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Words from the Author



Environmental Protection Administration is established in 1987. After long term construction and hard work, the comprehensive garbage disposal rate of Taiwan reached over 99% in term of garbage processing, thus completely solve the garbage disposal issues. The following promotion of four in one resource recycle project, restriction on plastic shopping bags as well as mandatory garbage classification policies have successfully reduce garbage volume and recycle resources comprehensively to achieve the goal of " changing garbage into gold".

The material culture brought by fast economy development result in speedy increases in categories and quantities of commercial wastes, and hence the increasingly complicate disposal methods and elevated costs. The traditional end of pipe treatment no longer meets the modern requirement. Therefore, the resources sustainability should be the target for future key focus while circular uses as the direction, introduces the concept of material life cycle circular uses, then gradually promote and move toward the ultimate target of zero wastes. Beside the traditional 3R (Reduction, Reuse, Recycle), the new concept of 6R, energy recovery, land reclamation and redesign is further introduced, moving toward promoting the new future of circular economy gradually through sustainable material management.

The best case analysis of this book selected famous suppliers from Taiwan and overseas or emerging small to medium businesses to analyze and summarize their key performances in promotion of circular economy as a reference for various domestic audiences. This report collected a total of 52 enterprises samples, including 32 domestic enterprises and 20 foreign enterprises. The selection reference principles of these chosen cases include enterprises who won major domestic and foreign environment and circular

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economy related awards, enterprises who received positive feedbacks from governmental bodies such as EPA or famous institutions as well as enterprises who was recognized by the think tank team of this project and has produced solid results. After many discussions by the think tank team of this project, cases that can be referred to by all audiences are selected from many domestic and foreign enterprises.

Taken into consideration of including larger cases scopes, this book did not select based on specific industry chains to provide references for more industries. In terms of case analysis, this report use the mainstream 5R principles (redesign, reuse, reduction, recycle, energy recycle) in promoting circular economy to classify and compare, classify by key promotion methods of each cases, then analyze on cases of the same categories. Meanwhile, domestic resources integration cases are added in order to complement the cases that promote circular economy through industry chain analysis and explain how to integrate upper stream, middle stream and downstream industries for practices. It is anticipated this book will provide precious references information for promoting circular economy of Taiwan, allowing the interested public or industry to be inspired and work hard together to promote circular economy for creating new milestones of balanced environmental and economy.

> National Taipei University of Technology Recycling oriented Environment Research Center. Professor Tien-Chin Chang Noted

Chapter 1 Foreword

1.1 Objective of compilation

The supply and demand of raw materials should be closely related to national security and daily livings, but the main target for materials in the past is to satisfy economic development, and neglected that material itself is a serious bottleneck for economy development. Thus, balance should be considered between security, development and sustainability. The current total annual consumption of material in Taiwan is about 0.3 billion tons. About 70% of material consumption relied on import, therefore; the material supply system of Taiwan is relatively weak by nature. Every time when there are material supply crisis across the globe, it has significant impact on material supply in Taiwan. The traditional pattern of mining, producing, consuming and disposing raw materials causes resources exhaustion and waste management issues.

Sustainable material management is a life cycle thinking management pattern that covering materials from supply stage, production stage, and consumption stage (design, manufacturing (or producing), sales and consumption), circular stage (collect, recycle and reuse) and promotes sustainable utilization of materials. The self-produced material supply rate is low in Taiwan, and often relied upon imports. Sustainable material management is more important in terms of national strategy, politic stability, economic development, household demands and sustainable environment. To implements the sustainable management of national materials, increase utilization efficiency, protects natural resources, and promotes environmental harmony and increase green competiveness as well as building circular and sustainable society.

To ensure the supply of key materials is smooth, reduce material reliability and risks. Environmental Protection Administration, R.O.C. (Taiwan) (EPA) continuously promotes sustainable material management in recent years. Under the popular trend of circular economy, Industries also start to understand that they need new generation of revolution and begins to attempts new research or new patterns in various aspects. This report collects innovative samples from domestic and oversea enterprises who adopt circular economy methods, undergoes key industry data collections and investigations

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and submits report. This report analysis results can be provided to industry, government, academic and research bodies for references.

This report collected a total of 52 enterprises samples, including 32 domestic enterprises and 20 foreign enterprises. The selection reference principles of these chosen cases include enterprises who won major domestic and foreign environment and circular economy related awards, enterprises who received positive feedbacks from governmental bodies such as EPA or famous institutions as well as enterprises who was recognized by the think tank team of this project and has produced solid results. After many discussions by the think tank team of this project, cases that can be referred to by all audiences are selected from many domestic and foreign enterprises. There are many small or new business models, although they don't have significant scales, but their efforts are worth to look up to. This report also includes relevant information as reference for all audiences.

Regarding to the structure of case analysis, the collected cases are considered to include range as large as possible during selection, thus no specific industry chain is chosen, which in turn result into difficulty in system analysis. In view of this, this report use the mainstream 5R principles (redesign, rethink, reduction, recycle, energy recycle) in promoting circular economy to classify and compare, classify by key promotion methods of each cases, then analyze on cases of the same categories. Domestic resources integration cases are added in order to complement the cases that promote circular economy through industry chain analysis and explain how to integrate upper stream, middle stream and downstream industries for practices.

In addition, besides the enterprises cases, small changes made in daily life by general public in fact contribute toward circular economy. This project also compiled several innovative green consumption cases for general public's reference.

In the end, domestic and foreign cases analysis results are summarized to provide important methods and comparisons between domestic and overseas cases as well as references can be taken from foreign cases.

1.2 Coverage

This report is divided into 4 chapters; the relevant content introduction is as follow:

- Chapter 1 "Forewords" : mainly explains objective of compilation and the coverage of report.
- Chapter 2 "The best practices in domestic and overseas" : explains the basic introduction of key business samples of circular economy, sources, method and products of waste recycling.
- Chapter 3 "Case analysis" : analyze the domestic and foreign cases by regulations and policy, technology, method, competiveness advantage, challenges and recommendations as a reference for all audiences.
- Chapter 4 "Conclusion and recommendation" : Summarize the contents and chapters stated above and submit relevant recommendations.
- Chapter 5 "References"

Chapter 2 The Best Practices of Domestic and Foreign Industries

Sustainable materials are a popular trend in the world. Many countries start to look for develop new opportunities in circular economy and cause enterprises to rethink on the new path for traditional supply chain, break through the traditional linear thinking, introduce the new concept of recycle and reuse, looks for the possibility of recycle wastes. Beside the re-inventory used by raw materials of one factory and attempt to increase the resource usage efficiency of raw materials produced by itself, bigger perspective is adopted to review the possibility of connections between different industries. Waste produced by an industry or factory maybe useful resources for other industries or factories. Under the reuse mindset of expanding scale and range, more reusable resources will be possible to become secondary raw materials and further promotes and activate circular economy.

Under this trend of circular economy, enterprises from various countries review its own supply chains and business modes, attempts to seek for methods and technology comply with circular economy concepts and help its industries to become more competitive across the globe and create new profit module. After many discussions by the think tank experts of this project, the best practices are selected for analysis in this report based on two principles:

- 1. Enterprises who won important awards in domestic and foreign environmental protection or circular economy.
- Enterprises who received highly positive evaluation from review system of Recycling Fund Management Board of EPA.

After selection based on these two principles stated above, this report selected a total of 52 domestic and foreign enterprises for analysis, including 32 domestic enterprises and 20 foreign enterprises, the list of selected enterprises is shown in table 2-1 below.

Countries	Industry cases			
	Wistron	O' right	Miniwiz	Cleantek
	Solartech	AMIA	Dong Da	Bee Sing
	SEG	Chinalab	Diamonchem	SDTI
	Uwin Nanotech	Yung Yuan	HJEC	Plum Monix
Domestic	Taiwan Cement	RDH	CLC	SRTI
(32)	DF Recycle	TSMC	Da Ai Technology	E&E Recycling
	CSC	CSC Far Eastern Delta New Century Electronics, Inc.		Ecove
	ShiHan Farm	Lixiang Living	Good to go box	Goldfish brain
	Phillips	SUBARU	Toyota	HP
	Xerox	REMON-DIS	Astec-irie	DOWA
Foreign (20)	MBA Polymers	Green Group	WRC Recycling	Olus
	Mitsubishi Electric	Nomura Kohsan	Umicore	AGC MATEX
	Tanaka koumuten	Du Pont	Evonik	Orsted

Table 2-1 The list of key enterprises included in case analysis afterselection

Source : Compiled by this project

8

2.1 The best practices in Taiwan

1. Wistron Corporation

(http://www.wistron.com.tw/index.htm)

(1) About the company

Enterprises continue work hard to practice circular economy concept to achieve the mutual symbiosis between human and nature, causing products to be effectively reused after redesigning the product.

(2) Type and sources of wastes

The waste plastic is the main process items, it can process various mixed waste plastic and wastes, which included ABS, PC/ABS, PC, HIPS.

(3) Type of waste disposals

The manufacturing process strives into achieving circular economy closed loop, waste can be fully recycled to new product manufacturing process, its execution process may be referred to figure 2-1 below. Different from the traditional technology, applicable optics classification and water purifications technology can automatically recycle renewable mixed plastic waste.



We are using plastics from the computers and parts we recycle through Dell's existing takeback and recycling programs to build brand new systems, driving a circular economy for the IT industry.

Source: Wistron, 2012.

Figure 2-1 Closed loop of manufacturing

(4) Waste recycled products

The recycled and reproduced secondary raw materials can be applied in manufacturing new electronic products.

2. Hair O'right International Corporation

(https://www.oright.com.tw/)

(1) About the company

The company vision aims to carry products that are benefit toward human health, social health and environmental health as well as producing environmental friendly products with creativity.

(2) Type and sources of wastes

Using redesign methodology to allow the bottle packaging of its product to re-enter biological cycle after use and reduce its impact on environment.

(3) Type of waste disposals

Produce biodegradable bottle using biomass, then put in seeds in the bottle body and then the bottle will regenerate into plant after degradation and enter biological cycle.

(4) Waste recycled products

"Recoffee series" is one of the representative product and its design concept is shown as figure 2-2. Manufacture packaging bottle from recycling used coffee powder. The bottle can be biodegradable after use and act as nutrients for coffee tree after biodegradation, which is helpful toward coffee planting and re-enter the new biological cycle.



Source: Lingjie Luo., 2016

Figure 2-2 O' right Recoffee series product

3. Miniwiz

(http://www.miniwiz.com/home.php)

(1) About the company

Miniwiz is found in 2005 and considers that perspective on the garbage should be changed. Under the concept of circular economy, garbage should equal to opportunity. Every type of waste has the possibility of recycling and reuse, as well as unlimited business opportunities and is beneficial in protecting our environment.

(2) Type and sources of wastes

Recycle various wastes such as waste plastic, waste paper, waste metals and waste biomass to produce various possible resourceful products.

(3) Type of waste disposals

Establish the one and only waste laboratory in the world to research on possibility and potential of renewing various wastes. The sample is shown below in Figure 2-3.



Source: ECOLOGICAL GLASSES Magazine, 2017.

Figure 2.3 Miniwiz lab continuously explore the recycle methods of various wastes



(4) Waste recycled products

The plastic and recycled paper applied on recycled waste electronic products were successfully developed in 2007 and manufactures three in one portable mini wind power, solar energy and manual power generator while achieve the standard of zero carbon footprint.

4. Rui Da hung technology materials co.

(http://www.rdh.com.tw/c_organization.html)

(1) About the company

Rui Da hung technology materials Co. is a professional metal tin smelt recycling manufacturer. It has extensive experience in metal tin and purified manufacturing, while obtained the license of harmful business waste reuse and recycle from Ministry of Economy in the beginning of 2003. Currently, license of reuse on many general cases of recycling Scrap tin solution (C-0202), Scrap tinning waste (C-0102) and Waste tin lead slag (C-0102) are obtained.

With the arrival of information age, electronic information industry will be the main stream that handles the future industry pulse, tin metal has been widely applied in these electronic parts and components. Due to lack of mining resources, Taiwan has to rely on expensive imported metals. Thus, without proper waste metal recycling channels, resource will be wasted and these waste metals have bioaccumulation that cause high danger in human and environment with hidden environmental risks. In order to respond to waste reduction policy as promoted by the government, Rui Da hung technology materials Co. uphold the passion and idea of resource recycle and reuse, while armed with the Company's professional techniques, is performing PCB industry related waste resource recycle and reuse plan. The company recycles and reuses tin alloy items from related industry such as tin containing waste, tin mud and waste tin lead slag.

(2) Type and sources of wastes

The main business wastes recycled are stripping tin solution, dross and anodic sediment.

(3) Type of waste disposals

After raw materials enter electric arc furnace, pure tin ingot and pure lead ingots are produced by refinement through electrolysis. The anodic sediment waste produced by electrolysis can be remade into pure silver ingot, copper sulphate and Bismuth hydroxide by separation and purification procedure. The detailed procedure is shown in figure 2-4.



Source: Rui Da hung technology materials co. website, compiled by this project

Figure 2-4 The flow chart of waste management

(4) Waste recycled products

Rui Da hung technology materials co. carefully handle pollution prevention of various recycling process and properly dispose the final leftover wastes, while manufacture tin and alloy into industrial tin products as well as solving relevant environmental issues.

5. Cheng Loong Corp.

(http://www.clc.com.tw/)

(1) About the company

CLC is found on February 04, 1959 with the core business in paper making and paper processing. The Company puts its heart to innovations and release diversified paper products, construct complete paper supply chain while develop into multi-

angle managed group. CLC dedicates to product research and development, introduces automation equipment, and performs process and procedure improvement and rationalization to increase service quality and operational performance. In the recent years, the one-stop production and marketing of paper making and paper equipment processing are continuously strengthen, promotes allround paper packaging services. Meanwhile, the Company receives unanimous affirmations from domestic and foreign paper packaging customers and consumers and become many international branded green packaging partners through sustainable development strategies of green production, energy conservation and emission reductions and low carbon environment protection. The product and process are innovative and environmentally friendly.

(2) Type and sources of wastes

CLC uses recycled paper as main raw materials, and is the largest recycled paper reuse company in Taiwan. It dedicates to reduce environmental impact from design, manufacturing, transportation and customer service of product. CLC is one of the first batches of enterprise that introduces ISO 14000 environmental management system. The Company integrates and applies process improvement and energy and resource to reduce the uses of raw materials and improve efficiency. In addition, highly efficient pollution control equipment is invested continuously to reduce pollutants emission. Meanwhile, promote relevant improvement plan through the operation of key systems like environment management, greenhouse gas management and energy management to create sustainable values of enterprises.

(3) Type of waste disposals

Water is one of the important resources for paper making industry. The water resource usage efficiency is increased through water resource management, dedicate to waste water reduction, paper mill returned the white water produced during production process to part of the process equipment for application after recycling filter. Meanwhile, through process improvement and daily management while using the concept of cycle, recycling and reuse to continuously pursue rationalization of water use. In terms of water pollution prevention, each factory area is established with waste water process system. Paper mill division properly process waste water by biological treatment to ensure the water quality of effluent is complying with the standard to reduce environmental impact. Paper product division recycle processed waste water to use in washing and paste making by chemical and physical methodology, hence substantially reduce water consumption.

In terms of waste product management, Da-Yuan Factory and Houli Factory established Heat Recovery Steam Generator and RDF (waste derived fuel) pelletizer. Waste paper mix and polluted mud can be thrown into Heat Recovery Steam Generator for burning and recycle its thermal energy to generate steam for process application, and RDF pelletizer can select, crush and dry waste paper mix and made into homogenous solid fuel rod. Such rod will be thrown into steam boiler to replace part of raw coal, reduce greenhouse gas emission. The percentage of waste recycled is increasing yearly. Table 2.2 below list out waste disposal and reuse applications of each industry.

Table 2-2 The	e process	and reuse	applications	of	waste	by	each
		departı	ment				

Waste water					
Item	Process	Reuse application			
Paper making department	Biological treatment				
Paper product department Physics and chemistry		Applied in washing and paste making			
	Waste				
Item	Process	Reuse application			
Recycling hot boilers	Throw waste paper mix and polluted mud into burning	Produce its thermal energy to produce steam for process application			
RDF pelletizer	After selection, crushing, drying process, waste paper mix is manufactured into homogenous solid fuel rod	Thrown into steam boiler to replace the application of partial raw coal			

Source: Cheng Loong Corp. website; compiled by this project

6. AMIA Co., Ltd.

(http://www.persee.com.tw/)

(1) About the company

AMIA Co., Ltd. is founded in 1974 and specializes in electronic chemicals and industrial copper salt product development; focus on professional experiences and technology of industry knowledge economy and practicing "Industry green production" and "resource recycling and reuse" concepts to create zero pollution resource recycling system and creating new miracles of Taiwan green technology economy. Currently, the etching line forming potions comply with various latest mobile phone requirements are developed and zero pollution recycling reuse waste liquid technology.

