附件四、IEMN 2018 Workshop 第三天簡報

行政院環境保護署
Environmental Protection Administration, Executive Yuan, R.O.C. (Taiwan)

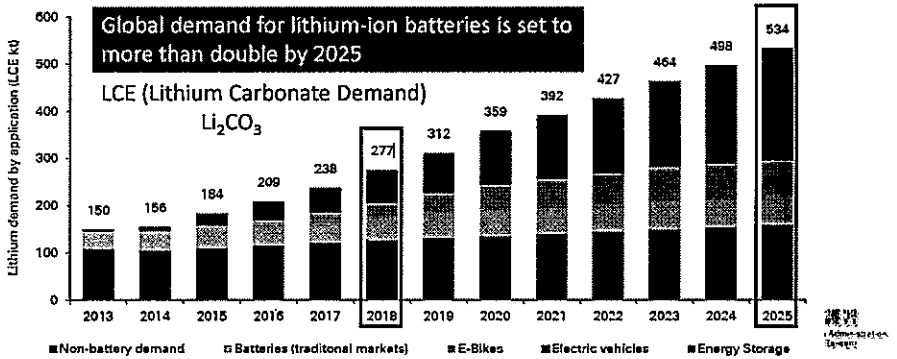
Challenge and Opportunity: Li-ion Battery

Presenter: Wen-yu Wang,
Chao-yang University, Taiwan

目錄

Lithium-ion battery demands increasing

- Mobile technology and a low-carbon future are unthinkable without batteries, a core technological enabler of the Fourth Industrial Revolution.
- The lithium-ion battery market increased by 15% between 2005 and 2015.
- The global battery market is estimated to see continued growth from currently $65 billion to a size of $100 billion by 2025.
- The lithium-ion battery market is the strongest growing battery market segment.



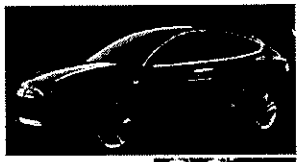
Source: Deutsche Bank

Lithium-ion battery components

Main components	Material category	Percentage (%)
Positive electrode	$LiCoO_2$, $LiNiO_2$ and $LiMn_2O_4$	44
Negative electrode	Hard Carbon	10
Positive/negative current collector	Al/ Cu	6
separator	Polyene microporous membrane	14
electrolyte	Lithium salt electrolyte	7
Tank Body	Nickel-plated low carbon steel, aluminum (or aluminum alloy)	6
Others	IC Protection、insulation/seal	13

Lithium-ion battery category

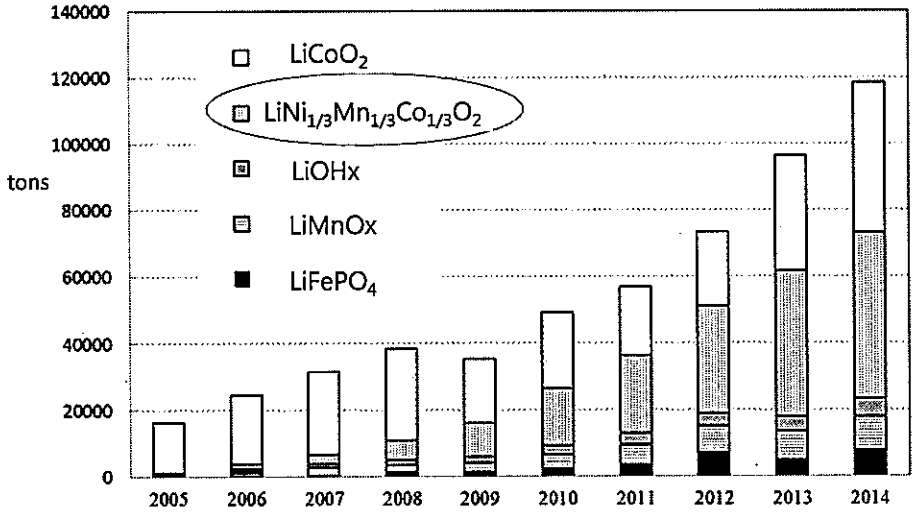
- Positive electrode material of Rechargeable
  - $LiCoO_2$
  - $LiNiO_2$
  - $LiMn_2O_4$
  - $LiCoO_2/LiNiO_2/LiMn_2O_4$
  - $LiFePO_4$
- $LiCoO_2$ has the highest market share, but it was replaced by Ternary Li-ion battery slowly.



TESLA MODEL S
NCA
$Li(Ni\text{-}Co\text{-}Al)O_2$

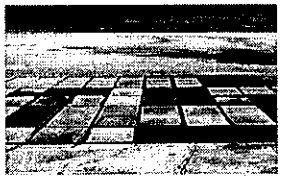
mobile phone battery
NMC
Ni:Mn:Co 5:3:2

Lithium-ion battery category



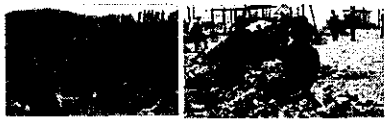
Primary ore causes huge impacts

Raw materials needed for batteries are extracted at a high human and environmental toll.



Salar de Uyuni, Bolivia. Various salts crystallise at different times as the solution becomes more concentrated. It is also treated with lime to remove traces of magnesium.

Rio Grande, Bolivia. The delta is mostly dry due to the effects of lithium mining, led to a lack of stability in water levels, both on top of and below the surface.

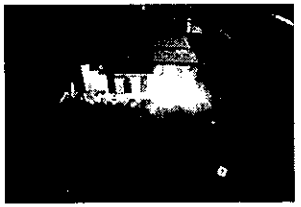


Two other key ingredients, cobalt and nickel, are more in danger of creating a bottleneck in the move towards electric vehicles, and at a potentially huge environmental cost. Cobalt is found in huge quantities right across the Democratic Republic of Congo and central Africa, and hardly anywhere else.

Recycling challenge looms over the eleven million tonnes of spent lithium-ion batteries forecast to be discarded by 2030, with few systems in place to enable reuse and recycling in a circular economy for batteries.

Waste Li-ion battery storage & transportation

- Li-ion battery once was damager by external crush or impurity of materials that is to create the overheating reaction easily.
- It can cause thermal runaway or trigger battery explosion, on fire, electrolyte leakage, flammable gas release, toxic and corrosion gas release.



Waste Li-ion battery storage & transportation

Standard

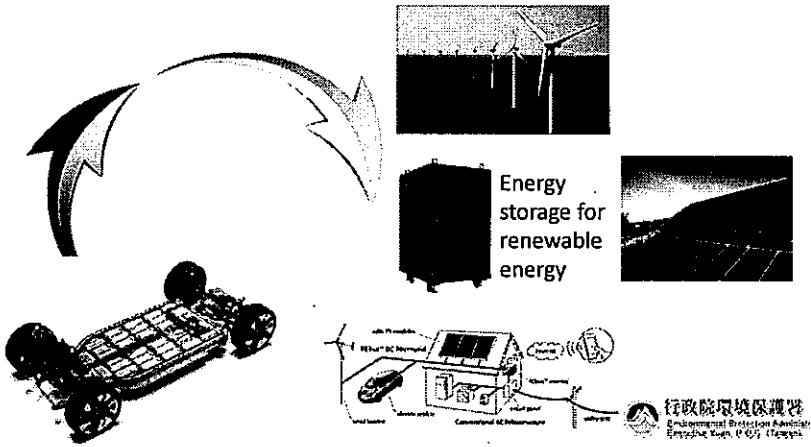
Type of battery	Name of rules	Specifically rules	Packaging rules
Damage battery	IMDG CODE	SP 376	P908 · LP904
	ADR	SP 376	P908 · LP904
	49 CFR	§ 173. 185(f)	Part 178, subparts L, M, P and Q
	TDGR	SP 137	P908 · LP904
Battery recycling	IMDG CODE	SP 377	P909
	ADR	SP 377 · SP 636(b)	P909
	49 CFR	§ 173. 185(d)	§ 173. 24 & 173. 24a
	TDGR	SP 138	P909 · LP904

Standards includes
- Packaging prevent battery short circuits.
- Strength of packaging to tolerate battery rupture and explosions
- The material of packaging needs to use flame retardant to prevent the damage increasing.

- Apply inert material to absorb electrolyte to prevent environmental pollution.
- Apply internal protection to reduce shake of transportations.
- Consider to design management system to contain gas seal.
- Have the clear label outside the packaging.

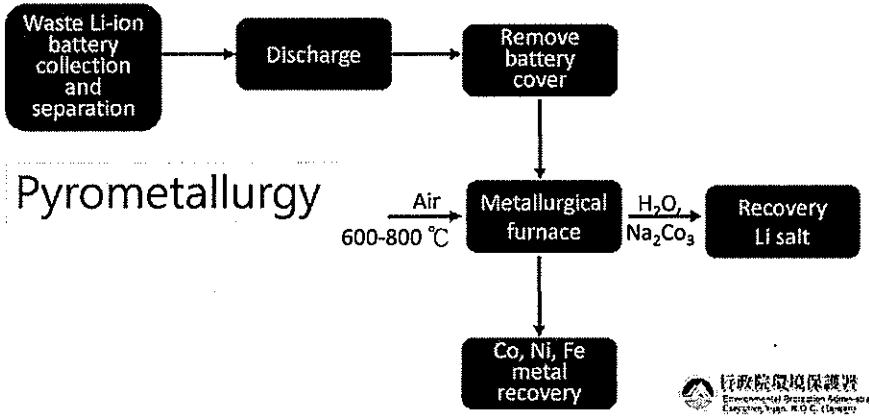
Waste lithium-ion battery reuse & recycling

- Reuse: Collect Waste battery to reuse in different types and characters to connect in series and parallel is not easy



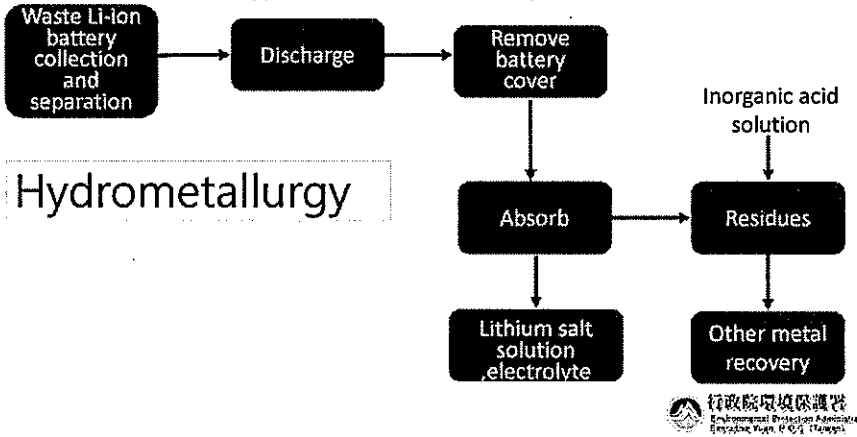
Waste lithium-ion battery reuse & recycling

- Recycling: Waste battery can be processed either in Pyrometallurgy and Hydrometallurgy methods to recovery the materials.



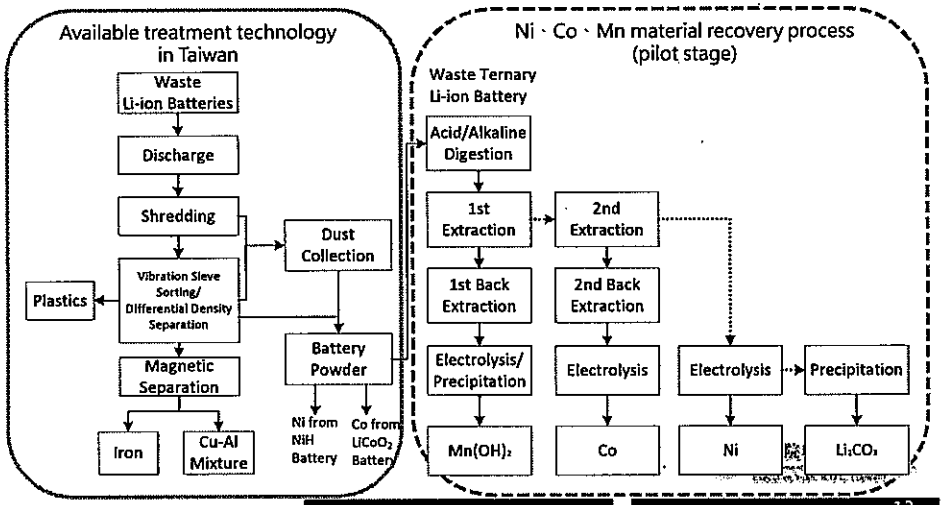
Waste lithium-ion battery reuse & recycling

- Recycling: Waste battery can be processed either in Pyrometallurgy and Hydrometallurgy methods to recovery the materials.



Waste lithium-ion battery recycling in Taiwan

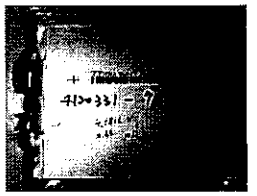
- In 2017, 152,652 kg of Li-ion battery were collected to export to Belgium and Korea.
- The main Li-ion battery treatment in Taiwain is operating in physical recycling such as shredding and magnetic separation, after classified metal, plastic and battery powder for sale.



