Progress in 3R for Industrial Waste Management in Taiwan

Speaker: Tien-Chin Chang, Professor
Institute of Environment Engineering and management

Jan, 17, 2007
1. Introduction

2. Management and accomplishment of Industrial wastes

3. 3R Management framework for Industrial wastes

4. The impact of WEEE, RoHS and EuP in Taiwan

5. Feature Research Direction for 3R in Industrial Wastes Management
1. **Introduction**
Introduction

Sustainable development


Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
Tendency Toward Environmental Development (1)

Resource in Disguise

Waste

(Money)

(Material)
Tendency Toward Environmental Development (2)

INDUSTRIAL ECOLOGY

Type I (a)
Ecosystem Components
Unlimited resources
Unlimited waste

Type II (b)
Ecosystem Components
Energy and limited resources
Limited waste

Type III (c)
Ecosystem Components
Energy

(a) Linear materials flows in Type I ecology.
(b) Quasicyclic materials flows in Type II ecology.
(c) Cyclic materials flows in Type III ecology.
Sustainable development

- Wastes disposal
- Pollution control
- Recycling
- Waste Minimization
- Pollution Prevention
- Clean Production
- Recycle Industry
- Recycle Environment
- Recycling
- Pollution control
Principles of Recycling

1. Can not disregard the cost to recycling
2. Recycling must include high additive value
3. Substance recycling is better than energy recycling
4. Recycling based on reduce, reuse and recovery
Direction of Recycling

1. Reduce/Reuse/Regeneration and Recovery
2. Create high additive value
3. Safe treatment for Hazardous and Toxic substances
2. Management of Industrial Wastes
Course of Industrial Wastes

1960~1980

- Administrative Regulation
- Waste Disposal Act

1990

- 7 TIMES OF REVISIONS
- Municipal solid waste plan
- Recycling 4 in 1 program
- Establish industrial waste control center
- ESTPs

2000

- Waste Disposal Act
- Resource Recycling Act

2008~

- Sustainable Development
- Clean Production
- Industrial ecology
- Zero waste

EPA

- Waste disposal Act declaration
- Treated by oneself

Industrial wastes

- Waste landfill
- Industrial wastes authority responsibility
- Sources reduction and Recycling
Announcement of Recycling for Industrial Waste

2005

• Categories: 370, including 2 resources

• 33,896 factories (95%) are subject to the authority, including the declaration of 12,525 factories.

• Total declaration in weight: 14,940 thousand ton.
  - General industrial wastes: 1,359 ton (90.9%)
  - Hazardous industrial wastes: 1,350 ton (9.1%)

Waste disposal Act

Responsibility: Ministries are responsible to plan the Categories, 92 substance should be recycled.
Industrial Waste Management, the Present Situation

Flow direction and reuse rate

- **Recycling**: 10,543,347 ton, 73%
- **Commission or collective**: 868,745 ton, 6%
- **Treated by oneself**: 883,369 ton, 6%
- **Stored in factory**: 2,106,586 ton, 15%
- **Transboundary treatment**: 68,894 ton, 0%

Unit: ton

Sources: EPA statistic (2004)
Announcement of Recycling for Industrial Wastes

Ministry of the Interior
Construction wastes

Ministry of Economic Affairs/NSC
Industrial waste

Department of Health
Medical waste

Ministry of Education
Education waste

Council of Agriculture
Agricultural waste

Ministry of National Defense
Military waste

Ministry of Transportation and Communication
Transportation waste
Industrial Waste Management, the Present Situation

Announcement of recycling
Permission of recycling
Public or private owned treatment organization
Common treatment organization

2002
2003
2004
2005
2006

15/70
Industrial Waste Management, the Present Situation

2002~2006

Unit: ton/yr

Sources: Industrial Development Bureau, Ministry of Economic Affairs
Recycling Techniques and Beneficial Commerce

