



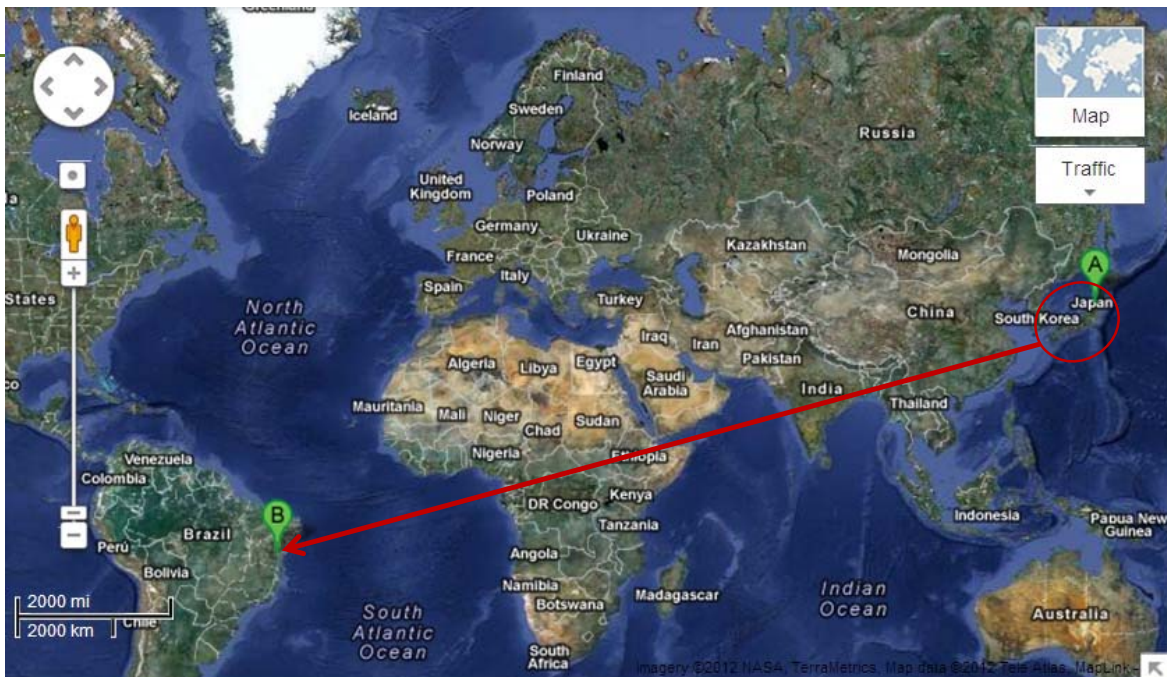
# Technology routes of municipal solid waste management in Japan

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## SWM in Japan



## Background information about Japan

- Has 6,852 islands with total area of 377, 835 sq. km (4.4% of Brazil's area)
- 126 million people (66% of Brazil's population)
- 336 persons per sq. km (15 times higher than Brazil's population density)



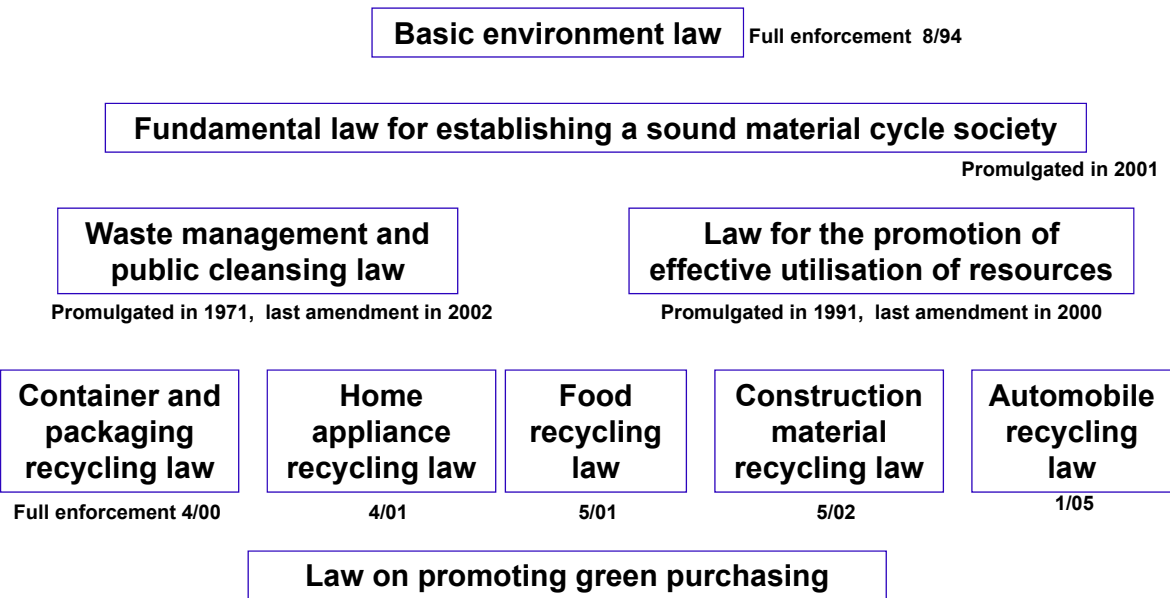
**Land scarcity is a major problem of SWM**

