

Research Opportunities and Challenges for Achieving Carbon Neutrality in the Global Aluminum Industry

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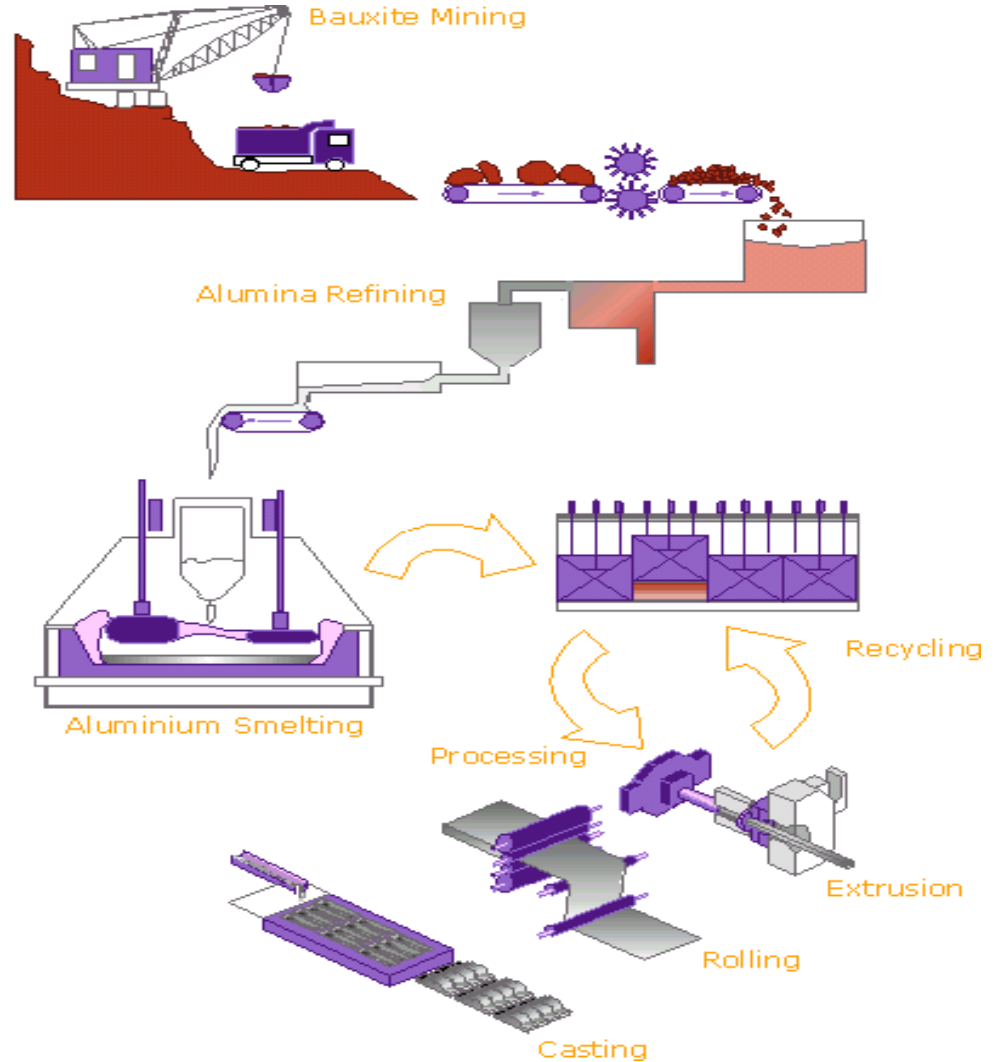
17th Annual KY EPSCoR Conference



