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A systematic and compatible classification of WEEE

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Abstract

Waste electrical and electronic equipment (WEEE) encompasses a great variety of products. The heterogeneous characteristics and lack of standardized classification create substantial difficulties to compare take-back and recycling performance. This paper proposes a systematic classification of WEEE, enabling improved scope definition and better comparability of performance results. It is organized based on three essential perspectives: product type, waste management and legislative relevancy. The proposed classification list is divided into 58 categories by linking all possible WEEE items (about 900 product types) and various conventional categorizations. Additionally, an important source facilitating the categorization is the international goods codes systems. By aligning with the classifications applied in trade statistics, custom authorities and national statistical offices, this categorization enables consistent comparison of performance between regions and compliance schemes. The approach developed is an important reference for an independent check of the registered EEE amounts put on the market and WEEE generated. As such this forms a relevant input for the upcoming WEEE recast collection target definition in Europe. A case study is conducted in the Netherlands for a system mapping of the national e-waste flows in 2011, and average weight for each category is provided.

1 Introduction

Traditionally, waste electrical and electronic equipment (WEEE or e-waste) has been a complex waste stream to comprehend. Due to its own heterogeneous and complex nature, e-waste encompasses a wide range of products with a diversity of functions associated. Also as regards material composition, there is great variety present in valuable materials and in hazardous substances.

From analyzing e-waste legislations across the globe, there is no universal agreement on the definition of e-waste identified and each applied scope does not correspond with those in other countries [1, 2]. Even in Europe, with in principle a more harmonised scope in the WEEE Directive and RoHS (Restrictions on Hazardous Substances) Directive, differences in scope have arisen due to national implementations and specifically in the product lists used by Producer Responsibility Organisations are observed [3]. The old WEEE Directive covers a comprehensive list of products under ten categories for end-of-life (EoL) management [4, 5]. In China and Japan, the domestic e-waste legislations are limited to several types of products perceived with higher environmental and social impacts [2]. Such incompatible and selective scoping of e-waste hampers consistent comparison of e-waste generation among different countries and their interregional flows. Furthermore, the categorization provided in Annex 1A of the EU WEEE Directive is too concise. On the contrary, the product list in Annex 1B is exhaustive, but without proper grouping by function and EoL characteristics [6]. In addition, the grouping does not correspond with actual return stream characteristics as occurring in actual practice. For scientific research and material accounting, a consistent and systemic classification of electrical and electronic equipment (EEE) can facilitate clear scoping of e-waste and compatible analysis.

This paper proposes a new set-up of a product categorization, which is organized based on three perspectives: product type (functionality and industry sector), waste management (return stream characteristics) and legislative relevancy (material composition, hazardous and valuable content). The list categorizes various products in a way that both a high level aggregation (per collection category) and a detailed analysis (per individual appliance type) are made compatible. Such classification of EEE and e-waste is instrumental to account the EEE related material flows in society. This can help to estimate the associated resources and toxics in an efficient way. It can also contribute to more detailed performance assessment of legislative targets and thus for more pinpointed monitoring and control in practice [6, 7].

The further sections of this paper is organized as follows: Chapter 2 explains the information sources and

approach for constructing such categorization; Chapter 3 shows the categorization obtained through this way of working; Chapter 4 presents a case study of mapping e-waste flows in the Netherlands, in which this classification has been applied for the first time; Chapter 5 discusses other potential application and dynamic update of such categorization.

2 Approach

There are and have been numerous types of EEE on the market. These types occur in the worldwide classifications of economic activities (ISIC in Figure 1) and of products (CPC). The statistical information from Eurostat (NACE, CPA) has been used as a primary reference to compile the current WEEE lists, which is derived from the worldwide lists. National statistical institutes document all commodities and economic activities in the society; so it can potentially present a harmonized and a dynamic description of complete EEE types in regional and global economies chronologically. In addition, statistical records can provide consistent sales figures for all products through historical years, as a fine data source for the estimation of e-waste generation.

