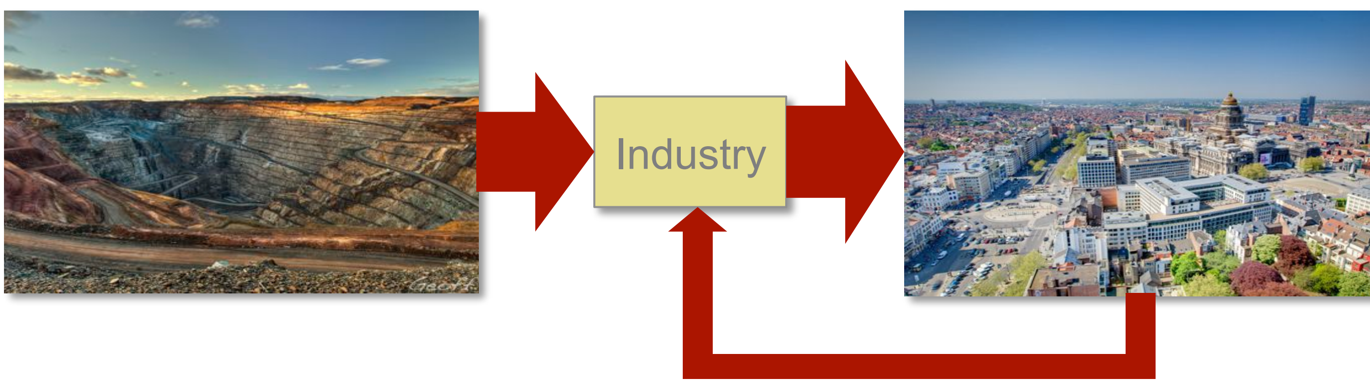
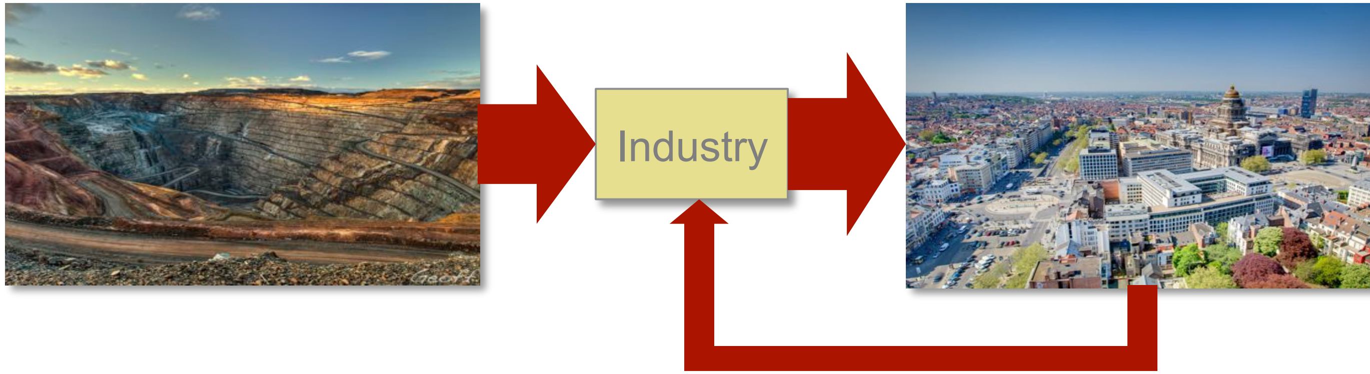
Session 2: Secondary and critical resources

