“We are going to get to a point where everything we do is driven by sustainable development.”
Bill Champion, President & CEO, Kennecott Utah Copper Corporation

At Kennecott, sustainable development is integral to our survival as a mining, smelting and refining company. It is essential to delivering value on the social and financial investment our stakeholders and surrounding communities have made in us.

This Molybdenum Environmental Profile is intended to inform our stakeholders of our Life Cycle Assessment efforts for molybdenum oxide from Kennecott’s Bingham Canyon Mine. A more detailed Profile can also be obtained to help our customers to better understand the environmental impacts of their products or services when conducting their own life cycle studies.
What is Molybdenum?

Molybdenum is primarily used in stainless steel and specialty steel alloys. It is highly versatile as an alloying element – it improves strength, hardness, toughness, weldability, elevated temperature strength, and corrosion resistance of steel.

One of the first applications of molybdenum was as a cost-effective replacement for tungsten in steels used at high speeds, such as in tools like drills and lathes. (The density of molybdenum is about half that of tungsten so it only takes 1% molybdenum to equal roughly 2% tungsten.)

Now, molybdenum is finding its way into a variety of alloys used in harsh operating environments. Molybdenum’s unique properties also make it ideal for many other applications beyond alloys.

For example, molybdenum is used in chemical applications such as catalysts, pigments, corrosion inhibitors, smoke suppressants, lubricants and other chemical applications.

How is it Produced?

Many copper mines contain molybdenum, and the Kennecott Bingham Canyon Mine is no exception. Following extraction and crushing, the ore from Bingham Canyon is sent to the concentrator where it is mixed with an aqueous solution and ground to a face powder consistency. Minerals containing molybdenum, copper, gold and silver are separated using a process known as froth flotation.

In froth flotation, the ore is mixed with water and chemicals that cause a change to the minerals surface. Those minerals containing sulfur (such as molybdenum, copper, etc) float to the surface of the flotation cells when nitrogen is injected allowing separation of the valuable minerals from the tailings (non-valuable) minerals. This first step is known as bulk flotation.

During the second step, molybdenum is separated from copper by adding chemicals that further alter the copper-bearing mineral surface. Molybdenum disulfide attaches to bubbles and floats to the surface of the flotation cell, separating itself from the copper. The molybdenum sulfide is then filtered, dried, and packaged in large “super sacks” for shipment.

The concentrate is shipped off-site to toll roasting facilities that further process the concentrate into the base finished product – molybdenum oxide. Molybdenum oxide can also be converted into ferromolybdenum using a silicothermal process.

This LCA is calculated through to the production of molybdenum oxide.

<table>
<thead>
<tr>
<th>2004 KENNECOTT UTAH COPPER PRODUCTION</th>
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</thead>
<tbody>
<tr>
<td><strong>Copper</strong></td>
</tr>
<tr>
<td>246,700 metric tonnes</td>
</tr>
<tr>
<td><strong>Gold</strong></td>
</tr>
<tr>
<td>300,000 troy ounces</td>
</tr>
<tr>
<td><strong>Silver</strong></td>
</tr>
<tr>
<td>3,444,000 troy ounces</td>
</tr>
<tr>
<td><strong>Molybdenum</strong></td>
</tr>
<tr>
<td>6,788 metric tonnes</td>
</tr>
<tr>
<td><strong>Sulfuric Acid</strong></td>
</tr>
<tr>
<td>869,196 metric tonnes</td>
</tr>
</tbody>
</table>

Figure 1 – Process Flow – Mining to Refining

INPUTS
Energy – Consumables – Raw Materials – (ore, water, air)

OTHER OUTPUTS
Air Emissions Water Tailings

Super sacks of molybdenum sulfide concentrate ready for shipment.
Life Cycle Assessment

Life Cycle Assessment (LCA) studies involve the collection, assessment and interpretation of data from an environmental perspective over a product’s life cycle (production, use, and end-of-life). Studies can evaluate:

- the entire product life cycle, often referred to as cradle-to-grave or cradle-to-cradle studies, or
- parts of a product life cycle, referred to as cradle-to-gate or gate-to-gate studies.

The LCA conducted to create the data contained in this profile encompasses the molybdenum life cycle from mining the ore to the roasted final product – molybdenum oxide.

Goal and Scope

This project included a complete cradle to gate LCA study for copper cathode, molybdenum oxide and sulfuric acid, consistent with ISO 14040 series LCA standards. The functional unit for the study was 1000kg of each product produced. Data gathered for the study represents operations at Kennecott’s facilities from July 2002 to June 2003.

The study was undertaken for internal use by Kennecott and for communication in a confidential, aggregated manner to select customers and LCA database providers.