Remaining lifetime of landfill in 2000 was 12.8 years

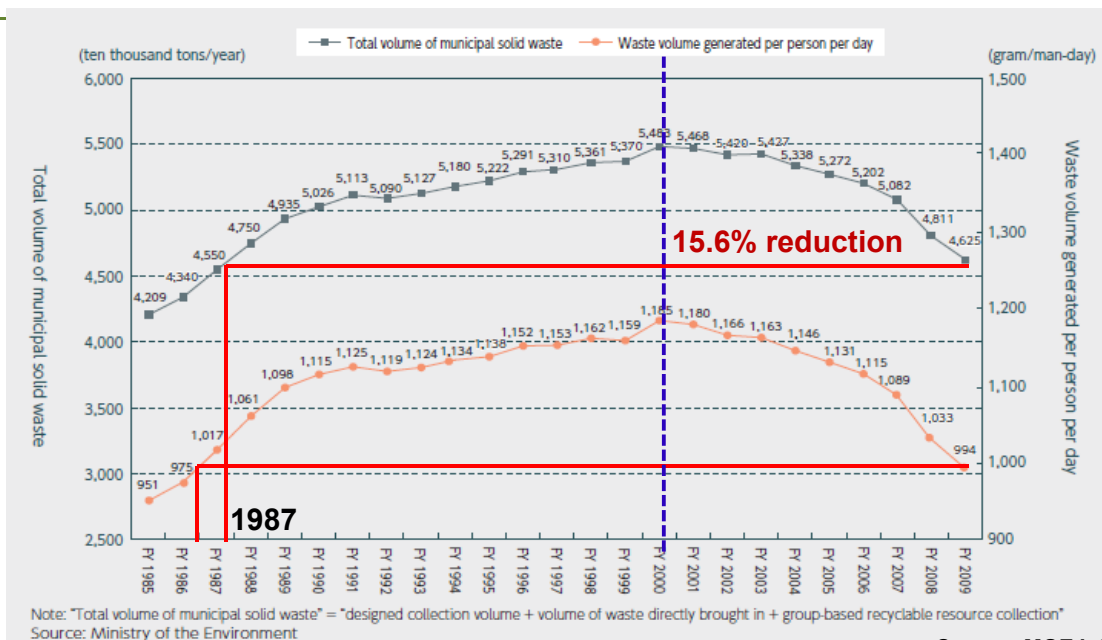
## How to extend lifetime of final disposal site?

- **Decrease waste to final disposal site**
  - Increase resource efficiency or promoting sound material cycle society → the 3Rs (reduce, reuse, recycle - including co-processing and energy recovery)
  - Incineration
- **Shortening biodegradation process in landfill**
  - Semi-aerobic landfill
- **Find new landfill site**
  - Sea reclamation for landfill → **Recently, it is not acceptable for new site development**

## Examples of regulation and policy that aligned with the sound material cycle society

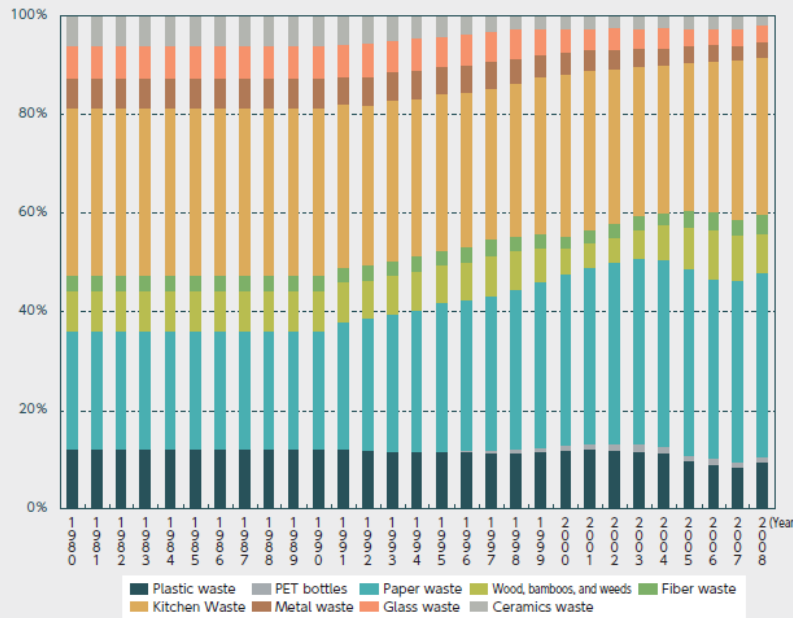


## Changes in MSW generations after introducing the sound material cycle society and 3R policies



Source: MOEJ, 2012

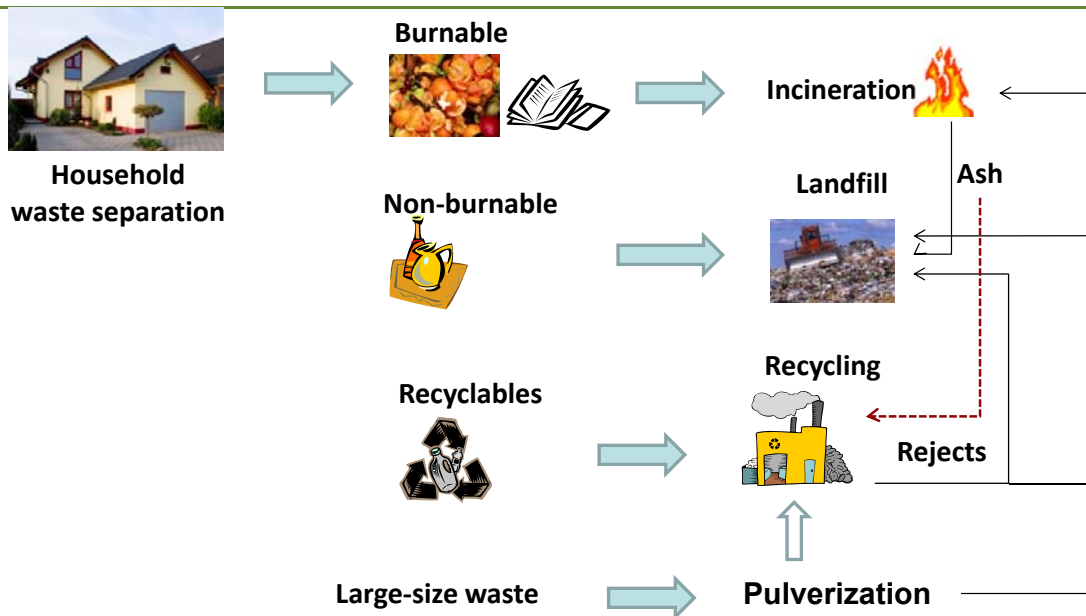
## Waste composition



- Paper ≈ 38%
- Food ≈ 31%
- Plastic & PET ≈ 10%
- Plant residues ≈ 8%
- Fibre ≈ 4%
- Glass ≈ 4%
- Metal ≈ 3%
- Ceramics ≈ 2%

Source: MOEJ, 2012

## Mandatory waste separation at source for efficient utilisation and treatment



# Detailed manual for waste separation of each city

Household brochure  
 23年度英語版  
 April 2011 edition  
**Separation and Disposal of Garbage and Recyclables**  
 ~ごみと資源物の分け方・出し方~

Table of Contents  
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In the City of Yokohama, we collect garbage and things that can be recycled by separating them according to type.

