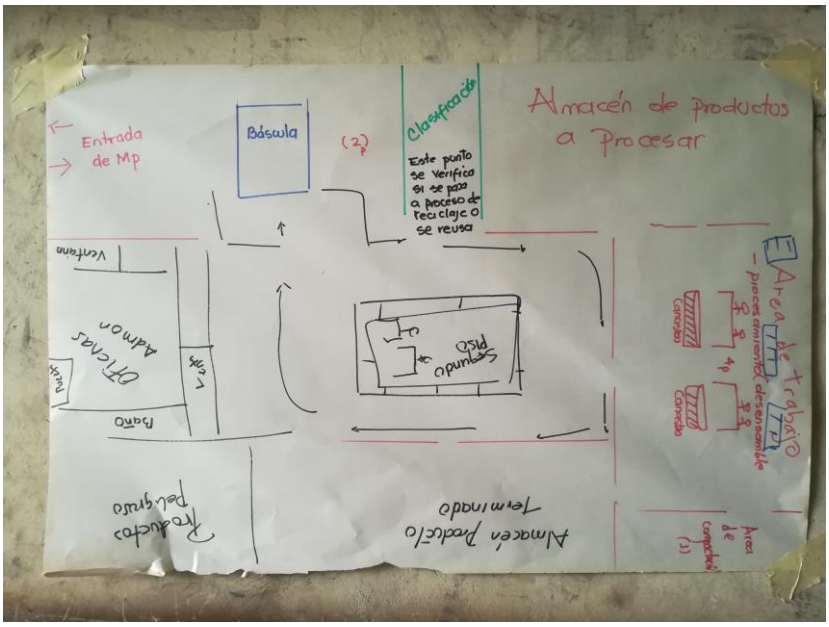
Participants will be assessed by conducting a practical dismantling of a specific WEEE combined with an oral examination.

As a main educational product for the LaWEEEda training centrtes, practical dismantling traiing courses have been developed and tested. In these trainings, products like PC, laptops, CRT or printers are dismantled under supervision.

Each step in the dismantling sequence is explained. Beside the quality and value of the output materials related hazards and personal protection is explained

4. Plant layout

Based on the practical dismantling training, the participants learn to plan and design dismantling facilities or specific treatment steps in the recycling chain. Beside technical skills, a focus is given to the economies of recycling. Two plant layout designs from the workshop are provided in the photos below.



