D Case Study / Switzerland: E- waste management

Dr. Mathias Schluep

Federal Laboratories for Materials Research and Technology (Empa), Technology & Society Lab

Table of Contents

D 1.Background and objectives

Introduction

The management of waste electrical and electronic equipment (WEEE), or e-waste for short, is a rather recent task on the agenda of organisations responsible for waste management. Experiences around the globe have shown that the usual waste manager, the municipality, is not adequately equipped to handle a complex waste stream such as obsolete electrical and electronic equipment (EEE). Mainly two new paradigms, however, started to change the management of e-waste: the "closed loop economy" and the "extended producer responsibility (EPR)". Some countries mainly in Europe (e.g. Switzerland, Netherland and Belgium) started to experiment with new approaches in managing this hi-tech waste stream more than twenty years ago. Soon a new international framework took shape and the roles of important stakeholders along the 'end of life path' of WEEE evolved: producers accepted the end of life responsibility for their products and initiated **p**roducer **r**esponsible **o**rganisations (PRO) to manage the material flows and the financing of unprofitable processing steps; the recycling industry went through a rapid evolution where specialists emerged amongst others for manual dismantling, mechanical processing or final refining of secondary raw materials; the legislators carefully developed regulations defining responsibilities and promoting a constant improvement of the systems efficiency; and last but not least the consumer, from the big corporate to the small household, who increasingly wanted a convenient and sustainable option to dispose of e-waste.

In developing countries and emerging economies this new paradigm shift did not seem to take place until recently. Disturbing news from NGOs such as The Basel Action Network (Puckett et al. 2002; Puckett et al. 2005), (Agarwal et al. 2003) or Green Peace (K. Brigden et al. 2005; Kevin Brigden et al. 2008) started to make their way to the mass media in the early 2000. Poor people in the slums of the mega cities in the South tried to recover valuables from the e-waste stream and put themselves and their environment at risk (Sepúlveda et al. 2010). As a result governments in these countries started to move WEEE up in their priority list of environmental issues, which need special legislative attention. In

addition, various international cooperation projects were launched, such as the Swiss e-Waste Programme, a pioneering initiative launched by the Swiss State Secretariat of Economic affairs with the aim to build “global knowledge partnerships in e-waste recycling” including China, India and South Africa (Widmer, Oswald-Krapf, et al. 2005; Widmer, Schluep, et al. 2008). Meanwhile the E-waste topic is a high priority area within the Basel Conventionand also within Strategic Approach to International Chemicals Management (SAICM). Furthermore the Stockholm Convention has started to address E-waste for management of polybrominated diphenylether containing material streams. Between 2007 and 2010 various international cooperation projects were launched by multilateral organizations (e.g. the Basel Convention Secretariat, SAICM, producers from the ICT (Information and communications technologies) industry, NGOs and governmental organizations.

WEEE Definition

WEEE or e-Waste is often misunderstood as comprising only computers and related IT equipment. According to the OECD, e-waste is ‘‘any appliance using an electric power supply that has reached its end-of life’’. In this chapter, WEEE and e-waste are used as synonyms, and include all the 10 categories (**Fehler! Verweisquelle konnte nicht gefunden werden.**) as specified in the EU WEEE directive (European Union 2012) which has become the most widely accepted classification.

Objectives of WEEE management

E-waste is usually regarded as a waste problem, which can cause environmental damage if not dealt with in an appropriate way. However, the enormous resource impact of EEE is widely overlooked. EEE is a major driver for the development of demand and prices for a number of metals as shown in Table 1. Consequently inappropriate disposal of e-waste not only leads to significant environmental problems but also to a systematic loss of secondary materials (Hagelüken & Meskers 2008). Hence the appropriate handling of e-waste can both prevent serious environmental damage and also recover valuable materials.

Besides the positive impact on resources, state of the art recycling operations also contribute to reducing greenhouse gas emissions. Primary production, i.e. mining, concentrating, smelting and refining, especially of precious and special metals is energy intensive and hence has a significant carbon dioxide (CO_2) impact. “Mining” our old computers to recover the contained metals – if done in an environmentally sound manner – needs only a fraction of this energy input (Hagelüken & Meskers 2008).

