Clark Butler, Guest Contributor
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Why Aluminium Smelters Are a Critical Component in Australian Decarbonisation

A Case Study of Tomago Aluminium and the Hunter Region

Executive Summary

"The full emergence of Australia as an energy superpower of the low-carbon world economy would encompass large-scale early-stage processing of Australian iron, aluminium and other minerals."[1]

As Ross Garnaut points out in *Superpower*, Australia has the potential to become a much more significant economic power in a decarbonised world. With abundant low-cost renewable energy sources, comparative advantage in the production of hydrogen, and huge deposits of minerals that form the basis of industrial production, Australia could lead the world in producing the components of low-carbon industrialisation: steel, aluminium, cement, silicon, lithium and rare earth minerals.

At about 35%[2] of total output, generation of electricity is Australia's largest source of carbon emissions.[3] But electricity is also key to rapid decarbonisation of other major emitters such as transport, industrial processing and manufacturing, that now account for 54%[4] of the country's emissions.

Green hydrogen, for example, could be a transformative element in the decarbonisation of polluting activity such as steel production, ammonia manufacture, alumina and silica refining, transport, and peaking electricity generation. But for that to occur, green hydrogen would have to be produced using clean, renewable electricity. And that puts the Australian industrial economy at a crossroads: embrace the clean energy transition or decline along with fossil fuels.

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[1] R Garnaut, *Superpower*. 2019. Page 11.
[2] Climate Council of Australia. Australia's Rising Greenhouse Gas Emissions. Page 2. Data sourced from Australian Government.
[3] All references to carbon emissions, CO_2 or emissions are to all greenhouse gas emissions – CO_2-e.
[4] Climate Council of Australia. Australia's Rising Greenhouse Gas Emissions. Page 2. Data sourced from Australian Government.

Closing down aluminium smelting, for example, would reduce Australian electricity demand by 10%[5]– with a consequential reduction in scope 2 emissions from fossil fuels. But this would significantly impair the Australian economy and its industrial capacity, undermine the viability of the remaining coal-fired power stations, and result in the loss of thousands of jobs. Or, these industries could transition rapidly to renewable electricity, invest in plant upgrades to support demand response management, and profit from the long-term growth of the metals and industrial processing markets.

Australia's aluminium sector is particularly interesting right now because it is failing[6], with all smelter operators losing money and considering closure. Australia is one of the world's most emissions-intensive aluminium producers.[7] Accelerated deployment of renewable electricity is a path out of this quagmire, but is it economically viable?

Australia's aluminium sector is particularly interesting right now because it is failing.

This briefing note examines New South Wales' Hunter Valley as a microcosm of the challenges and opportunities facing Australia and its major industrial electricity users, with a focus on NSW's largest electricity user, Tomago Aluminium.

[5] Calculated using smelter operators' published usage as a percentage of total Australian electricity consumption.
[6] AFR. Generators call for notice as smelters teeter on the brink. 18 October 2019. Pacific Aluminium reported an EBITDA loss of $US22 million in 2019.
[7] Australian t CO_2-e intensity averages 12.5 per tonne of aluminium compared with world average of 11.5 – Aluminium Council sustainability report; Aluminium Insider. Leaders Emerge in the Aluminium Industry's Race to Zero Carbon. 2 April 2019.

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The Problem

Aluminium and Carbon Emissions

Aluminium is known as "solid electricity" for good reason. It is created by applying electricity to alumina derived from bauxite. Electricity is roughly one-third of the production cost, with alumina making up another third and operating costs the balance.[8]

In Australia, aluminium smelting uses approximately 10% of the country's electricity[9] and creates 6.5% of total carbon emissions[10] (largely scope 2 emissions[11] from the generation of electricity itself), while aluminium exports are worth approximately 0.2% of GDP.[12] Additionally, there are other emissions and pollutants created in the smelting process[13] (and significant emissions and pollutants are created in the alumina refining process).[14] But it is the heavy consumption of electricity sourced from coal-fired generation that creates the overwhelming majority of CO_2-e emissions.

In response to Rio Tinto's recent commitment to invest $1.5bn to cut its carbon emissions globally, Glyn Lawcock, a mining analyst at UBS was quoted as saying: "We couldn't help but notice the closure of Pacific Aluminium alone would reduce emissions by approximately 25%."[15] At 10.3 million t CO_2-e[16], Rio Tinto's Australian smelters are among the most emissions-intensive in its global fleet.

"The closure of Pacific Aluminium alone would reduce emissions by approximately 25%"

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[8] According to the head of Rio Tinto Aluminium, Alf Barrios – Reuters. Rio Tinto Flags Higher Costs, Cloudy Australian Aluminium Future. 31 October 2019.
[9] Calculated using smelter operators' published usage as a percentage of total Australian electricity consumption.
[10] Calculated using disclosed operators' greenhouse gas emissions as a percentage of total Australian emissions, Clean Energy Regulator 2018.
[11] 'Scope 2 greenhouse gas emissions are the emissions released to the atmosphere from the indirect consumption of an energy commodity': www.cleanenergyregulator.gov.au.
[12] Calculated using approximately A$4.3bn of exports (Australian Aluminium Council 2018), A$1.86tn GDP (IMF World Economic Outlook Database 2019).
[13] Nitrogen oxides (NOx) and Sulphur oxides (SOx) can be removed using abatement units, or 'scrubbers'. CO_2 emissions are also caused by the use of carbon anodes in the smelting process.
[14] Alumina refining is another emissions-intensive industrial process, that accounts for 10 million t CO_2-e per annum in Australia. It can be decarbonised by replacement of the existing steam generated heat with process heat generated by renewable electricity.
[15] Sydney Morning Herald. Smelters 'stick out' in Rio Tinto's $1.5b push to cut carbon emissions. 28 February 2020.
[16] 2018 greenhouse gas emissions for Pacific Aluminium (includes NZ); 2018 Group greenhouse gas emissions were reported in the Rio Tinto Climate Change Report 2019 as 31.8Mt CO^2e, making Pacific Aluminium more like 32% of total emissions.

