

How Taiwan strives to turn into a Circular Economy: the E-Waste Sector

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The concept of Circular Economy (CE) has drawn the attention from various actors, not only because resources are used in a more sustainable way but also because it creates economic benefits, and spurs growth and innovation. Over the past years, Taiwan has, for several reasons, stepped up its efforts to transform into a circular economy, where the value of products and materials is kept as long as possible. First, Taiwan has limited natural resources and needs to import about 99% of its energy resources, 80% of minerals, and 70% of its food. Second, the island nation is a major player in several global industries, and it seeks to uphold this position. As a large OEM manufacturer, Taiwan needs to secure the steady availability of cheap resources for production. Third, space is scarce in Taiwan, thus there are large and densely populated urban areas. All in all, an exceptional testing ground for urban mining. With recycling rates of about 60%, Taiwan ranks third globally – only behind Germany and Austria. A thriving recycling industry that comprises of over 2,000 companies not only curbs the environmental burden but also creates income.

The tremendous expansion of global production over the last decades not only led to a larger variety of goods but also to rising amounts of waste. Particularly, levels of electronic waste are growing rapidly across the globe. In Asia, the amount of e-waste has increased by 63% between 2010 and 2015. In Taiwan, some 40,000 tonnes of e-waste are generated every year. Volumes of e-waste are on the rise since devices are becoming increasingly affordable, and people have more devices. Moreover, due to shortening life-cycles, they are also replaced earlier. Local recycling enterprises (e.g., Super Dragon, Jiin Yeeh Ding, Golden Plus...) have established treatment facilities that allow retrieving valuable substances from discarded electronic devices. About 1 ton of gold and millions of tonnes of copper can be retrieved from electronic scrap every year.

In 2016, remarks in the inaugural speech of the new president have indicated that Taiwan is set to enter "an age of circular economy, turning waste into renewable resources." As a result, the government has launched several projects to promote CE, such as the establishment of a special circular-economic zone in Kaohsiung, but also state-run companies (e.g., CPC) have pledged to invest large sums on promoting CE over the next years. Although the e-waste sector represents a good example, there is still a long way to go to transform large parts of the industry into a CE.

Keywords: Circular Economy, E-waste; Taiwan

Introduction

The tremendous expansion of global production over the last decades led to a larger variety of goods but also increased levels of electric and electronic waste across the globe. Large amounts of discarded electrical and electronic devices (Waste Electrical and Electronic Equipment, WEEE or e-waste) are becoming a major concern across the globe. WEEE is one of the fastest growing waste streams in the world today. Volumes of disposed personal computers, printers, televisions, mobile phones, air-conditioning units or refrigerators are on the rise globally. In East and Southeast Asia volumes increased rapidly between 2010 and 2015. As a United Nations study shows, e-waste generation is growing fast, not only in total volume but also on per capita basis (Balde et al., 2017). The study analyzes twelve countries in the region and concludes that rising incomes and high demand for new electric and electronic gadgets and appliances are the main drivers for the massive growth.¹ Between 2010 and 2015 the volume of e-waste increased by 63%, totalling some 12.3 million tonnes. While the average e-waste generation per capita in the region was about 10 kg in 2015, there are large differences among the countries. The highest generation of e-waste per year is found in Hong Kong (21.7 kg), followed by Singapore (19.95 kg) and Taiwan with 19.13 kg. The lowest generation of e-waste per capita was recorded in Cambodia (1.10 kg), Vietnam (1.34 kg) and the Philippines (1.35 kg). However, all of the countries in the region face a growth in the generation of e-waste. In China, the amount of e-waste doubled in the period between 2010 and 2015, now summing up 6.7 million tonnes.