To specify, foreign trade (import and export) statistics for each product are registered under the Harmonized Commodity Description and Coding System (HS codes) developed by the World Customs Organization. In Europe, a more detailed and fully compatible coding system named Combined Nomenclature (CN codes) is used, in which the first six digits correspond with the HS codes with the seventh and eighth digits relating to EU specific subheadings [8]. In parallel, domestic production of products are registered under the Community Production system (PRODCOM codes). In most cases, one PRODCOM code corresponds to one or more CN codes, and a linkage table with coding details is available annually in the EU Ramon database [8]. Figure 1 provides the overview about the global and European coding systems, together with their structural linkages [9]. Such an integrated system allows the comparability of statistics produced in different statistical domains. Using the European coding systems for classifying EEE would not limit its application to the EU only, because the coding systems are compatible and thus can be traced back to the international counterparts.

There are around 4000-6000 PRODCOM codes and 8000-9000 CN codes for all commodities per year. From this, there are around 160-250 PRODCOM codes to be regarded as EEE relevant, according to their literal descriptions. Meanwhile, descriptions that refer to parts of EEE were excluded, as it will create double counting. By using the linkage tables, the corresponding CN codes can be traced accordingly from EEE-related PRODCOM codes. A database with annual changes and inclusion of new goods codes is available through United Nations University (UNU).

After compiling all the descriptions and coding information for EEE chronologically, the main challenge is to group them into relevant primary and sub- categories. Criteria for classification are based on maximal grouping of products with similar function, comparable material composition (in terms of hazardous substances and valuable materials), and related EoL attributes. In addition, products within the same subcategory should preferably have identical average weight and lifespan distribution, which can simplify quantitative assessment for similar products. Meanwhile, linkage to other conventional classification is maintained for compatibility analysis with different organisations and systems. Such references include the EU WEEE Directive and Recast, WEEE Forum and EU WEEE Directive Impact Assessment and Review Study of UNU. From the legislation perspective, it is essential to maintain the major 10 categories of the old WEEE Directive and the 6 of the recast version for backwards compatibility and monitoring in the EU.

3 Result

Table 1 presents the classification results after adopting the approach in the previous chapter. All EEE are grouped into 10 primary categories, according to the EU WEEE Directive (with an extra category for central heating). Then these ten major product categories are broken down into 58 sub-categories as represented by the UNU-key codes. This UNU-58 classify all possible EEE (about 900 products), and link them to 5 to 7 collection categories, which exist in actual e-waste collection practice. Meanwhile, the 17 UNU subcategories used by the WEEE Forum and the 2007 WEEE Review Study are compatible with the ones of this list [10].

4 Case study

As an example, this classification method has been applied in the Netherlands in 2011, to conduct a systemic mapping of the national e-waste flows [11]. Information and data from Statistics Netherlands, industrial associations, producers, compliance schemes and recyclers were collected to estimate the quantities of products put on the market and e-waste generation over time. For each category in the list developed, its respective average weight in 2010 has been provided in Table 1. The result presents a comprehensive overview about all the existent electronic equipment in the country, by aligning statistic registration with categorized coding system of EEE. It therefore helps to account material flows, check the fulfilment of legisla-

tive target and identify priority for future e-waste management. Similar studies can be practiced in other countries or regions, by using this classification as a starting point.

5 Discussion

As demonstrated by the case study, this categorization can be applied to account the sales of all EEE and accordingly e-waste generation in a certain country in an organized way. Simultaneously a connection with statistic codes is being made. The quality of the data obtained depends on the completeness and accuracy of the registrations made for specific codes.