Aluminium Market Worldwide

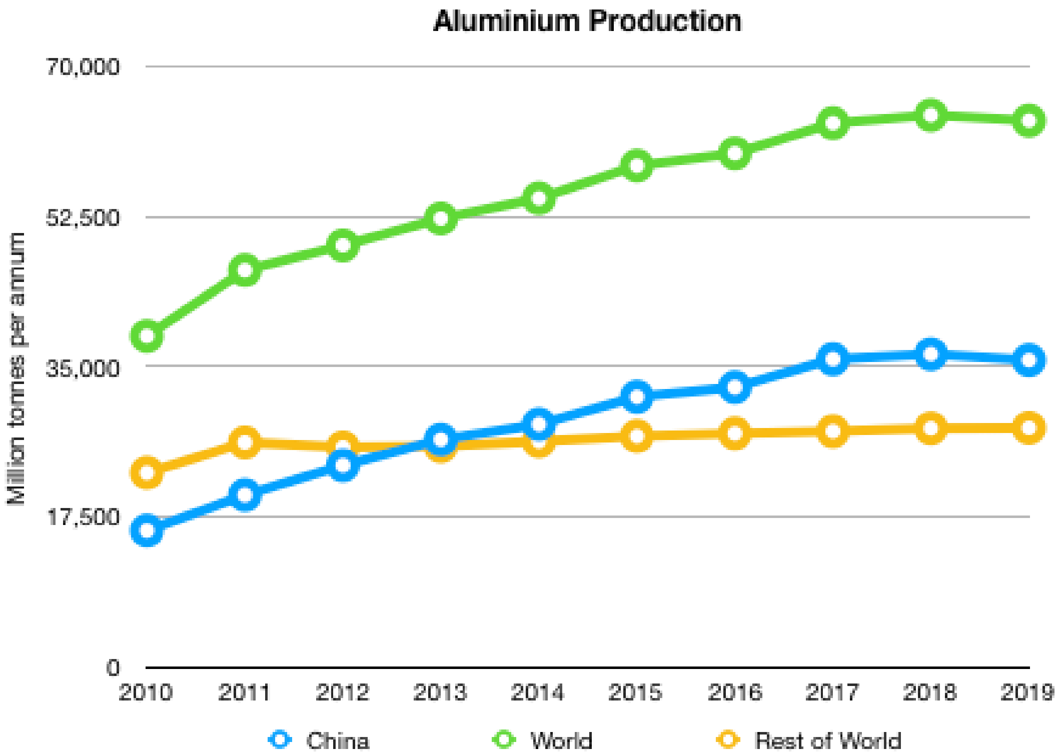
The global aluminium market has been difficult for suppliers for many years. Over the last decade, for example, the aluminium price has ranged between US$2,750 per tonne (t) in 2011 to a low of US$1,450/t in 2016. From there, the price rose to the second quarter of 2018 then fell sharply to around US$1,500/t in March 2020 (pre COVID-19).

Figure 1: World Aluminium Price 2010-2020 (US$/t)

Source: *Trading Economics*

Global production has grown at an average rate of 4% a year over the last decade but the last two years have seen a sharp slowdown, to 1.5% and -1.0%, respectively. The main driver has been China's production, which grew significantly in the first half of the decade and now represents over 56% of world production (up from 41% in 2010).

Figure 2: Aluminium Production – China and the Rest of the World 2010-2020



Source: World Aluminium

Australian Operators' Current Situation

Considering Their Futures

There are four aluminium smelters in Australia. Rio Tinto along with joint venture partners is involved in three (Tomago in NSW, Boyne Island in Queensland and Bell Bay in Tasmania) and Alcoa is involved with Alumina Limited, Citic and Marubeni in Portland in Victoria. Pacific Aluminium (now Rio Tinto Aluminium) reported an EBITDA loss of $22m in 2019 while Portland made a loss despite a $200m support package (which expires in 2021) from the state government of Victoria.[17] Alcoa was quoted as saying the smelter was in 'one of the highest energy price markets on the planet[18],' but wholesale electricity prices in Australia have since come down materially, as has the Australian dollar exchange rate. Likely further deflation in Australian electricity prices and the associated progressive decarbonisation would provide a valuable opportunity to modernise and reposition the Australian aluminium smelting sector.

[17] AFR. Portland Smelter Owners Want Out of the "Subsidy Cycle". 5 December 2019.
[18] AFR. Alcoa says Australia's power prices highest 'on the planet'. 16 January 2020.

Table 1: Australian Aluminium Production – Key Facts

Australian Aluminium

Production:

1.57 million tonnes per annum

1.45m of exports

Approx. 2.5% of global production

Carbon Emissions:
6.5% of Australian tCO_2-e
16% of electricity sector emissions

Smelters	Production capacity *tonnes*	Employees / contractors	Electricity consumption *GWh*
Boyne Island (Qld)	500,000	935 / 120	4,800 *8% of Qld*
Tomago (NSW)	595,000	950 / 160	8,300 *12% of NSW*
Portland (Vic)	350,000	500 / 150	5,200 *12% of Vic*
Bell Bay (Tas)	190,000	435 / 60	3,000 *27% of Tas*
TOTAL	1,635,000	2,920 / 490	24,300 *~10% of Aust*

2018/19 Figures
Sources: Operator websites
Australian Energy Regulator
Clean Energy Regulator

Tomago has the largest smelter operation in Australia. It is an independently run business. Rio Tinto has the largest shareholding in the Newcastle-based plant (51.55% but does not have control rights), together with CSR and AMP (in a 70/30 joint venture) (36.05%) and Norsk Hydro, the Norwegian aluminium producer (12.40%).

