

Recycling practices and material flow analysis of
mercury-containing fluorescent lamps in Korea

Yong-Chul Jang
Chungnam National University, Daejeon, Korea

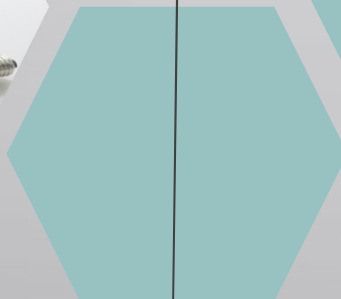
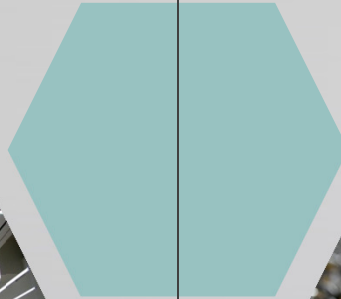
CONTENTS

2. EPR System of Fluorescent Lamps

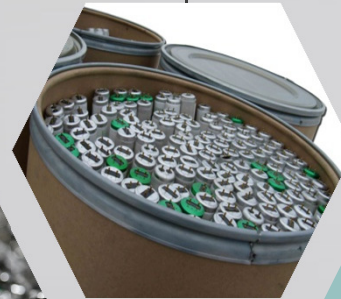
4. Current issues of Spent Fluorescent Lamps management



1. Intro



3. MFA of Fluorescent Lamps



5. Future direction



1.



Introduction

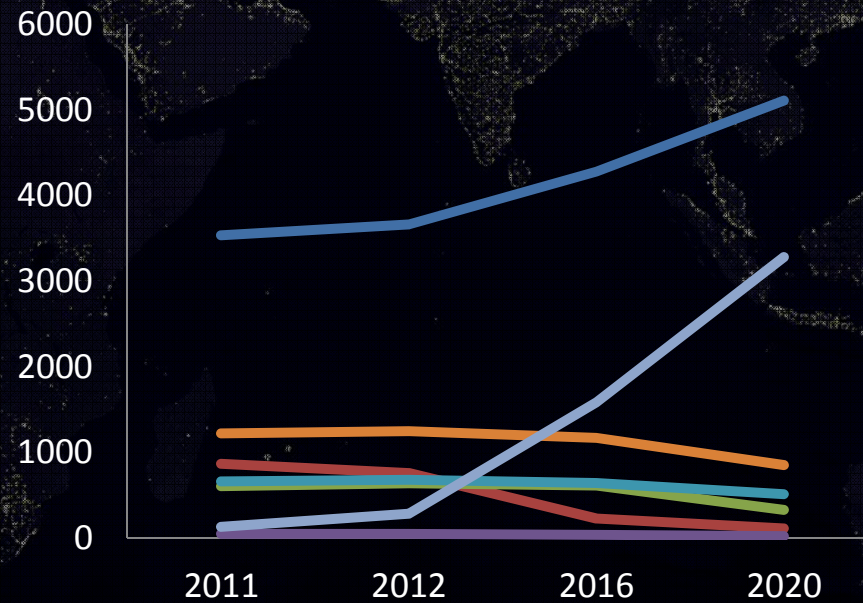
Intro.

World General Lighting Market



4 billion pcs/ year

(Unit : million pcs)

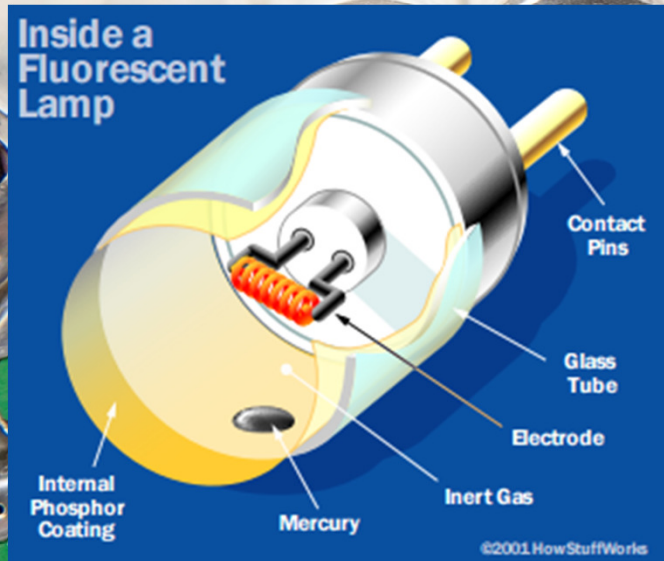


Source : McKinsey, 2012



Intro.

Fluorescent lamps



Quantities of Mercury in Lamps

Type of Lamps	Avg. Amount
CFL (Compact Fluorescent Lamps)	1-25 mg
U-Tubes FL	3-12 mg
Fluomeric Lamps	2 mg
LFL (Linear Fluorescent Lamps)	10-50 mg
Mercury Reduced LFL	3-12 mg
Mercury Vapour Lamps	25-225 mg
Metal Halide Lamps	25-225 mg
Sodium Vapour Lamps	20-145 mg

Source : Guide to Recycling Mercury- Containg Lamps, Northwest Territories Environment and Natural Resource

Intro.

Mercury and Minamata Convention



Hg




Elemental and inorganic
: Exposed directly through occupation

Organic (e.g., Methylmercury)
: Exposed indirectly through diet
(Bioaccumulation)

- Mercury is a chemical of global concern owing to its long-range atmospheric transport, its persistence in the environment, its ability to bioaccumulate in ecosystem and its significant negative effects on human health and the environment.
- Recently, Minamata Convention was agreed to ban on new mercury mines, the phase-out of existing ones, control measure on air emissions in 2013.




MINAMATA CONVENTION ON MERCURY



**MINAMATA
CONVENTION
ON MERCURY**

[HOME](#) [CONVENTION](#) [NEGOTIATIONS](#) [COUNTRIES](#) [AWARENESS RAISING](#) [NEWS](#)



Convention

The Minamata Convention on Mercury is a global treaty to protect human health and the environment from the adverse effects of mercury. It was agreed at the fifth session of the Intergovernmental Negotiating Committee in Geneva, Switzerland at 7 a.m. on the morning of Saturday, 19 January 2013.

The major highlights of the Minamata Convention on Mercury include a ban on new mercury mines, the phase-out of existing ones, control measures on air emissions, and the international regulation of the informal sector for artisanal and small-scale gold mining.


The Convention draws attention to a global and ubiquitous metal that, while naturally occurring, has broad uses in everyday objects and is released to the atmosphere, soil and water from a variety of sources. Controlling the anthropogenic releases of mercury throughout its lifecycle has been a key factor in shaping the obligations under the convention.