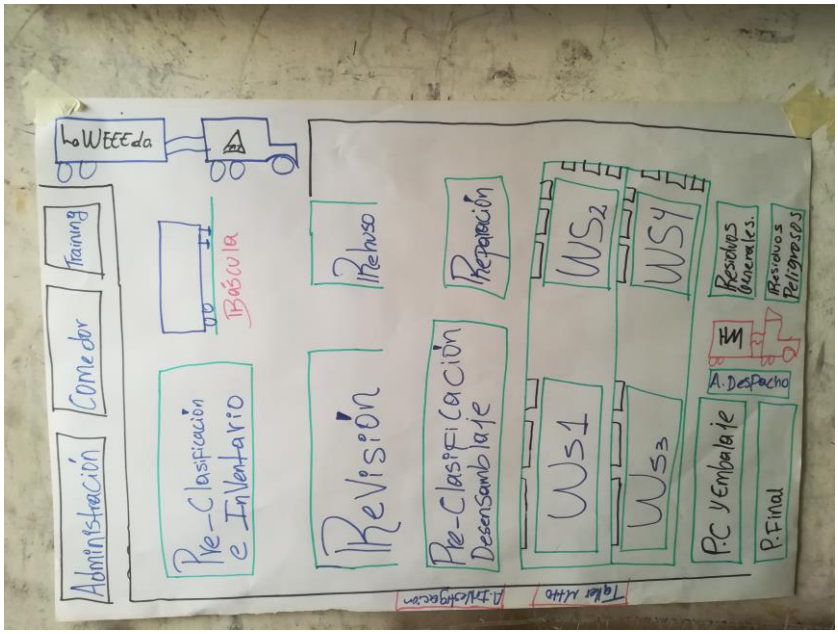


Fig. 7: Examples of the plan layout design outcomes

5. Entrepreneuship

Solving the E-waste Problem (StEP) is an initiative created to address issues and offer solutions with regards to the management of Waste Electrical and Electronic Equipment (WEEE). The United Nations University (UNU) founded the initiative in 2007. Since its founding, the StEP Initiative has steadily incorporated new active members including some of the most eminent players in the fields of Production, Reuse and Recycling of Electrical and Electronic Equipment, government agencies and NGOs as well as UN Organisations (see Table 2).

The supreme body of the StEP Initiative is General Assembly, which is defined by the Memorandum of Understanding – an agreement signed by all members and states and containing guiding principles of StEP. Furthermore, the core of the work is carried out by the five Task Forces (TF): "Policy", "ReDesign", "ReUse", "ReCycle" and "Capacity Building". These Task Forces conduct research and analysis in their respective domains and seek to implement innovative projects. From the perspective of CPD training courses, the publications of the TF "ReUse" are of the most relevance.

Table 2: Some of the prominent StEP initiative members

Production	**Reuse and Recycling**	**Universities and other agencies**
▪ Philips ▪ Hewlett-Packard ▪ Dell ▪ Microsoft	▪ Datec Technolgies Ltd. ▪ Dismantling and Recycling Centre Vienna ▪ EAGD ▪ Reverse Logistics Group Americas, ▪ E-Titanium	▪ Delft University of Technology ▪ Griffith University ▪ Massachusetts Institute of Technology (MIT) ▪ Basel Convention Coordinating Centre for Asia and the Pacific ▪ Deutsche Gesellschaft für Internationale Zusammenarbeit

The publications of the StEP Initiative can be classified as following: White papers, Green papers, Annual reports, and other works. The purpose of the White papers is to state and explain Step's position on e-waste related issues, to make scientific-based recommendations and provide guidance to relevant stakeholders and decision makers. The Green Paper Series is a publication platform for presentation of novel research findings regarding specific issues towards solving the e-waste management. The annual reports contain general information about the StEP Initiative and the results of the Task Force work. The other works include specific research findings such as: the report on the transboundary movement of e-waste, interdisciplinary compilation of international e-waste research, country reports and other. From the CPD training courses stand point, by far the most interesting research published by the StEP Initiative is the "Business Plan Calculation Tool for Manual E-waste Dismantling Facilities", which is going to be discussed in more detail in the following chapters.

5.1. Business Plan Calculation Tool for Manual E-waste Dismantling Facilities

The Step Business Plan Calculation Tool (further on in the text regarded simply as "the calculation tool") is a summary of experiences and solutions based on the operation of D.R.Z. Dismantling and Recycling Centre in Vienna. The calculation tool represents an elementary support for entrepreneurs for setting up an efficient WEEE manual dismantling plant with respect to the economic viability and environmental impacts. Furthermore, the tool was intended to also be used by policymakers to understand their region's current economic conditions for e-waste recycling.

There are two versions of the calculation tool currently available:

- an open source version for the calculation on an annual basis
- a version distributed within workshops - mainly for entrepreneurs - containing features to calculate an entire 5 years' business plan

5.2. Structure of the Business Plan Calculation Tool

Structure of the calculation tool follows processes, costs, and revenues for successful modeling of a WEEE manual dismantling plant. However, the logistics of collection and transport of the input material to the dismantling plant is not covered by the calculation tool.

Furthermore, the core of the calculation tool are experiences from the **dismantling campaign** carried out at the D.R.Z.-Dismantling and Recycling centre in 2013. Within this campaign most of the relevant factors, i.e. general material composition of the most relevant appliance groups, average dismantling time, and the most relevant costs, have been observed and described.