Table 1: Classification of WEE according to EU WEEE Directive (European Union 2003b)

No.	Category
1	Large household appliances
2	Small household appliances
3	IT and telecommunications equipment
4	Consumer equipment
5	Lighting equipment
6	Electrical and electronic tools (with the exception of large-scale stationary industrial tools)
7	Toys, leisure and sports equipment
8	Medical devices (with the exception of all implanted and infected products)
9	Monitoring and control instruments
10	Automatic dispensers

Furthermore, the environmentally sound management of end-of-life refrigerators, air-conditioners and similar equipment is significant in mitigating the climate change impact. The ozone depleting substances in these devices, such as chlorofluorocarbon (CFC) and hydrochlorofluorocarbons (HCFCs) (and fluorocarbons FCs & hydrofluorocarbons HFCs), have a very high global warming potential.

Hence the main services a comprehensive WEEE or e-waste management system has to deliver in order to ensure sustainability are (a) collection of e-waste, (b) recovery of valuables such as secondary raw materials and (c) segregation and safe disposal of hazardous waste. Costs for unprofitable processes as well as administration, monitoring and control to ensure quality have to be associated with all of these activities.

Table 1: Important metals used for electrical and electronic equipment (Schluep et al. 2009)

Metal	Primary production*	Byproduct from	Demand for EEE	Demand/ production	Main applications
	t/y		t/y	%	
Ag	20,000	(Pb, Zn)	6,000	30	Contacts, switches, solders…
Au	2,500	(Cu)	300	12	Bonding wire, contacts, integrated circuits…
Pd	230	PGM	33	14	Multilayer capacitors, connectors
Pt	210	PGM	13	6	Hard disk, thermocouple, fuel cell
Ru	32	PGM	27	84	Hard disk, plasma displays
Cu	15,000,000		4,500,000	30	Cable, wire, connector…
Sn	275,000		90,000	33	Solders
Sb	130,000		65,000	50	Flame retardant, CRT glass
Co	58,000	(Ni, Cu)	11,000	19	Rechargeable batteries
Bi	5,600	Pb, W, Zn	900	16	Solders, capacitor, heat sink…
Se	1,400	Cu	240	17	Electro-optic, copier, solar cell
In	480	Zn, Pb	380	79	LCD glass, solder, semiconductor
Total			4,670,000		

*based on demand in 2006; acronyms: PGM= Platinum Group Metals; CRT= Cathode Ray Tube; LCD= Liquid Crystal Display

D.2 Approach and implementation

The only tested formal e-waste management systems adhering to sustainability and extended producer responsibility principles are currently almost exclusively found in OECD countries (Deepali Sinha-Khetriwal et al. 2009; Deepali Sinha-Khetriwal et al. 2006; Ongondo et al. 2011).The European WEEE Directive (European Union 2003b), based on the concept of an extended producer responsibility (EPR) as an environmental policy, has set the global pace and standard in regulating e-waste management (Figure 1). A sister directive with the WEEE is the RoHS Directive (European Union 2011), which aims at reducing the environmental impact of EEE, by forbidding certain quantities of specified hazardous material in certain products.

While the WEEE Directive targets the end-of-pipe the RoHS Directive clearly targets the beginning-of-pipe of the EEE life cycle. Both had to be transposed to national laws which increased the possibilities to accommodate national peculiarities but also increased the complexity for global producers to cope with dozens of deviations in the implemented procedures throughout the EU (Huisman et al. 2008). Several European countries had started to implement WEEE management policies before the EU

WEEE Directive came into force. One of the oldest legislative frameworks is the Swiss “Ordinance on the return, the taking back and the disposal of electrical and electronic appliances” (ORDEA) (Schweiz. Bundesrat 2004). It’s principles of defining stakeholder’s obligation is presented in Figure 2

