JOHN CURTIN RESEARCH CENTRE POLICY REPORT NO. 8 | JULY 2022

CLEAN AND MEAN

NEW DIRECTIONS FOR AUSTRALIA'S STEEL INDUSTRY

JOHN CURTIN RESEARCH CENTRE | THE AUSTRALIAN WORKERS' UNION

About the Authors

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The authors wish to thank Professor Frank Jotzo and Associate Professor John Pye (Australian National University), and Paul Zulli (University of Wollongong) for their helpful suggestions and advice.

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Executive Summary

This report explores and seeks to provide practical, concrete solutions to the necessary decarbonisation of Australia's steelmaking and related industries. In the context of climate change, *Clean and Mean*:

- methodically identifies the risks involved in not taking action by allowing for repeated market failure and persisting with ill-planned or haphazard government intervention or rather non-intervention;
- the critical steps we need to make to enable technological leaps in the production of and deployment of clean energy hydrogen fuel into the steelmaking process; and
- the imperative of a tripartite approach bringing together government, business, and worker representatives to tackle these challenges.

At the same time, we argue that a golden, or in this case, clean steel economic opportunity lies before us if we take bold action, starting now. The rewards will be great. Yet if Australia does nothing while the rest of the world moves apace, the pitfalls will arguably be greater. As we outline, Australians and their elected representatives, along with businesses and workers, should know what the risk is, how it can be fixed, and many of our steelmakers are already doing so. This report makes the case for Australia becoming a clean steel industry leader in Asia and globally, with serious export potential. This transformation will have benefits for both steel and related industries and working people, meaning we can punch above our weight amongst big players such as China. We should be thinking big. Off the back of an attractive investment environment, readily available clean hydrogen, certified clean steel credentials and a growing export market, Australia can increase its production of steel and steel products by 1 million tonnes to over 6 million tonnes a year. This would constitute a win-win outcome for business and workers by increasing industry revenue to more than $30 billion a year and adding around 1200 jobs in steel manufacturing and many more downstream[1] – good, secure, and well-paying jobs. In the recommendations section of this report we outline the three crucial steps needed to be taken for Australia to seize this moment:

1. Building a National Clean Steel Roadmap including setting interim targets;
2. Relatedly, we need a national accreditation scheme for clean hydrogen and steel to ensure that meaningful signals are available to this emerging market; and
3. Making clear the critical role of strategic government investment to support Australia's major steelmakers in decarbonising, working hand in hand with labour representatives.

'Where there is a will there is way' is a well-worn cliché. Yet it is true of Australia's clean steel future; if we will it. *Clean and Mean: New Directions for Australia's Steel Industry* boldly sets out the pathway.

Foreword

Steelmaking is a vital part of the Australian Workers' Union's proud 136 year-old history and the history of our country. For decades our union has stood up for steelworkers' jobs and for Australia's ability to make steel here through good times and bad. Today, Australia's two largest steelworks – the Port Kembla steelworks in Wollongong and the Whyalla steelworks in South Australia – continue to create a source of good, union jobs.

Steel itself contains carbon and Australia's abundant supply of coal has long made our country an ideal place to make steel. But today steelmaking must face the inevitable global energy transition. Because of this, Australia must recognise the new opportunities that come with clean steelmaking. If we do not our sovereign capability to make steel will be lost to countries with no regard for emissions or for workers' rights.

The John Curtin Research Centre has laid out a practical pathway to continue and grow the Australian steel industry. This work considers the detail of how steel is made, as well as the commercial realities that government, industry, and workers must consider in expanding the Australian industry. I believe this report should provide the foundation of our union's work with the new Australian government to elevate the status of our steel industry to a world leader.

Australia should always be a country that makes things. And, for the foreseeable future, we will need steel for our construction and manufacturing. This report maps a path to ensuring that, in a low carbon world, the steel Australians use is the steel Australians make.

Daniel Walton
National Secretary
Australian Workers' Union

Introduction | Getting real on decarbonising Australian steel

The steel industry is a critical backbone of the Australian economy and will continue to be critical in our nation's evolution towards a mature post-carbon economy. This post-carbon economy must not allow working people, their families and communities to be simply thrown onto the scrapheap of long-term unemployment in the name of so-called 'just transitions' spouted by green ideologues and well-meaning progressives. Steel is one of the main components of our manufacturing, infrastructure-building, engineering, and construction supply chains. The common denominator of skyscrapers and bridges, cars and cruise ships, guns and washing machines is that they are all made of steel. We cannot exist in a steel-free world. Steel is the world's most commonly used metal, and is the foundation of our modern industrial economy. Not unexpectedly, then, steel has historically been and continues to be a major employer of Australian workers, providing secure and, in the main, well-paid employment. Around 72,000 people are directly employed in making primary metal products in Australia and another 66,000 are employed in making fabricated metal products – most of which are steel products.[2] Australia boasts two major primary steel producers: BlueScope, with its Port Kembla-located steelworks (New South Wales), and GFG Alliance, with its steelworks based in Whyalla (South Australia). In addition, GHG Alliance's InfraBuild operates secondary (recycled) steel plants in NSW and Victoria and there are over 300 steel distribution outlets dotted across the wide-brown terrain of our country alongside numerous fabrication, manufacturing and engineering companies each embedded in the steelmaking cycle. It is estimated that the Australian steel industry generates $29 billion in annual revenue.[3] For every person employed directly by the steel industry, this creates as many as six full-time Australian jobs in related and downstream industries.