THE MINAMATA CONVENTION ON MERCURY HAS BEEN ADOPTED FOR

605 DAYS

SIGNA **128** RATIFIC **12** NS

WATCH THE VIDEO



RELATED

*** Controlling the anthropogenic releases of mercury throughout its lifecycle has been a key factor in shaping the obligations under the convention**

MINAMATA CONVENTION ON MERCURY

Mercury-added Products	
Batteries	Date after which the manufacture, import or export of the product shall not be allowed (phase-out date) <u>2020</u>
Switches and relays	
Compact fluorescent lamps (CFLs) , Linear fluorescent lamps (LFLs) and High pressure mercury vapour lamps (HPMV) for general lighting	
Mercury in cold cathode fluorescent lamps and external electrode fluorescent lamps (CCFL and EEFL) for electronic displays	
Cosmetics (with mercury content above 1ppm)	
Pesticides, biocides and topical antiseptics	
non-electronic measuring devices: (a) barometers; (b) hygrometers; (c) manometers; (d) thermometers; (e) sphygmomanometers.	
Dental amalgam	Measures to phase down the use



2.



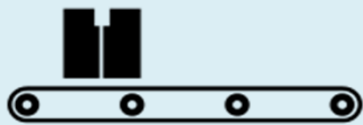
EPR System of FL in
Korea

EPR : Extended Producer Responsibility



EPR system is an environmental protection strategy to decrease total environmental impact of a product, by making the producer of the product responsible for the entire life-cycle of the product and especially for the take-back, recycling and final disposal.

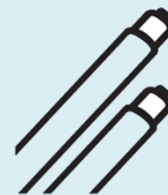
Responsibility



Production



Sale



Cosumption



Discard



Recycling





Past



Present



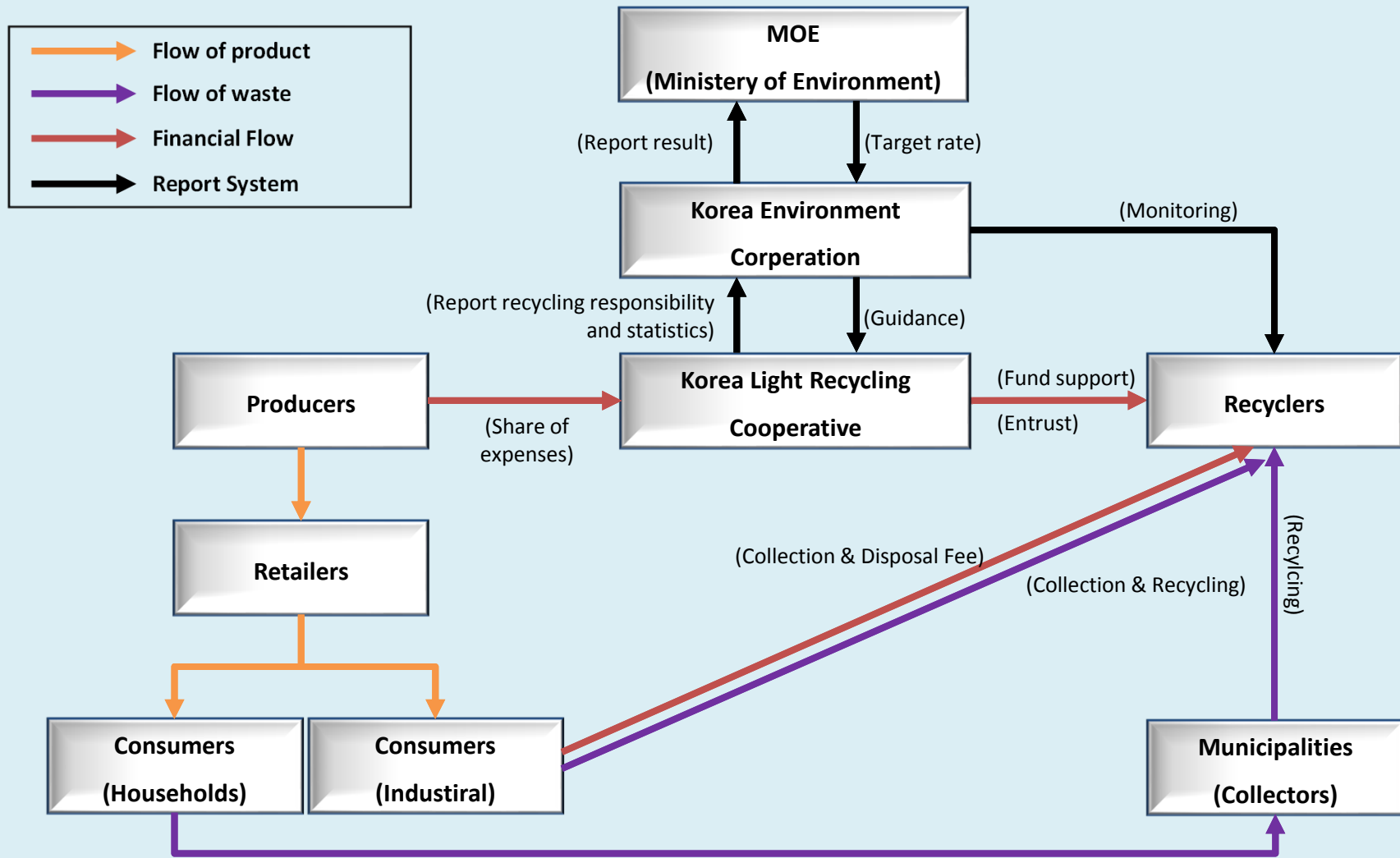
Recycling targets of fluorescent lamp in Korea EPR system

Linear shape (LFL)	Round shape (FCL)	U-tube shape (FPL)	Contains inverter (CFL)
			

- ▶ In Korea, there are 4 recycling targets of FL in EPR system .
- ▶ Each year, recycling target rate of used lamps is set and should be achieved.



EPR system of fluorescent lamp in Korea



(Source : MOE, EPR 시행 10년 성과평가 및 발전방향 연구, 2010)



Collection points of fluorescent lamp in Korea



Collection points of fluorescent lamp in Korea



Transfer station of fluorescent lamp in local government



Mercury lamps waiting for disposal at collection site in Korea

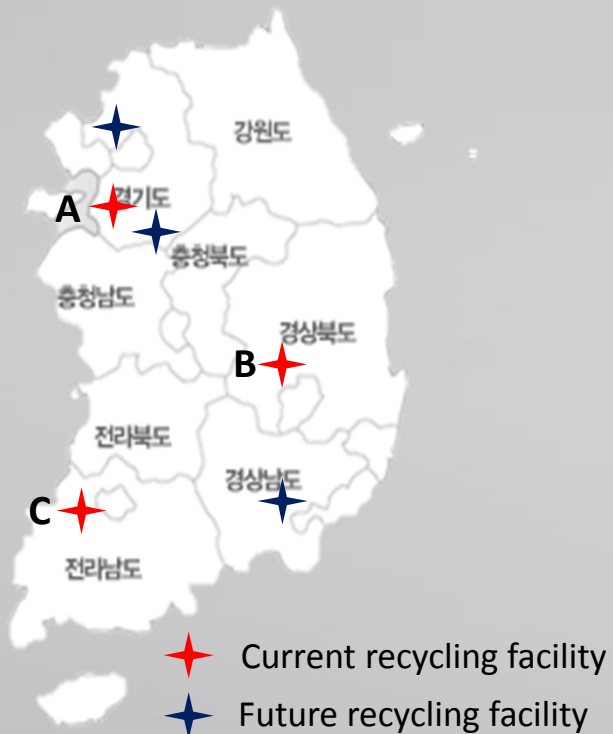
(Source : SBS News 2014. 10. 30)