燃やすごみ Dry-Cell Batteries	スプレー缶 Spray Cans	燃えないごみ Non-burnable Garbage
プラスチック製容器包装 Plastic Containers and Packaging		
びん・ペットボトル Cans, Bottles, and PET Bottles	小さな金属類 Small Metal Items	
古紙(新聞、段ボール、雑誌、紙パック、その他の紙) Paper (Newspapers, Cardboard, Magazines, Milk Cartons, Other Paper)		
布巾 Used Cloth	特大ごみ Oversized Garbage	

We ask that you cooperate with us through the 3Rs in order to protect the earth's environment and build a sustainable recycle-based society.

Resources & Waste Recycling Bureau  
 資源・ごみ管理課  
 横浜市政局環境部  
<http://www.city.yokohama.jp/jp/ig/igenv/>

What is 3R?  
**R**educer: Reduce the garbage itself.  
**R**euse: Use many times.  
**R**ecycle: Separate and use again as a Resource.

Separation and Disposal of Garbage and Recyclables

Please collect the collection materials at your designated pickup area and with the following instructions.

**Specifics**

- Charitable Donations:** Please use designated donation boxes for clothing, books, and other items.
- Spray Cans:** Please use designated collection points for spray cans.
- Dry Cell Batteries:** Please use designated collection points for dry cell batteries.
- Plastic Containers and Packaging:** Please use designated collection points for plastic containers and packaging.
- Cans, Bottles, and PET Bottles:** Please use designated collection points for cans, bottles, and PET bottles.
- Small Metal Items:** Please use designated collection points for small metal items.
- Paper:** Please use designated collection points for paper.
- Used Cloth:** Please use designated collection points for used cloth.
- Oversized Garbage:** Please use designated collection points for oversized garbage.

# Clear instruction of waste discard schedule (date and time) at waste collection points

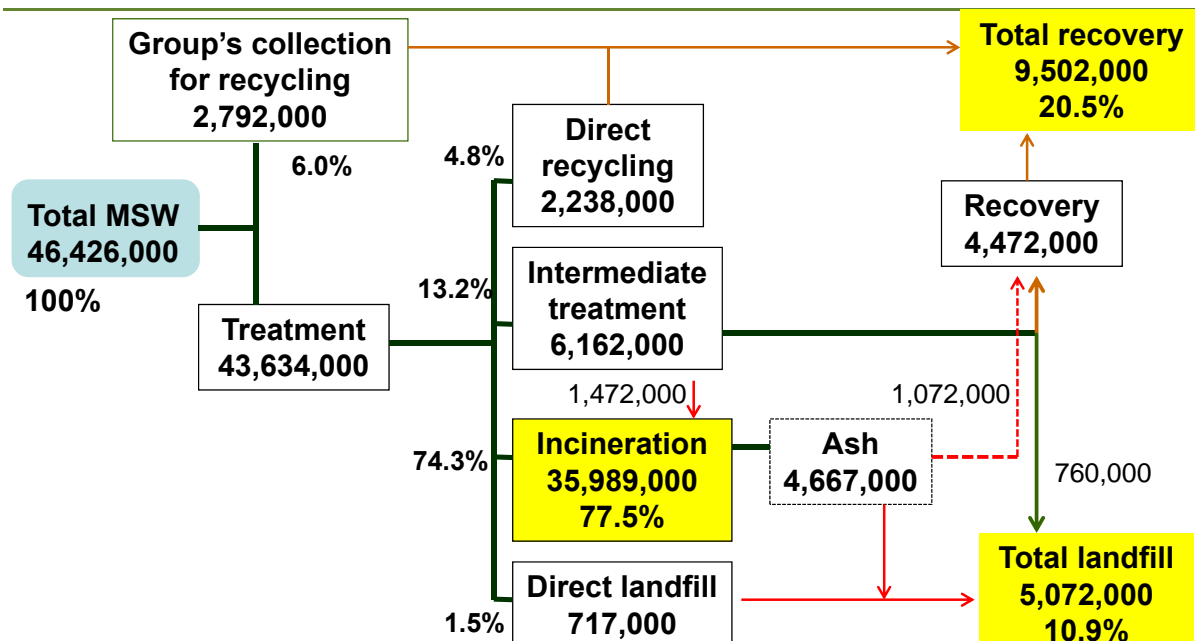


## Coverage of waste separation at source

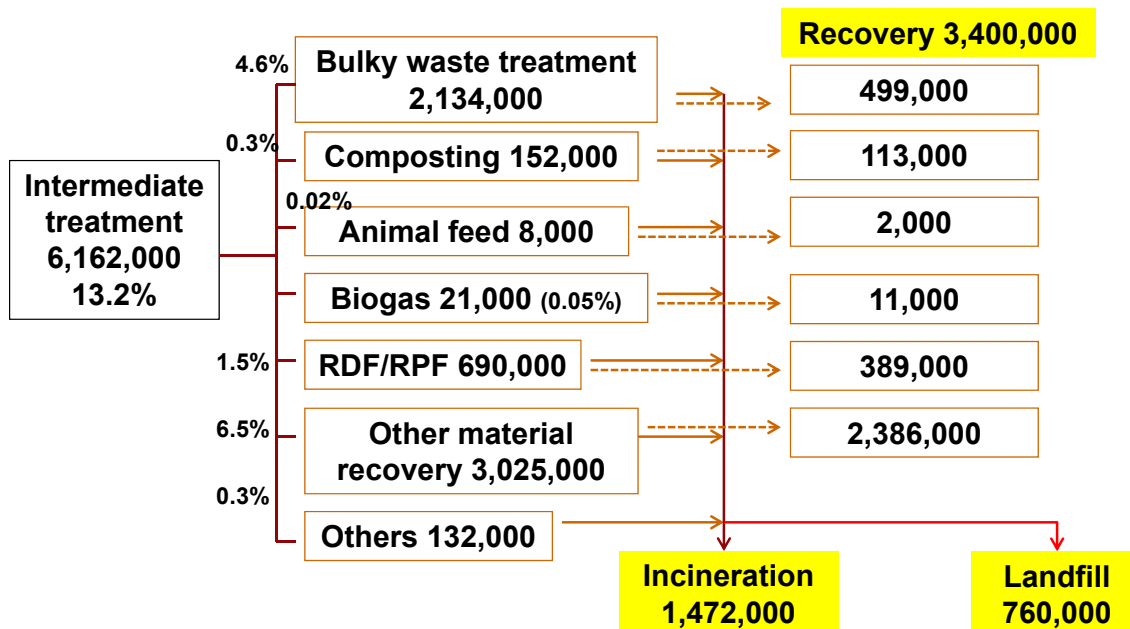


- 98% of municipality (out of 1750) implemented waste separation at source which covered 99% of population
- However, 86% of population is practicing waste separation
- The champion of less waste generation is Nosegawa village in Nara Prefecture (212 g/person/day in 2009).
- The champion of recycling is Osaki town in Kagoshima Prefecture (80.2% in 2009).