Table 1: Australian steel industry overview[4]

	Location	Technology	Products	Capacity (t/y)
BlueScope	Port Kembla	Blast furnace	Flat products	3.2 mt/year
GFG Alliance Liberty Primary Steel	Whyalla	Blast furnace	Long products	1.2 mt/year
GFG Alliance InfraBuild	NSW & Victoria	EAF	Recycled long products	1.5 mt/y
Others	Varied	Varied	Varied	0.5 mt/y

Australia must be a country that makes things – a catchphrase of politicians from both major parties – but our capacity to manufacture goods has been rated the lowest amongst peer nations in the Organisation for Economic Cooperation and Development (OECD) by the Australian Industrial Transformation Institute (AITI).[5] Our lack of sovereign industrial capability is alarming to the Commonwealth Department of Defence, which administers a 'Sovereign Industrial Capability Grants' program,[6] while broader fears about supply chain resilience have led the federal Government to release a Sovereign Manufacturing Capability Plan.[7] These concerns reflect the essential role of Australia's steel industry. Australia needs a strong, sustainable steel industry.

So how do we achieve this lofty goal in practical, fair terms? We need steel, but we need to decarbonise the process of producing it.

Steelmaking accounts for about nine per cent of global greenhouse gas (GHG) emissions, which the scientific consensus clearly demonstrates, is creating serious climate change.[8] Stabilising climate is an imperative for Australia: the costs of a hotter climate are too great. It's a race. A race against physics. A race to stabilise the climate before it forces a dangerous state of equilibrium. A race to capture the economic prizes of a post-carbon economy.

New and emerging technologies mean that for the first time, it is possible to produce steel without emitting any GHGs, but the necessary technology is still in its infancy: it has not yet been demonstrated economically or at scale. Nonetheless, our competitors are sprinting in the race to solve those problems. In Sweden, the steelmaking company SSAB have built the first pilot hydrogen Direct Reduced Iron (DRI) plant.[9] Approximately 100 tonnes of steel made from this process was sold to Volvo, who used it to build the first vehicle made from zero-carbon steel this year.[10] Right now, Australia is a step behind, but there is so much industry development necessary that we can easily catch up if we move now. This is a moment for bold action if governments, steelmakers, and representatives of steelworkers come together.

If we fall too far behind, other countries will begin to penalise us, but if we return to the front of this race, the potential opportunity is staggering and good for workers. Much has been made of the idea that Australia could become a renewable energy superpower, especially since the publication of Ross Garnaut's 2019 book, *Superpower: Australia's low carbon opportunity*.[11] Garnaut raised the prospect of Australia becoming "the world's main trading source of metals, other energy-intensive goods and carbon chemical manufacturers in tomorrow's zero-net-emissions world."[12] Since then, a number of reports have focused on Australia's natural endowment of renewable energy resources and opportunities flowing to industry from decarbonisation. For instance, the Grattan Institute's report Start with Steel declared "'Green steel' looks to be Australia's largest low-emissions export opportunity."[13] Beyond Zero Emissions, another Australian think-tank, have proposed a 'Million Jobs Plan'. Fortescue Metals Group and its chairman Andrew 'Twiggy' Forrest have also urged major investments in clean steel tied to the establishment of a clean hydrogen industry. Garnaut's idea has captured the imagination of many pundits and policymakers, but we are still not doing what needs to be done to turn the idea into reality. If Australia has, as many assert, the potential to be renewable energy superpower, then our nation is well placed to become one of the world's leading clean steel superpowers. This report argues that now is the time to act and outlines practical measures to get us there.

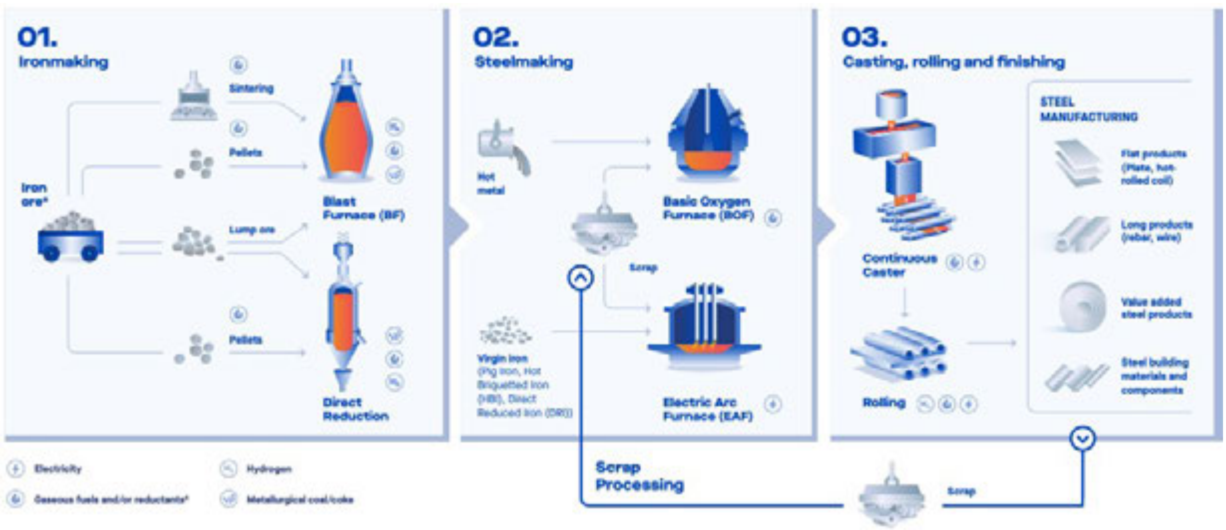
Part One explains how steel is made, how it produces emissions, and, furthermore, the practicalities of how decarbonised steel can be made. It also shows that Australia possesses some of the world's most abundant supplies of the key resources needed for the post-carbon economy. Part Two shows that we cannot afford to be complacent in decarbonising iron and steel: it's a race, and if we fall too far behind the costs can be severe. Part Three looks at our existing iron and steel industry and the efforts already underway to decarbonise. The recommendations section considers what we need to do to move faster. It shows that if we make the right decisions now, the post-carbon global economy can be very good for our iron and steel industries – including the workers who built it and communities they live in.