Anticipating challenges and opportunities for aluminium in a circular economy

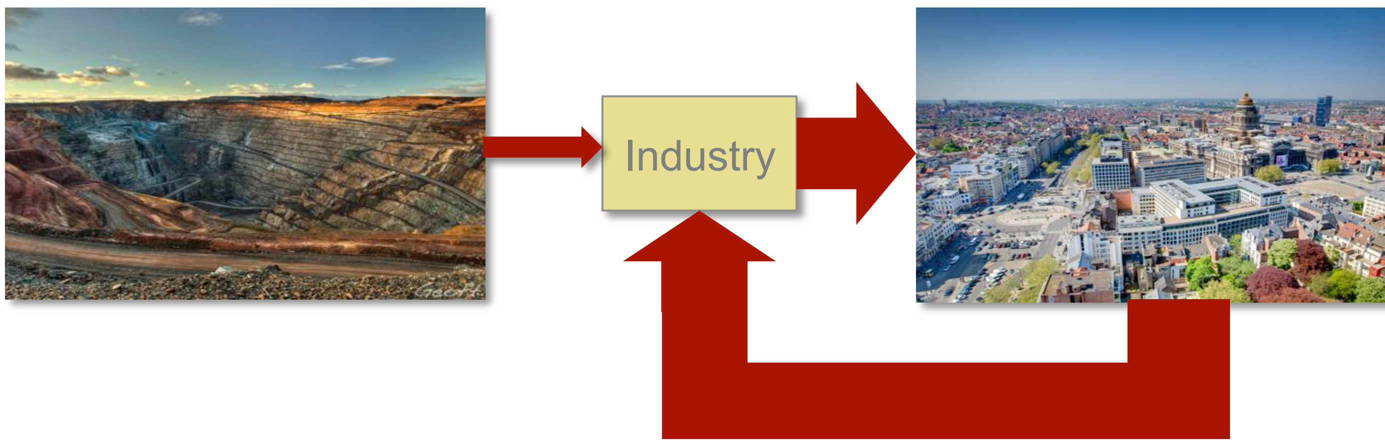
Daniel B. Müller



Current economy

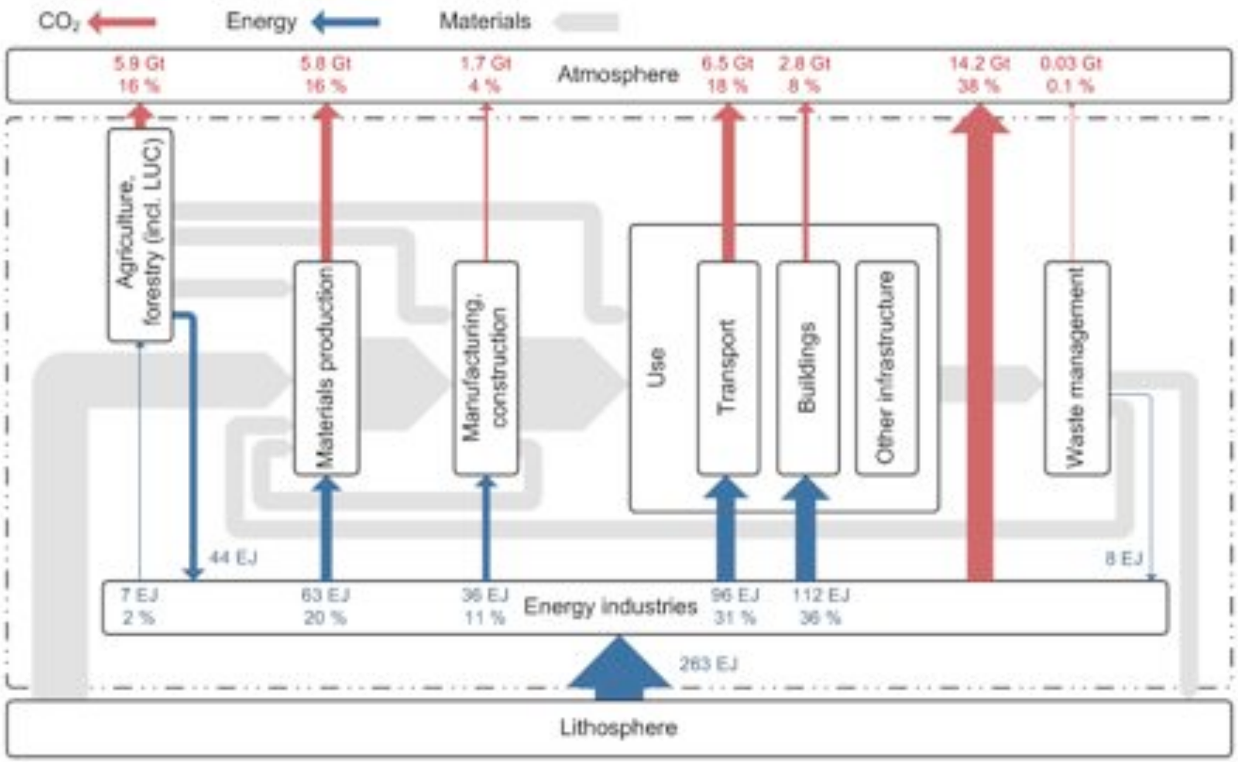


Circular economy



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

Linkages between materials, energy, and emissions: "socio-economic metabolism"

