Bauxite arriving at Alcoa's Wagerup Refinery

Marghanita Johnson, CEO of AAC

Australia's Bauxite and Alumina Industries – Partnering to reduce emissions through technology

While much of the global focus is on decarbonising the aluminium smelting sector, the emissions associated with the mining of bauxite and refining of alumina are not being forgotten. Australia has more than 50 years of technical experience in bauxite mining and alumina refining technologies. This experience helps not only us, but our bauxite, alumina and aluminium customers, to reach their sustainability goals. Alcoa, Rio Tinto and South32's Worsley Alumina operations all have their global research headquarters in Australia, helping develop new technologies for the world.

Australian bauxite and alumina will help meet global demand for aluminium

Australia is the world's largest producer of bauxite, mining more than 100Mt of bauxite a year, or about a quarter, of global production. About 40% of this is exported and 60% is turned into alumina here in Australia. We are the world's second largest producer and largest exporter of alumina, with production of more than 20Mt a year. Of this, about 85% is exported and the remaining 15% is turned into aluminium at the nation's four smelters. Meeting the continued and increasing global demand for primary aluminium will require proportionate increases in production of bauxite and alumina.

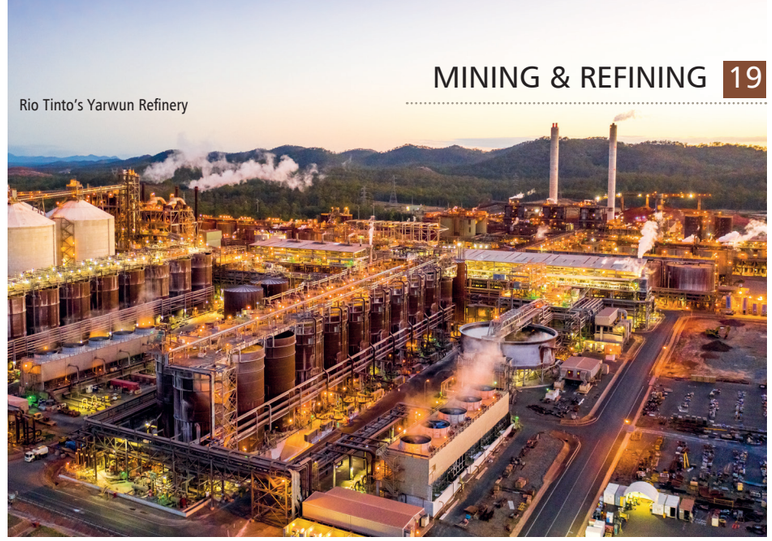
Australia's alumina already has some of the lowest emissions in the world, with an average emissions intensity of 0.7 tonnes of carbon dioxide per tonne of alumina (t CO_2-e/t), compared to the global industry average of 1.2 tCO_2-e/t. However, as a large producer and exporter, alumina emissions are a disproportionately large part of the Australian aluminium industry's footprint, accounting for just over 40% of sector's emissions. By comparison, while Australia produces around 100Mt a year of bauxite, national emissions from bauxite production are only 1% of the total Australian aluminium industry's emissions.

Helping develop low carbon alumina mining and refining technologies for the world

In 2021, the members of the Australian industry announced a number of key strategic partnerships to trial and commercialise key decarbonisation technologies within mining and refining operations. Also in 2021, the Australian Aluminium Council welcomed four new members, including South32's Worsley Alumina operations, made up of its bauxite mine and alumina refinery. South 32's membership means the Council now represents all five of Australia's major bauxite mines and all six of its alumina refineries. Having the full value chain of Australia's major producers collectively represented strengthens the industry's domestic and global voice on key policy issues, including decarbonisation.

Aluminium smelters are already electrified, so no technological conversion is required to enable them to run on renewable electricity, or a grid mixed with variable renewables, providing the electricity is supplied consistently with firm power. By contrast, alumina refineries have, to date, used thermal energy derived from gas, coal and fuel oil, supplemented by electricity.

Alumina refining is an energy intensive process, using about 10.5 GJ / t alumina produced. Digestion and calcination are the two most energy-intensive steps, with digestion consuming around two thirds of this energy. All of Australia's alumina refineries have some combined heat and power generation (cogeneration) facilities which use a combination of coal, gas, or biomass fuels. This cogeneration results in the refineries using, and in some circumstances where the co-generation is large scale, exporting low emissions electricity. About 5-10% of an alumina refinery's energy is used in electrically driven pumps, fans and conveyors.



Rio Tinto's Yarwun Refinery

Alternate Technologies

Electrification

There are a number of potential pathways which would enable renewable electricity to be used as the primary source of energy in the digestion phase of alumina refining:

- Mechanical Vapour Recompression (MVR) which uses electricity to drive mechanical vapour compressors to upgrade waste steam. Using renewable electricity for MVR would displace fossil fuel derived thermal energy. MVR technology is well established in other industries, but not currently used at the large scale required for an alumina refinery.
- Electric boilers can be used to generate steam and are commercially available, however are only likely to be commercially competitive when combined with an existing planned capital replacement and renewable energy.

