Chapter 6

Greening the Trade of Recyclable Materials: Recycling Certification for Improved E-waste Management in East Asia

Yoshiaki Totoki, Yasuhiko Hotta, Chika Suzuki-Aoki,
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Key Messages

- E-waste is growing in Asia, coupled with environmental and health concerns due to inappropriate recycling.
- This chapter explores ways to address hazardous e-waste recycling and argues that establishing a safe, responsible international trade would be more productive than merely discouraging the transboundary movement of e-waste.
- E-waste management capacity varies throughout Asia; establishing a regional resource circulation system via division of labour would be more efficient than creating complete recycling systems in each country.
- To ensure environmentally sound regional resource circulation, we need to identify and nurture high-standard recyclers and to develop traceability systems throughout the recycling chain, for which recycling certification schemes with high standards and proper compliance monitoring would help.

1. Introduction

1.1 E-waste as a regional environmental challenge

The amount of e-waste generated and traded across borders in Asia is increasing, and the capacity for safe treatment is far below the needs. As a result, huge volumes of e-waste are treated with primitive, low-cost methods, exposing people to harmful substances and polluting the environment. Regional economic integration, i.e., the systematic removal of barriers to trade, can facilitate further increases in such transboundary flows. Regional solutions are needed for dealing with these challenges. This chapter reviews policy responses, recycling and waste treatment capacity, and offers suggestions on how to improve the current unsustainable situation.

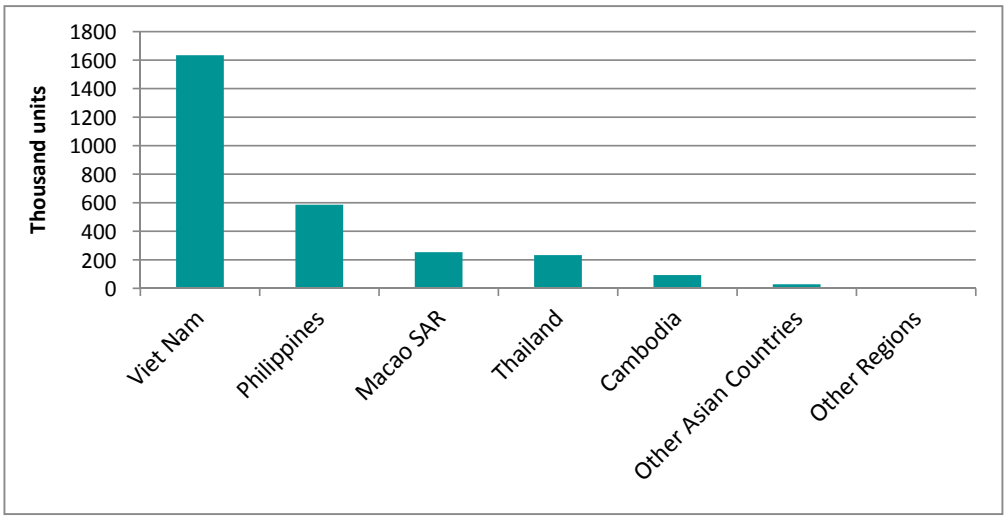
Along with the rapid economic growth, industrialisation and urbanisation in Asia over recent decades results in the growing need for resources in developing countries. According to the United Nations Environmental Programme (UNEP 2011), "the Asia-Pacific region accounted for 80% of the growth in world material use over the 35 years to 2005" (p.25). Growth and urbanisation means higher levels of production

and consumption of goods, as more developed and emerging economies with richer populations can afford to consume goods such as electronic products in larger volumes and with higher turnover rates, thus resulting in increased generation of waste and used goods. For example, the switch to digital TV broadcasts in Japan in 2011 created demand for new state-of-the art products such as flat-screen TVs, making the older Cathode Ray Tube (CRT) sets obsolete waste. Such turnover of obsolete or used goods generates huge amounts of waste but also valuable recyclable resources that in some cases can be used to help meet increased resource demands. These recyclable resources are being traded in increasing amounts. Secondary resources and second-hand goods play a significant role in fulfilling demand for affordable resources and goods in rapidly growing resource- and goods-consuming regional economies. Here, regional economic integration has played an important role because most recyclable secondary resources such as waste plastic, waste paper, scrap iron, copper, and aluminium generated in Asia have been traded within the region (Michida 2010).

Of the recyclable materials, problems associated with e-waste (or WEEE: Waste Electrical and Electronic Equipment) has received particular attention in Asia. E-waste includes end-of-life and used electronic and electrical appliances, used parts, and mixed metal scrap from electronics or other industries and usually comprises valuable as well as hazardous substances—such as lead, mercury and brominated fire-retardants. Concerns therefore surround the possibility of these hazardous chemicals being emitted into the environment due to inappropriate recycling processes (Tsydenova and Bengtsson 2011; Puckett et al. 2002).

Asia generates e-waste from domestic consumption of new electrical appliances at all levels of society, ranging from the individual, to businesses, governmental institutions and industry. For example, Viet Nam was projected to discard 17.2 million items—personal computers (PCs), TVs, air-conditioners, refrigerators, and washing machines—in 2010 (Nguyen et al. 2009) and China was expected to discard 71.9 million PCs, 58.3 million TVs, 12.4 million air-conditioners, 9.67 million refrigerators, and 11.6 million washing machines in the same year (Li et al. 2006).