Growth in volumes of e-waste is triggered by several factors. First, the electronic industry is a highly innovative industry, and more and more gadgets are developed and put on the market. Particularly the sector of portable devices and wearables grow rapidly. Second, due to economic development, the region is home to ever more consumers. Third, while there are more products on the market we also see that the usage time of products decreases rapidly. This is not only driven by new innovations but also by new hardware requirements and status thinking. The faster products are replaced the more e-waste is generated. Finally, also the import of electric and electronic equipment is a factor to consider. Although restrictions on international shipment of electric and electronic devices exist (Basel Convention), large volumes of end-of-life products or second-hand products are shipped across the globe, largely to Africa and Asia.² Improper techniques for dismantling of devices and retrieving valuable materials from discarded devices cause major environmental and human health damages. E-waste is categorized as hazardous waste since it contains toxic materials, but it also contains precious substances such as gold, silver, copper, rare earths, etc. which makes it a very special category of waste. Retrieving the valuable substances requires not only a collection scheme but also advanced recycling technologies, otherwise, it could cause severe health and environmental problems. In many countries, informal recyclers recover gold, silver, palladium, and copper, largely from printed circuit boards (PCBs) and wires using hazardous wet chemical leaching processes (acid baths). Improperly processed this methods results in the release of toxic fumes.

Rising volumes of e-waste are mainly caused by increased demand, but solely blaming consumers for their behaviour may not help to overcome the issue, as there are a series of obstacles for consumers to properly dispose end-of-life EEE. First, many consumers lack awareness as they do not know that they should dispose of their obsolete EEE separately or how and where to dispose their e-waste. Second, they lack incentives to properly dispose their EOL products. Consumers may ignore collection and/or recycling systems if they need to pay

¹ Cambodia, China, Hong Kong, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, Thailand and Vietnam.

² Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal www.basel.int.

for it. Third, lack of convenience. Despite the existence of a (free) collection scheme many people may choose not to dispose their e-waste in proper channels, simply out of inconvenience. Fourth, some countries fail to establish a nation-wide collection and recycling system for hazardous waste disposal, and others struggle with enforcement issues of e-waste legislation or non-compliance.

Taiwan possesses a solid recycling system for e-waste that shows high recycling rates. About 80% of the generated e-waste is recycled. Furthermore, Taiwan is home to a large number of enterprises that are dealing with discarded electric and electronic devices. But still, it struggles to move from a recycling nation into a circular economy.

The Evolution of Taiwan's Recycling System

In the 1980s, Taiwan faced a massive waste crisis. Economic development was accompanied by a rapidly growing volume of garbage. The first notable recycling program was established in 1989 ("*4-in-1 Recycling Program*"), following the 1988 amendment to the Waste Disposal Act (WDA). The WDA required manufacturers and importers to bear financial responsibility (polluter pays principle) for recycling by forming associations to fund recycling. In 1993, Taiwan still had a very low waste collection rate, almost a third of the trash was disposed outside the collection system. At that time, recycling was not a top-agenda. Knowledge about recycling technologies existed, but only in a limited way, and private recycling enterprises saw no big incentives to enter the market. However, only seven years later, Taiwan already reported a recycling rate of 18%. In 2016, the recycling rate was about 55% which puts the island in the league of recycling leaders such as Austria, Germany, and South Korea.³ However, the Taiwan Watch Institute recently criticized the high recycling rate provided by the Environmental Protection Administration (EPA) for being too optimistic, as it does not include electronic waste or waste dealt by private contractors.⁴