Part One | How steel is made and how it could be made

The basics of steelmaking are conceptually simple: iron ore (that is various rocks and minerals from which metallic iron can be extracted) is reduced into iron metal, and subsequently that iron metal is hardened into steel. Both conversion processes involve chemical reactions which necessitate producing intense heat. Iron reduction is a process of removing impurities, while converting iron metal to steel is a process of adding carbon: usually around 99 per cent iron and 1 per cent carbon. Figure 1 (altered slightly from BlueScope's recent 'Climate Action Report') shows an overview of iron and steelmaking in three steps: ironmaking, steelmaking, and casting/rolling and finishing.

The first two steps are where most of the carbon emissions are generated. Because iron ore isn't by definition pure iron, impurities need to be removed. This is step one and is a coal-intensive process. The most troublesome impurity is oxygen. Removing oxygen from iron-ore is called 'reducing' (a process which is the opposite of oxidation). The traditional method of reducing iron involves putting sintered iron ore into a blast furnace with coking coal. Under intense heat, the coal gassifies and the carbon binds with the oxygen from the iron ore, stripping it away and leaving reduced iron that can be used in the next stage of the steelmaking process. The problem is that combining carbon with oxygen makes carbon dioxide (CO2), which enters the atmosphere where it acts as a blanket over the planet, heating the climate. This is the hardest step to change, but it needs to be done.

Figure 1. Overview of iron and steelmaking processes[14]



The second stage turns molten iron into molten steel by adjusting the carbon content through chemical processes under extreme heat to control the hardness of the final product. The remaining processes also produce some greenhouse emissions, but they are relatively easy to abate. They mostly involve electricity use, so the solution is switching to renewable electricity supplies. Some steelmaking processes also use natural gas, such as in ovens used to cure coated and painted steel products, and use of biogas or electrification are potential alternatives there. That requires investment, but the policy problem is not intractable by any means. Most steelmakers already have clear plans for mitigating most of those 'easier-to-abate' emissions by 2030.

Recycling steel

Recycling steel from scrap using an Electric Arc Furnace (EAF) is the simplest way to produce low-emissions steel. Around 30 per cent of steel made in Australia is already made this way. Recycling steel has been a fully electric process for many years. Figure 1 shows scrap processing entering the steelmaking process at step 2, with steel scrap being used in either a 'basic oxygen furnace' (BOF) or an 'electric arc furnace' (EAF). Because recycling scrap does not need to repeat the highly emissions intensive process of iron reduction, the main source of emissions from steel recycling is the electricity used. This can be mitigated relatively easily, simply by providing fully firmed renewable electricity to secondary steelmakers. The main challenge for Australia is that, for these facilities to be undertaken economically, they must operate continuously. This requires that renewable energy supplies are fully firmed and reliable so that the recycling process is as economical as possible.

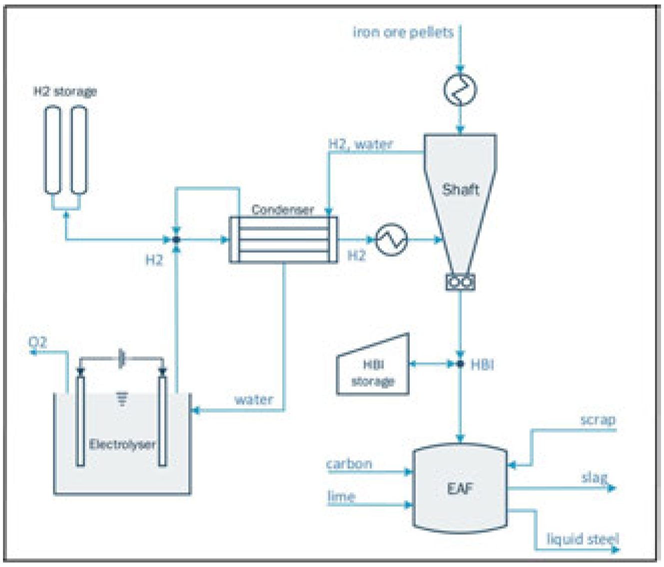
Unfortunately, there are limits to the amount of steel that can be recycled. One limit is the frequent need for very precise specifications that secondary steel or EAF processes sometimes cannot deliver. This limit means that recycling likely will never be able to supply 100 per cent of production. But the major constraint on recycling is simply the availability of scrap. Countries possessing large stocks from previous decades of steelmaking have an advantage here, but even in the United States only about two thirds of steel can be made from scrap. In countries such as China, there is no sufficient stock of scrap. Primary steel will be needed for many decades, so we cannot rely on recycling as the main method of decarbonising the industry. We need to decarbonise primary steel as well.

Decarbonising Primary Steel

The main source of carbon emissions from primary steel is the coal used in the iron reduction process. Central to the most advanced emerging technology for carbon-free steelmaking is clean hydrogen, which has stimulated increasing interest and major efforts to establish an Australian hydrogen industry. Australia's former Chief Scientist Alan Finkel suggests that the export opportunity clean hydrogen presents Australia is "almost beyond imagining"; and that it could rival LNG.[15] Put simply, an emissions-free fuel, in this case hydrogen produced by renewable energy such as solar and wind, or through steam methane reforming of oil and gas with carbon capture and storage, would be inserted into the steelmaking process instead of coal, thus creating carbon-neutral steel and steel-products. These technologies all need to be further advanced and proven. While some are more advanced than others, any technology that can be shown to work and can be done commercially may play a useful role. Every Australian state and territory government have hydrogen plans in place and are rapidly developing new plans and refining existing strategies. The Commonwealth Government also flagged hydrogen as a priority low-emissions technology in its so-called 'Technology Investment Roadmap'. We reviewed developments toward Australia's hydrogen future in our 2020 JCRC report: *Power State: Building the Victorian Hydrogen Industry*.[16]

One way that steel could be made without emissions is depicted in Figure 2. It shows how steel can be made with clean hydrogen and renewable electricity. In the diagram, iron ore pellets are reduced with hydrogen that comes either directly from an electrolyser or else via storage. The reduced iron is then sent to an electric arc furnace (EAF) where it is purified and hardened into steel. Throughout the process, there are very few emissions created other than those that are made in the generation of electricity for powering the electrolyser and the EAF. If the electricity is made from renewables, then the steel can be made with near zero emissions.