The high demand for electrical appliances is also met by imported Used Electrical and Electronic Equipment (UEEE). For example, Japan exported more than 2.8 million used CRT TVs in 2011, mainly to the Philippines, Viet Nam and the Macao Special Administrative Region (SAR) in China (Trade Statistics of Japan) (see Figure 6.1). Japan also exported 2.79 million laptops (new and used) to other countries in 2013. Of these, 1.97 million units were considered as second hand products and 93% were exported to Hong-Kong SAR in China, and then transferred onwards (Kobyashi 2014). UEEE products are those likely to have short lives and to become waste relatively early. Consumers in importing countries utilise the remaining life of such second hand equipment within a few years and generate e-waste. Hence, the UEEE trade has contributed to generation of e-waste in the importing countries.



Source: Trade Statistics of Japan (for year 2011)

Figure 6.1 ***Used CRT-TVs exported from Japan to other countries in 2011***

Some e-waste may be traded as mixed metal scrap to satisfy developing Asia's thirst for resources. This scrap can comprise by-products of the pressing process of electronic industries, failed parts, and undismantled end-of-life electronic and electrical appliances. Asia is one of the destinations for international trade in e-waste or scrap containing materials originating from electronic and electrical appliances, and e-waste is also traded within the region for reuse/recycling purposes, such as from Mong Cai in Viet Nam to China (Yoshida et al. 2012). Thailand also functions as a transfer hub of regional UEEE to neighbouring countries such as Cambodia, Myanmar, and Lao PDR (Sasaki 2013). These facts overturn the previously held belief that e-waste flows mainly from industrialised to least developed countries.

Under the current Basel Convention, much controversy over the trade of potentially recyclable resources, one of which is e-waste, has surfaced. This has prompted discussion for drafting the Basel Ban Amendment, designed to prohibit the export of hazardous waste from developed to developing countries. Some countries party to this convention, however, assert that an outright ban on hazardous materials trading may disrupt sound international resource circulation systems. To address this issue, Indonesia and Switzerland initiated the Country-Led Initiative (CLI) to supplement the Basel Convention, which was adopted at the 10th Conference of the Parties of the Basel Convention in October 2011. This initiative aims to clarify what exactly constitutes hazardous waste subject to the export ban from developed to developing countries and to allow recyclable resource circulation. Discussions on establishing an international standard for environmentally sound management (ESM) of hazardous wastes and potentially recyclable resources are underway by the expert working group on environmentally sound management related to CLI. The issue is also being addressed by UNEP (2013), which allows exporting of hazardous waste from countries that lack adequate sound e-waste management capacity to countries with such capacity. What exactly constitutes 'sound' relates to environmental impact, for which the expert working group drafted a practical manual of certification schemes in May, 2014, in order to codify the distinction (UNEP 2014).

Some recent studies reveal that trade in recyclables, especially e-waste, has become more complex (Michida 2010; Lepawsky and MacNabb 2010; Lepawsky 2015). By analysing trade statistics of electronic scrap, Lepawsky (2015) even argues that trade from non-OECD countries (i.e., developing countries) to OECD countries increased and become the dominant direction of trade from 1996 to 2012. Thus, a more nuanced approach than a simple ban in trade would appear necessary to green the trade in recyclable materials.

1.2 Objectives

This chapter aims to provide suggestions as to regional role sharing in e-waste management to address environmental issues created by increased uncontrolled waste flows in Asia. One such suggestion is to implement international recycling certification for e-waste management. This chapter also attempts to combine 'top-runner' and 'bottom-up' approaches to establish sound international recycling based on international recycling certification. In order to promote the implementation of recycling certifications and regional role sharing for e-waste management, creation of an international fund for sustainable resource management as an incentive system is also discussed.

2. Regional role sharing for e-waste management

2.1 E-waste recycling chain

The recycling chain for e-waste generally comprises several steps: collection, dismantling, resource recovery and transportation (see Figure 6.2). The recyclers are typically collection traders, dismantlers and material recyclers such as smelters and transporters. The sources of e-waste are the actual consumers of electrical equipment—individuals, commercial facilities, offices as well as industrial manufacturers producing electrical equipment or related components and generating scrap from manufacturing processes.