May 17, 2012

Aluminum Production Overview

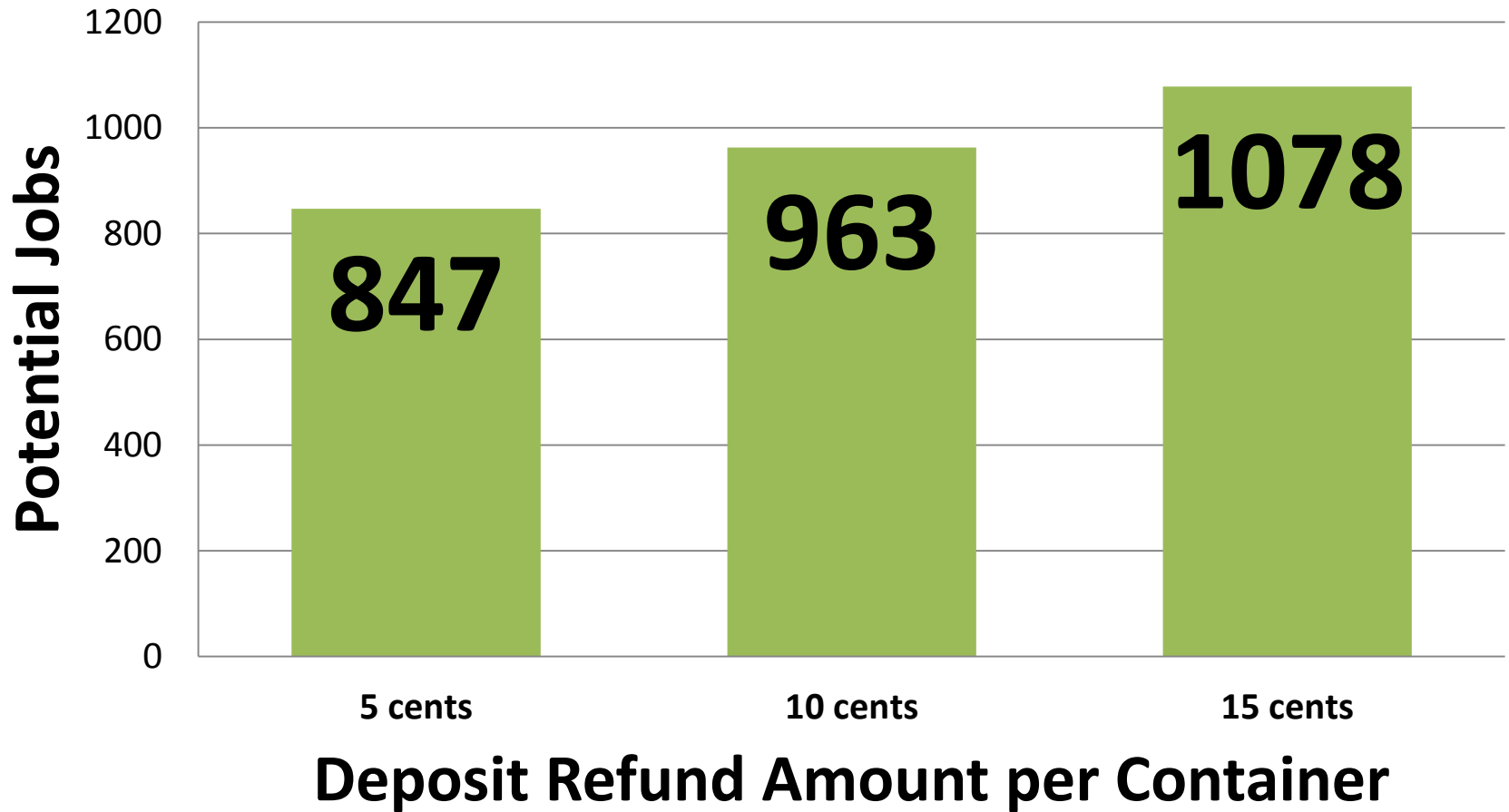
- Bauxite Mining
- Alumina Refining
- Smelting
- Processing
- Recycling



Kentucky Aluminum Production

- Average annual metals job wage is \$52,336
- Aluminum industries employ 15,000 citizens
- \$100 M generated yearly in state & local taxes
- Shipments totaled > \$2.5 billion (Largest in U.S.)
- Total State GDP > \$4 Billion

