Material Flow Analysis in the Aluminum Industry

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Introduction

The global aluminum industry, as part of its program of materials stewardship, is encouraging industry to collect and reuse aluminum by "mining the infrastructure of society" (e.g., cars, cans, and buildings). For such urban mining to take place, industries need to understand comprehensively the complete life cycle of aluminum and its products. Members of aluminum associations around the world have developed material flow analysis (MFA) models at both global and European scales to track aluminum throughout its life cycle from mining and manufacturing to use and recycling stages.

Through the use of MFA models, audiences and key stakeholders are better able to understand the flows of aluminum in commerce (e.g., recycled production, fabrication, and old scrap) and the ways these flows interact.

The main goals of the MFA models are

- to gain a better understanding of past and current aluminum stocks and flows;
- to show change over time;
- to predict global future scrap flows and the extent to which future worldwide aluminum market demand will be met by recycling versus new smelter capacity;
- to develop scenarios for inventories of future industrial greenhouse gas emissions; and
- to forecast the energy and ecological benefits of increased recycling rates, the use of aluminum products in energy-saving applications, and potential improvements in industry efficiency.

The aluminum MFAs are frequently updated, and global results have been published annually since 2006 (IAI 2009). Furthermore, a number of individual aluminum companies conduct their own corporate MFAs to illustrate market share and to help them develop recycling strategies.

From an Internal Activity to a Powerful Communication Tool

When the industry first started to populate the global aluminum MFA model with data in 2000, few recognized its potential as a communication, education, and lobbying tool. Instead, the expected result was primarily a realistic estimate of aluminum recycling worldwide, a figure on which the industry to this day has been unable to collect comprehensive statistics.

Following the first publications of the global model results by Bruggink and Martchek (2004) and the European Aluminium Association (EAA/OEA 2008) and the development of a European-specific MFA model, the industry began to illustrate its stocks and flows in a transparent way, communicating results regularly in industry and peer-reviewed publications. The aluminum industry has been a pioneer in developing such models and is still the only industry to publish quantitative results.

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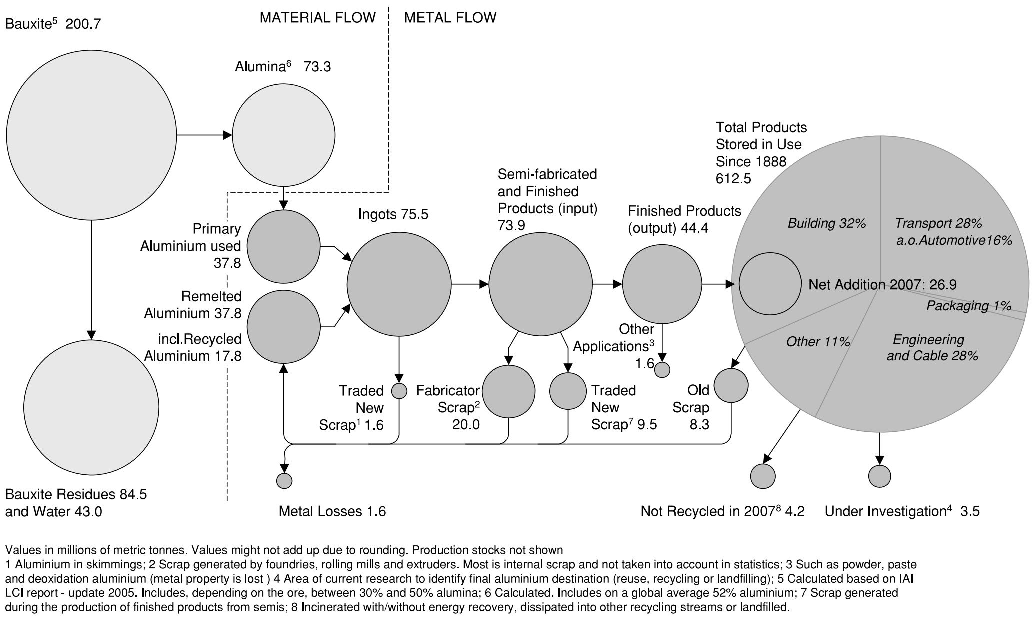

Figure 1 Global aluminum flow, 2007.

Today, the models have evolved into one of the industry's most powerful communication tools, used alongside its life cycle inventory data report (IAI 2007), sustainable bauxite mining report (IAI 2009), and annual anode effect and energy survey reports. The results of the models are reported annually in the *Aluminium for Future Generations* sustainable development indicator reports (IAI 2008). At present, most oral and written presentations by and about the aluminum industry include references to material flow models such as the one shown in figure 1[1] or to results of the models. For example, the commonly used statement "Today, approximately 75% of all the aluminum ever produced is still in productive use" is derived from the global aluminum MFA model.

Through the use of MFA models, audiences and key stakeholders are better able to understand the flows of aluminum in commerce (e.g., recycled production, fabrication, and old scrap) and the ways in which these flows interact. Visual representations of MFA results are critical to avoidance of the misunderstandings that inevitably arise in communication of such complex systems as metal flows.

The MFA results are used in presentations on topics such as recycling, energy efficiency, greenhouse gas emissions, durability, future scenarios, and trade that are given at conferences all over the world, including in China, Australia, India, the United States, Europe, and Japan.

