

***LIFE CYCLE OF ALUMINUM***  
***Dirk van Zyl, Mining Life-Cycle Center, University of Nevada, Reno***

**Key Concept:**

Life cycle evaluations of materials flow and their environmental impacts are done to better understand the opportunities for environmental improvement and material use.

**Objective:**

To explore some aspects of the life cycle materials flow of aluminum and to apply the results to a local problem.

**Applicable Nevada State Science Standards (2005):**

**Nature of Science**

- N.12 A.1:** Students know tables, charts, illustrations and graphs can be used in making arguments and claims in oral and written presentations.
- N.12 A.6:** Students know organizational schema can be used to represent and describe relationships of sets.
- N.8 B.1:** Students understand that consequences of technologies can cause resource depletion and environmental degradation, but technology can also increase resource availability, mitigate environmental degradation and make new resources economical.
- N.12 B.1:** Students know science, technology and society influenced one another in both positive and negative ways.
- N.12 B.2:** Students know consumption patterns, conservation efforts and cultural or social practices in countries have varying environmental impacts.
- N.12 B.4:** Students know scientific knowledge builds on previous information.

**Physical Science**

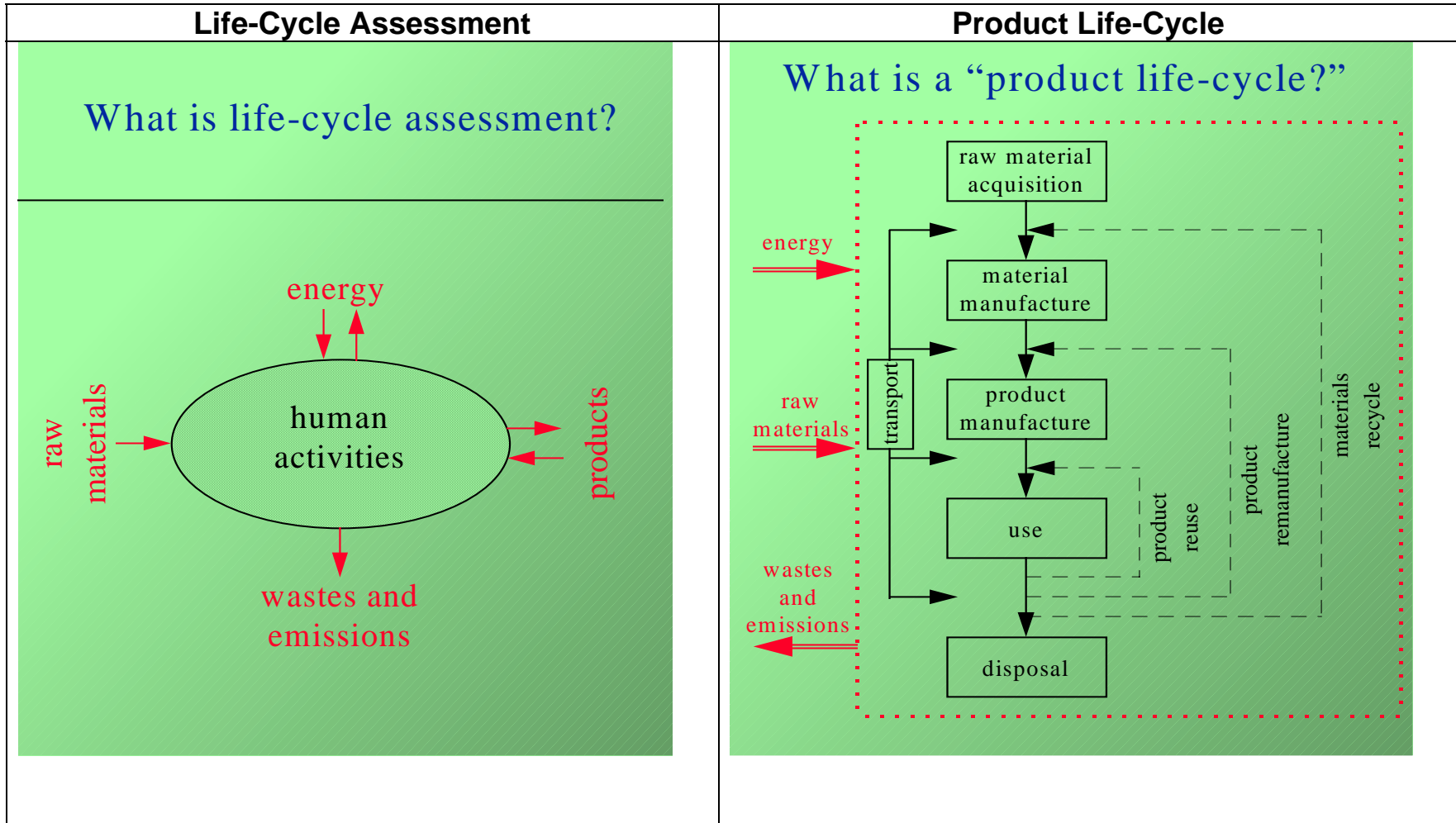
- P.12 A.6:** Students know chemical reactions either release or absorb energy.
- P.12 C.6:** Students know electricity is transferred from generating sources for consumption and practical uses.