Improper disposal of mercury lamps causes a concern in community by media in 2014





FL recycling facilities in Korea

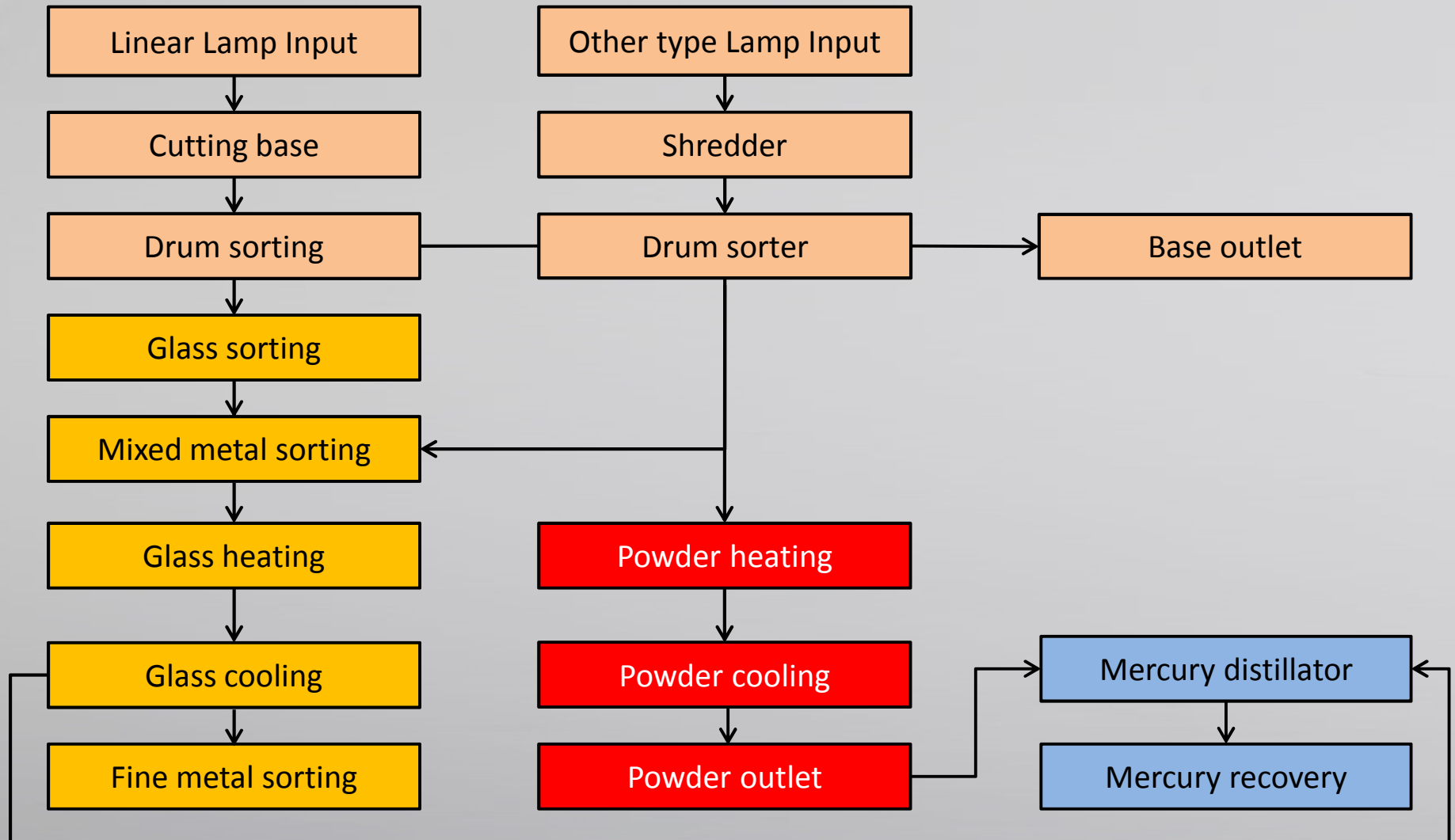


	Facility A	Facility B	Facility C
Equipment	Straight type 1 line other type 3 line HID type 1 line	Straight& other type 1 line	Straight& other type 1 line
Treatment Capacity	Straight type : 5,000 unit/h HID type : 2,500 unit/h	Straight & other type : 5,000 unit/h	Straight&other type : 5,000 unit/h
Treatment Technology	Modified MRT (Sweden)	Modified Herbon (Germany)	Modified Herbon (Germany)

- ▶ There are 3 FL recycling facilities operated in Korea
- ▶ 3 more FL recycling facilities are planned to operate in 2015