Figure 2. Steelmaking process using hydrogen DRI and EAF[17]



The potential of the hydrogen technological revolution is vast, but we are still at the very beginning of this story. Global consumption of hydrogen in 2020 was around 90 Mt with just 5 Mt used in steelmaking. Of the 90 Mt, only 0.3 Mt constituted "low-carbon hydrogen" made from renewable energy. The International Energy Agency's (IEA) projects, based on announced projects, that low-carbon hydrogen use will be 1.2 to 1.4 Mt per year by 2030.[18] Hydrogen may offer the best prospects for decarbonising steel and other industries, but far more than a few million tonnes will be needed. The technology is still at the stage of being demonstrated at scale. There is a lot of work to do.

Part Two | It's a race

Decarbonising steel is a race. It's a race against climate change and, equally importantly, it's a race against global market competitors. In the race against climate change, the IEA says that to meet global climate and energy goals by 2050, steel industry emissions must fall by at least half, with a decline to zero pursued thereafter.[19] But in their most recent emissions reduction tracking report, the IEA declares that the iron and steel industry is "not on track" and calls upon governments to help by "providing R&D funding, creating a market for near-zero-emissions steel, adopting policies for mandatory CO2 emissions reductions, expanding international co operation and developing supporting infrastructure."[20] The IEA also reports that steelmakers accounting for about a third of global steel production have set private targets for achieving net zero emissions before 2050. The transition is underway but the results we achieve by 2050 will depend significantly on decisions made in the next one to three years. In particular, new investments in steelmaking assets with thirty-year life expectancies need to be replacing, not extending the carbon-centric production processes.

In the race against competitors, industry insiders say that the market pull has already begun, with an increasing number of businesses demanding net zero emissions from their steel suppliers. Countries such as the United Kingdom have already introduced measures requiring net zero emission commitments from all firms bidding for any major government contract.[21] The approach is expected to become increasingly common and increasingly strict.[22] For Australia, around 20 percent of our export earnings are related to iron ore and will also face increased pressure on emissions in the supply chain,[23] especially China where the NDRC has issued guidance on achieving carbon neutrality that includes regulatory enforcement favouring low-emissions steel.[24] If we fall behind, we risk facing 'carbon border adjustment mechanisms' – taxes on the carbon embodied in Australian exports that could be crippling. At worst, Australian steelmakers could simply end up excluded from both domestic and global markets. If we do not act swiftly enough, we could lose what market share we enjoy.

In the context of the global steel industry Australia is a relatively small player, meaning that if we fall behind competitors in this race we could find our industry crushed. Globally, almost 2 billion tonnes of steel are produced each year.[25] Australia produces excellent steel, but we are not a significant producer by world standards. In 2019, Australia produced about 5.5 million tonnes (Mt) of crude steel, which was about 0.3 per cent of the global crude steel production that year (see table 2). Most steel production is made for domestic consumption in the countries where it is made because steel is heavy and expensive to trade internationally – only around 400 million tonnes are traded internationally (around a quarter).[26] Even that figure exaggerates the reality because such a large portion of internationally traded steel is both imported and exported within the EU.[27]

Similarly for Australia, of the 5.5 Mt of Australian-made steel, about 1.1 Mt (20 per cent) was exported in 2019 which was offset by importation of around 1.9 Mt the same year. Countries are often both importers and exporters of steel because most countries don't make every type of steel product locally. Steel products are made with high degrees of specification, and certain producers may be the only producer of a specific product that meets a particular need. Imports are mainly for products that aren't made domestically. Within the Asian and Indo-Pacific region, India, Japan, and South Korea are also major steelmakers, producing some 111 million, 99 million and 71 million tonnes respectively.[28] The largest single producer is China, which makes approximately half of the world's steel (around 1 billion tonnes). In China, 89 per cent of steel is made using emissions-intensive blast furnaces, compared with just 32 per cent in the

US and 58 per cent in the European Union (EU). Excluding China, 202 Mt of steel is produced in the rest of the Asian region using blast furnaces whilst 150 Mt is made using electric furnaces.[29]

Table 2: Production of crude steel (2019)[31]

Country	Production ('000 t)	Share of world total (%)	Share of production exported
World	**1,875,155**	**100%**	**23%**
Asia	1,349,427	72.0%	13%
Asia (excluding China)	353,085	18.8%	31%
EU	157,078	8.4%	n.a.[30]
Australia	5,493	0.3%	21%
Asia			
China	996,342	53.1%	6%
India	111,351	5.9%	12%
Japan	99,284	5.3%	33%
South Korea	71,412	3.8%	42%
Taiwan	21,954	1.2%	51%
Vietnam	17,469	0.9%	30%
Indonesia	7,783	0.4%	51%
Europe			
Germany	39,627	2.1%	61%
Italy	23,190	1.2%	77%
France	14,450	0.8%	94%
Spain	13,588	0.7%	69%
United Kingdom	7,218	0.4%	58%
Sweden	4,721	0.3%	95%
Americas			
United States	87,761	4.7%	8%
Brazil	32,569	1.7%	39%
Mexico	18,387	1.0%	28%
Canada	12,897	0.7%	60%

The suitability of clean steel as an internationally tradable product, however, would be different from standard steel. Certified clean steel would be a premium product, able to attract a higher price to satisfy customers who had particular regulatory obligations or business commitments, or who wanted to market their product (e.g. high-end residential construction projects) as carbon neutral. The premium nature of clean steel, at least during the transition period, means that it could be especially suited to export needs. If Australian-certified clean steel were able to be exported, the existing domestic demand might be less of a constraint on the potential growth of the industry.