Waste Li-ion battery material recycling procedure

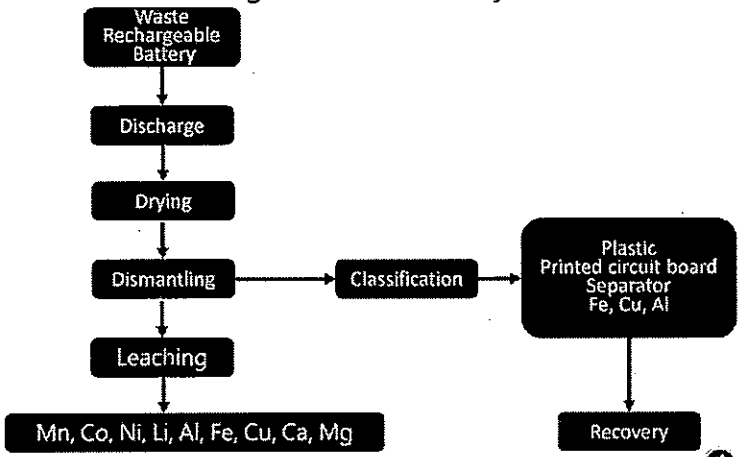
- Waste Battery
  - Waste $LiCoO_2$ battery
    Collect from registered waste battery collectors in Taichung

  - Waste Ternary Li-ion battery ($LiCoO_2/LiNiO_2/LiMn_2O_4$)
    Waste Li-ion battery from the ELV

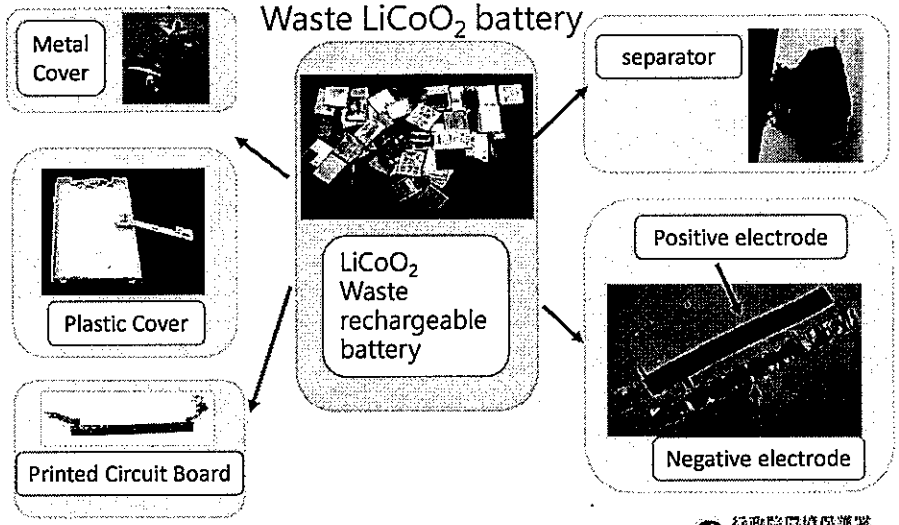


Waste Li-ion battery material recycling procedure

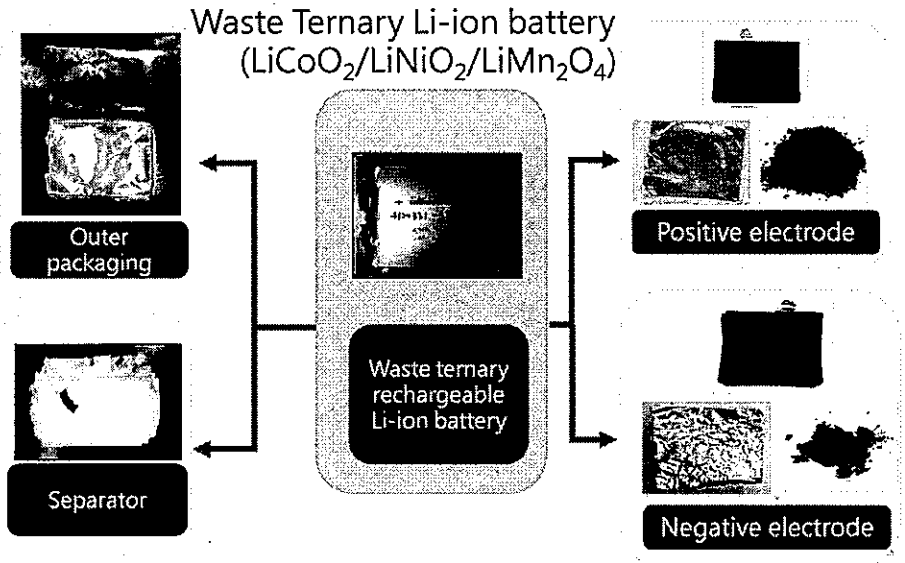
- Step One--Pretreatment
  - Waste rechargeable Li-ion battery



Waste Li-ion battery material recycling procedure



Waste Li-ion battery material recycling procedure



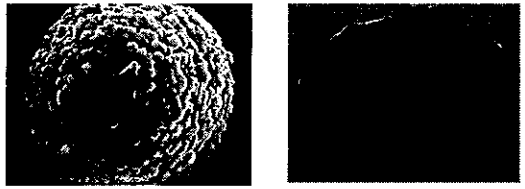
Waste Li-ion battery material recycling procedure

- Step Two--Decontamination
  - Comparison of Al metal content of the cathode materials before and after pretreatment

Metal weight (mg)	Al	Ca	Mg	Co	Li	Mn	Ni
Before pretreatment	276.9	9.3	ND	218.6	67.2	206.3	212.2
After pretreatment	4.1	8.4	ND	215.0	65.0	206.1	209.0
Loss %	98.5	9.7	-	1.6	3.3	0.1	1.5

Waste Li-ion battery material recycling procedure

- Step Three--Acid Leaching (Ni, Mn, Co, Li)
  - HCl、H_2SO_4 and HNO_3 dissolves metal-contained positive electrode powders.
  - HCl has the best leaching rate, H_2SO_4 is the second.
  - Most scientific approach is by using H_2SO_4 for Leaching

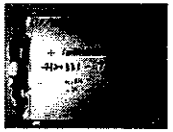


Waste Li-ion battery material recycling procedure

- Step Three--Acid Leaching (Mn, Ni, Co, Li)

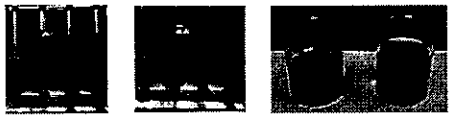
Comparisons between the positive electrode materials of $LiCoO_2$ battery and ternary battery

	$LiCoO_2$(%)	Ternary(%)
Co	89.00	30.82
Mn	0.09	28.38
Ni	0.80	31.58
Li	10.11	9.22

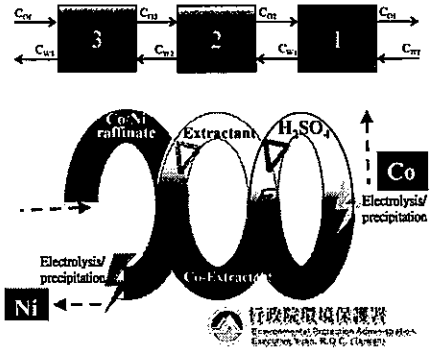


Waste Li-ion battery material recycling procedure

- Step Four--Solvent extraction and stripping



- Stripping is to back extract the Extracted metal ion using acid and then the stripped ion could be electrolyzed or precipitated to salt.



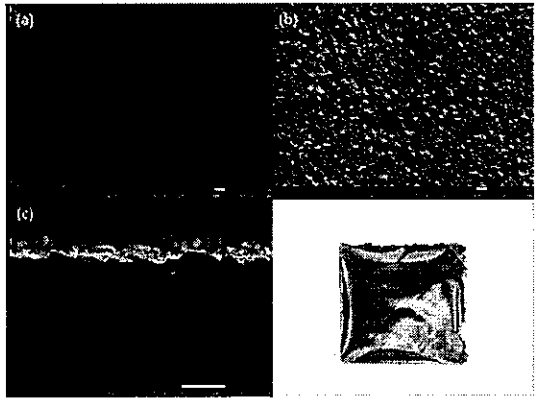
Waste Li-ion battery material recycling procedure

- Step Five -- Material Recovery
  - Electrolysis
    - Electrolysis is reduction of metal ions to metal elements. In the Pre-processing stages, it needs to extract and segregate valuable metal to avoid metal impurity.
  - Precipitation
    - Precipitation is using chemical precipitant to precipitated metal ion
    - Chemical precipitant: hydroxide, carbonate minerals and sulfide.
    - Different pH can remove some impurity metals.

Waste Li-ion battery material recycling procedure

- Step Five–Material Recovery

SEM micrographs of the Co deposit:
(a) 50X; (b) 3000X;
(c) cross-sectional view; and (d) original view of the Co deposit



Waste Li-ion battery material recycling procedure

- Step Five–Material Recovery

Comparison of the metal content in the Co deposit from electrowinning with or without solvent extraction. (ND=not detected)

	metal content in the Co deposit				Overall recovery ratio of Co
	Li	Mn	Ni	Co	
Without extraction	ND	1.6%	36.2%	62.2%	77%
With extraction	ND	ND	1.2~0%	98.8~99.96%	93~95%

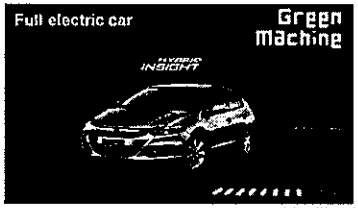
For more information, you can read the paper "Recovery of high-purity metallic cobalt from lithium nickel manganese cobalt oxide (NMC)-type Li-ion battery" by Wen-Yu Wang *et al.*, published in *Journal of Material Cycles and Waste Management*, online: 12.09.2018. https://doi.org/10.1007/s10163-018-0790-x

Future prospects

In the next 15 years, various Li-ion battery with its material composition will continue evolving. Recommend the relevant projects should stay closed on the material composition changes of Li-ion batteries with potential impacts on environmental pollution and recycling issues.

B2B【From Battery to Battery】

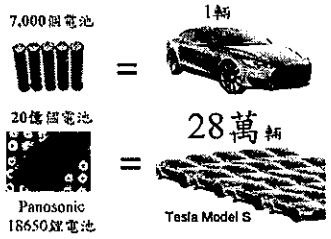
- The NiH batteries of the Hybrid electric vehicle can recycle Ni and rare earth, and the Co and Ni can be extracted and recycled from waste ternary battery of electric car
- The shortage of Co and Li will reverse the value of waste Li-ion battery recycling in the next 5-10 years



Thank You

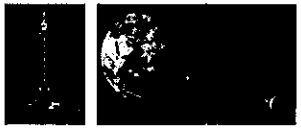
Used lithium-ion battery increasing

- 新舊型二次鋰電池正極材料皆以鈷酸鋰($LiCoO_2$)組成，鈷(Co)在自然界地殼含量只佔25 ppm，蘊藏量相當稀少
- 二次鋰電池，將在使用五年後被廢棄



一萬輛車用電池＝營收新台幣100億元
10,000*7,000*150 = 10,000,000,000

日本資訊技術綜合研究所在2010年第4季的調查報告指出，全球電動車的銷售量在2020年將大幅成長至857萬輛，其中高達90%為鋰電池電動車(約770萬輛)。若以特斯拉的電動車為例，每款車型使用的18650 (直徑18mmx長65mm) 鋰電池數量不一，平均約7000顆。串連約3.5X10^{6}km



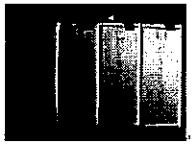
101大樓樓高0.5092公里 → 將近7百萬座101大樓

地球赤道周長為40,075公里 → 將近88圈地球的赤道

地球到月球距離384,401公里 → 9個地球到月球距離

Lithium-ion battery category

三元系	Ni	Mn	Co
高鎳	8	2	2
	6	2	2
高錳	5	3	2
	4	4	2
高鈷	3	3	3

三元系鋰電池種類			
NMC比例	1:1:1	1:1:1	1:1:1
資料來源	本研究檢測*	http://www.amitatech.com/tw/products_more.php?c=1&no=68	http://www.globalsources.com/si/AS.China-Industrial-600812745013/pdt/LiNi1-3Co1-3Mn1-3O2-Batteries-1050929097.htm
三元系鋰電池種類			
NMC比例	0：4：17	2：16：65	5：3：32**
資料來源	本研究檢測*	本研究檢測*	http://www.diydc.com/Products/sanxingshoujidianchi.html

註：

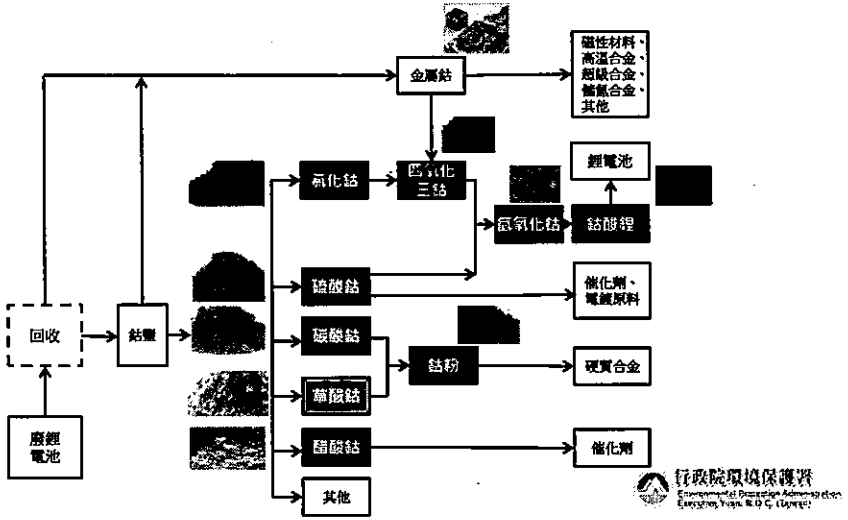
3M最早申請三元系材料專利，命名鎳鈷錳(NMC)

* 本研究對個別單一樣本之檢測結果，不代表該品牌同型號不同時期產品之典型成份值；個別樣本之成份仍需實測。

** 手機電池電芯，鈷酸鋰摻約25% NMC 532三元材料。

Waste Li-ion battery material recycling market

■ 鈷金屬與各種鈷鹽的產品市場應用途徑



LIB Recycling: Efficient Two Stage Process

1. **Black sand preprocessing** – discharges, grinds and separates batteries and scraps into a black sand containing cobalt, nickel, manganese and lithium

2. **Hydrometallurgical process** – extracts the precious metals through a chemical leaching and purification process

Low Environmental Impact

Economical Efficiency

75% Battery Recycling

95% Metal Recycling

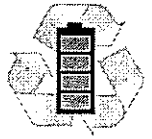
99.99% Purity of Retrieved Metals

BlueWhale MATERIALS

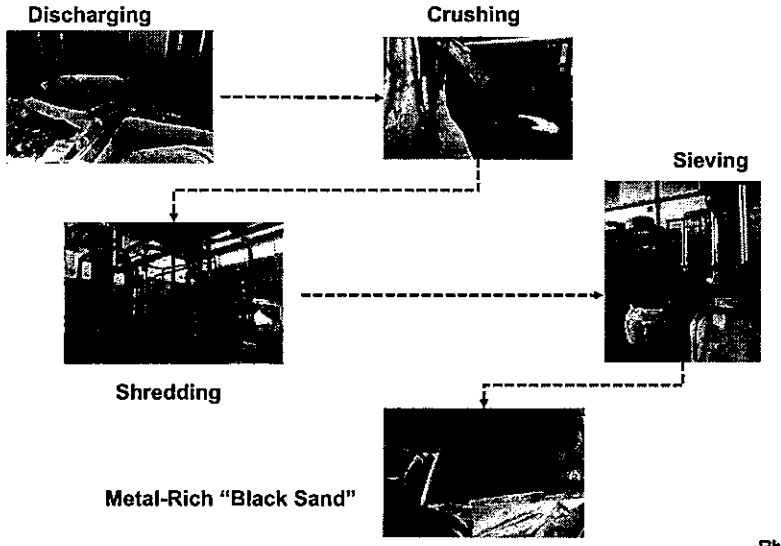
Li-ion Battery (LiB) Processing

Examining E-waste Trends

IEMN 2018 Workshop



Traditional First Stage Process



Risk of LIB Thermal Event

Blue Whale Materials Solution

Avoid Shipping Hazardous Waste
Expensive and dangerous to ship li-ion batteries as hazardous waste to foreign processors.

Accommodate Increasing Global Supply
Global demand for li-ion batteries expected to increase by a compound rate of 20% through 2024. (BNEF 6/8/17)

Add Value to Material by Processing
First-stage processing into concentrated metal-rich powder increases value of material.

Open Transboundary Movement
Black sand is traded freely with no EPA oversight and necessary approvals.

