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Plastics & Material Flow Analysis

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Plastic flows in Austria 1994

Flows: kt/yr
Stocks: kt

Source: Fehringer & Brunner 1997
Some figures

Packaging waste separately collected 20 kg/cap.yr
Plastics in use ca. 1.4 t/cap
Growth rate of stock in use ca. 5 %
Plastic flows in Poland and Austria 2004

Σ Import = 5,500, Stock = 53,000 + 3,600
Σ Export = 1,900, Σ Import = 3,700
Stock = 26,000 + 700, Σ Export = 3,000

Imports and exports of plastics in Poland and Austria in 2004

- **Raw materials**: 2,300 t/yr
- **Intermediate products**: 2,500 t/yr
- **Plastic products**: 680 t/yr

**Primary production**
- Duro- and polymers: 200 ± 0 t/yr
- Stock: 600 t

**Manufacturing**
- Intermediate products: 590 ± 570 t/yr
- Plastic products: 1,400 t/yr

**Consumption**
- Plastic products: 23,000 ± 1,700 t/yr
- Waste: 2,000 t

**Collection, sorting, transport**
- Plastic products: 3,000 t

**Energy recovery**
- Waste: 760 t

**Landfill**
- Waste: 260 t

**Recycling**
- Waste: 87 t

**Waste**
- Regranulate: 47 ± 0 t/yr
- Off-gas: 1 ± 0 t/yr

**Energy recovery**
- Production waste: 1 ± 0 t/yr

**Landfill**
- Production waste: 520 ± 71 t/yr

**Regranulate**
- Off-gas: 55 ± 0 t/yr

**Residues**
- Production waste: 25 ± 0 t/yr

Source: Bogucka et al. 2008
## Plastic flows and stocks

<table>
<thead>
<tr>
<th></th>
<th>Austria</th>
<th>Poland</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total [1,000 t/a]</td>
<td>kg/cap</td>
</tr>
<tr>
<td>Total plastic import plus domestic production</td>
<td>3 704</td>
<td>463</td>
</tr>
<tr>
<td>Total plastic export</td>
<td>2 417</td>
<td>302</td>
</tr>
<tr>
<td>Plastic consumption</td>
<td>1 287</td>
<td>161</td>
</tr>
<tr>
<td>Plastics to stock “in use”</td>
<td>359</td>
<td>45</td>
</tr>
<tr>
<td>Total plastics in stock “in use”</td>
<td>11 200</td>
<td>1 400</td>
</tr>
<tr>
<td>Plastic waste flow (incl. import-export of waste)</td>
<td>952</td>
<td>119</td>
</tr>
<tr>
<td>Plastic waste flow to recycling</td>
<td>127</td>
<td>16</td>
</tr>
<tr>
<td>Plastic waste flow to energy recovery</td>
<td>564</td>
<td>71</td>
</tr>
<tr>
<td>Plastic waste flow to landfills</td>
<td>261</td>
<td>33</td>
</tr>
<tr>
<td>Total plastic stock in landfills</td>
<td>15 500</td>
<td>1 938</td>
</tr>
</tbody>
</table>

Source: Bogucka & Brunner 2007
Additives in plastics

Additives:
- Stabilizers,
- Antioxidants,
- Lubricants,
- Processing aids,
- Antifogging and antistatic additives,
- Antimicrobials, flame retardants,
- Colorants,
- Fillers and reinforcement agents

Chemical industry
- Prim. raw materials
- Sec. raw mat.
- Rubber
- Polymers

Preparation, manufacture
- Semifin. prod. I
- Additives I
- Rubber I
- Polymers II