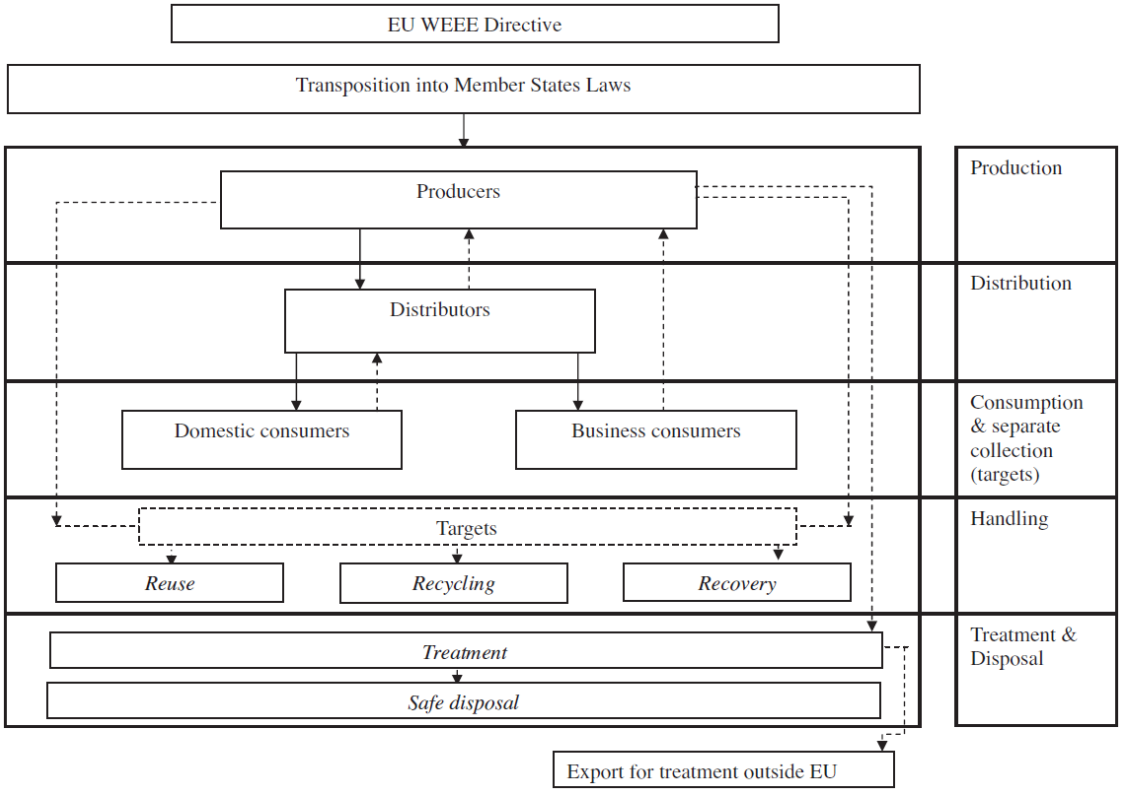

Figure 1: Simplified overview of the EU WEEE Directive (Ongondo et al. 2011)

