# Chapter 4

# Improving the Circular Value Chain of Electrical and Electronic Equipment

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# Chapter 4

# Improving the Circular Value Chain of Electrical and Electronic Equipment

## 1. Introduction

In Japan, Europe, and the United States (US), used electrical and electronic equipment (EEE) and e-waste are properly used as secondary resources. For example, e-waste is sorted and crushed into iron, non-ferrous metals, waste substrates, and plastics, and each material is processed by plastic recycling companies, electric furnaces, blast furnaces, and non-ferrous smelters. However, it is difficult for Association for Southeast Asian Nations (ASEAN) Member States (AMS) – which have insufficient capacity – to complete the circular value chains of EEE domestically. In this chapter, business cases that set examples to improve these circular value chains are collected.

## 2. Sources for Business Cases

The cases related to the circular value chains of EEE in AMS, Europe, Japan, and US were collected based on databases and reports outlined in Table 4.1. Roughly 150 cases were examined.

**Table 4.1. Databases and Reports Referenced in This Chapter**

| Reference | Details |
|---|---|
| Business Europe, Circulary Sectors, http://www.circulary.eu/sectors | A platform managed by BusinessEurope, it features examples of innovation across Europe. Cases are categorised by 21 sectors. |
| Ellen MacArthur Foundation, Our Network, https://ellenmacarthurfoundation.org/network/who-is-in-the-network | Strategies and business cases of each partner company are introduced in the foundation's website. |
| European Union, European Circular Economy Stakeholder Platform, https://circulareconomy.europa.eu/platform/en/good-practices | As a knowledge hub, it collects good practices related to the circular economy. |
| Japan Partnership for Circular Economy (J4CE), Cases, https://j4ce.env.go.jp/en/casestudy | J4CE was founded to strengthen public–private partnerships, with the aim of fostering understanding of the circular economy amongst stakeholders. There are more than 150 companies and industrial organisations in the partnership, and over 160 cases have been submitted by these members, which are introduced on the partnership's website. |
| Japan Environmental Management Association for | The award contributes to the promotion of |

| Reference | Details |
|---|---|
| Industry (JEMAI), Resource Recycling Technology and System Award, https://www.cjc.or.jp/commend/tech-sys.html | circular business by widely soliciting and awarding excellent projects and initiatives that contribute to the 3Rs. |
| Government of Japan, Ministry of Economy, Trade and Industry | This is creating a survey for establishing methods for evaluating companies implementing resource recycling efforts. |
| New Energy and Industrial Technology Development Organization (Japan) | This is a recycling technology research and development project that aims to build a highly efficient resource circulation system. It seeks to build an information linkage system to advance resource circulation. |

Source: Authors.

## 3. Screening Business Cases

The collected cases that can contribute to improving the EEE circular value chains were screened based on two criteria.

### 3.1. First Screening Criterion

The first criterion is the identification of gaps that need to be addressed to establish EEE circular value chains in AMS. Due to the insufficient capacities of AMS, some functions are missing in the circular value chains. Incomplete value chains cause problems, such as environmental pollution, health risks, and resource waste.

The business cases featured address these issues effectively. As mentioned in Chapter 1, there are five gaps in the circular value chains of used EEE and e-waste between Japan and AMS. Therefore, the business cases presented provide beneficial implication to these challenges:

(i) There is no well-managed reuse activity.

(ii) Licensed collectors and recyclers do not participate in the circular value chains.

(iii) A lot of e-waste is disposed of in landfills mixed with municipal waste.

(iv) There is insufficient domestic capacity to recycle metal scraps.

(v) There is a lack of remanufacturing activities.

### 3.2. Second Screening Criterion

The second screening criteria is the possibility of collaboration with AMS. It is difficult for AMS – which do not have advanced technologies, business ecosystems, and legal systems – to complete EEE circular value chains only domestically. The business cases presented seek to promote collaboration between AMS and other countries, such as Japan, while improving technical standards and increasing skilled researchers and employees in AMS.

Recently, some AMS have developed plans or strategies focussing on a circular economy. For example, Indonesia has an initiative, *The Future is Circular: Concrete Steps for Circular Economic Initiatives*; Cambodia has made an action plan for the circular economy; Thailand has announced a concept and main policies related to the circular economy; and the deputy prime minister of Viet Nam signed a decision approving a circular economy development scheme. Based on these plans, it is assumed that governments and businesses will promote various initiatives to implement circular businesses in these AMS. Companies that implement businesses related to these circular value chains in other countries have high potential to collaborate with these stakeholders.

As the second criterion, functions that are commonly featured were extracted:

(i) **Indonesia.** Refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycling, and recover.

(ii) **Cambodia.** Raw materials and design, production remanufacturing and distribution, consumption reuse and repair, collection, recycling, and residual waste.

(iii) **Thailand.** Reuse, refurbishment, repair, remanufacturing, recycling, and composting.