General SFL recycling process in Korea

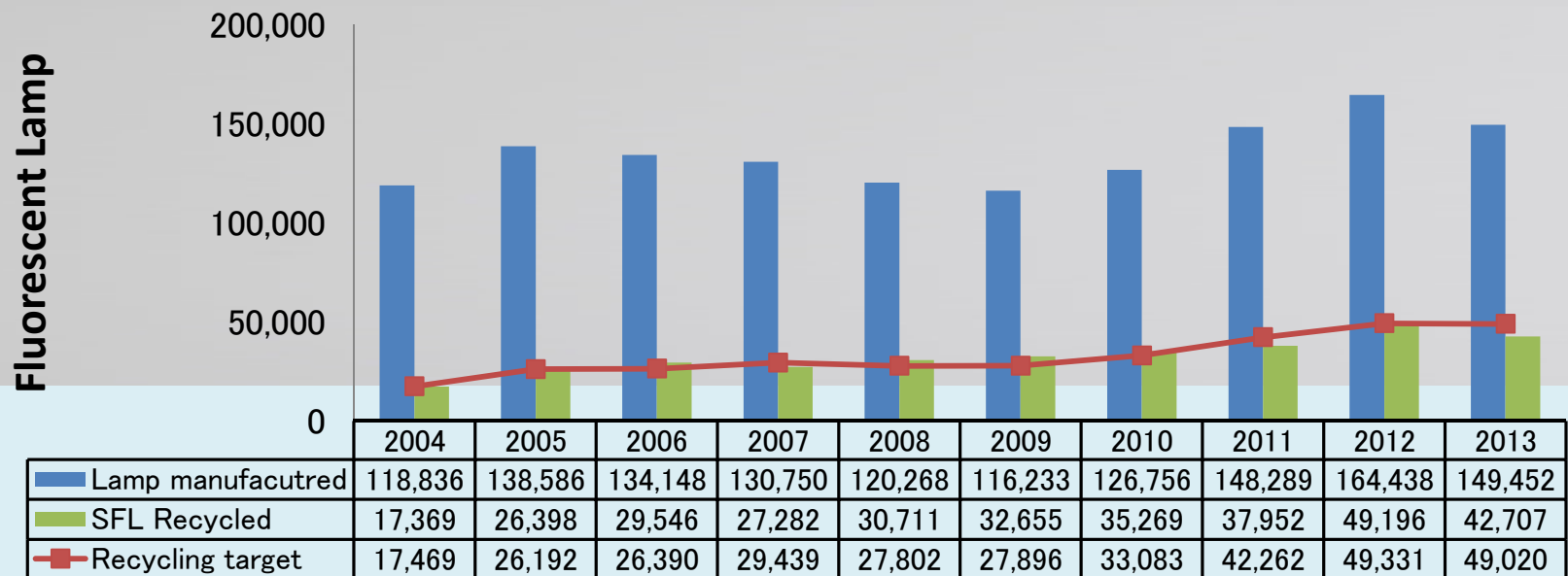


Source : Korea Lighting Recycling Corporation

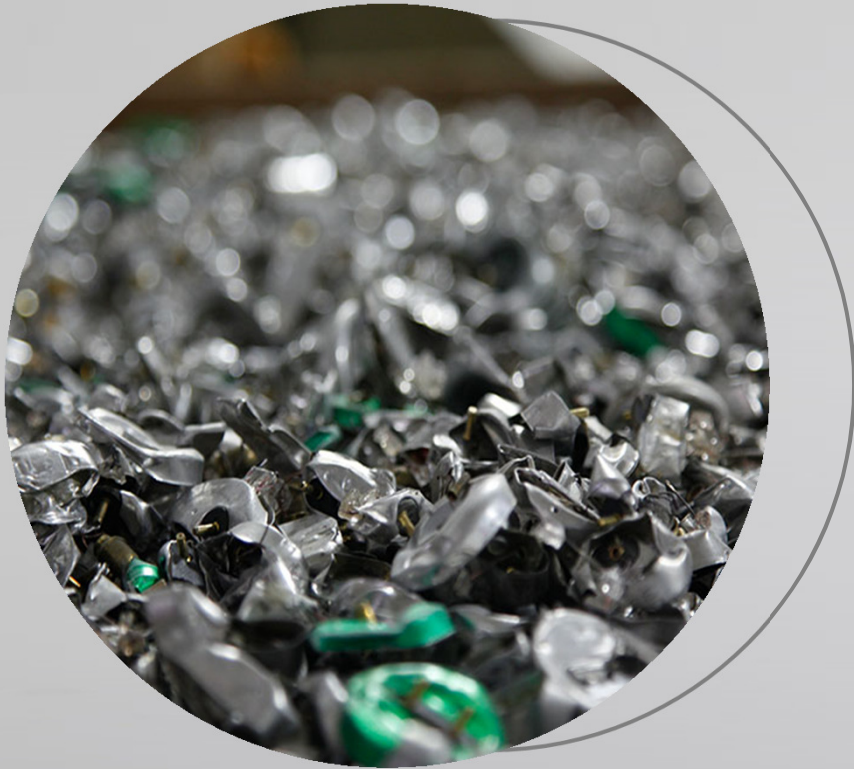


Statistic Data of FL Management in Korea

(Unit : 1,000 unit)



- ▶ SFL Recycling target has been continuously increasing since 2004
- ▶ SFL recycling rate is still low compared to the amount in the market.



3.

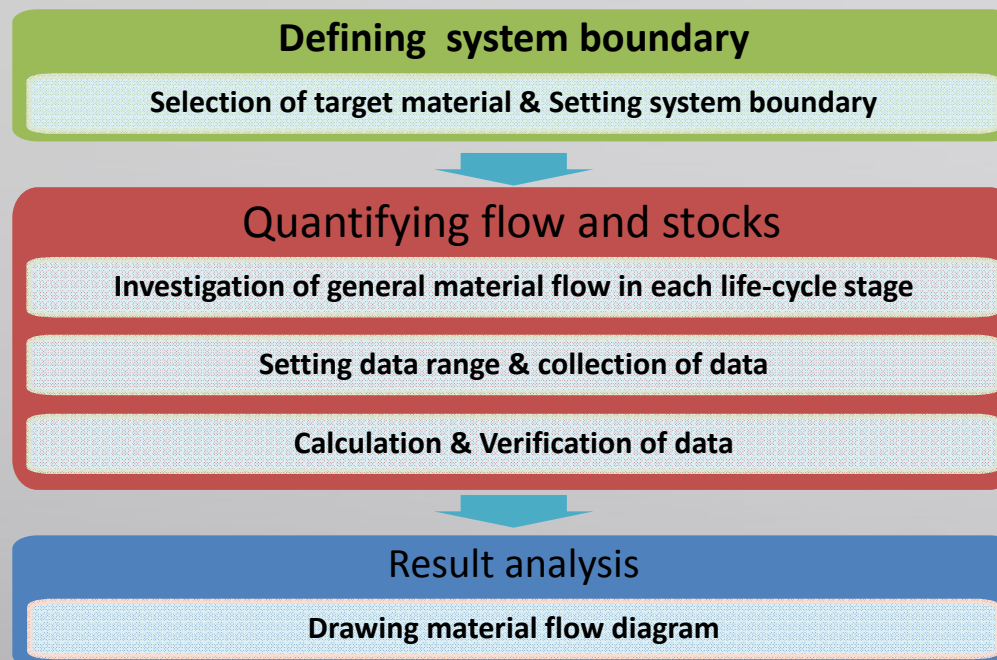


MFA of lamps in
Korea



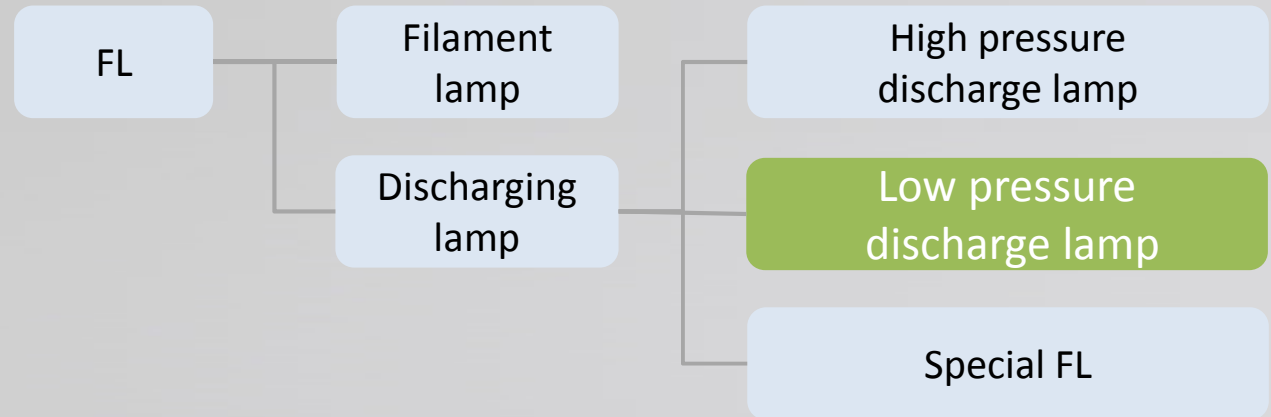
MFA Definition

MFA (Material Flow Analysis) is an analytical method of quantifying flows and stocks of materials or substances in a well-defined system. It is based on the law of mass conservation.