Blue Whale Proprietary Tech Advantage

Reduces Time and Waste
Reduces Processing Time from 21 days to 1 day
No Wastewater treatment necessary
Saves cost on labor and storage

Adds Value
Efficient process increases concentration of metal in material and increases value of output compared to competitors

Final Process Agnostic
Black sand can be refined through hydrometallurgical or pyrometallurgical process

Blue Whale Materials Closed Loop

Blue Whale Materials LLC
- BWM will discharge, grind, separate and create intermediate metal material containing cobalt, nickel, manganese, and lithium ("blacksand").
- Blacksand will be sold to refinery.
- For certain manufacturer customers, BWM will collaborate with the refiner to establish a closed loop solution.

Refinery
- BWM sells blacksand to refiner of cobalt, nickel, lithium and manganese.

Precursor Manufacturer
- The refinery sells high grade cobalt sulfate or liquid cobalt metal to the precursor manufacturer designated by the customer.

Cell Manufacturer
- Precursor manufacturer sells cathode material to cell manufacturer or OEM for manufacture of new battery.

Consumers
- Product containing LiB is sold to consumer.

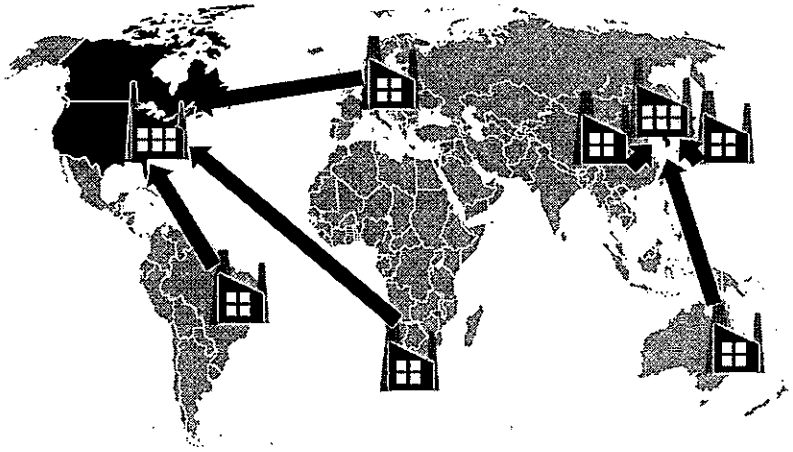
Collectors/Manufacturers/Refurbishers
- Collectors, Manufacturers and Refurbishers collect spent LiBs for endstage recycling.

Residual waste and recycled AL, CU, and plastic scrap

Black Sand End Product

Al/Cu chips | Fe chips | Metal powder

Global Network



Hydrometallurgical Refinery

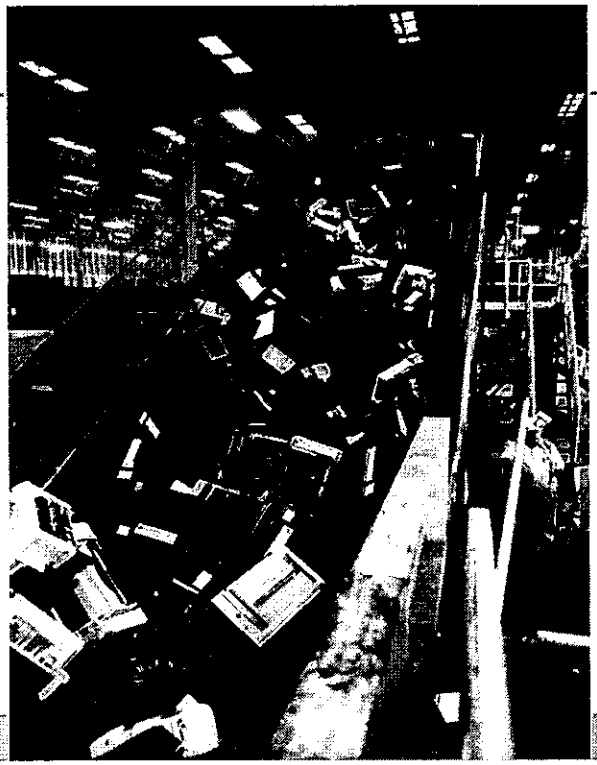
First Stage Processor

- POM
- PP
- PBT
- PC+ABS
- ABS
- HIPS
- PC
- PS-HI
- PPE+PS FR(40)
- PS-HI FR(17)
- PC-FR(40)
- ABS+ABS-FR(40)
- PC+ABS-FR(40)
- PET-(GF+MD)40 FR(70)

Technology for Today's Realities

- More products being made with plastics
- Multiple types of resins used
- Markets for mixed plastics disappearing
- Capital investment required to produce a marketable product