The potential to make steel without emitting GHGs is attracting huge attention around the world. There have already been successful demonstration projects, although the technologies and methods used remain in their early stages, as discussed elsewhere. For the Australian steel industry to be both sustainable and competitive, it needs to decarbonise. That reality does not depend on climate science alone – the rest of the world is moving to decarbonise their supply chains, and so there is a market imperative to decarbonise irrespective of how urgent we think stabilising the climate is. For instance, the EU has a target of becoming climate neutral by 2050.[32] The UN's Glasgow Climate Change Summit (COP26), held in late 2021, declared "near-zero emission steel" and globally available "affordable renewable and low carbon hydrogen" to be two of just four items on the Breakthrough Agenda. More than 27 countries including Australia, Japan, Korea, the EU, the UK, and the US signed on to participate in the Breakthrough Agenda.[33] The market for high-emissions processes, including traditional steel processes, is limited and likely to shrink. Australia needs to act lest we be excluded from the industry's future. But by acting, we open new opportunities for growth.

In this race to net zero, other countries are moving fast (see table 3).

Table 3. Other countries are moving – Emissions Targets[34]

Country	National Emissions Target
Australia	26-28 percent by 2030, net zero by 2050
Japan	46 percent below 2013 levels by 2030, net-zero by 2050
Korea	40 percent below 2018 levels by 2030, net-zero by 2050
China	Peak before 2030, net zero by 2060
EU	55 percent below 1990 levels by 2030, net-zero by 2050
India	Net zero target by 2070
United States	Net zero target by 2050

NB: the above are nationally determined contributions (NDCs) as submitted to the UNFCCC COP26 in Glasgow in October 2021. There are 165 NDCs in total.

China's State Council has released plans for the emissions related to the steel industry to peak by 2030.[35] In January 2021, the Chinese state-owned iron and steel company Baowu, the world's second largest steel producer by volume, announced it would peak emissions in 2023 and achieve carbon neutrality by 2050.[36] China has also committed to "bringing its total installed capacity of wind and solar power to over 1.2 TW by 2030."[37] The Japanese-maker Nippon Steel and Korean steelmaker Posco have both pledged net-zero steel by 2050.[38] These international movements are creating significant competitive pressure for the EU and other Western steel-making countries such as Australia.[39]

Indian-owned, but Luxembourg-headquarter ArcelorMittal, the world's largest steelmaker, is also among the steelmakers that have pledged net-zero emissions by 2050. Their immediate green steel plans are based on a phased introduction of hydrogen into blast furnaces.[40] ArcelorMittal has one site in Hamburg already making steel with electric arc furnaces. The plant uses natural gas to soften the iron ore, but the company intends to begin using hydrogen instead. ArcelorMittal's strategy is focused on two main technologies: hydrogen in DRI-EAF (Direct Reduced Iron – Electric Arc Furnace) and blast furnaces and expanding hydrogen in 'Smart Carbon'. The firm emphasises that hydrogen use plays a central role in its decarbonisation strategy.[41]

The world of steelmaking, as we can see, is rapidly changing on a global scale. Perhaps the most dramatic and analogous development for Australia is taking place in Sweden, where HYBRIT is a green steel technology trailblazer. HYBRIT is a zero-carbon steel project being developed by a partnership between three Swedish firms, SSAB (the steel maker), LKAB (high-tech mining and ore processing) and Vattenfall (a Swedish-based multinational energy company). They have used hydrogen instead of carbon during the iron reduction process and have already built a pilot hydrogen DRI plant in Sweden.[42] This pioneering project produced their first 100 tonnes of decarbonised steel in 2021, which they sold to Volvo who made the world's first vehicle from zero-emissions steel.[43] 100 tonnes is an incredible achievement, but it remains a small-scale demonstration: around 14,000 tonnes of steel are made each day in Australia. That first small but crucial step was the outcome of efforts that began in 2016 in partnership with the Swedish government – highlighting the critical role that

Australian governments must play – and LKAB. SSAB used high quality magnetite, and the Swedish government helped provide the hydrogen.[44] The Swedish consortium approached the challenge by dividing the process into six "work packages" that could be addressed in parallel rather than sequentially, ensuring that slow progress in one area (such as electricity production) did not impede progress in all the other areas. Each work package involved different commercial partners including Vattenfall[45], LKAB[46], KTH[47], and SSAB[48], a combination of large private companies, state-owned enterprises and a public university. The work packages identified include:

1. Renewable electricity production
2. Hydrogen production and storage
3. Iron ore pellet production
4. Iron production
5. Steel production
6. System integration, transition pathways and policy strategies

The Swedish approach offers a potentially useful framework for Australia to follow a similar path toward a zero-emissions steel industry – significantly unions had major input into the model.

The challenge

Like any large problem, we need to break this issue into smaller parts we can more easily manage and measure progress. Decarbonising Australian steel will require progress in at least three areas:

1. A major increase in firmed renewable electricity production;
2. Building a significant hydrogen industry; and
3. Demonstrating and deploying new iron and steel technologies at commercial scale.