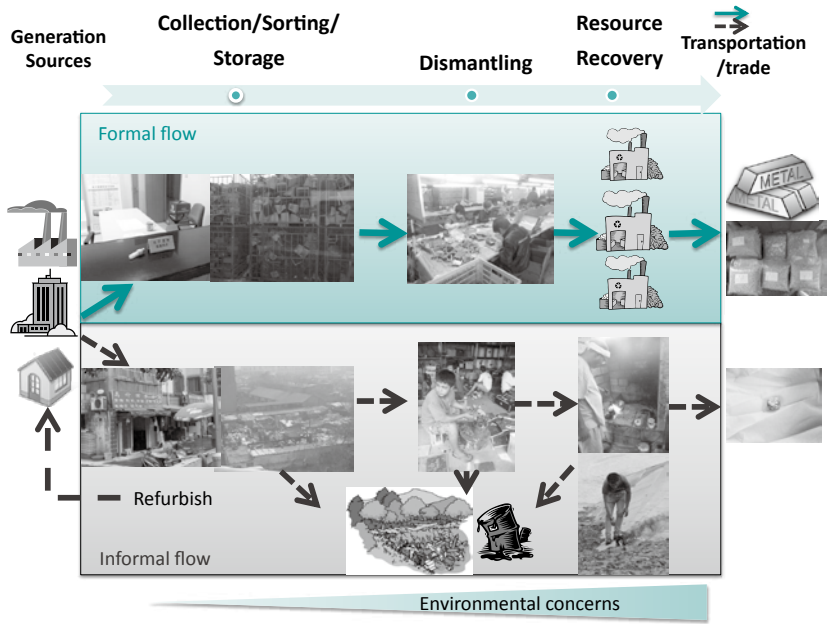


Figure 6.2 ***Recycling chain for e-waste***

Collection of e-waste from generation sources is an important activity as it determines the amount of materials actually available for recovery, and such determination is itself complex due to the presence of both formal and informal collection means. Informal sectors such as junk shops and scrap dealers collect e-waste from consumers in countries without formal collection systems for refurbishing or repairing and resource recovery. The collected e-waste are sorted and transported to the dismantling step. Collection, sorting and storage activities generally have minimal environmental concerns and do not require advanced technologies to handle e-waste safely.

Dismantling segregates the components for further resource recovery processing, and parts containing hazardous substances have to be removed and stored or treated in an environmentally sound manner with appropriate technologies, while the valuable substances need to be removed for efficient recovery processing. Formal dismantling processors need to identify environmentally sensitive components such as batteries, capacitors, ozone-depleting substances (mainly from refrigerators and air-conditioners), CRT glass, mercury-containing backlights from flat-panel displays and printed circuit boards and then dispose of them safely. On the other hand, informal dismantling processes focus on the valuable components for re-sale and material recycling, with the residual wastes often disposed of nearby. Such residual wastes are often burned in the open to reduce volume, generating toxic fumes that affect nearby populations. Further, burning plastic wiring sheaths and other parts may also generate toxic gases that affect unprotected workers at these locations.

For metal recovery, there are three major destinations: the ferrous fractions is transferred to steel plants for recovery of iron; aluminium is sent to aluminium smelters; and copper and other precious metals are sent to integrated metal smelters that can recover precious metals, copper and other non-ferrous metals (Schluep et al. 2009). In order to prevent environmental pollution during the smelting process, such as of volatile organic compounds (VOCs) and dioxins generated in the combustion of printed circuit board and organic components such as paint layers and flame retardants in plastic particles, smelters need to utilise advanced technologies for gases and strong acidic leaching effluents in the system. However, copper smelters and hydrometallurgical plants are not usually designed for such specialised treatment.

For plastic or glass recovery, the fraction containing these materials must be sent to appropriate facilities. Standard recycling technology can handle plastics and glass only if hazardous substances are not present. If present (e.g., lead in CRT glass, flame retardants in plastic resins), they need segregating and treating using appropriate processes.

The resource recovery process generally generates higher economic returns than the collection or dismantling processes, but does require advanced pollution control technologies to ensure environmental protection and work safety. Not all countries in the region have such facilities for environmentally sound resource recovery, and the process is usually performed on a small-scale, informal basis with low recovery rates and high risks of environmental pollution. For example, the Basel Action Network has reported serious environmental pollution in China, India and Pakistan caused by inappropriate recovery of valuable metals such as gold and copper (Puckett et al. 2002). Figure 6.3 summarises the flow of informal recycling sectors in India and China (Brigden et al. 2005).

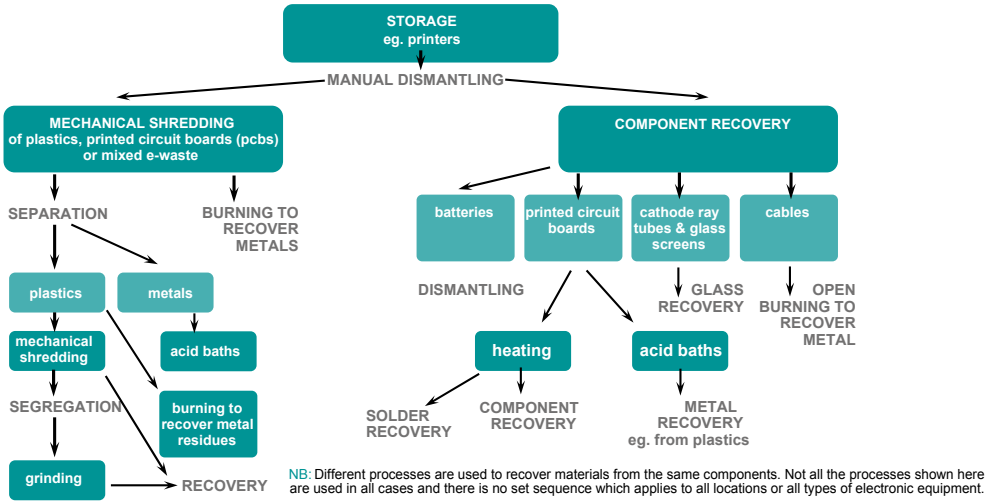


Fig. 4. WEEE recycling processes in India and China. Reproduced from Brigden et al. (2005) with permission from Greenpeace International.