(2) Type and sources of wastes

AMIA Co., Ltd. not only supply chemical potions for electronic industry process but also purchase special chemical waste liquid including copper and tin after customer uses.

(3) Type of waste disposals

Through unique zero pollution recycling and reuse process and high-level technical workmanship, extract precious metals from waste liquid and convert to copper salt products required by electronic industry, mining industry, dyeing and finishing, painting and other industries. The recycled waste liquid does not need to be disposed and can almost be reused fully.

(4) Waste recycled products

The waste recycled products of AMIA Co., Ltd. are copper sulfate, copper oxide and copper carbonate. The recycled products from AMIA Co., Ltd. are shown in table 2-3 below.

Title	Nature	Applications
Copper(II) Sulfate	Blue crystal powder or particles, Almost white in appearance beside crystallization water Lost moisture at 100°C Soluble in water and ethanol Dilute sulfuric acid is combined action of sulfuric acid and copper or copper oxide, concentrating into solution, and then produced by crystallization.	Printing ink system, batteries, Paris green, casein glue, mordant, Pesticide, Wood preservatives, waterproofing agent (no water body), colors of coating, leather tanning materials, metallic colorants and plating.
Cupric Oxide	Black power Soluble in acid but not water	Copper products processing or for the production of rayons, ceramics, Glaze and enamel, batteries, petroleum desulfurization agent, pesticide, hydrogen, catalyst, green glasses, plating
Verdigris	Dark green powder Heating decomposition Soluble in acid but not water. Add sodium carbonate into copper sulfate solution, precipitate, filter and dried	For pyrotechnics, Plating bronze on copper, paint, pesticide, antidote for carbon poisoning, plating.

Table 2-3 The recycled products of AMIA CO., LTD.

Source: AMIA CO., LTD. website, compiled by this project

7. Dong- Da Industrial Co., LTD

(http://www.dongda328.com.tw/about-us.html)

(1) About the company

Dong- Da Industrial Co., LTD is the approved and announced reuse institution by EPA. It is specialized in "acid etching waste R-2501" of PCB industry and "acid pickling water waste R-2502" of metal surface process industry. These are the main recycle and reuse items of the factory to implement the environmental friendly concept, "recyclable, low pollution and resource saving" of green mark. Meanwhile, "value creation" allows wastes to be fully reused and comply with regulations of EPA.

(2) Type of waste disposals

Through recycle and reuse technology, replace copper from waste liquid and convert to product required by water treatment pharmaceutical industry, including ferric sulfate solution (Ferrous sulfate) and Ferric chloride solution, create new values. Thus, the recycled waste liquid can be reused almost completely to achieve the goal of sustainable operation and development.

(3) Waste recycled products

The main waste recycled products of Dong- Da Industrial Co., LTD are acid etching waste R-2501, acid pickling water waste R-2502. Table 2-4 contains recycled and reused products of Dong- Da Industrial Co., LTD.

Title	Displaced Copper (Copper powder)	Ferric chloride solution	Ferric sulfate solution
Content	Raw materials of various copper products, Powder metallurgy applications	Waste code title: waste etching liquid R-2501 The maximum monthly recycling volume: 1200 Tons/Month concentration of copper ions produced from etching process : 50g/L and more	Waste code title: Waste acid washing liquid R-2502 The maximum monthly recycling volume: 600 Tons/Month The waste acid washing liquid that contain iron ions produced from acid wash treatment on metal surface by corroding iron or steels using hydrochloric acid and sulfuric acid. (concentration is above 80g/L)

Table 2-4 Dong- Da Industrial Co., LTD recycle reused product

Source: Dong- Da Industrial Co., LTD; compiled by this project

8. Beshine Stone & Son Industrial Co., Ltd.

(http://bee-sing.com/)

(1) About the company

Beshine Stone & Son Industrial Co., Ltd. is located in Dafa Industrial Park, Kaohsiung City. The factory has over decades of experiences since its establishment. It specializes in production of Ferric chloride acid etching solution and water treatment chemicals while selling chemical raw materials such as bleach, liquid alkali and hydrochloric acid. The factory set up storage tank with capacity of thousands of tons. The supply is adequate and meets the demand of different customers. The factory is equipped with precision instrument and professional full-time staffs to control quality strictly, providing appropriate, timely, suitably and good quality products.

(2) Type and sources of wastes

Business waste announcement reuse "acid etching waste R-2501" is the main service items of the factory. The factory provides highly efficient services that are professional, legal, reasonable price, quality assurance, honest and responsible and customer satisfaction guaranteed. The factory is equipped with fuel tanker which provides delivery and clean-up services.

(3) Waste recycled products

Beshine Stone & Son Industrial Co., Ltd. waste recycled products include Ferric chloride, Ferrous chloride, Ferric sulfate, Ferrous sulfate, Aluminum chloride, Sodium hypochlorite, hydrochloric acid and Copper powder. Table 2-5 is the recycled product items from Beshine Stone & Son Industrial Co., Ltd.

Table 2-5 Waste recycled products of Beshine Stone & Son IndustrialCo., Ltd.

Title	Acid etching waste	Waste hydrochloric acid
Code	R-2501	R-2502
Content	The waste acid etching liquid containing copper ions produced during etching process by the enterprises (The concentration is above 50g/L)	The waste acid washing liquid that contain iron ions produced from acid wash treatment on metal surface by corroding iron or steels using hydrochloric acid and sulfuric acid. (concentration is above 80g/L)

Source: Beshine Stone & Son Industrial Co., Ltd. website; compiled by this project

9. Spring Pool Glass Industrial Co., Ltd.

(http://springpoolglass.com/)

(1) About the company

Mr. Wu Chun-chi set up Spring Pool Glass Industrial Co., Ltd. in 1970. He start to dedicate to the work of "waste glass recycle and reuse", recycle majority of waste glass containers within Taiwan and manufactured into beautiful glass art and export to various countries across the world. In 1972, the glass industry in Taiwan take off, the raw materials are under tight supply. Spring Pool Glass supply shattered glasses from major factory to small factory as renewable materials. The company also visits each glass factory to recycle trimmed left over glasses and started glass recycle business. To allow wider application of waste glasses, funds are collected and the subsidiary, Taiwan tai bao glass industry co., ltd. was established. The environmentally friendly construction material, "colorful glass" was developed successfully. The product has many advantages and is practical and beautiful. It set off a new trend across international construction industry and turns unattractive waste glasses into dazzling "colorful glass" and relevant green materials. The company even put in reuse research and development of waste glass to successfully convert waste glass into multi-colored "colorful glass" by rapid cooling of heat fusion concept. Nowadays, the quantity of waste glasses recycled by Spring Pool Glass account for over half of total recycled volume in Taiwan. After renewal, the sale profit and additional value of pursuing environmental protection of colorful glass are best business and green model.

(2) Type and sources of wastes

Waste glass is a material that can be completely renewed and reused. Using Taiwan as an example, very large volume of waste glass is produced annually. These waste glasses will be very helpful to efficiency of environmental protection and resource application if these waste glasses can be efficiently recycled and reused. However, glass incineration is not easy to melt into ashes and cannot be biodegraded. However, the nature of glasses is fairly close to gravel. Thus, many business recycle glasses and reuse recycled materials to replace tiles, floor building materials, wall materials, sidewalk layout, home and gardening materials, asphalt pavement and glass furnace.

(3) Type of waste disposals

The production of colorful glasses starts from manual selection, color separation and impurities removal. Then, mechanical grinding and melting by glass furnace to completely fuse harmful shattered glass sharp side into harmless and high strength round particles. These glass beads combining characteristics such as fine refractive index, high hardness, excellent drainage, insulation and fireproof have turn the cheap waste glasses into high class building materials. (depending on color and particle size). Nowadays, Spring Pool Glass actively promotes the application of colorful glasses. Example: the wall of underground water underwater world in front of Keelung Rail Station is decorated with colorful glasses. The crystal clear colorful glasses successfully bring out the bright and cool of underwater world. Figure 2-5 shows the recycle reuse process of general waste glasses.



Source: Spring Pool Glass Industrial Co., Ltd.; compiled by this project Figure 2-5 The recycle and reuse process of general waste glasses

10. Chung Tai Resource Technology Corp.

(http://www.chinalab.com.tw/)

(1) About the company

Chung Tai Resource Technology Corp. upholds the belief of protecting natural environment. It insisted in the resource renewal idea to achieve sustainable operation. The Company mercury- containing waste disposal and waste lighting sources recycle and reuse business and green industry business. The Company forms a complete recycling system of sale and waste recycling of relevant electronic products as well as manufacturing of lighting sources with parent company, "China Electric", causing recycling and reuse of earth resources and sustainable development.

(2) Type and sources of wastes

Waste lighting resources disposal service include Grade A waste clearance institutions and disposal items and waste lighting sources that should be recycled.

- Grade A waste clearance and disposal items: shown as table 2-6 below.
- waste lighting sources that should be recycled (R-2405) :

To maintain appropriate illumination, the lighting tube frequently used in each major factory, workshop and production line should be replaced at any time. Family and school units needed light tubes and light bulbs even more to maintain the brightness and lightness of indoor space. Since light tubes and light bulbs often include trace amounts of harmful materials (Mercury and fluorescent powder), serious environmental hazards may be caused if such materials cannot be recycled properly.

According to EPA announcement, the waste lighting source required to be recycled include linear fluorescent tube, ring fluorescent tube, Self-ballasted fluorescent lamps (generally known as energy saving bulb, its shape include spherical, U shape and spiral shape), Compact fluorescent tube, Incandescent light bulb with lamp cap of 2.6 cm diameter and H.I.D lamp, such as mercury light bulb and Metal halide lamp.

Table 2-6 Grade A Waste Clearance and Disposal Items

Waste light industrial wastes				
C-0172	The waste lighting sources that contain mercury or phosphor (lamp, light bulb) (Does not belong to recyclable wastes as announced), and the mercury concentration per kg of dry base is lower than 260 Mg.			
C-0173	The waste lighting sources that contain mercury or phosphor (lamp, light bulb) (Does not belong to recyclable wastes as announced), and the mercury concentration per kg of dry base is lower than 260 Mg.			
	Harmful commercial waste that include mercury			
C-0101	Mercury and other compound (total mercury), Amalgam compound			
B-0220	Mercury (Class 1 Toxic Chemical Substances Control Act)			
	Waste glasses			
R-0401	Waste glasses (Recycling lamp glass)			
G-0401	Renewable resource glass (Recycled face plate glass)			
C-0102	Lead and its compound (Recovered cone glass)			

Source: Chung Tai Resource Technology Corp. website; compiled by this project

11. Sus Recycle Technology Inc.

(http://www.srti.com.tw/tw/)

(1) About the company

Growing with Taiwan information and electronic industry, Sus Recycle Technology Inc. is the pioneering leader supplier of domestic electronic waste cleaning and breaking many records of industry peers. In 2002, the Company is innovative and adopts business waste professional recycling OEM system. It is evidently shown that Sus Recycle Technology Inc. is always upholding the business philosophy of non-stop innovation, challenges and learning as well as mutual beneficial development of pursuing humanities, industrial economy and environmental management.

(2) Type and sources of wastes

The industries are mainly semi-conductor, electronics, computer parts and components, materials, printing PCB, technology lab, telecommunications, ornaments, petrochemicals and others. Sus Recycle Technology Inc. specializes in precious metal recycling and renewal technology. It can fully recycle and renew precious metal excrement produced during semiconductor and electronics industrial production, and create high value adding resource recycling benefits.

(3) Type of waste disposals

The disposal of electronic industry scraps of Sus Recycle Technology Inc. is classified into two major categories of solid and liquid. Solids will be weighed, classified, and resource renewal values judged. Scraps that are judged as renewal valuables enter each disposal process, scraps that are judged as not renewal valuables enter harmless treatment.

Waste source -Industry							
	Telecommunications industry		Material industry	Display		Computer components	Photoelectric LED
Industry	Industry semiconductor industry		electronics	Circuit board		Ornaments, Petrochemical industry	Solar energy
Waste source -Type							
	RareDisplay potion, waste semiconductors, permanent magnet, wastes from lighting industryd, idPtAerospace components, chips resistor, fuel cell, catalysts from automobiles and motorbikes, computer hard disks		Ag	Accessories, IC, cartridge, materia energy industry,	resin, filter als of solar bad electronics		
Solid, Liquid			Au	Plating potions, I board waste, res cartridge, bad ele	C, Circuit in, filter ectronics		
	Pd	Pharmaceutical Catalyst, Plating potions, Plating activator, resin, filter cartridge, catalysts from automobiles and motorbikes		ating sin, n			

Table 2-7 Sources of Rare Precious Metals

Source: Sus Recycle Technology Inc.; compiled by this project

(4) Waste recycled products

Sus Recycle Technology Inc. refines precious metal from recycled electronic business wastes into metal ingots of high purity and complying with international rules after a series of processes.

12. Super Dragon Technology Co., Ltd.

(http://www.sdti.com.tw/)

(1) About the company

Super Dragon Technology Co., Ltd. is established in September, 1996 as the first listed company of environmental technology stocks. It specializes in research development of "resource recycling process, reducing environmental load and build resource sustainable uses". Its service ranges cover information technology industries such as IC semiconductor, PCB, computer peripherals and photoelectric. Super Dragon Technology Co., Ltd. provide the most complete waste disposal and re-resource countermeasures while determine to lay out across the globe.

(2) Type and sources of wastes

Super Dragon Technology Co., Ltd. has self-recycling and resource processing harmful business waste abilities. It even introduces the most advanced technology and equipment from Japan and Germany. The Company has currently become the largest professional electronic waste recycling factory. The main precious metal recycling industry of Super Dragon Technology Co., Ltd. is shown in table 2-8 below.

Table 2-8 The key industry recycling precious metals by Super DragonTechnology Co., Ltd.

The key industry recycling precious metals				
Industry title Product recycled				
IC semiconductor	Wests IC wasts ship mixed hardware wasts silver			
Packaging and testing industry	liquid, copper scrap, waste silver slag and resin.			

PC board manufacturing and processing	Scrapped board, waste PCBA, gold plated board, tin edges, copper substrate, copper scraps
Computer peripherals manufacturing	Waste computer CPU and peripherals, components disassembled from waste computers, waste electronics
Precision electronics and Photoelectric manufacturing industry	Aging fluid, waste ceramic circuit board, waste resistor, waste condenser, waste resistor, tailings and catalysts, waste gold liquid (slag), precious metals coated waste
Communication and others Related products	end materials, waste end materials including precious metals.

Source: Super Dragon Technology Co., Ltd.; compiled by this project

(3) Type of waste disposals

Super Dragon Technology Co., Ltd. is responsible of waste computers recycling tasks of Northern Taiwan. After passing selections of waste information processing plant by Recycling Fund Management Board in August 1999, the Company accepts audits and certification staff stationed in the factory by Recycling Fund Management Board, EPA to ensure the processing of waste information items. Currently, EPA announced recycling items are personal computer CPU, monitor, laptop and subsequently announced waste printers. Plus, Super Dragon Technology Co., Ltd. adopt grinding method to dispose information items for implementing environmental friendly idea, while avoiding to rely on incineration and bury, further implement the concept of resource recycling.

(4) Waste recycled products

Super Dragon Technology Co., Ltd. reuse resource renewal artwork by electronic wastes. First of all, fine sorting the glass fibers, resin powder and waste CRT, then add hardener to perform mix, forming, stripping and polishing on output products, then moved on to packaging.

13. UWin Nanotech. Co. Ltd.

(http://uwin-nano.com/)

(1) About the company

UWin Nanotech. Co. Ltd. dedicate toward producing environmental friendly products to cherish precious environmental resources of Taiwan. The company use electronic waste as raw materials to reuse recycled precious metals.

(2) Type and sources of wastes

The main businesses are electronic and electrical appliances wastes of recycling personal computer, laptop, TV and mobile phones, reuse recycled precious metal through a series of recycle processes.

(3) Type of waste disposals

Using environmental friendly recycling process, its execution process can refer to figure 2-6 below. Research and development equipment of SnST-550A Tin stripper can quickly separate the metal part of waste motherboard to speed up recovery process. Such disposal equipment has been exported to U.S.A, China, Singapore and Switzerland.

(4) Waste recycled products

Important metals such as gold, silver, copper, palladium and tin can be recycled from electronics and electrical appliances wastes.