The calculation tool requires from the user to fill into the excel sheet the quantity and share of different WEEE subcategories (see Fig. 8). The total input quantity is expressed in tonnes per year. The input composition then is calculated as mass share of the yearly input classified into 13 subcategories: Small Household Appliances (SHA) kitchen, SHA cloths, PC and Server, Notebooks, Printer/Scanner/Copier, IT accessories, Mobile phones, Cathode Ray Tube (CRT) monitors, Flat Panel Displays (FPD) monitors, audio appliances, Video appliances, CRT TVs, FPD TVs.

The average times for dismantling of waste electronic appliance groups have been classified according to the three different scenarios (A, B and C):

a) Scenario A, De-pollution and highly valuable components: This dismantling depth focuses on the removal of hazardous components, e.g. capacitors, batteries, etc., and the separation of exceptionally valuable components, e.g. Printed Circuit Boards.
b) Scenario B, General dismantling: this dismantling depth foresees dismantling of electronic appliances into more or less homogenous materials and recyclable fractions including the de-pollution step.

c) Scenario C, In-depth dismantling: Envisions manual dismantling of electronic appliances up to a point at which further manual dismantling into homogenous materials is not possible without mechanical treatment.

Definition of Input Quantity and Composition/ Calculation of Collection Costs

Composition of input	Input composition	Input quantity	Purchase Prices *[curr/piece]**	Recycling Fees *[curr/t]***	Purchase Costs	Revenues from RF	Transport Costs****	Purchase Conditions
SHA kitchen (coffee machine)	0.0%	0 t/y			0 /y	0 /y	0 /y	0 /y
SHA cloths (iron)	0.0%	0 t/y			0 /y	0 /y	0 /y	0 /y
PC/ Server	20.0%	100 t/y			0 /y	0 /y	-375 /y	-375 /y
Notebook	2.0%	10 t/y			0 /y	0 /y	-38 /y	-38 /y
Printer/Scanner/Copier	5.0%	25 t/y			0 /y	0 /y	-94 /y	-94 /y
IT accessories (mix keyboard, mouse)	2.0%	10 t/y			0 /y	0 /y	-38 /y	-38 /y
Mobile phone (incl. recharger)	0.0%	0 t/y			0 /y	0 /y	0 /y	0 /y
CRT monitor	20.0%	100 t/y			0 /y	0 /y	-375 /y	-375 /y
FPD monitor	1.0%	5 t/y			0 /y	0 /y	-19 /y	-19 /y
Audio appliances (CD-/Radiorecorder)	10.0%	50 t/y			0 /y	0 /y	-188 /y	-188 /y
Video appliances (CD-/DVD-Player)	10.0%	50 t/y			0 /y	0 /y	-188 /y	-188 /y
CRT TV	10.0%	50 t/y			0 /y	0 /y	-188 /y	-188 /y
FPD TV	10.0%	50 t/y			0 /y	0 /y	-188 /y	-188 /y
Total	**90.0%**	**500 t/y**			**0 /y**	**0 /y**	**-1,688 /y**	**-1,688 /y**
** prices to be paid to the owner of the devices (-), prices paid by the owner to collect the devices (+)*					0 /t	0 /t	-3 /t	-3 /t
*** Recycling fees paid by a take-back-scheme*								
**** to carry the appliances from collection points to the dismantling plant*								

Fig. 8: Example of quantity and composition of the WEEE input according to the calculation tool

Based on the results of the dismantling campaign, the calculation tool offers an average material composition of waste electronic appliances. Furthermore, the material composition is presented in dependence of the dismantling depth, e.g. a material composition denotes resulting material fractions resulting from depollution and highly valuable components dismantling process. In the Fig. 9 is an exemplary material composition according to the appliance subcategory shown.

The input data provided by the user, the calculation tool will calculate necessary management requirements including minimal facility size, equipment requirements and other requirements necessary for the optimal operation of the plant. Finally, the calculation will provide an overall financial performance of the plant.