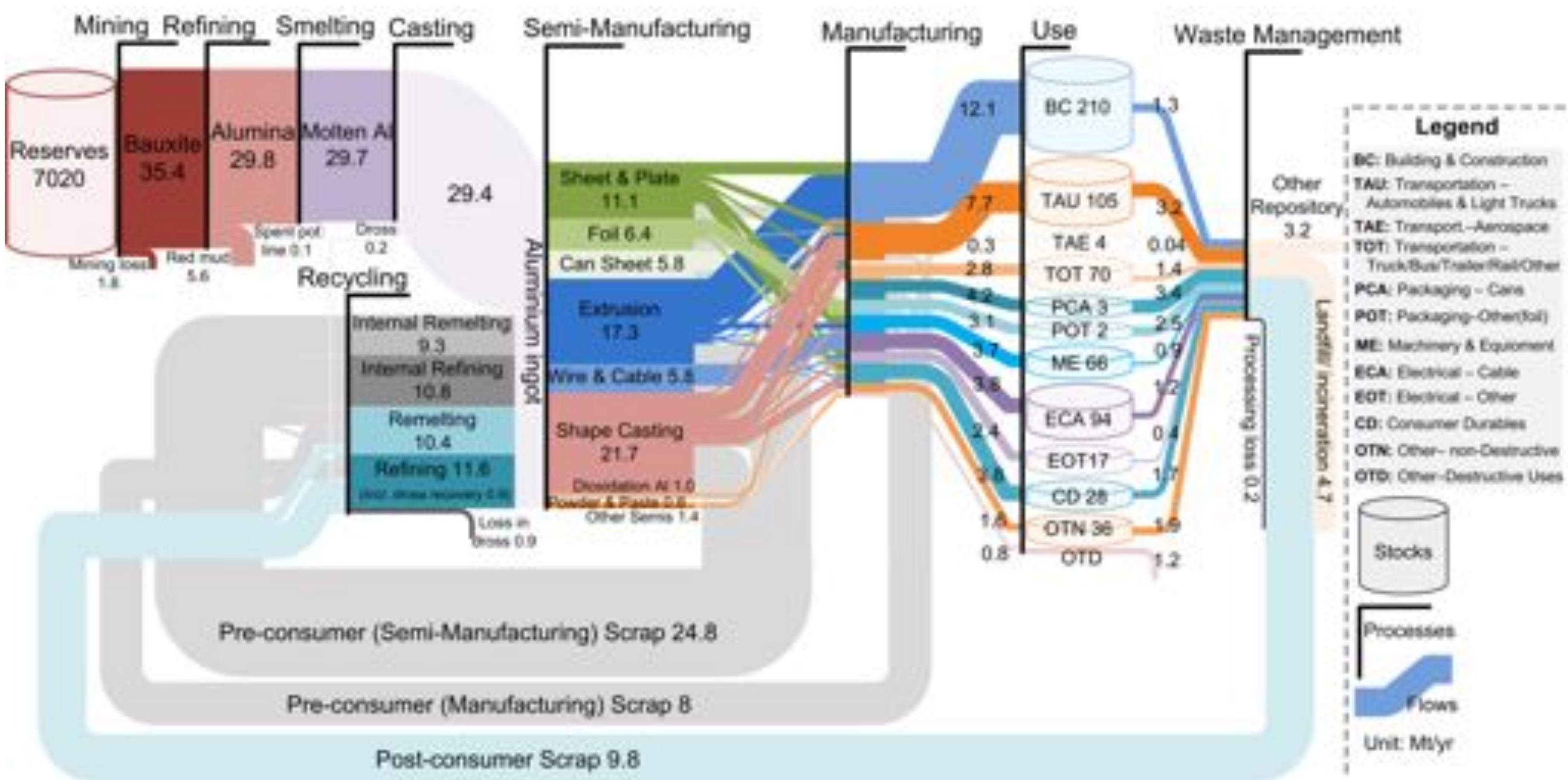


Data sources for 2008:
Emissions: EDGAR
Energy: IEA

Müller et al. 2013