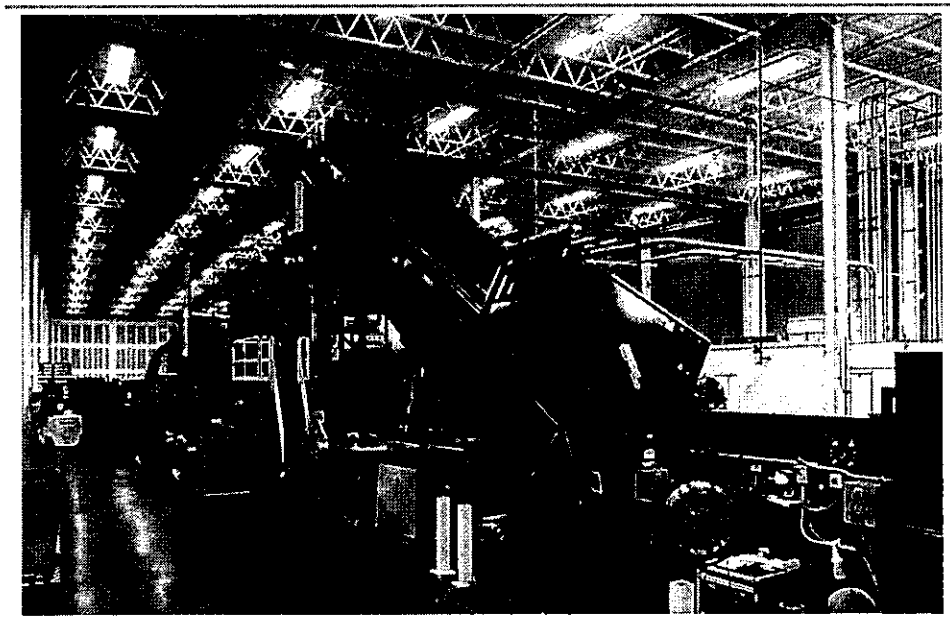
SIMS RECYCLING SOLUTIONS



SIMS RECYCLING SOLUTIONS

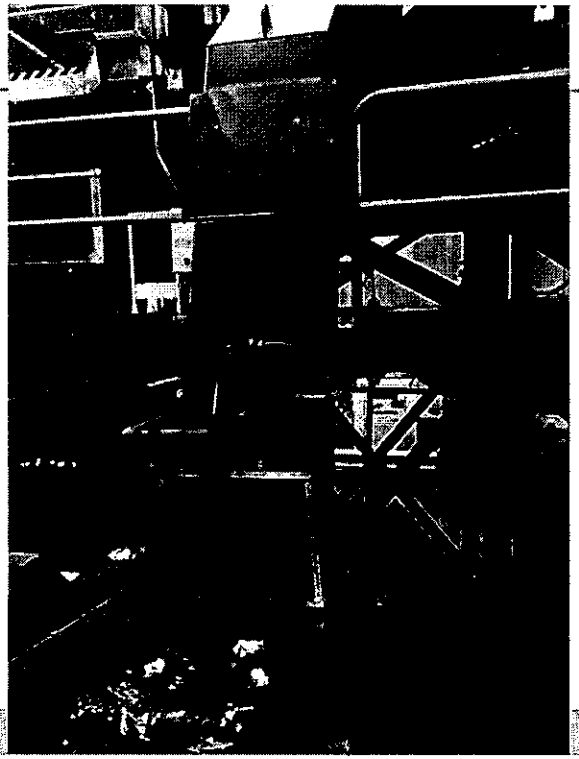
SIMS RECYCLING SOLUTIONS

SIMS RECYCLING SOLUTIONS



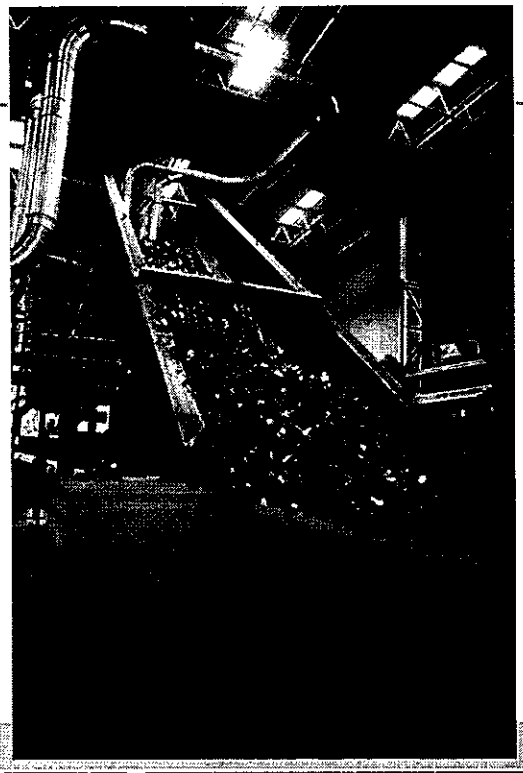
SIMS RECYCLING SOLUTIONS

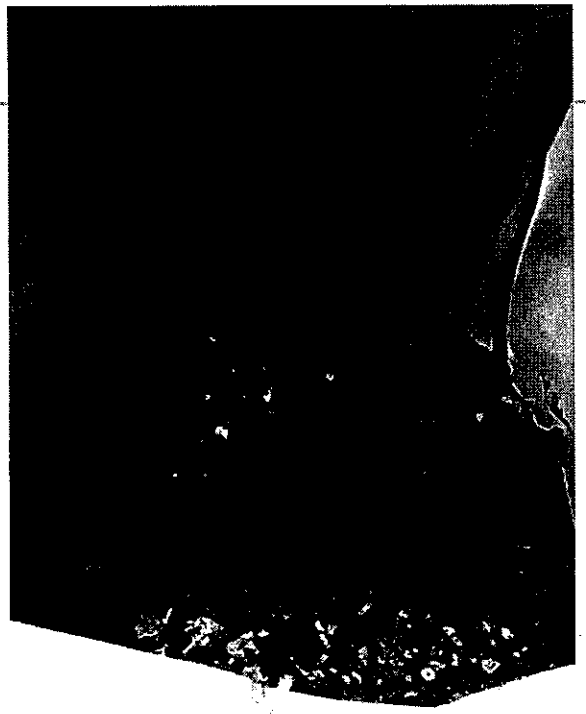
SIMS RECYCLING SOLUTIONS



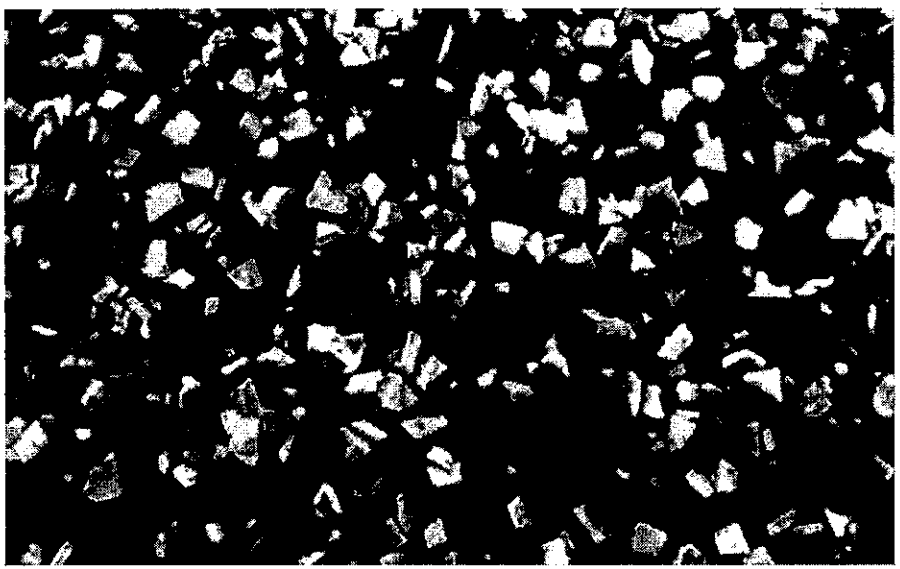
SIMS RECYCLING SOLUTIONS

SIMS RECYCLING SOLUTIONS

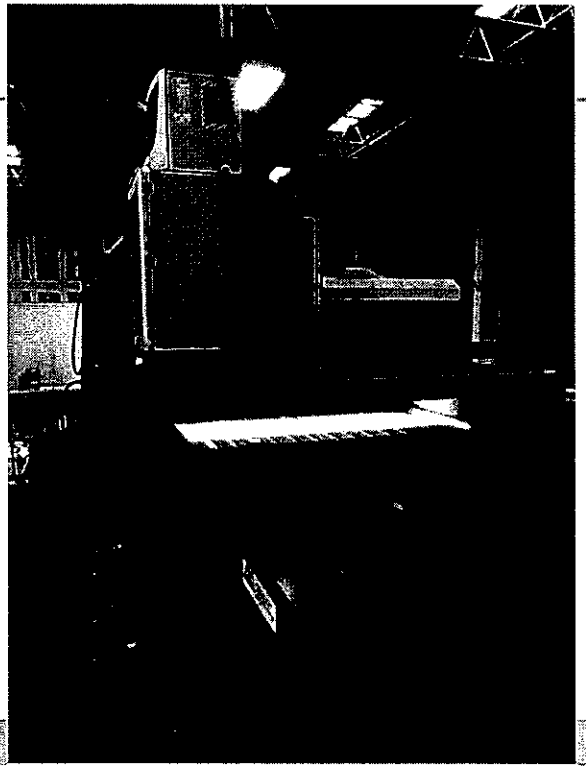




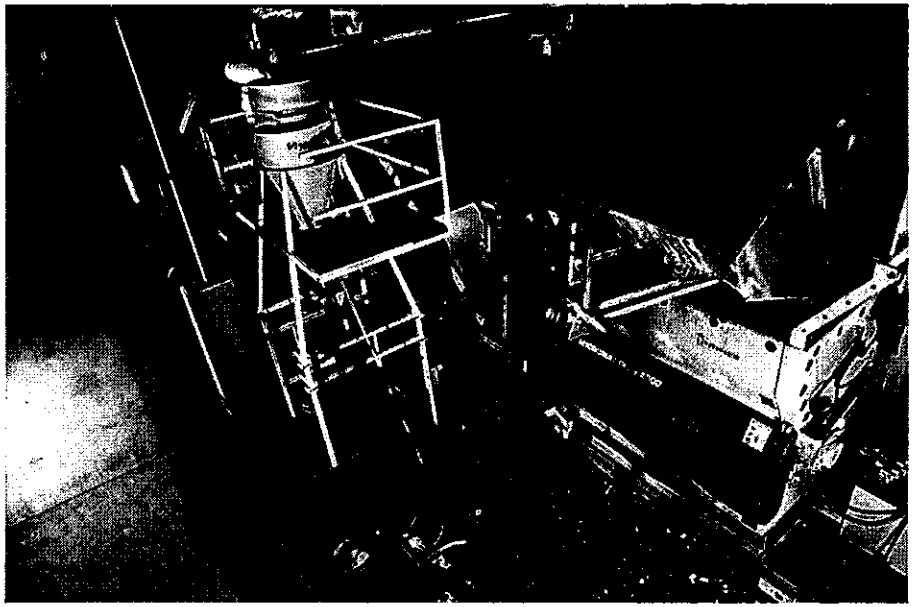
SIMS RECYCLING SOLUTIONS



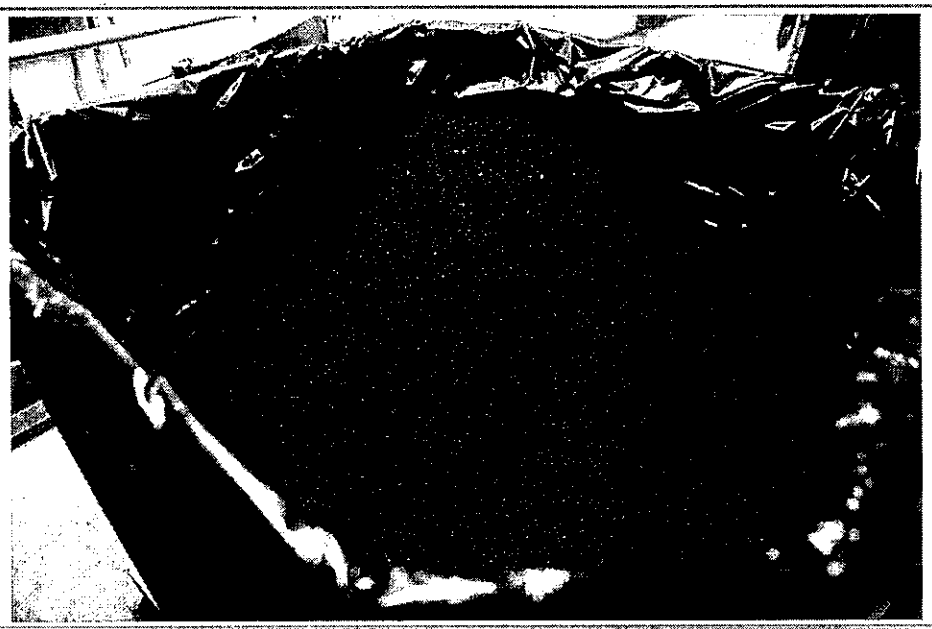
SIMS RECYCLING SOLUTIONS

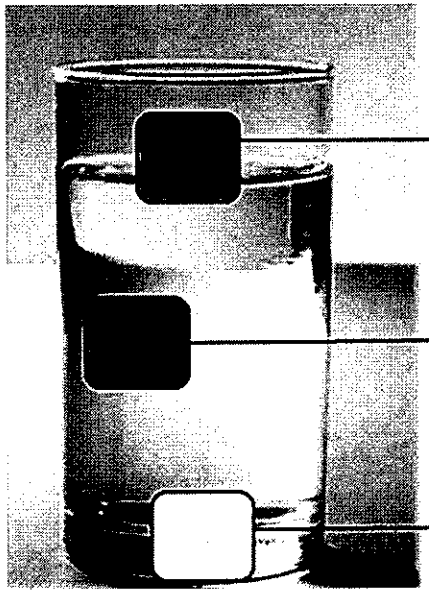


SIMS RECYCLING SOLUTIONS



SIMS RECYCLING SOLUTIONS




float (less dense than medium)
suspend (same density as medium)
sink (denser than medium)

Center for Green Economy
since 2013

- Recent Research Topics
  - Environment and energy policy research
  - Green economy and green deals
  - Global green trade
  - Green industry development
  - Regional/international cooperation on green economy
  - Green finance research and development

- An Inter-disciplinary Research Team
  - 5 research fellows in
    - Environmental Economics, Environmental Science, Environmental Management, Energy Engineering
  - 3 analysts
  - 20+ research associates and staff members

The Role of CIER

- A **policy think-tank** for Taiwan
- An autonomous policy **research organization**
- **A platform** to facilitate communications between government, industries and the general public

Producers in Taiwan's EPR System

Chun-hsu Lin 林俊旭, Ph.D.

Research Fellow, Deputy Director

Center for Green Economy

Chung-Hua Institution for Economic Research

CGE in CIER

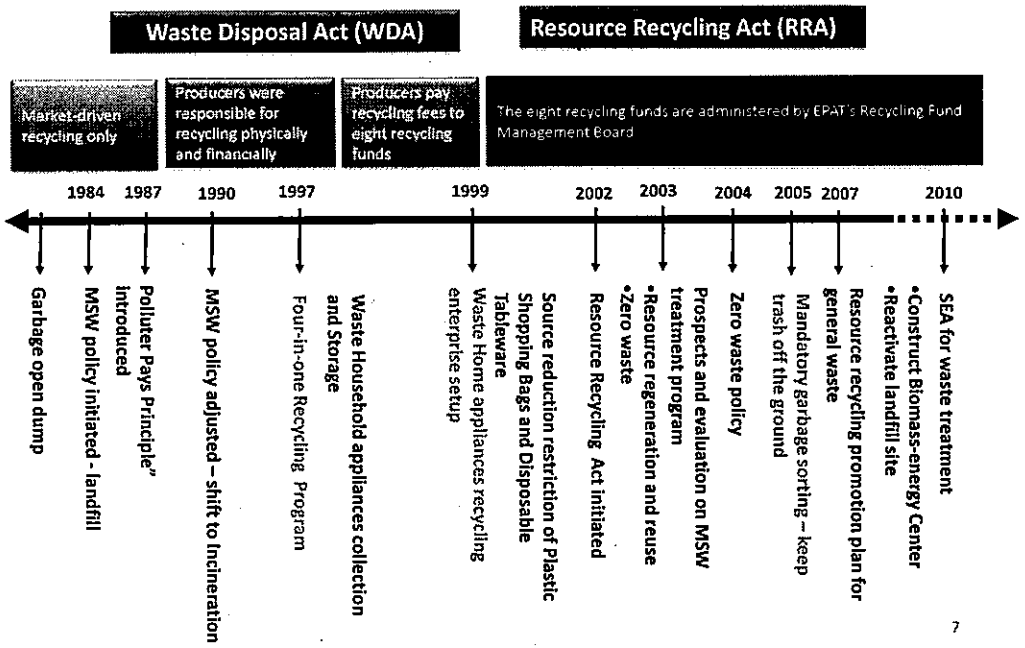
◆ Chung-Hua Institution for Economic Research (CIER)

- Established in 1981
- A think tank with about 400 employees
- Focused on the research of economic issues, mainly serving Taiwanese government for the policy analysis

◆ Center for Green Economy (CGE)

- Established in 2013 under CIER
- Specialized in environmental ecoomics, international trade and green policies.
- With about 30 research fellows, assistants, supporting staff members.

Recycling Management Policy



7

About Dr. Chun-hsu Lin

- **Education**
  - Ph.D. in Environmental and Natural Resource Sciences, Washington State University, USA, 2001
  - Master of Regional Planning, University of Pennsylvania, USA, 1993.
  - BSc in Civil Engineering, National Taiwan University, 1989
- **Experiences**
  - Chung-Hua Institution for Economic Research
    - Research Fellow , since Oct. 2010
    - Associate Research Fellow, International Division, 2005~2010
  - Green Trade Project Office, Ministry of Economic Affairs
    - Secretary-General, 2011~2016
  - Institute for Environment and Resources
    - Associate Research Fellow, 2001~2005

5

Trash Collection

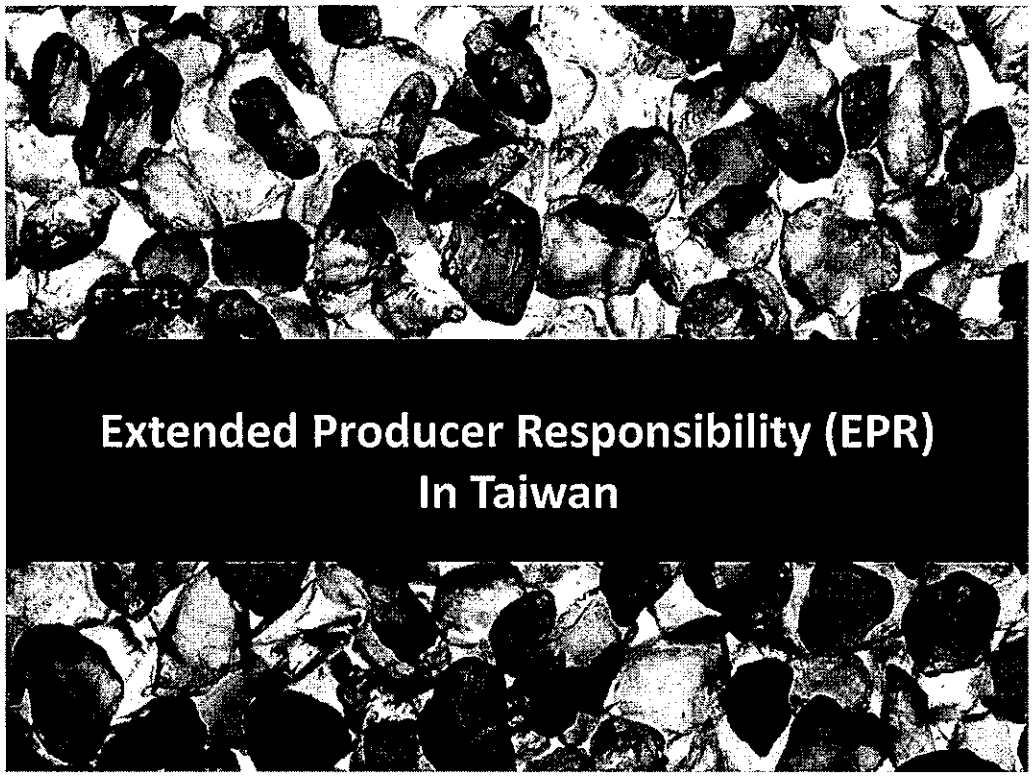
- **Unit-price bag system was adopted in July, 2000, while kitchen waste collection was started in December, 2003**

Trash Sorting:

1. **General Trash:** unit-pricing bags required
2. **Kitchen Waste:** no unit-pricing bags are required
3. **Recyclables:** no unit-pricing bags are required

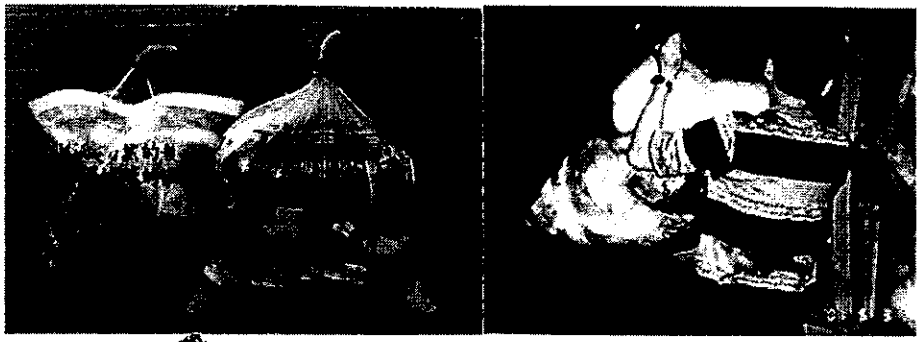
8

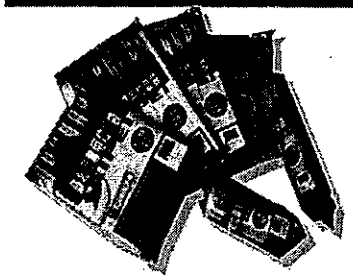
What made Taiwan a recycling-oriented waste management system?



Extended Producer Responsibility (EPR) In Taiwan

Unit-Pricing Bags



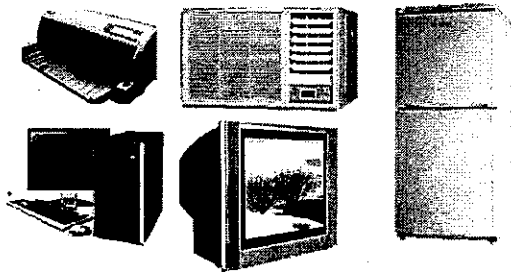


Legal Basis for Recycling

- Waste Disposal Act
  - Since 1974; last mandated 2006
  - Article 15
    - *For articles and the packaging and containers thereof that, after consumption or use, are sufficient to produce general waste possessing one of the following characteristics and cause concern of serious pollution to the environment, the **manufacturer or importer** of the articles and the packaging and containers thereof at issue or the manufacturer or importer of the raw materials shall bear responsibility for recycling, clearance and disposal and the vendor shall bear responsibility for recycling, clearance work.*
      - *I. Difficult to clear or dispose of*
      - *II. Contains a component that does not readily decompose over a long period*
      - *III. Contains a component that is a hazardous substance*
      - *IV. Is valuable for recycling and reuse*

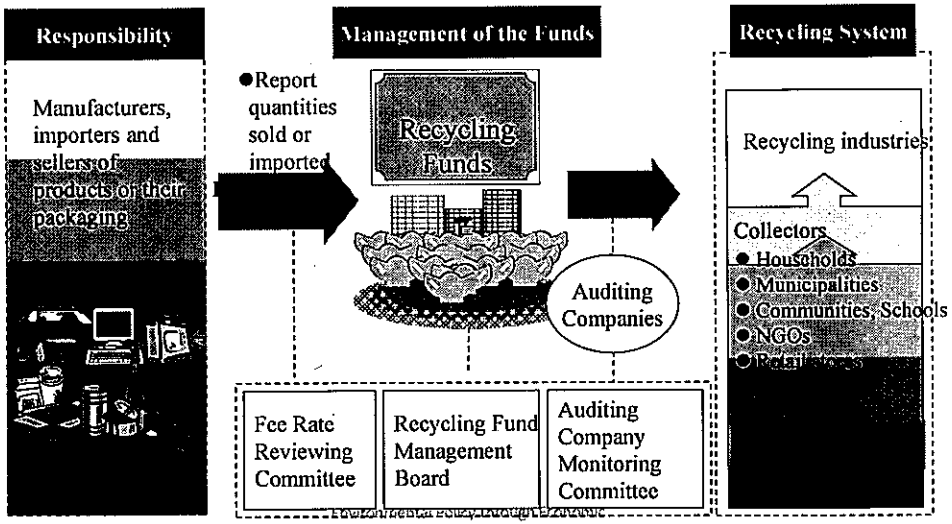
Giant Article Collection

Citizens who want to discard large furniture or appliance can call local environmental agency to arrange a pick up service for FREE



