AUSTRALIAN ALUMINIUM COUNCIL LTD

Aluminium

Australian Aluminium Smelting Provides Baseload Stability in a Decarbonising Grid

Primary aluminium is made from an ore called bauxite, which is refined to make alumina before being smelted to make aluminium.

It takes 4-6 tonnes of bauxite (depending on the grade) to make ~2 tonnes of alumina, which then makes **1 tonne of aluminium**.

Australia produces around **1.5 Mt of aluminium a year**, more than **90% of which is exported**. Australia's four aluminium smelters are all connected to the National Electricity Market (NEM).

Aluminium Smelting

Aluminium smelters use the Hall-Héroult process. Alumina (Al_2O_3) is made up of aluminium and oxygen which need to be separated in order to form aluminium metal. Alumina is dissolved in a bath of molten cryolite (sodium aluminium fluoride). A high electric current is passed through the alumina/cryolite mix, using a carbon anode which is consumed in the process. Electricity maintains the temperature of the process at about ~960°C and enables the alumina to split into aluminium and oxygen. This primary aluminium is then tapped and cast into different shapes including ingot, slab, billet or t-bar. This electrolysis process is very electricity intensive, with the four Australian smelters using about 2,600 MW of electricity, that is about 10% of the NEM, across four strategic regional locations.

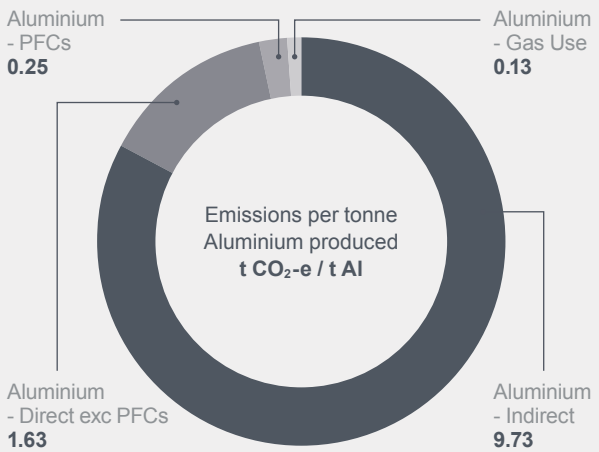
The main sources of emissions are those associated with the **electricity used (15.1 Mt CO_2-e)**, the consumption of the carbon anode in the process released as carbon dioxide (2.5 Mt CO_2-e), process emissions (perfluorocarbons [PFCs]) (0.4 Mt CO_2-e) and natural gas use for cast house and anode production (0.2 Mt CO_2-e).

Aluminium Extrusion

Australia also has more than 20 aluminium extrusion presses, which manufacture extrusions from primary aluminium for supply to metal fabricators. Aluminium extrusion is produced by heating aluminium billet, to soften it, then using an extrusion press to push the billet through a die. It is then subjected to stretching and further heat treatments to provide the required final shape and properties for the customer. Extrusion presses consume electricity and gas in commercial quantities and are grid connected.

2023 Industry Emissions

	(Mt CO_2-e)
Aluminium - Indirect	**15.1**
Alumina - Direct	10.2
Alumina - Direct (Calcination)	3.2
Aluminium - Direct (Other)	**2.7**
Alumina - Indirect	1.4
Bauxite	0.4
Aluminium - PFCs	**0.4**



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Alternate Technologies

Electricity

Providing electricity is supplied consistently, with firm power, and at internationally competitive prices, aluminium smelting can be run on renewable electricity. As smelters are already electrified, no technological conversion is required.

Smelter Flexibility

As there is increased penetration of variable renewable technologies, there will be increased demand by the grid for smelters to be able to offer power flexibility and interruptibility. Interruptibility is the loss of power to either a whole potline or whole smelter. Flexibility is the ability to use more or less power than normal, for short term periods (seconds to minutes through to hours) without too much instability. The ability to offer these services varies as each smelter has a unique aluminium reduction cell (also called a pot) design which impacts its ability to offer any demand response into the system. After around 75 minutes without electricity, aluminium begins to "freeze" in the pots, which can force plant/line interruption and potentially freezing of the cells with a restart which can take months to complete.

IMPROVED CELL DESIGN CASE STUDY

The Pacific Aluminium Low Energy Pot[1] (PALE) launched in 2015 at Tomago Aluminium enables the cell to operate using much less energy without compromising anode cathode distance (ACD). The new design also ensures the pot can operate in a broader amperage range, with the flexibility to accommodate market conditions and business needs by running at a low ACD. This has also delivered Tomago power cost savings and improved energy efficiency.

Inert Anodes

Replacing carbon anodes with non-reactive or inert anodes would remove both the carbon dioxide and PFCs emitted during the smelting process. However, inert anodes could potentially increase the voltage requirements of a smelter, so are best applied in conjunction with low or zero carbon electricity, to ensure the reductions are not offset with increased indirect emissions. Additionally, retrofitting of this, or any other new technology, in Australia's aluminium smelting industry would require substantial capital investment and this could only be undertaken when combined with internationally competitive long-term electricity contracts.

GLOBAL LEVERAGE CASE STUDY

Australian smelter operator's Rio Tinto and Alcoa are involved in a joint venture with Apple and the Government of Quebec, with funding assistance of the Federal Government in Canada on the Elysis process which would remove the use of carbon in the direct smelting process. Deployment of inert anodes relies not only on technology commercialisation, but on the availability of internationally competitive, low emissions electricity[2].

Alternate Fuels

Further investigations are required into the potential for use of alternate fuels, such as hydrogen, to replace the gas usage in the cast house and carbon bake (noting that a carbon bake would not be required with inert anode technology).

Summary of Pathways

The biggest pathway for decarbonising the aluminium industry lies in the decarbonisation of the grid using internationally competitive, low or zero emissions electricity.

TECHNOLOGY SOLUTION	STATUS[3]
READY Grid Connected Electricity	Grid connected smelters may be able to offer some demand management. The grid has increased penetration of renewable energy. Potential for commercial contracting arrangements to allow more rapid decarbonisation of electricity supply[4].
Flexible Power / Interruptibility	Helps support increased penetration of variable renewable electricity.
Inert Anodes	Commercial trials underway but need to be combined with internationally competitive and low carbon electricity. Has the potential to eliminate emissions associated with carbon anodes and PFCs.
Alternate Fuels	Currently at research stage. There are also uncertainties relating to the long-term cost, scale and supply for green hydrogen.

1 https://www.tomago.com.au/new-pot-design-could-deliver-10m-in-annual-savings/
2 https://www.riotinto.com/en/news/releases/2024/rio-tinto-to-install-carbon-free-aluminium-smelting-cells-using-first-elysistm-technology-licence
3 Partially derived from Energy Transitions Initiative, https://www.climateworkscentre.org/project/australian-industry-energy-transitions-initiative/
4 https://www.riotinto.com/en/news/releases/2024/queensland-government-and-rio-tinto-partnership-to-support-gladstones-boyne-smelters
https://www.tomago.com.au/tomago-aluminium-future-renewable-energy-needs/
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