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**

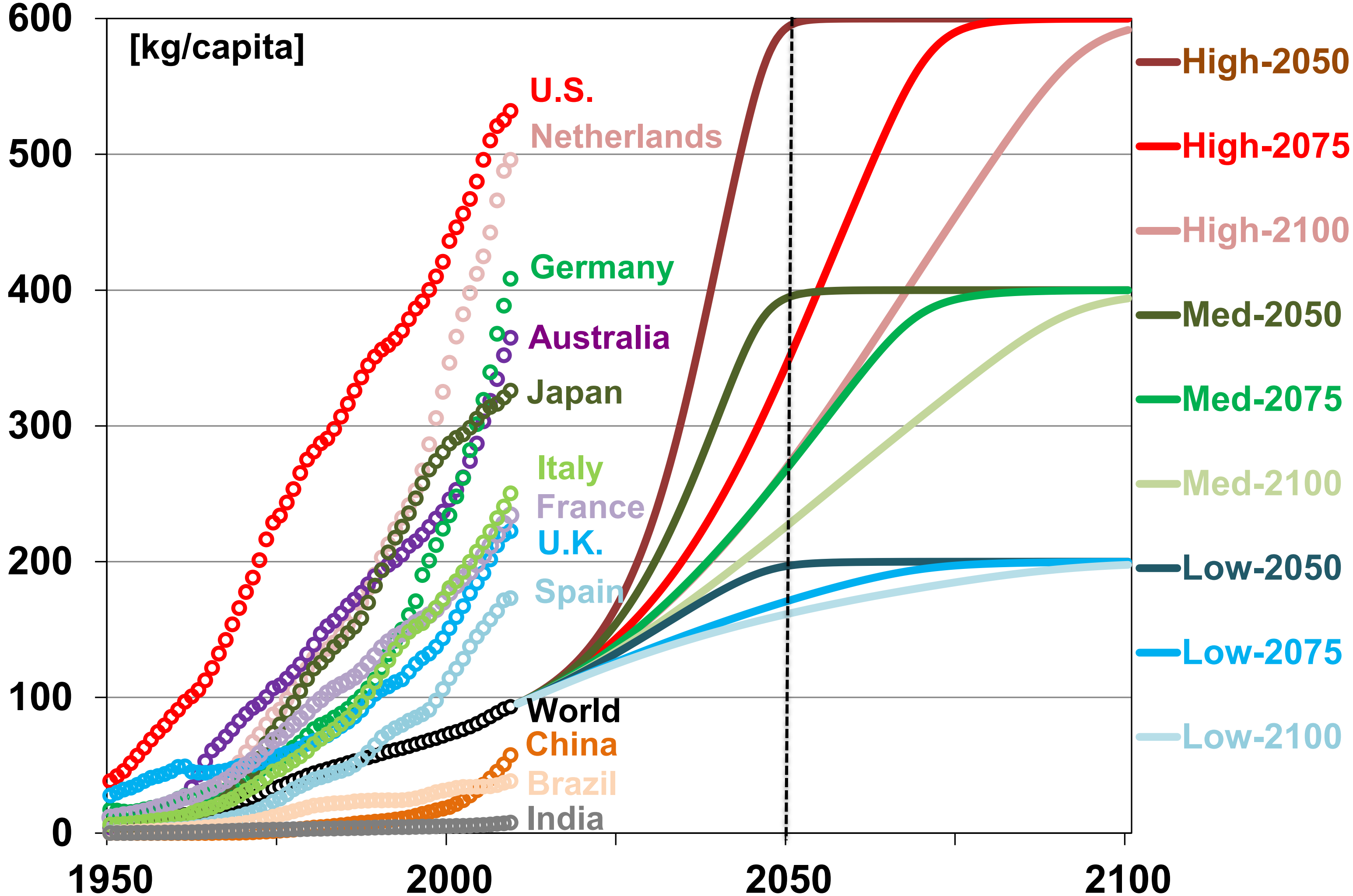
Global anthropogenic metallurgical Al cycle in 2009