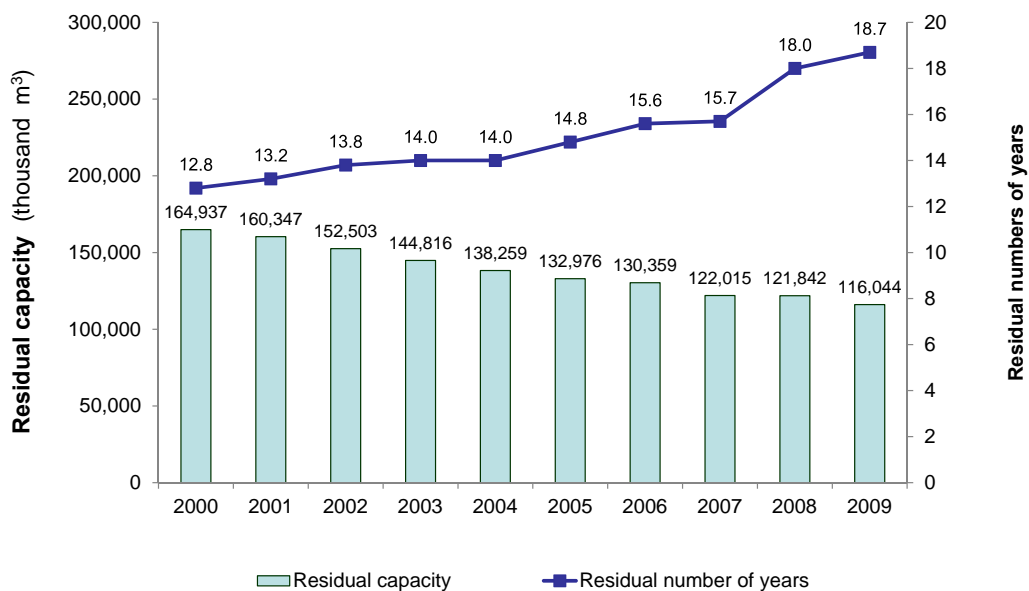
## MSW treatment flow in 2009



## Breakdown of intermediate treatment



## Changes in residual lifetime of landfill



## Changes in cost for MSW management

Year	Total cost (billion JPY )*	Cost per head (JPY/person/yr)*	Cost per tonne (JPY)*
2000	2,371 (47.4)	19,700 (394)	56,329 (1,127)
2004	1,934 (38.7)	15,200 (304)	36,236 (725)
2008	1,817 (36.3)	14,200 (284)	37,766 (755)

\* Values in (..) are Brazil Real

## Incineration

- Since 1990s, incineration plant in Japan is upgraded to large-scale with 24 hours operation to avoid dioxin emission
- To operate this large-scale incinerators, Japanese municipalities have to collect wastes in mass-scale in continuous manner.
- At the same time, rebuilding of old facilities into new large-scale facilities and its running/operating cost has become very expensive.
- Yokohama City can save operation cost of SWM by 3 billion JPY/year (60 M BRL) by discontinuing 2 incineration plants in 2000, however the costs for intensive source separation and recycling were increased by 2.4 billion yen/year (48 M JPY). Thus, the net annual cost savings were 600 M JPY (12 M BRL) (Hotta, 2012).



## Incineration

Capacity (tonnes/day)	Number of plants	Number of plants equipped with power generation
less than 30	288	1
30 to 50	142	1
50 to 100	225	8
100 to 300	392	123
300 to 600	136	113
larger than 600	60	58
<b>Total</b>	<b>1,243</b>	<b>304*</b>

\* Power generation in 2009 was 6,876 GWh/yr (11.29% efficiency)

## Incineration

Category	Number of facility
<b>Incineration with heat recovery</b>	
Hot water utilization within a facility	727
Hot water supply to the outside	240
Steam utilization within a facility	238
Steam supply to the outside	99
Power generation within a facility	301
Power generation in the outside	181
Others	46
Subtotal	800*
<b>Incineration without heat recovery</b>	443
<b>Total</b>	<b>1,243</b>

\* Excluding double counting

Source: modified from MOEJ, 2011

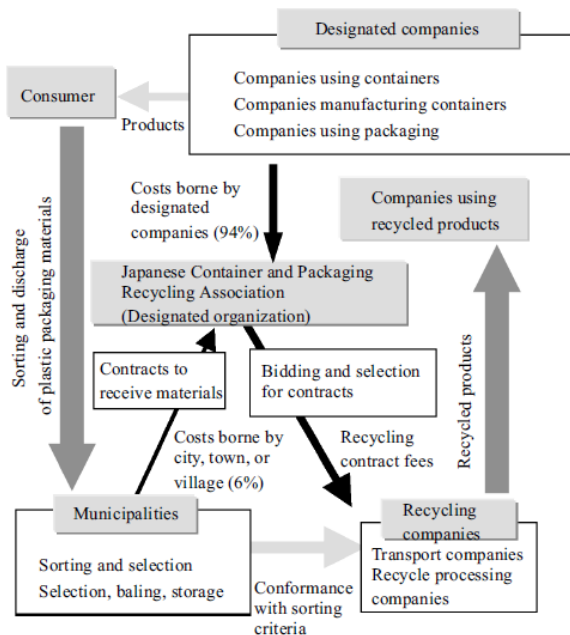
## Example of cost for construction and operation of an incineration constructed in 2000

Incineration facility	Construction cost (million JPY per capacity of one tonne/day in 2000)*	Operation cost** (JPY/tonne)
Incineration	40.48 (0.99 million BRL)	33,905 (829 BRL)
Power generation	9.52 (0.23 million BRL)	3,179 (77 BRL)
Total	50.00 (1.22 million BRL)	37,084 (906 BRL)

\*Capacity of 420 tonnes/day;

\*\* Estimated operation for 20 years = 1,764,000 tonnes of total waste incinerated