Source: Brigden et al. 2005

Figure 6.3 E-waste recycling practices in India and China

2.2 E-waste management capacity

E-waste management capacity in Asia varies by country in terms of institutional and physical infrastructure.

Most Asian countries lack proper institutional frameworks and recycling infrastructure or capacity for sound treatment of e-waste. Informal recycling of e-waste without proper environmental protection thus prevails and causes serious environmental problems (Schluep et al. 2009). Unfortunately, informal recycling generally has a competitive advantage over the formal one in the collection, dismantling, and smelting of e-waste, due to the cost savings of ignoring environmental protection and labour safety (Williams et al. 2013). Informal recycling and dismantling are often associated with physical dismantling and hazardous recycling operations such as ink toner sweeping, open burning, CRT cracking, circuit board recycling, acid stripping of chips, plastic chipping and melting and material dumping (Puckett et al. 2002; Yu et al. 2010; Chi et al. 2011), which often release hazardous materials such as lead, mercury and persistent organic pollutants such as dioxins and furans (Tsydenova and Bengtsson 2011; Brigden et al. 2008). Sound treatment of e-waste by the formal recycling sector requires not only recycling infrastructure and capacity but also effective governance and institutional frameworks based on the concept of extended producer responsibility (EPR) in order to establish an overall system composed of collection, transportation and treatment with proper financial consideration.

Countries can be classified into three groups based on their e-waste management capacity in terms of institutional framework, dismantling status and infrastructure for resource recovery, such as smelters (see Table 6.1).

Table 6.1 ***Categorisation of e-waste management capacity***

	Type 1	Type 2	Type 3
Institutional framework based on EPR policy for formal collection	○	×	×
Dismantling capacity	○	○	×
Infrastructure for resource recovery, such as smelters	○	△	×
Examples	Japan, China, Rep. of Korea, Taiwan, India, etc.	Thailand, Viet Nam, Philippines, Malaysia, etc.	Cambodia, Myanmar, Lao PDR, etc.
Remarks	Competition between formal and informal sector is high in some countries.	Integration of informal sector into formal recycling chain is the key. There is limited infrastructure for resource recovery such as smelting facilities.	Focus should be on the establishment of general waste management systems and formal collaboration on regional recycling for disposing of e-waste.

First are countries or a region with specific e-waste regulations. Japan, Republic of Korea, China, Taiwan, and India have introduced e-waste management laws based on the concept of EPR and established institutional frameworks covering collection, transportation, dismantling and material recovery of e-waste from individual consumers. Formal infrastructure for treatment of e-waste such as dismantling, recovery of recyclable materials and disposal of hazardous materials is also in place. In China and India, however, the informal sector is still dominant in the recycling market as the formal recycling chain usually collects and treats only a small portion of the generated e-waste despite the existence of formal recyclers specified for e-waste treatment.

Second are countries without specific e-waste regulations but with the potential infrastructure for resource recovery—countries categorised as in economic transition such as Thailand, Viet Nam, the Philippines, and Malaysia. E-waste is treated under a hazardous waste framework based on the 'polluter pays principle' (PPP), which mainly targets industrial waste rather than EPR. In these countries there is no scheme of collection from consumers. The numbers of electrical appliance consumers as well as domestic production of such appliances are significantly increasing, but apart from certain facilities for disposal of industrial waste (e-scrap from production processes), no formal collection system of e-waste from individual consumers generally exists. These countries generally rely on the informal sector for collection, dismantling, and limited resource recovery from e-waste and cannot perform the entire process of e-waste recycling alone due to lack of up-scale resource recovery facilities such as integrated smelters for metal recovery.

Third are countries without any institutional frameworks for e-waste management or infrastructure for resource recovery, and very limited dismantling capacity. They are usually least developed countries such as Cambodia, Lao PDR, and Myanmar. Currently they face no serious environmental issues related to e-waste and prefer to import cheap used electrical equipment to meet increasing demand. Since there are no recycling facilities, a practical solution to complete the recycling chain may be to export e-waste to other countries that have established proper facilities for resource recovery.

2.3 Regional role sharing for e-waste management

Given these conditions, a regional e-waste management system based on international role sharing along the recycling chain could be considered. Sharing roles in the recycling chain can be based on recycling processes such as the collection, dismantling, and resource recovery phase, and recycling capabilities in terms of institutional framework, dismantling capacity and infrastructure for resource recovery (Figure 6.4).