Consumption
- Duro- and polymers
- Plastic prod. II

Collection, sorting, transport
- Plastic products III
- Regranulate I
- Waste II

Recycling
- Recovery
- Energy recovery

Landfill
- Regranulate I
- Off-gas

Impurity
- Residues
- Waste water

Waste water treatment
- Lagoons, ponds, ponds

System Boundary: Austria 2004

Source: Bogucka & Brunner 2007

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## Additives in plastics

<table>
<thead>
<tr>
<th>material</th>
<th>consumption [1000t/yr]</th>
<th>thereof packaging [1000t/a]</th>
<th>in use stock [1000t]</th>
</tr>
</thead>
<tbody>
<tr>
<td>plastics</td>
<td>1,000</td>
<td>250</td>
<td>6,700</td>
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<tr>
<td>softeners</td>
<td>14</td>
<td>3</td>
<td>180</td>
</tr>
<tr>
<td>Ba/Cd-stabilizers</td>
<td>0.250</td>
<td>0.0002</td>
<td>4</td>
</tr>
<tr>
<td>Pb- stabilizers</td>
<td>1.6</td>
<td>0.002</td>
<td>27</td>
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<tr>
<td>flame retardants</td>
<td>2</td>
<td>0</td>
<td>34</td>
</tr>
</tbody>
</table>

Source: Fehringer & Brunner 1997
Better data on plastic products required

Trim strip

Recycling of PET bottles (LCA study 2004)

<table>
<thead>
<tr>
<th></th>
<th>New Pet bottle</th>
<th>PET-bottle from waste collection</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Analyse A</td>
<td>Analyse B</td>
</tr>
<tr>
<td>Cd</td>
<td>mg/kg</td>
<td>0,20</td>
</tr>
<tr>
<td>Tl</td>
<td>mg/kg</td>
<td>&lt;0,40</td>
</tr>
<tr>
<td>Hg</td>
<td>mg/kg</td>
<td>&lt;0,20</td>
</tr>
<tr>
<td>Sb</td>
<td>mg/kg</td>
<td>220</td>
</tr>
<tr>
<td>As</td>
<td>mg/kg</td>
<td>&lt;1,0</td>
</tr>
<tr>
<td>Pb</td>
<td>mg/kg</td>
<td>&lt;1,0</td>
</tr>
<tr>
<td>Cr</td>
<td>mg/kg</td>
<td>3,8</td>
</tr>
<tr>
<td>Co</td>
<td>mg/kg</td>
<td>27</td>
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<tr>
<td>Cu</td>
<td>mg/kg</td>
<td>25</td>
</tr>
<tr>
<td>Mn</td>
<td>mg/kg</td>
<td>4,2</td>
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<tr>
<td>Ni</td>
<td>mg/kg</td>
<td>1</td>
</tr>
<tr>
<td>Vn</td>
<td>mg/kg</td>
<td>&lt;1,0</td>
</tr>
<tr>
<td>Se</td>
<td>mg/kg</td>
<td></td>
</tr>
<tr>
<td>Sn</td>
<td>mg/kg</td>
<td></td>
</tr>
<tr>
<td>Te</td>
<td>mg/kg</td>
<td></td>
</tr>
<tr>
<td>Zn</td>
<td>mg/kg</td>
<td></td>
</tr>
</tbody>
</table>

Source: Detzel et al. 2004
Assessing the quality of PET as a fuel

![Graph showing the comparison of substance concentrations in PET vs. hard coal.](image)
Flows of plastics and cadmium in Austrian waste management

Plastics in kg/cap.yr

Source: Bogucka & Brunner 2007
Selected substances reaching appropriate target processes

Austria

Poland

I  appropriate target process
II  mean/conditionally appropriate target process
III  inappropriate target process

Source: Bogucka & Brunner 2007
Substance concentrating efficiency of plastics management

Source: Pilz 2007

Source: Bogucka & Brunner 2007
Difference between maximum and optimum recycling

Energy, Costs

Recycling rate

0 % 100 %

Environmental protection

Recycling rate

0 % 100 %

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Difference between maximum and optimum recycling

Source: Laner & Rechberger 2007
What to do?

Short-living products: near optimum

Solve problems with long-living products
- Find environmentally compatible substitutes for problematic additives
- Design for recycling (easy dismantling)
- Producer and recycler should be the same (producer responsibility)
- Remove plastics from construction and demolition waste