In the case study in the Netherlands this accuracy turned out to be very satisfactory. This has led to detailed and reliable data about sales-per-category of e-waste. However, it was discovered as well that applying statistic codes for estimating sales of EEE might also generate errors in some selective cases. For instance, codes relating to lamps are still general, therefore not specific regarding the multitudes of individual lamp types. A more general issue is that registration data obtained via CN might also contain second hand equipment, since that system does not distinguish between new and second hand goods when it comes down to import/export registration. Occasionally also large number of parts, components and assemblies for EEE are included in the coding system, and they shall be excluded. Overall, it requires multiple data sources and conducting comparison to screen data to guarantee high quality of assessment. For the application in the case study these drawbacks turned out to be minor in comparison with the many advantages which the proposed system is offering. In particular the amount of details which can be obtained through this approach is very helpful for a tailored management of e-waste systems.

The data obtained through the classification method for e-waste will have to be dynamically updated, according to developments in technology and in society. For instance, the introduction of FPD TVs has wiped out the sales of CRT TVs in a short time period. Desktop computers are replaced in rapid pace by portable products as well. Another observation is that not just sales volumes but also the average weights for many products are subject to change over time. Such dynamics will lead to substantial changes in the outcome of the classification process.

6 Conclusion

In this paper a classification method for electronic products has been presented which has turned out to be a very useful basis to organize information and data about e-waste.

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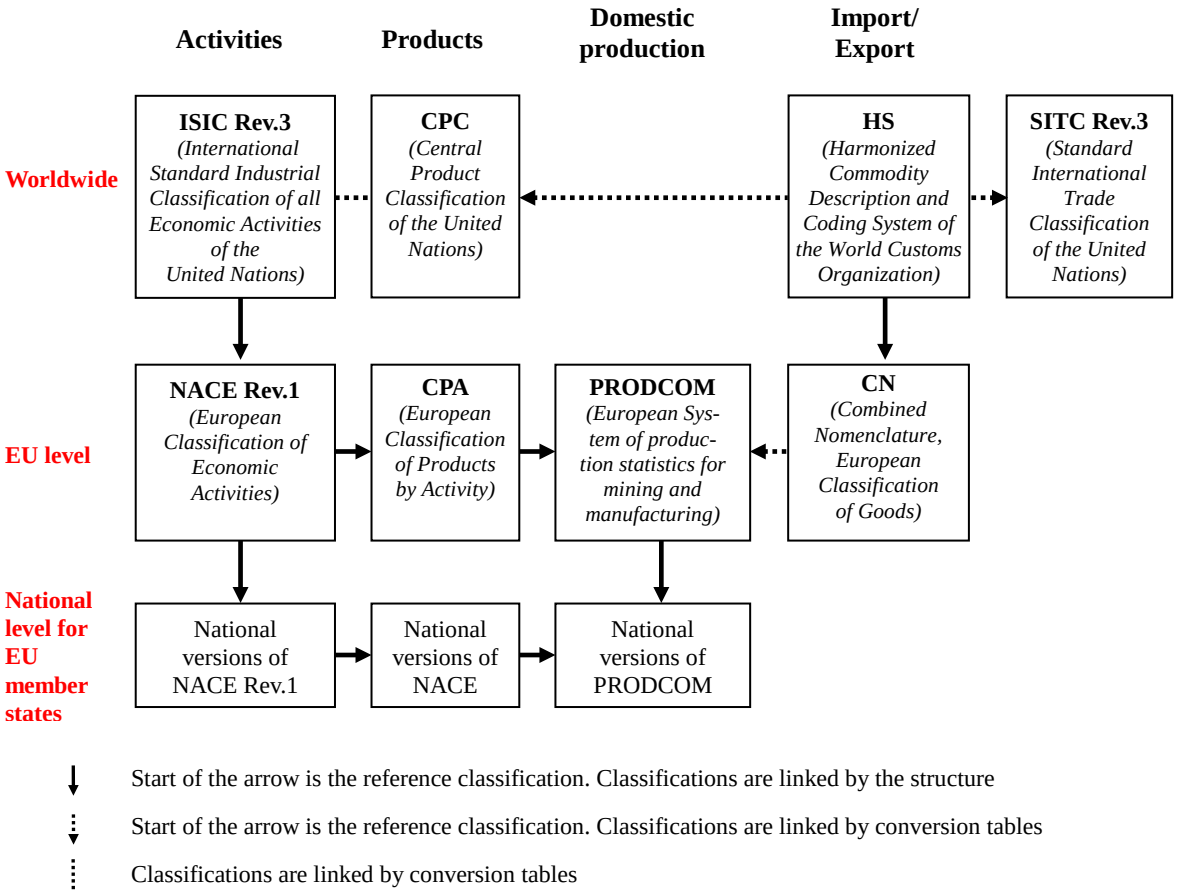