## 4. Summary of Business Cases

As a result, 34 business cases were extracted. Fourteen cases are business cases related to reuse, refurbishment, repair, and remanufacturing (Table 4.2). These cases comprise a wide variety of products: printers, refrigerators, air conditioners, computers, information technology equipment, mobile phones, and e-waste. The locations of the businesses vary. While the business cases in Japan tend to be mostly related to home appliances, the targets of most cases in the US and Europe are information technology equipment, such as computers and mobile phones.

Twenty cases relate to recycling and various products (Table 4.3). Those in the US and AMS cover the value chains of collection, dismantling, classification, and sorting; the recycling of non-ferrous metals and plastics is only confirmed in Japan and Europe.

**Table 4.2. Business Cases Related to Reuse, Refurbishment, Repair, and Remand**

| No. | Value Chain | Object | Country | Company | Overview |
|---|---|---|---|---|---|
| 1 | Collect Refurbish Reuse | Mobile phones | Singapore | **Mercantile Pacific Asia** | It provides business-in-lifecycle management of smart devices and has shipped repurposed devices to over 100 countries worldwide. Due to strategic collaboration with telecommunications operators, OEMs, and brands in their buyback programmes, quality used devices can be collected from various geographies at scale. After data wiping, testing, grading, and certification, phones that need repairs are refurbished with original parts. End-of-life cycle products are recycled through partners. |
| 2 | Collect Refurbish Dismantle Remand | Printers | Japan | **Ricoh** | It manufactures and sells products that have undergone a refurbishment process, such as parts that are guaranteed to meet prescribed quality standards and parts that are required to be replaced according to prescribed quality standards. |
| 3 | | | Japan | **FUJIFILM Business Innovation** | It implements a comprehensive approach for resource circulation by adopting advanced design for reuse and recycle, promoting the use of recycled plastic, supporting the efficient use of products, and promoting the use of reused parts included in used equipment and recycling of parts that are difficult to reuse. |
| 4 | | | Japan | **Canon** | It collects used equipment and disassembles it into components. These components are washed by suitable methodology. Deteriorated and worn parts are replaced according to strict remanufacturing standards. The same production and inspection lines as new products are applied to improve quality to the same level as new products. |
| 5 | Collect Refurbish | Refrigerators | Japan | **Panasonic** | By monitoring the operation status of commercial freezing and refrigeration equipment, the 'cooling function' as a service is provided. Used products are reused in other stores after inspection. |
| 6 | | Personal computers | Japan | **NEC** | It collects used computers and refurbishes them. Processed computers are shipped as 'NEC refurbished personal computers'. |
| 7 | | Personal computers Information technology equipment | US | **IBM** | It provides computer-leasing services and produces certified second-hand products. In 2020, 17,000 tonnes of end-of-life products were processed, of which 96.5% (weight ratio) of parts and materials were reused and remanufactured. |
| 8 | | | US | **Dell** | Used products are refurbished after sorting units based on appearance and function and restoring and repairing damaged parts with certified recycling companies. By 2030, it aims to convert all products purchased by customers to reused or recycled products. |
| 9 | Reuse | Mobile | Japan | **Reuse** | It established guidelines for the evaluation of reusable mobiles and authenticates |

| No. | Value Chain | Object | Country | Company | Overview |
|---|---|---|---|---|---|
| | | phones | | **Mobile Japan** | businesses and stores in accordance with these guidelines. The guidelines compile information on laws and regulations, standards, or desirable implementation methods for purchasing, inspection/grading, and sales in the reuse mobile business. |
| 10 | Refurbish | Air conditioners | Japan | **Daikin** | It provides products that can be replaced only with compressors and control boards, which are the main components of multi-split air conditioners for buildings, with new ones. This saves energy and shortens the construction period by partial replacement. |
| 11 | | Electronic equipment | Europe (Denmark) | **Refurb** | It erases data and repairing hardware of information technology equipment collected from public institutions and companies. Then, it sells them to the original institutions or companies or on their own platform. |
| 12 | Dismantle Repair | Mobile phones | Europe (Nether-lands) | **Fairphone** | By designing and developing modules for mobile phones that can be assembled without tools, it manufactures and sells smartphones that can be easily repaired and upgraded by customers as well as being easy to dismantle. |
| 13 | Dismantle Remand Recycle | Information technology equipment | US | **Microsoft** | It established Circular Centers in the Netherlands, Ireland, Singapore, and the US for on-site processing of end-of-life server hardware and sorting into reusable and non-reusable parts. Recycling functions will be planned in the future. |
| 14 | Repair | Electronic equipment | US | **iFixit** | It provides an online platform for promoting repair, on which various EEE are shared and updated. The repair information is expanded in collaboration with OEMs and brand owners. |

EEE = electric and electronic equipment, OEM = original equipment manufacturer, US = United States.