After the appointment is made, citizens should move the large waste to outside of their buildings after 22:00 for pick-up next day

Institutional Framework

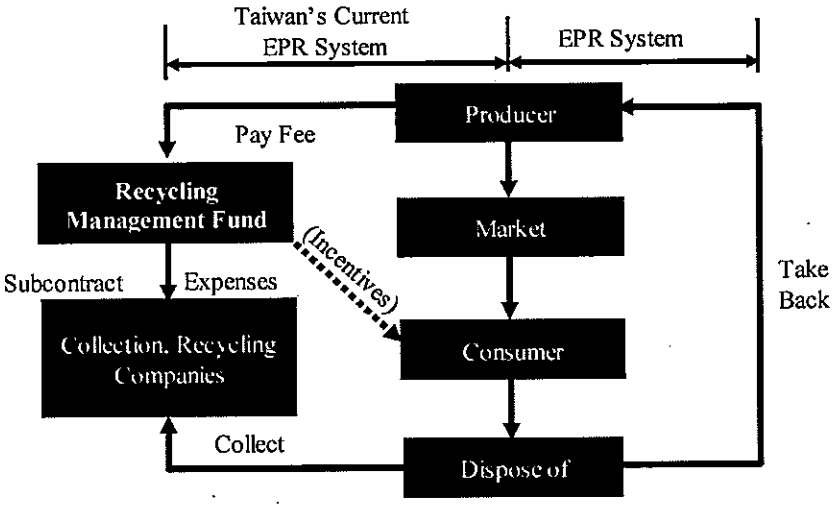


Mandatory Items for Recycling

• Tires	1989	☐ PET containers	1989
• Lubricants	1990	☐ Ferrous containers	1989
• Car batteries	1990	☐ Aluminum containers	1989
• Automobiles	1994	☐ Pesticide containers	1989
• Motorcycles	1994	☐ Foamed PS containers	1991
• Household appliances	1997	☐ PS containers	1992
• IT objects	1997	☐ PVC containers	1992
• Batteries	1999	☐ PP/PE containers	1992
• Fluorescent lamp	2002	☐ Al foil containers	1992
		☐ Glass containers	1993
		☐ Paper containers	1993

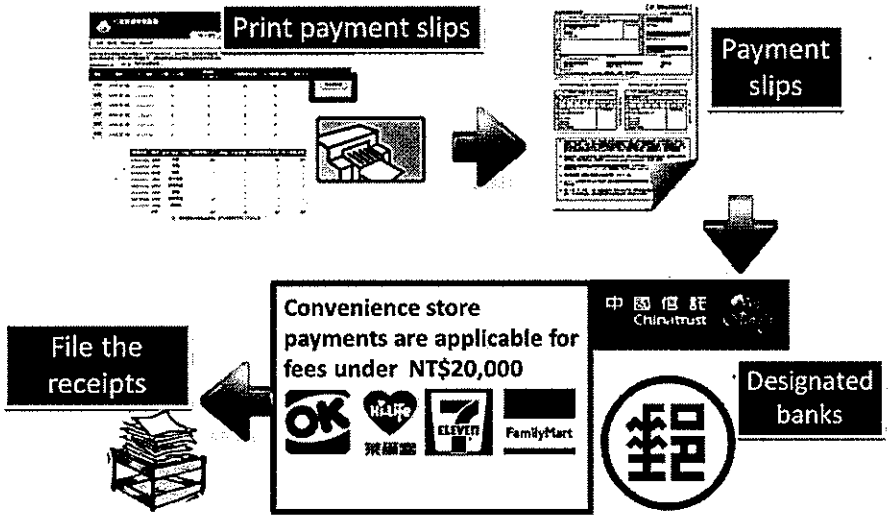
EPR System in Taiwan

Since 1998



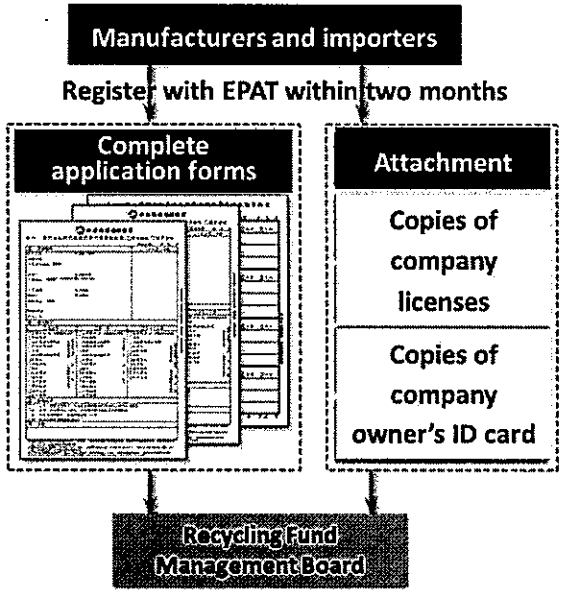
Responsibilities of Producers
Article 16 of the WDA

- Paying Recycling Fees

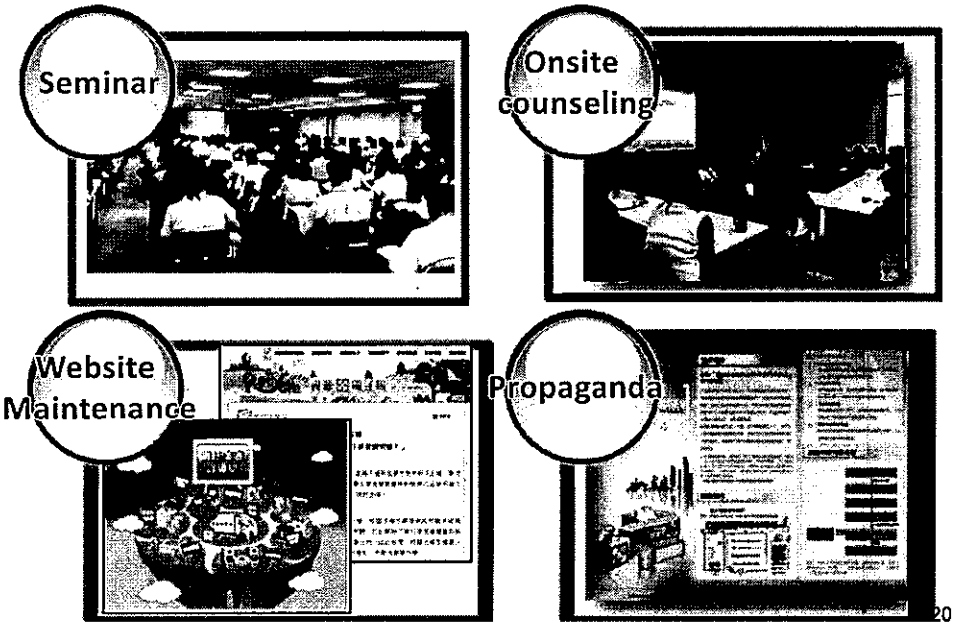


Responsibilities of Producers
Article 16 of the WDA

- Registration

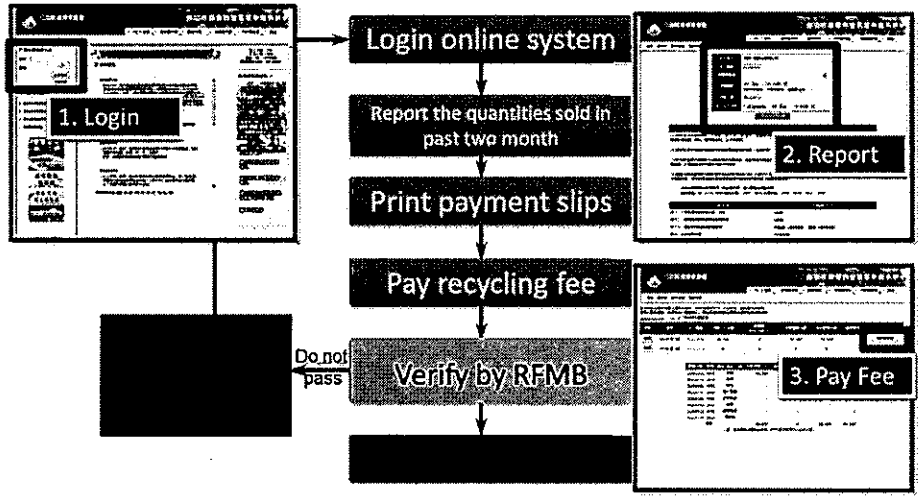


Services from RFMB to Producers



Responsibilities of Producers
Article 16 of the WDA

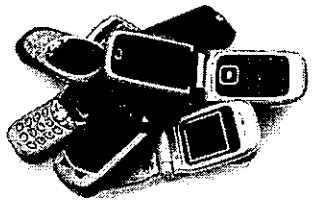
- Reporting

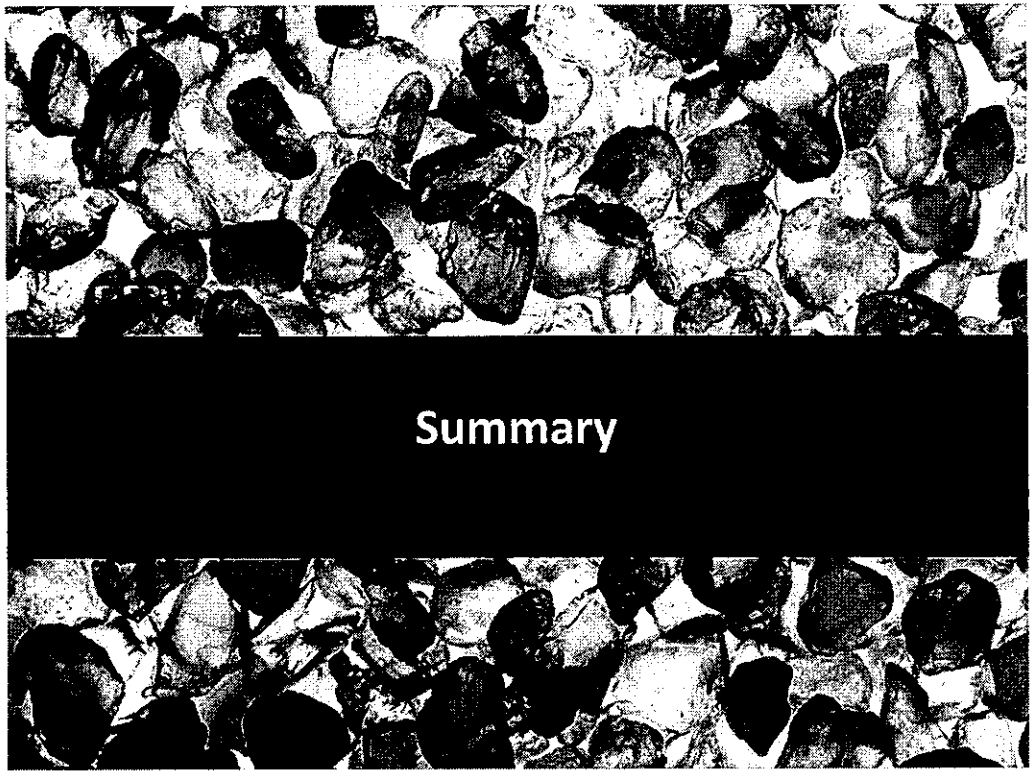


In addition to EPR

Voluntary Programs

- Mobile Phones Take-Back Program
  - Since 2004
  - MOU signed between EPAT and 19 producers/service providers/retailers
  - 12,446 collection points as of now
  - ***No min collection requirements***



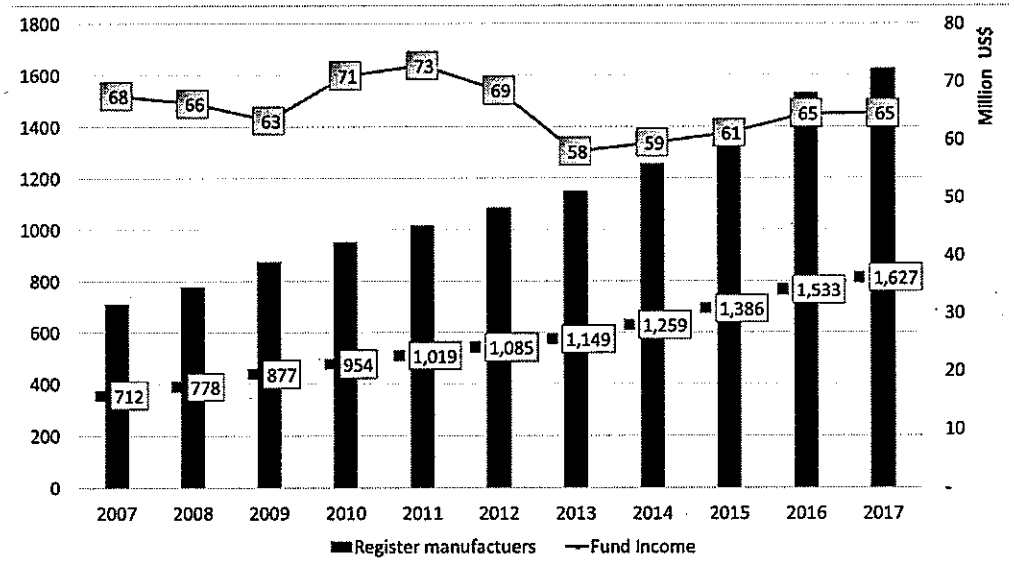


In addition to EPR

Mutually Agreed Programs

- Styrofoam Take Back Program
  - Since 2003
  - Agreement signed between EPAT and Styrofoam Recycling Association to take back the Styrofoam for packaging uses
  - The Association need pay at least US$ 0.03/kg or US$ 17/truck to local authorities
  - Min collection requirement: 60%

Registered Producers and Fees Submitted



Thank You

Partnership with CGE/CIER/EPAT

Contact Information

Dr. Chun-hsu Lin:
chlin@cier.edu.tw

Voluntary and Mandatory take-back programs

International E-Waste Management Network

IEMN, Manila, 26th September, 2018

Mandatory programs

Mandatory Take-Back & Recycling Programs

Why do OEMs implement them?

- Because the local legal framework is based on Extended Producer Responsibility (EPR) and forces producers to set up take-back and recycling programs for their EOL products
- If the regulation allows for it, they can:
  - be individual or collective (with other producers)
  - collect from end consumers (B2C) and/or companies (B2B)
- Typically there are **collection targets** based on put-to-market, but there are also countries with convenience or w/o targets
- Based on our experience when there are no collection targets OEMs tend to do only limited activities

Where do we manage mandatory programs?

- USA
- Europe
- India
- Vietnam
- Mexico
- Colombia
- Peru
- Argentina (implementing)
- Chile (planned)

What do we collect?