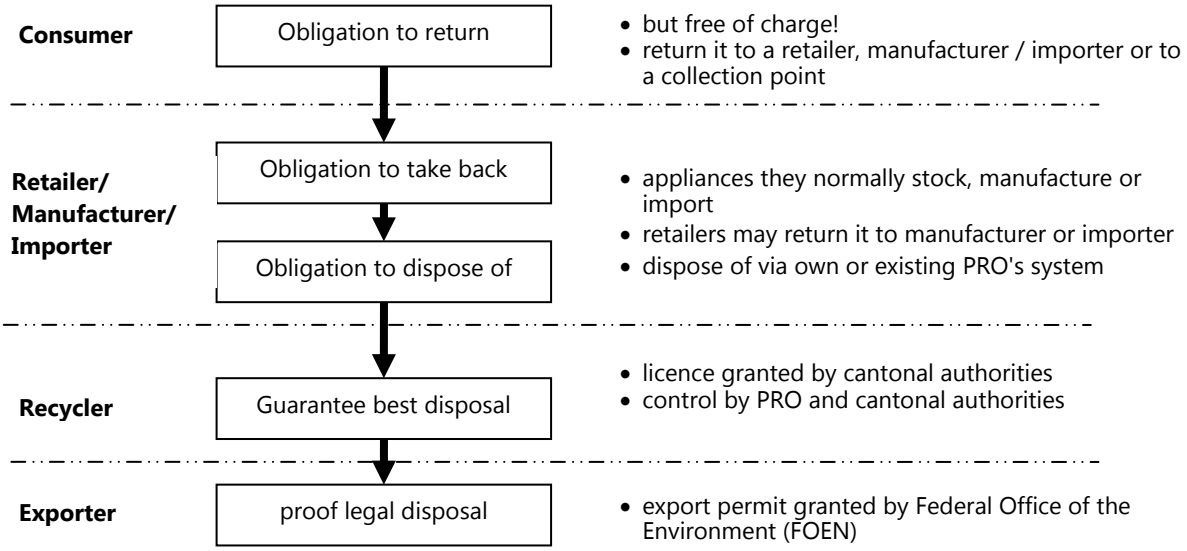

Figure 2: Schematic explaining the various stakeholders’ obligations according to the Swiss WEEE legislation ORDEA (Widmer, Schluep, et al. 2008)

Although the quantity of domestic e-waste per head is still relatively small in developing and transition countries, populous countries such as China and India are already huge producers of e-waste (Schluep et al. 2009). These countries also display the fastest growing markets for EEE, as well as the ones that are far from saturation (Yu et al. 2010). On top of WEEE generated out of domestic consumption, a considerable amount is – intentionally or unintentionally – imported via the trade of used EEE (Schmidt 2006).

In these countries a large, mostly urban workforce of cheap and unskilled workers is abundantly available. This allows for the creation of many jobs in this partly profitable waste stream but also poses a considerable threat as they often miss the needed know-how and technologies for a safe operation (Sepúlveda et al. 2010). Often this is amplified by the lack of suitable laws and their enforcement leading to a 'laisser faire' on all responsible sides resulting in for instance 'cherry picking' by the recyclers (get the best dump the rest) (D. Sinha-Khetriwal et al. 2005). Most of the participants in this sector are not aware of associated risks and do not know better practices or have no access to investment capital to finance even profitable improvements or implement safety measures.

Description of main activities with the emphasis on the fields of duty of the competent authorities

Key issues to consider for policy makers

In this section five key issues are explored, which are vital in any discussion about implementing e-waste management as e.g. demanded by the EU WEEE Directive. Each issue is related to EPR as a policy and is considered as an enquiry of how or what confronts a policy maker and the choices that may present themselves. The analysis is closely related to a study done for this purpose taking the Swiss experience as an example (Deepali Sinha-Khetriwal et al. 2009). The five key issues embrace:

1. Getting the system started: how to overcome inertia?
2. Securing financing: how to ensure that the system is financially sustainable?
3. Getting the collection logistics right: what should the scope and logistics arrangement of a system be?
4. Ensuring compliance: how to ensure all actors fulfil their responsibilities?
5. Restricting monopoly: how to prevent anti-competitive practices?

These issues, while by no means the only issues that a policy maker needs to consider, should provide some guidance in evaluating policy alternatives. It is believed that these five issues encapsulate the most relevant questions and provide a broad framework upon which further discussions can be based.

Getting the system started

Policy makers and producers, both grapple with the dilemma over who should take the first step. Should the policy first be in place before producers will be forced to follow? Or should the producers pre-empt policy, especially in the context of EPR, because policy deliberations are lengthy?

In Switzerland a producer led take back scheme for WEEE was started before legislation was in place. It began with a small loan from the producers associations to finance the initial year of operations, and only a few major companies, including major as participants. In a decade, this membership has grown to encompass most of the producers present in the Swiss market. There are similar instances in Sweden, Belgium, Norway and Netherlands where EEE producers have established take back system in advance of government or the EU WEEE Directive.