Sources: ASEAN (2022); J4CE, *Reuse Products Business: RICOH Company, Ltd.* https://j4ce.env.go.jp/en/casestudy/081; JEMAI, 'Resource Recycling Technology/System Award' [in Japanese] https://www.cjc.or.jp/cjc_news/31syshyo/r01_sys_hapyou.pdf#page=2; FUJIFILM Business Innovation, 'Promotion of Resource Circulation' [in Japanese] https://www.fujifilm.com/fb/company/csr/svp2030/environment/recycle.html; J4CE, Remanufacturing of Multifunction Devices: Canon Inc. [in Japanese] https://j4ce.env.go.jp/casestudy/133; J4CE, Refurbishment Scheme: Panasonic Corporation [in Japanese], https://j4ce.env.go.jp/casestudy/044; NEC, NEC Refreshed PC [in Japanese], https://www.nec-lavie.jp/products/refreshedpc/index.html; IBM, IBM Refreshed PC [in Japanese], https://www.ibm.com/jp-ja/financing/pre-owned/ibm-certified-used-equipment; Reuse Mobile Japan, *Reuse Mobile Guideline Version 2* [in Japanese], https://rm-j.jp/pdf/RMJ_Guidelines2.pdf; Daikin (2017); Microsoft (2021).

**Table 4.3. Business Cases Related to Recycling**

| No. | Value Chain | Object | Country | Company | Overview |
|---|---|---|---|---|---|
| 15 | Collect<br>Recycle | E-waste | Cambodia | **EcoBatt-Energy Cambodia** | It deals with battery sales, data centres, solar panel installation, and batteries and e-waste collection. Collected e-waste is classified into those that can be reused and those that can be recycled. It has constructed a collection network in collaboration with various actors. |
| 16 | | | Viet Nam | **Vietnam Recycling** | It provides a free e-waste take-back and recycling programme initiated by electronic manufacturers. It complies with Prime Minister's Decision No. 16/2015, which expresses the manufacturers' responsibilities to the environment and community. E-waste is collected from households or enterprises, transported to waste treatment facilities by licensed trucks, classified, and recycled. |
| 17 | Collect<br>Recycle | Mobile phones | Japan | **Telecommunications Carriers Association**<br>**Information and communications network industry** | It collects used devices at retail stores regardless of manufacturers of devices and delivers collected devices to recycling companies. It has assessment guidelines for 3R evaluation items and criteria. 32 items are defined for recycling, and these items are used as a standard for pre-evaluation conducted by each company. |
| 18 | | Mobile phones, computers | Europe<br>(Nether-lands) | **Closing the Loop** | A waste compensation service provides equivalent offset or compensation to newly manufactured and distributed mobile devices by collecting and recycling end-of-life devices. The service was adopted by ITOCHU and FCNT in Japan. |
| 19 | Collect<br>Dismantle | Mobile phone | US | **Apple** | Materials such as gold, cobalt, tungsten, and rare earth elements are recovered from collected used devices by decomposition robots. These materials are supplied to the raw materials market. It advocates the goal |

| No. | Value Chain | Object | Country | Company | Overview |
|---|---|---|---|---|---|
| | Recycle | | | | of making some parts 100% from recycled resources. |
| 20 | | E-waste | Thailand | **Wongpanit Garbage Recycle Separation Plant** | It collects and treats used paper, waste plastic, scrap metal, food waste, glass bottles, waste oil, and e-waste. Within Thailand, it has 3 dismantling plants, 1 purchase collection base, and more than 1,500 franchised collection bases. The informal sector (i.e. scavengers) also bring municipal waste to franchise collection bases. |
| 21 | | | Europe (Spain) | **Revertia** | It developed business related to e-waste management, reuse, data deletion, and reporting. It analyses the carbon footprint of refurbishment and recycling and reports to companies on quantified environmental and social contributions. |
| 22 | | | Japan | **TES-AMM Japan**<br>**Sojitz** | It uses on-site trucks equipped with crushable equipment on the customer's premises to promote effective utilisation of information technology assets such as used equipment and waste electronic substrates while ensuring security. |
| 23 | Collect<br>Dismantle<br>Recycle | Home appliances | Japan | **Panasonic**<br>**Petec**<br>**Tokyo Steel Manufacturing** | It established a scheme to manufacture electric furnace steel sheets using iron scrap generated in the home appliance recycling process as a raw material and circulate them as products. |
| 24 | Dismantle<br>Recycle | E-waste | Malaysia | **Jaring Metal** | The company is a licensed company for treating used EEE and recycling of unfinished EEE through hydrometallurgical methods. It recycles e-waste through processes including cutting, crushing, milling, separating, smelting, and refining. The recycled materials are exported. |
| 25 | | | Japan | **Dowa Holdings** | It recovers metals from smelting residue and recycled materials of |