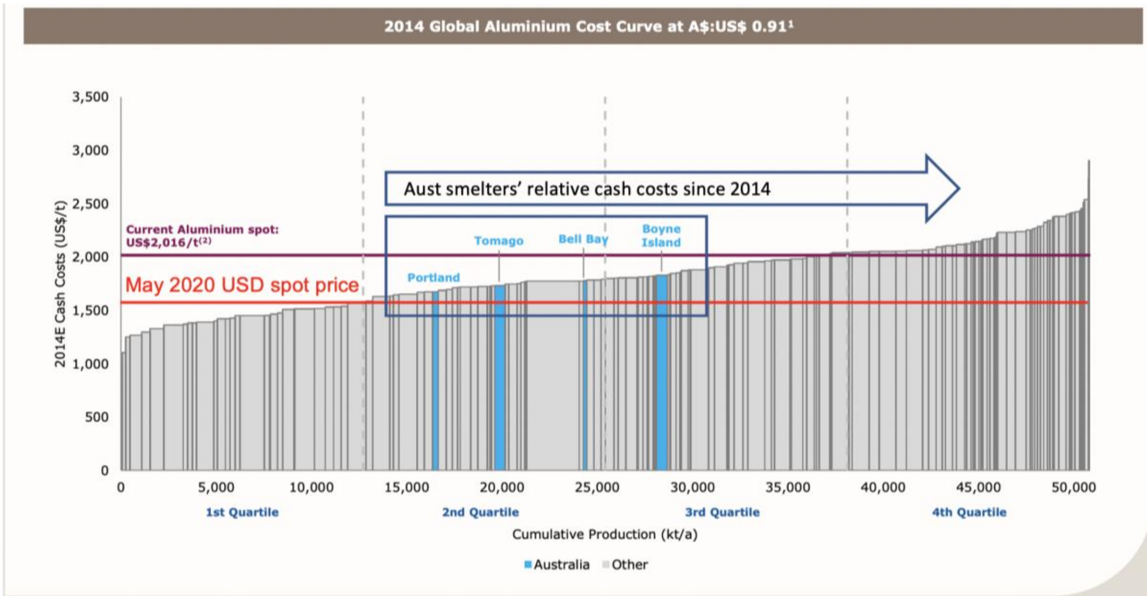
The Tomago smelter produces 595,000 tonnes of aluminium a year, 25% of Australia's primary aluminium. Some 90% of the product is exported to the Asia-Pacific region.[19]

Tomago buys all its electricity from AGL and is the largest customer for AGL's Hunter Valley generation. AGL acquired Macquarie Generation from NSW Government in September 2014. In its investor presentation on the transaction, AGL stated that it assumed that Tomago would close in 2017-[20] and that, based on its contract with AGL, Tomago was an "efficient producer with cost in the global second quartile, and profitable." with "upside if Tomago continues beyond 2017." Tomago has continued, the AGL contract was renewed in 2018 until 2028 and, according to CEO Matt Howell, it has struggled with high power costs.[21] Energy costs may have increased by as much as $200m per year.

Figure 3 below shows the wide range of cost structures of aluminium smelters around the world and the sensitivity to the aluminium price.

[19] Tomago Aluminium.
[20] AGL. Macquarie Generation Acquisition. 20 August 2014. Page 26.
[21] Newcastle Herald. Tomago Aluminium chief executive confirms the smelter's output is down due to the high cost of power. 27 November 2019.

Figure 3: Cash Costs of Aluminium Smelters, 2014



Source: AGL investor presentation, 'Macquarie Generation Acquisition,' 20 August 2014, p 26 (with IEEFA update overlaid)

With the aluminium price around $1,500/t, all Australian smelters are under water. However, it is worth noting that the Australian dollar has fallen 30% from $0.91 against the U.S. dollar in 2014 to $0.60 today. On the assumption that US$25-30/MWh is internationally competitive electricity pricing, then A$40-50/MWh is the target to provide Tomago a platform for success.[22]

Tomago CEO Matt Howell was recently quoted saying Tomago did not have a future at A$70/MWh for firmed renewables[23] but he indicated that a price of around A$45/MWh would work if the supply was reliable and the plant was not exposed to "freezing in an uncontrolled manner."

Impact on the Australian Economy

Their owners say the four smelters contribute around $4bn per annum to the Australian economy, in addition to exports.[24] This contribution includes direct employment and contracting of over 3,500 workers, supply contracts and the multiplier effect of investment and expenditure in regional communities.

Perhaps the most significant feature, however, is their role as providers of core demand for electricity in their home states. Reducing demand for a state's electricity by 10-12% would place a huge burden on the existing generation infrastructure to

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[22] ANFRE. Global smelters' production costs on decline. October 2019: 'Electricity costs vary widely depending on the region, with power tariffs around US$20/MWh in the Middle East, US$35-40/MWh in the USA and Europe, and around US$55/MWh in China, after the latest additional subsidies on electricity prices were introduced.'

[23] AFR. Tomago counts cost of energy transition. 7 February 2020.

[24] Tomago, Boyne Island, Bell Bay and Portland websites.

adapt. These foundational loads have historically created stability of demand for generators and provide a basis for investment. More importantly, large interruptible electricity loads could play a critical role in the move towards a low cost, modern electricity system of the future, balancing supply and demand during times of extreme volatility—hot summer days, for example.

At a time Australian industry needs to demonstrate its resilience and to be well prepared to 'snap back' after the COVID-19 contraction, a plan to reinvigorate Australia's smelting sector could underpin billions of dollars of investment in energy infrastructure. This ought to be an attractive option, but it requires a whole of economy industry plan, as argued by Ross Garnaut, that benefits grid stability while supporting electricity sector decarbonisation and creating an attractive low-risk return for infrastructure investors.

A plan to reinvigorate Australia's smelting sector could underpin billions of dollars of investment.

A Solution?

If Tomago could secure electricity at a price fixed for the long term (hedged into US$ terms to match its US$ revenues) that is internationally competitive and sourced from a majority decarbonised source, would it be a good long-term proposition?

The Aluminium Market as a Positive Long-Term Future

In a low-carbon world economy, there are several drivers of increased demand for aluminium, if it is produced using renewable electricity:

- Transportation*:* the transition to electric vehicles will increase demand for aluminium as car makers look to compensate for the weight of batteries[25]; environmentally conscious consumers and state regulators will increasingly require low-carbon components.