The benefit of having a working system in place before legislation was introduced meant that the producers had the chance to develop a system, which was both flexible and not as expensive. The Swiss experience shows that producers need not have to wait for the government to force them to

take responsibility for the end-of-life disposal of their products. Additionally, to get the system started, it is not practical to wait until all the producers are on-board. The critical mass is reached by a small group of large producers, mainly large multinationals, which dominate the market for EEE.

A pertinent question is whether this can be achieved in other countries as well? Given the global footprint of the EEE industry, and specially as it is dominated by large multinational corporations, it would be possible to easily transfer operational and system knowledge gained from setting up such voluntary systems as e.g. in Switzerland and apply them in other geographies.

This can work in OECD countries where new systems mostly are able to hook onto available e-waste management infrastructure. Developing countries generally lack such infrastructure and hence corporate take back systems are hard to implement without the backing of a strong legislative framework. In addition, in many developing countries, OEMs (Original Equipment Manufacturers) are not represented physically and often have little control over importing companies and second-hand imports. Therefore they have limited possibilities to influence and control the end-of-life management of their branded products. Hence challenges and mechanisms for the implementation of sustainable take-back systems are different to those known from experiences in industrialized countries.

Securing financing

One of the reasons why EPR is becoming popular as a policy measure to manage complex waste streams is because it does not place any financial burden on the local government. However, there are costs involved in the collection, transportation, sorting, dismantling and environmentally safe recycling of the waste. In case the intrinsic recoverable value is not enough to meet these processing costs, additional income streams are required. Moreover, recent studies reflecting the all-time high raw material prices and the economic conditions of developing countries suggest that also if recycling businesses can be run by relying on the intrinsic value of the treated material only, changing conditions can pose relevant risks to the business (Blaser & Schluep 2011). Hence some kind of financing safety net, which can be activated once unfavourable conditions prevail, needs to be in place in any e-waste management system. The questions that immediately arise are who should pay, how much, and at which point so that the system is financially stable and can meet its operating expenses.

Recycling fees is one possible mechanism often applied in OECD countries. Fees can be collected at two points - at the time of purchase, or at the time of disposal. In the Swiss system advance recycling fees (ARF) are collected. The Swiss ARF is in fact an intergenerational contract between appliances purchased in the past and those that are purchased in the present, akin to a pension system. The fees collected in the present are used to pay for appliances purchased in the past and being disposed of now. Similarly, when the appliances purchased today are disposed of in the future, their recycling cost will be met by the fees charged on a new generation of products being sold at that time. A fee can be collected in two ways: (a) as a visible fee, that is explicitly mentioned as an additional component in the price of the product or (b) as an invisible fee, where the product price includes the fee, without explicit information on its value.

The Swiss legislation for example does not stipulate whether a recycling fee is to be charged or not, or who should pay how much or when. The advantage of letting market forces dictate the financing of the system is a more responsive system that is able to adapt quickly to shifting market dynamics. Additionally, without financial stipulations, the system is more competitive because it gives producers and PRO's the choice on how to secure financing - how much to charge and when - for the take back and recycling.

Hence policy makers need to be cautious in pre-defining financing mechanism directly in their legislative framework. Complimentary control mechanisms need to be in place to ensure the transparent collection and utilisation of collected funds. If not, there is the danger that unscrupulous agents could abuse the system by charging recycling fees from the consumer for proper disposal, but

instead selling the e-waste to recyclers who pay the highest price and not necessarily follow sound disposal practices.

Getting the collection logistics right

The logistical implementation of an EPR policy is a hotly debated topic, especially when it comes to whether it should be an individual or collective take back system, what should be done about historical and orphan products whose producers have ceased to exist and which products to bring under the EPR purview. These questions are raised often by both policy makers and producers when formulating EPR based policies.