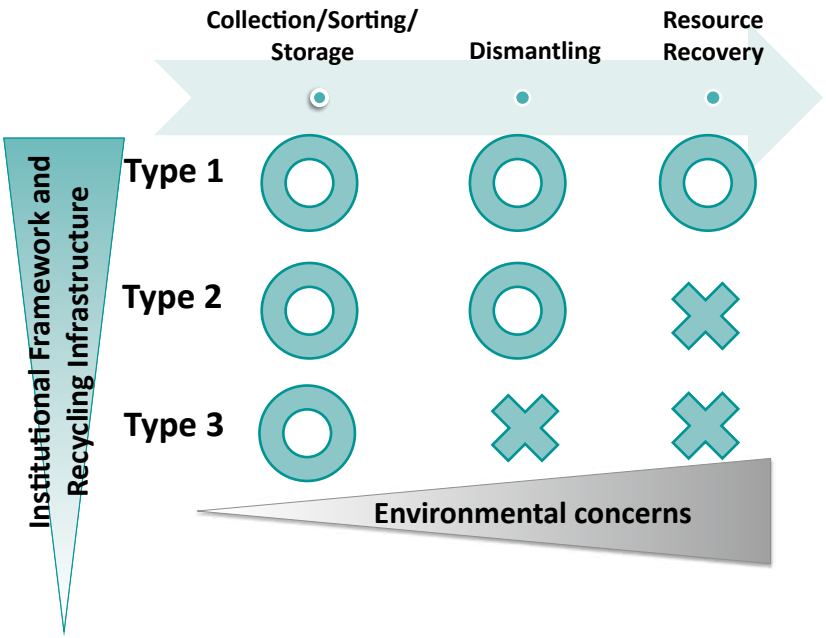


Figure 6.4 ***Viability of role sharing along recycling chain***

Type 1 countries can contribute to all the processes of collection, dismantling, and resource recovery. In particular, resource recovery represents the key to this regional role sharing since it requires advanced technologies and processes and involves no environmental pollution, labour, or health and safety issues.

Type 2 countries can contribute to collection and dismantling but not to resource recovery. They can also benefit from the informal sector in terms of any collection and dismantling systems already in place. The dismantling of e-waste is a labour-intensive process more suited to countries with low-cost workforces. Formalisation of existing informal sectors can help nurture the recycling industry in these countries. The advantage of establishing regional role sharing of e-waste management is not only in reduced environmental pollution from e-waste recycling but also job creation in the formal sector due to the conversion of informal recyclers into formal recyclers, with attendant income and health benefits.

Countries considered to be type 3 can make efforts in the collection and transfer of collected e-waste to other reliable countries under regional collaboration arrangements due to their lack of institutional framework and recycling infrastructure.

Figure 6.5 shows the envisioned concept of role sharing for the different country categories. As individual recyclers cannot complete all the recycling activities it is important to establish an environmentally sound e-waste recycling chain comprising collection, dismantling, and resource recovery, connected through transportation and trade of e-waste/dismantled components. Traceability up to the point of disposal is key throughout the process.

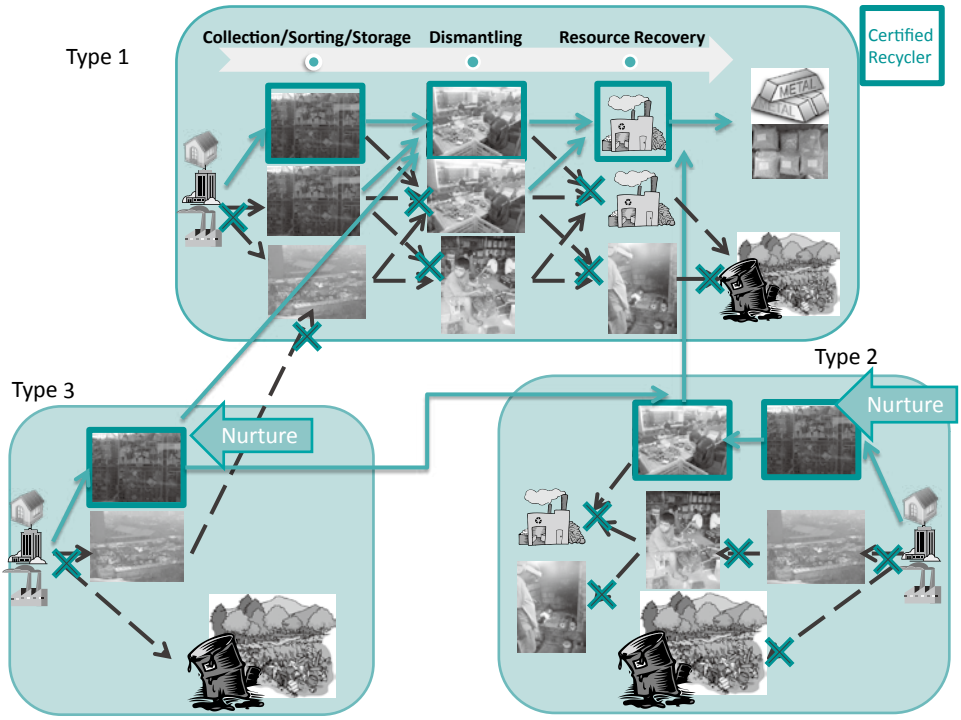


Figure 6.5 ***Image of improved e-waste management in Asia through the introduction of recycling certification***

2.4 A step to implement regional role sharing

There are only a limited number of countries with facilities to transform e-waste into recyclable resources, thus it is crucial to identify and nurture them for environmentally sound management whilst discouraging the environmentally unsound activities of informal recycling. Creating an international recycling network of quality recyclers is one way this could be done. To implement effective regional role sharing, responsible recyclers meeting international environmental and occupational health and safety management standards need to be identified for each stage of collection, dismantling and resource recovery. A traceability system also needs to be developed to avoid flows of e-waste to the informal recycling chain.