## Mandatory recycling scheme



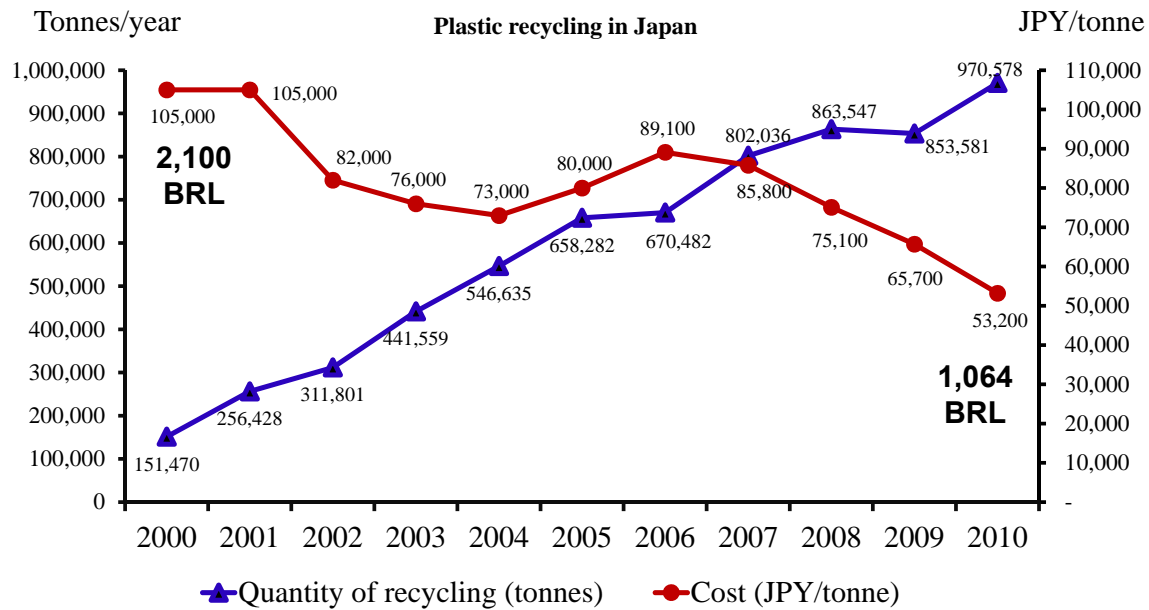
### Mandatory for recycling

- Plastics, PET, Paper, Glass

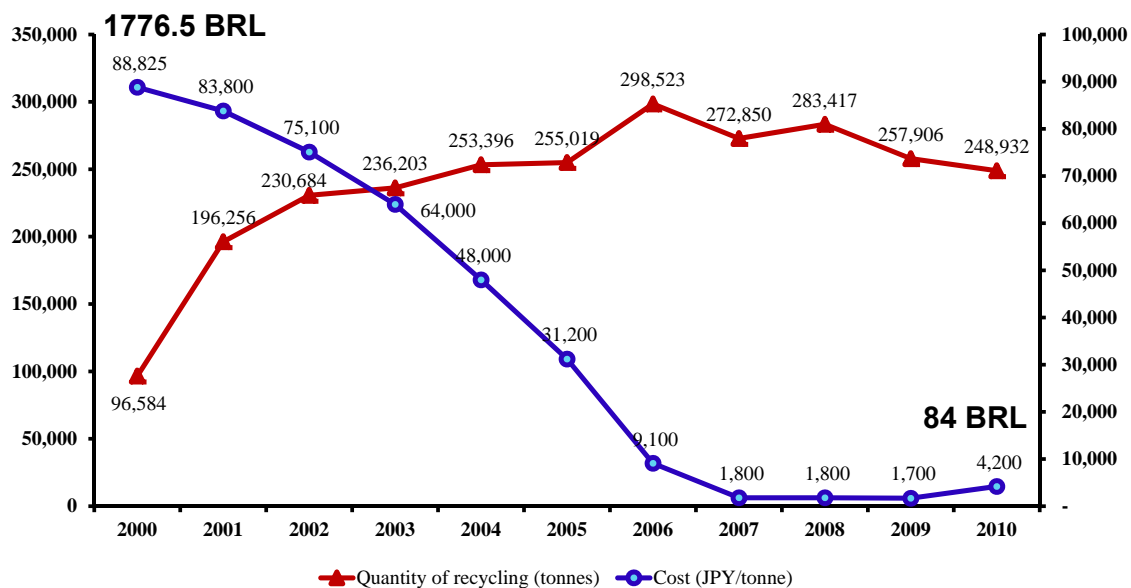
### Mandatory for sorted collection

- Metals, Cardboards, Cartons

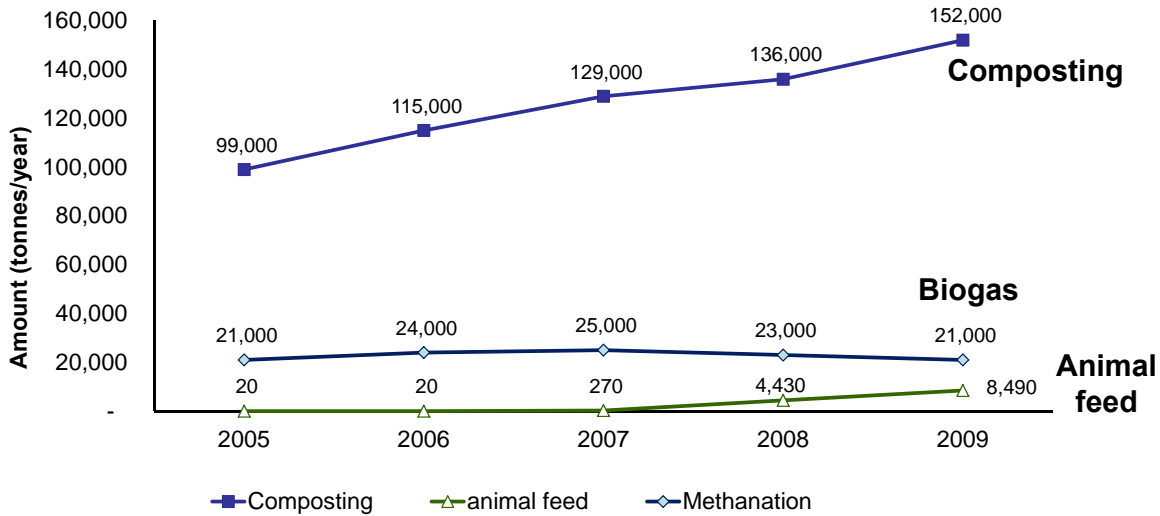
## Plastic recycling is the most expensive recycling treatment