Decarbonising steel will not be easy. It is often referred to as a "difficult to abate sector". Serious policy questions, economic challenges, and technological problems exist, not to mention the critical task of ensuring workers are equipped with the skills and expertise, or existing skillsets and expertise are re-tooled. While renewable electricity is a familiar technology, clean hydrogen is yet to be demonstrated at scale and there is still no successful prototype of clean steel in Australia. Hydrogen is also highly explosive and learning to safely handle it in iron and steel production will be essential. A major safety incident would set back development of the industry by many years. The technology has been demonstrated at small scale in the pioneering case of Sweden, but even there it is not yet economical and has yet to be achieved at scale.[49] While clean-hydrogen DRI and EAF processes are the simplest to understand and may be the most advanced, Australia should not limit itself to one method because, given our existing capacities, capabilities and resource endowment, it may not turn out to be the optimal way to decarbonise. Moreover, since no technology is yet proven, relying on a single option would be a mistake. The COVID-19 pandemic has given Australians recent experience with the potential costs of betting on a narrow mix of options. We should not repeat the mistake when it comes to clean steel.

The challenges we face force us to rely on imperfect technologies. Australia needs a national plan to ensure that it is ready in time to meet decarbonisation imperatives. The first step of which is to understand what needs to be done and how to approach a problem of this type. The IEAS's Technological Readiness Level and depicted in figure 3 is extremely useful for this purpose.

The most advanced hydrogen projects in Australia are three 10 MW hydrogen electrolyser demonstration projects. These equate to 'large prototypes', or stage 5 of the IEA's technological readiness level. The most advanced technology for clean steel (SSAB's) is around the same level, with the technology demonstrated in normal conditions (as opposed to laboratory conditions). However, Australia is not yet at the global frontier of that technology. In both of these core technologies, the most advanced prototype has yet to be proven at deliverable scale. The IEA's scale provides a roadmap for what needs to be done by 2030 for decarbonised steel to begin being used commercially. We need successful demonstrations of the technology at scale, it needs to work in the circumstances it would be used commercially, and it needs to be made commercial. SSAB expect to reach stage 8, the "first-of-a-kind commercial

Figure 3. Technological Readiness Level – scale applied by the IEA[50]

demonstration", by 2026. This presents an opportunity for Australia to build on the research and development undertaken to commercialise the technology. Yet our steelmakers need to demonstrate that the technology works in Australian conditions, not simply Swedish terms. We cannot wait for them to demonstrate commercial success, then immediately import their method. To solve such a major challenge, we need to break it into smaller, more manageable components, and incremental development which in turn leads to further progress. To keep us on track, Australia should set a target of at least one full-scale prototype by the second half of this decade. We need to be in the early adoption phase by 2030 to provide enough time to properly integrate the technology across the industry, as we explore in the recommendations section.

Now that the federal government finally seems ready to support a target of achieving net-zero emissions by 2050, it's time to move with speed to accomplish these pressing tasks. COP26 demands intermediate targets of reduced emissions by 2030. BlueScope's Climate Action Report, alluded to earlier in this report, is consistent with this aim, indicating their assessment of the broad timeframe within which different methods of decarbonisation can achieve practical results. However, none of the decarbonisation they expect to achieve by 2030 is made by fundamental changes to the steelmaking process, and almost all of the emissions reductions by 2050 come from "breakthrough technologies" that are not expected to have any significant impact until after 2030. Making sure that those breakthrough technologies are ready in time is essential if we are to have any hope of achieving the 2050 targets. That means we need targets for the action taken now but which will have consequences in 10-30 years. Focusing on the most well understood path to decarbonising steel, we assume that very large quantities of cost-competitive renewable energy and clean hydrogen will be needed. The following two sections deal with two matters that make this a challenge: scale and firming.

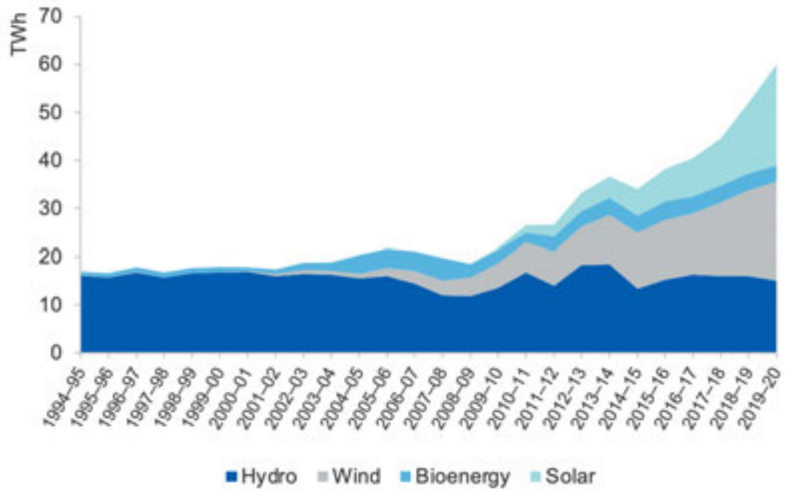
(1) Scale

As the technology is undeveloped, estimates of the amount of renewable energy needed to produce steel vary. One credible estimate is in the region of 3.5 MWh per tonne of steel.[51] More recently the European Parliamentary Research Service estimated that about 2.5MWh of renewable electricity per tonne of steel would be needed. The EPRS estimate was based on 50-55 kWh of electricity being required to produce 1kg of hydrogen, and 50kg of hydrogen needed to produce 1t of steel.[52]

Taking both estimates as a range of 2.5-3.5 MWh of renewable electricity per tonne of steel, the 5 million tonnes of steel that Australia produces each year would require 12.5 to 17.5 TWh of renewable electricity, just for steel. By way of comparison, over the past year Australia generated almost 23 TWh from wind and another 24 TWh from solar (about two thirds from rooftop solar and one third from utility solar).[53] That recent generation is significantly higher than the levels achieved as recently as 10 years ago when 6.1 TWh was produced from wind and just 1.5 TWh from solar (Figure 4).