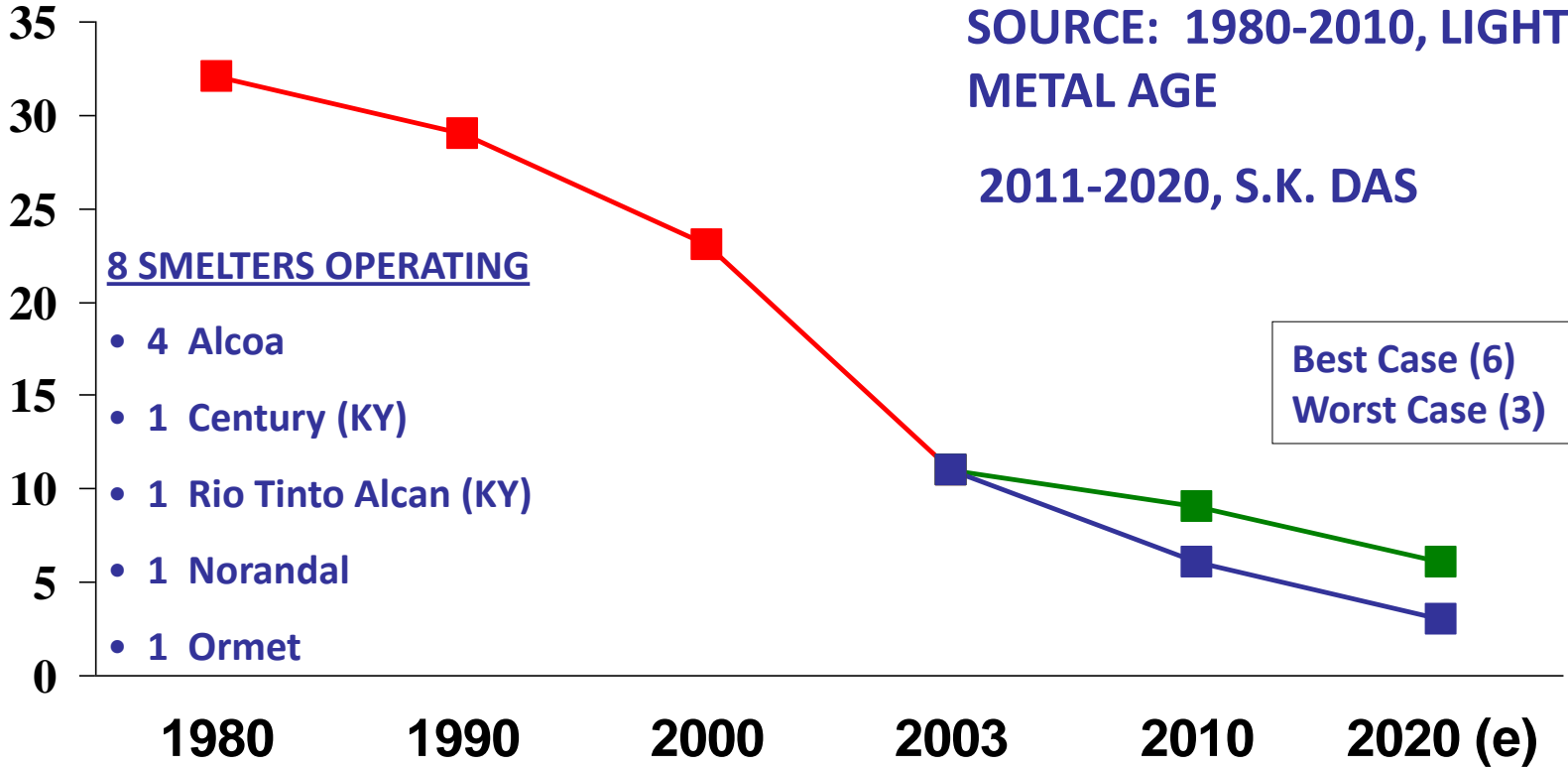
Deposit Amount and Job Creation



U.S. ALUMINUM INDUSTRY TRENDS

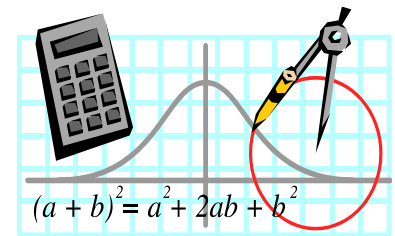
- **MARKET** – U.S. remains largest consumer of aluminum products
- **CLOSED** – All bauxite mining
- **DECLINING** – 3 alumina refineries operating, 1960s vintage
- **CURTAILED** – Only 8 aluminum smelters operating
 - < 4% of world's capacity
 - Last new smelter built 1979
 - Electricity 60 % of Cost – No new smelters will be built in US
- **REMAINING** – Remelting/Casting/Extrusion/Rolling/Recycling