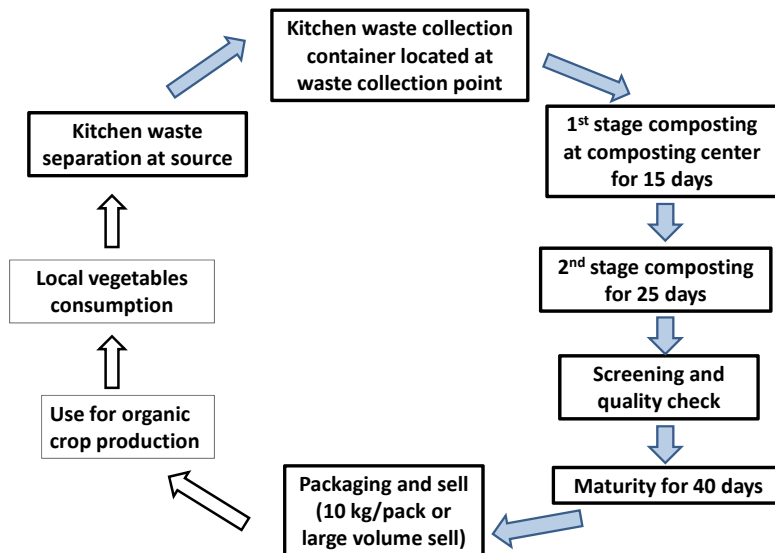
## PET recycling is very cheap



## Kitchen waste utilisation



## Closed loop composting model in Nagai City: Rainbow plan



## Nagai composting

<b>Capacity</b>	<b>9 tonnes/day or 2,400 tonnes/yr</b>
Area	9,690 m <sup>2</sup>

<b>Construction cost</b>	<b>434,177,300 JPY (8,683,546 BRL)</b>
Operation cost	29,149,830 JPY (582, 997 BRL)
Waste collection cost	11,566,800 JPY (231,336 BRL)
Receive of manure disposal fee	211,950 JPY (4,239 BRL)
Selling of compost	1,759,171 JPY (35,183)



Photo by Eiji Yamaji

## Household composting

- On voluntary basis in many cities such as Idabashi (Tokyo), Itoshima (Fukuoka Prefecture), and Kitakyushu.
- Using selective or effective microorganisms to enhance rapid degradation of rapid biodegradable waste. The starters help shorten the time for composting and ensure no foul odor.
- Replication in other Asian countries

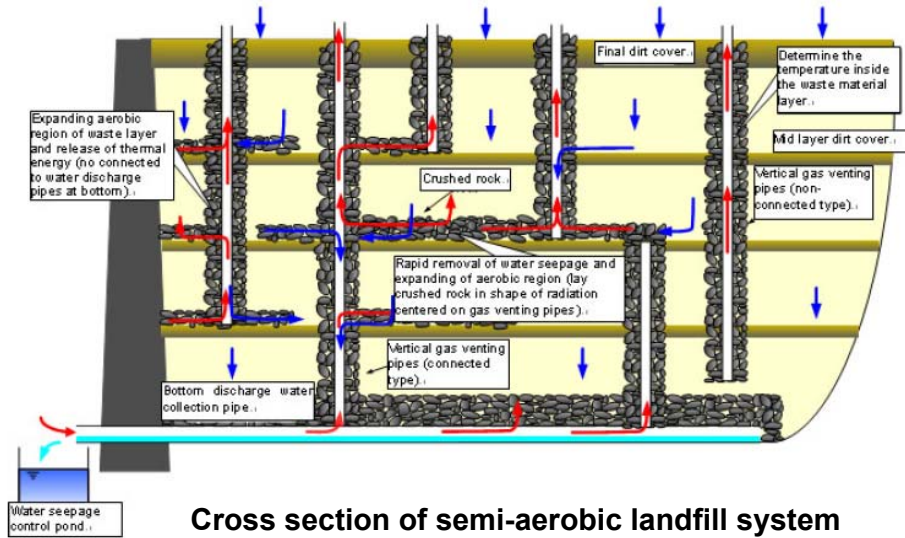
### Household composting in Kitakyushu: Takakura home composting method

Subsidy	Base year (2003)	2006	Increased
Compost box (3,000 JPY/box) (60 BRL)	1,191sets	2,225 sets	86.8%
Electric composter (50% cost share but not >20,000 JPY; 400 BRL)	278 sets	1,119 sets	302.5%

Source: City of Kitakyushu

## Landfill

- Two systems: anaerobic landfill and semi-aerobic landfill



**Cross section of semi-aerobic landfill system**

Source: Matsufuji, 2007

## Construction and maintenance cost of landfill

Average area (m <sup>2</sup> )	Capacity (m <sup>3</sup> )	Capacity of water treatment (m <sup>3</sup> /day)	Total construction cost (JPY/m <sup>3</sup> )
14,584	83,528	55	32,219 (644 BRL)

Estimated total lifecycle cost per unit (including land price and construction cost) for landfill that have capacity of 100,000 m<sup>3</sup>  
(JPY/m<sup>3</sup>)

5 yrs	15 yrs	30 yrs	50 yrs
20,000-32,000 (400-640 BRL)	22,000 – 40,000 (440-800 BRL)	25,000 - 52,000 (500-1,040 BRL)	29,000 - 68,000 (580-1,360 BRL)

Source: modified from Endo et al, 2010

## Conclusions

- **The Sound Material Cycle Society Policy and national regulations are major drivers for planning of MSW management in Japan.**
- **Incineration is the main MSW treatment in Japan because it could reduce the total volume of waste to final disposal site by approximately 90%, but it is expensive.**
- **Some local governments try to promote reduction of waste generation and improve efficiency of waste separation at source to reduce cost and carbon dioxide emissions from incineration.**

## Japan's strategy and technology that implemented in other countries

- **The 3R strategy → Bangladesh, Cambodia, Indonesia, Malaysia, the Philippines, Thailand, Viet Nam, etc.**
- **Takakura composting methods → Indonesia, Malaysia, Philippines, etc.**
- **Semi-aerobic landfill → Samoa, Pakistan, China, Iran, Malaysia, Mexico, etc.**
- **Incineration with electricity generation → Thailand, etc.**

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**Thank you for your attention and  
any questions is welcome**

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**Solid fuel: Refused derived fuel (RDF) & Refused paper  
and plastic fuel (RPF)**