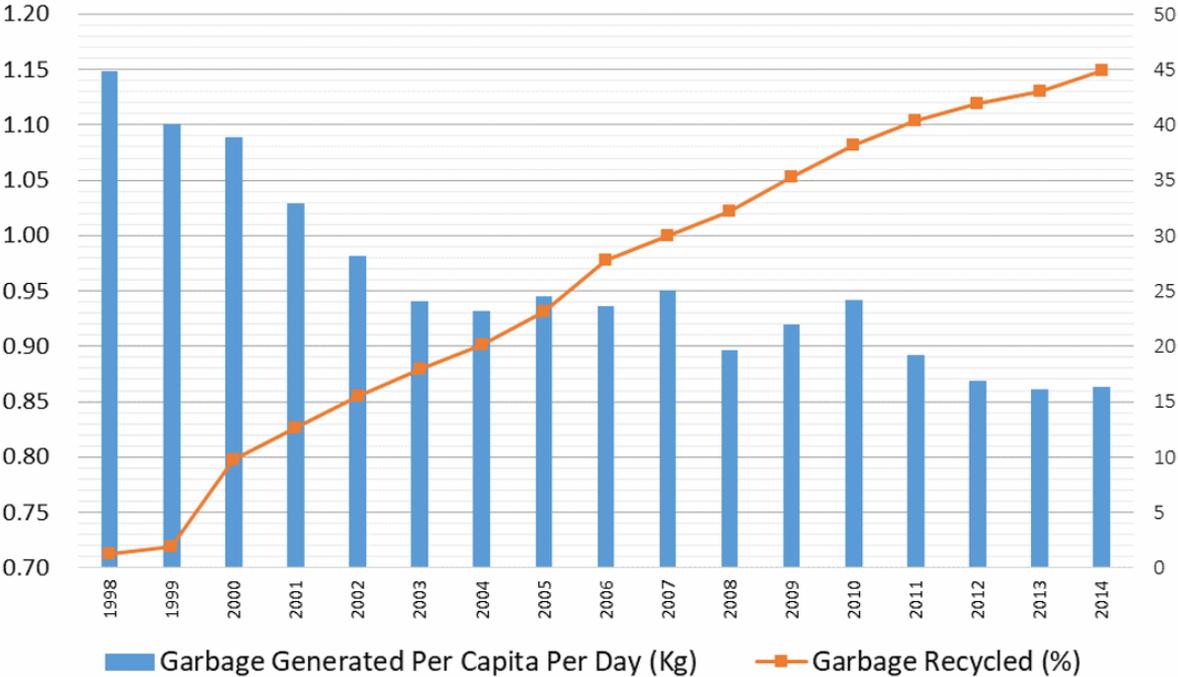
During the 1990s, Taiwan saw several major public protests driven by environmental concerns and waste issues. Rapid economic development led to increased volumes of garbage. Rising incomes strongly correlate with increased levels of consumption and major changes in the lifestyle. By 1996, Taiwan approached the limits of its landfills and as the island with a population of about 22 million faces severe scarcity of land, the expansion of landfills was not an option. As a consequence, the EPA planned to build 36 new incinerators. However, the plans triggered massive public anger. And the strong opposition of the public against incinerators and landfills required substantial policy changes towards recycling waste and waste reduction. Therefore, in 1998 the Legislative Yuan amended the Waste Disposal Act to include and prioritize recycling and waste reduction. Taiwan expanded its recycling system aimed at promoting recycling of hazardous materials and difficult-to-process valuable items. The extended producer responsibility scheme requires manufacturers (or importers) to pay a small fee for manufacturing (or importing) goods into a Recycling Fund aimed at developing waste management infrastructure or recycling industries (Fan et al., 2005). The fund is managed by the Recycling Fund Management Board (RFMB). The EPR scheme seeks to tackle the issue from two sides. It requires manufacturers to pay for the produced goods and to support innovative manufacturers to establish products that are more easily recycled, dismantled, and re-used. This fund helps to promote innovation and to develop new recycling processes but also finances educational projects. Recycling helps to divert a portion of the waste from landfills but the overall amount of waste must also decrease. In 2001, the Waste Disposal Act

³ Wall Street Journal, May 17, 2016, "Taiwan: The World's Geniuses of Garbage Disposal", <https://www.wsj.com/articles/taiwan-the-worlds-geniuses-of-garbage-disposal-1463519134>.

⁴ Taipei Times, Dec. 10, 2017, "True recycling rate lower than published: institute", <http://www.taipeitimes.com/News/taiwan/archives/2017/12/10/2003683741>.

was revised again with the aim to clarify responsibilities of manufacturers, importers, and recyclers under the *4-in-1-Program*. As a consequence of all these efforts, the recycling rate increased and also the amount of garbage generated per person declined steadily (see Figure 1). Between 2000 and 2010, waste generation in Taiwan decreased from 8.7 to 7.95 million tonnes, while the GDP increased by over 40% in the same period, also leading to a sharp decline of the amount of waste incineration.

Figure 1: Garbage generation per capita vs. Recycled Garbage.



