Mitigating aluminum industry emissions: Industrial carbon management could reduce costs

July 1 2024

TechXplore

ISSN 1831-9424

European Commission

Decarbonisation Options for the Aluminium Industry

Zore, L.

2024

Credit: European Commission, Joint Research Centre (JRC)

A new report released by the European Commission's Joint Research Center (JRC) confirmed industrial carbon management (ICM) as a range of promising technologies for mitigating CO_2 emissions, in particular in energy-intensive industries such as the aluminum industry. Some adjustments will be required to tailor the process to the specific sector.

Aluminum is an essential material to manufacture many products, from cars to health care and aerospace components. To produce it more responsibly, it is key to find ways to decarbonize the production process. We will need to make use of the full range of low carbon technologies.

Decarbonizing the aluminum sector is challenging mostly because the production of alumina, the main ingredient in aluminum, is energy-intensive (the primary aluminum industry emitted 2.75 million metric tons of CO_2 in 2022 in the EU, equivalent to 9.4 million newly registered passenger cars in the EU in 2022 driving 2,705 km each).

Therefore, reducing its emissions is essential for the industry to contribute to the EU's 2030 and 2050 decarbonization targets.

The JRC's report assesses four decarbonization options (inert anodes, hydrogen, electrification and ICM) and concludes that ICM is among the technologies at hand with the largest potential to mitigate emissions in this sector.

What is ICM?

ICM is a set of technologies that capture CO_2 from industrial operations or energy production plants and safely transport and store it underground (carbon capture and storage—CCS). The CO_2 can also be utilized as input for creating other products, such as chemicals and materials (carbon capture and utilization—CCU). Finally, the CO_2 can be removed from the atmosphere, where permanent storage involves biogenic or atmospheric CO_2.

In the U.S., ICM has mostly been used in the oil and gas industry as a way to obtain a CO_2 stream for enhanced oil recovery (EOR—a process where CO_2 is pumped into an oilfield in order to enhance the oil recovery). However, there has been an increasing focus on applying ICM as a climate-mitigation tool for managing and storing carbon emissions to support the decarbonization of heavy industries, such as the aluminum one.

In the aluminum sector, ICM could be one of the feasible decarbonization solutions, especially for facilities that: have access to cost-effective fossil fuels, lack access to affordable renewable energy sources, are still operational, have long decommissioning horizons, and have available CO_2 transport and storage infrastructure.

ICM application in the aluminum sector

ICM technology in primary aluminum production can be first used in the fossil fuel-based alumina refining process, followed by the smelting process, where emissions stem from carbon anode consumption. To date, the most advanced technology uses a solvent to absorb CO_2 emissions from flue gas (the exhaust gas of combustion at power plants).

The captured CO_2 can then be transported through pipelines, ships, trains, and trucks. While this practice is well established in the oil and gas sector, especially in the U.S., in a European context the aluminum industry would have to join forces with other industries emitting significant CO_2 volumes. The CO_2 emissions from the aluminum industry in the EU are about 30 and 100 times smaller than in the cement and steel industry, respectively.

Finally, the transported CO_2 is injected deep underground into porous rock layers, typically in deep saline formations or depleted oil and gas reservoirs, with an impermeable layer to prevent leakages. This is a tried-and-tested method, both from the oil and gas industry but also in the Sleipner and Snøhvit CCS projects in Norway that have been operational for almost 30 years.

Main barriers

One of the main barriers to the widespread implementation of ICM is the high initial investment required, as well as the high operating cost. This could potentially be minimized or offset if the captured carbon is integrated into a value chain that generates revenue or through mechanisms such as the EU Emissions Trading System (ETS), which sets the CO_2 price.

The cost of capturing carbon varies greatly depending on the concentration of CO_2 at the emission source and the technology used to capture it. It can range from approximately €15 per metric ton of CO_2 for high-concentration emissions to over €100 per metric ton for low-concentration sources.

In aluminum smelters, where the CO_2 concentration is relatively low (about 1%–1.5%), the cost of carbon capture is high. To reduce this cost, smelters may need to implement measures such as redesigning electrolytic pots to prevent carbon emissions and compressing flue gas before capture, although this also requires investments. In alumina refineries, CO_2 concentration in flue gas is higher, thus implementing carbon capture would in principle be economically more favorable.

Alternative decarbonization technologies

Inert anodes could replace carbon anodes, eliminating the need to use carbon as a reductant, and thus, practically eliminating almost all emissions from the smelting process and at the same time increasing smelters' efficiency by 25%. This is why they are considered potential game-changers in the aluminum production.

Hydrogen can also be used to offset emissions from fuel burning in high-temperature processes. However, in order to be an effective decarbonization option, it should be produced from renewable energy sources.

The electrification of low and mid-temperature applications is also viable, but its cost-effectiveness is dependent on the respective costs of electricity and carbon.

More information: Decarbonisation Options for the Aluminium Industry. publications.jrc.ec.europa.eu/ … ory/handle/JRC136525

Provided by European Commission, Joint Research Centre (JRC)

Citation: Mitigating aluminum industry emissions: Industrial carbon management could reduce costs (2024, July 1) retrieved 2 July 2024 from https://techxplore.com/news/2024-07-mitigating-aluminum-industry-emissions-industrial.html