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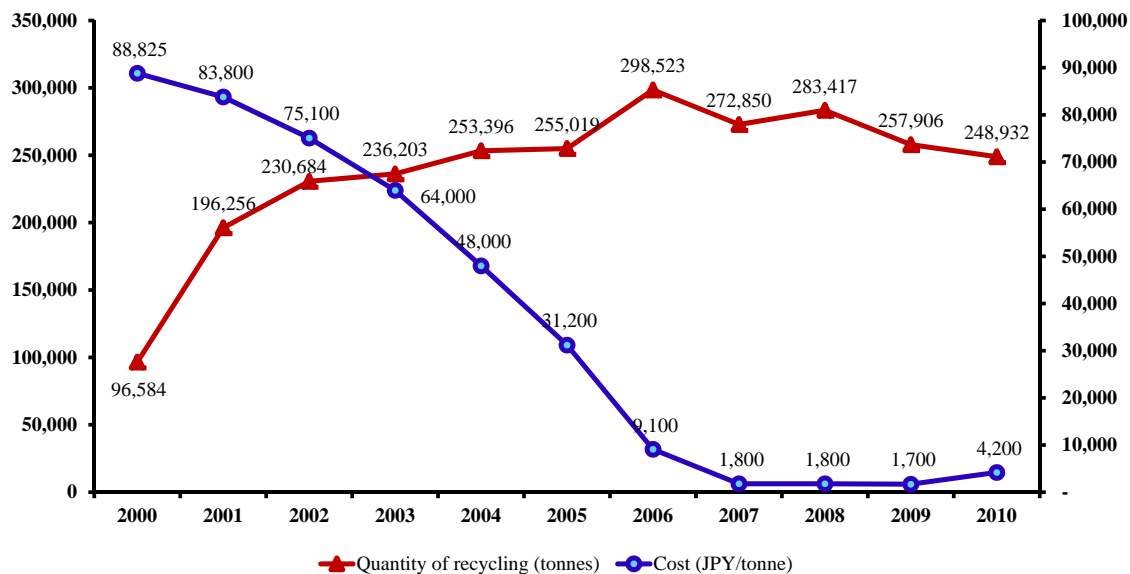
- **690,000 tonnes or 1.5% of MSW in 2009**
- **Produced in 29 Prefectures**
- **Construction cost 8.0 billion JPY for 150 tonnes/day of waste input  
(53 M JPY/ capacity of 1 tonne/day)**
- **Operation cost is 30,000 JPY/tonne of RDF or 10,000-19,000  
JPY/tonne of waste**
- **Waste : RDF conversion ratio is 1.6 : 1**



## Recycled products from plastics

Recyclables and products	Sales volume (tonnes)		
	2000	2005	2010
<b>Plastics</b>	<b>43,830</b>	<b>365,924</b>	<b>418,681</b>
Plastics	98.8%	99.7%	99.8%
<i>Molding materials</i>	<i>11.1%</i>	<i>24.3%</i>	<i>39.1%</i>
<i>Pyrolytic oil</i>	7.7%	1.9%	0.3%
<i>Reducing agent (carbon monoxide) in blast furnaces *</i>	56.3%	10.0%	5.9%
<i>Chemical raw materials for the coke oven</i>	<i>22.3%</i>	<i>47.6%</i>	<i>41.9%</i>
<i>Synthetic gas</i>	1.5%	16.0%	12.7%
Tray	1.2%	0.3%	0.2%
<i>Molding materials</i>	1.2%	0.3%	0.2%
<i>Pyrolytic oil</i>	0.03%	0.00%	0.00%

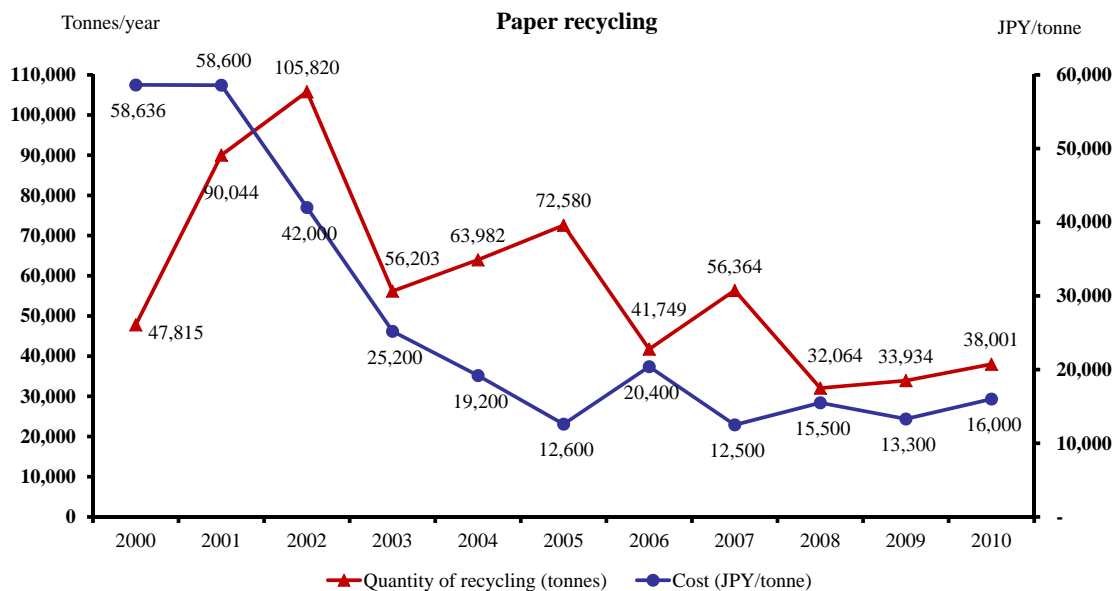
## PET Recycling



## Recycled products from PET bottles

Recyclables and products	Sales volume (tonnes)		
	2000	2005	2010
<b>PET bottles</b>	<b>68,575</b>	<b>143,032</b>	<b>153,192</b>
<b>Textiles</b>	<b>55.9%</b>	<b>44.8%</b>	<b>52.1%</b>
<b>Plastic sheet</b>	<b>34.1%</b>	<b>41.1%</b>	<b>37.6%</b>
<b>Bottles</b>	<b>0.5%</b>	<b>8.5%</b>	<b>5.8%</b>
<b>Moulded products</b>	<b>5.5%</b>	<b>4.3%</b>	<b>4.2%</b>
<b>Others</b>	<b>4.0%</b>	<b>1.3%</b>	<b>0.00%</b>