**Life Science**

- L.12 C.3:** Students know the amount of living matter an environment can support is limited by the availability of matter, energy, and the ability of the ecosystem to recycle materials.

**Earth Science**

- E.8 C.6:** Students know minerals have different properties and different distributions according to how they form.
- E.8 C.7:** Students know the characteristics, abundances, and location of renewable and nonrenewable resources found in Nevada.
- E.12 C.4:** Students know processes of obtaining, using, and recycling of renewable and non-renewable resources.



### Aluminum Production and Manufacturing

Stage	Energy use kWh/kg Al	kg of CO <sub>2</sub> Equivalent per kg of product
Mining	0.34	0.085
Anode Production	5.84	1.81
Refining	7.87	1.621
Smelting	31.1	3.83
Furnace and Primary Casting	1.2	8.41
Hot Rolling	1.1	0.20
Cold Rolling	1.3	0.22
Extrusion	1.5	0.28
Shape Casting	2.6	0.48
<b>Total Primary</b>	<b>52.85</b>	<b>16.936</b>
Furnace and Secondary Casting	2.8	0.58
<b>Total Secondary</b>	<b>2.8</b>	<b>0.58</b>

### Some Important Statistics

- **Primary Aluminum**

- No major mines in the USA
- US share of production in 2000 was 15.3%
- In 2000 total supply in US was 10,698,000 tonnes
  - 3,668,000 tonnes primary
  - 3,450,000 tonnes secondary
  - 3,580,000 tonnes imported
- Majority of imports from Canada, Russia, Venezuela and Argentina
- Use of Al in US in 2000 (tonnes):

Use	Amount	Recycling
Construction	1,130,000	0
Transportation	2,836,000	488,000
Electrical	527,000	0
Containers/Packaging	1,883,000	1,130,000
Consumer Durables	602,000	163,000
Other	527,000	0

- **Secondary (Recycled) Aluminum**

- Al recovery from scrap requires about 5 to 6 percent of the energy required to produce primary Al
- Lag times for recycling:
  - Beverage cans 65 days
  - Automobiles 12 to 15 years
  - Building frames 40 to 50 years

**Activities**

1. Based on the energy use information on page 3 of 4, calculate the percent of energy required to produce secondary Al when compared to producing primary Al.
2. Based on the CO<sub>2</sub> release information on page 3 of 4, calculate the percent CO<sub>2</sub> equivalent released to produce secondary Al when compared to producing primary Al.
3. In 1999, 1.93 billion pounds of aluminum scrap were collected in the US. Assume that one pound of aluminum yields 33.1 beverage containers.
  - a. How many aluminum cans were recycled in 1999 if all the scrap were cans?
  - b. 102.2 billion aluminum cans were produced in 1999. What percentage of cans was recycled?
4. For Clark County with a population of about 1,650,000; assume that on the average the per capita consumption of beverages in aluminum cans is 10 per month.
  - a. How many pounds of aluminum would be required on an annual basis to supply these containers?
  - b. How many pounds of aluminum will not be recycled if the recycling rates in Clark County are about the same as the national rates?