Source: UWin Nanotech. Co. Ltd., 2017

Figure 2-6 The environmental friendly recycling procedure of UWin Nanotech. Co. Ltd.

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14. Yung- Yuan Chemicals

(http://www.yung-yuan.com.tw/)

(1) About the company

Yung- Yuan Chemicals is founded in 1988 and mainly focus on business wastes (include heavy metal sludge) recycling service, the company has been around for over 20 years. Considering that the circuit board manufacturing, electroplating and copper foil substrate manufacturing produce large amount of heavy metal sludge during the flourishing development of high technology industry, to effectively reduce waste such as heavy metal sludge to damage the environment while promoting sustainable reuse of resources. Yung- Yuan Chemicals founded professional resource recycling and reuse factory that target at recycling heavy metal sludge on April 20, 2001. The Company recycles and reuse heavy metal sludge disposal, turn heavy metal sludge into metal oxide, the raw material for metal smelt through heat treatment and export to overseas.

(2) Type and sources of wastes

Since April 02, 2002, Yung- Yuan Chemicals recycle copper sludge of print PCB boards through reuse to become the raw materials of copper ingots as approved by Industrial development bureau, Ministry of Economic Affairs. The approved volume is 2,375 Tons, and since the reuse effect is outstanding. Copper sludge from copper foil process recycle and reuse permit is obtained on March 31, 2004. Currently, the industries reuse copper sludge through recycle include metal surface finishing industry, circuit board manufacturing and copper foil substrate manufacturing.

(3) Type of waste disposals



Source: Yung- Yuan Chemicals website

Figure 2-7 The process flow chart of Yung- Yuan Chemicals first factory



Source: Yung- Yuan Chemicals website

Figure 2-8 The process flow chart of Yung- Yuan Chemicals second factory

(4) Waste recycled products

Yung- Yuan Chemicals refine resource product such as silver copper powder, Wire bonding agent and copper powder according to different characteristics.

15. Hong Jing Environment Company

(http://www.hjec.com.tw/)

(1) About the company

Hong Jing Environment Company is the professional waste catalyst recycle provider, it mainly recycle waste catalyst generated by petrochemical refining and vanadium-containing fly ash generated by power plant. Using matured recycle technology and cautious attitude to check the recycle process of all waste to allow efficient recycle. The subsidiaries include Hong Jing Environment Company, Hong Jing Metal Company, Hong Jing Resource Company and Hong Jing Technology Company.

(2) Type of waste disposals

The waste disposal by Hong Jing Environment Company is shown in figure 2-9 below.



Source : Hong Jing Environment Company website; compiled by this project



(3) Waste recycled products

The waste recycled products by Hong Jing mainly are molybdenum oxide, vanadium pentoxide, vanadium iron, cobalt sulfamate and ammonium metavanadate.

16. Taiwan Cement

(http://www.taiwancement.com/)

(1) About the company

The company provides and designs highly efficient prevention to reduce pollution and use the characteristics of process to assist industry to reduce wastes and reuse resources. Waste reduction service reuse resources through advance instrument control and quality control facilities on top of high temperature from the process itself and soluble ash and desulfurization. Not only useful resource is recycled, but helps other industries to remove pollution.

(2) Waste recycled products

The current resource and reuse items of Taiwan Cement are waste organic solvent, Calcium fluoride sludge, hearthstone and slurry of steel mills, plaster from chemical plant, waste stone dust of stone processing plant, sapwood and coal ash of power plant. The waste recycled product items are listed in table 2-9 below. On the other hand, the Company is assisting the government to research on burning waste tires by cement kilns. If such plan can be implemented, not only incineration equipment construction can be reduced, dangers on public health and safety caused by waste tires can be avoided. The ultrahigh temperature tunnel kiln De-Nox Equipment of Taiwan Cement affiliated enterprise, Kuan-Ho Refractories has over 80~90% efficiency. Therefore, when the pollution emission during production is far lower than the standard as set by environmental regulation (The NOx emission value after denitration is 349 ppm, lower than the 400 ppm as set by environmental regulation).

In the meantime, the Company successfully develops waste catalyst produced by CPC to replace raw materials of clay and efficiently solve the environmental issues caused by waste catalyst from petrochemical industry.



Table 2-9 The recycled reused items of Taiwan Cement

Source: Taiwan Cement, compiled by this project

17. Cleantek Corporation

(http://www.cleantek.com.tw/)

(1) About the company

Cleantek Corporation is established in 2004. It is a manufacturer that provides professional production service in ITO demould recycle refining and Pump cleaning. All of the operation team of the Company has research background in chemical engineering. It has accumulated over many years of chemical washing and material development professions, is able to dismantle, wash and demould, assembly and further recycle precious metal to seek for maximum benefits.

In addition, Cleantek Corporation put in research of high purity indium refining technology. Not long after working in ingot industry, the indium ingots produced reached over grade 4N5 (99.995%). Majority of products are sold to advanced countries such as Japan, U.S.A and Europe.

(2) Type of waste disposals

The wet chemical recycle ITO coating production line of Cleantek Corporation adopt single and independent area of cleaning process and completely avoid cross contamination issues. Then develop exclusive washing agent formula targeting on different materials and work pieces. The cleaning efficiency is high but there is no worry on damaging work pieces. The company also develop independent tool for various work pieces as protection and achieving maximization of cleaning efficiency. The physical water jet strip off ITO coating production line is pairing different engineering terms by coating types and thickness to achieve the quality optimization and efficiency maximization.

(3) Waste recycled products

Cleantek Corporation can refine ingots excrements of different purity. The company refines and produce product such as indium ingots and indium chips.

Item	Categories	Pictures	Descriptions
Indium ingot	5 kg/ingot		Provide customized refining service that is able to refine different purities of indium excrement (30%-99%) as pure as over 99.995%. The recycling rate has market competitive advantage There is ICP platform to perform indium metal detections and the quality of each batch is strictly monitored.
	0.5 kg/ ingot	CTC :: Emet	Provide customized refining service that is able to refine different purities of indium excrement (30%-99%) as pure as over 99.995%. The recycling rate has market competitive advantage There is ICP platform to perform indium metal detections and the quality of each batch is strictly monitored.

Table 2-10 Cleantek Corporation recycled products



Source: Cleantek Corporation website, compiled by this project

18. Solar Applied Materials Technology Corporation

(http://www.solartech.com.tw/tw/index.html)

(1) About the company

Solar Applied Materials Technology Corporation, the largest optical data storage thin film manufacturer worldwide is founded in 1978 and one of a leading players in precious metal and rare material refining, special forming, processing and selling. SOLAR offers key materials and integrated service model to customers for application in Optoelectronics, Information, Petrochemicals, and Consumer Electronics industries. The major products consist of four categories: precious chemicals/ materials, special chemicals, resources recycling and targets/ materials for thin film application.

(2) Type and sources of wastes

Solar Applied Materials Technology Corporation use rare and precious metals recycling and refining as the platform to develop close-loop model, comprehensive

green and clean production indicators, develop rare and precious metal material applications and produce targets/ materials for thin film application by Inside Chamber Total Solution, ICTS. These targets/ materials for thin film are applied in disk, hard drive, semiconductor, photoelectric and solar energy to cultivating the development of key materials in Taiwan with innovative values.

(3) Type of waste disposals

Select different pre-treatment methods according to characteristics of raw materials, then select different refining methods according to the nature of products from each pre-treatment. The precious metal final products are refined at last. The process is shown in figure 2-10 below. Each pre-treatments and refine methods are shown below as table 2-11.



Source: Solar Applied Materials Technology Corporation; compiled by this project

Figure 2-10 The process flow of precious metal by Solar Applied Materials Technology Corporation
Table 2-11 The refining method and pre-treatment methods of SolarApplied Materials Technology Corporation

Method	Content
Pre-treatment	Incineration, pickling, alkaline cleaning, displacement, electrolysis, resin, solvent
Refine	Chemical refining, Electrolytic refining, high temperature melting, resin refine

Source: Solar Applied Materials Technology Corporation; compiled by this project

19. Da Fon Environmental Technology Co., Ltd.

(http://www.df-recycle.com.tw/)

(1) About the company

Da Fon Environmental Technology Co., Ltd. is the leader in environmental industry in Taiwan, the largest recycling company and is established in 2001. For many years, the Company dedicate toward environmental industry development, determined in resource classification and recycle, resource renewal and recycling to achieve zero waste resource full cycle as the company' s mission. Its business philosophy is about diligence, innovations and the Mida's touch, insist on creating an enterprise that has the most positive and active effect on human. In view of resource shortage is increasingly serious, but resource recycling industry is still maintaining traditional management and business mode, Da Fon Environmental Technology Co., Ltd. introduce enterprise management and expand service area to North, Middle and South regions of the entire Taiwan, establish branch offices in first tier cities such as Shanghai and Fuzhou to improve industrial competiveness. To manage more efficiently and improve the overall marketing ability of the Company in the future, E- technology management system is actively introduced, combining with big data and IOT platform to break through traditions, create new mindset and become a model for recycling industry.

Da Fon Environmental Technology Co., Ltd. has been working in the resources recycling and reuses process for many years, and received various acknowledgment

and licenses, obtained Grade A and grade B waste clearance and disposal permits from Competent Authority. Da Fon Environmental Technology Co., Ltd. dedicated toward zero wastes, full recycling and serves customers from general community buildings, schools, hospitals, hotels, department stores, small to medium enterprises, hypermarkets, retailers and large technology factories, science parks and industrial parks. Customize complete service planning, designs and turnkey specific toward different industry and market demands. Assist customers in building complete and efficient on-site resources recycling storage area, stationed personnel on site to sort and classification, or provide packaging equipment for volume reduction. Provide highly efficient material trucks to dispatch and clear away resources recycles. In addition, the classified document destruction that enterprises interested in is also being provided with secured and safe destruction system to assure the customers.

(2) Waste recycled products

The crushed recycled materials of PC,PE,PET,PP through professional equipment and comprehensive process, after a series of selection, packaging, crushing and washing, then moved on to the last procedure of granulation. The application levels are extensive and are able to satisfy various customers' needs. These recycled materials are renewal products that are of high quality and high efficiency, effectively reduce the resource wastes, save energy and reduce carbon for the environment. The recycled and reused products are listed in table 2-12 below.

Item	Content
Scrap metals	Scrap steel, scrap iron, scrap stainless steel, scrap wire, scrap copper (copper foil, copper ball, copper block, bronze), scrap iron fillings, special alloys, etc.
Waste plastics	PE. PP polyethylene (PE), high molecular polyethylene (UPE), polypropylene (PP), MC nylon, PU. ABS, polyurethane products PU, ABS resin, polyacetal (POM), PVC, polyvinyl chloride (CPVC)

Table 2-12 The recycle and reused products of Da Fon Environmental			
Technology Co., Ltd.			

Waste paper	Blank electronic factory pad lining paper, waste paper boxes, waste paper trimming materials, PE coated paper, cardboard boxes, paper reports, Dafon also provide confidential document destruction services.
Precious metals	All kinds of gold scrap (lead frame, gold plate, gold frame), silver scrap (copper coated silver, nickel coated silver, Ag paste, waste silver liquid), palladium scrap, indium scraps.
Electronics /waste IC	Waste IC, waste chips, waste BGA, waste PCB, transistor, soft board, electronic components, LED, Electronic components waste, inventory (material).

Source: Da Fon Environmental Technology Co., Ltd.; compiled by this project

20. Far Eastern New Century Corporation

(http://www.fenc.com/)

(1) Corporate social responsibilities

(1) Green products

Under the trend of promoting environmental friendly and circular economy by international brands, Far Eastern New Century Corporation continuously to put in resources, research and develop prospective and sustainable green products, provide recycling and green solution that reduce energy resource waste, create new values for the enterprises, increase sustainable business strengths, allowing Far Eastern New Century Corporation to play an indispensible key roles in the sustainable trend.

- I .Replace fossil fuels
 - 100% Bio-PET

Polyester is consisted of 70% (PTA), 30%Monoethylene Glycol (MEG). After few years of research and development, the technology of Bio-MEG produced by biomaterials has been matured and is equipped with economy efficiency. Far Eastern New Century Corporation is the leading global provider of 30% Bio-PET. However, the 70% of polyester to PTA is the last mile to the success of

• 100% Bio-PET.

Far Eastern New Century Corporation is based on over 30 years of polyester synthesis technology, dedicate to reduce the reliability of polyester to petrochemical raw materials and work with Coca Cola to develop the first 100% Bio-PET that completely use biomaterials, allowing the materials of PET in future can be completely obtained from plant source. It is the world's first attempt. The manufacturing process chart is shown as figure 2-11 below.



Source: Far Eastern New Century Corporation website

Figure 2-11 100% Bio-PET manufacturing process || .Recycle and reuse

• Pro-green® Food grade Recycled PET, (rPET)

Using recycled PET bottles as raw materials to replace the traditional process of petrochemical raw materials on the market. Far Eastern New Century Corporation use high technology recycling skills and high temperature melting process to remade waste PET bottles into Recycled PET (rPET). The cleanliness has passed through the food grade certification from Food and Drug Administration (FDA) and SGS leaching test. Far Eastern New Century Corporation continuously supply international beverage manufacturers such as Coca Cola,Pepsi and Danone, the carbon emissions of Pro-green® is reduced by 50% comparing to food grade polyester grains made by traditional petrochemical raw materials.

Recycled PET (rPET) become the brand new clean PET bottles after hand building and blow molding which reduces environmental burden, and also achieves the environmental concept of zero regeneration and Bottle to Bottle.

21. Da Ai technology CO.,LTD.

(http://www.daait.com/index.php/tc/)

(1) About the company

Da Ai technology CO.,LTD. is founded in 2008, aims to solve current environmental issues and promote environmental education. Combining Da Ai recycling system to maximize the uses of recycled resources and produce secondary raw materials for reuses.

(2) Type and sources of wastes

Recycle waste PET bottles by self-developed recycling system, remade into various resources products.

(3) Type of waste disposals

Remade recycled PET bottles into fibers can save 84% of energy uses and 77% of greenhouse gas emissions.

(4) Waste recycled products

The process flow of effective recycle and reuse waste PET raw materials to made into blankets are shown in figure 2-12, Then these products are sold to various countries through various shops locations and thus promote the environmental concept.



Source: Da Ai technology, 2016

Figure 2-12 The recycled blanket by Da Ai technology

22. E & E Recycling

(http://www.eer.com.tw/)

(1) About the company

In view of the worsening electronic appliances and electronics wastes issues, E & E Recycling thus introduced advance technology from Europe, combined with abundant labor forces in Asia to dispose wastes and recycle usable resources.

(2) Type and sources of wastes

The main business is on recycling electronics and electronic appliance wastes.

(3) Type of waste disposals

The Asia's first waste electronics and electronic appliances disposal factory is founded, the advanced technology from Germany is introduced for process. Currently, waste TV, waste washer, waste aircon and waste fridges can be processed together at the same time, with separate processing flow and production line. The process flow of various waste electronics is shown in figure 2-13.

(4) Waste recycled products

It is estimated to recycle 4,100 tons of metals,1,300 tons of plastics, 640 tons of glasses, 130 kg of coppers, 20 kg of tins and 0.4 kg of gold from electronic appliances and electronics wastes.



Source: APO Center, 2013.

Figure 2-13 The process procedure of various electronic wastes

23. China Steel Corporation

(http://www.csc.com.tw/)

(1) About the company

To implement environmental protection measures, CSC dedicate toward executing measures and technology to save water and energy, allowing the enterprises to reduce uses on natural resources and achieves the purpose of environmental friendly.

(2) Type and sources of wastes

Recycle and reuse the domestic waste water and business waste water discharged

by the factory, reduce uses on original natural water resources.

(3) Type of waste disposals

Recycle waste water by electro dialysis reversal (EDR); industrial waste water plus advanced waste water disposal unit module (include filter, reverse osmosis and ion exchange) to made into reusable pure water, the process flow can be referred to figure 2-14.



Source: APO Center, 2013

Figure 2-14 reclaimed water and process procedure

(4) Waste recycled products

Waste water is recycled to front end process for reuses, the water recovery rate reaches 98% can reduce water resources input and energy wastes to reduce costs and unit water consumptions.

24. Taiwan Semiconductor Manufacturing Company Limited

(http://www.tsmc.com.tw/chinese/default.htm)

(1) About the company

TSMC expects to become the leader in worldwide water resource management. It reviews product water consumption of each unit while executing water conservation and recycle reuses measures; which can be used as emergency water resources and effectively saves on water resources. The real-time monitoring platform is established to assist effective management of water resources applications.