PRIMARY SMELTING PLANTS IN USA



Trends in Aluminium Industry

- **Safety** – 1950s (Zero Lost Time Accident)
 - ✓ Industry Standard Now
- **Environmental** – 1970s (Zero Discharge)
 - ✓ Industry Standard Now
- **Quality** – 1980s (Zero Defects)
 - ✓ Industry Standard Now
- **Carbon Neutrality** – 2000s (Zero Carbon Impact)
 - ☐ New Industry Paradigm



Global Metal Carbon Footprint (2008)

| Metals | World Production (MMT) | CO _{2eq} (MT/MT) | % Global GHG Emission |
|------------------|------------------------|---------------------------|-----------------------|
| Iron & Steel | 1,330 | 1.0 | ~ 4.4 |
| Aluminium | 38 | 12.7 | ~ 1.7 |
| Copper | 17 | 5.5 | ~ 0.3 |
| Zinc | 10 | 3 | ~ 0.1 |
| Magnesium | 1 | ~ 18 | ~ 0.06 |
| Titanium | 0.1 | ~ 20 | ~ 0.007 |

Carbon Footprint of the Global Aluminium Industry (2008)

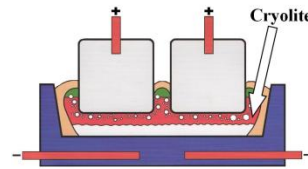
| Items | Production (MMT) | Unit Emission CO ₂ eq (MT/MT) | Total Emission MT CO ₂ eq | Comments |
|--------------------|------------------|------------------------------------------|--------------------------------------|--------------------------------------------------|
| Smelting | 38 | 10.7 | 406 | World Average |
| Anode Effect (PFC) | 38 | 2.0 | 76 | 0.3 kg/MT GWP = 6,500 |
| Recycling | 37 | 0.5 | 18 | 5 % of Primary |
| Total Emission | | | <u>500</u> | 1.7 % of Global 29,888 MMT CO ₂ eq |

What is Carbon Neutrality?

- No International Definition
- My Definition:
“Cradle-to-Cradle” Paradigm

$$\sum \text{CO}_{2\text{eq}} = \text{ZERO}$$

- + Emitted during production.
- Green energy uses.
- Energy efficiency.
- “In-Use” energy saving products.
- Recycling, Reduce, Reuse
- Urban Mining



KWH



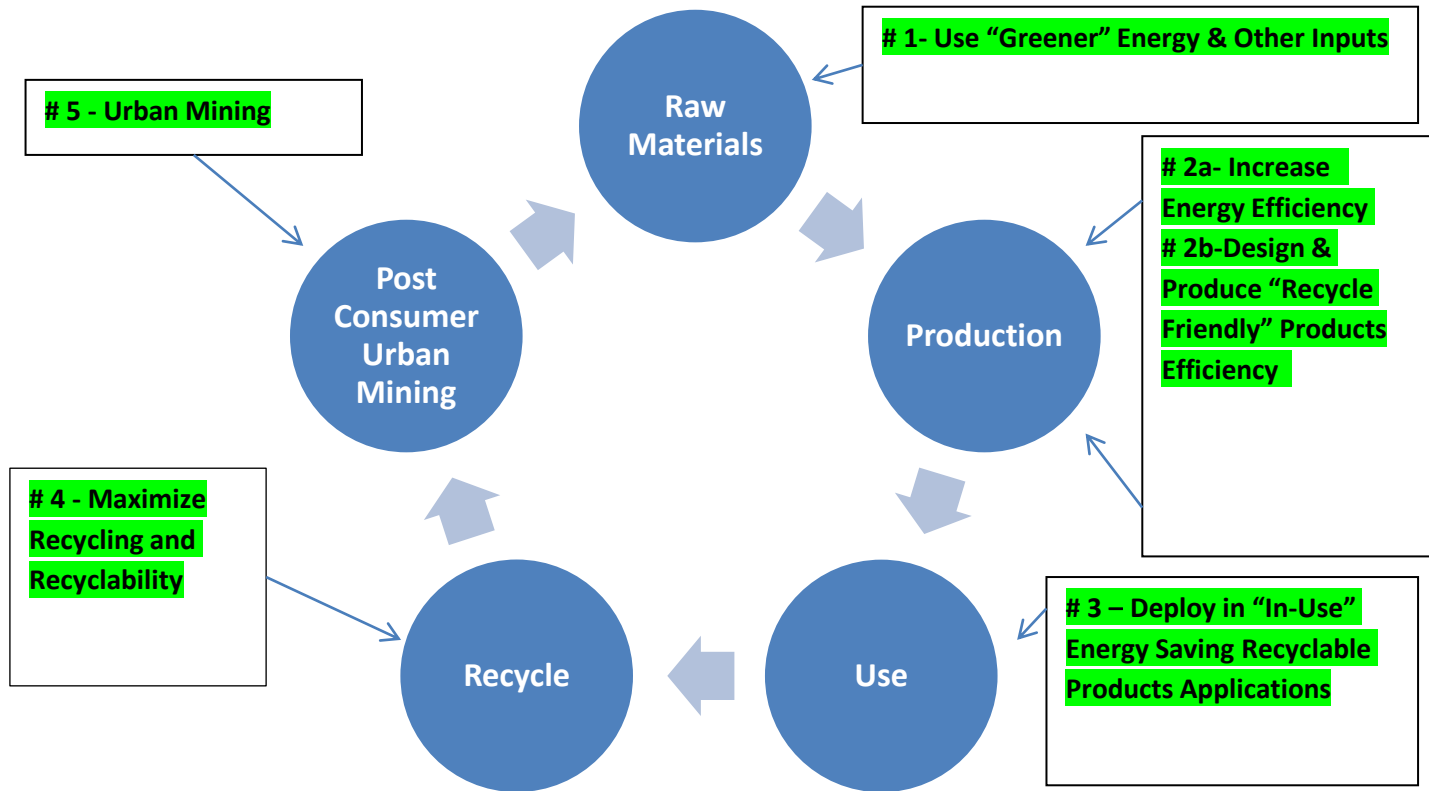
EXPERIMENTAL PROGRAM to STIMULATE CoMPETITIVE RESEARCH