A collective take back system is all-inclusive that does not differentiate between different brands of a product type. Individual take back systems are brand-specific, catering only to different products of one particular producer. Both approaches have their advantages and drawbacks. The advantages of a collective system are two-fold. Firstly, especially for small countries and/or small WEEE volumes, this allows for better efficiency by building economies of scale. Secondly, a collective system is often more consumer-oriented, taking into consideration consumers' habits, who would find it more convenient to bring all their various e-waste items to one place rather than have to go to different places for different brands.

The main drawback of a collective system is the lack of competition. However competition can also be ensured on alternative levels by regularly tendering the various tasks of a system (transport logistics, recycling, etc.). Still producers usually want to have a choice to fulfil their obligation of WEEE management through either individual and/or collective schemes as they see it fit best under the given circumstances. For the development of a legislative framework it is therefore suggested that policy makers should concentrate on defining the producer's obligation and leave it open to them how to comply.

D.3 Conclusions and Lessons learned

As mentioned before, developing and transition countries often face completely different challenges than OECD countries. This demands to put special attention to the main issues specially related to the implementation of e-waste management systems in developing and transition countries. However it is thought that the general goal of e-waste management should not differ from the EPR approaches taken in OECD countries. The five key issues when applying EPR as a policy as discussed above need to be considered as well and systems need to achieve the same international standards for sound e-waste management as prescribed e.g. under the EU WEEE Directive.

As a result of experiences made in the Swiss e-Waste Programme (Widmer, Schluep, et al. 2008) and further international collaboration projects, especially in Africa, the main issues related to an improvement of the current e-waste management practices encountered in developing and transition countries were summarized in the Durban Declaration (WasteCon 2008). Stakeholders from various African and European countries classified those issues sufficiently generic and of equal concern to the other developing and transition countries. The declaration avoids the formulation of ready-made implementable solutions as it was agreed that every country requires its own process to define a roadmap related to specific projects. The suggested recommendations are as follows:

- improve cooperation among stakeholders (a) by ensuring the right level of representation in relevant international fora (e.g. Solving the E-waste Problem (StEP), Pacific-Europe Network for Science and technology (PACE-Net), (b) by establishing regional platforms and/or an e-waste forum in cooperation with established regional networks and international bodies, and (c) by identifying with relevant initiatives, learning from them and utilising their expertise;
- establish an institutional framework (a) by initiating a suitable process that will accommodate negotiation amongst relevant stakeholders within local, national, regional and global levels,

and (b) by identifying and/or creating appropriate institutions to allocate the responsibilities, objectives and schedules within the e-waste sector;

- create awareness at all levels of governance and the general public (a) by making information available through appropriate means (e.g. websites, training, campaigns), and (b) by identifying and targeting the right audience with tailored solutions (e.g. schools, vocational/technical institutes, the informal sector, governments, and the general public) towards commitment to sustainable e-waste management;
- support markets (a) by identifying, quantifying, and evaluating existing down-stream material markets and alternative material flows, (b) by sharing of information on new technologies for optimized resource recovery, and (c) by promoting fair local e-waste markets wherever possible;
- collect and manage data (a) by establishing a process for data acquisition which allows for design, monitoring and control of e-waste management, (d) setting up a mechanism for continuous update of these data, and (c) by using data for transparent decision making and system improvements;
- develop a legal framework (a) by reviewing existing legislations in order to enforce sound e-waste management, (b) by highlighting permitting or licensing requirements for improved compliance to existing legislation, (c) by promoting policies that meet the minimum of legislative requirements, (d) by implementing a system of minimum requirements, and (e) by amending existing waste management legislation to allow for a regulation on e-waste management;
- develop a qualified and efficient e-waste recycling sector (a) by documenting tested and best available processes and practises, (b) by developing and improving skills and competencies through training, (c) by satisfying the need for business models to ensure appropriate investments on the right technological and geographical level, (d) by connecting existing and new processes in the e-waste stream in so-called green e-waste channels, and (e) by ensuring continuous improvement of the infrastructure through the establishment of standards and auditing procedures.

D.4 Guidance materials available

D.5 References cited in the chapter

Agarwal, R., Ranjan, R. & Sarkar, P., 2003. Scrapping the hi-tech myth: computer waste in India, New Delhi: Toxics Link.

