Session 2: Secondary and critical resources

Anticipating challenges and opportunities for aluminium in a circular economy

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1. Is a circular economy better than the current economy? Why?
   - Comparison of apples and pears (growing vs. mature stock in use)
   - Stocks (services) are ultimately more important than flows (changes)

2. How can we move towards a circular economy?
   - Quality challenges
   - Affects entire system, including stocks, materials, energy
1. The socio-economic metabolism shapes the quality of our life (services provided by stocks in use and environment)

2. Current socio-economic metabolism is not sustainable:
   - poverty / inequality (lack of access to essential services)
   - resource depletion, limited sinks for pollutants

3. Sustainable development requires transformation of socio-metabolic system → from design of processes/products to design of systems
Recycling > Primary production, but mainly pre-consumer scrap
Growing stocks in use
Historical country-wise and future global stock patterns (scenarios)

Source: Liu, Bangs, and Müller 2012: Nature Climate Change
GHG emission pathways and mitigation wedges for nine stock development scenarios

M1: Near perfect collection
M2: Technologies for yield improvement
M3: Technologies for energy and emissions efficiency improvement
M4: CCS and electricity decarbonization

Source: Liu, Bangs, and Müller 2012: Nature Climate Change
Aluminium is used in different alloyed form

Beverage can
- Lid: 2.6% Mg, 0.25% Cr
- Body: 1.2% Mn, 1% Mg

Foil
- >99% Al

Bicycle frame
- 0.6% Si
- 0.25% Cu
- 1.2% Mg
- 0.2% Cr

Window frame
- 0.4% Si
- 0.05% Cu
- 0.8% Mg

Wheel
- 7% Si
- 0.4% Mg

Engine block
- 17% Si
- 5% Cu
- 0.5% Mg
- 1% Zn

Airplane
- 2% Cu
- 3% Mg
- 6% Zn

Properties (pure Al)
- Low density
- High conductivity
- Corrosion resistant
- Soft

Aluminium is used in different alloyed form
Today’s aluminium recycling system: cascading use

- The bottom reservoir is formed by automotive secondary castings (mainly engine parts).
- Today, the cascading system is economically and ecologically meaningful.
  - It makes use of all the metals (aluminium, alloying elements, other elements)
  - This saves alloying elements for secondary casting
- In the future, the same system with the same resources may become unsustainable.
  - Increasing amounts of scrap
  - Limited capacity of engine parts to absorb this scrap
  - Scrap surplus in about a decade if cascading structure is maintained
Tomorrow’s aluminium recycling system: Closed alloy cycles?

- A closing of alloy cycles would reduce the amount of scrap to be absorbed by automotive secondary castings.
  - Use scrap for alternative applications (sinks)

Closing of alloy cycles is not trivial:
- Currently, about 200 Al alloys used in vehicles.
- Shredding and sorting of ELVs generates one mixed aluminium scrap fraction.
- Avoiding a scrap surplus requires changes in the entire aluminium system.
Conclusions

1. The development of in-use stocks ("cities") defines boundary conditions for a circular economy
   - Material demand
   - Potential scrap availability (quantity & quality)
     → Recycling opportunities, technologies, energy use, emissions, jobs…

2. Recycling targets: more is not always better
   - Pre-consumer scrap recycling: inefficiency causing more resource use
   - Post-consumer scrap recycling: effectively saves resources (ore & energy)
     but even better if products are still used
     → The most efficient economy would be one without recycling

3. The most fundamental challenge for the aluminium industry will be to keep recycling the increasing amount of post-consumer scrap
   - Quality challenge
   - Requires action and co-operation among various actors in the supply chain (system design)