Recycling techniques for
Heavy metal sludge

Recycling techniques for
Calcium fluoride

Recycling techniques for
clean water sludge

Recycle by high Temperature melting

Heavy Metal sludge → Flash furnace → Melt metal → Temperature decrease → Glass products

Gas

Flux

Melt slag
Recycling Techniques and Beneficial Commerce (2)

Recycling techniques for Heavy metal sludge

Recycle by acid dissolved to crystallize

Copper sludge

Acid dissolved (220°C) → pH control (pH=2.7) → Filter → High polymer → Oxidizer solution

Acid liquid

NaOH → pH control (pH=7.9) → Filter → Sulfate solution → Crystallize → Centrifugal filter → Sulfate

Copper oxide
Recycling Techniques and Beneficial Commerce(3)

**Recycling techniques for Heavy metal sludge**

**Recycling techniques for Calcium fluoride**

**Recycling techniques for clean water sludge**

**Smelt by drying machine to recycling**

1. Heavy metal sludge → Sedimentation tank → Metal sludge dewatering → Sludge cakes
2. 1,300~1,600°C
3. Metal oxide → Smelt → Copper
4. Coke and Silicide

Vibrate and smash put into drying machine
Recycling Techniques and Beneficial Commerce(4)

One of the Cement Industry Stuff Used by CaF₂

Recycling techniques for Heavy metal sludge

Recycling techniques for Calcium fluoride

Recycling techniques for clean water sludge

Calcium fluoride sludge → Additional and mix evenly → Grind → Stir → Sintering

clay

Gypsum

Ciment

Grind
Recycling Techniques and Beneficial Commerce (5)

Recycling techniques for Heavy metal sludge

Recycling techniques for Calcium fluoride

Recycling techniques for clean water sludge

Clean water sludge → Acid (pH=3) → Solid waste

H₂SO₄

5~10% Sulfuric acid solution → Ion exchange → Non-hazardous solution

Aluminum sulphate → Water treatment

Treat and disposal
Recycling Techniques and Beneficial Commerce(6)

Recycling benefits result

- Recycling quantity of industrial waste 10 million ton per year
- Total value $327 hundred million.
- Recycling products include:
  1. Rubber
  2. Engineering Materials
  3. Plastic
  4. Metal

Plastic and its material

Fertilizer

Metal
Recycling Benefits and Results

Total value of recycling industry

Hundred Millions

Shows an Increasing Tendency

Sources: Industrial Development Bureau ministry of economic Affairs
Recycling Techniques and Beneficial Commerce(8)

- Removal from the global warming potential
- Process product decrease the greenhouse gas of 4.94 million ton by industrial recycling.
- The contribution quantity will exceeded in number

- Steel-making industry
  - Water-quenched BF slag
    - 274 million ton/year
  - Coal ash
    - 311 million ton/year

- Coal equipment
  - Raw material

- Water-quenched BF slag
  - Reduce CO₂
    - 217 million ton/year
  - Cement paste/mortar with fly ash
    - Reduce CO₂
      - 277 million ton/year
Recycling Techniques and Beneficial Commerce (8)

- **Recycled products Quantity achieve**: 10,816 thousand ton/year million
- **Env-quality Loss achieve**: 30.35 billion/year
- **Recycling value achieve**: 8.5 billion/year
- **CO₂ emission reduce to**: 940 thousand ton/year

Image of recycled products and bottles.
3. 3R Management Framework for Industrial Waste
3R Management Framework for Industrial Waste

- Market demand
- Administrative Regulation
- Strategies
- Marketing
- Industrial Constitution