Source: The International News Lens

As of now, Taiwan operates 25 incinerators with a daily capacity of about 24,000 tonnes.⁵ About 65% of the processed garbage is household garbage, while 35% is industrial waste. Due to increased recycling rates, several incinerators struggle with low capacity now, resulting in some kind of "garbage row" between operators and municipalities.⁶ Disposal rate at landfills was reduced by 98%, the number of landfills fell from 187 (in 2007) to 83 in 2017.⁷ In 2003, the EPA submitted a report and suggestions on waste disposal to the Executive Yuan to promote a Zero-Waste Strategy and to promote green manufacturing, green consumption, source minimization, resource recovery, and reuse.⁸ The policy included waste diversion targets of 25% by 2007, 40% by 2011, and 75% by 2020. Although Taiwan makes steady progress towards a zero-waste-society the next steps require much larger efforts. The next steps must include cleaner production and the promotion of a circular economy in Taiwan.⁹

Over the past decades, amendments to the Waste Disposal Act have resulted in shifting the developmental strategy for the recycling systems away from a traditional end-of-pipe approach towards a comprehensive sustainable materials management (Lu et al., 2006).

⁵ Taipei Times, Oct. 12, 2015, "Environmentalists trash EPA's incineration policy", <http://www.taipeitimes.com/News/taiwan/archives/2015/10/12/2003629868>.
⁶ Taipei Times, June 3, 2017, "Kaohsiung burned waste, exported slag elsewhere", <http://www.taipeitimes.com/News/taiwan/archives/2017/06/03/2003671824>.
⁷ EPA, <https://www.epa.gov.tw/site/epa/public/MMO/EnvStatistics/c4070.pdf>.
⁸ EPA, <https://www.epa.gov.tw/ct.asp?xItem=61486&CtNode=35686&mp=epaen>.
⁹ Taipei Times, Oct. 12, 2015, "Environmentalists trash EPA's incineration policy", <http://www.taipeitimes.com/News/taiwan/archives/2015/10/12/2003629868>.

While the amendment of 1988 made manufacturers and importers financially responsible for recycling, the 1997 amendment put required upfront payments that enabled the government to subsidize recycling. Fees are collected on a wide range of products, and the scope of covered products is adjusted periodically to take into account market changes and the development of new products. As a consequence of the introduction of the *4-in-1-Program*, the government was not only able to finance new projects and thus advance recycling technologies, but it also allowed companies to create a market for recycling. Meanwhile, the local recycling industry consists of several hundred companies that generate considerable income.¹⁰ However, the collection and recycling is mainly funded by governmental subsidies (through the recycling fund) and not driven by revenues generated from recycled materials. Recycling fees received from manufacturers are fixed and not collected accordingly to the degree of recyclability of products. Thus, the system does not really reflect the willingness of manufacturers to foster sustainable measures. There are no strong economic incentives for design changes in the products. Eco-design is a major part of the development of a circular economy (Hollander et al., 2017). The current system does not encourage early-movers and innovative companies that are open to design changes and also does not prevent free-riders (companies that are not willing to move towards more sustainable options). However, besides soaring prices of recycled materials and precious metals, new government policies are needed to re-consider the business models of the local industry.

In Search of a new Waste Management Policy Framework: Circular Economy

The term Circular economy (CE) was first introduced by Pearce and Turner in 1989, however, the concept itself builds on earlier approaches (e.g., cradle-to-cradle). Circular economy marks a clear shift away from the linear take-make-dispose processes of our current production system and stresses the necessity to consider recycling and the reuse of resources to assure sustainable development of the economy (McDonough & Braungart, 2010; Ghisellini et al., 2016). In a circular economy the value of products and materials is kept as long as possible, extract the maximum value from them whilst in use, then recover and regenerate products and materials at the end of each service life. The concept focuses on increased resource efficiency and reducing environmental impact at every stage of the product and service lifecycle (see Figure 2). The concept of CE has drawn the attention from various actors (Golsteijn & Valencia Martinez, 2017), not only because resources are used in a more sustainable way but also because it creates economic benefits, and spurs growth and innovation.¹¹

In line with global trends, the government aims to promote the concept of Circular Economy in Taiwan. In 2016, remarks in the inaugural speech of the new president Tsai Ing-wen (蔡英文) have indicated that Taiwan is set to enter "an age of circular economy, turning waste into renewable resources." It was the first time that the concept was mentioned in an inaugural speech. Since then the government launched several projects to promote CE, such as the establishment of pilot projects, such as the special circular-economic zone in Kaohsiung, but also state-run companies (e.g., CPC) have pledged to invest large sums on promoting CE over the next years.¹² The Tsai administration's five-plus-two innovative industries initiative is a comprehensive government program that seeks to foster industrial restructuring and upgrading. The plan focuses on the development of five high-growth sectors

