Current and future recycling potentials for Aluminium in Austria

David Laner and Rainer Warrings
Institute for Water Quality and Resource Management
TU Wien

Science to support Circular Economy
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• Aluminium stocks and flows in Austria
  • Static:
    • Al budget for 2010
  • Dynamic:
    • Evolution of stocks and flows from (1964 – 2012)
    • Future development of anthropogenic resource stock and supply (1964 – 2050)

• Al cycle from a product perspective
  • Material efficiency of Al packaging use in Austria
  • Management of aluminium packaging in selected European countries
Aluminium stocks and flows in Austria
Adapted from Buchner, H., D. Laner, H. Rechberger, and J. Fellner. 2014. In-depth analysis of aluminum flows in Austria as a basis to increase resource efficiency. Resources, Conservation and Recycling 93(0): 112-123.
Production and Trade Data

<table>
<thead>
<tr>
<th>Year</th>
<th>Prim. Production</th>
<th>Sec. Production</th>
<th>Rolling</th>
<th>Extruding</th>
<th>Casting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1964</td>
<td>77,000 t</td>
<td>14,000 t</td>
<td>22,000 t</td>
<td>10,000 t</td>
<td>5,200 t</td>
</tr>
<tr>
<td>1965</td>
<td>78,000 t</td>
<td>17,000 t</td>
<td>21,000 t</td>
<td>9,000 t</td>
<td>5,400 t</td>
</tr>
<tr>
<td>2012</td>
<td>0 t</td>
<td>410,000 t</td>
<td>151,000 t</td>
<td>133,000 t</td>
<td>123,000 t</td>
</tr>
</tbody>
</table>

Modeled using MATLAB incl. uncertainty analysis

Al in-use stock and old scrap

1982 - 2012:
Per capita stock increased by a factor of 3.8
Per capita scrap amount increased by a factor of 3.4

Based on Buchner et al. (2015a)
Al model: Calibration and plausibility

Plausibility check of the model with independent bottom-up estimates

Calibration
Consumption: Transport Packaging

Individual Sectors

Stock:
Transport EI. engineering

Plausibility

Plausibility
Consumption: Buildings

Based on Buchner et al (2015a)
Forecasting Al stocks and flows

Forecast model

Historical model

Future final Al demand

Stock-driven
- Transport: Inhabitants, level of motorization, Al content /car
- Buildings & infrastructure: projected dwelling units
- Electrical Eng.: strategic grid development plan

Input-driven:
- Mechanical Eng.
- Consumer
- Packaging

Current in-use stock (2012)

3.0 x 10^6 [t]

Packaging
Consumer
Electrical Eng.
Mechanical Eng.
Buildings & infrastructure
Transport

Future stocks and old scrap generation

**Total in-use stock**
- middle: 530 kg/cap
- high: 440 kg/cap
- low: 360 kg/cap

**Total old scrap**
- middle: 31 kg/cap.yr
- high: 24 kg/cap.yr
- low: 14 kg/cap.yr

Buchner et al. (2015b)
Self-supply from national old scrap regarding final Al demand
Increase recycling rate for Al packaging

- 40% (2012)
- 75% (2025)

**Al self-supply – Austrian final Al demand**

- Packaging Recycling Rate +35%
- Termination of vehicle exports
- Base case scenario

![Graph showing Al self-supply](image)

Buchner et al. (2015b)
Quality aspects of Al recycling

Recycling only within certain alloy families or into cast alloys
Potential problems caused by unsorted/mixed scrap fractions

No separation of transport old scrap

Future Al content in cars

Excess-supply of unsorted Al scrap

Availability of unseparated Al old scrap exceeds national cast Al demand in a (hypothetical) closed system

Buchner et al. (2017)
Wrap-up: National Al management

- Detailed Al budget to evaluate current Al use and losses (inefficiencies) of the system
- Calibrated dynamic model to investigate Al stock and current and future secondary raw material potentials
- In-use stock increase of 50% and increase of old scrap generation of 120% by 2050
- Potential self-supply will most likely not exceed 40% with respect to final Al demand
- Extreme measures (EOL vehicle export bans, recycling) could raise self-supply by another 27%. Primary metal will still be necessary.
- Quality aspects (e.g. alloy compositions) may become critical for secondary production
  - trade as a balancing factor
  - enhanced sorting and upgrading to avoid quality constraints
Aluminium from packaging and households
Focus for research:

„Aluminium recycling“

- Status Quo Al- packaging & household goods / MFA
- Market volume, waste quantities, waste flows
- Recovery rates, losses
- EU: Circular Economy Package

- Ecological & economical assessment
- Potential for change: Recovery, EcoDesign
Al packaging & non-packaging – Market volume / waste generation

Kg/cap t/a

- Composite foils
- Beverage cartons
- Other packaging
- Beverage cans
- Other non-packaging
- Household foil

Al packaging: 19,200 t
Al non-packaging: 5,900 t
System boundary "Aluminium packaging and non-packaging, Austria, 2013."