Based on Sustainable Development
## Industrial Waste Recycling SWOT Analysis

<table>
<thead>
<tr>
<th></th>
<th>Strength</th>
<th>Weakness</th>
<th>Opportunity</th>
<th>Threat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2. Law standard</td>
<td>2. Short of economic capacity</td>
<td>2. Lifecycle Management</td>
<td></td>
</tr>
<tr>
<td><strong>enterprises</strong></td>
<td>1. Taiwan's small and medium enterprises have maneuverability</td>
<td>1. Technology promotion needed</td>
<td>1. Policy support</td>
<td>1. Training and education needed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. suit global challenges</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>To manage</strong></td>
<td>1. Tax favorable</td>
<td>1. Technology and market are not into maturity</td>
<td>1. Green consumption</td>
<td>1. Regularly blemished</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Hard to Large-Scale production</td>
<td></td>
<td>2. Hard to quality control</td>
</tr>
<tr>
<td><strong>market</strong></td>
<td>1. High quality, law, price</td>
<td>1. Hard to quality control</td>
<td>1. Tendency toward 3 R</td>
<td>1. Risk to invest abroad</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Hard to Large-Scale production</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Industrial Waste Management
System Boundary

Material flow analysis

- Systematic Assessment of Resources for Input, Flow, Stock and Output.

- Domestic Extraction
  - fossil fuels
  - minerals
  - biomass

- Unused Domestic extraction

- Imports

- Indirect Flows Associated to imports

- Emission waste

- Unused Domestic extraction

- Exports

- Indirect Flows Associated with exports

- Material accumulation

- Economy

- Recycling
Industrial waste management
System boundary

- Sources Reduction
- Restriction of the Use of Certain Hazardous Substances
- With High Additive Value
- Environment Benefit Maximum
### Mission, Vision, Goal and Objective of Recycling for Industrial Waste

- **Mission**: Toward sustainable development
- **Vision**: ROS (Recycle-oriented Society)
- **Goal**: Zero Waste
- **Objective**: counted and un-counted

<table>
<thead>
<tr>
<th>Objective</th>
<th>Integrated department organization 3R</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Source Reduction work out</td>
</tr>
<tr>
<td></td>
<td>Strength Production/Market Mechanism of 3R</td>
</tr>
<tr>
<td></td>
<td>Add attraction from economy</td>
</tr>
<tr>
<td></td>
<td>Information exchange needed</td>
</tr>
<tr>
<td></td>
<td>Education of professionals</td>
</tr>
<tr>
<td></td>
<td>the community realize 3R</td>
</tr>
</tbody>
</table>
## Recycling Rate for Industrial Waste

<table>
<thead>
<tr>
<th>Year</th>
<th>Industrial waste</th>
<th>Medical</th>
<th>Construction</th>
<th>Agriculture</th>
<th>education</th>
<th>military</th>
<th>Recycling rate</th>
<th>Land-treatment reduce rate</th>
<th>Incineration treatment reduce rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>75%</td>
<td>20%</td>
<td>5%</td>
<td>5%</td>
<td>15%</td>
<td>65%</td>
<td>75%</td>
<td>10%</td>
<td>85%</td>
</tr>
<tr>
<td>2011</td>
<td>80%</td>
<td>30%</td>
<td>10%</td>
<td>10%</td>
<td>20%</td>
<td>70%</td>
<td>80%</td>
<td>25%</td>
<td>50%</td>
</tr>
<tr>
<td>2020</td>
<td>85%</td>
<td>45%</td>
<td>20%</td>
<td>20%</td>
<td>70%</td>
<td>80%</td>
<td>85%</td>
<td>25%</td>
<td>50%</td>
</tr>
</tbody>
</table>

Source: EPA(2005)
Mission, Vision, Goal and Objective of Recycling for Industrial Wastes

Goals and strategies

- Give an impetus to product exchange abroad and to form an association
- Build national standard and self-management
- Promote high Additive value production, and new market.