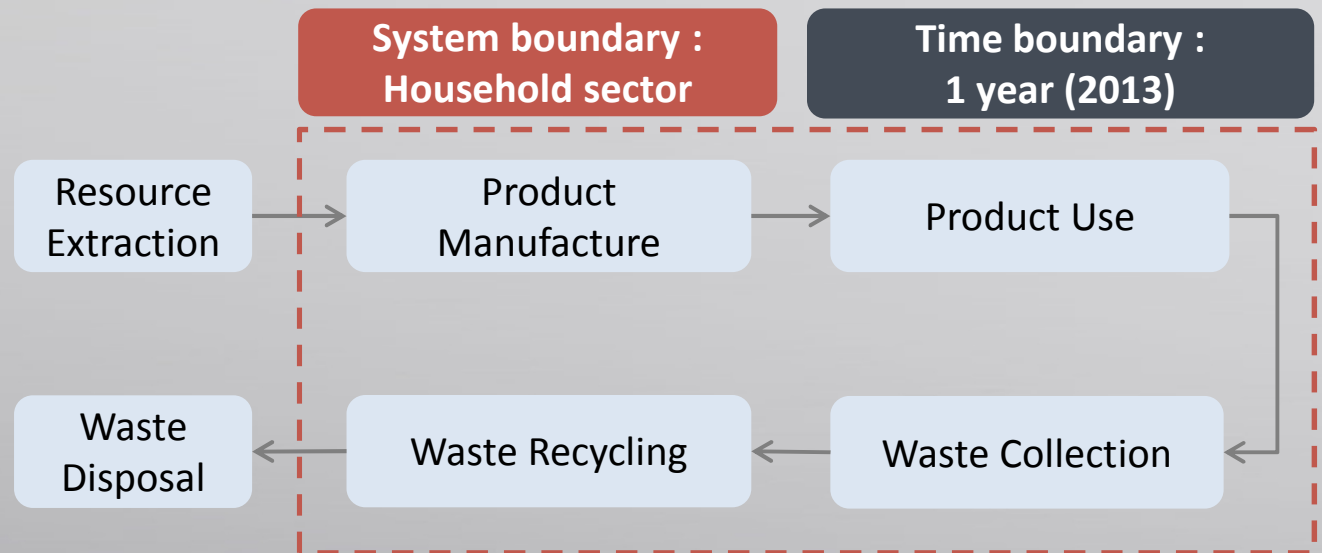


<MFA Process >

Target of MFA subject of Fluorescent lamps



Defining system boundary



Data collection & Sources for MFA of FL

Data collection : Field & Literature survey

- ▶ Data of disposal stage was not sufficient whereas data of production stage and recycling stage is available to collect
- ▶ Stages difficult to collect data were estimated through field survey, literature investigation, expert advice
- ▶ When data estimated through mass balance had uncertainty, they were modified and complemented with consideration of material flow interrelationship

Life cycle	Data	Data collection method		
		Statistics	Literature survey	Field survey & advice
Import	FL Import	○		
Production	Shipment	○		
	FL Production·Domestic market·Export	○		
	LED market		○	
Use	Household use		○	
	Industrial use		○	
	Stock			○
Collection	Municipality collection	○		
	Collection by entrustment	○		
	Dumping			○
Recycling	Input of RC	○		
	Output of RC	○		
Disposal	Incineration		○	
	Landfill		○	



Unit : 1,000 unit

	Total Output	Import	Production	Shipment	Stock	Domestic Market	Export
2013	149,453	107,521	45,958	45,572	4,129	41,932	3,640

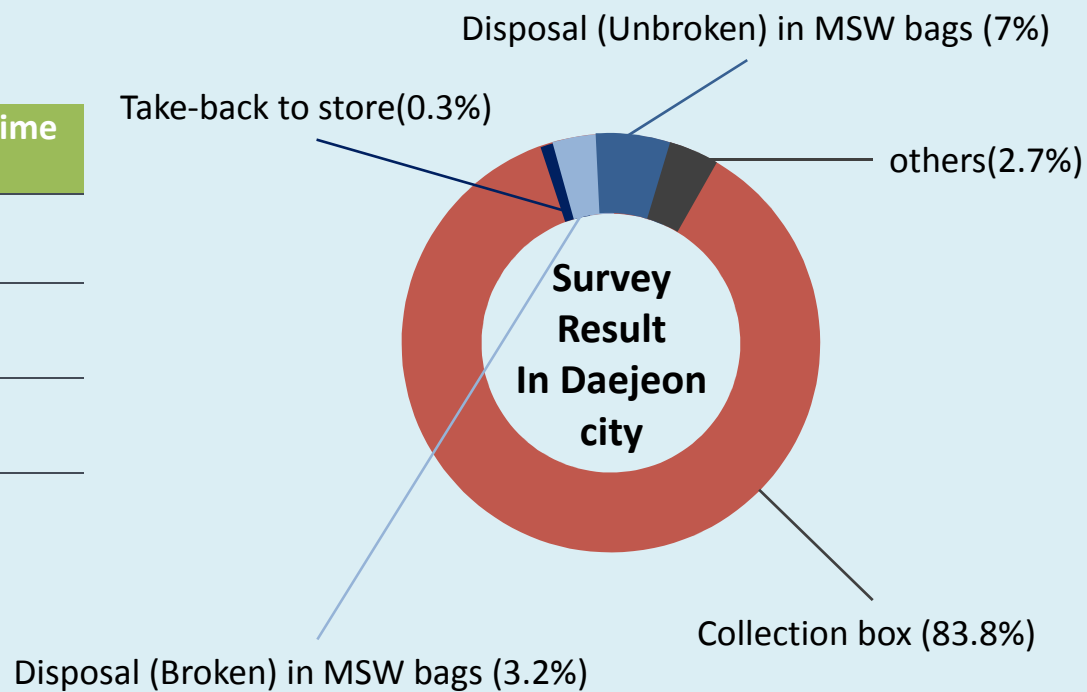
*Source : Statistics Korea, Korea Environment Corporation

- ▶ Shipment = Domestic Market + Export
- ▶ Total Output = Domestic Market + Import



