Green Alumina a Technological Roadmap

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Abstract

The Green Aluminium phenomena although recent in notion, has been materializing over the last century with the first dedicated hydroelectric power stations for Aluminium production being commissioned early in the 20th century. With the EU emission target strategy in full swing, individual producers setting their own values and speculation on the formation of a newly indexed metal, producers, technology suppliers and regulators are trying to common ground to materialize a niche portion of Aluminium production to meet the emission related targets. The carbon dioxide makeup of Aluminium production is dominated by the electrolytic reaction followed by the anode consumption and then the Bayer process. Industry has spent significant efforts in decarbonizing the former two, the later still needing strong conceptual development. This paper intends to explain the conceptual contribution towards Green Aluminium from the perspective of a Bayer process technology supplier.

Keywords: Aluminium, Alumina, Green, Renewable Energy, Zero Carbon.

1. Introduction

The Paris Agreement is a **legally binding international treaty on climate change adopted by 190 countries with the clear intent to combat climate change.** In the United States approximately 46% of carbon dioxide emissions are generated through manufacturing processes or electricity production [1], the latter constituting the majority of emissions (approx. 67 %). Aluminium production is an important emissions contributor and has often been denoted as “Congealed Energy”. The actual amount of electricity (Figure 1) dedicated to the primary Aluminium production process is relatively small when compared to overall electrical energy production, however Aluminium production still generates 760 million tonnes of carbon dioxide every year, also considering that 15% of world Aluminium production is generated by renewable means (IEA, 2020) [2].

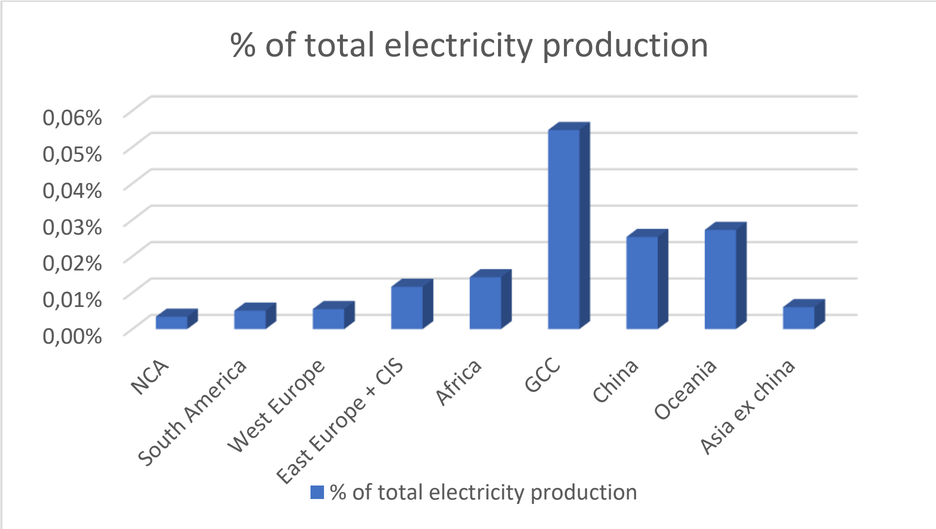

Figure 1. Percentage of total electricity production directed to aluminum smelting by region (note only Aluminium producing countries were taken into consideration, IEA 2020).

In recent years a series of primary Aluminium producers have flagged their intent to produce and market low carbon Aluminium with a specific carbon dioxide footprint of 4 tonnes of carbon dioxide per tonne of Aluminium. To complement these initiatives the European commission is proposing a carbon border adjustment mechanism, where the EU will start to equalize the price between domestic primary produced Aluminum against low carbon imports (European Carbon Border Commission, 2021). Arguably this trend is compounded by trading houses to facilitate the indexation of this new product separately. Considering that the Aluminium consumption in Europe is approximately 15- 20 % of total production (European Aluminium Association, 2019), this combination of initiatives certainly pushes producers and technology providers to achieve a new benchmark in Best operating or Best engineering practice.

2. The Carbon Footprint of Aluminium Production

The wide acceptance of the Bayer process and Hall-Heroult processes as being the benchmark for primary Aluminum production is a given. These process routes have received the majority of attention from an R&D, product management and engineering perspective and moving forward in the future, this is unlikely to change. The primary Aluminium production carbon footprint typically oscillates between 12-20 tonnes of carbon dioxide per tonne of Aluminium metal, the majority of this comes from the endothermic reduction process, followed by anode consumption and then the Bayer process. Major industry players have already invested in powering Aluminium reduction by renewable means (mainly hydroelectricity). The difference on the carbon makeup between Aluminium reduction fueled by non-renewable means versus renewable means is highlighted in Figure 2.

The technological advances of inert anodes such as the Elysis based partnership between Rio Tinto and Alcoa [5] and UC Rusal's own development [7] is slowly turning into a full-scale commercial rollout followed by a new benchmark in technology for the primary Aluminium smelting process. The full-scale implementation of renewable energy into primary Aluminum production coupled with inert anode technology could definitively mean an Aluminium carbon footprint of 2.5 tonnes of carbon dioxide per tonne of Aluminium is realistic, which largely leaves the Bayer process itself as the last node to untwine, and although a "*Zero Carbon Aluminum billet*" maybe stretching reality, however a significant reduction in the carbon footprint is definitely within reach.

Figure 7. Aerial view of Metso Outotec's Hydrogen driven circulating fluid bed iron ore reduction plant built in Trinidad.

Figure 8. Ground level view of Metso Outotec's Hydrogen driven circulating fluid bed iron ore reduction plant built in Trinidad.

5. Conclusion

This manuscript introduces the highlights associate with decarbonizing the Bauxite to Alumina value chain as a contribution to overall Aluminium value chain decarbonization. The challenge associated in decarbonizing the alumina production process is highly orientated around key energy sinks and their interaction with energy "*conduits*" capable of relaying the renewable energy source to the intended destination. Each concept needs to be carefully considered based on the technology available, however the level of technical maturity based on capacity will ultimately determine the technology selected. This latter aspect is clear for the hydrometallurgical section of the Bayer process, as the technology selection would clearly depend on the size of individual technologies and the willingness of technology suppliers meeting a certain thermal demand.

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