- Construction*:* ongoing long-term growth in China and developing markets will underpin demand for aluminium but, in addition, increasing demand for low-emissions building materials (and regulatory focus on embedded emissions) will drive demand from producers that can supply low-carbon aluminium;

- Consumer durables, especially electronics: companies such as Apple use a relatively small amount of aluminium but their prominence in consumers' lives and Apple's (and its competitors') focus on reducing carbon emissions in supply chains will increase demand for low-carbon materials across the consumer durables sector.

[25] Automotive News. The Hidden Carbon Footprint of Aluminium Cars. 22 July 2019.

Volume growth of 4%[26] is estimated over the long term, driven particularly by increased demand from the automotive sector. BMW, for example, uses low-carbon primary and recycled aluminium in its i3 electric car. BMW uses more aluminium each year than Tomago's entire production and electric vehicles contain between 140kg for a battery-electric vehicle (BEV) and 180kg for a plug-in hybrid electric vehicle (PHEV) more aluminium on average than internal combustion engine vehicles.[27] Consumer packaging brands such as Tetra Pak and Nespresso are also looking to reduce the carbon footprint of the aluminium they use.[28]

BMW uses more aluminium each year than Tomago's entire production.

Low carbon aluminium is defined as aluminium that generates 4t CO_2-e per tonne of aluminium (including emissions from alumina refining) or lower. Many global producers now actively promote a low carbon product.

It is possible that low carbon aluminium will attract a price premium at some stage. The London Metals Exchange (LME), recently considered a separate price but decided against it in 2019. But Edgardo Gelsomino, Wood Mackenzie Head of Aluminium, suggests that a premium may be supported in the next year or so: "2020 may well be the year when there is a consolidation of the concept of a two-tier market for primary aluminium."[29]

In any case, the rapid rate at which global investors and leading corporates are signing on to the Taskforce for Climate Related Disclosures (TCFD) means that over time investors will demand full accountability from manufacturers for emissions reduction in their supply chains as they transition to products whose demand is conditional on carbon emission reduction. BlackRock, the world's largest investor, committed in January this year to asking all companies globally to follow TCFD guidelines in public reporting,[30] changing TCFD from a voluntary to a now de facto mandatory reporting standard for global corporates.

If renewable energy can deliver internationally competitive electricity pricing at a fixed rate with zero risk over the long term, it would also position Tomago as a supplier of low carbon aluminium.

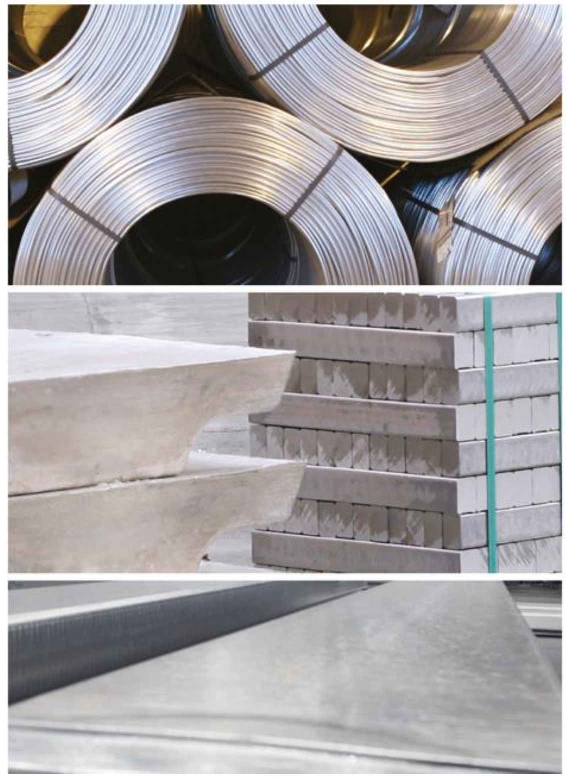
[26] Aluminium Insider. Low-carbon Aluminium Boosts Industry's Green Credentials. 15 November 2017.
[27] Ducker Frontier. Aluminium Content in European Passenger Cars. 10 October 2019.
[28] TetraPak website.
[29] Wood Mackenzie press release. Global energy transition and supply issues key for aluminium in 2020. 3 February 2020.
[30] BlackRock. Sustainability as BlackRock's New Standard for Investing, January 2020.

ECOLUM™

Primary aluminum produced at Alcoa predominantly hydro-powered smelters that generate no more than 2.5* mt of CO2e per mt of aluminum (both direct and indirect emissions)

– Low carbon footprint— 75 percent better than the industry average
– Full range of alloys and shapes, including billet, foundry, slab, rod, and unalloyed high purity
– Certificates of origin provided, confirming sustainability metrics of the product line
– Environmental Product Declaration (EPD) available in Europe and US, in accordance to ISO 14025 and verified by a third party, which can be used to obtain more points under LEED® and BREEAM® certifications for building and construction products

* total carbon footprint, including emissions from bauxite mining and refining, is under 4 mt of CO2e per mt of aluminum. Calculations are performed in accordance with WRI and IAI GHG Protocols.



Source: Alcoa[31]

What Does Transition Look Like?

Transition to sustainable and reliable renewable energy in the Hunter Valley involves taking a long-term and system-wide perspective to align the needs of the corporate supply chain (power generation and domestic bauxite mining plus refining into alumina and then aluminium for export) with the interests of the government and regional communities, rather than a narrow single corporate view. This alignment would consist of key components such as:

- Sufficient renewable energy generation capacity;
- Sufficient transmission capability so that renewable electricity can be distributed to where it is needed;
- Increasing distributed generation to leverage scale and geographic diversification benefits and storage assets that will change the traditional demand profile across the grid;
- Firming and balancing at an optimal level to ensure a reliable supply of electricity to consumers regardless of the solar and wind conditions;

[31] Alcoa website.