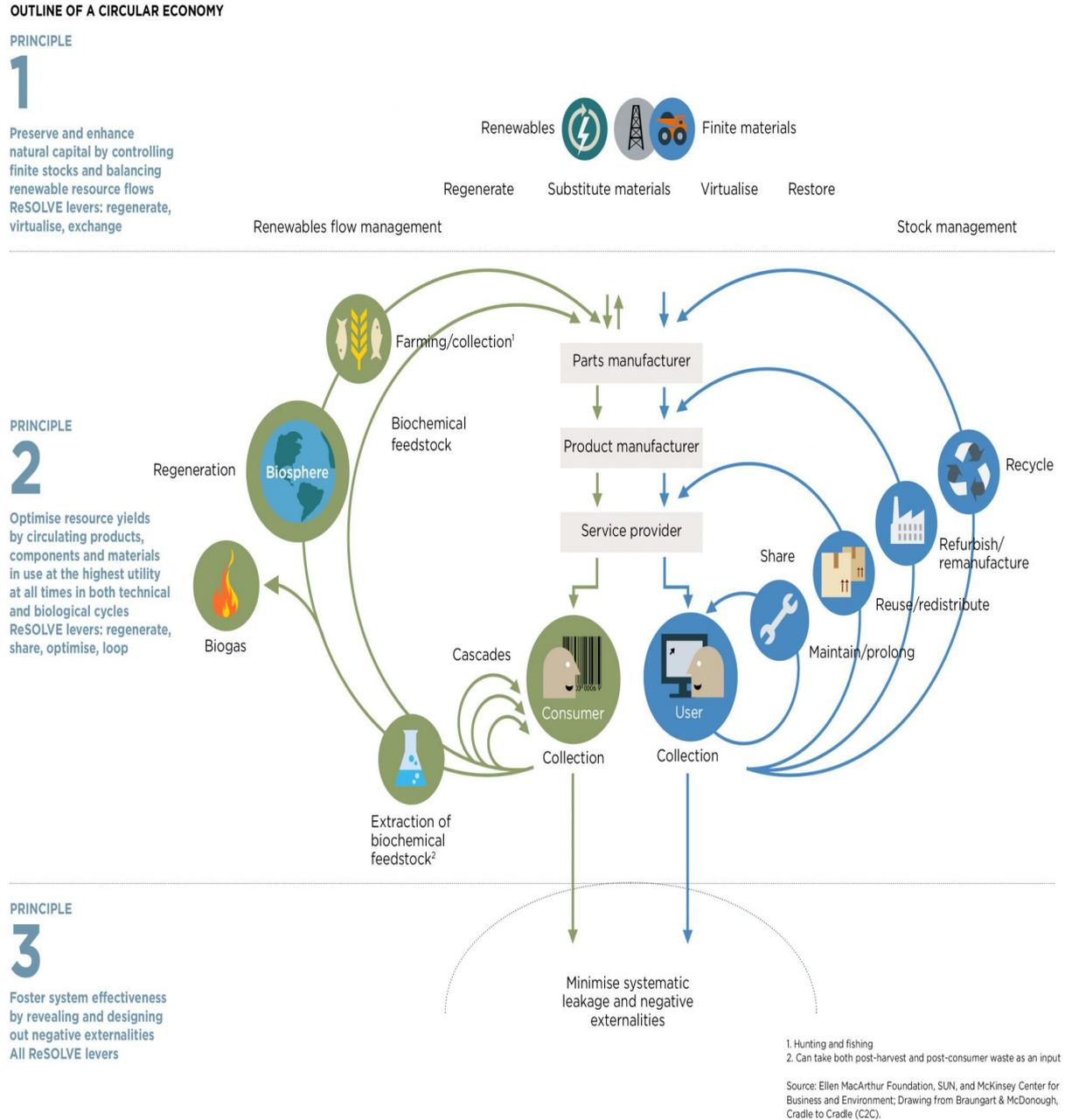
¹⁰ Taiwaninsight, <https://taiwaninsight.org/2018/01/31/taiwans-circular-economy-a-new-era-for-waste-management/>.