3. Recycling certification for waste management and regional resource circulation

International certification for recycling of e-waste can be an approach to help the region identify responsible recyclers and to develop traceability throughout the recycling chain (Hotta et al. 2008). This approach would be able to identify environmentally sound facilities and help nurture and support recycling businesses operating in an environmentally sound manner. Introduction of recycling certification at the regional level and support of establishing traceable recycling chain between qualified recycling businesses would improve resource efficiency and environmental protection through economies of scale in the region. Recycling certification can also help to reduce the burden on national governments in downstream management such as monitoring as well as to complement other procedures set out in the Basel Convention.

3.1 What is recycling certification for e-waste management?

The certification schemes discussed here are voluntary systems or standards to identify businesses that can appropriately manage and treat resources in recycling markets, through third party certification bodies or trading companies that can certify appropriate recycling businesses. Such certification would mean information on sound recycling businesses could become publicly available. This definition includes certification by affiliated industry groups (second-party certification) and third-party certification based on standardised specifications, but excludes certification via internal audits (first-party certification). Targeted e-waste under this scheme may cover two types of wastes— post-consumer waste and industrial waste. The former is generated from consumed products (including scrap) and the latter includes electric and electronic items/components derived from the by-products, industrial waste and business waste resulting from the production of electric and electronic items.

3.2 Existing recycling certification and standards for e-waste management

North America and Europe have already taken steps to develop certification systems to qualify recycling businesses for e-waste. The US Environmental Protection Agency (US-EPA) convened a multi-stakeholder process to develop responsible recycling practices for use in accredited certification programmes, which led to the Responsible Recycling (R2) solution in 2008, and in 2009, e-Stewards was established in the US, via the Basel Action Network. US-EPA recommends domestic recyclers to obtain R2 or e-Stewards certification (US-EPA 2013).

In Canada, the Electronics Product Stewardship Canada established the Recycler Qualification Programme (RQP) for end-of-life electronics recycling in 2010, the goal of which is to ensure sound management of end-of-life electronic products—safeguarding worker health and safety and environmental protection—from the point of primary processing to final disposition.

In Europe, the WEEE Forum, an association of 39 WEEE producer responsibility organisations, established a set of standards for management of waste electrical and electronic equipment (called WEEELABEX) for various recycling processes, including transport, sorting, storage, preparation for re-use, treatment and final disposal. The WEEE Forum's standards are to form the basis for European Standards (ENs), which are documents ratified by the European Committee for Electrotechnical Standardisation (CENELEC), a standards organisation. Once WEEELABEX is incorporated into ENs, this standard will act as the global benchmark for e-waste recycling.

While the extent of certification covering responsible recycling of e-waste is low, it is expected to grow (Chaplin and Annne 2013). Existing voluntary recycling certification for e-waste (e.g., Responsible Recycling and e-Stewards) requires environmental management as well as occupational health and safety management systems. As a minimum regulatory requirement, recycling certification system must ensure environmental, health and occupational safety throughout the recycling process.

Another key point is that recycling certification should focus on guaranteeing traceability throughout the recycling chain. This can be secured through a 'Chain of Custody' which combines the following two approaches. First is to record the quantity of recyclables and wastes received, recycled, disposed of and transported in each recycling process. Second is to ensure sound transactions and management of recyclables, through capacity assessment, audits, and written contracts for downstream actors by upstream actors in the recycling chain. Developing such custody chains would encourage domestic transactions and international trading of recyclable resources. In particular, country case studies and comparative analyses of existing voluntary recycling certification systems indicate that traceability and mass balance systems within the recycling chain serve as keys to satisfy informational demands and control point management (Hotta et al. 2013). Systems such as 'manifest' enable tracing of the waste stream in each treatment process. The 'mass balance' system involves keeping records of weight-based input/output data on materials such as metals entering and leaving treatment facilities.

These recycling certifications also identify the hazardous components and materials requiring caution during and after dismantling. R2 defines 'focus materials' of potential environmental concern and outlines the management of such to ensure environmental and worker safety (R2 Solutions 2013). e-Stewards also identifies components similar to problematic components and materials. WEEELABEX sets the standard for treatment by providing general requirements, including de-pollution guidelines to ensure treatment operators remove all liquids, substances, preparations, and components from waste electronics, etc. according to article 8(2) and annex II of directive 2002/96/EC (WEEE Forum 2013). WEEELABEX additionally provides specific requirements for components such as CRT displays, flat-panel displays and lamps.

Table 6.2 gives examples of hazardous components of R2, e-Stewards, and WEEELABEX. The common components are those containing PCBs (polychlorinated biphenyls) or mercury, CRTs, batteries and printed circuit boards. e-Stewards and WEEELABEX also list plastics with brominated flame retardants, toners/ink cartridges, radioactive devices/components, etc.