- Stability in the grid to cope with a far more complex ecosystem of utility and distributed generation assets, notably frequency control and demand response management;
- Potentially microgrid capability to share generation assets on a local basis;
- Storage to support firming, whether pumped hydro, battery or other technologies; and
- Control systems that can manage the interaction of all of these.

There are also many interested parties, including:

- Tomago's owners;
- Other major industrial energy users in the Newcastle region such as Molycop, Orica and InfraBuild[32];
- AGL, the main generator of electricity in the Hunter Valley;
- Renewable generation developers and investors;
- TransGrid and Ausgrid;
- The Federal, NSW and Hunter Valley local governments; and
- The Newcastle and Hunter Valley communities who rely on sustainable jobs, maximised by a planned, orderly industry transition.

Tomago

Investors in Tomago need internationally competitive electricity, without the price volatility and grid reliability issues that have been evident over the last decade. If it is to compete in the fastest-growing sector of the aluminium market (low-carbon), it also needs renewable energy that is reliable. The Sydney Morning Herald quotes Rio Tinto: "Repowering our aluminium assets and increasing the share of renewable electricity more broadly will be central to our decarbonisation strategy to 2030."[33]

Elsewhere in the world, Rio Tinto and its competitors have invested in upgrading aluminium smelters to improve efficiency, capacity and renewable generation. In Canada, for example, Rio spent C$4.5bn upgrading the Kitimat smelter and its captive hydro generation plant, as well as C$12m upgrading its Alma smelter in

[32] Molycop, formerly part of Arrium Limited, manufactures steel for grinding balls in mining and rail wheels and axles in Waratah; Orica has an ammonia plant on Kooragang Island and InfraBuild, formerly OneSteel Limited, is a steel manufacturer.
[33] Sydney Morning Herald. Smelters 'stick out' in Rio Tinto's $1.5b push to cut carbon emissions. 28 February 2020.

Quebec. Hydro Norsk, a shareholder in Tomago, invested at least US$172m in upgrading a smelter in Norway.[34]

Could Tomago Become a Top Quartile Aluminium Producer?

Potlines are at the heart of aluminium production, and despite the age of its smelter, Tomago has relatively efficient potlines—well-maintained and upgraded in the last few years. The potline technology is highly energy efficient (believed to be less than 13,000kWh/t and, whilst it is not as current as some (progressively upgraded to the AP22 standard, cells are replaced every six years), the capital expenditure needed to make Tomago world class is in the range of millions not billions. Proximity to the Port of Newcastle and the high-capacity grid transmission lines that connect the facility to the Bayswater and Liddell power stations makes the current site attractive, and there is good access to Australian alumina.[35]

Smelters with renewable energy sources claim to produce aluminium at around 2.5t CO_2-e. Rusal, the Russian producer and the largest supplier after China, and Rio Tinto's and Alcoa's joint venture Elysis, (Canada), say they will have new "inert anode" technology in commercial operation by 2021[36] and 2024[37], respectively, which would reduce carbon emissions even further.

There is a question over whether this incremental change will be financially justifiable and scalable. However, assuming these recent conversions were based on a sound business case in both the Canadian and Russian smelters, the same commercial logic should justify upgrading Tomago, if there is a supportive government framework to retain and modernise Australia's key heavy industry participants.

The key question, then, is certainty over the cost and emissions intensity of electricity supply.

Towards A $40/MWh Electricity in the Hunter Valley

Bearing in mind capacity factors, 2.5-3GW of solar/wind generation capacity would be needed to supply Tomago's demand. The installed capital cost is in the range of A$4-5bn.

Firmed renewable energy costs were referenced at below A$70/MWh in 2018.[38] However, looking out to the cost of procuring a long term supply of firmed renewables for supply starting at some point over the next 3 to 8 years, it is highly likely providers will be able to put together contracts for firmed renewable energy in the target US$25-30 or A$40-50/MWh range, using a mixture of financial

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[34] Aluminium Insider. Hydro to Invest US$172mm in Upgrades to Idled Line at Husnes. 20 September 2018.
[35] Queensland Alumina, a joint venture between Rio Tinto and Rusal, refines alumina in Gladstone.
[36] Financial Times. Rusal targets 2021 to roll out carbon-free aluminium. 1 April 2019
[37] Alcoa press release. 10 May 2018.
[38] Renew Economy. Snowy Hydro smashes price benchmarks for "fair dinkum" wind and solar. 2 November 2018.

structuring (insurance, hedging) and physical firming (pumped hydro storage, gas peakers and/or batteries). The scale benefits of infrastructure capacity to meet a demand load the size of Tomago's could further reduce prices.

With the Australian dollar down more than 10% against the greenback in the last two years, and down 30% in the last five years, the US$ cost of renewable energy in Australia has declined accordingly.

The key cost of renewable energy is the long-term cost of capital. We note the U.S. 10-year bond rate has dropped from an average of 2.9% in 2018 to just 0.7% today,[39] a 75% reduction in just two years that dramatically and permanently reduces the cost of capital for a new renewable infrastructure project. Australian government 10-year bonds have similarly dropped from 2.6% in 2018 to 0.8% today.[40]

The key cost of renewable energy is the long-term cost of capital.

The other factor is that solar module prices have been falling by more than 10% annually over the last decade. IEEFA expects this trend to continue over the coming decade, given dramatic ongoing improvements in technology and economies of scale.[41] A recent study by Andrew Blakers and Matthew Stocks at ANU suggests solar pricing could be $30/MWh as a result of continuing technology advancements and increasing manufacturing scale.[42] This ongoing module price deflation has been masked in Australia by the devaluation of the AUD. While onshore wind is a more mature technology, ongoing deflation is still expected as average installed turbine sizes are expected to double over the coming five years from 2-3MW to 4-6MW per turbine, and average utilisation rates continue to rise over time.