| No. | Value Chain | Object | Country | Company | Overview |
|---|---|---|---|---|---|
| | | | | | smartphones and waste electronic substrates. It collects metals from a wide variety of scraps, such as incineration residue from the waste incineration plant and waste substrates from home appliance recycling plants. |
| 26 | | | Japan | **JX Metals** | It produces copper ingots with a purity of 99.99% through a highly efficient smelting process from copper ore and recycled materials such as used home appliances and electronic devices. Saganoseki Smelter & Refinery has adopted an advanced method that uses the heat of the oxidation reaction of the sulphur content in the ore to melt ore itself and recycled materials, resulting in low environmental impact. It also established a global scale collection system for recycled materials. By 2040, the ratio of recycled materials will increase up to 50% of the raw materials handled at the copper smelters. |
| 27 | | | Japan | **Mitsubishi Materials** | It processes scraps containing copper and precious metals as secondary raw materials through a copper smelting process. In addition, lead, tin, and rare metals can be recovered to almost the same grade as bare metals. The Mitsubishi Continuous Copper Refining Process was developed to achieve the lowest environmental impact. |
| 28 | | | Europe (Belgium) | **Umicore** | Through 2 types of recycling processes, 28 kinds of metals are recovered. At the recycling centre in Hoboken, scraps such as printed circuit board and mobile phones are processed as raw materials. Other bases carry out recycling processing of process waste. It has a sales and storage base in Thailand. |
| 29 | Collect | Home | Japan | **Panasonic** | From shredder residues generated in the home appliance recycling process, resins with different applications and physical properties are |

| No. | Value Chain | Object | Country | Company | Overview |
|---|---|---|---|---|---|
| | Dismantle Recycle | appliances | | **PETEC** | sorted with a purity of 99% or higher. Recovered materials are purified and restored to high purity and physical properties at a resin circulation plant. |
| 30 | | | Japan | **Mitsubishi Electric** | It recovers high-purity single plastics from mixed plastics generated by the crushing process of used home appliances. It implemented material recycling to be used in newly manufactured home appliances. Approximately 70% of resin recovered from used home appliances is recycled. |
| 31 | | Refrigerators | Europe (Germany) | **BASF**<br>**KraussMaffei**<br>**RAMPF Eco Solutions**<br>**REMONDIS Electrorecycling** | For the polyurethane insulation of used refrigerators, it circulates it as a material through chemical recycling instead of energy recovery. |
| 32 | | E-waste | Japan | **Pranic**<br>**Toyota Tsusho**<br>**Veolia Japan**<br>**Kojima Sangyo** | It recycles used plastics from automobiles and home appliances as well as product plastics such as packaging materials, used pallets, and containers. It aims to produce high-quality, low-cost recycled plastics by utilising advanced specific gravity sorting technology. |
| 33 | | | Europe (France) | **Veolia**<br>**Suez** | It recovers e-waste in France and elsewhere. At a plant in Angers, an advanced process can sort resin into 10 types. Suez established a factory in Thailand to manufacture resin from plastic containers and packaging. |
| 34 | Recycle | Televisions | Japan | **Sony** | It adopts recycled plastic SORPLAS, which has a high recycled usage rate and promotes designs that contributes to reducing environmental impact. SORPLAS is a product that uses used water bottles collected from the |

| No. | Value Chain | Object | Country | Company | Overview |
|---|---|---|---|---|---|
| | | | | | market, waste discs discharged from factories and markets, and flame-retardant recycled plastics made from flame retardants. |

3Rs = reduce, reuse, recycle; EEE = electrical and electronic equipment.

Sources: EcoBatt-Energy Cambodia, https://ecobatt-energy.com/; Vietnam Recycle, https://www.vietnamrecycles.com/en; Mobile Recycle Network, https://www.tca.or.jp/mobile-recycle/; Apple, Environment, https://www.apple.com/jp/environment/; Toyama Kankyo Seibi (2017); J4CE, Reuse and Recycling of IT Assets: Sojitz Corporation TES-AMM JAPAN K.K. [in Japanese], https://j4ce.env.go.jp/casestudy/124; J4CE, Building a Recycling Scheme for Scrap Iron: Panasonic Corporation [in Japanese], https://j4ce.env.go.jp/casestudy/052; Jaring Metal, https://www.jaringmetal.com/index.html; J4CE, Recovering Various Types of Valuable Metals by a Large-Scale Smelting and Recycling Complex: Dowa Holdings [in Japanese], https://j4ce.env.go.jp/casestudy/042, J4CE, Contributing to the Promotion of Resource Circulation through Large-Scale Processing of Recycled Materials in the Copper Smelting and Refining Business: JX Nippon Mining & Metals Corporation [in Japanese], https://j4ce.env.go.jp/casestudy/053; JX Metals (2022); Mitsubishi Materials, Environmental and Recycling Technologies, https://www.mmc.co.jp/corporate/ja/product/environment.html; Umicore, Sustainability Champion, https://www.umicore.com/en/sustainability; J4CE, Enhanced Use of Recycled Resin: Panasonic Corporation [in Japanese], https://j4ce.env.go.jp/casestudy/049; Mitsubishi Electric, Plastic Material Recycling, https://www.mitsubishielectric.co.jp/corporate/randd/list/appliance/b11/index.html; BASF (2022); J4CE, Contributing to a Recycling-Oriented Society by Recycling Plastics: Toyota Tsusho Corporation and Veolia Japan K.K. Kojima Sangyo [in Japanese], https://j4ce.env.go.jp/casestudy/105; Veolia, Treating WEEE: Waste Electrical and Electronic Equipment, https://www.veolia.com/en/solution/recycling-weee-electronic-waste; J4CE, SORPLAS, Sony's Proprietary Flame-Retardant Recycled Plastic with up to 99% Recycled Material Utilisation Rate: Sony Group Corporation [in Japanese], https://j4ce.env.go.jp/casestudy/150