(2) Type and sources of wastes

Review the water recycling analysis of all product process as shown in figure 2-15. Waste water from different processes is treated and attempted to recycle and reuse to conserve uses of water resources.





Figure 2-15 TSMC water balance analysis graph

(3) Type of waste disposals

TSMC manages various aspects from process, recycling, reuses and real time water resources uses monitoring systems to effectively reduce the uses of water resources.

(4) Waste recycled products

There are as many as 20 types of water pipelines within the factory, and are classified according to the characteristics of various recycled water and over 15 process flows, resulting in over 85% of recycling rate.

25. Delta Electronics, Inc.

(http://www.deltaww.com/default.aspx?hl=zh-TW)

(1) Corporate social responsibility

Delta Electronics, Inc. focus on enterprises sustainable development, the range include providing energy conserving products and system solutions, healthy company governances, take into account of stakeholders' balanced interests, protect planet earth, concerning environmental issues and invest in energy conservation and environmental education. Delta Electronics, Inc. took the lead and announced "Delta Climate Action Plan Report" in 2015 to share its concerns on climate issues in the hope to pose impacts across the globe. Meanwhile, to achieve the three commitments of "information disclosure of climate change", "carbon reductions effect policy" and "voluntary carbon reduction by enterprises" of "We Mean Business" to fully showcase Delta Electronics, Inc. adopt physical actions of energy conservation and participations from all members to respond toward its concern on global warming.

(2) Enterprise related measures

A. The active countermeasures for climate change

- a. Commitment
 - Delta Electronics, Inc. include climate changes into one of key risks items of enterprises sustainable operations, and manage according to two major areas of "slowing down" and "adapting".
- b. The promotion key points and methodology of facilitating SDGs development
 - Research global risks and the energy policy of major country of carbon emission

- Use risk map to identify climate change risks
- Build the capacity in adapting climate risks and further reduce possible climate risks
- · Generalize the opportunities of climate changes
- c. Future planning
 - Set up climate risk adjustment project team and built climate change risk evaluations and adjustment mechanisms. Then implement such mechanisms into key Delta factories across the globe in stages, including Taiwan, China and Thailand locations. Meanwhile, regular review on mitigations and adjustments countermeasures while strengthen climate change disaster management.
- B. Green Operation
 - a. Energy management
 - Commitment : after the production electricity intensity in 2014 decrease by 50% comparing to 2009, Delta Electronics, Inc. promises to expand the energy conservation range to new factory, research and development office buildings and data center; using 2014 as the base year, to decrease the overall electricity intensity by another 30% before 2020. Delta expects to use solid actions to face the challenges of climate changes with enterprises worldwide.
 - The promotion focus and methods to promote SDGs development
 - -Expand energy management range and establishes physical target while implement the actions
 - -Develop high efficiency products and solutions
 - -Energy online monitoring information system
 - Future planning
 - -Continue to promote energy conservation project to fulfill the promise of decreasing overall electricity intensity by 30% by 2020.
 - -Promote the factories to use renewable energy



Source: Delta Electronics Inc. website

Figure 2-16 To respond to sustainable development objective of Unite Nation

26. ECOVE Environment Corporation

(http://www.ecove.com/?L=CH)

(1) About the company

ECOVE is one of the subsidiaries of CTCI Corporation. It has been working in the incineration plant operation technology and management for many years and accumulated around 23 years of experiences. ECOVE continuously expand the operational territory and become the important operation agent of Asia and continuously concern on the trend and development of circular economy, dedicate toward renewable energy and waste resource technology.

(2) Type and sources of wastes

The main businesses are acting as an operation agent for general waste incineration plant to process domestic wastes.

(3) Type of waste disposals

ECOVE Obtained the World' s First BS 8001 Circular Economy Certification in 2017 and honored with top grade in overall evaluations. In the field of solar power,

high efficiency modules are used and has established capacity around 26MW, closed 12MW at landfill yard that include building, which is the largest in Taiwan. In the field of recycling and reuses, ECOVE continue to improve and integrate its technology to apply in the recycle of regenerated water and recycled materials (such as PET bottles, waste solvents and incinerator bottom ash).

(4) Waste recycled products

Provide professional equipment management and maintenance through effective energy recycling and reuse by incinerate general wastes, as shown in figure 2-17. Then recycle and produce recycled water and secondary raw materials focusing on waste resources.



Source: ECOVE environment Corporation website, 2017

Figure 2-17 ECOVE providing professional management service on power plant by incinerator

27. Shihan Farm

(http://www.shihanfarm.com.tw/)

(1) About the company

Shihan Farm produces healthy eggs bases on the idea of food must be "safe, focus on the checks and tests of each production process to ensure the products are safe and risk free. Also, environmental production equipment is actively introduced to convert excretion wastes from domestication effectively into energy and reduces the uses of petrochemical fuels.

(2) Type and sources of wastes

Promote automatic production using circular economy concepts to recycle and reuse the biomass wastes, waste water and waste gas generated by the farm using technology as much as possible, in order to achieve the goal of zero wastes.

(3) Type of waste disposals

The fully automatic production equipment is used in the farm to ensure product quality and safety while properly uses all biomass resources to replace natural resources. Its biomass recycling procedure is shown as figure 2-18.



Source: Business today magazine, 2016

Figure 2-18 The demonstration of waste recycle and reuse by Shihan Farm

(4) Waste recycled products

Introduce advance biogas equipment from Europe, collects biomass wastes of chicken manure, and then effectively recycle wastes from the factory to produce usable energy through fermentations and relevant procedures.

28. Emerging industry

The domestic industries are starting to rethink if there are any areas of current business model or production mode could be considered again or if there are any new business opportunities could be developed. Many successful domestic cases are discussed in the previous paragraph, and some enterprises are starting up and trying out without noticeable performances yet, but these enterprises are worth to be included as the references for other industry interested in the circular economy.

(1) Plum Monix Industry Co., Ltd

The main origin of raw materials Plum Monix Industry Co., Ltd imported from is industry such as refineries in Middle East. The current resource products are mainly Molybdenum, vanadium alloy and relevant chemicals. The resource level from waste catalyst (waste sources) to the final products is about 80%, the waste recycling rate inside factory is about 10%. The products are supplied to domestic and oversea steel making industry, steel industry and chemical industry.

(2) Diamonchem International Co., Ltd

Diamonchem International Co., Ltd is a professional zinc compound manufacturer and its main products are producing raw materials needed to add to rubber, electronics, foaming, glass and cosmetics. It is trying to research and develop relevant resource products.

2.2 The best practices in overseas

1. Phillips

(https://www.phillips.com/)

(1) About the company

Phillips is the one of the world's largest lighting equipment supplier. To engage in the idea of continuously improving human living quality and environmental friendly products, enterprises introduce ecological designs and circular economy concepts into production chain and review based on product life cycle analysis, then learnt that over 80% environmental impacts are concentrated on application stage; the product design can be improved based on this knowledge.

(2) Type and sources of wastes

Under the traditional industry pattern, waste lighting equipment is the main waste sources. However, under the "renting instead of buying" pattern that complies with circular economy, the design direction is modified accordingly to extend product's life and relatively reduce the wastes productions on a large scale.

(3) Type of waste disposals

To comply with circular economy concept, enterprises create new business pattern from providing lighting hardware equipment to lighting services. The new pattern where lighting solutions are built according to users' needs, then enterprise design, provide equipment and maintaining services while entitled to the hardware ownership, hence increasing produce reuse rate. The recycle and reuse concept of Phillips' s designed product is shown as figure 2-19 below. Improve the maintenance and recycling to allow more efficient uses of more raw materials or components.



Source: Phillips, 2017.

Figure 2-19 The concepts graph of circular production by Phillips

(4) Waste recycled products

Under the new business pattern, maximization of product life becomes the new purpose. The research and development of lighting equipment that uses longer life, or combined module of lighting systems with multiple changes become the new research and development goal. Phillips has professional laboratory to redesign new products according to demands, reduces the needs of production volume and enable the usable parts or equipment entering recycle cycle, hence increasing resource use efficiency.

2. Subaru

(http://www.subaru.asia/tw/zh/home/)

(1) About the company

Subaru believe in the idea of promoting the harmonious symbiosis among human, society and environment, provide the products of highest quality, focus on reducing greenhouse gas emission, maintain biodiversity, mitigating global climate change related issues, dedicate to increase energy use efficiency, reduce waste productions, decrease environmental impacts and relevant measures while adapt into the planning and execution of the entire enterprises production chain.

(2) Type and sources of wastes

Under the car production and recycling structure as constructed, it is mainly focusing on recycling existing cars and dismantles, sort, recycle and reuse.

(3) Type of waste disposals

When designing the product, the impacts of corporate responsibilities and product life cycle on the environment and procurement must considering biodiversity and environmental protection should be considered. Production and logistics reduces environmental impacts through increasing energy efficiency and waste management, while increasing resource efficiency and reducing wastes are the center of thought for the product sales.

(4) Waste recycled products

Built the complete system of car recycling, Aerosols and CFCs produced by the crushers all need to be processed comprehensively to allow usable parts of recycled cars properly recycled or reused. The entire process flow can refer to figure 2-20.



Source: Subaru, 2016.

Figure 2-20 Car recycling process by Subaru

3. Toyota

(https://www.toyota.com.tw/)

(1) About the company

Using resource acquisitions and greenhouse effects reductions as the starting point, then regarding 3R (reduce, reuse and recycle) as the center to reduce using raw materials.

(2) Type and sources of wastes

Recycle old cars in the self-developed recycling system, use the current technology to maximize the reuse of usable components parts and raw materials, then applied to car maintenances or manufacturing of new cars.

(3) Type of waste disposals

To realize the concept of circular economy at the manufacturing end and sales end. The manufacturing end establishes car to car recycling system, build closed loop to substantially reduce uses of raw materials. The sales end use computer system to pair up usable components for recycling and select the best match according to consumer's needs. The entire execution process can be referred to figure 2-21.



Source: Toyota, 2017.



4. HP

(http://www8.hp.com/tw/zh/home.html)

(1) About the company

HP has been working hard continuously to recycle used products for years to respond to the new trend of circular economy. Currently, the blueprint of enterprises promoting circular economy has been built, submitted corresponding new type of printing solutions, which reduce uses of raw materials by 57% per page printed.

(2) Type and sources of wastes

It is mainly about the recycle and reuse of used ink cartridge, toner cartridge and printing equipment.

(3) Type of waste disposals

The circular economy blueprint build by HP is shown as figure 2-22, HP uses resources more efficiently by material recycling, equipment reuses and provides services and maintenances or upgrade. Currently, 75% ink cartridges and 25% toner cartridges are produced by recycled plastics of closed loop.

(4) Waste recycled products

The recycled hardware equipment can be reused in production process, maintenances and upgrades through backfill, crushing, sorting and re-granulations.



Source: HP, 2016.

Figure 2-22 HP Circular economy mode

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5. Xerox

(https://www.xerox.com.tw/)

(1) About the company

Xerox focus on two aspects for achieving the goal of sustainable operation: (I) use paper resources at maximum efficiency and (II) waste reduction and management. In terms of efficiently using paper, important measures include selecting the paper supplier with green certification, research to increase use efficiency equipment and software, increase deinking recovery and dedicate toward protecting forest resources. As for waste management, engage in global recycling plan and complete zero waste factory and support electronic waste recycling policy. Xerox received award from Green Electronics Council (GEC) in 2017, encouraged Xerox for its hard work and contributions in promotion of circular economy.



Source: Xerox, 2017.

Figure 2-23 Xerox received 2017GEC Award

(2) Type and sources of wastes

It is mainly about the recycle and reuse of used ink cartridge, toner cartridge and printing equipment.

(3) Type of waste disposals

Xerox fully develop the technology to reduce paper and ink usage, and has successfully reduced 47,500 tons of wastes and recycled 43,000 tons of recycled products.

(4) Waste recycled products

The general waste recycling rate of Xerox' s zero waste factory reached 93%, and reintroduce recycled secondary raw materials into productions, the new product include 5% of recycled plastic secondary materials.

6. REMONDIS

(http://www.remondis.com/en/home/)

(1) About the company

REMONDIS is the one of the world's largest recycling provider. It has built the comprehensive recycling structure and system with 30 million tons of different recycled products every year. It provided the entire set of complete recycling plan, includes material flow analysis, material conversion analysis, recycled product quality certifications and recycled product collection plan, logistic and transport services and smart recycling plan.

(2) Type and sources of wastes

REMONDIS can dispose various types of wastes, including various chemicals, batteries, construction wastes, harmful wastes, waste glasses, waste paper, waste plastics, general wastes, electronic appliances and electronics wastes and leftovers.

(3) Type of waste disposals

The Lippe factory is the largest recycling center of REMONDIS that assist in reducing 0.466 million carbon emissions annually through recycling activities. The key recycling demonstration is shown in figure 2-24 below. The factory mainly provides material flow management, quality certifications, management instruction, research and development process and relevant recycling and reuse research.

(4) Waste recycled products

Lippe factory generate 0.8 million tons of recycled and reused products through recycling and regeneration procedure, including adhesives, biodiesel, certified agricultural products and plastic pellets raw materials.



Source: REMONDIS, 2017.

Figure 2-24 The recycling direction of REMONDIS closed production loop

7. Astec-irie

(http://www.astec-irie.co.jp/)

(1) About the company

Astec-irie is one of the suppliers in Kitakyushu ecological village center project in Japan, this project is one of first regional circular economy hot spot project in Japan. Astec-irie expects to achieve the goal of zero wastes through participations in the project and convert all wastes into useable resources.

(2) Type and sources of wastes

It is mainly about the recycling of motherboards from personal PC, and also engages in recycling actions such as collecting suspended dust from steel industry.

(3) Type of waste disposals

Astec-irie engages mainly in colored metal recycling technology on motherboard of personal computers and researches to develop technology that collects suspended dusts from steel industry to make into iron powder.

(4) Waste recycled products

After recycling electronic wastes, recycle previous metals and reuses through

sorting, decomposition, separation and extraction. The process is shown in figure 2-25.





Figure 2-25 The recycled product process of Astec-irie

8. DOWA

(http://www.dowa.co.jp/)

(1) About the company

DOWA has complete recycling system and technology and can dispose wastes that usually cannot be recycled and recycle valuable metal for reuses.

(2) Type and sources of wastes

It is mainly about recycling chemical waste liquid and used cleaning liquid from the electronic industry, then recycles and extracts precious metals and reuses.

(3) Type of waste disposals

Use unique and high technology to dispose wastes that usually cannot be recycled, and then recycled them into valuable metals. Recycle rare metals from organic wastes liquid and used cleaning solvent. The overall key disposal process is shown in figure 2-26.



Source: DOWA, 2017.

Figure 2-26 The main flow chart of recycling by DOWA

(4) Waste recycled products

Recycle rare metals of gold, silver, platinum, palladium, rhodium and ruthenium from the wastes and reuse.

9. MBA POLYMERS

(http://www.mbapolymers.com/home/)

(1) About the company

MBA POLYMERS is the world's largest waste plastic recycling enterprise; it is established by Dr. Mike Biddle in 1992. It is mainly about developing disposals and recycling of complex plastic compounds, and has currently become the leading supplier in the world.

(2) Type and sources of wastes

The various waste plastics and relevant compounds are main targets for recycle and reuses. The various waste plastics are shown in figure 2-27, including fridge, screen displays and televisions.











ICT Plastics



TV/CRT Plastics

Some typical fractions from WEEE plastics (waste electrical and electronic equipment)



Typical pre-processed and concentrated plastics from automotive shredder residues.

Source: MBA POLYMERS, 2017.

Figure 2-27 Various waste plastics

(3) Type of waste disposals

Research and develop to recycle waste plastics from complex wastes and reuse.

(4) Waste recycled products

The closed loop production pattern has been successfully completed with fully recycle and reuse of plastic products. Compare to manufacturing plastic products by petrochemical raw materials, energy used is reduced by 80%, and over 90% of metal raw materials required by production can be recycled from wastes.

10. Green Group

(http://www.green-group.ro/en/)

(1) About the company

Green Group integrates its 6 subsidiaries to establish the largest recycling system business of South East Europe. It is mainly about recycling wastes and recovery, and then made into secondary raw materials for reuses.

(2) Type and sources of wastes

The recycling system can recycle waste plastics like PE, PP, PS, ABS, technology wastes, waste electronics, and wastes optical equipment.

(3)Type of waste disposals

The smart resources recycling station is developed to recycle various recycling in one station while feedback public with rewards and thus effectively promote and increase recycling rate. Also, glasses recycling are one of the important services too. The main concept is about reduces wastes, green productions, water resources conservations and reduce greenhouse emissions as shown in figure 2-28.



