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2. Waste Related System
3. Market/ Technology Status
4. Status of Technology Development
5. Conclusion
Waste Volume Generation Forecast

### Waste Recycling Market: Volume Generation Forecast, Global, 2017 and 2018

<table>
<thead>
<tr>
<th>Volume in Million Tons</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic</td>
<td>6000</td>
<td>6400</td>
</tr>
<tr>
<td>C&amp;D</td>
<td>4596.3</td>
<td>4697.4</td>
</tr>
<tr>
<td>E-waste</td>
<td>48.2</td>
<td>49.9</td>
</tr>
<tr>
<td>Industrial (Non-hazardous)</td>
<td>16079.5</td>
<td>16401.1</td>
</tr>
<tr>
<td>MSW</td>
<td>1745.2</td>
<td>1760.9</td>
</tr>
</tbody>
</table>

### Waste Recycling Market: Percent of Waste Volume Generation Forecast by Segment, Global, 2018

- **Plastic**: 21.8%
- **C&D****: 16.0%
- **Industrial (Non-hazardous)**: 56.0%
- **eWaste**: 0.2%
- **MSW**: 6.0%

### Waste Recycling Market: Percent of Waste Volume Generation Forecast by Regions, Global, 2018

- **Europe**: 32.5%
- **APAC**: 45.1%
- **Americas**: 16.5%
- **MEA**: 5.9%

Global waste volume generation is expected to increase from 28,469.2 Mton in 2017 to 29,309.3 Mton in 2018.

The industrial segment is projected to generate the highest waste (non-hazardous) volume (16,079.5 Mton), followed by plastic (6000 Mton) waste and construction and demolition (C&D) (4596.3 Mton—data for Europe only), MSW (1,745.2 Mton), and WEEE (48.2 Mton).

Asia-Pacific (APAC) and Europe are expected to generate highest waste volumes, followed by the Americas and MEA.
MSW (Municipal Solid Waste) **Generation Status in Korea**

(생활쓰레기 발생 현황)

<table>
<thead>
<tr>
<th>Year</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSW</td>
<td>48,934</td>
<td>48,990</td>
<td>48,728</td>
<td>49,915</td>
<td>51,247</td>
</tr>
<tr>
<td>Industrial</td>
<td>334,399</td>
<td>345,520</td>
<td>344,398</td>
<td>351,748</td>
<td>366,975</td>
</tr>
</tbody>
</table>

**MSW Treatment (2015, t/d)**
- Lanfill (7,719)
- Incineration (13,176)
- Recycle (30,352)

**Industrial Treatment (2015, t/d)**
- Lanfill (30,081)
- Incineration (12,917)
- Recycle (322,472)
1. **Separate Discharge System** (생활쓰레기 분리배출제도)

2. **Waste Charge System** (폐기물 부담금제도)

3. **Voluntary Agreement of Plastic Waste Collection-Recycling** (자발적 협약제도)

4. **Separate Discharge Mark System** (분리배출 표시제도)

5. **EPR : Extended Producer Responsibility** (생산자책임 재활용제도)

6. **Beverage Container Deposit System** (빈용기 보증금제도)
1. MSW Separate Discharge System (1995.1.1~)
(생활쓰레기 분리배출제도)
1. MSW Separate Discharge System (1995.1.1~ )
(생활쓰레기 분리배출제도)
Ban on Single-use Plastic Bag (2019.1.1~) (1회용 비닐봉투 사용금지)

From 1 January 2019
개정된 자원재활용법 시행규칙에 따라

Law Revision

Replacement
Shopping Basket
Regular Bag
Paper Bag
2. Waste Charge System

(폐기물 부담금제도)

The Waste Charge System is a policy that holds manufacturers and importers responsible for the waste disposal cost of products, materials and containers that contain harmful or toxic substances or are difficult to be recycled in order to reduce waste from the production stage and to save resources.

3. Voluntary Agreement of Plastic Waste Collection-Recycling

(자발적 협약제도)

Voluntary Agreement of Plastic Waste Collection-Recycling is the system that the manufacturer-importer of plastic products targeted by Waste Charge and associations of voluntary agreement can get exempt from Waste Charge. This may be successfully carried out under an agreement made with the minister of Environment when the participant meets their obligations.
4. Separate Discharge Mark System (분리배출표시제도)

This System is initiated for promotion of collection and recycling of packages under EPR. EPR items except products (lubricants, tires, etc) should apply the identification mark which is specially designed to indicate items’ recyclability.