The purpose of the project was to assess the environmental performance of Kennecott’s operations and products. The analysis examined how the results for copper, molybdenum and sulfuric acid contribute to environmental inputs and outputs such as water and hazardous waste as well as indicators such as smog, acid rain, energy, and greenhouse gases from a cradle to gate perspective. The results can be used to enhance communication with clients as well as process improvement and scenario analysis.

A key step in LCA is the Life Cycle Inventory or LCI

The LCI analyzes multiple environmental aspects of the inputs and outputs of a product system. Depending on the goal and scope definition, data may be collected first-hand from measurements and estimates of key activities, or the data will be based on information drawn from existing LCA databases. At Kennecott, the majority of inventory data is collected on-site and modeled using GaBi 4.0™ LCA software. Data included or excluded from the study is dependant on the system boundaries identified during the goal and scope definition. Table 1 and Figure 3 on the following page provide the system boundaries for the study.
An allocation based on mass was performed in the concentrator model in order to divide the burden in the system to that point between molybdenum and copper concentrate. The copper concentrate is eventually refined into copper cathode and gold and silver bullion. The inputs and outputs of the concentrator, as well as all preceding processes (back to earth), were allocated proportionally based on the mass of each product leaving the unit process. For example, if a product accounted for 20% of the total mass of all the products, 20% of the inputs and outputs are assigned to it.

A critical review, or independent verification, was not carried out for this study given the goal definition outlined above and the requirements of ISO 14040. However, internal reviews were carried out by project team members at both Kennecott and Five Winds International. The Five Winds International reviewers included Dr. Konrad Saur and Dr. Jim Fava, internationally recognized experts in the field of LCA.

The sections on the following pages provide the LCIA results for the production of 1000kg of molybdenum oxide.
Life Cycle Impact Assessment

Estimates for potential environmental impacts are organized under four main impact categories (shown below in Table 2). These impact categories were selected based on:

- the geographical location of Kennecott’s operations, or
- issues Kennecott currently addresses either through its internal reporting or its Environmental Management System.

Kenncott uses LCIA to determine the contribution of life cycle stages, groups of processes or individual processes to the results of the inventory and impact assessment. This process helps to pinpoint “hot spots” in the inventory or impact assessment results, as described in the analysis below.

### Table 2 – LCIA Categories

<table>
<thead>
<tr>
<th>IMPACT CATEGORY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Energy Demand</td>
<td>A measure of the total amount of primary energy extracted from the earth, including petroleum, hydropower and other sources, taking into account the efficiency of electric power and heating processes.</td>
</tr>
<tr>
<td>Greenhouse Gas Emissions</td>
<td>A measure of emissions of greenhouse gases, calculated using the IPCC 1996 Global Warming Potential Index (GWP_{100}).</td>
</tr>
<tr>
<td>Acidification Potential</td>
<td>A measure of emissions to air known to contribute to atmospheric acid deposition (acid rain).</td>
</tr>
<tr>
<td>Photochemical Oxidant Potential</td>
<td>A measure of emissions of precursors that contribute to low level smog, produced by the reaction of nitrogen oxides and VOCs under the influence of UV light.</td>
</tr>
</tbody>
</table>

In molybdenum oxide production, the roasting process contributes the most to PED. This process is conducted at an off-site toll manufacturer and uses a natural gas fired furnace to heat the molybdenum sulfide and convert it into molybdenum oxide. The second largest contributor to PED is the concentrator, which demands a significant amount of energy for the milling process.
Greenhouse Gas Emissions (GHG)

Consistent with the contribution analysis for PED, roasting dominates the GHG results for the molybdenum oxide production system. This is a result of greenhouse gases emitted from the combustion of natural gas during the roasting process. Electricity production for the Concentrator is the second largest generator of greenhouse gases in the Molybdenum production system.

Conclusion

LCA provides Kennecott with a new, systematic method for evaluating and communicating the environmental aspects of its products and processes. It can help the company ensure that a change made in one of its processes will not result in an increase elsewhere. It also provides Kennecott with a way to benchmark the performance of its products from a sustainable development perspective. Finally, LCA provides Kennecott a broader view of how its products impact the world, both positively and negatively.
Stainless steel utensils that contain molybdenum.

Disclaimer: The data reported in this Molybdenum Oxide Profile includes off-site impacts as appropriate for LCA. Consequently, the inclusion of such aspects must be considered when comparing the information included in this Profile to other reported data that does not include off-site life cycle impacts. For more information see Table 1 – LCA BOUNDARY SYSTEM on page 3 of the Profile.

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Life Cycle Assessment