Challenges & Benefits of Mandatory Programs

Challenges

- Very ambitious in case of fast growing collection targets
- Missing, weak or biased enforcement can lead to unfair competition *("level playing field")*
- Free riders and orphan products
- Access to end consumers and involvement of distribution channels through OEMs
- Effectiveness and efficiency of awareness programs
- Competition with or involvement of the informal sector
- How to manage growing number of EPR obligations for different type of products efficiently
- Control over downstream channels

Benefits

- Compliance with all regulatory requirements
- Potentially access to tax or other incentives (if applicable, depending on country)
- Access to customers with "sustainable procurement" programs
- Synergies between voluntary and mandatory programs can lead to cost reductions
- Limiting "cherry picking" of material as all stakeholders have to fulfill clearly defined obligations
- Controlled downstream with formalization of informal channels

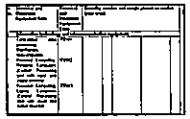
RLG Solutions supporting mandatory programs

Collection | Receiving | Sorting | Dismantling | Processing

- ✓ EPR Plan / registrations

- ✓ Doc. tracking

- ✓ Regulatory Reporting



- ✓ Downstream transparency

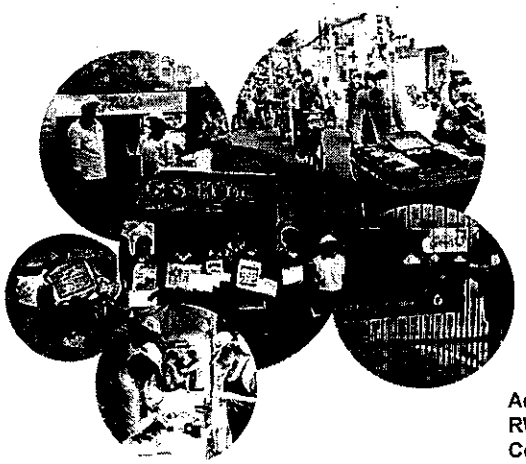
- ✓ Material collection

- ✓ Material tracking

- ✓ Auditable massflow balance

➢ Compliance with relevant WEEE Regulation

PRO: Awareness & Capacity Building



Activities run in RWAs, Schools, Communities, Office Clusters, local shop dealers + Social Media & PR

Voluntary programs

Voluntary Take-Back & Recycling Programs

Why do OEMs offer voluntary programs?

- As a service for their customers (mainly for corporate customers, but some also for end consumers) and for customer loyalty
- As part of their CSR programs and corporate standards
- To avoid the equipment being resold (or refilled) outside their control
- To avoid the equipment being handled by the informal sector through processes harmful to the environment
- To avoid bad press and/or negative impacts on brand or reputation
- To plan ahead for upcoming mandatory take-back and recycling programs
- Financially driven

Where do we manage voluntary programs?

- USA
- Europe
- Vietnam
- Mexico
- Costa Rica
- Panama
- Colombia
- Ecuador
- Peru
- Chile
- Argentina

What do we collect?

Electronic hardware | Printing supplies | Lead Acid Batteries

Challenges & Benefits of Voluntary Programs

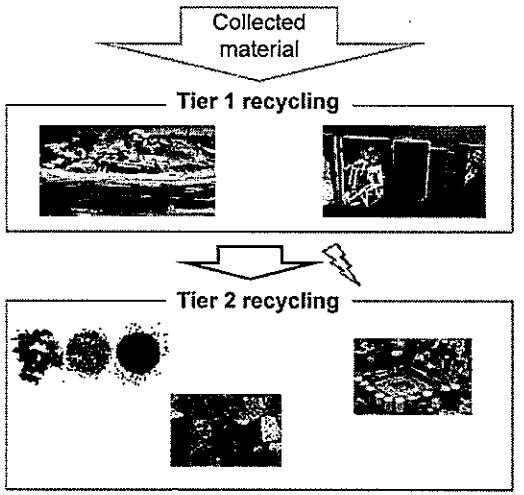
Challenges

- High collection costs (in particular when door-to-door collection for end consumers offered)
- Dealing with customers can be highly demanding and labor-intensive
- Focus on B2B channels mainly
- Wrong or missing information for the pick-up
- Generators (especially B2B) not used to EOL products being picked up or inadequate internal processes to dispose of products
- Logistics suppliers not used to "reverse" logistics
- *"Cherry picking of material"* – focusing on the most convenient material fractions

Benefits

- Customer loyalty
- Positive impact on reputation and being seen as a "green" or sustainable company
- Increased control over own products and return flows
- Reduce flows to refilling market (toner)
- Access to key information about own products with regards to EOL (e.g. lifespan), insights into customer behavior
- Potential value return from resale, harvesting & recycling
- Closed material loops to enable circular economy
- Control over secondary raw material and price levels

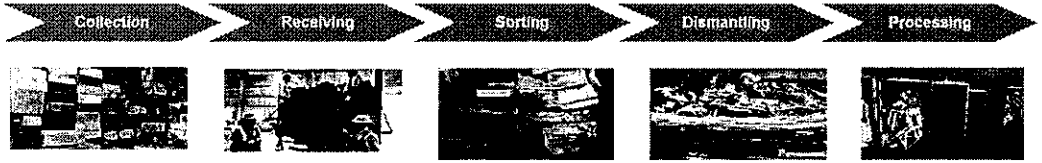
Downstream challenges and controls



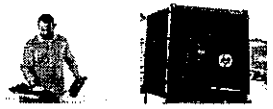
Main Challenges

- Leakage of material out of the stream
- Informal competition reduces competitiveness of the formal activities
- "Paper" trading

RLG Solutions supporting voluntary programs



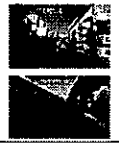
✓ Reverse logistics coordination



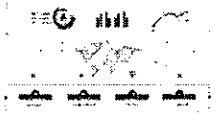
✓ Doc. tracking

✓ Material tracking and downstream transparency

✓ Supplier audits



✓ Reporting



Voluntary and Mandatory programs comparison

Voluntary Programs

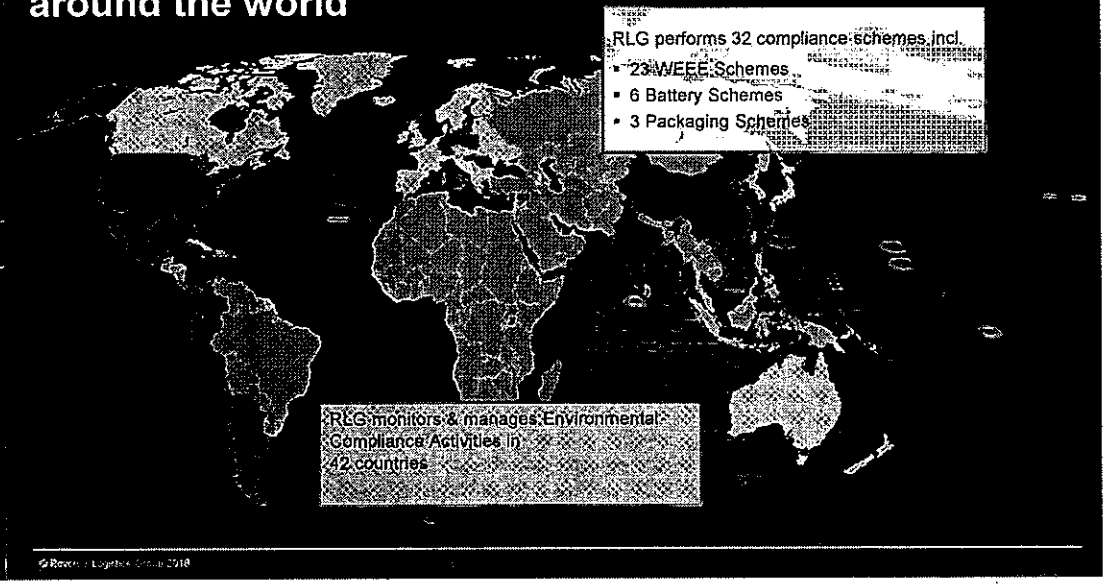
- Activities driven by market conditions
- Financially incentivized OEMs activities
- Lack of focus on environmental and social aspects
- Missing downstream control
- Focus on high value products
- Low value products remain untouched

Mandatory Programs

- Focus on a wide scope of valuable and nonvaluable products
- Buildup and establishment of robust collection mechanisms
- Formalization of informal activities
- Downstream network development and control increase
- Buildup of a new and formal ecosystem
- Awareness generation among stakeholders, especially consumers

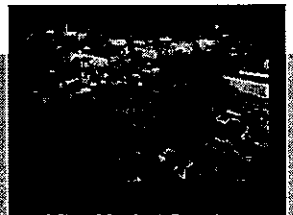
RLG
REVERSE LOGISTICS GROUP

RLG operates & manages Compliance Activities around the world



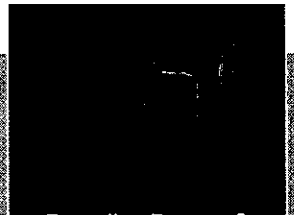
RLG
REVERSE LOGISTICS GROUP

RLG Divisions



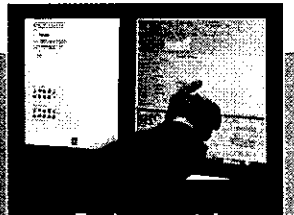
After Market Services

Integrated solutions for product return and downstream management



Recycling Returns & Trade

Individual take-back and disposal solutions for end-of-life products



Environmental Compliance Services

Compliance management for packaging, electronics and batteries

RLG
REVERSE LOGISTICS GROUP

Global Scope – local Reach

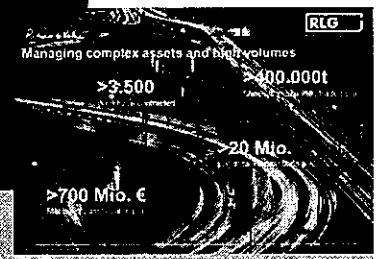
Reverse Logistics Group (RLG) services are offered across the globe

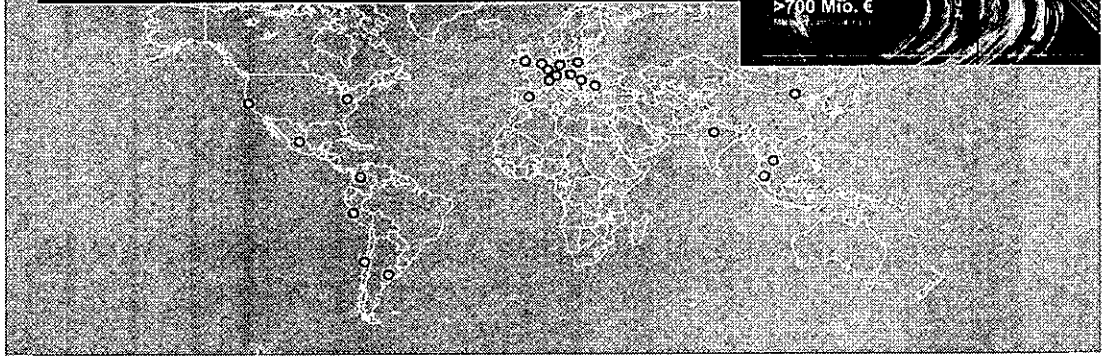
30+ subsidiaries and 20+ regional offices on 4 continents

Customers live in more than 80 countries

500+ employees collaborate with hundreds of partners

This enables us to act locally, while developing globally





Designing the future - Together with you.

Patrick Wiedemann
CEO Reverse Logistics Group
patrick.wiedemann@rev-log.com

Challenges & Benefits of Voluntary Programs

Challenges

- High collection costs (in particular when door-to-door collection for end consumers offered)
- Dealing with customers can be highly demanding and labor-intensive
- Focus on B2B channels mainly
- Wrong or missing information for the pick-up
- Generators (especially B2B) not used to EOL products being picked up or inadequate internal processes to dispose of products
- Logistics suppliers not used to "reverse" logistics
- *"Cherry picking of material"* – focusing on the most convenient material fractions

Benefits

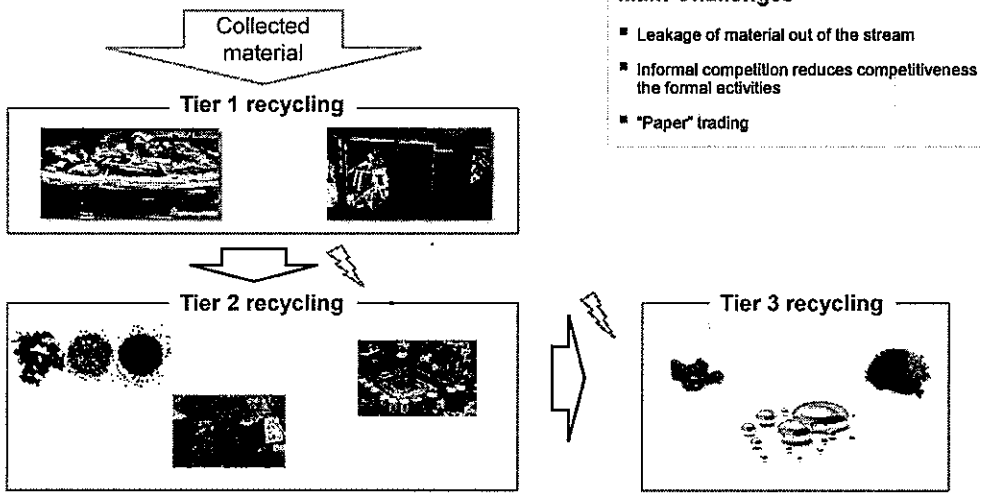
- Customer loyalty
- Positive impact on reputation and being seen as a "green" or sustainable company
- Increased control over own products and return flows
- Reduce flows to refilling market (toner)
- Access to key information about own products with regards to EOL (e.g. lifespan), insights into customer behavior
- Potential value return from resale, harvesting & recycling
- Closed material loops to enable circular economy
- Control over secondary raw material and price levels

Voluntary take-back programs

International E-Waste Management Network

IEMN, Manila, 26th September, 2018

Downstream challenges and controls



Main Challenges

- Leakage of material out of the stream
- Informal competition reduces competitiveness of the formal activities
- "Paper" trading

Voluntary Take-Back & Recycling Programs

Why do OEMs offer voluntary programs?

- As a service for their customers (mainly for corporate customers, but some also for end consumers) and for customer loyalty
- As part of their CSR programs and corporate standards
- To avoid the equipment being resold (or refilled) outside their control
- To avoid the equipment being handled by the informal sector through processes harmful to the environment
- To avoid bad press and/or negative impacts on brand or reputation
- To plan ahead for upcoming mandatory take-back and recycling programs
- Financially driven

Where do we manage voluntary programs?

- USA
- Europe
- Vietnam
- Mexico
- Costa Rica
- Panama
- Colombia
- Ecuador
- Peru
- Chile
- Argentina

What do we collect?