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# 5. Solved Issues and Enablers of Business Cases

## 5.1. Solved Issues

Circular businesses aim to maximise the efficient utilisation of resources. Additionally, these businesses have the potential to address social problems related to the environment, society, and economy. For instance, by effectively using existing products, circular businesses can reduce the amount of new product inputs, subsequently reducing carbon dioxide emissions from materials production, parts manufacturing, product manufacturing, mining activities, and resources transport. Furthermore, promoting proper waste treatment can lead to improvements in public health, and the traceability of natural and recycled resources can help eradicate illegal labour practices. Lastly, the introduction of new services through circular businesses can create new employment opportunities and contribute to the development of new industries.

Due to these outcomes from circular businesses, cases were solved regarding industry creation, improving public health, effective use of resources, promotion of decarbonisation, and consideration for human rights.

## 5.2. Enablers

There are various challenges to implementing circular businesses. For example, it is essential for any company to prepare sufficient financial resources. Furthermore, well-educated executives and employees, current goods and fixed assets, and information resources containing intellectual property are crucial. It is important to apply the management resources of individual companies, build networks, and formulate rules that encourage behavioural changes in stakeholders. In this chapter, these factors are defined as enablers, which are categorised as financial resources, human resources, physical resources (i.e. materials, parts, end-products, sites, and factories), informational resources, system networks, and rules and standards.

## 5.3. Reuse

As many business cases relate to reuse, two cases were extracted (Table 4.4). One promotes the reuse of mobile phones through Reuse Mobile Japan, which is an industrial organisation concerned with mobile phones. It developed guidelines for the evaluation of used mobile phones to help second-hand shops judge if the device is reusable. The fact that collection of used devices is encouraged by Japan's the Act on the Promotion of Effective Utilisation of Resources is an enabler of this case. The another manages the life cycle of smart devices effectively by Mercantile Pacific Asia. It was possible to promote reusing through technological development in data erasing and reusing and wide network with stakeholder.

**Table 4.4. Values, Issues Solved, and Enablers Business Cases Related to Reuse**

| Company | Value Created | | | | Issue Solved | Enablers |
|---|---|---|---|---|---|---|
| | ① | ② | ③ | ④ | | |
| Reuse Mobile Japan | | ● | | | Effective use of resources | Rules<br>Promoted reuse/development of guidelines under the Act on the Promotion of Effective Utilization of Resources |
| Mercantile Pacific Asia | | ● | | ● | Effective use of resources<br>Promotion of decarbonisation | Informational Resource<br>Developed technology for data erasing and reusing (diagnosis and grading)<br>Network<br>Collaborated with carriers, manufacturers, brand owners<br>Rules<br>Developed software certification |

Notes: ① Creating added values with design and technologies, ② Retaining values through efficient uses, ③ Recovering the values of used products, ④ Maintaining circulation for rebuilding lost values.
Source: Authors.

### 5.4. Repair

Two business cases related to repair were found (Table 4.5). One is the case of a sharing platform conducted by iFixit, which shares information useful to repair a wide variety of products, such as mobile phones and computers, and provides the tools needed for the repairs. It has the strength of a network with various stakeholders, especially partnerships with original equipment manufacturers like Google, Microsoft, and Samsung. This differentiates it from other platforms, resulting in increased social impact. Another case is the development of new mobile phones with high repairability by Fairphone. Its phones can be easily dismantled into components and replaced or upgraded without any tools. The environment friendly design was developed with support from the European Union Horizon 2020 project.

**Table 4.5. Values, Issues Solved, and Enablers of Business Cases Related to Repair**

| Company | Value Created | | | | Issues Solved | Enablers |
|---|---|---|---|---|---|---|
| | ① | ② | ③ | ④ | | |
| iFixit | | ● | | | Effective use of resources | Informational Resource<br>Accumulated information about repairs<br>Network<br>Created a network with various stakeholders (i.e. manufacturers, repair shops, private persons) |
| Fairphone | ● | ● | ● | | Effective use of resources<br>Promotion of decarbonisation | Financial Resources<br>Obtained research grant from the European Union Horizon 2020 project (sustainablySMART project)<br>Informational Resource<br>Developed technology towards phones that are easy to dismantle, repair, and upgrade |

Notes: ① Creating added values with design and technologies, ② Retaining values through efficient uses, ③ Recovering the values of used products, ④ Maintaining circulations for rebuilding lost values.
Source: Authors.