¹¹ European Commission, http://ec.europa.eu/environment/circular-economy/index_en.htm.

¹² AmCham Taipei, May 15, 2017, "Saving Resources with a Circular Economy ", <https://topics.amcham.com.tw/2017/05/saving-resources-circular-economy/>.

(biotech and pharmaceuticals, green energy, national defence, smart machinery and the Internet of Things) and also introduces two core concepts: circular economy and a new paradigm for agricultural development.

Figure 2: Outline of a Circular Economy.



Source: Ellen MacArthur Foundation.

Stepping up the transformation into a circular economy is not without logical reasoning: First, Taiwan has limited natural resources and needs to import about 99% of its energy resources, 80% of its minerals, and 70% of its food. Second, the island nation is a major player in several global industries, and it seeks to uphold this position. As a large OEM manufacturer, Taiwan needs to secure the steady availability of cheap resources for production. Third, space is scarce in Taiwan, thus there are large and densely populated urban

areas. Therefore, Taiwan provides an exceptional testing ground for a circular economy and urban mining. For Taiwan, a major goal is to cut the reliance on imports (e.g., rare earth, fossil fuels, etc.) and simultaneously to increase productivity. In order to achieve the government's plan of greening the island's industrial base, the involvement of the local industry is vital (Tsai et al., 2007). However, since Taiwan's economy is mainly backed by small-and-medium enterprises, the concept of CE must reach local SMEs.

Taiwan was not able to join the Basel Convention but it controls the import of e-waste through its national legal framework. And since its regulations are in accordance with the Basel Convention, international shipment of e-waste is not an issue in Taiwan. However, Taiwan does not restrict the international shipment of second-hand electronics (similar to Japan, the Philippines, Republic of Korea, Singapore and Vietnam).¹³ While enforcement of the measures remains a significant challenge in some countries, international shipping of second-hand electronic devices does not appear to be a major issue. As a consequence, it is the domestic generation of e-waste that is of great interest. In Taiwan, some 40,000 tonnes of e-waste are generated every year. Volumes of e-waste are on the rise and there is a clear tendency to have more electric and electronic devices in Taiwanese households. Due to its early engagement with recycling Taiwan has a head-start in the region in establishing e-waste collection and recycling systems. As of now, the recycling rate of e-waste is about 80%. The government adopted a zero landfill policy in 2010 to promote a more sustainable approach to deal with electronic waste. Taiwanese have made clear that they are very active in collecting waste, however, creating closed-loops and up-cycling is a new challenge (Hu & Hsu, 2010). The government proposed a series of measures that include educational efforts, innovative eco-designs, new technological applications, and increased efforts in environmental governance (Yang et al., 2016; Tsai & Chou, 2004).

Efforts include areas of resource extraction but also industrial manufacturing, products, and services. A huge challenge to implement a circular economy is the establishment of an information system that is able to catch the whole flows of materials and goods in order to be able to create closed-loops within the economic system. Local recycling enterprises (such as Super Dragon, Jiin Yeeh Ding, Golden Plus...) have established treatment facilities that allow retrieving valuable substances from discarded electronic devices. About one ton of gold and millions of tonnes of copper can be retrieved from electronic scrap every year. For Taiwan, the semiconductor industry is a major industry. According to government statistics IC products accounted for over 30% of the nation's total exports in 2016, in 2005 it was only 15%.¹⁴ Taiwan is the world's largest consumer of semiconductor materials and the procurement amount continues to rise.¹⁵ The local semiconductor industry consists of three major segments, the integrated circuit design, manufacturing, and packaging and testing. Hsinchu based TSMC is the world's largest IC foundry, while Advanced Semiconductor Engineering Inc., based in Kaohsiung, is the largest IC packaging and testing services provider. The importance of the semiconductor industry provides a major reason to uphold the industry's competitiveness and prevent missing major industry trends.