May 17, 2012

Achieving Carbon Neutrality (MMT CO_{2eq} Per Year)

| | |
|--------------------------------------------------------------------------------------------------------------|----------------|
| World Carbon Footprint (2008) | +29,888 |
| Aluminium Carbon Footprint (~ 1.7% of Global) | +500 |
| Increase Use of “Greener” Sources of Electrical Energy by 8 % | (27) |
| Reduce Process Energy Requirements by 16% Eliminate Anode Effects/ Process Improvements/ New Technologies | (79) |
| Deploy 35 % of Products in “ In-Use” Energy Savings Applications Transportation & Renewal Energy Sectors | (266) |
| Divert 6.1 MMT per Year from Incinerators / Landfills | (74) |
| Recover 4.5 MMT per Year from “Urban Mining” | (54) |
| Global Carbon Impact | ZERO |

CYCLE OF CARBON NEUTRALITY



SUGGESTED RECYCLE-FRIENDLY ALLOYS

Current Number of Alloys : 110 to Possible RFA : 15

| Industry/Field | Recycle-Friendly Alloy |
|---------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| Electrical | 1350 |
| Can Sheet | One “ uni-alloy” 3104 (For body, lids, tabs) |
| Building and Construction | 3105 (painted sheet); 606X (extrusion) |
| Automotive | 5754 , 6111-O (interior) ; 6111-T4 (exterior) ; 6061-T6 (bumpers/structural); A356, 380, 319 |
| Aerospace | 2X24, one 7X50 (plate, extrusion) |
| Marine | 5052 (plate); 6063 (extrusion) |
| Guide Lines for Material/Metallurgical Engineers & Alloys Designers | Minimize use of Li, Ag, Be, Bi, Pb, Ti, Cr, Zr, V (“Entropy Enhancers/Recyclability Reducers”). Only Need: Cu, Zn, Mg, Mn, Fe and Si |