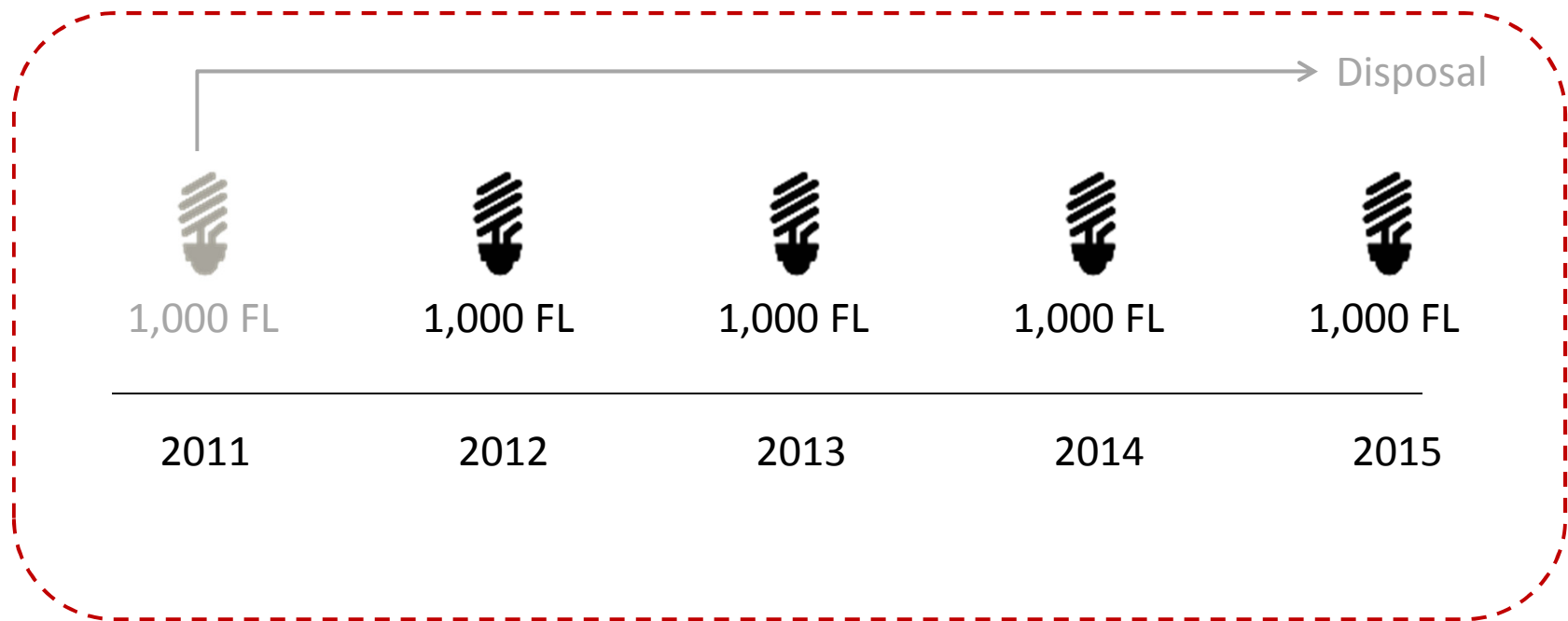
**Product
Life Time**

Source	Product Life time (Years)
Korean Standards & Certification	2.47
Green Purchasing Network	2.81
OSRAM	5.21
Average	3.5



Example-Lifetime

Produce 1000 unit/ year, Product Life time : 4 years





SFL componets by product type

Unit : g, %

	Straight FL	Compact FL	Contains inverter	Average	% Ratio
Glass	134.60	89.60	54.90	103.43	80.2%
Fluorescent material	2.80	0.90	0.05	1.64	1.3%
Metal	1.45	1.20	0.60	1.18	0.9%
Aluminum	2.25	-	3.30	1.95	1.5%
Glue	9.10	2.90	90	7.25	5.6%
Plastic	-	9.80	18.90	7.18	5.6%
Inverter	-	-	25.40	6.35	4.9%
Sum	150	104	111	128.96	100.0%