Blaser, F. & Schluep, M., 2011. Current situation and economic feasibility of e-waste recycling in Morocco, St.Gallen / Switzerland: Empa.

Brigden, K. et al., 2005. Recycling of electronic waste in china and india: workplace & environmental contamination, Greenpeace International.

Brigden, Kevin et al., 2008. Chemical contamination at e-waste recycling and disposal sites in Accra and Korforidua, Ghana, Amsterdam, The Netherlands: Greenpeace International. Available at: http://www.greenpeace.org/raw/content/international/press/reports/chemical-contamination-at-e-wa.pdf.

European Union, 2011. EU directive 2011/65/EU of the European Parliament and of the Council of 08 June 2011 on the Restriction of the use of certain Hazardous Substances in Electrical and Electronic Equipment (RoHS).

European Union, 2012. EU Directive 2012/96/82/EC of the European Parliament and of the council of 24 July 2012 on waste electrical and electronic equipment (WEEE).

Hagelüken, C. & Meskers, C., 2008. Mining our computers- opportunities and challenges to recover scarce and valuable metals from end-of-Life electronic devices. In Electronics Goes Green 2008+. Reichl H., Nissen N.F., et al. (eds): Stuttgart: Fraunhofer IRB Verlag, 2008, ., pp. 623-628.

Huisman, J. et al., 2008. 2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipment (WEEE), Final Report, United Nations University.

Ongondo, F.O., Williams, I.D. & Cherrett, T.J., 2011. How are WEEE doing? A global review of the management of electrical and electronic wastes. Waste Management, 31(4), pp.714 - 730.

Puckett, J. et al., 2002. Exporting harm, the high-tech trashing of Asia, Seattle, WA., USA: The Basel Action Network (BAN)Silicon Valley Toxics Coalition (SVTC).

Puckett, J. et al., 2005. The digital dump, exporting re-use and abuse to Africa, Seattle, WA., USA: The Basel Action Network (BAN).

Schluep, M. et al., 2009. Recycling - from e-waste to resources, Sustainable innovation and technology transfer industrial sector studies, Paris, France: Empa, Umicore, UNU.

Schmidt, C.W., 2006. Unfair trade - E-waste in Africa. Environmental Health Perspectives, 114, p.A232-A235.

Schweiz. Bundesrat, 2004. Ordinance of 14 January1998 on the return, the taking back and the disposal of electrical and electronic equipment (ORDEA). Available at: http://www.umwelt-schweiz.ch/imperia/md/content/abfall/vreg_2004_e.pdf.

Sepúlveda, A. et al., 2010. A review of the environmental fate and effects of hazardous substances released from electrical and electronic equipments during recycling: Examples from China and India. Environmental Impact Assessment Review, 30(1), pp.28–41.

Sinha-Khetriwal, D., Kraeuchi, P. & Schwaninger, M., 2005. A comparison of electronic waste recycling in Switzerland and in India. Environmental Impact Assessment Review, 25, pp.492-504.

Sinha-Khetriwal, Deepali, Kraeuchi, Philipp & Widmer, R., 2009. Producer responsibility for e-waste management: Key issues for consideration - Learning from the Swiss experience. Journal of Environmental Management, 90(1), pp.153-165.

Sinha-Khetriwal, Deepali et al., 2006. Legislating e-waste management: progress from various countries. elni Review, 1+2/06, pp.27-36.

WasteCon, 2008. The Durban Declaration on e-Waste Management in Africa.

Widmer, R., Oswald-Krapf, H., et al., 2005. Global perspectives on e-waste. Environmental Impact Assessment Review, 25, pp.436-458.

Widmer, R., Schluep, M. & Denzler, S., 2008. The Swiss Global e-Waste Programme. In Waste Management Conference (WasteCon2008). Durban, South Africa.

Yu, J. et al., 2010. Forecasting Global Generation of Obsolete Personal Computers. Environmental Science & Technology, 44(9), pp.3232-3237.