Communicating Industry Positions to External Stakeholders Using MFAs

Aluminum associations around the world represent bauxite miners and alumina refiners, primary and recycled aluminum producers, and downstream fabricators. These associations promote the contribution that the aluminum industry and its products make to sustainable development while maintaining and improving the image of the industry, the material, its applications, and the recycling of metal after use. Associations accomplish these goals through the development of environmental and technical expertise, economic and statistical analyses, scientific research, education and sharing of best practices, and public affairs and communication activities.

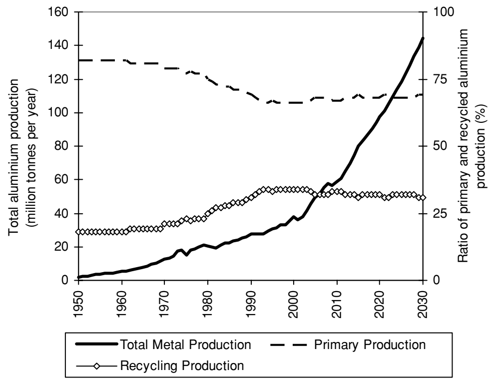

Figure 2 Global share of recycled and primary aluminum.

The European Union (EU) is one of the largest aluminum end-users worldwide, and it therefore has a strong domestic fabrication and manufacturing industry. In view of limited ore resources and energy constraints, the EU is structurally dependent on domestic recycled aluminum and aluminum imports. MFA models created for the European Aluminium Association underline the importance of recycled aluminum in the EU: A total of 10.5 million tonnes of aluminum is used for the production of fabricated goods in the EU, whereas primary aluminum production in the EU amounts to just 3.1 million tonnes. The availability of local recycled aluminum provides a market alternative to greater dependence of imported aluminum.

Several governments, aluminum industry customers, and sustainable product certification schemes (e.g., Leadership in Energy and Environmental Design [LEED] for buildings) request a high proportion of recycled contents for their products. MFA results help the aluminum industry show policy makers that eco-labeling for aluminum should be based on end-of-life recycling rates rather than the recycling input rate or recycled content, which cannot be increased in all applications due to limited scrap availability. Through MFA, the aluminum industry is able to demonstrate that if all aluminum applications were grouped together, the average global recycled content (with the exclusion of fabricator scrap) would stand at around one-third overall (see figure 1). With the continued growth of the aluminum market and the fairly long life span of most aluminum products (in the case of buildings, potentially more than 50 years), however, it is not possible to achieve a high proportion of recycled content in all new aluminum products, simply because the available quantity of end-of-life aluminum falls considerably short of total demand, as shown in figure 2. In the case of a material in increasing demand, with potentially long-life products and with inherent recyclability, such as aluminum, maximization of its environmental benefit comes from increased recycling of products at the end of their useful life.

The Value of MFAs to Companies

Despite limits in estimates of the regional distribution of material, product lifetimes, and market growth rates, MFAs can be used to provide information that supports the development of business strategies for individual companies. Alcoa and Hydro Aluminium are examples of individual aluminum manufacturers that are conducting MFAs to understand their corporate and regional material flows, as well as their current energy consumption and ecological impacts.

Forecasts of material flows and energy and emissions intensities are used to quantify potential financial climate-measure obligations as well as product opportunities for individual companies. Such quantitative modeling of material flows and impacts is also serving as input to business strategies and market developments, with a focus on lowering energy costs and emissions exposures. In fact, companies are also beginning to track the material flows of selected products in an attempt to understand better their "carbon footprints" as a basis for responding to customers' inquiries and for prioritizing process improvements and flow efficiencies.

The depletion of nonrenewable resources and the availability of alternative raw materials are of great concern in the metallurgical industry, as in other base material industries. Consequently, the use of MFA gains increasing importance to companies operating in those regions where primary raw materials are limited or dependent on expensive energy. In the case of the European aluminum industry, the increasing cost of electricity and an economically driven greenhouse gas tax scheme have created a decrease in smelter capacity. Consequently, the aluminum semifabrication industry has been forced to look for alternative metal sources. All kinds of scrap have become more attractive as raw material because of the high cost of remelting imported primary ingots. Depending on the final product properties, the chemical composition of aluminum alloys has to fulfill strict specifications. In these cases, the choice of aluminum scrap can be very limited. Therefore, for some material flows, MFAs performed at the scale of individual companies must be very accurate to be useful.

When MFAs are used to forecast the production and use of a material, further temporal uncertainties arise, especially when long-life applications and high growth rates influence the material's supply and demand. Nevertheless, MFAs in the aluminum industry are used to forecast regional scrap availability and composition and have been used to inform companies as they make decisions about melting technologies, capacity, site selection, and scrap pretreatment requirements.

Conclusion

The MFA models created by the aluminum industry have proven to be very useful tools for communicating, lobbying, closing data gaps, and developing business strategies. The aluminum industry, recognizing these benefits and the importance of transparency and credibility of its models, will continue to improve its database and modeling tools through engagement with Norwegian University of Science and Technology, Yale University, and Vienna University of Technology.

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Note

1. Additional figures showing global and EU MFAs developed by the aluminum industry, as well as further references to relevant literature, can be found in the Supplementary Material on the Journal's Web site.

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Supplementary Material

Additional Supplementary Material may be found in the online version of this article:

Supplement S1. This supplement contains additional figures depicting global and EU MFAs as well as references to MFAs and aluminum in Europe that were not specifically cited in the article.

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