- BW ... bulky waste
- MSW ... municipal solid waste
- RDF ... refuse derived fuel
- MBT ... mechanical biological treatment
- RW ... residual waste
MFA – Aluminium packaging & non-packaging
MFA – Aluminium packaging & non-packaging

Packaging
- Beverage cans
  - F1.01
- Beverage cartons
  - F1.02
- Composite foils
  - F1.03
- Other packaging
  - F1.04

Households
- Separately collected waste
  - F2.01

Separate collection and sorting
- Al
  - F3.02
- RW & BW
  - F3.03
  - F3.04

Collection
- RW & BW
  - MS
  - FI

Non-packaging
- Household foil
  - F1.05
- Other non-packaging
  - F1.06

Litter
- F2.04
MFA – Aluminium packaging & non-packaging
MFA – Aluminium packaging & non-packaging

Diagram showing the flow of aluminium losses, including processes like cement industry, mechanical treatment, MSW incineration, and melting plant. The diagram also includes pathways for bottom ash treatment, fly ash, and other residues leading to landfill and various scrap or secondary aluminium points.
• Results
AI packaging & household non-packaging, Product flows

Austria, 2013
AI packaging & household non-packaging, Product flows

Austria, 2013

Waste Supply

Packaging & Non-Packaging 25,100 t

Collection

Separate collection and sorting

Mechanical treatment

MSW incineration

Landfill

Cement industry

Secondary AI

100%

29%

71%

52%

48%

40%

19%

11%
AI packaging & household non-packaging, Product flows
Austria, 2013

Packaging & Non-Packaging 25,100 t

Waste Supply

Separate collection and sorting

Collection

Mechanical treatment

MSW incineration

Cement industry

Secondary AI

Landfill

Oxidation losses

Melting plant

40%

19%

52%

71%

29%

13%

39%

11%

48%
• Results:

39% recycling of Al from households

• 26% separate collection
• 8% BA
• 5% mechanical treatment
39% recycling of Al from households

• 26% separate collection
• 8% BA  \( \rightarrow \) 1.74 kg per t waste input
• 5% mechanical treatment  \( \rightarrow \) 2.85 kg per t waste input
• **Results:**

  • Recycling rates are significantly lower than generally assumed
  • Recovery becomes more difficult if not separately collected
  • Thickness of material has huge influence on recycling rates
    • Oxidation
    • Small size particles
Results

- Packaging 100%
- Oxidation loss (MSW incineration) 10%
- Recycling 39%
- Fly ash 0.5%
- Bottom ash 33%
- MBT/MT 16%
- Bottom ash & MBT/MT (insufficient sorting/separation) 49%
- Salt slag (remelting) 1%
Conclusions:

Main losses of Al

- through oxidation (10%) during incineration
- limited recovery from subsequent waste treatments (losses 49%)

Improvement

- recovery rates & collection systems
- Eco-design

EU objectives for reuse and recycling: Al in packaging waste

- 50% for 2025, resp. 60% for 2030
Management of aluminium packaging in selected European countries

• Evaluation of recycling quantities for Al packaging in comparison to the projected targets of the EU Circular Economy Package

• Al packaging is recovered through different systems
  • selective collection
  • deposit refund system (DRS)
  • informal collection
  • bottom ash of MSWI
  • mechanical treatment
Aluminium packaging in Europe
Aluminium packaging in Europe

Recycling (%)
Aluminium packaging in Europe

Selected EU Member States

Deposit Refund System

Losses

Selective Collection

BA/MBT

BE

DE

SE

NL

IT

AT

GB

FR

GR

CZ

PT
• **Results:**

• Mostly high recycling rates (7 of 11 countries > 50%)

• Al packaging between 0.9 and 2.7 kg/cap

• 2 countries (Sweden, Germany) use a deposit refund system (DRS)
  • overall highest rates of collected Al packaging (selective collection and DRS)

• Other countries with similar or higher recycling rates (Belgium, Netherlands) do not use DRS, but recover large volumes from bottom ash (BA) treatment from municipal solid waste incineration (MSWI).
• **Results:**

  • Low recovery rates = high landfilling rates (50-84%)
  
  • high recycling rates (except Italy) = low landfilling rates (1-3%)
  
  • No overall correlation between consumption and recycling rate
    
    • Germany: low consumption rate (1.4 kg/cap), high recycling rate (88%)
    
    • Portugal: low consumption rate (0.9 kg/cap), low recycling rate (20%)
    
    • UK: high consumption rate (2.7 kg/cap), medium recycling rate (50%)
• **Conclusions:**

**Objective**

• *through which system and to what extent Al packaging was recovered?*  
  *(reliability of the data was not questioned)*

**Results**

• *based on different assumptions*

• *difficult to compare*
• **Conclusions:**

**Bottom ash recovery from MSWI**

- *assumption that 100% of the Al in BA is originating from Al packaging*

- *based on estimations of average recovery yields for non-ferrous (depending on particle size and degree of separation)*

- *partly commercial waste in MSWI*

- *considerable quantities of waste are imported (e.g. NL)*
• **Conclusions:**

Selective collection & sorting

• *proportion of non-Al present materials are unknown*
  
  • *Italy (67.8% collection, but only 43% of MSW & 25% landfilled)*

• *partly Al non-packaging & commercial waste*
Conclusions:

EU Action Plan for the Circular Economy

- need for a uniform and precisely formulated requirement for data collection
- originally intended higher goals for Al packaging (70% for 2025)

Why not realized?
Thank you!

Contact:
Dr. David Laner  
E-mail: david.laner@tuwien.ac.at

DI Rainer Warrings  
E-mail: rainer.warrings@tuwien.ac.at