2005
- Recycled products value 3.65 billion
- Technology and innovative ability for equipments
- Industrial wastes recycling rate achieve 73%

2010
- Recycled products value 5.85 billion
- Technology export achieve 2,000 million
- Industrial wastes recycling rate achieve 78%

2015
- Recycled products value 9.5 billion
- Technology export achieve 5,000 million
- Industrial wastes recycling rate achieve 85%
Industrial Waste Management Framework

**Vision**
- Recycling-oriented Society

**Goal**
- Zero Waste
  - Integrate all Ministries into 3R
  - Promote industrial source reduction
  - Gradual awakening to recycling for people
  - Increased enticements of economy to recycling
  - Strengthen marketing mechanism of resources and recycled products

**Objective**
- Integrity to exchange information for industrial waste recycling
- Staff education and training

**Strategies**
1. Combination of the Waste Disposal Act and Resource Recycle Act to form one Act
2. Integrate all the Ministries into recycling.
3. Promote industrial source reduction.
4. Positively carry out 3R.
5. Increased enticement of economy to recycling.
6. Strengthen marketing mechanism of resource and recycled products.
7. Integrity of industrial wastes recycling baseline.
8. Train employees for recycling professionalism.
10. Strengthen education and information of recycling.
Strategies for Recycling of Industrial Waste(1)

- **Implement waste management and recycling law**
  - Definition of the terminologies integrated
  - Incorporate resource reduction, self-criticism, and get information flowing

- **Develop framework of waste management data**
  - Audit/check recycling data, report, and information from enterprises

- **Integrate different departments**
  - Design an inter-departmental plan to develop a 3R mechanism through a 3R commission
  - Building data collection system, such as resource reduction, design for environment, environmental management. Supply suggestions within a dateline.
Strategies for Recycling
Industrial Waste(2)

- **Emphasize on source reduction**
  - Include *source reduction in law*
  - Limit goods which use harmful substance and packaging. Should adapt WEEE (European Union)

- **Promote resource recycling**
  - Announce *types of waste for recycling*, include other items gradually
  - Build *market mechanism for 3R*, draw up rules and regulations

- **Promote enterprises by attracting economic investment**
  - Award prizes
  - Allocate land at low prices
Strategies for Recycling of Industrial Waste(3)

- **Build market mechanism**
  - Test and verify
  - Build national standard
  - Build self-management such as ISO14001
  - Encourage design for environment

- **Educating professionals**
  - Promote technology
  - Put research findings in a high rate
  - To edit a handbook for 3R

- **Overseas Marketing**
  - Give an impetus for product exchange abroad and to form an association
Strategies for Recycling of Industrial Waste(4)

- **Government**
  - Combine the Waste Disposal Act and Resource Recycling Act to form one Act
  - Promote industrial source reduction
  - Positively carry out 3R

- **Academic**
  - Integrate all the Ministries into recycling process
  - Strengthen education and information on recycling
  - Increase enticements of economy to recycling

- **Industry**
  - Overseas marketing
  - Train employees on recycling professionalism
  - Strengthen marketing mechanism for resource and recycled products

Sponsor:
- EPA
- MOEA, NSC
- MOI, COA

Assist:
- Academic
- Industry, Academic
# Industrial Waste Recycling Performance Index

<table>
<thead>
<tr>
<th>Category</th>
<th>Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input</strong></td>
<td>Waste management cost</td>
</tr>
<tr>
<td></td>
<td>Invest equipment cost in DfE</td>
</tr>
<tr>
<td></td>
<td>Examine the cost of testing for certain hazardous substances</td>
</tr>
<tr>
<td></td>
<td>Total resource use and recycled products</td>
</tr>
<tr>
<td></td>
<td>Examination expense for the quality of recycled products</td>
</tr>
<tr>
<td></td>
<td>Staff education and training cost</td>
</tr>
<tr>
<td><strong>Output</strong></td>
<td>Benefit of saving energy</td>
</tr>
<tr>
<td></td>
<td>Promote Product effectiveness</td>
</tr>
<tr>
<td></td>
<td>Economic benefit of recycled material</td>
</tr>
<tr>
<td><strong>Quantity</strong></td>
<td>Recycled products quality rate</td>
</tr>
<tr>
<td><strong>Outcome</strong></td>
<td>Objective of achieving Industrial waste reduction</td>
</tr>
<tr>
<td></td>
<td>Objective of achieving Industrial waste recycling</td>
</tr>
<tr>
<td></td>
<td>Final landfill disposal rate is lessen</td>
</tr>
</tbody>
</table>
4. The Impact of WEEE, RoHS and EuP in Taiwan
WEEE, RoHS and EuP