Source: GREENGLASS, 2017.

Figure 2-28 The recycling concept of green glasses

(4) Waste recycled products

Recycle wastes to make into secondary raw materials of precious metals and plastic raw materials.

11. WRC Recycling

(http://wrcrecycling.co.uk/)

(1) About the company

WRC Recycling is founded in 1998 and its primary business is about recycling waste plastics, and has built distribution channels across Unite Kingdom, as shown in figure 2-29, where materials can be transport to various locations in the country. Beside plastic recycling, waste paper, waste metals and waste management inquiry services are provided.



Source: WRC Recycling, 2017.

Figure 2-29 The transportation trucks of recycles of WRC Recycling

(2) Type and sources of wastes

The main business is about recycling various plastic wastes and provides services such as collection, crushing and granulations.

(3) Type of waste disposals

Develop the technology and equipment that are able to dispose various wastes of thin films, hard plastics, waste paper boards, waste papers and waste metals.

(4) Waste recycled products

Recycle materials such as paper, waste plastic and waste metals, then perform sorting and screening for suppliers to reuse.

12. OLUS

(http://www.naturallythinking.com/olus-oil.html)

(1) About the company

Olus is founded in 1994 and mainly focus on reducing waste landfills through high quality recycling. Olus can produce high quality fertilizers that complied with national standards from recycling biomass wastes, and then provide 40 liters to a few thousand tons of fertilizers according to customers' requirements.

(2) Type and sources of wastes

It is mainly about collecting biomass such as wood material wastes, which primarily come from waste construction materials, wood factory and paper mill.

(3) Type of waste disposals

It is a super factory that has annual disposal volume of 25,000 tons of wood materials wastes as shown in figure 2-30, and can be remade into fertilizers, building materials and biomass fuels.



Source: OLUS, 2017.

Figure 2-30 OLUS Biomass process plant

(4) Waste recycled products

Over 30,000 tons of biomass is recycled annually and remade into organic fertilizers or building materials.

13. Mitsubishi Electric

(http://www.mitsubishielectric.com/)

(1) About the company

Mitsubishi Electric is one of the famous electronic suppliers in Japan, and will celebrate its centennial anniversary in 2021. It hopes to increase product recycling rate through building comprehensive recycling system for achieving the enterprise goal of low carbon, recycling based society.

(2) Type and sources of wastes

Mitsubishi Electric is mainly about recycling its own electronic appliances and electronic products to re-recycle to the industry chain for reuses.

(3) Type of waste disposals

The first electronic recycling factory, HCS is built in Japan in 1999 (it is mainly about recycling TV, air conditioner, fridge and washing machine). Over 700,000 tons of materials has been recycled by 2016, the changes in recycling volume can be referred to figure 2-31.



Source: Fiscal, 2016.

Figure 2-31 The recycled status of four major electronics categories

(4) Waste recycled products

Through the recycling network and system currently built, the recycle and reuse rate of electronic products on average reached 87.4%, while the recycle and reuse rate of personal computers on average reached 77.7%.

14. Nomura Kohsan Co.

(http://nkcl.jp/)

(1) About the company

The main service is about collecting, transporting and disposing general and

business wastes. The recycled wastes are remade into secondary raw materials or recycled products.

(2) Type and sources of wastes

Extensively collect general or business wastes and remade into reusable products.

(3) Type of waste disposals

The factory has its own processing furnace equipment to ensure comprehensive disposals and adjust the process according to mercury concentration. The processed mercury wastes are strictly controlled to prevent mercury emission at a standard higher than national standards. The final process adopt protection measures such as double cover, water seal, cement reinforced layer to protect the environment from pollution, the main process is shown in figure 2-32.



Source: Nomura Kohsan, 2017.

Figure 2-32 The main process procedure of mercury waste

(4) Waste recycled products

Make recycled general or business wastes into reusable products such as fertilizers, glasses and metals.

15. Umicore

(http://www.umicore.com/)

(1) About the company

Umicore is one of the important material suppliers in the world that achieves 11.1 billion USD in its turnover. It mainly provides complete product solutions and the product sold can provide wastes recycle and reuse services.

(2) Type and sources of wastes

It is mainly about recycling rechargeable batteries, electronic optical materials, jewelries and waste catalysts.

(3) Type of waste disposals

The concept of Umicore promoting circular economy is shown in figure 2-33, providing chemical solvents needed by various industries through chemical materials relevant professions while providing recycle and reuse services. Its cobalt catalyst recovery technology is top of industry in the world.





Figure 2-33 The circular economy concept graph of Umicore

(4) Waste recycled products

After recycle rechargeable batteries, electronic optical materials, jewelries and waste catalysts, then recycle reusable precious metals or produce reusable chemical solvents or catalysts.

16. AGC MATEX

(http://www.agm.co.jp/ENG/)

(1) About the company

AGC MATEX is a member of Asahi Glass Group and has over 60 years glass fibers production experiences. It provides product demand by industry such as buildings, communications and high quality building materials.

(2) Type and sources of wastes

The recyclable glass fibers or other glass products are remade into applicable particles.

(3) Waste recycled products

The lighting sources of recyclable wastes fluorescent lamp are made into high quality particles according to customer's needs, the regenerated particles granules are shown in figure 2-34.



Source: AGC MATEX, 2017.

Figure 2-34 The recycled reproduced aggregates

17. Tanaka koumuten

(http://www.tanaka-koumuten.co.jp/)

(1) About the company

Tanaka koumuten is located in the Kanagawa province, Japan. It is a middle process provider for business wastes and its process capacities are about 80 tons/ day.

(2) Type and sources of wastes

It is mainly about recycling waste building materials for reuses, including steel, scrap iron and waste wood.

(3) Type of waste disposals

The overall process flow is shown in figure 2-35. The collected waste building materials can be remade into raw materials for paper, fertilizers, building materials and energy industries after processing by crusher and sorting. Also, Tanaka koumuten can provide speedy weighing and convenient transportation spots, allowing customers to complete the wastes collection swiftly.



Source: Tanaka koumuten, 2017.

Figure 2-35 The reuse process of recycled waste building materials

(4) Waste recycled products

The waste building materials can be recycled through recycling system, remade into pulp, fuel, composting and recycled building materials.

18. Du Pont

(http://www.dupont.com.tw/)

(1) About the company

Du Pont is in business for 215 years, has solid chemical manufacturing technology system and is a world's leading supplier. It is the first enterprise in the world to target at zero waste and dedicate toward developing clean production pattern. The circular economy work project promoted by Du Pont received acknowledgement from 2017 sustainability award. Du Pont use an experimental project from South Africa to try to use composite layer plastic for packaging while delivering solutions such as providing children with nutrition, reduction of plastic wastes and waste recycling education promotion.



Source: Packaging Europe Ltd., 2017.

Figure 2-36 Du Pont received 2017 sustainable award on its circular economy pilot program

(2) Type and sources of wastes

The raw materials, waste inventory and management used by production line of each factory, maximize wastes reduction or recycling wastes to increase resources use efficiency.

(3) Type of waste disposals

Built closed loop circular economy system within factory to allow cycling of process materials within the production chain and effectively reduce the uses of raw materials and energy.

19. Evonik

(http://corporate.evonik.com/en)

(1) About the company

Evonik is one of the largest chemical product enterprises and its main business expansion target is in the high growth fields of health, nutrition, resources efficiency and globalizations.

(2) Circular economy promotion method

It promote solar energy as emerging energy replacement, use ecological friendly materials to produce solar energy systems and produce more economical efficient product with over 60 years of silicon chemical technology, then complement with supports from professional laboratory teams, hence is able to comply with various demands.

(3) The main product of circular economy

It performs research and development by material laboratory consisted of over 230 professionals which provide surface analysis, material characterization, bulk material analysis, trace material analysis, film analysis and can produce silicon of high purity and manufacture ultra-thin solar energy board module. For examples, new type of solar energy boards for garage products as shown in figure 2-37, not only with beautiful shapes, these solar energy board modules can provide power recharge for electric cars.



Source: The greater China area of Evonik, 2017 Figure 2-37 The solar garage products of Evonik
20. Orsted

(https://orsted.com/en)

(1) About the company

The main business is on renewable energy equipment and the enterprise's target goals are (1) develop green energy in anticipation of the world to meet the demand with green energy (2) develop smart energy so that energy uses can be more efficient ; (3) sustainable operations so that every employees can find pleasures from work.

(2) Circular economy promotion methods

Continually promote to replace petrochemical energy with renewable energy of biomass and wind power and set up the target of zero coal by 2023, the gradual promotion schedule is shown as figure 2-38 below. The green energy has reached 50% of energy supply by 2016.





Figure 2-38 The promotion schedule of zero coal burning

(3) The main product of circular economy

It is mainly about providing renewable energy facilities such as biomass energy, thermal energy technology and win power technology and equipment and provide customers with options of renewable energy that include offshore wind machine and biomass waste to energy conversions that are leading the world.

Chapter 3 Case analysis

3.1 The international case analysis of promoting circular economy policy

Summarize the main regulations, policy and information challenges from countries focus on promoting circular economy across the globe and compare with the current promoting situations in Taiwan.

1. European Union

Starting from 1990, the foreign advance countries felt that despite the traditional waste management strengthen recycle and reuse, but was not sufficient to correspond to environmental impacts derived from resource application, a long term solution with more prospect is needed. It was acknowledged that wastes and materials management must be integrated under the concepts of life cycle.

European Union submit Integrated Product Policy (IPP) in 2001 aiming to reduce the environmental impacts from products, and review the possible approaches toward reducing environmental damages based on the complete life cycle from manufacturing to uses. In 2002, the sixth Environmental Action Plan is submitted, emphasizing on the uses of natural resources and the environmental impacts of wastes, while the future development direction is decoupling resources uses, waste productions and economy growths. In 2003, products are used as a guide to decide the strategy tool of optimizing policy portfolio through the Integrated Product Policy, in order to improve the environmental performance of the products. In 2008, the continuous raw materials supply is ensured through EU Raw Materials Initiative. In 2011, resource Efficiency Roadmap is established with the following main strategies: 1. Adjustment in economic system operation: strategy include sustainable consumption and productions, turning waste into resources, support research/ innovations and eliminate subsidy harmful to the environment and push the price to truly reflect on resource costs ; 2. Ecological system conservation: the coverage include ecological system price correction, biodiversity, the proper uses of water, air, earth/soil and ocean resources. 3. Living system : include three key industries operation adjustment – sustainable production of food and prevention of waste, improve the resource and energy efficiencies of the entire life cycle of civil structure, transportation energy efficiency increase and system management/ monitoring, include indicator drafting/establishment.

In terms of biological cycle, European countries have been promoting organic wastes anaerobic digestions for many years and adopted co-digestion as promotion strategy in order to increase methane production while efficiently recycle wastes. Agricultural wastes, food wastes and biological sludge were collected, mixed and codigested. Thus, co-digested factories are mostly located in the animal farms to be close to source of and to collect organic wastes. Germany, Switzerland, Denmark and Holland are all important cases: Germany co-digest animal dungs with agricultural wastes and established over 10 thousands of biogas plants. Switzerland treated biomass wastes and sewer sludge as common source, and has established 264 biogas plants; Denmark mix agricultural wastes, food wastes, raw and cooked kitchen wastes and sewer sludge and there are 154 biogas plants under the implementation by Government. Since the organic waste issues are worsening and expanding, Taiwan has started to promote the co-digestion of organic wastes. The newly established plant at Taoyuan need to process kitchen wastes from the households, expired food, business wastes and other organic wastes. Ilan county otherwise plan to add anaerobic fermentation plant in existing sewage treatment plant where the sources came from kitchen wastes, pig manures and water hyacinth. Taichung city plan to transform composting plant, collect kitchen wastes and rice straws from nearby areas for co-digestion. In accordance to "The Building Green Energy for Sustainable New Generation of Garbage Disposal Plan" proposed by EPA, there will be 3 regional kitchen waste biogas generation systems built in the future, each built at the North, Central and South regions. For current stage, Yunlin County is the priority place for establishment. It is expected to increase kitchen waste disposal volume to 180 thousand tons/year, the power generated will increase to 0.0216 billion kWh/year, the sales of electricity will receive 86.5 Million dollars/year and reduce 11.4

thousand tons of carbon emissions annually.

To generalize the difficulties faced by European Unions, including: (1) market operation, price, various taxes and subsidies that cannot reflect the true prices of resources uses, causing the entire economy market unable to walk toward sustainability (2) Enterprises, finance and public policy are all lack of innovative long term thinking so the entire environment is harmful to practical sustainable cases (3) There was not practical and constant attention and resource use efficiency related to international competiveness issues.

2. Organization for Economic Co-operation and Development (OECD)

Starting from 1990, the foreign advance countries felt that despite the traditional waste management strengthen recycle and reuse, but was not sufficient to correspond to environmental impacts derived from resource application, a long term solution with more prospect is needed. It was acknowledged that wastes and materials management must be integrated under the concepts of life cycle. Organization for Economic Co-operation and Development (OECD) established Sustainable Materials Management (SMM) work in 2004, propose that sustainable material management is a way which aim to promote the uses of sustainable materials. The material life cycle concept run through the entire method, integrate various policies to reduce negative environmental impacts and maintain the natural resources, while considering the economic benefits and social justices. The main strategies include:

- Reserving natural capital: improve material flow and the information completeness of corresponding environmental impacts, increase resource productivity and resource efficiency, increase reuse and innovative evaluation technology.
- (2) Design and manage safety and sustainability of materials, products and procedures from the angle of life cycle: detox, dematerialization and is designed as valuable reuse.

- (3) Use various policy instruments to promote and strengthen sustainable economy, environment and social outcomes. Policy instruments include regulations, economic incentives/ penalties, trading and innovative policies, information and voluntary partnerships.
- (4) Stakeholders adopt active and moral responsibilities to realize the sustainability.

Naturally encountered difficulties include:

(1) economic factors mainly include:

- the availability of natural resources and raw materials, such as increasing prices of metals and energy.
- (2) cost cutbacks (high processing costs)
- (3) did not include environmental cost and impede the development in green market.

(2) environmental factors include:

- (1) continued increase of wastes productions
- (2) landfill is not sufficient to use and there are lots of illegal disposals.
- (3) The harmful/toxic substances of products pollute the environmental during disposals. Regarding the materials management issues in recent years, it is has been noted the change from long term and gradual observations to material management promotion. The subjects of these materials managements are called critical raw materials, relevant reports include the updated reports by 2012 SMM and the Material resource, productivity, and the environment report in 2015.

3. Germany

Germany established its national sustainability policy in 2002 on the goal to increase resource productivity by 2020 comparing to 1994, then pass the German

Resource Efficiency Programme, ProgRess on February 29, 2012 to achieve its goal. Germany also regulated that evaluation report must be submitted every 4 years afterward. The promotion strategies of ProgRess include five strategies of ensuring the sustainable supply of raw materials, increase the resource use efficiency of production process, create consumption patterns that comply with resource use efficiency, strengthen resource highly efficient closed loop recycling management and using diverse instruments. The guidelines and countermeasures of five strategies are: (1) ensuring the sustainable supply of raw materials: implement the raw material strategy by federal government of Germany and expand uses of renewable resources to as raw materials for production (2) increase the resource use efficiency of production process: inquire private organizations about the resource use efficiency to increase innovations and competiveness, develop and promote highly efficient (resource and energy) production process, the promotion and application of environmental management system, integrate resource use efficiency on product designs for the benefit of integrating innovations, resource conservations and standardizations. (3) increase resource use efficiency on the consumption side: facilitate public awareness, include resource use efficiency into trading and consumption decisions guidelines, establish new certification measures and promote current system, then employ government procurement as promotion tool on resource use efficiency. (4)strengthen resource highly efficient closed loop recycling management: strengthen product accountability, strengthen large waste recycling and reuse, prohibit illegal export of wastes and support the waste recycling system of emerging industrial countries and developing countries.(5) Using comprehensive system and method: improve the market penetrations of high efficiency resource products and service. Use economic measures and abolishes the subsidy that encourages resource consumption, develop sound and healthy research and development. Strengthen knowledge bases and include resource use efficiency in the law structure, technology and knowledge transfer of developed countries as well as develop political and law structures in European Union and across internal levels. The five strategies previously mentioned cover a total of 20 implementations, using physical measures as basis. The main implementation key points have market incentives, information, professional consultations, training, research and development and strengthen the voluntary methods and propositions of industry and society.