For capacity at this scale, physical firming using a mixture of pumped hydro, batteries, peaking gas and hydrogen production could be feasible. Australian National University research[43] identified 3,000 promising sites for off-river pumped-hydro capability in Australia and concluded that it is most cost-effective when provided as National Electricity Market (NEM)-level storage rather than as a behind-the-meter solution. There are a number of pumped-hydro sites within range of the Hunter Valley and/or New England regions that could provide firming of NSW sourced renewables.

A key consideration for Tomago, and any large electricity user, is counterparty risk. The criticality of the electricity supply to the smelter makes the ability to rely, both

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[39] Macrotrends. 10 Year Treasury Rate – 54 Year Historical Chart. Accessed 17 April 2020.
[40] Investing.com. Australia 10-Year Bond Yield Streaming Chart. Accessed 17 April 2020.
[41] PV-Tech. Solar manufacturing expansion plans for Q1 2020 top 500GW in unprecedented record. 5 April 2020.
[42] Renew Economy. Technology leaps driving cost of solar PV electricity in Australia to just A$30/MWh. 7 May 2020
[43] ANU media release. ANU finds 530,000 potential pumped-hydro sites worldwide. 1 April 2019.

operationally and financially, on the supplier one of the key factors in considering alternative arrangements.

Hydrogen Production

Hydrogen produced using electrolysis powered by renewable electricity is a zero-emission energy source. The cost of producing hydrogen for export remains-prohibitive, but production for local use could be a powerful way to provide storage—both for feedstock for gas peakers[44] and an energy source for industry—and make economic use of surplus renewable generation.

Ammonia production capability at Orica has been severely undermined by the trebling of fossil gas prices in NSW this past decade, given gas represents 85% of its variable costs. Orica CEO Alberto Calderon was quoted last year: "Orica has two comparable ammonium nitrate plants, one in Kooragang Island near Newcastle in NSW which is fuelled by gas from the Sydney hub. The other is in Carseland in Alberta, Canada, which sources cheaper local gas."[45] Orica has only recently upgraded the Kooragang Island plant at a cost of A$100m. It employs 150 workers directly and is responsible for an estimated 1,000 additional jobs in the region. A progressive transition to hydrogen would not only change the financial dynamics, it would position Orica as a producer of 'green ammonia'. A feasibility study for a similar project is being considered by Dyno Nobel in Queensland and has been funded by ARENA.[46]

Ammonia production capability at Orica has been severely undermined by the trebling of fossil gas prices in NSW.

In the longer term, green hydrogen could be used locally in steel production with an electric arc furnace to create 'green steel'. InfraBuild and Molycop employ 1700 workers between them in the Hunter Valley, as well as 1000 contractors. Green steel production could add significant value to their businesses and see the region restore its traditional position as a steel making power, only transformed by forward-looking low carbon technology.

A hydrogen electrolysis facility could take surplus renewable electricity and so improve the utilisation of renewable generation. At a system level, this would enable a greater supply of lower cost but variable electricity, reducing the cost for Tomago. Other countries have started: Ningxia Baofeng Energy in China recently announced a $200m investment in a 160 million standard square meter solar electrolysed

[44] A South Korean plant uses a GE gas turbine with a 70-90% hydrogen fuel blend: GE website. Accessed 16 April 2020.
[45] Newcastle Herald. The High Price of Gas has made the Operation Uncompetitive on a Global Level. 8 March 2019.
[46] Arena. Renewable hydrogen could power Moranbah ammonia facility. 30 September 2019

hydrogen plant that aims to generate A$135m per annum revenue and reduce carbon emissions by 445,000 tons.[47]

While it may be impossible to produce green hydrogen at prices competitive with fossil gas right now, IRENA notes in the *Global Renewables Outlook 2020* report: "Production costs of around US$2-3 per kilogram for green hydrogen are feasible in the coming decade in the best locations. Low cost can also be achieved earlier at locations with good renewable energy resources."[48] Investment may well generate sufficient returns at a system level (taking into account employment, industry support and use of surplus renewable energy) to justify taking this step now.

Analysis is needed to assess:

- The full cost of implementing 2.5-3.0 GW of solar and wind generation for supply to the Hunter Valley;
- The impact of various strategies on the cost of firmed electricity to Tomago;
- The feasibility (and cost) of establishing a hydrogen production facility in the region over the coming five years.

Demand Response Management

Some successful smelters generate considerable revenue from supplying energy or energy services, the so-called demand-side response. Smelters with captive generation capability—Rio's Kitimat in Canada and Hydro in Norway—view integration of electricity and smelting as critical to manage both aluminium and electricity price volatility. They can make an objective, value-maximising choice between ramping up aluminium production (and using more electricity) when aluminium prices are attractive and curtailing production (and selling surplus electricity) when that provides a better return. Similarly, a smelter without captive generation can be configured to modulate energy use up or down to optimise its productivity.

Some successful smelters generate considerable revenue from supplying energy or energy services, the so-called demand-side response.

In this respect, it is worth re-imagining a smelter as a giant virtual battery, one that also produces aluminium. Tomago CEO Matt Howell, has acknowledged this key change in thinking in comments supporting the continuation of the Australian Energy Market Operator's Reliability and Emergency Reserve Trader (RETR) scheme: "We've got a very large load that can come off in a very short space of time to avoid large-scale rolling blackouts, and that has value."

[47] Xinhuanet Yinchuan. Baofeng Energy Builds an Integrated Solar Electrolytic Water and Hydrogen Energy Storage Application Project. April 20th, 2020 (link in Mandarin).
[48] IRENA. Global Renewables Outlook 2020. April 2020.

He refers to 600MW of capacity that can be switched off in minutes. Most smelters can provide a very periodic reserve system of demand response, notably the ability to occasionally reduce electricity demand for up to 3 hours at a time. But without a technology upgrade, this capacity does present significant risk to the integrity of smelter potlines. An unplanned 5½ hour outage at Portland in Victoria in 2016 reduced smelting capacity to 27% for many months.[49]

Australia's energy system is undergoing a total disruption. Modernisation, reliability, lowering total system costs and decarbonisation are all key objectives, but pursuing these all concurrently is constrained by industry and consumer resistance after a decade of energy price inflation. The core drivers of electricity inflation were the gold-plating of the grid transmission[50] for demand growth that never eventuated and the move to export price parity (or higher) for both thermal coal and fossil gas (which has seen domestic coal prices double and domestic East Coast gas prices treble this past decade).