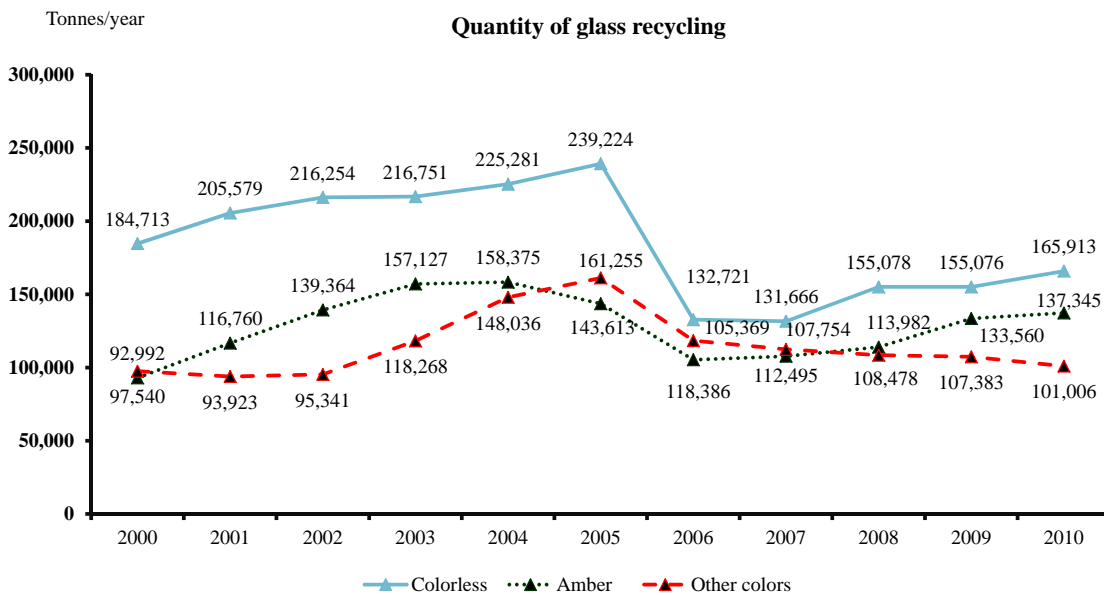
## Paper recycling



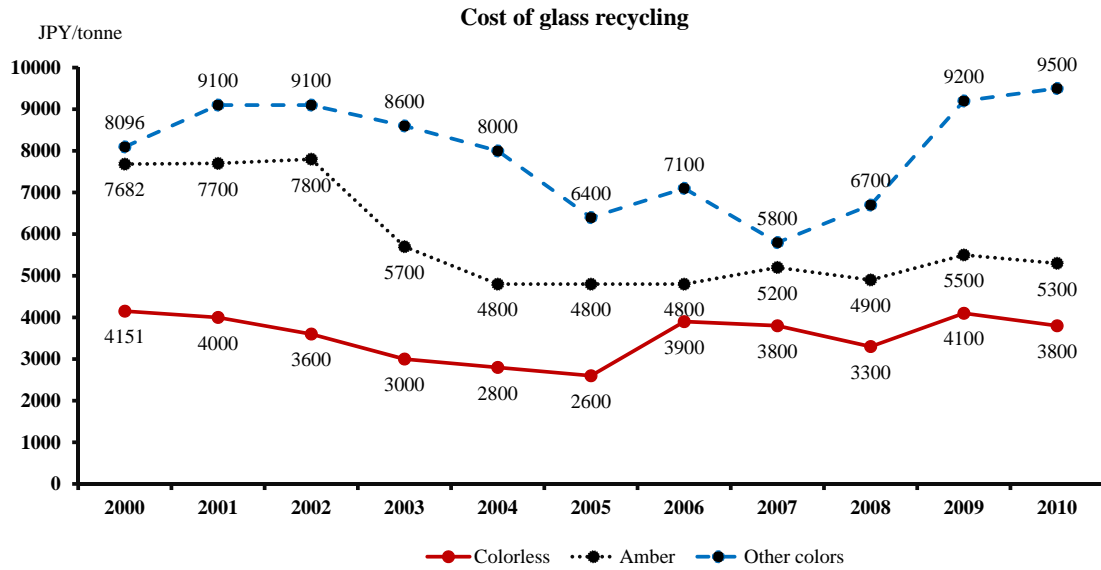
## Recycled papers

Recyclables and products	Sales volume (tonnes)		
	2000	2005	2010
<b>Paper</b>	<b>10,230</b>	<b>26,471</b>	<b>27,297</b>
<b>Materials</b>	<b>44.4%</b>	<b>94.0%</b>	<b>92.8%</b>
<b>Materials for other than paper</b>	<b>25.1%</b>	<b>0.8%</b>	<b>0.9%</b>
<b>Refuse Derived Fuel</b>	<b>30.5%</b>	<b>5.1%</b>	<b>6.3%</b>

## Glass recycling



## Cost of glass recycling



## Glass recycled products

Recyclables and products	Sales volume (tonnes)		
	2000	2005	2010
<b>Glass bottles</b>	<b>264,688</b>	<b>321,990</b>	<b>322,090</b>
Colourless	27.9%	30.0%	31.6%
<i>From bottle to bottle</i>	<i>26.6%</i>	<i>29.0%</i>	<i>31.2%</i>
<i>Others</i>	<i>1.3%</i>	<i>0.9%</i>	<i>0.4%</i>
Amber	39.2%	36.5%	35.0%
<i>From bottle to bottle</i>	<i>31.8%</i>	<i>32.0%</i>	<i>33.7%</i>
<i>Others</i>	<i>7.3%</i>	<i>4.5%</i>	<i>1.3%</i>
Other Colours	32.9%	33.5%	33.4%
<i>From bottle to bottle</i>	<i>2.8%</i>	<i>6.2%</i>	<i>9.3%</i>
<i>Others</i>	<i>30.2%</i>	<i>27.4%</i>	<i>24.1%</i>

## Major advantage and disadvantage of each technology

Technology	Advantage	Disadvantage
Incineration	Very fast Almost 90% reduction of waste to landfill	Required high personnel skill in operation, may emit dioxin and GHG
Recycling	Recover valuable resources	Require efficient waste separation
RDF	Easy to transport for energy use at heavy industrial factory	Need to control heating value of RDF to ensure stable heat supply
Composting	Recover nutrient for agriculture	Require efficient waste separation Taking time for processing (> 1 month)
Animal feed	Recover food for animal	Require high quality of food waste that will not affect animal health
Anaerobic digestion	Recover both energy and nutrients/RDF	Require high personnel skill in operation, require efficient waste separation, taking time for processing (almost 1 month)
Landfill	Easy to operate	Require large area, aftercare cost is high, emit methane, NIMBY