Fractions	Small household appliances coffee			Small household appliances cloths			PC/ Server			Notebook		
	A	B	C	A	B	C	A	B	C	A	B	C
Aluminium								3.0%	7.9%			5.4%
Iron/ Steel			6.7%		35.1%	35.1%	46.1%	46.1%	59.1%		1.1%	4.8%
Copper									1.3%			0.1%
Neodym Magnet									0.1%			0.2%
Bronze/ Brass												0.3%
Stainless Steel									0.5%			1.0%
Plastics		27.0%	56.4%		39.5%	39.6%	6.2%	6.2%	8.8%		14.5%	27.6%
Wood												
Cable with plugs		2.5%			1.2%		3.3%			7.5%	0.4%	
Cable without plugs			2.1%			1.0%		3.0%	4.5%		5.9%	7.0%
Processors								0.4%	0.4%			0.7%
HDD with PWB							4.3%				4.8%	
HDD without PWB								3.4%				
Power supply							9.5%	9.5%				
Drives							15.3%	15.3%			9.0%	
Printed Wired Board, Q1							9.2%	9.7%	9.8%		12.5%	14.0%
Printed Wired Board, Q2									0.3%			0.2%
Printed Wired Board, Q3								0.3%	2.0%			
Mobile Phone without batteries												
Motors/Inductors/Transformers									1.1%			1.2%
Deflection Coil												
Getterpill - electrogun												
Mixed Scrap	100.0%	70.5%	34.8%	100.0%	24.2%	24.3%	5.4%	2.4%	3.1%	56.5%	15.3%	15.8%
Glass												
Residual waste												0.6%
Batteries							0.3%	0.3%	0.3%	15.0%	15.5%	15.5%
Capacitors							0.4%	0.4%	0.8%			
LCD-displays										21.0%	21.0%	5.5%
Fluorescent Tubes												0.1%
Printer Cartridges												
CRT tubes												
CRT-glass												
Phosphor-powder												
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Fig. 9: An exemplary overview of material composition according to the WEEE subcategory and dismantling procedure

The costs structure of the calculation tool has been calculated during the dismantling campaign carried out at the D.R.Z. Dismantling and Recycling Centre. They are classified into investment, input material (costs of WEEE), personal, transport costs, and disposal costs.

Transport costs represent complicated issue, which concerns both input as well as output material logistics. The transport costs can generally been separated into local, regional, long-distance, and overseas transport (see Fig. 10). In the calculation tool, the transport costs are addressed only in very general terms and for the efficient management of the plant this issue needs more detailed consideration.

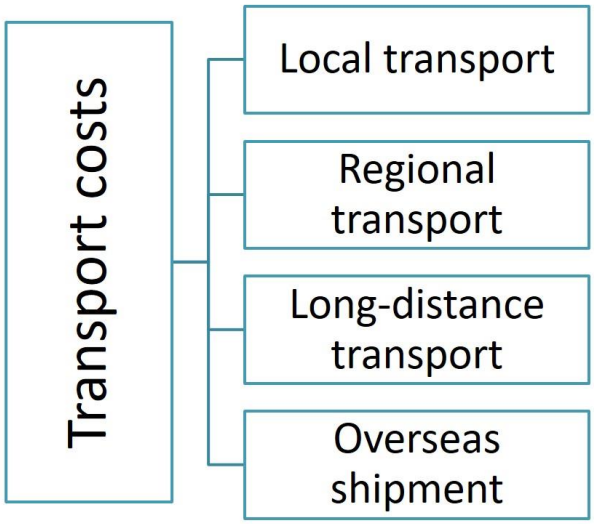


Fig. 10: An overview of investment and transport costs classification according to the calculation tool

After filling in all / most of the required input data, the calculation tool provides an evaluation of the treatment process expressed as following:

- Required resources – represents necessary minimal requirements for the optimal operation of the plant. The required resources include approx. dismantling time in dependence on the three levels of dismantling, required stuff including the administrative stuff and the dismantling workers, required infrastructure and equipment.
- Investment costs – includes the costs of the plant facilities, e.g. administrative department, dismantling stations, storage, etc., and the costs of equipment, e.g. working tools, collection boxes, scales, etc.
- Operation and depreciation costs – are general costs of the already established minimal resource requirements for the optimal operation of the plant

Finally, the financial results based on the input data are classified into three different blocks: revenues and downstream costs, investment costs, running costs. Furthermore, the overall results are represented according to the applied dismantling procedure (see Fig. 11).