Reuse/Recycle Recovery

Restriction of the use of hazardous substance

Eco-design

WEEE

RoHS

EuP

Environment Load for electronic products
Development of WEEE, RoHS and EuP

**Duration**
- **2003.02**
- **2003.08**
- **2004.08**
- **2005.08**
- **2006.7**
- **2006.12**

**WEEE**
- **2002/96/EC**
- Member states bring into force the laws
- Extend producer responsibility
- Recycling target 4 kg/people/year

**RoHS**
- **2002/95/EC**
- Member states bring into force the laws
- Restriction of the use hazardous substances

**EuP**
- **2005/32/EC**
- European Commission
- Number
- Resolution adoption year
- Draft plan
- First amendment
- Second amendment
- Accomplish third amendment
- OJ L 191 of 22.07.2005
- 2005.8.11 effective
- Twenty day
- Member states Shall bring into force the laws, regulations and administrative provisions necessary before 11 August 2007
## Categories of Electrical and Electronic Equipment Covered by this Directive

<table>
<thead>
<tr>
<th>Category</th>
<th>Image Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Large household appliances</td>
<td><img src="image1.png" alt="Image of a washing machine" /></td>
</tr>
<tr>
<td>2. Small household appliances</td>
<td><img src="image2.png" alt="Image of a toaster" /></td>
</tr>
<tr>
<td>3. IT and telecommunications equipment</td>
<td><img src="image3.png" alt="Image of a computer" /></td>
</tr>
<tr>
<td>4. Consumer equipment</td>
<td><img src="image4.png" alt="Image of a television" /></td>
</tr>
<tr>
<td>5. Lighting equipment</td>
<td><img src="image5.png" alt="Image of a light bulb" /></td>
</tr>
<tr>
<td>6. Electrical and electronic tools</td>
<td><img src="image6.png" alt="Image of an electric drill" /></td>
</tr>
<tr>
<td>7. Toys, leisure and sports equipment</td>
<td><img src="image7.png" alt="Image of a toy" /></td>
</tr>
<tr>
<td>8. Medical devices</td>
<td><img src="image8.png" alt="Image of a medical device" /></td>
</tr>
<tr>
<td>9. Monitoring and control instruments</td>
<td><img src="image9.png" alt="Image of a control instrument" /></td>
</tr>
<tr>
<td>10. Automatic dispensers</td>
<td><img src="image10.png" alt="Image of a dispenser" /></td>
</tr>
</tbody>
</table>
WEEE DIRECTIVE

Product Design
- Member States shall encourage the design and production of electrical and electronic equipment which take into account and facilitate dismantling and recovery, in particular the reuse and recycling of WEEE.

Recovery
- Distributors to return such waste free of charge
- Recycling rate: 4 kg per person by 31 December 2006

Information for users
- Symbol for the marking of electrical and electronic equipment
# WEEE Reuse, Recycling and Recovery Targets