RECYCLING RATES BY MARKET SEGMENT

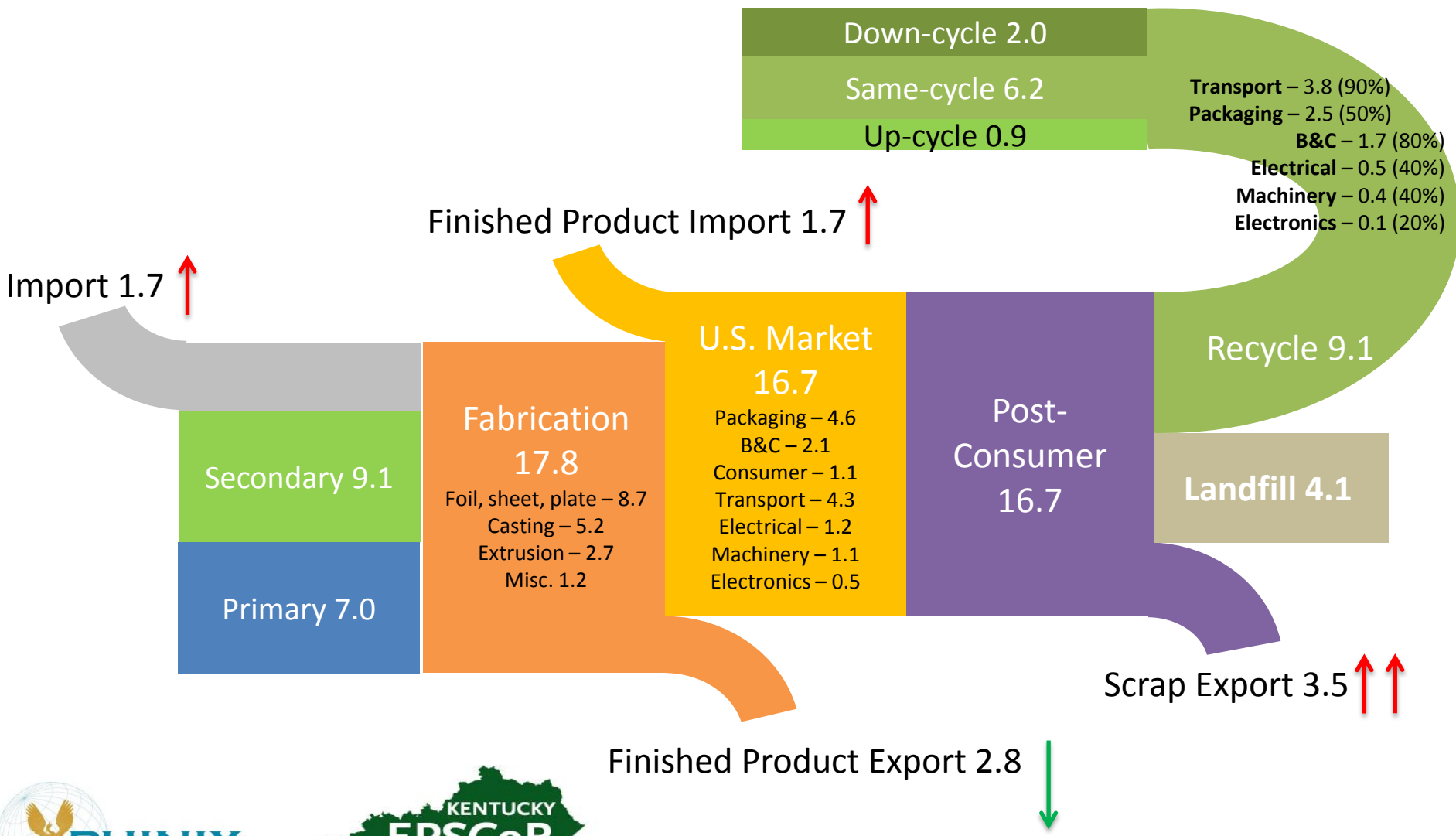
| Sector | Market Share | Use Life Cycle (Y) | Recycling Rate (%) | Recyclability | Opportunities |
|-------------------------|--------------|----------------------|--------------------|---------------|-------------------------------------|
| Transportation Ground | 30 | 8-12 | ~ 90 | High | Multi -Metal Components |
| Marine | 5 | 10-15 | ~ 70 | Medium | Low Mg |
| Aerospace | 10 | 20-25 | ~ 50 | Low | Avoid Li 2XXX/7XXX Mix |
| Building & Construction | 20 | 25-40 | ~ 80 | Medium | Extrusion / Rolled Separation |
| Packaging LG | 10 | 1-3 (m) | ~ 20 | Low | Avoid Zn |
| Packaging Cans | 10 | 1-2 (m) | ~ 50 | Low | Uni alloy |
| Electrical / Machinery | 10 | 20-30 | ~ 40 | Medium | Oxidation |
| Electronics | 5 | 1-3 | ~ 20 | Low | Recycling |