The estimated range of efficiency (2.5–3.5 TWh/t) implies that decarbonising Australia's steel industry may require building dedicated renewable electricity on a scale of 30-40 per cent of our current entire stock of solar and wind capacity. Assuming Port Kembla and Whyalla remain the main centres of primary steel production in Australia, and that both renewable electricity and hydrogen was produced locally so as to minimise the costs of transport, each region could anticipate that clean steel will generate renewable electricity demand upwards of 5 TWh per year.

Figure 4. Australian renewable electricity production by fuel type (TWh/year, 1994-2020)[54]



As Australia has such a strong natural comparative advantage in renewable energy, there is a potential to expand beyond current production volumes. This could involve one of the existing majors scaling up their operations, or it could involve a new producer entering the market. Either way, it is feasible to contemplate Australia producing 1 million tons per year of clean steel above the current average production levels. An expansion at that scale could underwrite demand for an additional 2.5-3.5 TWh of renewable energy generation, whether it be the Hunter Valley region or Queensland. Australia could potentially go much further and set a target of producing 500 million tonnes of zero emissions iron metal by 2035. This scenario is contemplated by the EU, describing it as conceivable that iron reduction occurring in China may shift to Australia.[55] Assuming clean hydrogen is the basis of a technology deployed, and that about 30 per cent of the electricity used in steelmaking from renewable hydrogen is needed just for the iron reduction stage, reducing a ton of iron might use around 1 MWh of renewable electricity, and 500 million tons would require 500 TWh of renewable electricity. This considerable amount is around eleven times more electricity than Australia produced from solar and wind over the last year. Such an accomplishment would mean that almost forty per cent of the world's iron reduction is achieved at zero emissions, equating to reducing global emissions by over three per cent. Obviously the above figures are only intended to be loosely indicative of the scale of investment needed. More precise and accurate estimates will only become possible as progress is made toward these goals, but understanding the broad scale of the task is an important step toward giving it the priority and investment that it demands.

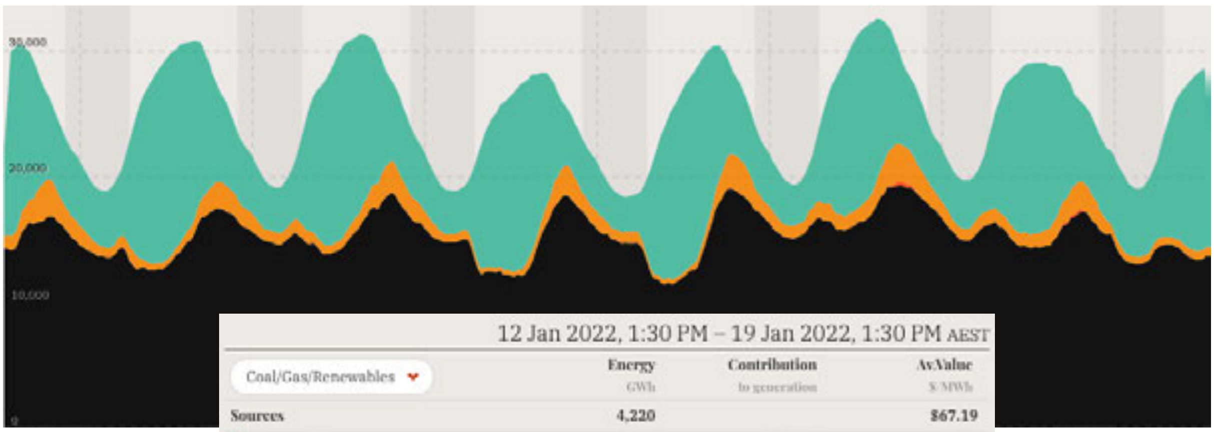
Can we achieve such a transformation? We examine current efforts in the following section, but first we need to consider another aspect of the challenge: firming the supply of renewables.

(2) Firmed Renewable Electricity Supply

Part of the challenge of building a clean steel industry is economically ensuring a continuous supply of renewable electricity – both to feed directly into electric arc furnaces, and to generate hydrogen for use as an industrial fuel. Steelmaking is a continuous operation. It does not stop at night, as other manufacturing processes do. Partly this is a matter of ensuring a return on capital investment, but there is also a materials problem with repeatedly heating equipment to extremely high temperatures then allowing them to cool again every day. Thermal expansion would quickly damage facilities making them either dangerous or impossible to operate. The intermittency of renewables is well known, and there are a range of solutions to this challenge, but they do increase cost. They also have to actually be done, not merely talked about. 5 shows electricity production in Australia's national electricity market (NEM) over a week. The variability from renewables is immediately clear, with high contributions from solar, by definition, during the day.

In this particular week (12– 19 January 2022), renewable energy sources provided as much as 54 per cent and as little as 14 per cent of electricity demand at any one time. While batteries are incredibly useful, in this particular week they only contributed as much as 100MW twice. That compares with an average daily peak of 30 GW and an average daily trough of 19 GW. Batteries are ideal for optimising the energy market at the level of microseconds up to hours, but are unlikely to be sufficient by themselves to guarantee firmed supply to post-carbon industry. The problem is unquestionably solvable: pumped hydro is likely to contribute a major part of the solution. Gas is playing an important firming role in the grid, particularly on the east coast; this role may be filled by hydrogen or other storage methods in the future. Whichever mix of storage methods is used, we will need significant investments soon.