Producers meet the following targets by 31 December 2006

<table>
<thead>
<tr>
<th>Recovery Item</th>
<th>Reuse and Recycling target</th>
<th>Recovery target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large household appliances</td>
<td>75%</td>
<td>80%</td>
</tr>
<tr>
<td>Small household appliances</td>
<td>70%</td>
<td>50%</td>
</tr>
<tr>
<td>IT and telecommunications equipment</td>
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<td>65%</td>
</tr>
<tr>
<td>Consumer equipment</td>
<td>75%</td>
<td>65%</td>
</tr>
<tr>
<td>Lighting equipment</td>
<td>70%</td>
<td>50%</td>
</tr>
<tr>
<td>Electrical and electronic tools</td>
<td>70%</td>
<td>50%</td>
</tr>
<tr>
<td>Toys, leisure and sports equipment</td>
<td>70%</td>
<td>50%</td>
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<tr>
<td>Monitoring and control instruments</td>
<td>70%</td>
<td>50%</td>
</tr>
<tr>
<td>Automatic dispensers</td>
<td>80%</td>
<td>75%</td>
</tr>
</tbody>
</table>
Restriction of the Use of Certain Hazardous Substances Contents

- Member States shall ensure that, from 1 July 2006, new electrical and electronic equipment put on the market does not contain lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE).

- National measures restricting or prohibiting the use of these substances in electrical and electronic equipment which were adopted in line with Community legislation before the adoption of this Directive may be maintained until 1 July 2006.
A maximum concentration value of 0.1 % by weight in homogeneous materials for lead, mercury, hexavalent chromium, PBB and PBDE and of 0.01 % by weight in homogeneous materials for cadmium shall be tolerated.
EuP Directive Framework

- Prioritize Promotion of Energy Efficiency
- Eco-design for energy-using products
- Based on EuP Directive Framework
- Ensuring the Free Movement of those Products which Comply and Improving their Overall Environmental Impact.

- Follow Integrated Product Policy, IPP
- Lifecycle Thinking, consumer understand the energy consumption, and build Eco-profile
Restrains and objectives of EuP

Source: *Energy Using Products, EuP*

### Objectives

- Boiler, Heater, PC monitor, TV etc
- Not including transportation

### Design for environment: Eco-design Requirements

- Design for environmental effects follow EuP, such as energy efficiency, lead-containing products, pollution emission, etc.
- Eco-design Requirements for Energy using Products
Industrial Impact of EuP Directive

- Total: 212.75 billion dollars
- 27,015 factories export to Europe
Impact of EuP, WEEE, and RoHS

- Influence 30,000 factories
- 400 billion dollars

WEEE
- Restriction of the use of hazardous substances
- Environmentally friendly materials research
- Change processes, Cost increased

RoHS
- Lack of information
- Short of DfE ability
- Short of product environmental impact assessment
- Short of Eco-profile database

EuP
5. Feature Research Direction for 3R in Industrial Waste Management
Spatial Distribution of Global Emissions of Mercury to Air

Waste Mercury Treatment and Recycling

Rotating Rotary - Batch Vacuum

Continuous Rotary Thermal

 Courtesy of ETG

Southern Maryland Project – Performed by ETG for USACE 55/70
Waste Mercury Treatment and Recycling (2)

Stationary Rotary Retorts

Stationary Ovens

Courtesy of Mercury Waste Solution

Courtesy of Summit Valley
Waste Mercury Treatment and Recycling (3)

High potential of mercury treatment and recycling

Success case
- Formosa plastic Mercury sludge
- Yi-Fang chemical industry soil contaminant by mercury

Interior of 30 cubic foot capacity retorts shown during loading.

Courtesy of Summit Valley
Waste Mercury Treatment and Recycling(4)

Core Unit: Mercury Recycling and Solidify

Mercury concentration 90-99%
Waste Mercury Treatment and Recycling(5)

Distillation System of Mercury

- **Triple Distillation** – Technical pure mercury (99.99% purity)

- **Quadruple Distillation** – Virgin quality (99.9999% purity)

Courtesy of Bethlehem Apparatus
1. Mercury-Containing Lamp Recovery

- **Production**: Pure mercury
- **Concentration**: 99.999%

AERC, and PA works treatment process in America
2. Mercury-Containing Script Recovery

(1) Thermometer

(2) Sphygmomanometer

(3) Fluorescent lamp

(4) Cosmetic

(5) Battery

(6) Tooth-filling substance

(7) Motor vehicle switch, ABS
On average each car has 1.06 switch, and each one contain 0.8g mercury.