To summarize the difficulties faced, they are: (1) For more economical growths, prosperity and living quality that cause environmental burden: environmental issues and economical risks mainly caused by demands of mineral resources. (2) The economic potential of resource use efficiency is yet to be developed: the stability of raw materials supply has economic benefits and substantially reduce costs while increase the international competiveness of enterprises. (3) resources conservation is an important subject for decision makers: Since Germany submit national sustainability development strategy in 2002 with the goal to "protect the environment, economy efficiency and social responsibilities to integrate perspectives and facilitate mutual sustainability. All political targets should be limited by the earth and seek for highest benefits under this structure".

4. Holland

Holland government has been very dedicated toward waste management; end-ofpipe treatment is the main focus in the early days. "Order and control measures" (include centralized management of wastes) is promoted in 2001 with excellent results. Wastes reuse rate has reached 83% in 2006. Although the performance is excellent viewing from the angle of traditional waste policy, Holland government still consider the relative independent measures such as efficiencies of landfill tax and landfill ban are not sufficient to reduce environmental impacts on a big scale. Thus, Netherland's (second) National Waste Management Plan (LAP) 2009-2021 is aims toward material linked society. That is, it is expected to mediate different areas of management policies such as natural resources, product designs, waste management and cradle to cradle. The policy previously stated is "waste policy guided by product supply chain management".

In national environmental policy planning, it is clearly stated regardless of how the new material flow policy is stipulated, its goal is to assist the current environmental policy and integrate into a complete material flow policy system, which means the existing environmental policy is the subject while the new material flow policy is the supplement. Currently, the environmental strategies connected tomaterial flow policy is classified into three aspects: 1.dematerialization: cutback on the raw materials or increase resource use efficiency; 2. Material replacement: replace the current raw materials with materials of fewer environmental impacts; 3. Reuse or use renewable raw materials. It should be noted that the "dematerialization" by Holland does not only refer to the opposite of materialization. A simple reduction in material uses cannot completely describe the perspective. In fact, dematerialization represents "to achieve the goal of improving or maintaining a product or service through material reductions or energy uses", while satisfying users' needs, effectively reducing materials or energy flow. The more important objective of dematerialization is to reduce the environmental impacts of material flow. Holland has selected seven priority streams from national level 110 materials flows based on environmental impacts and industry' s willingness to cooperate: including textile, paper and paper board, civil/construction wastes, aluminum, PVC, large urban wastes and food. The government planned to reduce 20% of corresponding environmental impacts The most difficult parts in the targets previously mentioned are on how to integrate industry chains to submit action plan together and implement accordingly.

5. U.S.A

U.S.A is a big and rich country with lower population density. Therefore, waste resource is not yet listed as the first objective in consideration of circular economy. At the current stage, the focus is on reduction of food wastes. Food wastes are account for 21% of 0.258 billion tons of urban solid wastes in U.S. EPA currently promote life cycle of sustainable management to increase resource use efficiency. The promotion start from filling up the people, feeding the livestock and ends on composting, the final wastes cannot be processed are then buried or incinerated. After combining participations from public, enterprises and NGO, reduce 50% of food losses and wastes before 2030 together.

6. Japan

Every year, Japan also produces large volume of wastes, besides indicating improper uses of resources; dilemma of serious insufficient landfill yards for the final disposal of wastes is derived as well. Due to industry demands, the high concern of natural resources trigger problems; therefore, adopt forward looking approach to build the new economy systems of environment and economy balancing with each other. The economical society pattern of "mass production, mass consumption and mass wastes" is being changed in full force, transform into production, material, consumption to wastes, undergoes effective resource uses and promotion of reuses, and then inhibit the "recycling oriented society" of resource consumption and environmental load reduction.

Japan announced "The Basic Law of Promoting Recycling- oriented Society" in 2000, established the implementation directions and basic principles of relevant policies, other relevant policies are modified or formulated according to the objectives set by such basic law. The main content of The Basic Law of Promoting Recycling- oriented Society includes the definitions of recycling-oriented society, the principles of wastes, recycling and reuse, the obligations and responsibilities of relevant main body and the establishment of basic plan of The Basic Law of Promoting Recycling-oriented Society. The principles of wastes, recycling and reuses are followed according to below priorities: (1) Reduce,(2) Reuse,(3) Material Recycle,(4) Thermal Recycle,(5) Proper treatment.

Japan implement the second stage of "The Basic Plan of Promoting Recyclingoriented Society" (5 years) since 2008. The summary of evaluation of implementation during promotion: although the overall resource productivity within Japan increased continuously, but there are obvious reductions of soil and rocks from the analysis of natural resources input. The crude oil and metal resources input continuously increased due to production of high technology products. It is noticed that the reduction of resource uses at the source is insufficient, industrial wastes therefore continuously increased in recent years, causing lack of landfill yards for the long term. To correspond toward industry development demand, the issues caused by exhaustion of natural resources is highly concerned, there are room for improvement.

7. Taiwan

Taiwan has a small area and is densely populated, therefore waste management has been a subject of keen interests, and the evolution of policy start from terminal disposal, waste resources, resources recycling to the highly promoted circular economy for now. Taiwan's approach is to focus on developing sustainable material managements. The approach includes building national key materials database to gradually set up crossbodies platform. In terms of industry, plastics, food and constructions are priority industry for promotion, assisting to promote cradle to cradle concepts, thinking together about how to reuse waste resource to achieve the goal of zero wastes. Also, the international cooperation and communications are continuously expanded currently; regular international forums are organized every year where key countries are invited for discussion panels and cooperation. European and American countries are actively interviewed and visited to promote international cooperation opportunity, introduces successful cases and patterns to speed up the circular economy related tasks within Taiwan.

Taiwan still face some problems on promotion within the country and needs helps from various fields to seek for solution: (1) the incomplete connection of venous and arterial industries, industry do not actively participate in relevant tasks. The secondary raw materials produced and recycled by venous industry, the source of raw materials, development scale and fund are not strongly connected with arterial industry.

(2)General public still has doubts in reuse products. General public is used to traditional consumption pattern and either has doubts or bad perspectives on the reuse products under the existing concepts. (3)The price of secondary raw materials is higher than original raw materials, when environmental cost did not include into considerations, the market price of raw materials that use large amount of natural resources is still lower than secondary raw materials, so suppliers prefer to use raw materials.(4) resource recycling technology is yet to be improved, new technology or skills are needed to reuse recycling wastes or remade into raw materials or the rethink of product design before actually achieve resource recycling concept, Taiwan has a lot of room of development in this area.

The key policy and regulations of SMM promoted by individual international organizations and countries as well as challenges they faced are summarized in table 3-1. Through comparing the methods of key countries adopted in promoting circular economy worldwide, there are still many things Taiwan should learn from. These include (1) specialized regulations: many countries set up specialized regulations for promotion as a basis and quickly promote such measures. Taiwan has not yet formulated such measures since the legislation system and procedures are complicated. The establishment of special regulation and its content should wait for follow up researches from various fields.(2)For the specific realization of goals, many countries focus on circular economy promotions to establish specific schedule and corresponding quantification targets to monitor the entire country to achieve the goals together, while ensuring the implementation is more efficient and the results can be reviewed easily. Taiwan has built many relevant indicators at the current stage, but the establishment of targets still needs coordination and research from across the bodies and multi-parties before establishing reasonable and active national goals. It is recommended to set up relevant policy targets as quickly as possible, which is the important common consensus that needs to be promoted as soon as possible. (3) Built circular economy hotspot and selected demonstration area for circular economy cooperation and demonstrations are helpful in terms of promotions and encouragement of promoting relevant measures. Under the continued smooth expansion, cluster efficiency will allow effective increases of the promotion speed. Taiwan has many individual suppliers are actively participating and research, but not yet develop into medium to large regional plan. It is recommended to plan and conduct trial tests at the appropriate areas in the future.

	1
Challenges faced	
Market operations, prices and various tax and subsidies cannot reflect the resources use the true prices, resulting in the entire economic market cannot walk toward sustainability.	
The accessibility of raw materials and natural resources, such as increase prices of metals and energy. Save the cost (treatment cost is high). Did not include environmental cost and cause obstacles in green market.	
The more growths in economy, living quality that cause increase in environmental burden, it is mainly about the environmental issues and economic risks by demands of mineral resources	
The government planned to reduce 20% of corresponding environmental impacts by 2015. The difficulties of above targets are on how to integrate the industry chains to submit the action plan together and indeed implemented.	
Tried to draw food waste map to understand the leftovers distributions in the country. Develop technological assistances tools to disclose more transparent information.	
The main issue is long term deficiency of landfill yard, due to industry demands, the high concern of natural resources trigger problems.	
Venous and arterial industries are not completely linked. Public has doubts in reuse products. The price of secondary raw materials is higher than raw materials. Resources recycling technology is yet to be improved.	

Source: Compiled by this project

Regulations and policy		
In 2008, passed the EU raw materials proposals to ensure raw materials are supplied continuously. The resources use efficiency schedule plan is established in 2011.	*** * * * * * *	EU
Design and manage the safety and sustainability of materials, products and procedures, the designs should be detox, dematerialized and valuable for reuses.	OECD	OECD
Five major strategy guidelines and measures.		Germany
Dematerialization, save raw materials or increase resources use efficiency. Material replace environmental impact materials to replace current raw materials. Reuse and use recycled materials.		Holland
Promote life cycle style of sustainability management. Promote by the order of feeding human, domesticated animal then composting. Reduce 50% food wastes by 2030.		USA
The reuse and recycle principles of wastes should be performed in following orders: 1. Source reductions 2. Use again 3.Reuse 4. Thermal energy reuse 5. Comprehensive treatment		Japan
The focus is on developing sustainable materials management in the beginning stage. Write up policy program and promotion plan (draft). The priority promotion focus is on plastic, food and constructions. Continuously expand international cooperation.	*	Taiwan

Table 3-1 The comparison of method and challenges to promote circular economy in the world

3.2 The analysis on best practices in domestic and foreign industries

The 52 domestic and foreign enterprise samples collected in Section 2.1 and 2.2 are compared and analyzed, the technology, methods and competitive advantages of each enterprises said above are analyzed as key items. Since every enterprise is different in how they promote circular economy, this project classifies the 5R of circular economy (table 3-2) for comparisons. In addition of enterprises cases, small changes made in daily life by general public in fact contribute toward circular economy. This project also compiled several innovative green consumption cases for general public' s reference.

Types of methods	Enterprises cases		
redesign	Wistron,O' right,Miniwiz,Phillips		
reuse	Rui da hung technology materials co., CLC, AMIA Co., Ltd., Dong-Da Industrial Co., LTD, Beshine stone & Son Industrial Co., LTF. , Spring Pool Glass		
reduction	Subaru,Toyota		
recycle	Chinalab, Sus Recycle Technology Inc., SDTI, Uwin Nanotech, Yung Yuan, HJEC, Plum Monix, Taiwan Cement, Cleantek, Solar tech, Diamonchem, Da Fon Environmental Technology, Far Eastern New Century Corporation, Da Ai technology, E&E Recycling, CSC, TSMC, HP, Xerox, REMONDIS, Astec-irie, DOWA, MBA POLYMERS, Green Group, WRC Recycling, OLUS, Mitsubishi Electric, Nomura Kohsan Co., Umicore, AGC MATEX, Tanaka koumuten, Du Pont		
energy recovery	Delta Electronics Inc., ECOVE, Shihan farm, Evonik, Orsted		
green consumption	Good to go box, Goldfish brain, Pear Life		

1. Redesign

Redesign is to achieve the circular economy targets of reuse, reduction, recycle and energy recycle, review and think about existing production mode or business mode, create new mode allowing industrial materials or biological materials to enter

Source: Compiled by this project

recycle continuously, while creating zero waste during the entire process as much as possible. The key enterprise samples include Wistron, O' right, Miniwiz and Phillips that conduct this kind of circular economy tasks, the comparative analysis is arranged as table 3-3 below.

	Technology	Methods	Competitive Advantage
Wistron	Different from the traditional technology, applying optical classifications and water purifications technology process can effectively recycle regenerated mixed plastics wastes automatically.	To achieve the harmony between nature and humans, circular economy concept is continuously practiced to allow products can be effectively recycled after redesign.	Successfully complete the closed loop of manufacturing process, the wastes can be completely recycled to the new product manufacturing process.
O' right	Manufacture biodegradable bottle using biomass, then put seeds inside the bottle so that it can be renewed into plant after biodegradation and enter biological cycle.	Arming with the purpose to be beneficial to the human, social and environmental health, environmental friendly products are made with creativity.	Creative products received many awards such as Red dot design awards from Germany, IF design award and Taiwan Excellence Awards
Miniwiz	Set up the world's only waste laboratory to research the possibility and potentials of reusing various wastes.	Miniwiz considers that the perspectives on garbage should be changed, under the concept of circular economy, garbage should equal to opportunity. Every type of waste has the possibility of recycling and reuse, as well as unlimited business opportunities and is beneficial in protecting our environment.	It is recognized as the technology leading enterprises in energy/ environmental/ public construction fields on 2015 World Economic Forum.

Table 3-3 The enterprise case analysis of redesigned work

	Technology	Methods	Competitive Advantage
Phillips	Under the new business pattern, maximization of product life becomes the new purpose. The research and development of lighting equipment that has longer life, or combined modules of lighting systems with multiple changes become the new research and development goal. Phillips has professional laboratory to redesign new products according to demands.	Enterprises create new business pattern from providing lighting hardware equipment to lighting services. The new pattern where lighting solutions are built according to users' needs, then enterprise design, provide equipment and maintaining services while entitled to the hardware ownership, hence increasing product reuse rate.	One of the largest lighting equipment providers and is able to provide possible circular economy solution depend on national situations

Source: Compiled by this project

2. Reuse

Reuse means collecting used products, making into products for sale or reuse instead of using new materials after cleaning and processing. The key enterprise samples include Rui Da hung technology materials co., CLC, Spring Pool Glass, Dong- Da Industrial Co., LTD, Beshine Stone & Son Industrial Co., Ltd. and AMIA Co., Ltd. adopting reuse as key task, the comparative analysis is arranged in table 3-4.

	Technology	Methods	Competitive Advantage
Rui Da Hong	After raw materials enter electric arc furnace, pure tin ingot and pure lead ingots are produced by refinement through electrolysis. The anodic sediment waste produced by electrolysis can be remade into pure silver ingot, copper sulphate and Bismuth hydroxide by separation and purification procedure.	Rui Da hung technology materials Co. has extensive experience in metal tin treatment and purified manufacturing	Licenses of reuse on many general cases of recycling Scrap tin solution (C-0202), Scrap tinning waste (C- 0102) and Waste tin lead slag (C-0102) are successfully obtained
CLC	Established Heat Recovery Steam Generator and RDF (waste derived fuel) pelletizer to recover thermal energy and recycled fuel, then reduce the uses of raw coals.	Improve process and energy resources integration applications to reduce the uses of raw materials and increase efficiency, and then input highly efficiency pollution control system to reduce the emissions of pollutants.	The largest recycled paper reuse company in Taiwan
AMIA Co., Ltd.	Through unique zero pollution recycling and reuse process and high-level technical workmanship, extract precious metals from waste liquid and convert to copper salt products required by electronic industry, mining industry, dyeing and finishing, painting and other industries. The recycled waste liquid does not need to be disposed and can almost be reused fully.	Practice "industrial environmental production" and "resource recycling and reuse" concepts, assisting PCB industries across the straits to develop and grow while create pollution free resources recycling and reuse system, thus resulting in the new miracle of Taiwan green technology economy.	Through the accumulation and development from long term supply of chemicals to electronic industry, and the reuse technology of used waste products, the zero pollution recycle and reuse technology of potions and waste liquid that met the requirements are currently developed.

Table 3-4 The enterprise case analysis of reuse

	Technology	Methods	Competitive Advantage
Dong- Da Industrial Co., LTD	Through recycle and reuse technology, replace copper from waste liquid water, the recycled waste liquid can be reused almost completely.	Through recycle the waste liquid from PCB industry and metal surface treatment industry, convert the waste liquid to products required by water treatment pharmaceutical industry, including ferric sulfate solution (Ferrous sulfate) and Ferric chloride solution, create new values.	
Beshine Stone & Son Industrial Co., Ltd.		It specializes in production of Ferric chloride acid etching solution and water treatment chemicals and recycled metals from the waste liquid.	
Spring pool glasses	Develop colorful glasses, it has diversities of colours and granules and great refractive index. The buildings will be shiny when the glasses are inlayed on the surfaces and generate shiny effect.	Recycle majority of waste glass containers within Taiwan and manufactured into beautiful glass art and export to various countries across the world.	The environmental friendly building material, "colorful glass" was developed successfully. The quantity of waste glasses recycled by Spring Pool Glass account for over half of total recycled volume in Taiwan.