### 5.5. Refurbishment and Remanufacturing

Related to refurbishment and remanufacturing, four business cases implemented by Japanese manufacturers (i.e. FUJIFILM Business Innovation, NEC, Panasonic, and Daikin) were found (Table 4.6). To implement a refurbishment and remanufacturing business model, human resources, information resources, physical resources, and rules are important factors. In terms of human resources, employees must have sufficient skills of inspection, replacement, assembly, and quality assurance. While educating employees, technologies need to be developed such as appropriate inspection methods, monitoring systems, parts design suitable for replacement, and guidelines or standards for quality assurance.

Stable procurement of used products is also essential. Building solid reverse logistics is required with a high management level of individual recognition of each product and care. In the business cases, some companies collect used products through product-as-a-service model or trade-in service. Laws, such as the Act on the Promotion of Effective Utilization of Resources, is also thought to contribute to effective collection.

**Table 4.6. Values, Issue Solved, and Enablers of Business Cases Related to Refurbishment and Remanufacture**

| Company | Value Created | | | | Issues Solved | Enablers |
|---|---|---|---|---|---|---|
| | ① | ② | ③ | ④ | | |
| FUJIFILM Business Innovation | ● | | ● | ● | Creation of industries and jobs<br><br>Effective use of resources<br><br>Promotion of decarbonisation<br><br>Consideration for human rights | <u>Human Resources</u><br>Developed human resources who carry out inspections and quality assurance<br><u>Informational Resources</u><br>Developed technology for refurbishment<br><u>Network</u><br>Created a network with recyclers around Japan<br><u>Rules</u><br>Matched quality assurance in terms of performance, reliability, and machine life with internal standards. |
| NEC | ● | | ● | ● | Creation of industries and jobs<br><br>Effective use of resources<br><br>Promotion of decarbonisation<br><br>Consideration for human rights | <u>Human Resources</u><br>Developed human resources who carry out inspections and quality assurance<br><u>Physical Resources</u><br>Collected used computers<br><u>Informational Resources</u><br>Developed technology for refurbishment<br><u>Rules</u><br>Promoted collecting used computers under the Act on the Promotion of Effective Utilization of Resources |
| Panasonic | ● | | ● | ● | Creation of industries and jobs | <u>Physical Resources</u><br>Procured used products through product-as-a service model |

| Company | Value Created | | | | Issues Solved | Enablers |
|---|---|---|---|---|---|---|
| | ① | ② | ③ | ④ | | |
| | | | | | Effective use of resources<br><br>Promotion of decarbonisation<br><br>Consideration for human rights | Informational Resources<br>Developed technology for refurbishment |
| **Daikin** | ● | | | ● | Effective use of resources<br><br>Promotion of decarbonisation<br><br>Consideration for human rights | Informational Resources<br>Developed technology for refurbishment |

Notes: ① Creating added values with design and technologies, ② Retaining values through efficient uses, ③ Recovering the values of used products, ④ Maintaining circulations for rebuilding lost values.
Source: Authors.

### 5.6. Recycling

For business cases related to recycling, six business models were found (Table 4.7). Panasonic/Petec/Tokyo Steel Manufacture and Wongpanit built solid networks. The former case promotes collaboration across the value chain with manufacturers, recyclers, and electric furnace operators. Through the collaboration, technologies for utilising used home appliances as raw materials were developed. The latter case built a network with companies, households, and informal sectors. In addition to the network, it has a high collection capacity because it established franchise collection bases. The enablers of other cases, which are implemented by Apple, JX Metals, Mitsubishi Electric, and Umicore, are mainly informational and physical resources. In terms of information resources, technologies on sorting and smelting are the key factors, and collection bases and recycling plants as physical resources are also required.

**Table 4.7. Values, Issue Solved, and Enablers of Business Cases Related to Recycling**

| Company | Value Created | | | | Issues Solved | Enablers |
|---|---|---|---|---|---|---|
| | ① | ② | ③ | ④ | | |
| **Panasonic/**<br>**Petec/**<br>**Tokyo Steel Manufacture** | ● | | ● | | Effective use of resources<br><br>Promotion of decarbonisation | <u>Informational Resources</u><br>Technological development for thinning steel sheets and improving coating corrosion resistance to ensure quality performance<br><u>Rules</u><br>Stable procurement of used products according to the Act on Recycling of Specified Kinds of Home Appliances |
| Wongpanit Garbage Recycle Separation Plant | | | ● | ● | Creation of industries and jobs<br><br>Improving public health<br><br>Effective use of resources<br><br>Consideration for human rights | <u>Physical Resources</u><br>Created various franchise collection points<br><u>Network</u><br>Developed a purchase network involving companies, households, and scavengers |
| EcoBatt-Energy Cambodia | | ● | ● | ● | Creation of industries and jobs<br><br>Improving public health<br><br>Effective use of resources<br><br>Consideration for | <u>Informational Resource</u><br>Developed data-erasing and diagnosis technology<br><u>Network</u><br>Created a collection network with various stakeholders |