Financial Results			
Revenues and Downstream Costs	**A** *[curr/y]*	**B** *[curr/y]*	**C** *[curr/y]*
Revenues from Take-Back-Systems	0 /y	0 /y	0 /y
Sales Revenues	125,326 /y	202,011 /y	224,452 /y
Disposal Costs	-34,548 /y	-34,548 /y	-15,848 /y
Transport Costs (Input)	-1,688 /y	-1,688 /y	-1,688 /y
Transport Costs (Downstream)	-38,045 /y	-39,088 /y	-37,159 /y
Purchase Costs	0 /y	0 /y	0 /y
Total per year	**51,045 /y**	**126,687 /y**	**169,757 /y**
Investment costs	**A**	**B**	**C**
Investment Costs Infrastructure	0	0	0
Investment Costs Equipment	-13,615	-14,615	-26,665
Total	**-13,615**	**-14,615**	**-26,665**
Running costs per year	**A**	**B**	**C**
Staff costs	-65,340	-70,620	-79,200
Rental Costs	-2,715	-5,585	-8,835
CMR Building	-8,487	-11,644	-15,219
Equipment Costs	-1,579	-3,425	-5,823
CMR Administration	-9,600	-9,600	-11,200
Depreciation Infrastructure	0	0	0
Depreciation Equipment	-1,702	-1,802	-2,107
Training/ other costs	0	0	0
Total per year	**-89,422 /y**	**-102,675 /y**	**-122,384 /y**
Operating Result	**-38,377 /y**	**24,012 /y**	**47,373 /y**

Fig. 11: Example of financial results according to the calculation tool

5.3. Summary of the StEP calculation tool

The calculation tool provides an excellent overview of the processes of a generic WEEE manual dismantling plant especially with respect to the operating and the investment costs. Furthermore, it offers a classification of the dismantling depth with relation to the respective minimal time / resource requirements as well as respective homogeneity and revenues of the output fractions. Although, in the reality it is near impossible to segregate these dismantling approaches into three completely distinct processes, it is nevertheless a valuable input for the entrepreneurs with little recycling experience to emphasise different output efficiencies depending on the invested time.

Furthermore, the calculation tool focuses strongly on the managerial / entrepreneurial aspects of the WEEE dismantling offering detailed insight into the stuff, infrastructure, and equipment costs. However, the provided costs show only general relations between different costs, so that before the calculation tool is applied for specific problems, they need to be adjusted to the local situation in Nicaragua and Brazil.

Given the scope of the calculation tool, number of different aspects and variables, and depending on the intended users, it is necessary to organise a workshop, where potential users will have an opportunity in order to ensure the proper handling of the calculation tool and to avoid possible misunderstandings. Moreover, the calculation tool is available only in English language. In order to ensure better recognition with various potential users in Nicaragua and Brazil, it is necessary to provide also Spanish and Portuguese versions.

Finally, the calculation tool does not provide **any indication** of the technical dismantling procedure for waste electronic appliances. A development of a dismantling manual containing basic steps in accordance to the different dismantling depths is absolutely necessary for the successful application of the calculation tool.

Within the scope of CPD trainings and as part of the newly developed materials, also a business plan will be developed. For this purpose the Business Model Canvas by Alexander Osterwalder will be used.