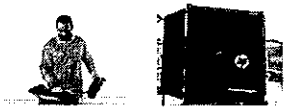
Return to Value

RLG
REVERSE LOGISTICS GROUP

RLG Solutions supporting voluntary programs

Collection → Receiving → Sorting → Dismantling → Processing

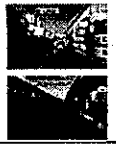
✓ Reverse logistics coordination



✓ Doc. tracking

✓ Material tracking and downstream transparency

✓ Supplier audits



✓ Reporting

Return to Value

RLG
REVERSE LOGISTICS GROUP

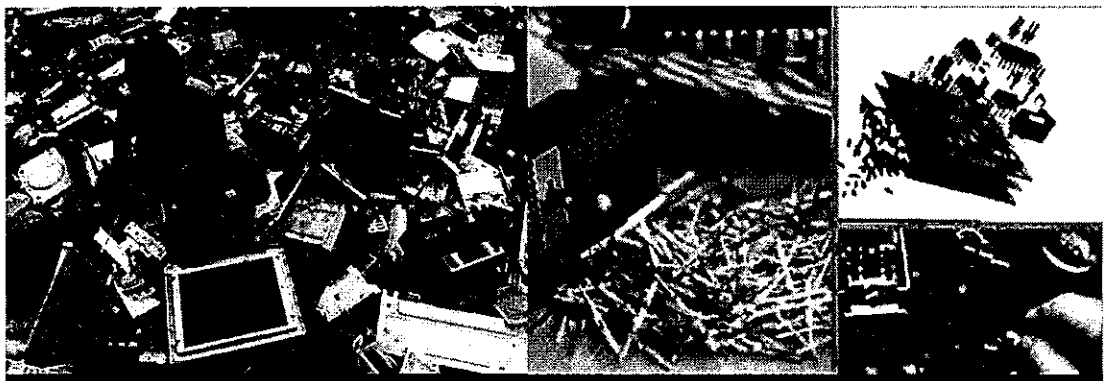
Voluntary and Mandatory programs comparison

Voluntary Programs

- Activities driven by market conditions
- Financially incentivized OEMs activities
- Lack of focus on environmental and social aspects
- Missing downstream control
- Focus on high value products
- Low value products remain untouched

Mandatory Programs

- Focus on a wide scope of valuable and nonvaluable products
- Buildup and establishment of robust collection mechanisms
- Formalization of informal activities
- Downstream network development and control increase
- Buildup of a new and formal ecosystem
- Awareness generation among stakeholders, especially consumers



Toxic landfills; Improper recycling damages environment and human health

Precious metals and raw materials unrecovered

acer

Acer Voluntary Recycling Program in Taiwan

8th IENM Workshop
Acer Inc. Julia Hsieh
2018/09/26

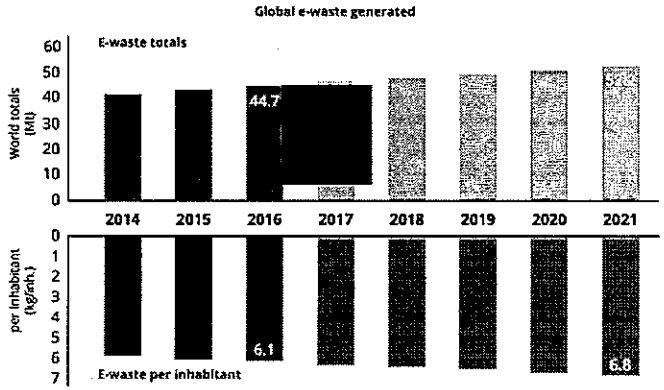
Acer Earth Recycling Program

July 2018, Acer has kicked off the Acer Earth Program in Taiwan

To collect dry cell batteries & all brands' consumer electronics products (laptops, tablet, and mobile phones)

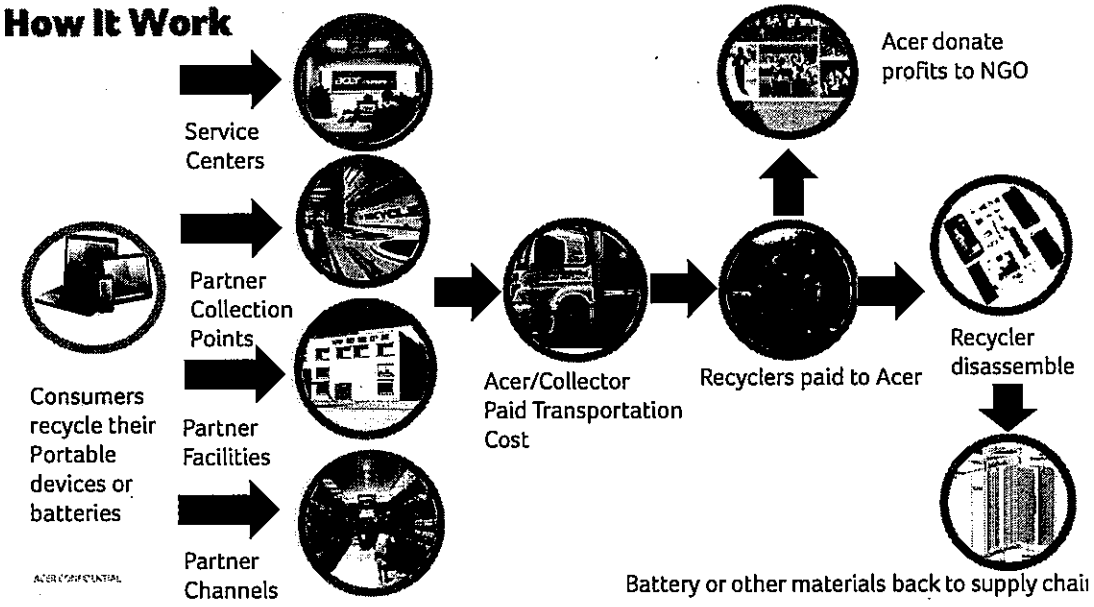
- Close Loop: Reuse of precious materials for new products
- Secure: Hard disk physically destroyed to erase data
- Caring: Program's net profit will be used to offer scholarship to orphan kids

According to UNU report, e-waste : In 2016, total is up to 44.7 million tones & ets.17% percent growth from 2016 to 2021, with only 20% being collected and recycled



*UNU, Global E-waste Monitor 2017

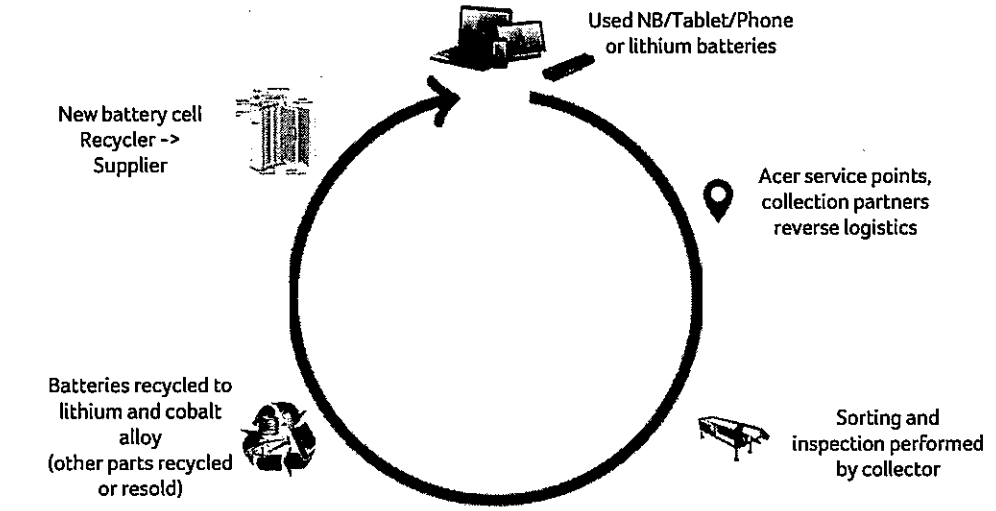
How It Work



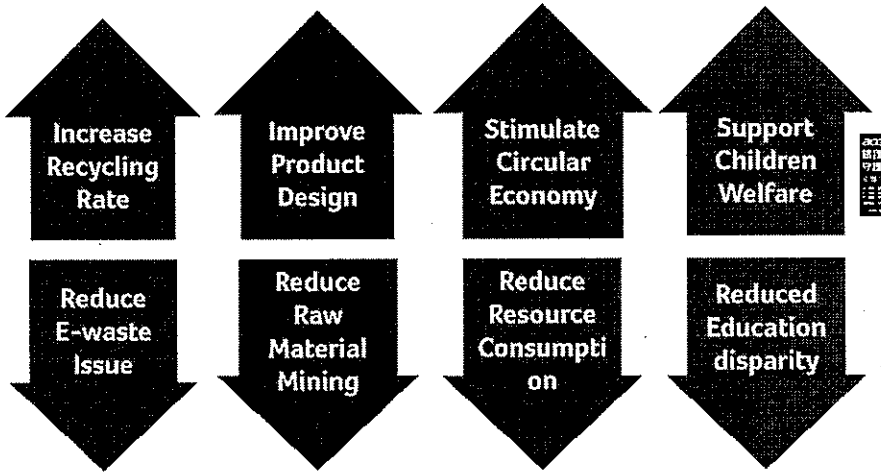
EPAT Press Conference – Voluntary Recycling Program

- Since July this year, this program has connected 326 recycling locations to recycle batteries and portable electronic products.
- **Closed loop recycling process:** When recycle dry cell batteries and all branded phones, tablets and notebooks to the above-mentioned locations, these recycled and extracted materials will be used for manufacturing new products
- Net proceeds from the program will be donated to foundations that support the disadvantage children programs.

Acer Circular Close Loop Model

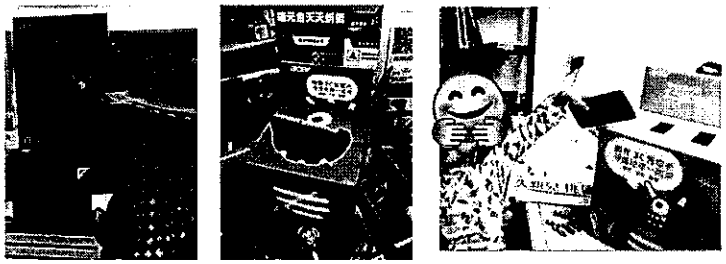


Partnering with Tsannkuen Electronics

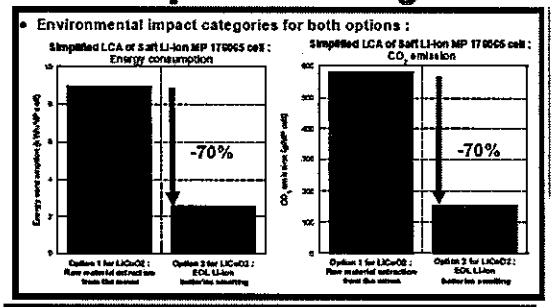


Offering consumers approx. 330 recycling locations in Taiwan

Consumer Earth Mission Program



Recycling batteries reduces energy consumption and CO2 emissions by 70% compared to using raw material



CONCLUSION

On top of the fact that it is anyway always better for the preservation of our natural resources, the conclusion of the study clearly shows the advantage of recycling the batteries, to keep the metals into the loop, allowing lower environmental impacts (-70% of energy consumption and of CO_2 emissions).

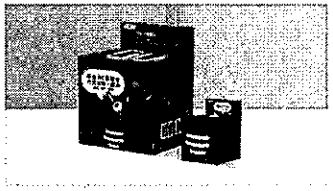
Saft
111, Bd Alfred Daney
33074 BORDEAUX Cedex
France
Contact:
clemence.siret@saftbatteries.cc
www.saftbatteries.com

Commercial Partnership Program

Targets:
Welfare committee or volunteer team
Organizing employee recycling program

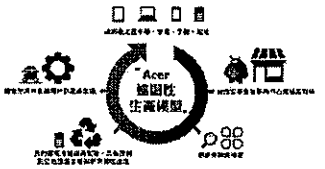
Items for recycling:
All dry cell batteries and other electronic products

Resources required:
Annual or biannual volunteer efforts and prizes for lucky draw

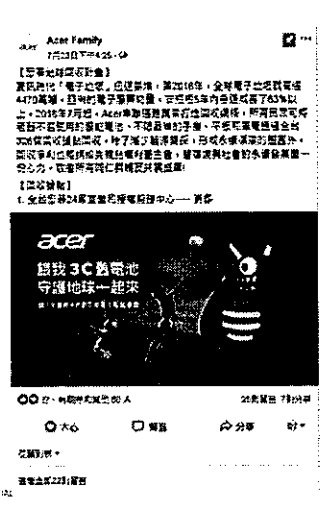


Creative Assets
Poster: 420mmx297mm (editable to add company's logo)
Recycling Box: 30cm(L)x23cm(W)x30cm(H)

Consumer-Facing Communications

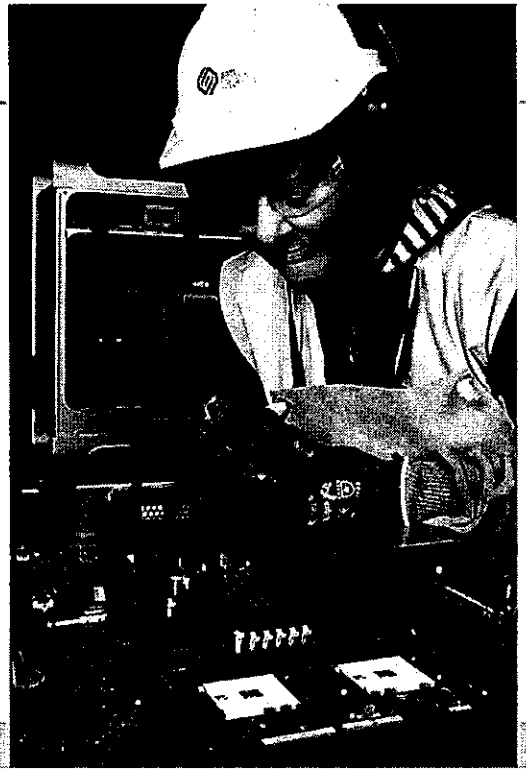


Internal Promotional Program
Coffee Voucher and Volunteer Incentives



THANK YOU ☺

email: julia.hsieh@acer.com



Improving E-waste Management

- Internal health and safety programs

Need for 3rd party certified partners

- Driven by global customers
  - Looking for consistent processing standards
  - Reduces customer risk = $$$
- Worked with SERI (the housing body for R2 standards) to help get local recyclers certified
- Provided funding to help move the program forward
- Acting as consultants to the local recyclers
- Conducted the internal audits as final preparation before formal audits

Establishing downstream markets

- Closed loop plastic project is prime example
  - Requires:
    - Capital
    - Knowledge
    - Right partners
    - More than just economic justification

- Internal health and safety programs
- Third-party certifications

Third-party certifications

- Working towards all SRS sites being R2 certified
  - All US, European, Australian, South African, Dubai sites
- Helping our partners obtain R2 certification
  - Worked with SERI in Latin America
    https://sustainableelectronics.org/programs

THE OBJECTIVE OF AN AUDIT...