Global Aluminum Industry

CARBON NEUTRALITY VOLUNTARY GOALS

1. Increase recycled aluminum supply by > 1.05 tonnes for 1 tonne of incremental primary production.
2. Develop internationally accepted and approved carbon footprint credit protocols

Aluminum Flow (2009 Billions of Pounds) US and Canada



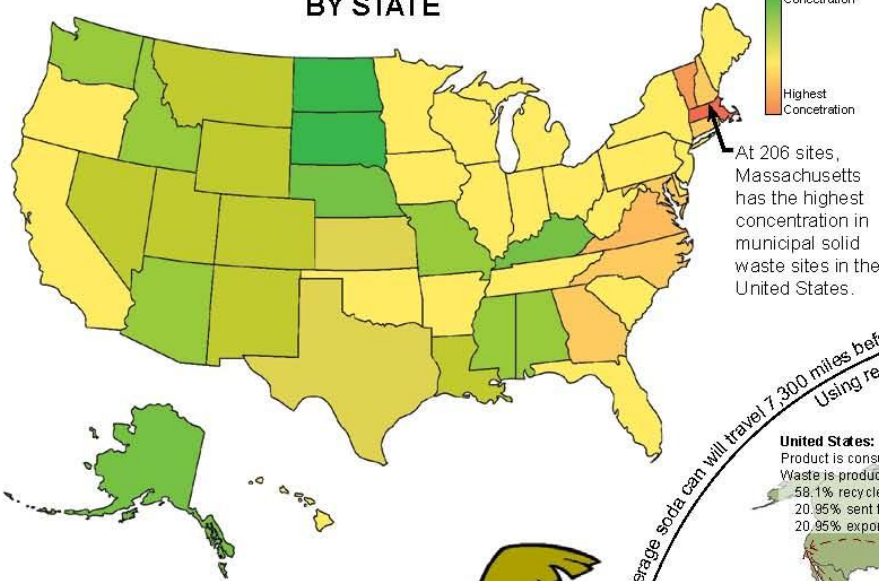


URBAN MINING



the process of reclaiming materials from buried trash

LANDFILLS PER SQUARE MILE BY STATE

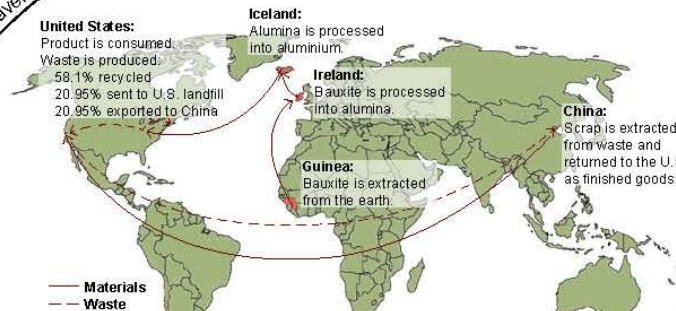


There is an estimated **\$80 Billion** of salvageable metals buried among layers of waste in US landfills.

The average soda can will travel 7,300 miles before it is consumed and emit a total of 250 grams of carbon dioxide equivalent.

Using recycled materials can reduce the carbon footprint by up to 60%.

Only 58.1% of aluminum beverage cans were recycled in the US in 2010.



BEVERAGE CAN MATERIALS SOURCING AND RECYCLING

Sources: Adams, Nicholas A., and Henry F. Sattlithigh. U.S. Aluminum Beverage Can Recycling. 2011. www.aluminum.org; EPA. Number List of Municipal Solid Waste Landfills Sites in the U.S. 1995; Phinix, LLC. <http://www.phinix.net/>

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Example of Carbon Management Copenhagen, Denmark Taxi



- Less Idling
- Better Fuel Mix
- Less Dead Weight
- Less “Scenic” Routes
- Better Driving Habits
- Local Offsets

RESEARCH OPPORTUNITIES

Primary: Game Changing New Technologies

Melting: 25% Efficient, Increase Melting Efficiency

Fabrication: Sustainable/Recyclable Products

Recycling:

Develop Recycle-Friendly Alloys

Sorting Technologies – Minimize Export

Urban Mining: \$80 billion / \$2 billion per year

In-Use Energy Savings Products: Transportation /
Renewal Energy