Mercury-containing element can be recycled in recycling system. (ELVs)

To avoid 75 ton mercury-pollution emission into air.
4. Electric Arc Furnace Dust Recovery

Electric arc furnace dust consist of lead, nickel, chromium, manganese, and copper.

- Treatment capacity: 70,000 ton
- Stock: 70,000 ton
- Altogether 140,000 ton of Furnace Dust
  - Immeteo process recycling: 35,000 ton
  - Stock or solidification: 20,000 ton

Recycling
- Acid Rain Lead to Dissolved Contaminants
- Volume Increased
  - Condensation and collection
  - Cement material
Diameter: 3.6m O.D (3.1m I.D)
length: 40m
Gradient: 2%
Refractory bricks thickness: 25cm

Batcher system

Dust collector system

Exhaust pipe

Zinc oxide

Micro-carbon

Slag (<100nm)

ACCRETIONS > 200nm
## 5. Lithium Battery Recovery

<table>
<thead>
<tr>
<th>Material</th>
<th>composition</th>
<th>danger</th>
</tr>
</thead>
<tbody>
<tr>
<td>The positive electrode</td>
<td>LiCoO₂</td>
<td>1. lung symptoms</td>
</tr>
<tr>
<td></td>
<td>LiMn₂O₄</td>
<td>2. Noxious air will be made</td>
</tr>
<tr>
<td></td>
<td>LiNiO₂</td>
<td></td>
</tr>
<tr>
<td>The negative electrode</td>
<td>Carbon</td>
<td>1. Skin allergy</td>
</tr>
<tr>
<td></td>
<td>Black lead</td>
<td>2. lung symptoms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. CO, CO₂</td>
</tr>
<tr>
<td>Electrolyte</td>
<td>LiPF₆</td>
<td>1. HF, and P₂O₅</td>
</tr>
<tr>
<td>Dissolvent</td>
<td>EC, PC, DMC, DEC</td>
<td>1. CO, and CO₂</td>
</tr>
</tbody>
</table>
5. Lithium Battery Recovery

- **Technique**
  - **Dry**
    - High-temperature
    - Acid solution Dissolution with metal plus electrolysis
  - **Wet**
    - Low-temperature
    - Acid solution Dissolution plus ion exchange
5. Lithium Battery Recovery

Dry processing for Lithium battery recovery
5. Lithium battery recovery

- Lithium battery recovery
- Discharge
- Push aside shell
- Inorganic Acids solvent
- Absorb chamber
- Residue
- Recovery Li-solvent and electrolyte
- Other metals

Wet processing for Lithium battery recovery
6. Recycling glass with lead

- It would lead to air pollution and acid rain if the process were incinerated.
- It would cause serious pollution if glass were buried in landfill.

Key point

- CRT component
- Lead source
- Neck of glass
- Awl-shaped glass
- Panel-board glass
## 6. Recycling glass with lead

### Waste glass from CRT

<table>
<thead>
<tr>
<th>Waste CRT</th>
<th>Faceplate of glass</th>
<th>Awl-like glass</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Popular kinds</strong></td>
<td>1. Flux Added for bricks/ceramics</td>
<td>1. Flux Added for Melted</td>
</tr>
<tr>
<td></td>
<td>2. Used in the process of brick making</td>
<td>2. Used in the process of new CRT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. recycling</td>
</tr>
</tbody>
</table>
Potential Products with 3R

- Ash
- Sludge
- Electrical raff
- Heavy metal
- Waste Pickling Acid
Technology used for 3R

- Recycling Waste Incinerator Ash
- Electrical raff
- Heavy metal slugging
- Technique for cement
- Recovering Waste Pickling Acid
- Recycling Heavy metal
The end

Thanks for your attention