Several large companies in Taiwan have joined government efforts in promoting the circular economy. Taiwan Semiconductor Manufacturing Company (TSMC) - the world's largest contract chipmaker - announced that it set the goal to recycle 61% all waste products internally by 2020. Currently, the rate of recycling is under 20%.¹⁶ ASUS announced that it plans to recycle 20% its global e-waste by the year 2025. ASUS is operating in 14 countries

¹³ United Nations University, Jan. 15, 2017, <https://ehs.unu.edu/media/press-releases/e-waste-in-east-and-southeast-asia-jumps-63-percent-in-5-years-un-university.html>.

¹⁴ Taiwan Today, April 5, 2017, "Taiwan remains the world's largest IC materials buyer", <https://taiwantoday.tw/news.php?unit=6&post=113468>.

¹⁵ TAITRA, News, https://bucharest.taiwantrade.com/news/detail.jsp?id=21998&lang=en_US.

¹⁶ Taiwan Today, May 1, 2017, "Greening the Economy," <https://taiwantoday.tw/news.php?unit=8,32&post=114991>.

and works together with local recyclers to step up recycling processes of e-waste. In 2016, ASUS recycled about 11,000 tonnes of e-waste (12.2% recovery ratio of total products sold).¹⁷ In 2016, the company launched a new e-waste recycling program in India, and opened 40 e-waste collection sites across the country, also providing services, such as a free on-site pickup.¹⁸ In addition, ASUS seeks to promote environmental awareness through a series of educational events.

China Steel Corporation (CSC) - Taiwan's largest integrated steel manufacturer - already provides by-products from its steel production for other producers. The company also provides steam and power to a network of several enterprises in the vicinity.¹⁹ Cheng Loong Corporation is a leading manufacturer of packaging paper with several paper plants and mills in the country. The company provides boxes for international sportswear producers and uses 94% of its raw materials from recycled paper.²⁰ The number of sustainability reports for Taiwanese companies has risen significantly over the last years. According to Morningstar Sustainability Ratings, Taiwan is now the second largest equity market in the Asia-Pacific region. Among the 46 most important equity markets in the world that were considered in the study, Taiwan was listed ahead of Japan, South Korea, and the USA, only behind Australia. The first three places on the world ranking were taken by the European countries Portugal, Denmark, and Finland.²¹

The involvement of large and state-related companies is definitely a positive tendency. However, small-and-medium sized businesses are the backbone of Taiwan's economy. And they face mounting pressure since they have to compete in a global market, respond to volatile resource prices, and also need to take into consideration local environmental regulations. A transition into a circular economy is only achievable with a government-led assistance for SMEs, supporting them with knowledge and guidance.

Conclusions

Taiwan was able to set up a solid recycling system that earned an international reputation. However, moving beyond the current linear production system may well provide a substantial challenge for Taiwan. The government has implemented first measures to move towards a zero-waste society and to transform into a circular economy, but larger efforts will be needed to ensure a smooth transition and to uphold international competitiveness of the local semiconductor industry. The promotion of a circular economy provides many benefits, particularly for an economy that relies substantially on imports. While imports are costly, the creation of a circular economy could boost the re-use of materials within the economy. The strongest arguments for the transition into a circular economy are global competitiveness, securing raw material supplies for the local industry, and increasing productivity and innovation. It could thus not only prevent the generation of waste but also boost resource productivity and enable Taiwan to better address future security and scarcity issues. Furthermore, it could help to reduce environmental impacts of the economic system and spur economic growth. Moreover, the transformation into a circular economy will result in the generation of new jobs. However, since required skills will differ largely, the education system would need to be included in the transformation process. Taiwan still lacks experts and innovative power in closing loops and establishing material cycles within the economic

¹⁷ TAITRA, News, <https://bucharest.taiwantrade.com/news/detail.jsp?id=22554>.

¹⁸ TAITRA, News, <https://bucharest.taiwantrade.com/news/detail.jsp?id=22554>.

¹⁹ Taiwan Today, May 1, 2017, "Greening the Economy", <https://taiwantoday.tw/news.php?unit=8,32&post=114991>.

²⁰ *ibid.*

²¹ The China Post, Dec. 5, 2017, "Tainan aims for circular economy leadership", <https://chinapost.nownews.com/20171205-166210>.

system. While Taiwan was able to build up a solid waste management system that was able to deal with a variety of waste categories, transforming the economy into a circular economy will be a much bigger challenge. First steps are set but more policy measures are needed to bring the economy on a sustainable track.

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