The program is running in accordance with the Act on the Promotion of Saving and Recycling of Resources.
1. Designated Maker for Item

<table>
<thead>
<tr>
<th>Item</th>
<th>Designated Maker</th>
</tr>
</thead>
<tbody>
<tr>
<td>PET</td>
<td>![PET Icon]</td>
</tr>
<tr>
<td>Plastic</td>
<td>HDPE, LDPE, PP, PS, PVC, OTHER</td>
</tr>
<tr>
<td>Vinyl</td>
<td>HDPE, LDPE, PP, PS, PVC, OTHER</td>
</tr>
<tr>
<td>Can</td>
<td>철, 알미늄</td>
</tr>
<tr>
<td>Paper Pack</td>
<td>종이박</td>
</tr>
<tr>
<td>Paper</td>
<td>종이</td>
</tr>
<tr>
<td>Glass</td>
<td>유리</td>
</tr>
</tbody>
</table>
5. EPR : Extended Producer Responsibility (생산자 책임재활용제도)

Extended Producer Responsibility (EPR) mandates producers and importers of products that fall under EPR requirement or producers and importers of products with packaging materials that fall under EPR requirements to recycle a certain amount of wastes from products or packaging materials. Ones who fail to follow this obligation are subject to recycling charges.

**Item for Mandatory Recycling**

- **4 packaging materials**: paper packs, metal cans, glass bottles and packaging materials made synthetic resin

- **7 products**: lubricants, batteries, tire, fluorescent lamps, buoys for faming marine products, sheet film for baled silage and racks of synthetic resin mats
3. EPR PROCESS (Extended Producer Responsibility Process)
6. Beverage Container Deposit System
(빈용기 보증금제도)

This system promotes collection and reuse of the spent containers by establishing refundable deposits on recyclable containers, which customers can redeem when they return them.

It also regulates that operational fees be granted to distributors or retailers for their job to circulate the used containers.

Producers who failed to refund 80% of the deposits to their customer, recycling dues will be levied on the unfulfilled amount with the surcharges up to 30%
6. Beverage Container Deposit System (빈용기 보증금제도)

- **Beverage Container Deposit System**

**Flow Diagram**

- **Packing Company** (포장재업체)
- **Recycling Company** (재활용업체)
- **Collection Company** (수집운반업체)
- **Operator** (운영기관)
- **Retail Store** (소매점)
- **Warehouse** (도매점)
- **Consumer** (소비자)

**Key Points**

- Material revenue
- Purchase cost (including deposit)
- Membership fee + collection fee + operating costs
- Beverage container flow
- Finance data flow
- Subsidy flow
Necessity of Technology Development

China’s ban on import foreign waste

- Total Export 2017: 3,542
- China Export 2017: 2,097
- Total Export 2018: 1,625
- China Export 2018: 1,774

Types of Treatment

- Recycling: 65%
- Incineration: 35%
- Landfill: 5%

- Domestic PET Production (by 2015) 15,641 Bottles
  - 96.4% Reusable Difficult materials
  - SRF Fueling → Energy Recovery through Incineration

Air pollution
Global Warming & Treatment Charge

Need to expand Recycling
<table>
<thead>
<tr>
<th>Recycle Technology Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Separate Selection</strong></td>
</tr>
<tr>
<td><strong>Material Recovery</strong></td>
</tr>
<tr>
<td><em>Chemical Recycle</em></td>
</tr>
<tr>
<td>화학적 리싸이클</td>
</tr>
<tr>
<td><strong>Physical Recycle</strong></td>
</tr>
<tr>
<td>물리적 리싸이클</td>
</tr>
<tr>
<td><strong>Energy Recovery</strong></td>
</tr>
<tr>
<td><em>Thermal Recycle</em></td>
</tr>
<tr>
<td>열적 리싸이클</td>
</tr>
<tr>
<td><strong>Upcycling &amp; ICT Application</strong></td>
</tr>
<tr>
<td>▶ High Productivity &amp; Low Cost</td>
</tr>
<tr>
<td>▶ High Tech</td>
</tr>
<tr>
<td><strong>Chemical decomposition &amp; use as chemical raw material</strong></td>
</tr>
<tr>
<td>▶ Semi-permanent Use</td>
</tr>
<tr>
<td>▶ High Tech &amp; High Cost</td>
</tr>
<tr>
<td><strong>Melted &amp; Regenerated</strong></td>
</tr>
<tr>
<td>▶ Low Cost</td>
</tr>
<tr>
<td>▶ Separation process required &amp; Degradation of quality</td>
</tr>
<tr>
<td><strong>Used as thermal energy by incineration</strong></td>
</tr>
<tr>
<td>▶ No separation process required &amp; Cost Reduction</td>
</tr>
<tr>
<td>▶ Incineration Problems</td>
</tr>
</tbody>
</table>