Source: Compiled by this project

3 Reduction

Reduction is to reduce resource consumption, reduce waste production and reduce environmental pollution emissions through optimization or change in production process as much as possible. The key enterprise samples include automobile manufacturers such as Subaru and Toyota adopt waste reduction as the main methodology to promote circular economy. The comparative analysis is arranged in table 3-5.

	Technology	Methods	Competitive Advantage
Subaru	Continuously reduces harmful materials such as lead, mercury, cadmium, hexavalent chromium or use alternative environmental friendly raw materials. Voluntary reductions of 13 volatile harmful substances The recycle rate of crusher wastes is around 97.5% Zero landfill is achieved since 2011 The recycle rate of air bag reached 93.3%	When designing the product, the impacts of corporate responsibilities and product life cycle on the environment and procurement must considering biodiversity and environmental protection should be considered. Production and logistics reduces environmental impacts through increasing energy efficiency and waste management, while increasing resource efficiency and reducing wastes are the center of thought for the product sales.	Built the complete system of car recycling, Aerosols and CFCs produced by the crushers all need to be processed comprehensively to allow usable parts of recycled cars properly recycled or reused.
Toyota	The manufacturing end establish car to car recycling system, set up closed loop and substantially reduce the uses of raw materials. The sales end use computer systems to pair up recyclable components then make the best match according to consumer's need.	Regarding the resource acquisitions and greenhouse effects reductions as the purpose, then executing the plan of reducing raw materials uses with 3R (reduce, reuse and recycle) as the center thought.	Establishes self- developed recycling system and technology, maximized the uses of recycled materials to manufacture new cars.

Table 3-5 The enterprise case analysis of reduction

Source: Compiled by this project

4.Recycle

The recycle collects materials or wastes that were going to be disposed and made into new products or secondary raw materials through screening, decomposition, extraction and treatment. The majority enterprise cases adopt recycle as main strategy, which indicates that recycle is still the mainstream option. The cases fall in this category include 32 enterprises of Chung Tai Resource Technology Corp, Sus Recycle Technology Inc., Super Dragon Technology Co., Ltd., UWin Nanotech. Co. Ltd., Yung- Yuan Chemicals, Hong Jing Metal Co. Ltd., Plum Monix Industry Co., LtD, Taiwan Cement, Cleantek Technology Co., Ltd., Solar Applied Materials Technology Corporation, Diamonchem, Da Fon Environmental Technology Co., Ltd., Far Eastern New Century Corporation, Da ai technology, E&E Recycling, CSC, TSMC, HP,Xerox,

REMONDIS,Astec-irie,DOWA,MBA POLYMERS,Green Group,WRC Recycling,OLUS,Mitsubishi Electric,Nomura Kohsan Co.,Umicore,AGC MATEX,Tanaka koumuten and Du Pont. The comparative analysis is arranged in table 3-6.

	Technology	Methods	Competitive Advantage
Chung Tai Resource Technology Corp.	Has the most advanced waste lighting source recycling dismantling technology in the world and can recycle and reuse 95% of derivatives. The recycled mercury is of high purity and high recycle ratio.	Recycle and reuse lighting equipment and PCB, physically realize the "Urban mine" concept, promote the resources sustainable recycling, and then achieve the goal of zero wastes.	The lighting equipment recycling technology is first in the world, and establishes the first waste lighting source treatment factory in the country.

Table 3-6 The enterprise case analysis of recycle

	Technology	Methods	Competitive Advantage
SRTI	Sus Recycle Technology Inc. specializes in precious metal recycling and renewal technology. It can fully recycle and renew precious metal excrement produced during semiconductor and electronics industrial production.	The Company is innovative and adopts business waste professional recycling OEM system, seeking harmless complete waste recycle and reuse management process, and ensuring the treatment process is transparent.	Work with Japanese companies to develop electrolysis machine and can create higher recycle values comparing to general electrolysis.
SDTI	Beside effectively recycle precious metals, it even reuses electronic wastes and made into recycled artwork.	Provide the most comprehensive waste treatment and recycle strategy for IT industry while dedicate to make global arrangement and establishes factory in Jiangsu.	It is the first company that listed on the market with environmental technology shares; work together with ITRI on technology development and introduces the most advanced technology and equipment from Japan and Germany.
Uwin Nanotech	Research and develop the Equipment, SnST- 550A Tin stripper that can quickly separate the metal part of waste motherboard to speed up recovery process.	To cherish precious environmental resources of Taiwan, it dedicate toward producing environmental friendly products by electronic wastes as raw materials to reuse recycled precious metals.	The disposal equipment it developed has been exported to U.S.A, China, Singapore and Switzerland while receiving 2013 environmental innovations and technology research and development award.

	Technology	Methods	Competitive Advantage
yung yuan	Refine copper sludge effectively to become the raw materials of copper ingots	It turns heavy metal sludge into metal oxide, the raw material for metal smelt through heat treatment and export to overseas.	On April 02, 2002, the Company was approved to recycle copper sludge from PCB recycling industry with Copper sludge. Sludge from copper foil process recycles and reuse permit is obtained on March 31, 2004.
Hong Jing Metal Company	Important metals such as Molybdenum, vanadium and cobalt are effectively recycled and reuse.	It mainly recycles waste catalyst generated by petrochemical refining and vanadium- containing fly ash generated by power plant, allowing effective recycle and reuse of waste materials.	
Plum monix industry co.,Itd	The resource level from waste catalyst (waste sources) to the final products is about 80%,	After import industrial waste catalysts, recycle and produce Molybdenum, vanadium alloy and relevant chemicals.	
Taiwan Cement	The Company collects waste catalyst produced by CPC and successfully replace the raw materials of clay	Using the process characteristics to assist industry to reduce wastes and reuse resources.	It can use cement kilns to assist in treating waste catalysts from petrochemical industry, then remade into raw materials for clay.

	Technology	Methods	Competitive Advantage
Cleantek	It actively invested into high purity indium refining technology and the indium ingots produced reached over grade 4N5 (99.995%).	It provides professional production service of ITO demould recycle refining and Pump cleaning and can even recycle precious metals.	The refined indium ingots are export to destinations like Japan, the United States, Europe and other countries. The quality has been the main target of ITO manufacturers worldwide(such as Mitsui, Umicore) verified recognized.
Solartech	It is one of a leading players in the world for precious metal and rare material refining, special forming, and processing.	Solartech uses rare and precious metals recycling and refining as the platform to develop close-loop model, comprehensive green and clean production indicators, develop rare and precious metal material applications and produce targets/ materials for thin film application in disk, hard drive, semiconductor, photoelectric and solar energy industries.	Solar Applied Materials Technology Corporation is the largest optical data storage thin film manufacturer worldwide.
Diamonchem	There was no water solutions added into recycling process and lower cost can be achieved.	Recycle zinc scraps, extract and recycle zinc metals.	The purity of metal smelting is higher than industry

	Technology	Methods	Competitive Advantage
Da Fon	The crushed recycled materials of PC,PE,PET,PP are effectively used to produce multi- purposes recycled particles.	For many years, the Company dedicate toward environmental industry development, determined in resource classification and recycle, resource renewal and recycling to achieve zero waste resource full cycle as its mission.	Da Fon Environmental Technology Co., Ltd. is the leader in environmental industry in Taiwan, the largest recycling company
Far east new century	Work with Coca Cola to develop the first 100% Bio-PET that completely use bio materials Far Eastern New Century Corporation use high technology recycling skills and high temperature melting process to remade waste PET bottles into Recycled PET (rPET) and replace the raw materials made by petrochemicals.	Effectively recycle and reuse waste PET raw materials that can remade into food grade rPET, while develop Bio-PET to reduce the negative impacts on environment brought by waste PET.	Allowing the materials of PET in future can be completely obtained from plant source. It is the world's first attempt. Also, recycled PET bottles as food grade rPET to replace the traditional process of petrochemical raw materials.
Da Ai technology	Remade recycled PET bottles into fibers can save 84% of energy uses and 77% of greenhouse gas emissions.	Effectively recycle and reuse waste PET raw materials to remake into blankets	It has the largest recycle volunteer system in Taiwan and can export the products to 10 countries.

	Technology	Methods	Competitive Advantage
E&E Recycling	Waste TV, waste washer, waste aircon and waste fridges can be processed together at the same time, with separate processing flow and production line.	In view of the worsening electronic appliances and electronics wastes issues, E & E Recycling thus introduced advance technology from Europe and recycle reusable resources.	The Asia's first waste electronics and electronic appliances disposal factory is founded, the advanced technology from Germany is introduced for process.
CSC	Recycle waste water by electro dialysis reversal (EDR); industrial waste water plus advanced waste water disposal unit module (include filter, reverse osmosis and ion exchange) to made into reusable pure water	To implement environmental protection measures, CSC dedicate toward executing measures and technology to save water and energy, allowing the enterprises to reduce uses on natural resources and achieves the purpose of environmental friendly.	Waste water is recycled to front end process for reuses, the water recovery rate reaches 98% and reduce water resources input and energy wastes to reduce costs and unit water consumptions.
TSMC	There are as many as 20 types of water pipelines within the factory, and are classified according to the characteristics of various recycled water and over 15 process flows, resulting in over 85% of recycling rate.	TSMC manages various aspects from process, recycling, reuses and real time water resources uses monitoring systems to effectively and substantially reduce the uses of water resources.	Has world leading water resource management technology

	Technology	Methods	Competitive Advantage
HP	75% ink cartridges and 25% toner cartridges are produced by recycled plastics of closed loop.	The annual hardware recycle volume has exceeded 102,000 tons and ink cartridges recycle volume has exceeded 17,000 tons. Establishes the goal of recycling 1.2 Million tons of hardware by 2025.	The blueprint of enterprises promoting circular economy has been built, submitted corresponding new type of printing solutions. This reduces uses of raw materials by 57% per page printed.
Xerox	The new product include 5% of recycled plastic secondary materials. The general waste recycling rate of Xerox' s zero waste factory reached 93%.	Xerox fully develop the technology to reduce paper and ink usage, and has successfully reduced 47,500 tons of wastes Recycled 43,000 tons of recycled products.	Establishes natural conservation partners and dedicate toward protecting forest resources.
REMONDIS	The Lippe factory is the largest recycling center of Europe generate 0.8 million tons of recycled and reused products through recycling and regeneration procedure, including adhesives, biodiesel, certified agricultural products and plastic pellets raw materials. This factory reducing 0.466 million carbon emissions annually through recycling activities.	It provided the entire set of complete recycling plan, includes material flow analysis, material conversion analysis, recycled product quality certifications and recycled product collection plan, logistic and transport services and smart recycling plan.	One of the largest recycle service provider in the world. It has built the comprehensive recycling structure and system with 30 million tons of different recycled products every year.

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	Technology	Methods	Competitive Advantage
Astec-irie	It is mainly about the colour metal recycling technology of motherboards from personal PC It collects suspended dust from steel industry and made into iron powder.	It is one of the suppliers in Kitakyushu ecological village center project in Japan, Astec-irie expects to achieve the goal of zero wastes through participations in the project and convert all wastes into useable resources.	The first circular economy hot spot plan in Japan.
DOWA	DOWA use unique technology and can dispose wastes that usually cannot be recycled and recycle valuable metal for reuses. It is mainly about recycling organic waste liquid and used cleaning liquid, then recycles and extracts precious metals and reuses.	Recycle rare metals of gold, silver, platinum, palladium, rhodium and ruthenium from the wastes and reuse.	It has complete recycling system and technology and can dispose wastes that usually cannot be recycled and recycle valuable metal for reuses.
MBA POLYMERS	Compare to manufacturing plastic products by petrochemical raw materials, energy used is reduced by 80%, The closed loop production pattern has been successfully completed with fully recycle and reuse of plastic product over 90% of metal raw materials required by production can be recycled from wastes.	Research and develop waste plastic from compound waste materials and reuse.	The world's largest waste plastic recycling enterprise.

	Technology	Methods	Competitive Advantage
Green Group	The smart resources recycling station is developed to recycle various recycling in one station while feedback to public with rewards and thus effectively promote and increase recycling rate.	The recycling system can recycle waste plastics like PE, PP, PS, ABS, technology wastes, waste electronics, and wastes optical equipment.	Green Group integrates its 6 subsidiaries to establish the largest recycling system business of South East Europe.
WRC Recycling	Develop the technology and equipment that are able to dispose various wastes of thin films, hard plastics, waste paper boards, waste papers and waste metals in the same time.	The main business is about recycling various plastic wastes and provides services such as collection, crushing and granulations.	The distribution channels have been built across Unite Kingdom, where materials can be transport to various locations in the country. Besides plastic recycling,waste paper, waste metals and waste management inquiry services are provided.
OLUS	It is a super factory that has annual disposal volume of 25,000 tons of wood materials wastes as shown in figure 2-30, and can be remade into fertilizers, building materials and biomass fuels.	Over 30,000 tons of biomass is recycled annually and remade into organic fertilizers or building materials.	Olus can produce high quality fertilizers that complied with national standards from recycling biomass wastes, and then provide 40 liters to a few thousand tons of fertilizers according to customers' requirements.

	Technology	Methods	Competitive Advantage
Mitsubishi Electric	Through the recycling network and system currently built, the recycle and reuse rate of electronic products on average reached 87.4%. The recycle and reuse rate of personal computers on average reached 77.7%	The first electronic recycling factory, HCS is built in Japan in 1999 (it is mainly about recycling TV, air conditioner, fridge and washing machine). Over 700,000 tons of materials has been recycled by 2016, the changes in recycling volume.	Mitsubishi Electric is one of the famous electronic suppliers in Japan It hopes to increase product recycling rate through building comprehensive recycling system.
Nomura Kohsan Co.	The factory can process mercury wastes and the processed mercury wastes are strictly controlled to prevent mercury emission at a standard higher than national standards. The final process adopt protection measures such as double cover, water seal, cement reinforced layer to protect the environment from pollution	Collect general or business wastes and remade into reusable products such as fertilizers, glasses and metals.	The factory has its own processing furnace equipment to ensure comprehensive disposals and adjust the process according to mercury concentration.
Umicore	Its cobalt catalyst recovery technology is top of industry in the world.	After recycle rechargeable batteries, electronic optical materials, jewelries and waste catalysts, then recycle reusable precious metals.	Umicore is one of the important material suppliers in the world that achieves 11.1 billion USD in its turnover. It mainly provides complete product solutions and the product sold can provide wastes recycle and reuse services.

	Technology	Methods	Competitive Advantage
AGC MATEX	The lighting sources of recyclable wastes fluorescent lamp are made into high quality particles according to customer's needs and for reuse.	The recyclable glass fibers or other glass products are remade into applicable particles.	AGC MATEX has over 60 years glass fibers production experiences.
Tanaka koumuten	The collected waste building materials can be remade into raw materials for paper, fertilizers, building materials through recycling system.	It is mainly about recycling waste building materials for reuses.	Tanaka koumuten can provide speedy weighing and convenient transportation spots, allowing customers to complete the wastes collection swiftly.
Du Pont	Built closed loop circular economy system within factory to allow cycling of process materials within the production chain and effectively reduce the uses of raw materials and energy.	It is the first enterprise in the world to target at zero waste and dedicate toward developing clean production pattern.	Du Pont is in business for 215 years, has solid chemical manufacturing technology system and is a world's leading supplier.

Source: Compiled by this project

5. Energy recovery

Using the analysis and inspection of energy balance to maximize the recycling of available energy, reduce energy escapes that causes waste while saving petrochemical energy as well as reducing greenhouse gas emission. The key enterprise samples include Delta Electronics, Inc., Ecove, Shihan farm, Evonik and Orsted that engage in this type of circular economy promotion. The comparative analysis is arranged in the table 3-7 below.

	Technology	Methods	Competitive Advantage
Delta Electronics	The self-developed energy recovery system recycles 310.47 Million units of electricity in 2015.	Delta Electronics, Inc. took the lead and announced "Delta Climate Action Plan Report" in 2015 to share its concerns on climate issues in the hope to pose impacts across the globe.	
ECOVE	It has the largest solar power generator, use high efficiency module and has established capacity around 26 MW. Develop integrate system platform to be applied in each operating factory, use intelligent and data management efficiency to increase management efficiency.	Incinerate general wastes by effective energy recycling and reuse and dedicate in recycled water and the applications and productions of recycled secondary raw materials.	ECOVE is one of the subsidiaries of CTCI Corporation and can effectively integrate resources for operation. ECOVE Obtained the World' s First BS 8001 Circular Economy Certification in 2017 and honored with top grade in overall evaluations.
Shihan Farm	Introduce advance biogas equipment from Europe, and then effectively recycle wastes from the factory to produce usable energy.	Shihan Farm produces healthy eggs bases on the idea of food must be "safe, focus on the checks and tests of each production process to ensure the products are safe and risk free. Also, environmental production equipment is actively introduced to convert excretion wastes from domestication effectively into energy and reduces the uses of petrochemical fuels.	The fully automatic production equipment is used in the farm to ensure product quality and safety while properly uses all biomass resources to replace natural resources.