Figure 1: Overview of statistical classification systems of goods (worldwide and Europe)

Table 1: Classification of WEEE with their average weights in the Netherlands

Primary category	Sub-category		Main products/ comments	Collection category	17 WEEE forum category	Average weight 2010 Kg/ unit
	UNU key	Description				
Central Heating	0-01	Central Heating	Central heating on natural gas, geysers, boilers	0 CH	0 CH	30.9
Large household appliances	1-01	Professional (PROF) heating and ventilation	Excl. cooling equipment	A LHA	1A LHHA	83.7
	1-02	Dishwashers	Dishwashers	A LHA	1A LHHA	43.3
	1-03	Kitchen	Large furnaces, ovens, cooking equipment	A LHA	1A LHHA	47.7
	1-04	Washing machines	Washing machines, incl. combined dryers	A LHA	1A LHHA	72.5
	1-05	Drying machines	Wash dryers, centrifuges	A LHA	1A LHHA	46.0
	1-06	Room heating and ventilation	Household (HH) room heating + ventilation, excl. small (table) ventilators, hoods	A LHA	1A LHHA	12.7
	1-07	Sun beds	Sun beds and tanning equipment	A LHA	1A LHHA	72.5
	1-08	Fridges	Fridges for food, wine, ice, etc.	B C&F	1B C&F	40.8
	1-09	Freezers	Freezers for food, ice, etc.	B C&F	1B C&F	44.1
	1-10	Combined fridges and freezers	Combined fridges and freezers for food, wine, ice	B C&F	1B C&F	69.5
	1-11	Air conditioners	HH air conditioners, excl. large split-systems	B C&F	1B C&F	26.7
	1-12	C&F Other (Cooling and Freezing)	HH Dehumidifiers, ventilation w. cool., heat pump dryers	B C&F	1B C&F	9.8
	1-13	PROF C&F	PROF Air conditioners, fixed cooling installations, cooled displays and fridges	A LHA/ B C&F	1B C&F	147.9
	1-14	Microwaves	Incl. combination microwaves, excl. grills.	C SHA	1C SLHA	22.9
Small household appliances	2-01	Small HH	Incl. small ventilators, irons, time, scales, adapters. Etc.	C SHA	2 SHA	1.2
	2-02	Food processing	Kitchen and food processing, frying pans, cooking plates	C SHA	2 SHA	3.3
	2-03	Hot water	Coffee, tea, espresso makers, hot water, rice cookers	C SHA	2 SHA	1.9
	2-04	Vacuum cleaners	HH Vacuum cleaners	C SHA	2 SHA	5.9
	2-05	Body care	Tooth brushing, hair dryers, trimmers, razors	C SHA	2 SHA	0.6
IT and telecom equipment	3-01	Small IT&T	Small IT&T external components and accessories, incl. memory sticks	D IT	3A IT	0.4
	3-02	Desktop PC	Excl. monitors , accessories	D IT	3A IT	8.8
	3-03	Laptop PC	Laptops, notebooks, net books, tablets, excl. accessories	D IT	3A IT	3.2
	3-04	Printing and imaging	Scanners, printers, MFS, faxes, copiers	D IT	3A IT	10.3
	3-05	Telephones and equipment	Telephones and equipment	D IT	3A IT	0.5
	3-06	Mobile phones	Mobile phones	D IT	3A IT	0.1
	3-07	PROF IT	PROF IT equipment, servers, routers, data storage unit, incl. copiers, plotters	G PROF/ D IT	3A IT	40.0
	3-08	CRT monitors	Cathode Ray Tube Monitors	E1 CRT	3B IT CRT	22.0
	3-09	FPD monitors	Flat Panel LCD, LED Monitors	E2 FDP	3C IT FDP	5.5
Consumer equipment	4-01	Small CE	Small CE components, headphones, microphones	C SHA	4A CE	0.4
	4-02	Portable audio/ video	MP3, digital audio/video, e-readers, car navigation, etc.	C SHA	4A CE	0.2
	4-03	Radio and Hifi	Radio / Hifi sets, amplifiers, CD, tape, car audio	C SHA	4A CE	3.7
	4-04	Video and projection	VCR, DVD(R), projectors, incl. components	C SHA	4A CE	3.5