Source: Liu, Bangs, and Müller 2012: Nature Climate Change

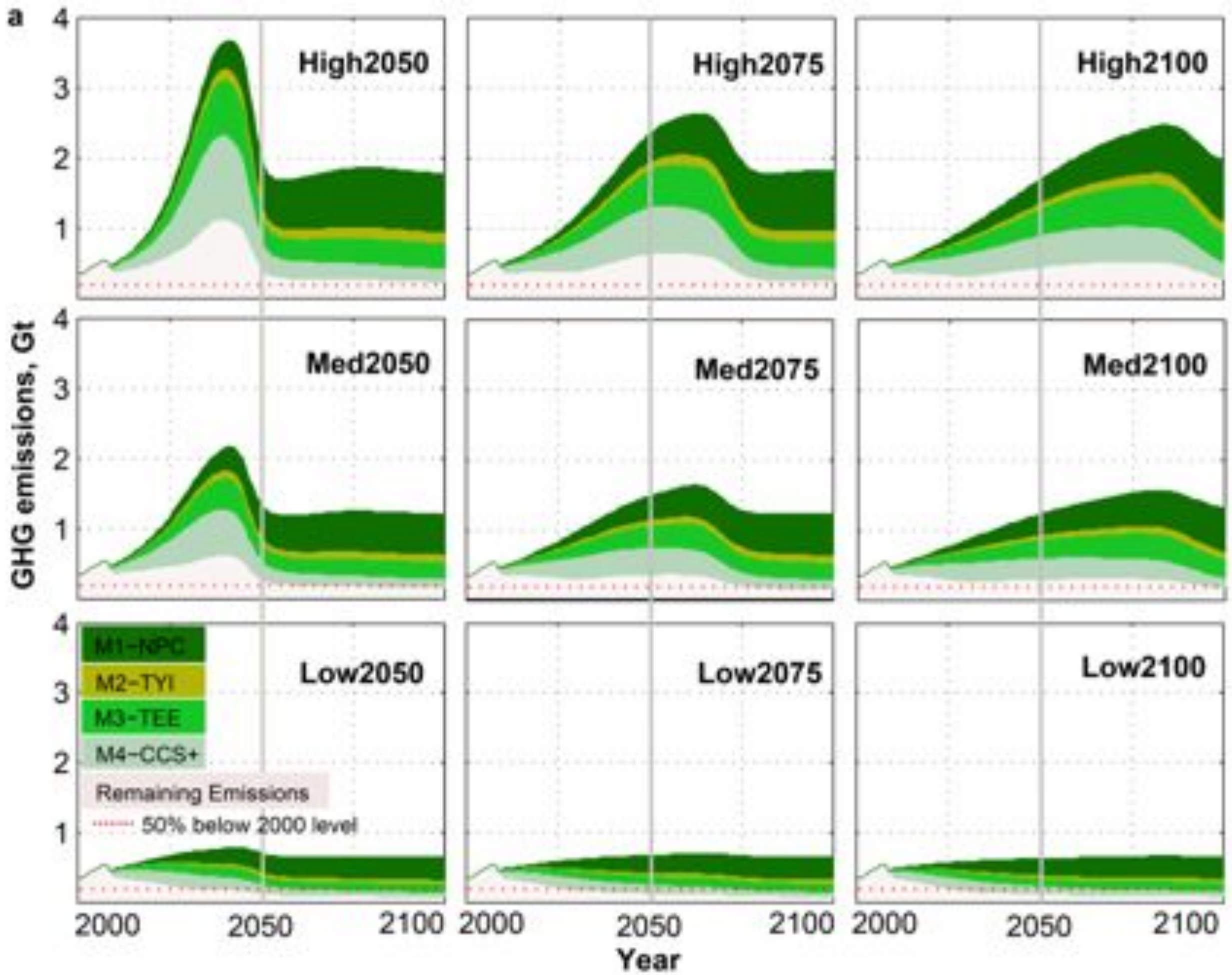
Recycling > Primary production, but mainly pre-consumer scrap
Growing stocks in use

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



Source: Liu, Bangs, and Müller 2012: Nature Climate Change

M1: Near perfect collection

M2: Technologies for yield improvement

M3: Technologies for energy and emissions efficiency improvement

M4: CCS and electricity decarbonization

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

Properties (pure Al)

