Moving to CO_2-Neutral Alumina and Aluminium Production at Norsk Hydro

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Extended Abstract

In this presentation, Norsk Hydro's approach to sustainability throughout the whole value chain is outlined. The sustainability of a material covers several aspects like emissions, waste, social and societal influence and resource efficiency but the carbon footprint is by far the most important, also in terms of material competitiveness. The presentation will therefore have main focus on carbon footprints but also waste and other emissions will be touched upon.

Figure 1 shows Hydro's total CO_2 emissions. Hydro emits a total of 15 million tonnes of CO_2 annually. Main contributions are seen to be electricity generation and fossil fuel combustion (mainly from alumina refining, casthouse operations and anode baking furnaces), while a smaller part is due to direct process emissions from the aluminium electrolysis process. The figure further shows that for a smelter based on renewable power, the two main sources of CO_2 emissions are the alumina refining and the direct emissions from the smelter electrolysis itself. The latter is one of the most expensive and difficult emissions to remove.

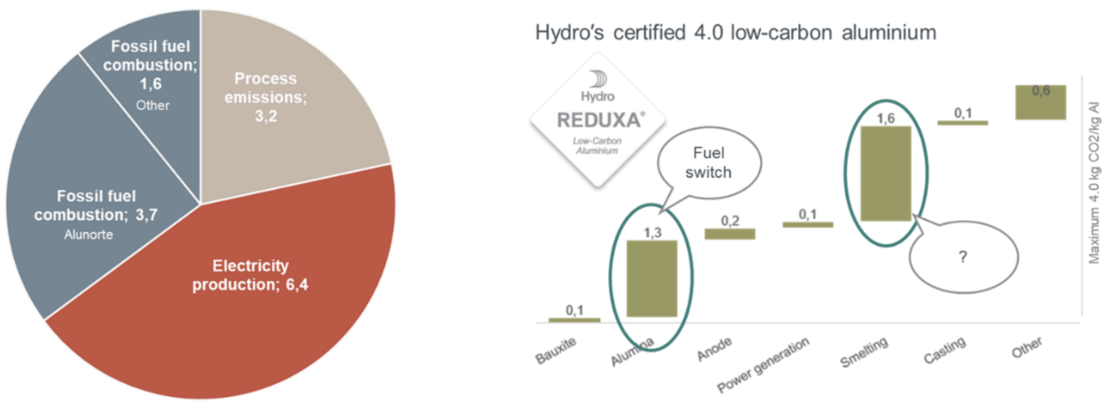

Figure 1. CO_2 emissions in Norsk Hydro. Left: Hydro's total emissions sorted on source. Right: Emissions from the various steps in the value chain for the certified Reduxa low-carbon aluminium.

For bauxite and alumina, the two key sustainability challenges are bauxite residue and carbon footprints. Main decarbonization actions are fuel switch from coal and heavy oil via natural gas as a probable intermediate stage and electrification and use of hydrogen as the likely longer-term solutions. Hydro is in a process to convert to natural gas at our Alunorte refinery. This will significantly reduce the carbon footprints from Alunorte, the world's largest alumina refinery.

Bauxite residue is another sustainability challenge. The huge deposits of bauxite residue around the world are not good for the perception of aluminium as a sustainable metal of the future. More than 1 billion tonnes are deposited globally and this increases with more than 100 million tonnes per year. In Alunorte, we have already installed press filters, which reduce alkalinity and water content of the residue. This is a step towards safer deposit but not a final solution. The industry needs to reach a state of utilization of the bauxite residue for product applications. Here, we follow several paths where civil construction (cement, concrete, aggregates, components and cementitious products like pavers), gravel, soil refinement and proppant are among the most promising.

Globally, the power production is the biggest source for CO_2 emissions in the smelter area. Thus, energy efficiency and conversion to renewable energy are the most important actions. On the energy efficiency, we are proud of the results of our latest electrolysis technology, the HAL4e technology. This technology in the Karmøy Technology Pilot has proven to produce consistently at industrial scale with an energy consumption of 11.7 and 12.4 kWh/kg Al, for low energy and high productivity versions, respectively, and with a total CO_2 emission of 1.4 kg CO_2 per kg Al. Hydro has a good power source portfolio with a high fraction of hydropower and wind sources. We continuously work on converting the rest of the portfolio to renewable power as well.

Direct CO_2 emissions are still a huge financial and technical challenge for the industry. We are looking into carbon capture and storage technologies for our existing Hall-Héroult smelters. Here, the challenges are low concentrations of CO_2 and pollution in the off-gases, which makes standard amine technology costly. We have evaluated and tested out a range of technologies, also based on direct air capture technology. In addition, we are exploring a chloride route and following work on bio carbon and inert anodes. For the chloride process, we have proven on lab-scale the efficiency of converting alumina to aluminium chloride by reacting it with carbon monoxide and chlorine. The idea of this process is to convert the resulting CO_2 to CO through electrolysis, thus running a process where the chlorine as well as the carbon run in closed loops, hence, producing aluminium with no or very low carbon footprints through electrolysis of the aluminium chloride. A cost and feasibility study of a full-scale plant has been executed and the next step would be a pilot plant for the chloride route.

In the casthouses we are working on replacing natural gas with hydrogen and also strongly focusing increased and more efficient use of post-consumer scrap which contributes to reduced overall carbon footprint but also more challenging exhaust gases. For recycling of post-consumer scrap, the challenges are contamination and the huge variety of alloys. We have for some time run a pilot for LIBS (Laser Induced Breakdown Spectroscopy) sorting. With LIBS it is possible to distinguish elements like Mg and Si, which is not possible with X-ray technology, so that 5xxx and 6xxx series can be distinguished and also alloys within the 6xxx series. By combining X-ray sorting and traditional sorting methods like eddy-current and sieving, and utilizing furnace technology with rotary kilns for delacquering and removing other contaminants we are able to process challenging post-consumer scrap into valuable products.

Downstream is very much about increased use of low-carbon aluminium and substituting less sustainable materials and high-carbon aluminium. Examples of such products are Hydro's Reduxa and Circal, where Reduxa is certified to have less than 4 kg CO_2 per kg aluminium (including the whole value chain) and Circal has a minimum of 75 % post-consumer scrap.

Keywords: Sustainability of aluminium production, Carbon footprint, Emissions, Waste.