The Business Model Canvas method is based on a specific, process-oriented approach to the content development of the various business model components. The method supports the analysis of the market potential of business ideas and business models in order to make the relationships and influences on a business model tangible and comprehensible. The method can be used in the initiation and implementation phase of various projects and business ventures. Stakeholders can be included depending on the business model component to be developed. Due to the complexity of the method, the inclusion of a moderator for the process-oriented and content-related accompaniment is recommended. An illustration of the Business Model Canvas is shown in the Fig. 12.

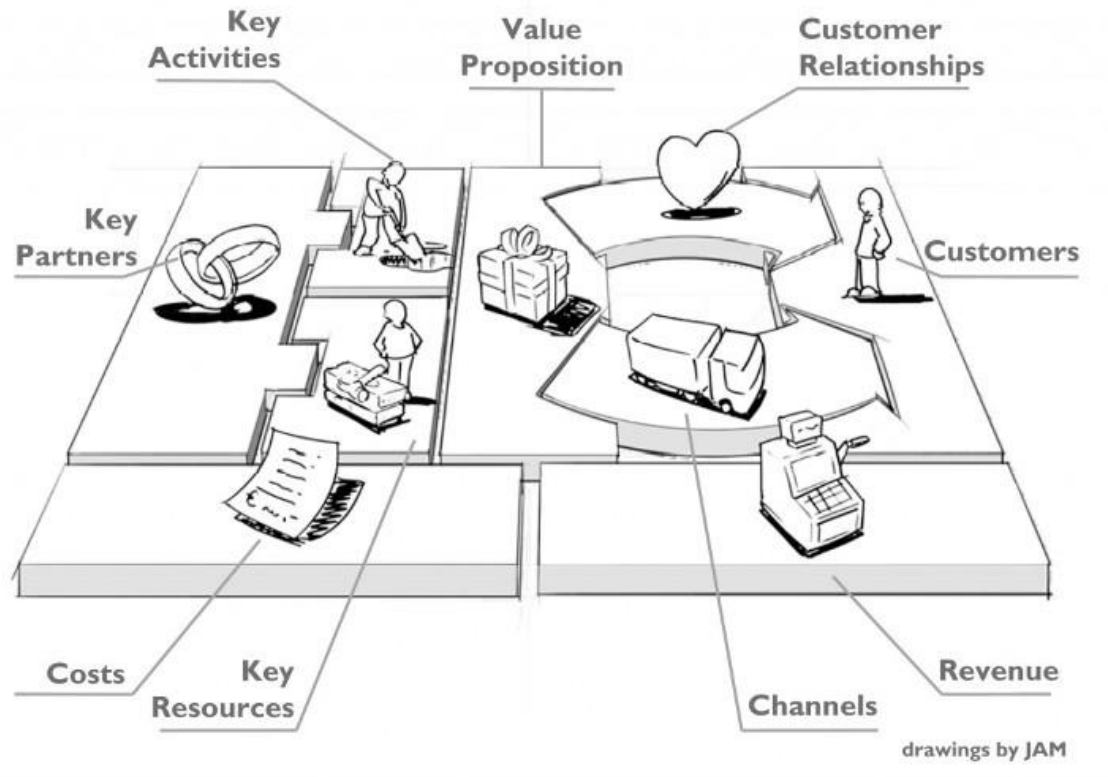


Fig. 12: An illustration of the Business Model Canvas

The Business Model Canvas method uses special visualization and creativity techniques and templates in several workshop settings to develop nine essential building blocks of potential business models: customer segments, value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partnerships and cost structure.

Essentially, the model is based on the nine core components, which reflect the main topics of business models in companies:

Building block 1 – Costumer segments

Customers are at the heart of any business and without them, they could not survive. To better serve customers, they are usually segmented according to common needs, behaviors or other attributes. Thus, a company always serves one or more small or large customer segments. The purpose of this first building block is to identify and select the various groups of clients or organizations that want to reach or edit a business, or which they want to ignore.

