Landfills represent a potential valuable source of aluminum.

Landfill Mining: The Untapped Source for Aluminum and Its Relevance in the U.S.

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Aluminum is one of the most highly consumed metals in today's world, with its demand growing multifold every year in line with the gradual shift to renewable energy and a low-carbon economy. It is also one of the most recycled metals in the world. Around 75% of the almost 1.5 billion tons of aluminum ever produced is still in productive use today.

That said, aluminum continues to be on the radar of environmentalists because of its energy-intensive primary production process, GHG emissions, and inadequate recycling. A large volume of aluminum produced ends up in landfills, despite the recycling and recovery of automotive, packaging, and construction scrap worldwide.

Notably, a new report from the International Aluminium Institute (IAI) and CRU pegged global aluminum demand to increase by almost 40% or by 33.3 million tonnes to 119.5 million tonnes in 2030 from 86.2 million tonnes in 2020, and it is further expected to increase by about 80% by 2050.[1] Recycled or secondary aluminum contributed about 33% of total demand (33 million tpy) in 2020. Secondary aluminum is expected to play a critical role in the growing market, with planned capacity expansions bringing its contribution up to about 54% (81 million tpy) in 2050. Considering the ever-increasing production and consumption year-on-year, it has become mandatory to recalibrate the recycling strategies for this metal.

Understanding Landfill Mining

Landfill mining involves excavating landfills to recover the buried resources that can then be processed for environmental, economic, or social benefits. The vast quantities of metal buried in landfills can be suitable for use as potential secondary resources. Nonferrous metals, especially aluminum, have the maximum potential to be used as a secondary raw material after being recovered from landfills, thus contributing to the added value of waste materials.

Landfill mining is similar to mining in general,[2] and the basic steps remain the same. First, there is an exploration of the landfill and assessment of the available materials (economic feasibility), followed by excavation and processing, transportation to material processor, and site restoration. The potential material recovery from landfills depends on the outflow of materials from these sources into the waste stream. Landfill mining provides a number of benefits, including optimum use of materials at the end of the life cycle, national security (reduced imports), lower prices of valuable materials and metals (lower inflation), generational employment, and enhanced profitability of landfills. It can also provide enhanced sustainability, since virgin metals and materials production has high carbon (solid, water, and GHG discharge) footprints compared to recycled metals.

Landfill mining is especially relevant for the U.S., because it is one of the key consumer markets for aluminum. This country produces over one hundred billion aluminum cans per year and consumes one can per day for every American. Although domestic recycling has improved and enabled a large market for secondary aluminum as an industrial feedstock, the overall amount of recycling is still relatively low and quite variable from industry to industry and state to state. The U.S. has been burying aluminum cans in landfills since Coors launched their aluminum beer cans in 1959.

Looking at the statistics, the current used beverage can (UBC) recycling rate in the U.S. hovers around 45% (2020).[3] This compares to about 100% in Brazil, nearly 80% in Japan, and 73% in Europe.[4] Nevertheless, the number of UBCs recycled by the industry increased by about 4 billion cans yearly to 46.7 billion in 2020. This low rate of recycling is partially attributed to growing can sales in the year, which increases the amount of cans on the market with no similar increase in collection and recycling.

Therefore, the Can Manufacturers Institute (CMI) pledged to raise the U.S. UBC recycling rate from 45% to 70% by 2030, 80% by 2040, and 90% by 2050. In July, the CMI published a detailed aluminum beverage can recycling primer and roadmap to achieve the target. The report proposed a four-pillar approach to raise the recycling rate, as follows:

• Implement well-designed deposit systems at the state and federal levels.

• Increase and improve household and away-from-home recycling.

• Ensure proper sorting at recycling centers.

• Increase understanding of the importance of aluminum can recycling.

While the industry representatives are simultaneously implementing these four pillars across the U.S., a potential fifth pillar for recovering aluminum could be landfill mining. According to the Environmental Protection Agency (EPA) data, roughly 4 million tons of aluminum entered the municipal solid waste (MSW) stream in 2018,[5] 50% of which was from containers and packaging. The other half was from other sources (which needs more organized data). Of that total, 68% (2.6 million tons) of the aluminum was eventually landfilled, meaning only 32% was removed for recycling or recovery.

Many assume that the biggest source of aluminum headed for landfills is aluminum cans. However, if one compares the 2.6 million tons of landfilled aluminum to 477,000 tons of unrecycled aluminum cans in 2018 (according to an Aluminum Association report), it is clear that UBCs comprise less than 20% of landfilled aluminum. Note that this is based on the assumption that the UBCs produced and shipped and not collected (recycled) in a given year ended up going to landfill.

Hence, U.S. landfills not only contain UBCs, but also other forms of aluminum scrap. This means a further investigation into the most common sources of landfilled aluminum is needed to design a collection system that will effectively target all sources of aluminum in a landfill. Whether UBCs or any other type of aluminum scrap, U.S. landfills can be a potential source of secondary aluminum recovery, if a recovery roadmap is strategically outlined.

A Lost Revenue Stream: As reported by the Aluminum Association, about 3 billion lbs (1.5 million tons) of cans were shipped in 2020, while 1.3 billion lbs (650,000 tons) of cans were recycled by U.S. consumers, which means that 850,000 tons of cans were left unrecycled.[6] Considering the dollar value of UBC scrap in 2020 at $991/tons, around $840 million worth of aluminum ended up in landfills. That volume could have otherwise been responsibly recycled, made into new cans, and added to the revenue stream. Considering the present value of UBC scrap per ton (about $1,300/ton), the current amount of unrecycled UBCs could be worth more than $1 billion.