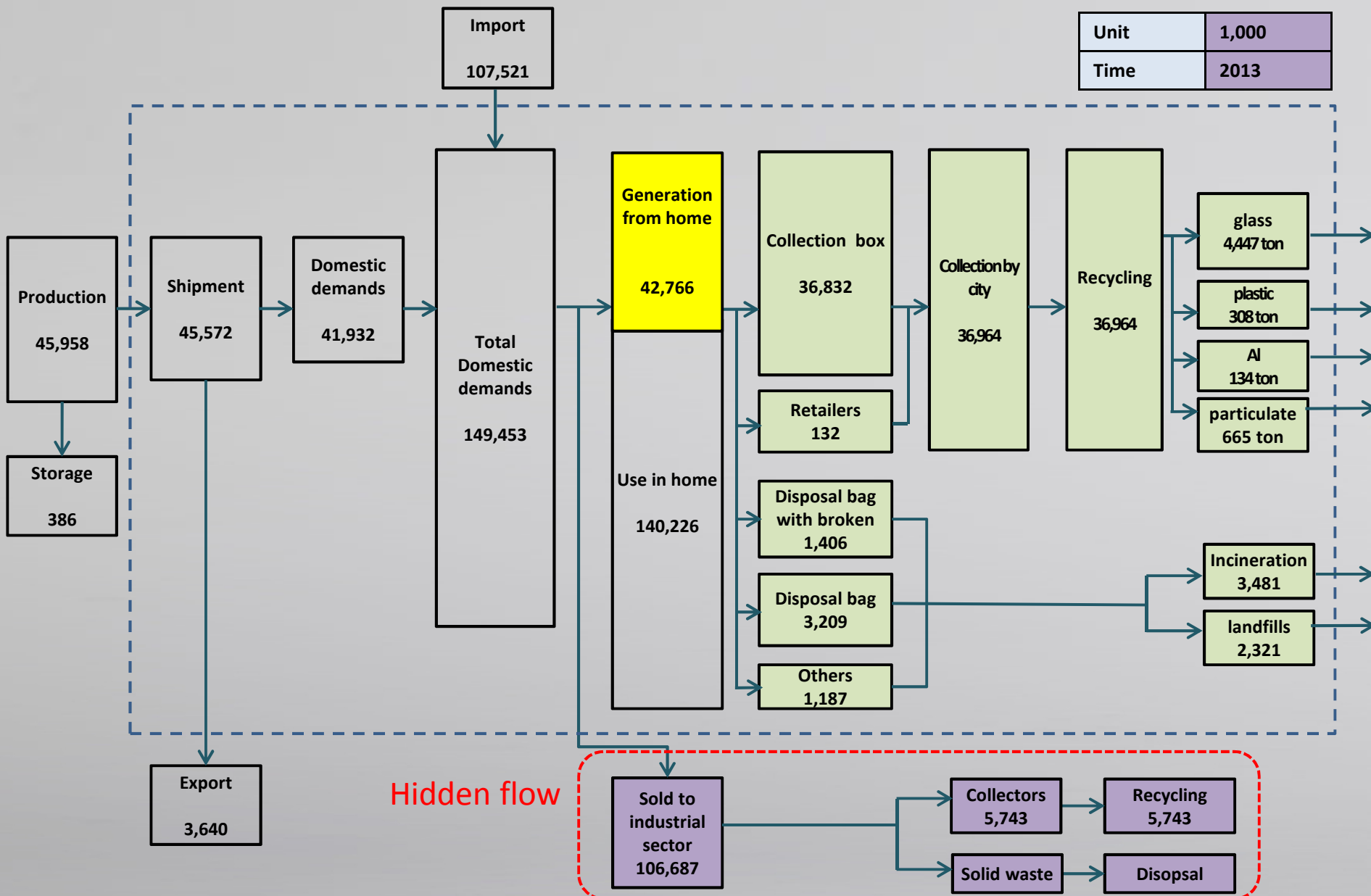
SFL recycling amount by componets

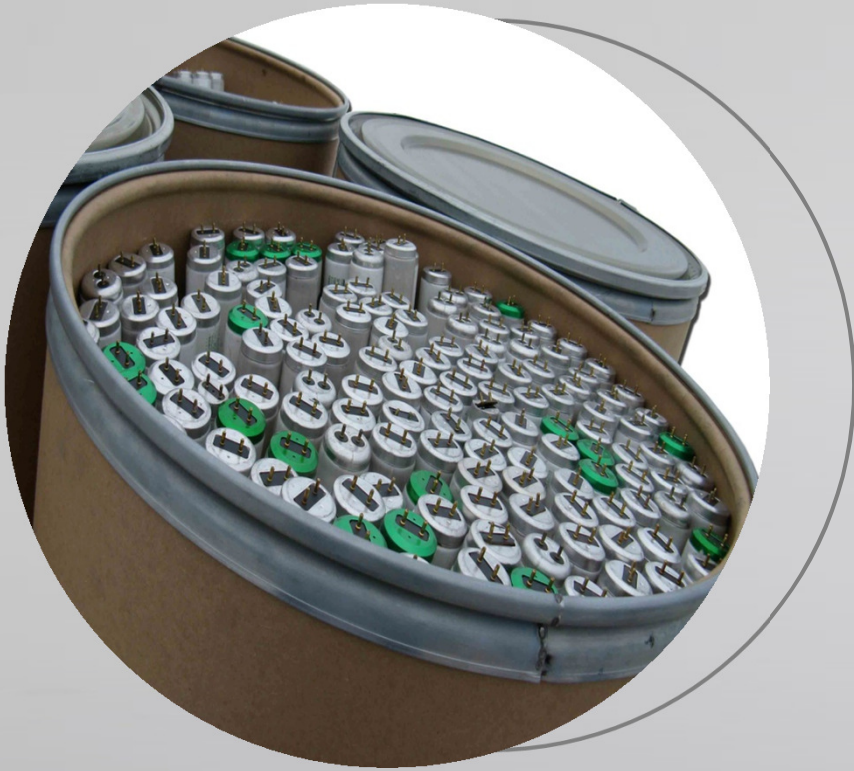
Unit : g, %

	% Ratio	Recycling amount	Actual result*
Glass	80.2%	4,447	4,015
Plastic	5.6%	308	372
Aluminum	2.4%	134	170
Powder	11.8%	655	469
Sum	100.0%	5,545	5,025

* Source : Korea Environment Corporation

MFA





4.



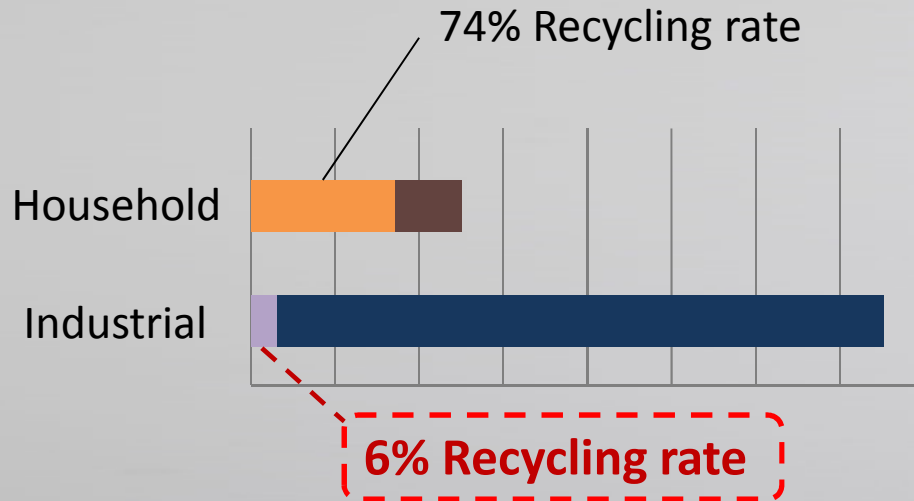
Current issues of lamps

Management in Korea



- If SFLs are discharged in broken shape, mercury vapor will be exposed to the surrounding environment
- Mixed waste in SFL collection box caused additional cost and labor force on segregation and collection stage

Current issues of SFL Management in Korea



Unit : 1,000 unit

	Generation	Recycling
Household	50,000	36,964
Industrial	100,000	5,793

- Recycling rate from industrial sectors is relatively low compared to household sectors



- ▶ Transportation cost is high because of long distance from municipality to recycling facility
- ▶ Cumulated SFL have been issued in capital region because of high transportation cost and long distance



- ▶ Mercury concentration in recovery materials was higher than standard level(0.005mg/L)
- ▶ There is no regulation on mercury concentration in recovery materials of SFL
- ▶ Mercury concentration in workplace atmosphere was higher than OSHA PEL standard in US (lower than 0.1 mg/m³ every moments)
- ▶ Management of elemental mercury storage and transportation was incomplete
- ▶ Introduced recycling technology from abroad was modified or some facilities are eliminated for convenience