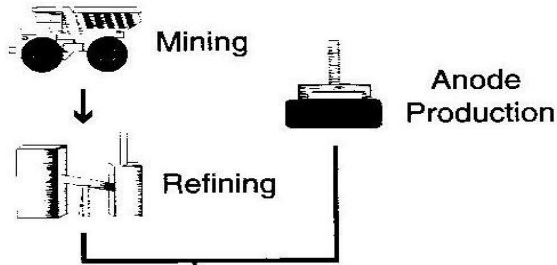
5. Assume that the aluminum in the latter containers was all from primary production, how many kWh of electricity did it take to produce it?
6. Assume that the average house may use about 2,000 kWh electricity per month how many houses can be run per month on the amount of electricity in No. 5?

**References**

<http://www.eere.energy.gov/industry/aluminum/>

<http://minerals.usgs.gov/minerals/pubs/commodity/aluminum/>

### Primary Metal



### Secondary Metal

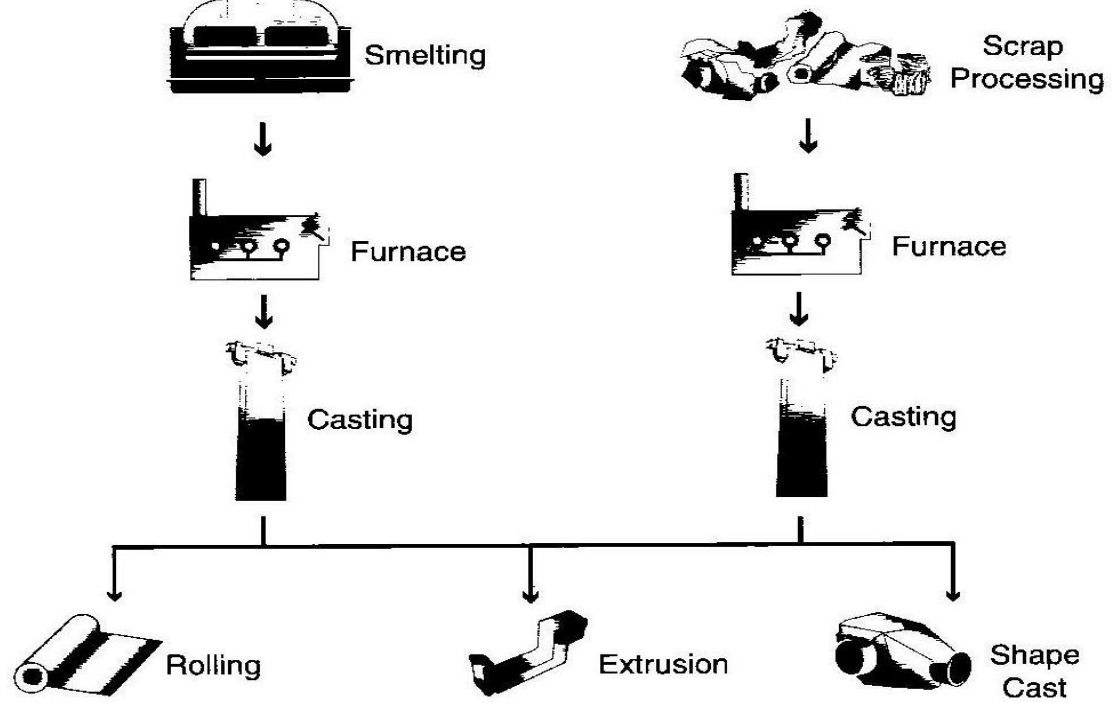


Diagram A - Aluminum Industry Flow Diagram