Table 6.2 ***Examples of hazardous components listed under R2, e-Stewards, and WEEELABEX***

R2 (Focus Materials)	e-Stewards (Problematic Components & Materials)	WEEELABEX
PCBs containing items	PCBs containing components	PCB containing capacitors, capacitors containing mineral or synthetic oil, electrolyte capacitors containing substances of concern
Mercury containing items	Mercury-containing components, including mercury lamps, LCD screens, switches, batteries and subcomponents	Mercury containing components
CRTs & CRT glass	CRTs	CRT displays (specific requirements)
Batteries	Lithium button, lithium ion, and lead acid batteries	Batteries and accumulators
Whole or shredded circuit boards	Printed circuit boards	Printed circuit boards
	Glycolant coolants (e.g., in old rear projection CRT devices) Toners, inks and toner/ink cartridges and their uncleaned cartridges Magnetrons in microwave ovens and other equipment, if containing beryllium oxide ceramic insulators Printer and copier drums and other components containing selenium and/or arsenic Radioactive devices or materials Any additional materials deemed hazardous, explosive, corrosive, or otherwise problematic for mechanical processing, by the organisation or applicable regulations	Plastics containing certain types of brominated flame retardants Volatile Fluorocarbons and volatile hydrocarbons Asbestos Flat panel displays (specific requirements) Components containing radioactive substances Lamps (specific requirements) Other components (toners, lamps, components containing refractory ceramic fibres, and oil)

3.3 Benefits of recycling certification

Applying the recycling certification system to Asia can facilitate regional role sharing for e-waste management as doing so would:

- Identify responsible recyclers, through registration, ensuring legal requirements such as facility compliance and import/export compliance are met, and provide protection measures for workers, public health and the environment. Certification organisations as second or third parties would verify the quality of recyclers based on international unified standards. Further, certified recyclers could easily locate reliable downstream processors to form effective national or international networks.

- Provide guidance in the management and technical standards for collection, dismantling and resource recovery, with special attention to treatment of materials of concern.

- Improve traceability and mass balances in the recycling flow and guarantee the chain of custody by requiring certified recyclers to ensure downstream recyclers actually treat e-waste, especially hazardous components, in an environmentally sound manner. WEEELABEX and R2 employ proprietary traceability and mass balance systems.

- Reduce burdens on national governments by reducing the frequency of monitoring and auditing, and involving use of certification organisations.

4. Combining top-runner and bottom-up approaches to establish sound international recycling

Recycling certification should be applied in accordance with the various institutional and operational environments in Asian countries. In particular, it requires considering how certification criteria should be set, since each country may require a different licence scheme for recycling activities. In this regard, this section elaborates on two approaches for applying certification systems in Asia, based on country goals.

One is to use a 'top-runner' approach, involving issuing recycling certification to distinguish the good from the bad recyclers of e-waste in the recycling market, with preferential treatment given to the sound operators.

Another is to use a 'bottom-up' approach, in which recycling certification is used to identify potential recyclers not yet defined as 'sound' recyclers in the market and to target such operators for capacity development and investment. This would enable countries without specified recycling regulations for e-waste to build domestic recycling capacity and ensure labour health and safety and environmental protection.

As discussed in Sections 2.2 and 2.3 of this chapter, Asia's institutional and physical/industrial infrastructure is diverse. A certification system would thus identify the most advanced treatment facilities in each region, which would form the basis of a recycling chain, to which top-runner facilities with differentiated functions and technical requirements would plug into. Utilising this network of top-runner facilities, countries with lower capacity, such as type 3 countries, would use the bottom-up approach to upgrade their recycling systems into type 2. Type 2 or 3 countries with lower capacity would utilise the concept of certification for specific requirements and capacity development for collecting, separating and sorting hazardous components for relatively less developed facilities. Under such coordination, the combination of top-runner and bottom-up approaches would help establish a sound recycling chain that incorporates the disparate infrastructures of each country much more efficiently than having to establish a complete set of recycling facilities and systems in each country from the outset.

More specifically, each type of country identified in Section 2.2 could utilise certification in the following manner:

Type 1 countries would act as recycling hubs owing to their greater capacity to recycle e-waste and dispose of hazardous components in an environmentally sound manner. Recycling certification would assuredly trace domestic and international flows of e-waste between responsible recyclers to prevent it ending up in informal sectors.

Certified recyclers would act as 'top-runners' for resource recovery and could be incentivised with funds for infrastructure upgrades or grants to ensure formal collection,

in order to avoid competition from the informal sector. Simplifying the international trade between certified recyclers under the Basel Convention will facilitate regional cooperation.

For countries lacking appropriate advanced technologies (smelting), establishing effective means of collection from consumers and industry, combined with cooperation from international recyclers with access to such technologies, would suffice.

Type 2 countries in economic transition should focus on recycling e-waste from industries associated with industrial waste regulation due to the lack of systematic recycling system of consumer e-waste. Since type 2 countries have no formal collection route or specified recycling facilities such as smelting they must utilise the informal sector's recycling capacity and promote regional cooperation. In this case, they can nurture sound recyclers by establishing a collection and dismantling system with cooperation from existing informal collectors, which would be upgraded based on recycling certification criteria. This could be promoted via incentives, i.e., loans or grants to certified recyclers and penalties for violators. Simplification of shipping e-waste from domestic to international recyclers would help. There are certain needs of international trade from type 2 countries to type 1 countries for environmentally sound management and resource recovery. For example, companies operating in type 2 countries may need to ensure treatment of their produced waste certified recyclers in type 1 countries in order to follow their CSR policies.

Type 3 countries face no serious sustainability challenges related to e-waste management due to their limited economic development and industrial infrastructure for resource recovery. Here, development of a general waste management system for increased recycling capacity should be prioritised, together with creation of collection points for potential collectors such as junk shops to export waste via international routes to certified recyclers in type 1 or type 2 countries for resource recovery.