- To continually improve the management system
- Checks and balances
- For everyone to learn what they can be doing better

8TH ANNUAL MEETING OF THE INTERNATIONAL E-WASTE MANAGEMENT NETWORK (IEMN) WORKSHOP

CONDUCTING A FACILITY AUDIT FOR WORKER HEALTH & SAFETY AND ENVIRONMENTAL PROTECTION

KELLEY KEOGH, CO-FOUNDER, GREENEYE PARTNERS

MANILA, PHILIPPINES - SEPTEMBER 21ST-28TH 2018

TYPES OF AUDITS

INTERNAL AUDITS

- Internal staff
- Reviewing another department's work
- Valuable tool if you are not auditing your own department or responsibility

EXTERNAL AUDITS

- Conducted by an interested party:
  - Certification Body
  - Customer
  - Federal or local regulator
- Valuable to have an outside set of eyes review your systems and company

AGENDA

1. The Objective
2. Types of Audits
3. The Preparation
4. Where to start
5. What to Cover
6. Follow up
7. Questions
8. Contact Information

THEN...
COMPLETE YOUR AUDIT FORM

HERE ARE SOME EXAMPLES FROM THE GREENEYE PARTNER'S COMPLIANCE AUDIT FORM....

THE PREPARATION

ARE YOU READY?

1. Research:
   Map of the area, news sources, company website, internet search
2. Documents in advance:
   You may want to review their management system in advance
3. Local and Federal Laws:
   Have a basic understanding of what they are required to do
4. Audit Form:
   Have a plan for what you will review while on site

WHAT TO COVER...

Greeneye Partners
Compliance Audit Form

GREENEYE PARTNERS

Table of Contents

EXAMPLE

HOW TO START

START WITH A TOUR OF THE FACILITY. FOLLOW THE FLOW OF THE MATERIAL...

Inbound Receiving → All Processing Steps → Outbound Shipping

Section 9: Hazardous Waste Management

GREENEYE PARTNERS

SECTION 9: HAZARDOUS WASTE MANAGEMENT			
Does the facility generate/store/treat hazardous waste on site? If no, skip this section. If yes, what is the volume? ☑ Yes ☐ No ☐ Less than 5 Kg ☐ 5-100 Kg ☑ 100-1000 Kg ☐ Over 1000 Kg			
Questions	**Yes**	**No**	**N/A**
Is the facility generation and/or storage amount verifiable to their permit applicability? (i.e., LQG or SQG)	☑	☐	☐
Are weekly inspections noting containers, labeling, secondary containment, leaks, compatibility, etc. available to review?	☑	☐	☐
Are hazardous waste manifests kept for three years?	☑	☐	☐
Are manifest copies matched with land disposal restrictions and destination facilities?	☑	☐	☐
Are waste codes correctly identified?	☑	☐	☐
Are local response agencies informed of material on site?	☑	☐	☐
Does the facility conduct audits of downstream vendors that manage their hazardous waste?	☑	☐	☐
Can auditor track all inbound material and outbound hazardous waste streams to final destination through either paperwork review or inventory tracking systems?	☑	☐	☐
Is hazardous waste stored, labeled and tracked (manifest) appropriately to regulatory agency requirements?	☐	☑	☐

EXAMPLE OF A NON-CONFORMANCE

LET'S REVIEW SOME REAL FACILITY EXAMPLES...

HEALTH AND SAFETY

HAZARDOUS WASTE MANAGEMENT

Section 15: Site Security

GREENEYE PARTNERS

SECTION 15: SITE SECURITY Questions	Yes	No	N/A
Does the facility have a visitor program in effect? Describe process (i.e., Is there a badge program? Visitors escorted? Visitor sign in?)	☑	☐	☐
Does the facility have a key control program in place? Describe system.	☑	☐	☐
Does the facility perform criminal background checks on their employees? Note program and schedule.	☑	☐	☐
Are the facility buildings secure from unauthorized entrance?	☑	☐	☐
Is the property secure from unauthorized entry? (i.e., perimeter fencing CCTV, security services, locked gates)	☑	☐	☐
Does the facility have CCTV? Note how long recordings are kept.	☑	☐	☐
Are there areas that have secure levels of access? Ex. Storage of data devices or precious metals.	☑	☐	☐
Is there a security officer or department?	☑	☐	☐

EXAMPLE OF CONFORMANCE

Section 12: Health and Safety

GREENEYE PARTNERS

Questions	Yes	No	N/A
Does the facility conduct hazard assessments/risk assessments of all job classifications?	☑	☐	☐
Does the facility have a designated and appropriately trained representative to manage health and safety responsibilities?	☑	☐	☐
Does the facility have an ergonomic program or conduct ergonomic evaluations?	☑	☐	☐
Has the facility conducted noise testing? Review results and Hearing Conservation program, if applicable.	☑	☐	☐
Has the facility conducted air testing? If yes, list constituents and frequency.	☑	☐	☐
If required, does the facility have a Respirator training and written program?	☑	☐	☐
Does the facility have First Responder or First Aid, EMT personnel or Haz Woper personnel?	☑	☐	☐
Does the facility have a safety committee?	☑	☐	☐
Does the facility conduct accident and/or injury investigations?	☑	☐	☐
Do employees appear to wear the appropriate PPE for the tasks performed?	☑	☐	☐
Is general facility housekeeping up to the industry standard?	☐	☑	☐
Does the facility have any open or recent OSHA (or equivalent) violations? Fines?	☐	☑	☐

EXAMPLE OF A NON-CONFORMANCE

AIR EMISSIONS

SITE SECURITY

Section 3: Waste Water

GREENEYE PARTNERS

SECTION 3: WASTE WATER

Does the facility generate any of the following?
If yes, check all that apply. If no, skip this section. ☑ Yes ☐ No

☑ Process Wastewater ☐ Non-Contact Cooling Water ☐ Wastewater Treatment Plant Effluent

☐ Washwaters containing detergents/other cleansers off site (e.g. used to clean equipment, facility floors) ☐ Other:

Questions	Yes	No	N/A
Is facility waste water generation and treatment monitored for constituents on an ongoing basis? Note constituents and treatment methods. (see Executive Summary)	☑	☐	☐
Is there third party or regulatory agency observation of the treatment process and its effectiveness? If so, review reports.	☑	☐	☐
Is treated water released to surface waters, lakes, bays, oceans and tributaries? If yes, please note testing methods to manage outflow contamination/temperature issues. (see Executive Summary)	☐	☑	☐
Is outflow testing information available for review?	☐	☑	☐

EXAMPLE OF A NON-CONFORMANCE

Section 2: Air Emissions

GREENEYE PARTNERS

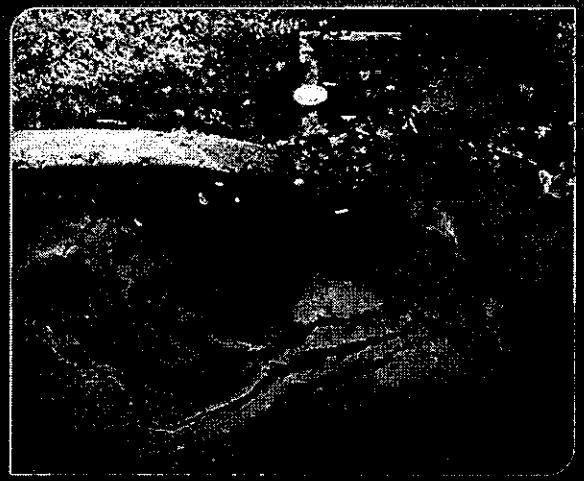
SECTION 2: AIR EMISSIONS

Does the facility have/generate any of the following air emissions to outside of the building? ☑ Yes ☐ No
If yes, (check all that apply), If no skip this section.

☑ Stacks or Vents ☐ Storage Tanks ☐ Incinerators ☐ Boilers
☐ Other Fugitive Sources (e.g. valves, leaking pipes):

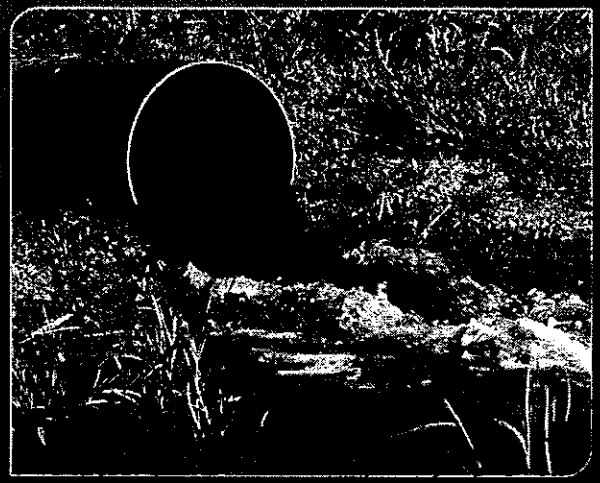
Questions	Yes	No	N/A
Do processes create releases to the atmosphere? Please note constituents and number of emission points. (see Executive Summary)	☑	☐	☐
Are air testing/emission monitoring systems in place? Please note calibration/testing system and whether documentation is available to review. (see Executive Summary)	☑	☐	☐
Are stack and/or calibration tests performed by a third party or regulatory agency? Note intervals and if test results are available for review. (see Executive Summary)	☐	☑	☐
Is off site air monitoring conducted? Note intervals andif test results are available for review. (see Executive Summary)	☐	☑	☐

EXAMPLE OF A NON-CONFORMANCE



STORMWATER

WASTE WATER



Section 5: On-Site Waste Generation

GREENEYE PARTNERS

SECTION 5: ON-SITE WASTE GENERATION			
Does the facility generate/store/treat waste on site? If no, skip this section	☑ Yes	☐ No	
If yes, what is the volume?			

Questions	Yes	No	N/A
List wastes that the facility generates. (see Executive Summary)	☑	☐	☐
Does facility have appropriate waste analyses, characterizations or profiles available for UW, HW, or Special Wastes?	☑	☐	☐
What material is incinerated? (see Executive Summary)	☑	☐	☐
Does facility have a program to reduce landfill waste?	☐	☑	☐

EXAMPLE OF A NON-CONFORMANCE

Section 4: Stormwater

GREENEYE PARTNERS

SECTION 4: STORMWATER		
Does the facility discharge stormwater off site?	☑ Yes	☐ No

Questions	Yes	No	N/A
Are there active outside material storage areas, processing areas that are uncovered, fugitive dust or air emissions that could affect stormwater quality?	☑	☐	☐
Is the facility paved with collection areas for stormwater? If so, describe collected stormwater management or treatment system/ process. (see Executive Summary)	☐	☑	☐
Does facility employ best management practices to reduce stormwater runoff and/or contamination?	☐	☑	☐
Does the facility have a permit for stormwater management that is monitored by a regulatory agency? Is facility exempt due to SIC or has filed a Certificate of No Exposure?	☑	☐	☐

EXAMPLE OF A NON-CONFORMANCE

STORAGE TANKS

EXAMPLE: PETROLEUM

ONSITE WASTE GENERATION

Section 9: Hazardous Waste Management

GREENEYE PARTNERS.

SECTION 9: HAZARDOUS WASTE MANAGEMENT

Does the facility generate/store/treat hazardous waste on site? If no, skip this section. If yes, what is the volume? ☑ Yes ☐ No

☐ Less than 5 Kg ☑ 5-100 Kg ☐ 100-1000 Kg ☐ Over 1000 Kg

Questions	Yes	No	N/A
Is the facility generation and/or storage amount verifiable to their permit applicability? (i.e., LQG or SQG)	☑	☐	☐
Are weekly inspections noting containers, labeling, secondary containment, leaks, compatibility, etc. available to review?	☑	☐	☐
Are hazardous waste manifests kept for three years?	☑	☐	☐
Are manifest copies matched with land disposal restrictions and destination facilities?	☑	☐	☐
Are waste codes correctly identified?	☑	☐	☐
Are local response agencies informed of material on site?	☑	☐	☐
Does the facility conduct audits of downstream vendors that manage their hazardous waste?	☑	☐	☐

EXAMPLE OF CONFORMANCE

Section 11: Storage Tanks/Petroleum Management

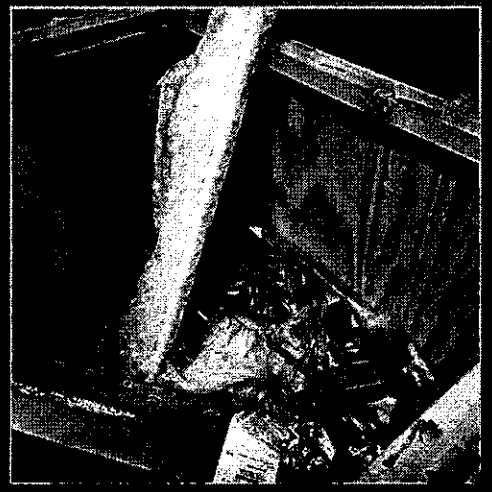
GREENEYE PARTNERS.

SECTION 11: STORAGE TANKS/PETROLEUM MANAGEMENT

Does the facility have storage tanks for petroleum or chemical products? If no, skip this section. ☐ Yes ☐ No

Questions	Yes	No	
As required by regulatory agencies, are tanks double walled, have secondary containment, are equipped with electronic leak detection, etc? If yes, describe systems.	☑	☐	
Are tanks appropriately labeled and visible to responding agencies and employees with appropriate information? NPFA, HW, reg's, name of material.	☑	☐	☐
Are visual inspections conducted? Note frequency.	☑	☐	☐
If a US facility, are the above ground storage tanks more than 1,320 gallons? (Only count containers of a capacity of 55 gallons or greater.)	☑	☐	☐
If yes, does facility have a SPCC Plan? US companies.	☑	☐	☐
Is the SPCC Plan up to date with current operations? Check plan map.	☑	☐	☐
Does a civil engineer certify the SPCC Plan?	☑	☐	☐

EXAMPLE OF CONFORMANCE



LAMP AND MERCURY DEVICES

HAZARDOUS WASTE MANAGEMENT

QUESTIONS & DISCUSSION

Section 13: Lamp and Mercury Devices

GREENEYE PARTNERS

SECTION 13: LAMP AND MERCURY DEVICES		
Does the facility receive or process mercury containing lamps or devices? If no, skip this section.	☑ Yes	☐ No

Questions	Yes	No	N/A
Are lamps processed on site? Describe system, closed loop, end process materials, filtration system.	☐	☑	☐
Is industrial hygiene and/or bio monitoring conducted? Describe testing parameters, frequency, and results. Review documents.	☐	☑	☐
Are waste streams analyzed? Describe stream and final destinations.	☑	☐	☐
Are ballasts managed on site? If sent off site for processing, describe process and final destination.	☐	☑	☐
Are employees who handle mercury familiar with handling and emergency procedures?	☑	☐	☐
Are there Mercury Spill Kits available?	☐	☑	☐

EXAMPLE OF A NON-CONFORMANCE

CONTACT INFORMATION

Greeneye Partners consults, does internal audits, and training for all types of recycling companies.

Kelley Keogh

Greeneye Partners

707-843-1632

kelley@greeneyepartners.com

www.greeneyepartners.com

FOLLOW UP – AFTER THE AUDIT

KEEP IN MIND AUDITS SHOULD BE LEARNING LESSONS

- Audit Report - items which need to corrected or improved
  - **Non-conformances:** items where they do not meet legal or voluntary standard requirements
  - **Areas of concern:** not non-conformances, but may become one
  - **Opportunities for Improvement:** helpful ideas or suggestions to help improve their systems or processes