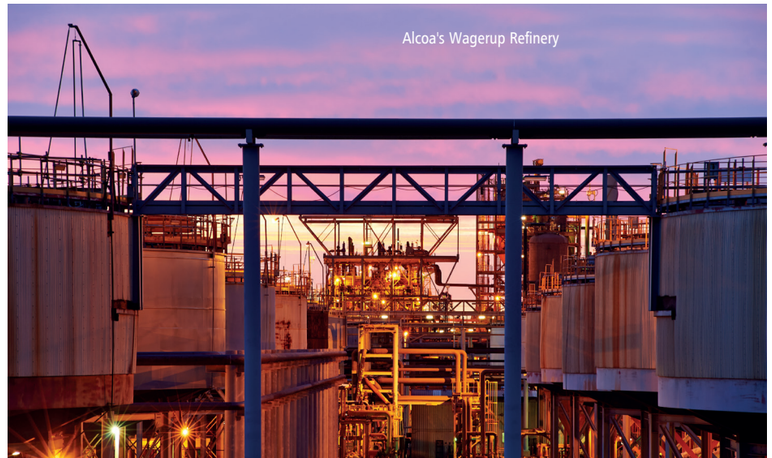
Alternate Energy Sources

As well as electrification, there are a number of alternate energy sources the industry is considering:

- *Concentrated solar thermal* – this is a hybrid technology which could replace 30-45% of the energy used in the Bayer process with energy derived from concentrated solar thermal technology.
- *Cogeneration plants can be co-fired on biomass*. Despite the technical feasibility of this option, the volume of biomass required given the high heat requirements for alumina refineries is limiting.
- *Hydrogen* - The industry is currently investigating options which include the production and use of renewable hydrogen in its processes, particularly in the calcination, as the required temperatures could be difficult to achieve with electrification. Additionally, hydrogen could potentially be used to replace gas in boiler technologies for digestion.

Electricity and Demand Response

Australia's grid-connected bauxite mines and alumina refineries already provide some demand response to the grid. However increased supply of competitively priced zero emissions electricity, could allow a material increase in the electrification of alumina refineries. This, when combined with demand response, could supplement electricity firming, helping to boost the broader



Alcoa's Wagerup Refinery

penetration of variable renewable electricity. Electrification of Australia's six alumina refineries would materially affect grid demand, with a large fully electrified alumina refinery having potentially the same electricity consumption as a smelter (i.e., ~ 1000MW of electricity).

Australia also has a number of bauxite mines that are not grid connected and self-generate electricity in remote areas, largely using diesel power stations. In September 2021, Rio Tinto approved a new solar farm and battery storage at Weipa to more than triple the local electricity network's solar generation capacity, with work expected to be complete by late 2022. The new 4MW solar plant and 4MW/4MWh of battery storage will complement the existing 1.6MW solar farm. Importantly, the battery system will help provide a stable power network for both the bauxite mines and the Weipa township. When complete, the combined facility and upgrades to the existing power generation network will reduce annual carbon dioxide emissions by about 20,000 tonnes - the equivalent of taking more than 3,750 cars off the road. While this reduction may be modest for an aluminium smelter, emissions from bauxite produced are less than 0.5% of the aluminium mine to market emissions, making this a substantial for this operation.

Case Study

In May 2021 Alcoa of Australia Limited (Alcoa) announced it had received funding from the Australian Renewable Energy Agency (ARENA) to test the potential use of renewable energy technology in a process known as Mechanical Vapor Recompression (MVR). Alcoa is currently conducting technical and commercial studies to adapt MVR technology to refining. Electricity sourced from renewable energy would power compressors to turn waste vapor into steam, which would then be used to provide refinery process heat.

If the feasibility studies are successful, Alcoa plans by the end of 2023 to install a three-megawatt MVR module with renewable energy at its Wagerup refinery in Western Australia, to test the technology at scale.

The MVR technology powered by renewable energy could reduce an alumina refinery's carbon footprint by 70%. The technology also has the potential to significantly reduce water use in the refining process by capturing water vapor that would otherwise be lost to the atmosphere.

Weipa's First Solar Plant - Aerial View

Case Study

Rio Tinto announced a partnership with ARENA in June 2021, to conduct a feasibility study investigating the potential to partially decarbonise its alumina refining operations using renewable hydrogen. Rio Tinto will investigate the technical implications of displacing natural gas with renewable hydrogen at its Yarwun alumina refinery in Gladstone, particularly focussed on simulating the use of hydrogen in the calcination process.

In August 2021, Rio Tinto announced a further partnership with Sumitomo Corporation to study the construction of a hydrogen pilot plant at Rio Tinto's Yarwun alumina refinery in Gladstone and explore the potential use of hydrogen at the refinery.

Importantly, the findings of these studies may have applications in other high temperature Australian manufacturing processes, beyond alumina and even beyond the mineral processing sector. Additionally, if successful, the technical and commercial lessons could lead to the implementation of hydrogen calcination technology, not only in Australia, but also internationally.

Beyond Mining and Refining

In addition to looking at bauxite and alumina specific technologies, the Australian Aluminium Council and its members are working across major industry to help accelerate the development of technologies which may have multiple applications in the transformational change required to achieve net zero emissions.

In June 2021, the Australian Government announced a ten-year partnership arrangement with the Heavy Industry Low-carbon Transition Cooperative Research Centre (HILT CRC). The Council, Alcoa, South32 and Rio Tinto are all partners in the HILT CRC which focuses not only on alumina but also on iron, steel, cement, lime, hydrogen and ammonia. Australia has a unique opportunity to leverage the critical clustering of skills, resources and energy demand in the regions in which alumina refineries and aluminium smelters are located. Partnering across industries provides a framework for industry to collaborate, sharing knowledge and experience while lowering the risk of trialling technology.

Conclusion

Australia is leading the way in developing technologies for the adaptation of brownfield alumina refineries to lower carbon technologies. It is here where global emission alumina trials are being conducted. The need for low carbon solutions applies across the global mine to market aluminium sector. Australian industry certainly demonstrated its commitment in 2021 and will continue to do so for many years to come. ■