▶ Advantages  ▶ Disadvantages
Recycling Market & Technology

Recycling Market, 2007 ~ 2030

- **<Unit: Million Dollars>**
- **Domestic Growth Rate: 24.2%**
- **Global Growth Rate: 2.4%**

<table>
<thead>
<tr>
<th>Year</th>
<th>Domestic</th>
<th>Overseas</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>243</td>
<td></td>
<td>656,100</td>
</tr>
<tr>
<td>2012</td>
<td>1,156</td>
<td></td>
<td>870,800</td>
</tr>
<tr>
<td>2020</td>
<td>7,628</td>
<td></td>
<td>1,052,700</td>
</tr>
<tr>
<td>2030</td>
<td>66,623</td>
<td></td>
<td>1,334,400</td>
</tr>
</tbody>
</table>

Recycling Technology

- **<Unit: %>**
- **Physical (79)**
- **Chemical (12)**
- **Thermal (6)**
- **Other (3)**

*Source: The Magazine Plastics Korea*
Recycling by Material

Waste Plastic Type

<table>
<thead>
<tr>
<th>구분</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>PET</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>폐고형 (1,000Ton)</td>
<td>195</td>
<td>199</td>
<td>208</td>
<td>225</td>
<td>249</td>
</tr>
<tr>
<td>재활용량 (1,000Ton)</td>
<td>161</td>
<td>168</td>
<td>175</td>
<td>186</td>
<td>195</td>
</tr>
<tr>
<td>재활용률 (%)</td>
<td>82.6</td>
<td>84.4</td>
<td>84.1</td>
<td>82.7</td>
<td>78.3</td>
</tr>
<tr>
<td>EPS (스티로폼)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>폐고형 (1,000Ton)</td>
<td>27</td>
<td>26</td>
<td>26</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>재활용량 (1,000Ton)</td>
<td>20</td>
<td>19</td>
<td>21</td>
<td>23</td>
<td>25</td>
</tr>
<tr>
<td>재활용률 (%)</td>
<td>74.1</td>
<td>73.1</td>
<td>80.8</td>
<td>74.2</td>
<td>80.6</td>
</tr>
<tr>
<td>기타 (PP,PE,PVC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>폐고형 (1,000Ton)</td>
<td>388</td>
<td>392</td>
<td>405</td>
<td>527</td>
<td>559</td>
</tr>
<tr>
<td>재활용량 (1,000Ton)</td>
<td>318</td>
<td>325</td>
<td>311</td>
<td>453</td>
<td>560</td>
</tr>
<tr>
<td>재활용률 (%)</td>
<td>82.0</td>
<td>82.9</td>
<td>76.8</td>
<td>86.0</td>
<td>100.2</td>
</tr>
</tbody>
</table>

• PET takes the most amount

PET Recycling Products

PET Recycling Products

• More than 56.0% Fiber Products

<Source: The Magazine Plastics Korea>
1. Separate Selection

Mixing Waste Envelope Recycling (L) & Vinyl Recycling (R)
Plastic Recycle (Color)

- **Green**
- **Gray**
- **Mix**
Status of Technology Development

- Plastic Separate Selection Recycle Research
- Material Recovery (Civil Engineering) / Low Quality PVC & Film Recycle Research
- Material Recovery (Architectural Engineering) / Low Quality PVC & Plastic Film Recycle Research
- Material Recovery (Fiber) / Application of PET Recycling Research (Fashions)
- Energy Recovery / Incineration & SRF (Solid Refuse Fuel) Research
- Energy Recovery / Oil Production Technology Research
Plastic Separate Selection Recycle Research(1)
Plastic Recycle Research(2)

9) Third Selection
10) Fourth Selection
11) Crush
12) Primary Washing & Drying
13) Gravity Selection