| Company | Value Created | | | | Issues Solved | Enablers |
|---|---|---|---|---|---|---|
| | ① | ② | ③ | ④ | | |
| | | | | | human rights | |
| Apple | ● | | ● | | Effective use of resources<br><br>Promotion of decarbonisation<br><br>Consideration for human rights | <u>Informational Resources</u><br>Developed automatic sorting equipment |
| JX Metals | | | ● | | Creation of industries and jobs<br><br>Effective use of resources | <u>Physical Resources</u><br>Established collection and sales bases in Japan, Taiwan, and the United States<br><u>Informational Resources</u><br>Developed technologies for recovering valuable metals and controlling impurities |
| Umicore | | | ● | | Creation of industries and jobs<br><br>Effective use of resources | <u>Physical Resources</u><br>Installed a recycling plant<br><u>Informational Resources</u><br>Developed technologies for metal recovery and refining<br><u>Rules</u><br>Participated in the CEWASTE Project to formulate certification for collection, transport, and processing |
| Mitsubishi Electric | | | ● | | Effective use of resources | <u>Informational Resources</u><br>Developed sorting and colour-matching technologies for valuable recycled materials<br><u>Rules</u><br>Procured used products according to the Act on Recycling of Specified Kinds of Home |

| Company | Value Created | | | | Issues Solved | Enablers |
|---|---|---|---|---|---|---|
| | ① | ② | ③ | ④ | | |
| | | | | | | Appliances |

Notes: ① Creating added values with design and technologies, ② Retaining values through efficient uses, ③ Recovering the values of used products, ④ Maintaining circulations for rebuilding lost values.
Source: Authors.

## 6. Reuse, Remanufacturing, Refurbishment, and Repair Cases

### 6.1. FUJIFILM Business Innovation (Japan)

FUJIFILM Business Innovation has built a closed-loop system that produces and sells remanufactured multifunction peripherals (MFPs) to achieve zero waste. Used MFPs are collected, classified, and reused to remanufacture MFPs. The quality of the reused parts is assured through this unique process. Assembled machines are inspected in the same way as new products; then, these machines are shipped as products that have the same quality and safety levels as those of the new machines. Parts and machines that cannot be reused due to damage or wear are entrusted to recycling companies.

Development of human resources who carry out inspections and quality assurance seem to be an enabler in this case. Technological development for the remanufacturing process also seems to be a key factor. Various technologies, such as monitoring the operation status of each machine, inspection for parts reusability, and a lifetime expectancy database for each part, were developed. Furthermore, networks with recyclers around Japan and quality assurance in terms of performance, reliability, and machine life matched to internal standards also seem to be enablers.

### 6.2. Reuse Mobile Japan (Japan)

Reuse Mobile Japan is an industry group consisting of second-hand goods dealers. The organisation aims to create a society in which diverse and inexpensive communication services are provided to consumers safely and securely by developing the reusable mobile communication device market. In 2019, it established reused mobile guidelines that summarise laws and regulations that must be complied with as well as standard methods of implementation and desirable implementation methods for the purchase, inspection, grading, and sales in the reused mobile businesses. Furthermore, it formulated reused mobile operator certification in 2020, which enables consumers to purchase and to sell reusable mobile devices safely and securely. Reused mobile operators are certified after checking ‘compliance with reusable mobile guidelines’, ‘management status’, and ‘governance’.

### 6.3. Mercantile Pacific Asia (Singapore)

Mercantile Pacific Asia has conducted business related to mobile phones for the last 2 decades. It expanded its business in life-cycle management of smart devices about 10 years ago, shipping repurposed devices to over 100 countries through the strategic collaboration with telecommunications operators, OEMs, and brands in their buyback programme. This network is an enabler in collecting high-quality used devices from various geographies at scale. After data wiping, testing, grading, and certificating the devices with in-house software, phones that need repairs are refurbished with original parts. End-of-life-cycle products are recycled through partners. Certified

phones are sold to a network of over 10,000 retailers and wholesalers across the world. Technical development of the repair and refurbishment process and certification methods are important to implementing this business. It also saved a significant carbon footprint by preventing each phone from going to landfills. In the last 2 years alone, it saved 160 million litres of water, more than 1 million tonnes of carbon dioxide, and 52,000 tonnes of mineral ore (ASEAN, 2020).

## 7. Dismantling, Classification, and Sorting Cases

### 7.1. Panasonic, PETEC, and Tokyo Steel Manufacturing (Japan)

Panasonic, PETEC, and Tokyo Steel Manufacturing have established a scheme to manufacture electric furnace steel sheets using iron scraps with high efficiency and purity. Waste home appliances are transported to the PETEC factory, then dismantled, classified, sorted, and recycled as raw materials. In accordance with the Act on Recycling of Specified Kinds of Home Appliances, it is possible to collect waste home appliances efficiently and consistently.

Steel sheets for some uses, such as construction, are produced by Tokyo Steel Manufacturing. Controlling impurities and adjusting supply and demand to increase usage of iron scraps are difficult. By adopting advanced technologies and processes developed through a collaboration between Panasonic and Tokyo Steel Manufacturing, high-quality recycled materials are obtained. Their collaboration was made possible because of the relationship built by joint technology development. Technological development and stable procurement of used products, according to the Act on Recycling of Specified Kinds of Home Appliances, are enablers of this case.