Building block 2 – Value positions

The second building block describes the utility or value that a package of selected products and / or services represents for a specific customer segment, e.g. solving a problem, meeting one or more needs. This specific benefit or added value is often the reason why customers opt for or against a product or service offering.

Building block 3 – Channels

The third field "Channels" comprises all communication, distribution and sales channels with which the identified customer segments are to be reached and addressed in order to convey the value proposition. The channels are so-called points of contact with the customers and play an important role in customer satisfaction and in the customer experience. The company has the choice to reach customers through their own channels, e.g. sales department, internet sales, own store, through partner channels or through a mix of both types. A distinction can also be made here between direct, e.g. internal sales department, website, and indirect channels.

Building block 4 – Customer relationships

This module describes the relationship that a company develops and enters into a particular customer segment. The company can manage its customer relationships in a variety of ways, e.g. personal support, personal and individual support, self-service, automated services, communities, participation. They range from personal contact to automated service

Building block 5 – Revenue streams

The fifth building block represents the income that a company derives from each customer segment. A company must answer the question, for which services are customers really willing to pay. If a company can answer this question, one or more sources of revenue can be tapped per customer segment. Each revenue source can have different price mechanisms. List prices, negotiation basis, auctions, market-dependent, volume-dependent, or revenue management.

Building block 6 – Key resources

This module describes the most important resources that are necessary for the functioning of a business model. It can be distinguished between physical, financial, intellectual and human resources that can be owned, leased or acquired by the key partners.

Building block 7 – Key activities

The key activities are the seventh building block in the Business Model Canvas and describe the key things a business needs to do to make its business model work. They include, for example, creating and submitting value propositions, reaching markets, building and maintaining customer relationships to generate revenue.

Building block 8 – Key partnership

The eighth module describes the network of suppliers and partners that contribute to the success of the business model.

Building block 9 – Cost structure

The ninth and last module describes the costs that arise in a business model. These include all costs arising for the company including stuff, operating, and overhead costs.

Although at this point, different aspects of the business plan are still being discussed, an example of applied approach for the laWEEEda Project is shown in the Table 3.

Table 3: An example Business Plan Canvas for laWEEEda Project

8-Key Partners	7-Key Activities	2-Value Proposition	4-Customer Relationships	1-Customer Segments
Departments (Escola Politécnica, IMA, Escola de Química)	Prefessional Training	Leading knowledge on the management of WEEE, trasmitted in a differentiated way, with technological resources	Contact (e-mail) of students receiving LaWEEEda content in any subject	University Students (undergraduate, graduate and doctoral students)
Laboratories (SAGE, COPPE, LIpE, NERDES,NIDES, MUDA)	Dissemination of courses and opportunities (administrative)	Team of teachers responsible for the pedagogical part of the project	Contact of students who wish to receive LaWEEEda content by e-mail (advantage)	
CETEM	Organization and preparation of the physical space and materials of the course (administrative)	Dissemination of the project among students	Credit utilizantion if student decides to complete LaWEEEda certification (advantage)	
ACAMJG, COOPAMA		Constant monitoring of industry trends		
ZYKLUS, E-LIXO		Bridge between students and companies of the sector		
BOKU, TUHH, TUON, ULSA, UCAN, UNESP				
Recicla CT, CT Eletroeletrônicos				
	6-Key Resources		**3-Channels**	
	Human Resources (teachers, administrative, marketing)		Presential training in own space within the university	
	Physical Resources (classrooms, training centre, wi-fi)		Online platform for access to complementary activities and content	
			Social Networks / Sites for the dissemination of the courses	
			Social Networks / Sites for the dissemination of the opportunities	

9-Costs	5-Revenue
All the physical resources involved are already made available by the university All the human resources involved are already part of the professional staff of the university	UFRJ as a public university can not, by law, cash in for undergraduate, master's and doctorate courses offered to
Some activities will be carried out by scholarship students or volunteers	In the future, revenues may arise such as financial support and publicity