To solve the e-waste challenges in Asia, therefore, differences in recycling capacity can be coped with through role sharing, in which all countries in the region cooperate for mutual benefit. The role of type 1 countries is to contribute to regional cooperation and resource efficiency; that of type 2 countries is to utilise and upgrade existing recyclers; and type 3 countries can focus on developing collection of e-waste.

5. Towards implementation of an international recycling certification scheme

To apply and operationalize an effective and feasible recycling certification scheme in the region, the following issues should be examined.

First, who—or which organisation—should take the lead in such certification scheme? This could be a voluntary but semi-public industrial initiative or start out as a regional working group of experts to consider guidelines for certification. Second, incentive mechanisms should be developed along with application of the certification scheme. Third and fourth, how to harmonize or coordinate with existing international rules such as the Basel Convention, as well as existing domestic rules, need discussing.

To bring this about, governments, experts, industrial associations such as those of manufacturers of electronic and electrical products, recyclers, and waste managers, as well as international organisations, including the Basel Regional Office, will all need to work together closely. International certification and standards for sound recycling of

e-waste should be utilized as a communication tool to enable such cooperation, in which the above players develop appropriate standards, guidelines and certification schemes. As seen in the case of R2 Standards or WEEELABEX, leading entities for certification development and application internationally should be industrial associations or related multi-stakeholder organisations, in collaboration with national governments. The application of certification schemes would also aid manufacturers of e-products and recycling industries in terms of transparency and accountability, both of which are needed in an increasingly internationalised recycling market. The concept of certification would also help build trust between governments and the recycling market to ensure sound recycling, and serve as an information disclosure mechanism covering the location and capacity of sound recyclers. Building trust is needed since the region lacks a competent regional authority for environmental governance, and together with information disclosure on location, these would represent a first step towards a functioning e-waste management and recycling system.

The potential impacts of recycling certification on informal recyclers may depend on their roles within the recycling chain. Certification could assist in upgrading informal recyclers to engage in collection and dismantling processes that do not generate serious environmental impacts. For these recyclers, certification would incentivise their activities through education, training, and investments. Certification would also deter harmful 'backyard' recyclers (such as for gold recovery). Since most type 1 and type 2 countries prohibit backyard recycling for metal recovery, stronger regulations and supportive measures such as training and subsidies would be needed, in order to make operations at informal backyard recyclers legitimate.

Recycling certification could be an effective policy tool if combined with incentive systems such as investments for nurturing recycling infrastructure. For this it will be important to establish international branding and reliability of recycling industries in order to promote environmentally sound resource circulation in the rapidly integrating Asian market. Hotta and Kojima (2012) propose an international fund be created for sustainable resource management as a source for financing bilateral and multilateral cooperation programmes in the 3R/materials circulation field. This type of fund could encourage technological development and infrastructure investment for resource efficiency improvements, and be fed from revenues generated through economic instruments for domestic resource management and circulation, such as virgin material taxes and recycling fees. The presence of such a fund would also bolster the efficacy of recycling certification as a tool for regional cooperation and help in sound e-waste management.

6. Conclusion

Under the present state of economic growth in the region, developing Asian countries will face environmental and economic challenges under the existing recycling system, which relies on market-based transactions and a largely informal recycling market to recycle resources. Further, environmentally sound management of recyclable resources is gradually taking hold as the way forward, and policy development related to 3R and institutional frameworks has taken place. What is needed now is to develop the physical infrastructure. This could be done—in step with institutional arrangements for promoting recycling facilities and a system to ensure environmentally appropriate treatment and recovery processes—through the use and nurturing of existing recyclers. Further, international role sharing of recycling activities through intra-regional flows can progress alongside economic integration in Asia.

Under these conditions, utilisation of recycling certification is a potential policy approach to facilitate regional collaboration for ensuring sound recycling of e-waste. Regional economic integration may aggravate environmental impacts associated with uncontrolled flow of e-waste but also provide a good incentive to establish a regional resource circulation framework. Introducing standardised recycling certification, at least for top-runners, can contribute to role sharing of recycling activities in the region by identifying and disclosing information on responsible recyclers in both developed and developing countries in Asia. This role sharing is also beneficial for countries with less capacity in e-waste management to ensure sound management of e-waste in the face of increasing consumption of e-products. It should be noted that this is not a call for waste trade liberalisation, as this would be counter to the Basel convention. Rather, the proposed model for international recycling, based on regional role sharing and recycling certification, should be seen as a measure to facilitate environmentally sound e-waste management for countries that lack adequate domestic recycling or treatment capacity of e-waste (UNEP 2013). The concept of using recycling certification schemes would naturally require compliance with regulations and legislation, as would transboundary movement, in line with the process of the Basel convention.

Recycling certification can be used in a number of ways: National governments can request or suggest recycling facilities to obtain specified certification and to adopt auditing schemes to promote environmentally sound management of e-waste; business sectors can voluntarily participate in recycling certification to meet growing market demands of e-waste recycling and management; and Basel regional centres in China, Indonesia and Iran could act as springboards to implement regional recycling certification and to promote regional role sharing for environmentally sound management of e-waste. An incentive system could also be combined with recycling certification, via an international fund for sustainable resource management, which could operate through the Basel regional centres in cooperation with the World Bank or Asian Development Bank.

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