### 7.2. Wongpanit (Thailand)

Wongpanit is a recycling company located in Thailand. It purchases recyclable goods from households, waste from retailers and wholesalers, and industrial waste. Through waste treatment processes, raw materials are collected from collected goods and waste. Indeed, it collects and treats a wide variety of waste and goods, including used paper, waste plastic, scrap metal, food waste, glass bottles, waste oil, and e-waste. It has 3 dismantling plants, 1 purchase collection base, and 1,500 franchised collection bases in Thailand, Cambodia, Lao People's Democratic Republic, Malaysia, Myanmar, and the US. Prices for purchasing waste and goods fluctuate daily according to the amount of demand. The informal sector also brings municipal waste to franchise collection points. Multiple franchise collection points and the purchase network involving companies, households, and scavengers are enablers in this case.

### 7.3. EcoBatt-Energy Cambodia (Cambodia)

EcoBatt-Energy Cambodia was founded in 2019. In 2022, it signed an official memorandum of understanding with the Ministry of Environment in Cambodia. A wide variety of waste management and recycling solutions are provided to battery sellers and users complying with royal decrees, cabinet orders, and the Basel Convention through the collaboration with the company and ministry. It provides a wide variety of businesses related to battery sales, battery installation for data centres, solar panel installation, energy audit services, and battery and e-waste collection. Its collection service covers many stakeholders, such as offices, schools, and other workplaces. As to January 2023, 35 companies have become members of the battery collection service, which collects waste batteries

and reports the quantity to the ministry. Items that can be reused are provided for reuse, and other items are provided for recycling. Data erasing and diagnosis technology and collection network with various stakeholders are enablers of this case.

# 8. Recycling

## 8.1. JX Metals (Japan)

JX Metals conducts global business operations in non-ferrous metals, focussing primarily on copper and rare metals. Its operations cover resources development, smelting and refining, and development and manufacture of advanced materials. The group's operations also encompass recycling for end-of-life electronic equipment and devices. Moreover, it produces copper ingots with a purity of 99.99% through a highly efficient smelting process from copper ore and recycled materials, such as those derived from used home appliances and electronic devices. Saganoseki Smelter and Refinery has adopted an advanced method that uses the heat of the oxidation reaction of the sulphur content in ore to melt ore itself as well as recycled materials, resulting in low environmental impact. In addition, its industrial waste detoxification business does not generate secondary waste that requires landfill disposal by applying incineration and melting technologies cultivated through smelting and refining.

In 2010, it set up a collection base for recycled materials in Taiwan, and in 2014, it established a sales base in the US. It aimed to raise the ratio of recycled raw materials consumed at copper smelters to 50% by 2040. Collection bases and sales bases in Japan, Taiwan, and the US – as well as technologies for recovering valuable metals and controlling impurities – are enablers in this case.

## 8.2. Dowa Holdings (Japan)

Dowa Holdings have advanced technologies for recovering around 20 types of valuable metals, including various rare metals, which are contained in minute quantities in ore as well as copper and zinc from various raw materials. The company has cultivated these technologies through many years of mining and smelting business operation, and these technologies are applied to recycled metals from various scrap materials.

At Kosaka Smelting and Refining, smelting residues from Akita Zinc are processed, and metals from recyclable materials (e.g. discarded electronic substrates and smartphones) are recovered. Moreover, it built a business model that has enabled the recovery of metals from incineration residues generated at the group's waste incineration plant as well as diverse scraps, including discarded electronic substrates from household appliance recycling plants. It recovers zinc from steel dust generated at steel plants. Technological developments and cooperation of neighbouring facilities are enablers in this case.

## 8.3. Mitsubishi Materials (Japan)

Mitsubishi Materials conducts a recycling business that processes scraps containing copper and precious metals as secondary raw materials through its copper smelting process. In addition to copper smelting, it has strengths in lead smelting, tin smelting, precious metal smelting, and platinum group metals refining. It has constructed a strong business ecosystem by linking the fields in which each production base excels, such as efficient processing and recovery of lead-containing by-products generated from copper smelters at lead smelters, and efficient processing and recovery of tin-

containing by-products generated from lead smelters at tin smelters. It also developed the Mitsubishi Continuous Copper Refining Process, which achieves the lowest environmental impact in the industry. As mentioned in the business case of Dowa Holdings, technology and advanced networks are keys to the smelting business.

### 8.4. Jaring Metal (Malaysia)

Jarling Metal is a licensed company for treating and recycling e-waste through hydrometallurgical methods. It recycles e-waste by cutting, crushing, milling, separating, smelting, and refining. The recycled materials are then exported. It can treat e-waste, including printed circuit board, properly thanks to its technology. Technological development for treating hazardous materials and hydrometallurgy and sales channels of recycled materials are enablers in this case.

## 9. Conclusion

In this chapter, business cases are introduced in line with the circular value chains of EEE. The created value, solved issues, and enablers were outlined as well. These cases can be referenced when collaboration amongst AMS and Japan is considered.

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