The total amount of aluminum landfilled in the U.S. is estimated to be around 90.2 million tons, according to research from Phinix LLC. The average amount landfilled yearly since 2010 is about 2.55 million tons. The data shows approximately 25.5 million tons of aluminum were landfilled in the last decade (about 28% of the total amount of aluminum landfilled to date). That indicates that about $25 billion worth of the material was dumped in landfills. The EPA estimates that 340,000 tons of aluminum were landfilled in 1960, which means the country saw an eight-fold increase in landfilling in 60 years, despite an increasing focus on recycling and conservation in that timeframe (Figure 1).

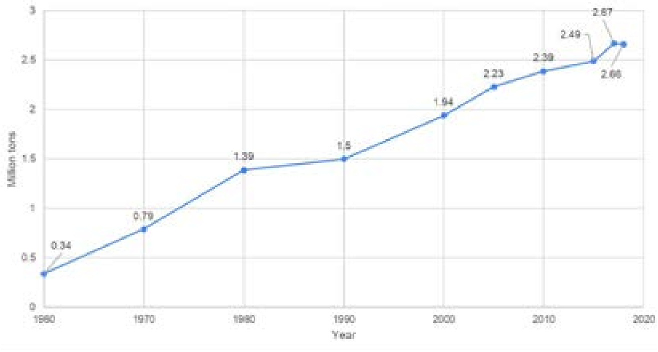

Figure 1. Total amount of aluminum landfilled each year.

The Challenges of Landfill Mining

Considering the amount of valuable aluminum available in landfills, a pertinent question is raised about viability of recovering the cans and other aluminum products that have been landfilled in the U.S. This has prompted a renewed interest in the technical, economic, and environmental feasibility of mining landfills for aluminum, which could be a revolutionary method for sourcing aluminum as a secondary raw material.

Landfill mining is a complicated process and can be expensive enough to consume about 80% of the project budget. The cost of excavating trash, sorting out the materials (such as metals), and reburying the rest could exceed the revenues from selling recovered materials.[7] Therefore, new technologies will need to be developed to reduce these costs.

Boring into a landfill will also release the methane generated as the trash decomposes. Since methane is a greenhouse gas, this will need to be managed to prevent it from being released into the atmosphere. One possibility would be to collect the methane, which could then be used as a fuel. Increasingly, methane is being used for combustion in steam generation and to heat large institutional buildings.

Another concern is that the aluminum scrap recovered from a landfill will be more contaminated than the usual end-of-life waste. It will require extra processing to clean it and, therefore, it might not be an attractive option to remelt operators.

Moreover, there could also regulatory hurdles for accessing and processing the landfilled material, which would be a hindrance to raw material recovery from landfills. This comes with numerous political, economic, environmental, and legal liabilities.

The Way Forward

Despite the challenges mentioned, with the development and implementation of advanced technologies, the larger current commercial usage of aluminum, and the inherent energy savings versus virgin aluminum (92%) production may make it worthwhile to mine for aluminum in landfills. Phinix LLC has started researching the viability of landfill mining aluminum in the U.S. The team has begun to develop information that will allow for the strategic targeting of priority states and specific locations for landfill mining. Data has been assembled for three primary variables to allow for a rough ranking of each state's overall aluminum disposal, including state population, annual state per capita aluminum can disposal, and the current state-specific aluminum can recycling rate.

Landfill size, activity, and operational years data are available for each state from EPA statistics. Seeing how drastically the amount of aluminum being landfilled has increased in recent decades may influence the strategy to target prime locations for landfill recovery. For instance, it might make more sense to target a smaller landfill that has been more recently active than a larger landfill that has been accepting material for a longer time. This is based on the fact that the aluminum discarded in the early decades was much lower than in recent decades. The plan to develop landfill mining could involve several steps, including:

- Contact relevant state agencies and U.S. EPA offices regarding landfill management, solid waste characteristics, aluminum disposal, and recycling programs within the area.
- Contact the owners and county officials of the high-priority areas identified in each state and engage them in conversations about their attitudes and openness towards landfill mining for aluminum recovery.
- Learn more about the opportunities and challenges associated with this approach from the relevant stakeholders and explore their interest in a potential pilot project.
- Initiate research into the landfill mining operational process flow that would be required to separate aluminum from landfilled waste.
- Develop estimates of capital and operational requirements and compare them to the potential revenue generated from aluminum recovery under several operating scenarios.

References

1. "Opportunities For Aluminium In A Post-Covid Economy," IAI and CRU, international-aluminium.org/resource/opportunities-for-aluminium-in-a-post-covid-economy.
2. "Mining Landfills," Massachusetts Institute of Technology," Massachusetts Institute of Technology (MIT), web.mit.edu/12.000/www/m2016/finalwebsite/solutions/landfill.html.
3. "Report: Aluminum Beverage Can Retains Edge as Most Sustainable Drinks Package," The Aluminum Association, www.aluminum.org/news/report-aluminum-beverage-can-retains-edge-most-sustainable-drinks-package.
4. Taylor, Brian, "Europe records 73 percent UBC recycling rate," *Recycling Today*, December 15, 2022, www.recyclingtoday.com/news/aluminum-can-ubc-recycling-europe-rate-2020.
5. "Aluminum: Material-Specific Data," EPA, www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/aluminum-material-specific-data.
6. "The Aluminum Can Advantage:Sustainability Key Performance Indicators," The Aluminum Association, November 2021, www.aluminum.org/sites/default/files/2021-11/2021_KPI_Report_1.pdf.
7. "Why Aren't We Mining Landfills for Valuable Materials Like Metals and Soil?" Ensia, https://ensia.com/features/landfill-mining. ■

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