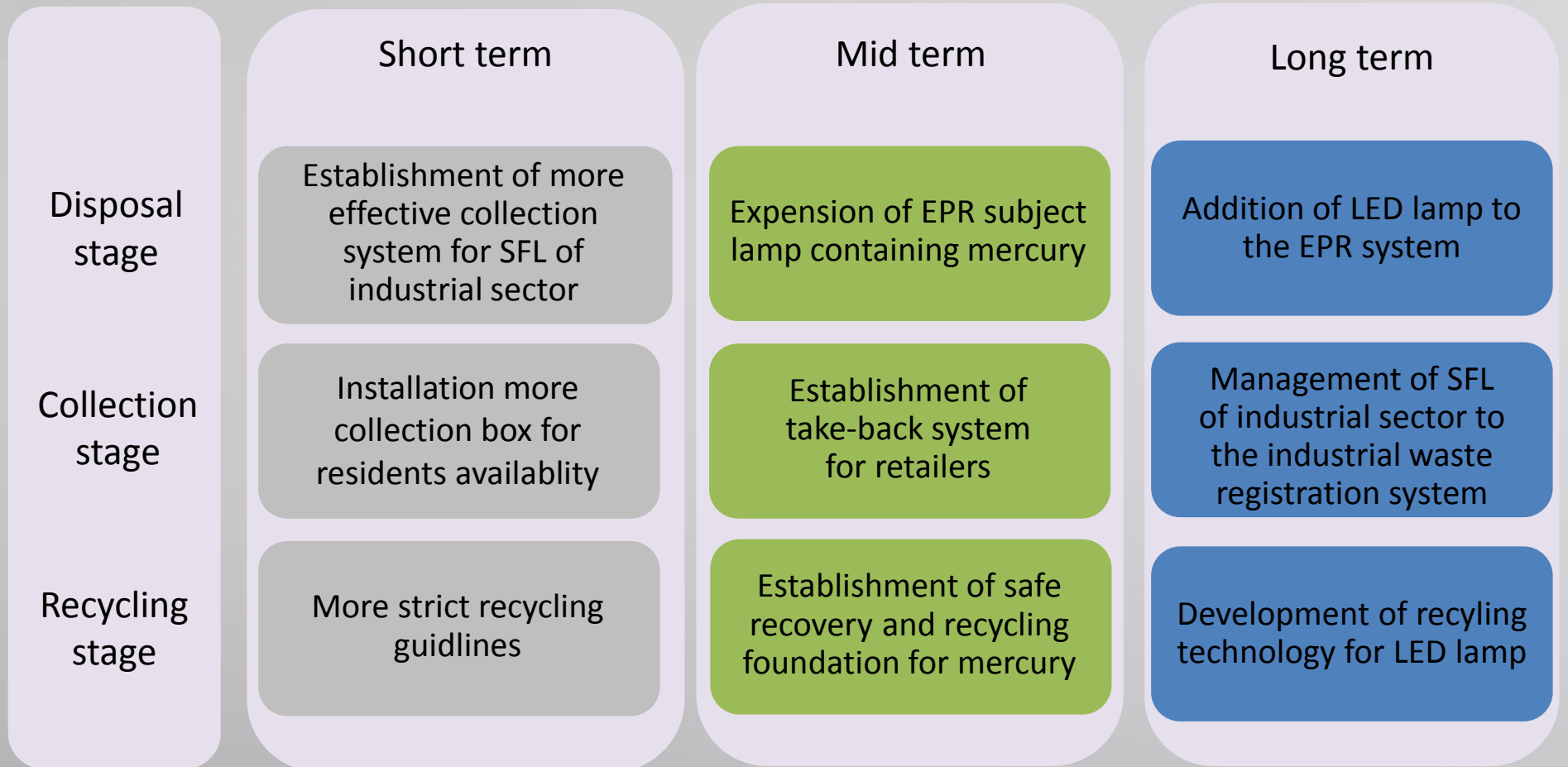


5.



Future Directions
and summary

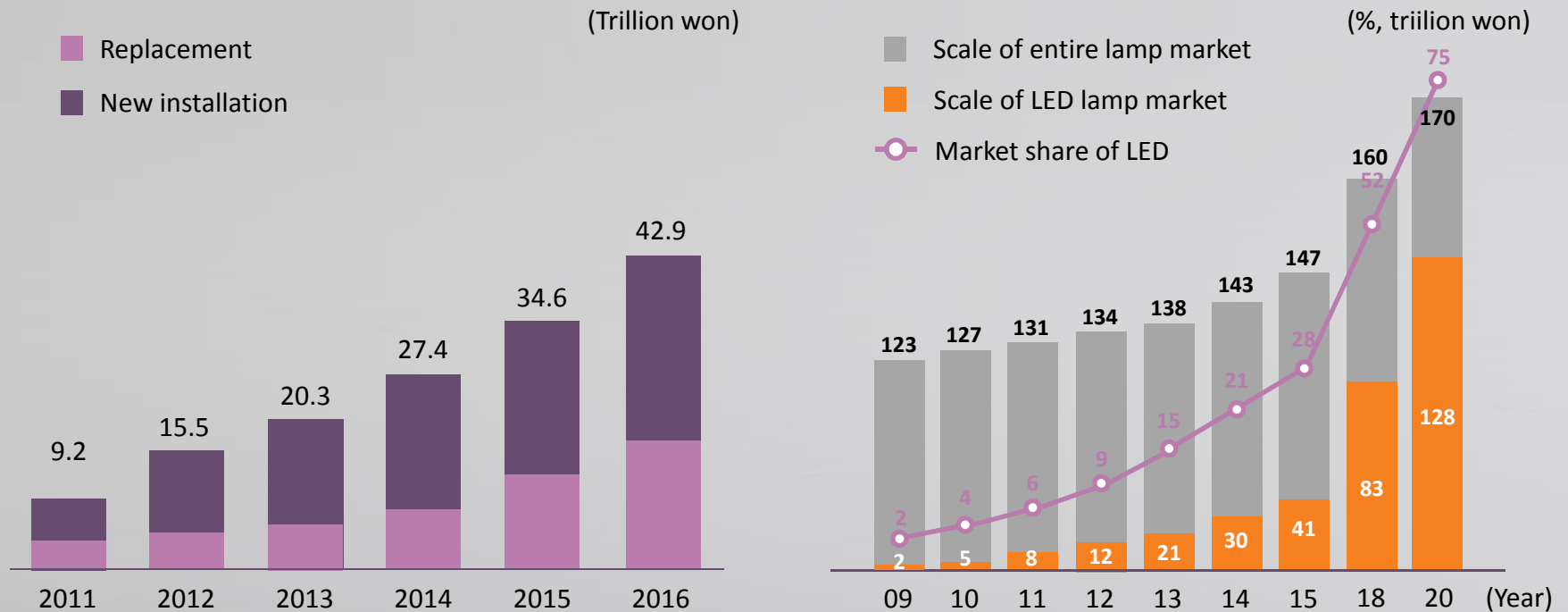
Remediation direction of SFL management



Future Direction



Current states and anticipation of the world LED industry



(Source : Meritz Investment Bank Research Center)

- LED lamp market is anticipated to sharply grow with decreasing LED price and impelmentation of carbon emission trading system
- Life-time of LED lamp (30,000-50,000 hours) is 3~4 times longer than that of fluorescent lamp (8,000 hours)

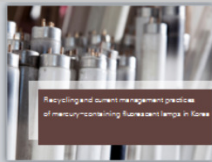
Future Direction

LED lamp

- Even though LED lamp doesn't contain Mercury, it has hazardous and valuable materials such as antimony, copper, lead, nickel, and zinc
- In some crushed specimen, leaching test results showed some concerns of leaching due to several hazardous materials found in LED lamp (Lim et al., 2010)
- Some EU country have already been implementing LED recycling duty with fluorescent lamp
- It may be required to add LED lamp to the EPR system and establish appropriate management directives

Thank you for your attention !

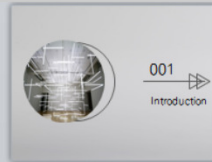
Q&A



1



2



3



4

5



6



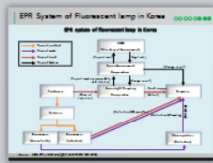
7



8

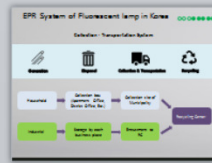


9



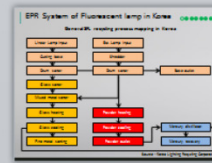
10

11

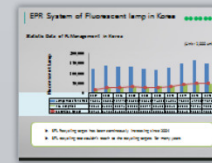


12

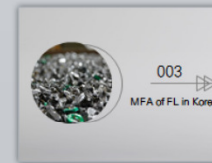
13



14

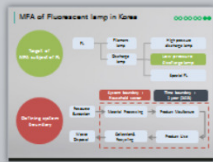


15



16

17



18

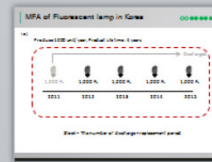
19



20

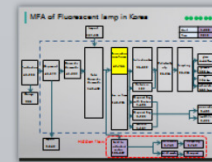


21

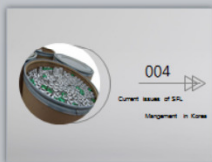


22

23



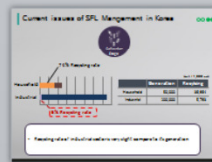
24



25



26



27



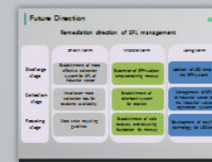
28



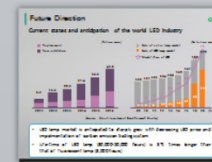
29



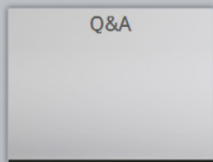
30



31



32



Q&A