Table 3-7 The enterprise case analysis of energy recovery

	Technology	Methods	Competitive Advantage
Evonik	It performs research and development by material laboratory consisted of over 230 professionals which provide surface analysis, material characterization, bulk material analysis, trace material analysis, trace material analysis, trace material analysis, and can produce silicon of high purity and manufacture ultra-thin solar energy board module.	It promote solar energy as emerging energy replacement, use ecological friendly materials to produce solar energy systems and produce more economical efficient product with over 60 years of silicon chemical technology, then complement with supports from professional laboratory teams, hence is able to comply with various demands.	Evonik is one of the largest chemical product enterprises in the world.
Orsted	Its offshore wind power plant is leading the world.	Promote to replace petrochemical energy with renewable energy of wind power and set up the target of zero coal by 2023	The green energy has reached 50% of energy supply by 2016.

Source: Compiled by this project

6. Green consumption

Besides promoting circular economy from product manufacturing aspect (arterial industry) and recycle aspect (venous industry), general public can start from daily life, a small change will become great boost in promoting circular economy. Everyone can change the existing economy model through green consumptions. Generally speaking, the main goal of "green consumption" is mainly to protect consumers' health and collectively called as all consumer behaviors and consumption patterns that comply with promotion of human health and environmental protections. It is the consumption pattern that expected to increase natural resources usage efficiency and reduce toxic substances uses and pollution emissions, while maintaining and even improve people's living quality. The three innovative cases of Pear Life, Good to go box and Goldfish brains for

public' s reference.

(1) Pear Life

Nutritious and delicious top-grafted pears have always been loved by the public. However, the grafting is a very important step in the planting process of topgrafted pears and required insulation tape for winding. Also, to isolate pests and sun, pockets contained "wet strength agent" and lined with wax will be put on the pears and winded with iron strings. There will be lots of agricultural wastes accumulated after harvest. Traditionally, these wastes are burned in the open area, which waste natural resource and cause serious air pollutions in the environment, such as carbon dioxide, aerosols and dioxin.

Two male university students, Xu Zhenjie and Lin Yi-Wei Soil from Houli, Taichung try to set up Renli People workshop through 2015 Rural Up! of Soil and Water Conservation Bureau. They recycle and reuse these agricultural wastes by special creativeness (such as figure 3-2). First of all, collect and recycle the waste together, sort and recycle, then creatively manufactured into pear smoke pen from waste pear scion (Figure 3-3) and become new creative products, while being recognized as top ten souvenir of Taichung. 2 tons of agricultural wastes were effectively recycled in 2016 and reuse. The figure increased to 20 tons by 2017. Pairing with village experiences as follow up, new business model is gradually created. The earnings are paid back to the village and encourage more participation from farmers. Not only wastes and pollutions are effectively reduced, new opportunities are brought to promote circular economy together.

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Figure 3-2 The business mode of Renli people studio



Source: flyinyV website

Figure 3-3 The pear smoke pen of top ten souvenir of Taichung

(2) Good to go box

It is a common scene that each and every modern people carry a glass of handmade drinks with them, but the plastic or styrofoam cups used by most shops are one time use products that can be used only once before becoming garbage. The

number of waste disposable cups in Taiwan is 1.5 billion per year. Good to go box founders, Sung Yi-Chen and Li Yi Ho are design graduates of National Cheng Kung University. They attempt to use new business models to correct this problem, anticipate to effectively reduce one time use garbage through promoting reusable containers. They promote business mode similar to Youbike to the food and beverage world. For example, the "Zhengxing cup cup plan" promoted in Tainan city. The beverage providers in that business district provide glasses cups for their drinks and adopt diverse consumption mode for operation. Consumers can choose to direct return after use, return in another visit, return to other shop and retrievals by the team, effectively assisting in reducing disposable garbage under the premise of consumers still enjoying convenience. The hygiene and user experiences that consumers cared about during promotion, the team also submit effective solution. The team established SOP for cleaning and outsource professional cleaning service provider to ensure the product quality. Also, there is regular third party certification for inspection to assure the consumers. In term of user experiences, beside combining environmental education concepts, specialized tags and app are designed to allow consumers to find the participating shops and even calculate the contribution value toward environment by accumulated consumption through record system (figure 3-5). This will allow interested public to easily make contribution toward circular economy promotion.



Source: Vita news website, good to go website.

Figure 3-4 Good to go concept



Source: Good to go website

Figure 3-5 the interactive design of good to go boxes

(3) Goldfish brain

Goldfish brain is founded by Ms.Chen Chin-Yen who also noticed that the beverage market is using too much disposable consumer products, resulting in large volume of garbage. The main target for goldfish brain is to reduce the use of plastic straws. Every year, as much as 3.0 billion plastic straws are used in Taiwan. Through a series of video shot and put on Youtube to share and analyze other reusable straw replacements. Those videos were very popular with a total of number of views at high as 19 million. This is done to encourage public to use straws of reusable materials:

- 1. 304 stainless steel: food grade materials but are not suitable for acid drinks.
- 2. 315 stainless steel: medical grade materials with higher corrosion resistance than 304 and can be used for acid drinks; however, the inside of straws cannot be seen to determine if dirt is precipitate or attached.
- 3. Glasses: diverse shapes that have attractive appearances. The transparent materials will assured the uses and is easier for cleaning. However, glasses need special protection to prevent from breaking.
- Bamboo: manufactured by natural materials and is biodegradable after disposal. But it is hard to preserve compare to other materials. Bamboo is easier to become moldy and can no longer be used.
In future, through the effect of high popularity, promotion will be carried out in physical stores (as figure 3-6). Through media communications and actual experiences, more public can enjoy actual participations while encouraging more stores in joining the team as well as continuously promoting Goldfish brain' s idea. Everyone work together to reduce the consumption of plastic straws and team up together to promote circular economy.



Source: Goldfish brain, 2017

Figure 3-6 The concept promotion of Goldfish brain

3.3 The case analysis of domestic energy resources integrations

After the case analysis included in the previous chapter, the countermeasure methodology and trends on circular economy movement by key domestic and foreign enterprises at the current stage can be understood. To further understand the whole picture of circular economy, energy and resource integration are one of the key working target for promoting circular economy. This project specifically selected China Steel Corporation as a sample to describe the domestic energy and resources integrations. The concept of energy and resource integrations is about reintegrate and recycles surplus energy or waste from factories specifically in the same industrial area. The surplus or waste from each factory may be the raw material or energy source of the other factory. This way, the natural resource can be applied more efficiently and reduce the operational costs of vendors, hence creating a win- win situation.

Using seashore industrial park of China Steel Corporation (CSC) as an example, it is one of the few domestic cases that complete the "regional energy and resource integration". The CSC application process will produce characteristic such as much gas and waste heat by-product and promotes cogeneration system greatly. Beside the recyclable energy can provide the steam requirement for process, supply back-up power and selling steam to nearby factories for most efficient application. The capacity accumulated from cogeneration system until now is 471,770kW (Xiaohui Huang, 2012). Heat and electricity are the basic requirements for industry productions and are at different ratio of requirements depending on product categories. Examples of high thermal energy industries such as petrochemical, papermaking, textile, dyeing and finishing and sugar making industries. Examples of high power industries such as steel and electronic industry. If industries of different heat and power ratio requirement in the same region can be integrated effectively, resources waste can be substantially reduced, need on energy and resources can be reduced and greatly reduce the production of wastes.

The resource and energy integration network of Kaohsiung seashore industrial park figure is shown in figure 3-7, allowing the efficient exchange and making up of what is lacking between factory and factory. For example, the waste wood chips from wood factory can be used as fuel for steel boilers. The high temperature waste gas produced from boilers can produce steam as resources and even generate electricity. Steam can be transported to other factories for heating application of process, this make the highly integrated Kaohsiung seashore industrial park a great demonstration example.



Figure 3-7 The resource and energy integration network of Kaohsiung seashore industrial park

Table 3-8 The resource and energy integration network of Kaohsiungseashore industrial park

Input	
China petrochemical development corporation, Hsiaokang plant	Waste gas, condensation vapour, hydrogen
CPC, Dalin factory	hydrogen, fuel oil, natural gas

Output	
C.S. Aluminum Corporation	steam, nitrogen, hydrogen
Hung Li Steel.	steam
CSEC	Power (shore power)
CSCC	Coke-oven gas, compressed air, steam, nitrogen, demineralized water
ShangChen Steel Co., Ltd.	steam
TCIL	steam
CPC, Dalin factory	steam, nitrogen

Output	
Tang Eng Iron works Co., LTD	steam, nitrogen
Linde LienHwa/ Air Products and Chemicals, Inc.	nitrogen
CPDC, Xiaogang factory	steam, nitrogen
LCY Chemical Corp.	steam, nitrogen, hydrogen, oxygen
SYSCO.	Steam

Source: China Steel website, 2017

Through the promotion of energy and resource integration cases by Kaohsiung seashore industrial park, a lot of pending issues and items to be attended to are discovered. These issues and items can be reference for experiences copy or promotion expands.

(1) Pre-design and planning

Most of the existing industrial park has been established for a period of time, there was not much consideration in the energy and resources integration during the initial planning stage, causing lack of hardware and software facilities in the follow up promotion and many difficulties in promotion such as public material channel and channel layout planning. If the newly established industrial park can be included in the energy and resource integration, the promotion will be more effectively promoted.

(2) Providing economic incentives

For the existing factories, additional cost planning and energy resource integration channel should be established. Economic incentives should be provided to strengthen willingness to promote, such as public material price lower than selfproduction cost. To ensure material source can be provided stably within long term, the sharing ratio of construction expenses and the communication of public and environmental friendly benefits. All of these are key items should be fully communicated and negotiated before integration.

Chapter 4 Conclusions and Recommendations

4.1 Conclusions

Taiwan is a small, densely populated island lacking natural resources. Promoting circular economy is a must action. President Tsai Ing-wen promotes 5+2 industrial innovation plan after her inauguration, circular economy is part of its policy for stable supply and industry development of national raw materials. The promotion related tasks in the future will be continuously increased and expanded in the future. EPA will continuously promotes sustainable materials management in waste management and review regulations, promote methodology and planning to speed up key task promotion. At the current stage, the focus are on promoting industry as a priority, expanding international cooperation, planning action roadmap, key cases analysis and environmental education promotion. The current challenges faced are (1) arterial and venous Industry are not completely connected (2) General public still has doubts in using reused products (3) the price of secondary raw materials is higher than original raw materials (4) resource cycling skills are yet to be improved.

Through the key case analysis of 52 domestic and foreign enterprises, it is discovered that domestic enterprises gradually understand the importance of circular economy and put in relevant research and developments with many outstanding performance at initial stage, while being acknowledged on across the globe. It is anticipating this case analysis will assist in promoting the hard work by enterprises in the future and letting many Taiwanese and industries peers to receive relevant information, thus being acknowledged and support the relevant policies.

4.2 Recommendations

Upon referring to the key country and international organization in terms of their approaches toward circular economy promotion, there are many great samples for Taiwan to look up to for promoting circular economy in the future. These samples include (1) promote relevant measures quickly based on regulations (2) establish solid goal to monitor the entire country to achieve the goal (3) build circular economy hot spot, the critical mass will efficiently increase the promotion speed. In the case analysis of domestic and foreign enterprises, it is discovered that many foreign enterprises have been practicing circular economy actions for years and has developed many important technology, allowing abundant wastes that are difficult to be processed able to be recycled and made into recycled product. Domestic enterprises can continuously observe and learn on this working pattern, even introduce into Taiwan for cooperation and research. The waste composition in Taiwan is different from foreign country, thus foreign technology may not be directly applicable to domestic cases; there are possibility of further research and development. In addition, Taiwan is the only country that has waste monitor centre, which is a relative advantage compare to current foreign situations and it is able to be familiar with domestic material flow with higher precisions. If the advantage of this database can be properly used, the sustainable material management database with high applicability can be developed and hence contributes greatly toward promoting circular economy in the future.

Chapter 5 References

- [1] Phillips, 2017. Philips Circular lighting.
- [2] Subaru, 2016. Automobile Recycling Process. https://www.subaru.co.jp/en/csr/environment/080_recycle.html
- [3] Toyota, 2017. How e-commerce works. http://newsroom.toyota.co.jp/en/ download/3785595
- [4] HP, 2016. HP sætter grønne mål for sin forsyningskæde. http://www.scm. dk/hp-sætter-grønne-mål-sin-forsyningskæde
- [5] Xerox, 2017. Award-Winning Xerox Remanufacturing Takes the Spotlight. https://connect.blogs.xerox.com/2017/06/28/award-winning-xeroxremanufacturing-takes-the-spotlight/#.Wg-uTh-SGUl
- [6] REMONDIS, 2017. REMONDIS' recycling operations. https://www. remondis.de/en/library/
- 【7】Astec-irie, 2017. 都市 山リサイクル技術の蓄積. http://www.astec-irie. co.jp/special_site/fm_medal
- [8] DOWA, 2017. Recycling process for precious metals. http://www.dowaerc.co.jp/en/pro/pro-01.html
- [9] MBA POLYMERS, 2017. Sourcing Material. http://www.mbapolymers. com/home/
- [10] GREENGLASS, 2017. GREENGLASS RECYCLING. http://www. greenglass.ro
- [11] WRC Recycling, 2017.WRC Recycling Homepage. https://www. facebook.com/WRCRecycling/
- [12] OLUS, 2017. Biomass Recycling Facility. http://www.olus.co.uk/ Biomass-Recycling-Facility
- [13] Fiscal, 2016. Environmental Report 2016. Mitsubishi Electric.
- [14] Nomura Kohsan, 2017. Overview. http://nkcl.jp/recycle/overview/

- [15] Umicore, 2017. About Umicore. http://www.umicore.com/en/about/ about-umicore/
- [16] AGC MATEX, 2017. About Recycled Fluororesin. http://www.agm.co.jp/ ENG/product/material/recycle_flororesin.html
- 【17】Tanaka koumuten, 2017. 資源リサイクル. http://www.tanaka-k.com/ recycle.html
- [18] Packaging Europe Ltd., 2017. CIRCULAR ECONOMY AWARD FOR VIRTUOUS CIRCLE PROJECT. https://packagingeurope.com/circulareconomy-award-goes-to-dupont/
- [19] Greater China regions of Evonik,2017. Product story. http://corporate.evonik.cn/region/greater_china/han-t/products/productstories/pages/default.aspx
- [20] Orsted, 2017. DONG Energy: No Oil, No Gas, No Coal. http://lunarwind. org/wp/2017/02/02/dong-energy-no-oil-no-gas-no-coal/
- [21] Wistron, Patrick SN Lin, 2012.ICT industry cradle to cradle closed-loop solutions.
- [22] Lingjie Luo,2016. "Waste PET bottles are not garbage but to be used in the right places" - enterprises promote circular economy, discover the secret gardens in empty bottles. Social Enterprises Insights
- [23] ECOLOGICAL GLASSES Magazine, 2017. MINIWIZ launches RE-VIEW: a sustainable solution against waste. http://www. leslunettesecologiques.com/review-miniwiz-lunettes-de-soleil-en-dechetrecycle/
- [24] Uwin Nanotech, 2017. Eco-friendly Recycling Process of E-waste.http:// uwin-nano.com/en/news.php?id=52
- [25] Da Ai Technology,2016. R 2 R Environmental friendly blanket, surprises Leipzig, Germany. http://www.daait.com/index.php/tc/2014-06-05-09-49-09/2014-10-01-06-14-21/10536-2016-11-03-06-52-7

- [26] APO Center, 2013.Overview and Case Studies on Resource Recycling in R.O.C. APO Center of Excellence on Green Productivity.
- [27] Water Resources Agency,2006.Excellence Award TSMC .https://www.ftis.org.tw/water/2012sw/history/95c/e_company/ company03.html
- [28] ECOVE,2017. ECOVE provide comprehensive monitoring management, test and test runs, annual maintenance and upgrading, promote the successful operation and management of incinerator power plant http:// www.ecove.com/?L=CH&C=0301
- [29] Xiaohui Huang,2012.Regional energy and resource integrations cases in Taiwan. China Steel Corporation.
- [30] CSC enterprise website,2017. Regional energy and resource integrations. China Steel Corporation.
- [31] Gold fish brain,2017. Future prospect. Goldfish brain fb group.

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