IEEFA suggests that one corporate entity should not be required to bear a disproportionate share of the costs and risks of the much-needed Australian economic transition. Being responsible for 12% of the state's total demand, Tomago is potentially the key enabler of NSW's energy system modernisation, but this requires a significant investment that needs to be derisked and valued according to the system strengths it would enable (in terms of total system cost reductions, decarbonisation and system reliability).

One aluminium business, Trimet in Germany, has employed EnPot[51] heat exchange technology to increase its ability to modulate smelter production. EnPot technology claims to increase modulation to +/-30% without any risk to the pots and the reduction in energy usage can last indefinitely.[52] This is because the EnPot heat exchanger system traps heat that would normally be expelled into the atmosphere (approximately 50% of energy used by the pots is expelled as waste heat to keep the pot cell in balance) and uses it as insulation to maintain the required pot temperature (of around 960°C). It also protects the pots in the case of a complete power outage by preserving heat without electricity for longer.

This is not the only way to improve a smelter's modulation capacity. Tomago's current cells are designed for maximum energy efficiency but this has the side effect of reducing their thermal reserve (from around 8 hours in previous generations to around 3 hours now) and therefore limiting the ability to provide demand side response. The commercial model drives the investment decision: when electricity is expensive and provide DSR provides no financial return, the investment focus is naturally on energy efficiency; if, however, Tomago could generate a better return

[49] ABC. Portland smelter to operate at just 27pc capacity after unexplained power failure. 5 December 2016.
[50] AFR. Fears new 'gold-plating' will push up power prices. 25 November 2019.
[51] Patented technology developed by the Light Metals Research Centre at the University of Auckland and commercialised by Energia Potior Limited: www.energiapotior.com.
[52] Energia Potior. Transforming the Future of Aluminium Smelting.

by providing demand side response, investment in more robust, lower efficiency cells would be justified.

Our analysis would suggest Tomago wears a disproportionate share of the investment risk with, currently, little financial incentive to provide demand response management services to the grid. With the Australian government also removing the price on carbon pollution by cancelling the emissions trading scheme (ETS) back in 2014, there is no policy framework to encourage Australian industry to progressively decarbonise (particularly in contrast to Europe and South Korea, global leaders in terms of their ETS). As a result, an Australian evaluation of an investment in an EnPot technology smelter retrofit (at a capital cost of perhaps $100m) has to-date not made commercial sense.

However, IEEFA believes it is in AEMO's, AGL's and Tomago's interests to maintain reliable electricity supply and support grid stability, while it is in Australia's national interest to put the economy on a progressive path to decarbonisation, with all the benefits of energy system price deflation this could bring. Assuming the Reliability and Emergency Reserve Trader pilot was successful, there would be strong business case, at a system level, for investment in Tomago to enhance its ability to provide demand response management. Consequently, there ought to be a contractual and/or investment solution that can enable this if all the relevant long-term vested interests can be aligned. The Federal Government has the tools available to evaluate (via ARENA, the Australian Renewable Energy Agency) and then underwrite, or help to structure, (through CEFC, the Clean Energy Finance Corp) a low risk, long term investment in modernising a critical key part of Australian industry, along with the benefits of securing the many thousands of jobs involved.

It is in Australia's national interest to put the economy on a progressive path to decarbonisation.

AGL CEO Brett Redman stated, at an investor briefing in 2019, "We will work as a good citizen to do everything we can to keep those smelters going."[53] It is not just good corporate citizenship: maintaining significant electricity demand is important for AGL's business. This could include opening up the Tomago contract for renegotiation prior to 2028 to consider renewable energy, firming options and demand side response pricing.

Regional Economic Development

The Hunter Valley contributes $50 billion to the NSW gross state product, roughly 8% of the state economy but, according to the NSW Government's Hunter Regional Plan 2036, the region indirectly 'drives around 28% of the state economic output.'[54] It has a population of 700,000 and a workforce of around 300,000. Thermal coal

[53] Reuters. Australia's AGL vows to try to keep aluminium smelter customers open. 30 October 2019.
[54] NSW Department of Planning, Industry and Environment Hunter Regional Plan 2036. Accessed April 2020.

mining for both domestic and export markets is already in a long-term structural decline and the 8% of jobs in the Hunter Valley attributable to the coal sector will need to be progressively replaced over the next two decades. Moreover, the Port of Newcastle relies on coal exports for more than 90% of its total volume throughput, as do many support industries in the region. Building up a sustainable heavy industry in this region would make use of existing infrastructure like the port and the transmission capability as well as underpinning jobs, both existing and new.

There is a large area of unproductive land in the region because of contamination, not the least being the 10,000 hectares at the Liddell/Bayswater sites[55], and including included the associated Lake Liddell that needs to be quarantined for many decades to come as a result of brain-eating amoebas that have grown in the coal plant-heated water).[56] Quarantined industrial and coal mine wasteland could be used for renewable generation siting and expansion of low carbon heavy industry. If the industry potential in the region and community and workforce needs could be viewed as a whole, the business case for investing in large-scale renewables backed by firming is far stronger. In addition, the energy load used by heavy industry could be utilised for demand response management: it is a small percentage of Tomago's usage but it can cost-effectively help balance supply and demand as well as enhancing grid reliability and system strength.

Overlaying an industrial district heat energy plan for the Newcastle area could add additional system value (novel in Australia, but a mainstream business structure in Germany, for example).