	4-05	Speakers	Speakers	C SHA	4A CE	2.1
	4-06	Camera	Camcorders, photo + digital cameras	C SHA/ D IT	4A CE	0.3
	4-07	CRT TVs	Cathode Ray Tube Televisions	E1 CRT	4B CE CRT	33.2
	4-08	FPD TVs	Flat Panel LCD, LED TV's	E2 FDP	4C CE FDP	14.7
Lighting equipment	5-01	Lamps	Other Lamps incl. halogen, Christmas, torches,	F Lamps/ C SHA	5A Lamps	0.1
	5-02	Compact fluorescent lamps	Compact fluorescent lamps, integrated and non-integrated lamps)	F Lamps	5A Lamps	0.084
	5-03	LED retro	Retrofit LED lamps, incl. halogen replacements	F Lamps	5A Lamps	2.67
	5-04	Straight tube fluo-rescent lamps	Straight tube fluorescent lamps	F Lamps	5A Lamps	0.114
	5-05	LED luminaries	Non retrofit LED lamps and fittings	C SHA	5B Lum	0.1
	5-06	Special lamps	Hg, Na (high + low pressure, street lighting)	F Lamps	5A Lamps	0.095
	5-07	Household luminaries	All HH luminaries and fittings, transformator, cable, sensors	C SHA	5B Lum	0.45
	5-08	PROF Luminaries	PROF Luminaries at offices, public space, in-dustry.	A LHA/ C SHA	5B Lum	-
Electrical and electronic tools	6-01	Small Tools	All HH tools, soldering, energy, cleaning, drill-ing, sawing, etc.	C SHA	6 Tools	23.2
	6-02	Garden tools	All garden tools	C SHA	6 Tools	-
	6-03	PROF Tools	PROF large tools, excl. dual use ones)	G PROF	6 Tools	2.5
Toys, lei-sure and sports equipment	7-01	Small toys	Incl. trains, music instr. and other, excl. games + sports	C SHA	7 Toys	0.2
	7-02	Video game	Game consoles and external accessories	D IT	7 Toys	0.5
	7-03	Large toy	Large music instruments, sports and exercising)	G PROF	7 Toys	7.4
	7-04	PROF toy	PROF bowling alleys, non HH entertainment	G PROF	7 Toys	80.0
Medical devices	8-01	Small medical	HH blood pressure, thermometers, etc.	C SHA	8 Medical	0.2
	8-02	PROF medical	PROF hospital, dentist, diagnostics, treatment	G PROF	8 Medical	67.0
Monitoring and control instru-ments	9-01	Small monitoring	HH alarm, heat, smoke, measuring, security, excl. CRTs)	C SHA	9 M&C	0.2
	9-02	PROF monitoring	PROF monitoring equipment, garage, diagnos-tic, etc.	G PROF	9 M&C	5.5
Automatic dispensers	10-1	PROF dispenser	PROF non-cooled, hot drinks and food, coffee, tea, etc.	A LHA	10 Disp	89.1
	10-2	PROF dispenser	PROF cooled, vending food, bottles, cans, can-dy, etc.	G PROF	10 Disp	92.2