- Low density
- High conductivity
- Corrosion resistant
- Soft

Wheel

7% Si
0.4% Mg

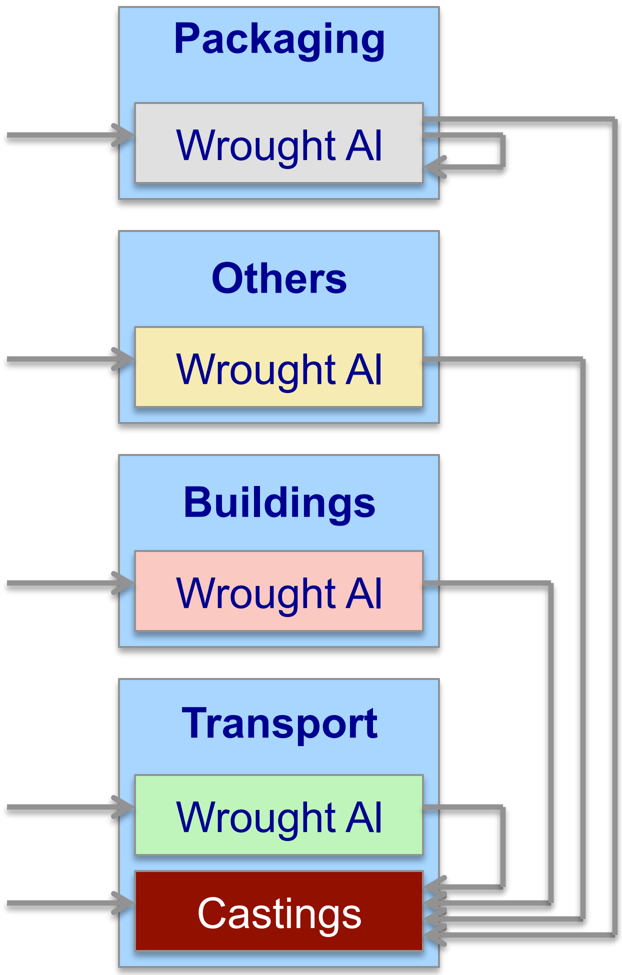
Engine block

17% Si
5% Cu
0.5% Mg
1% Zn

Airplane

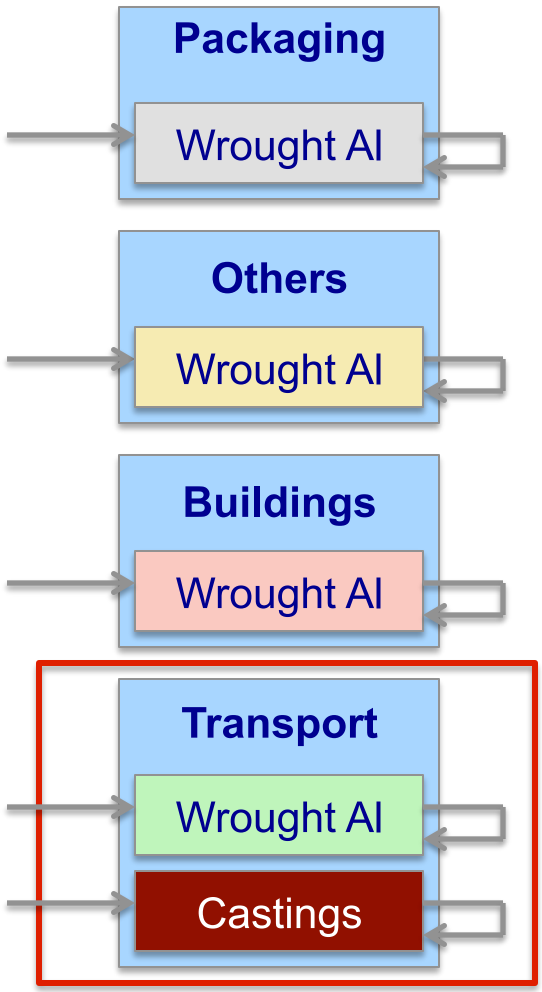
2% Cu
3% Mg
6% Zn

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)