14) Storage
15) Chemical Washing
16) Multiple Washing
17) Hot/Cool Drying
18) Primary Material Color Selection

19) Secondary Material Color Selection

20) Product Packaging

21) Deliver

Plastic Recycle Research (3)
Plastic Recycle Research (Selection Part)

Before R&D (Handwork)

After R&D (Automation)
Material Recovery (Civil Engineering) / Low Quality PVC & Film Recycle Research

Tetrapod (TTP)

Retaining Wall
Material Recovery (Civil Engineering) / Low Quality PVC & Film Recycle Research

Collected Raw Materials → Selection → Crush → Remove Impurities → Electrical Sorting

Compression → Tile → Car Stopper → Manhole

Products
### Material Recovery/ PET Recycling by Color

<table>
<thead>
<tr>
<th>Color</th>
<th>Clear</th>
<th>Green</th>
<th>Gray</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Products</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clothing</td>
<td>- Clothing</td>
<td>- Packing Band</td>
<td>- Cement</td>
<td>- Car Seat (Black)</td>
</tr>
<tr>
<td>Car Seat</td>
<td>- Car Seat (Black)</td>
<td>- Reinforcement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent</td>
<td>60%</td>
<td>20%</td>
<td>5%</td>
<td>15%</td>
</tr>
</tbody>
</table>
Material Recovery / Application of PET Recycling Research (Industry)

1. Vehicle Material
   - Air-Bag
   - Tire Cord

2. Residential Material
   - Roofing
   - House Wrap

3. Functional Filter
   - Gas, Liquid Filter
   - Engine Filter

High-strength Filament
Long Fiber Non-woven
Long Fiber Non-woven
Material Recovery (Fiber) / Application of PET Recycling Research (Fashions)
Performance/ PET Recycling Certification

- GR (Good Recycled) Certification in Korea
  < Certification : NTSI >

- C2C (Cradle to Cradle Certification in EU, US)
  < Certification : EPEA(Europe) / MBDC(US) >
Energy Recovery / Incineration & SRF (Solid Refuse Fuel) Research

SRF Manufacturing Capacity: 5 ton/day
Energy Recovery / Incineration & SRF (Solid Refuse Fuel) Research (2)
Energy Recovery / Oil Production Technology Research

Input → Processing → Output

Waste Processing Capacity : 10 ton/day
Conclusion

**Economic Impact**
- High added Value
- Reduce Cost

**Industrial Impact**
- Market Demand by Regulation
- High Quality Recycling

**Environmental Impact**
- Promotion of PET Collection
- Reduction of Greenhouse Gases
- Environmental Protection
Research Scope and Segmentation

Base Year
2017

Forecast Period
2018

Market Segmentation

- Recycling of Municipal Solid Waste
  - Organics, Plastics Paper, Metals and Glass
- Recycling of Industrial Waste
  - Non-hazardous waste from energy, agricultural, metallurgy, textile, food and beverage, and cement production industries
- Recycling of eWaste
  - Large household appliances, small household appliances, IT waste, and EE tools
- Recycling of C&D waste
  - Construction, road demolition, and excavated waste
- Plastic Waste Recycling
  - Recyclable plastics (different grade)

Geographical Scope

Europe
- Americas: The US and Canada
- APAC: China and India
- Middle East and Africa (MEA)

Source: Frost & Sullivan
MSW Recycling Trends
Increase in plastic packaging leads to increasing emphasis on sustainable plastic packaging.

Recycling Trends of Municipal Solid Waste

- China’s ban on import of foreign waste
- Internet of bins to tackle MSW woes
- Growing trend of electric vehicles for waste collection
- Steep growth trends in Indian waste to energy market
- Innovative business models for waste collection
- Energy from landfill

Source: Frost & Sullivan
Plastic Waste—General Outlook
According to UN, packaging plastics contribute to the highest plastic waste in the world with a share of 39.9% followed by consumer goods at 22.4% share.

Recycling Trends of Plastic Waste

- Increase of plastic dumping in ocean
- Bioplastics to take over non-biodegradable plastic
- Europe-wide strategy on plastics and plastic waste recycling adopted in 2018 for transition to circular economy
- Adopting sustainable packaging to avoid about 40% of plastic waste generated around the globe
- Ban on import of plastic waste by China replaces the recycling emphasis back on the developed countries
- Ban on single-use plastics

Source: Frost & Sullivan