An investment in a regional energy plan would improve energy security, be a key enabler of the NSW Government's Net Zero Plan Stage 1: 2020-2030 strategy and provide significant momentum for the establishment of renewable energy hubs:

> *The NSW Government's first priority is to provide a pathway to deploy those technologies at scale over the next decade. To do this, the NSW Government will remove unnecessary barriers to entry for those technologies and make co-investments to address the high upfront capital costs that may stand in the way of their take-up.*[57]

Investors

In order to support the necessary investment, developers require a financial investment proposal that at least matches the cost of capital available. The riskier the investment proposition, the higher the cost of capital. At the scale required for long term sustainability, the most attractive equity capital comes from long term infrastructure investors: superannuation and pension funds, sovereign wealth funds such as Australia's Future Fund, and other low-risk, long-term investors (including, for example, Japanese investors such as Marubeni and Sumitomo, which have a long

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[55] AGL. Liddell Innovation Project Supporting Information. AGL website. Accessed 21 April 2020.
[56] Newcastle Herald. Brain-eating virus forces lake closure. 12 August 2016.
[57] NSW Government Net Zero Plan Stage 1: 2020-2030. Page 12.

history of investing in large scale industry in Australia where it supports their trading activities).

Large long-term capital investors have not participated in renewable energy infrastructure to-date in Australia in any material way for four main reasons:

1. Scale: Given the size of their funds and the amount of capital they need to deploy, large investors look for $500m plus equity investments. Other than AGL-QIC's Powering Australia's Renewable Future (PARF) Fund, there have been no large-scale renewable infrastructure opportunities in Australia.

2. Term: Infrastructure time frames are usually in the 40 year plus range, certainly more than 20 years.

3. Risk: Policy uncertainty has made the sector unattractive for long-term investors. With more than a dozen material policy changes in the last 12 years, the Australian energy sector has been hard to gauge over the short term, much less the timeframe for long-term investors. Further, price volatility and technology risk have added to the return profile required to make investment in this sector attractive.

4. Politics: the global imperative to invest in a progressive decarbonisation consistent with the Paris Climate Agreement has not been converted into policy in Australia, even though many of the required financial institutions are in place (ARENA, CEFC).

A Tomago-scale renewable energy investment addresses scale. A financial structure, incorporating additional investors that manage the risk of mismatched power purchase agreements (PPA) terms with the life of the assets as well as pricing volatility and policy uncertainty, could deliver infrastructure returns at a level of risk typically priced by long-term investors. Further, this structure could accommodate additional assets (for example, a similar scale infrastructure investment could be undertaken in Queensland to supply low cost, zero emissions electricity for the Boyne Island smelter, and in Victoria at the Portland smelter), providing a key investment opportunity for deployment of more capital to replicate this move once the commercial case has been proven.

Layers of risk include:

- Long term: ownership of commissioned renewable energy generation with PPA for 20-25 years

- Credit risk managed by high quality counterparty

- Volatility risk addressed by insurance/hedging

- Currency, mirroring the loan currency exposure with the US$ nature of aluminium pricing

- A gap in market PPA and desired term taken by equity investors with higher return hurdle; potential for AGL or other generators to participate in this equity.

Swing for the Future – Get 5 Years Ahead or Fall 5 Years Behind

This Hunter Valley plan is a template for expansion across the aluminium sector, in Victoria and Queensland. By focusing on large scale, low cost of capital, zero emissions, renewable investments tied to significant energy users with long-term growth prospects in a low carbon economy, there is a real chance to build momentum for the Superpower that Garnaut discusses. If the aluminium sector could be reinvigorated and put on a globally competitive footing, Australia can get five years ahead on the decarbonisation path. However, if the smelters close and all that load is lost, building this kind of investment momentum will be far more difficult and Australia could fall five years or more behind more forward-looking countries.

Building investment momentum will be difficult, and Australia could fall five years or more behind the most forward-looking countries.

The current COVID19 crisis is an appropriate time to reassess the strategic importance of sustainable domestic manufacturing industry at scale, and to provide scope for a green investment stimulus. The prime minister has raised the question of 'economic sovereignty' in light of the supply chain issues caused by COVID19. When asked what Australia needed to reinvigorate local manufacturing to address this sovereignty issue, former Manufacturing Australia chair and board director, Sue Morphett pointed to internationally competitive energy prices.[58] This can only be achieved in any sustainable way by a concerted industry effort.

A study to detail the economics of the approach described in this briefing note and to map out an implementation path would be invaluable in galvanising government, community and industry support for change. Rio Tinto has raised awareness of the pending closure threat for Tomago, and now is the time to reimagine Australian industry and put it on a path to sustainability. Pricing energy system flexibility is a key to viability, for Tomago and Australian heavy industry more widely.
Key questions to be answered:

- Infrastructure**:** Is there siting (including any existing projects) for 2.5-3GW of renewable energy with reliable transmission to Tomago?

- Cost**:** What is the $/MWh cost of delivering electricity to Tomago using that infrastructure?

[58] ABC Radio National interview. 13 April 2020

- Firming**:** Is there a firming solution that can be implemented to ensure sufficient reliability to protect smelting operations at a price that meets the $40-50/MWh international benchmark?

- Demand response management**:** Can demand response management play a role to (a) make Tomago a more flexible user of electricity; and (b) provide a financial contribution that supports a lower electricity price? What is the right investment structure to facilitate demand response management?

- Hydrogen**:** Can hydrogen production play a role in managing variable renewable supply and generating revenue for the Hunter Valley that would support firming and demand response management?

- Industry plan**:** Would the NSW Government invest in the Hunter Valley to reinvigorate its heavy industry as a low-carbon employer of thousands of workers and a growing contributor to NSW gross state product?

- Financial structure**:** Can a financial structure be created to partition risk so that long-term investors with the lowest cost of capital are attracted to investing in this significant infrastructure renewal?

About IEEFA

The Institute for Energy Economics and Financial Analysis conducts research and analyses on financial and economic issues related to energy and the environment. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. www.ieefa.org

About the Author

Clark Butler

Clark Butler is an IEEFA guest contributor, and a corporate adviser with a background in the technology and finance sectors. In additional to being a director of and investor in technology and data companies, he is exploring technology and financing solutions to encourage investment in renewable energy solutions.