Figure 5. Electricity production on the NEM by source (7-day period, MW)[56]



12 Jan 2022, 1:30 PM – 19 Jan 2022, 1:30 PM AEST

Coal/Gas/Renewables	Energy GWh	Contribution to generation	Av.Value $/MWh
Sources	**4,220**		**$67.19**
Renewables	1,409	33.4%	$61.15
Battery (Discharging)	2.7	0.06%	$81.02
Gas	212	5.0%	$77.71
Distillate	1.5	0.04%	$92.75
Coal	2,595	61.5%	$69.43
Loads	**-23.1**		
Pumps	-19.4		$49.62
Battery (Charging)	-3.7		$52.60
Net	**4,197**		
Renewables	**1,413**	**33.4%**	

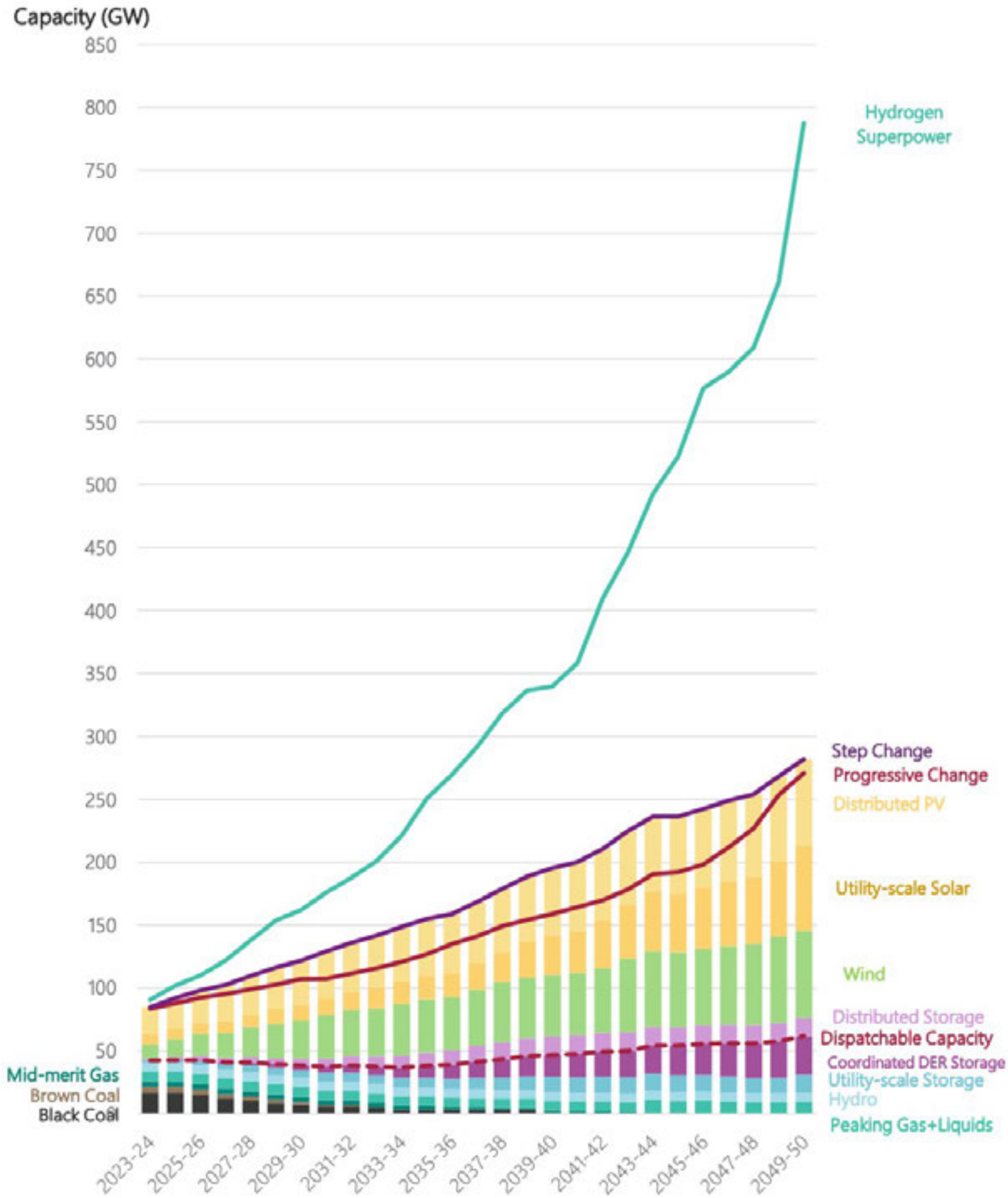
Part Three | The Current State of Play

Australia produces around five million tonnes of steel each year and about 900 million tonnes of iron ore[57]. We are a relatively small producer of steel but the largest exporter of iron ore in the world (nearly 40 per cent of the world's iron ore is produced here). Australia also has some of the largest potential supplies of renewable energy in the world giving us a great opportunity to decarbonise the steel industry both here and globally at low cost and to the benefit of working people and local communities. If Australia makes prudent decisions over the next two years, we can lay the foundations for a strong and sustainably growing industrial sector. However, the Commonwealth Department of Industry says that Australia's efforts to decarbonise steel are "advancing slowly" relative to both 2025 and 2030 goals. Despite clean steel being a priority technology in Australia's Technology Investment Roadmap, there has been "limited activity in this area" so far.[58] Of the current projects supported by the Australian Renewable Energy Agency (ARENA), none are specifically focused on decarbonising the steel industry. There is one project in progress in which Rio Tinto is aiming to partially reduce emissions from alumina and there is significant state-based effort to develop clean hydrogen, which is central to the most promising efforts to produce clean steel, however Australia's two main steelmakers, BlueScope and GFG Alliance, have only been involved in one ARENA-supported project each: GFG Alliance's efforts to establish the Middleback Ranges Pumped Hydro plant to power its facility, and the Australian Industrial Energy Transition Initiative (AIETI), which includes BlueScope amongst its 16 industry partners.[59]

BlueScope has also announced memoranda of understanding (MoUs) with Shell Energy, to work together to develop a pilot renewable hydrogen electrolyser at Port Kembla and a hydrogen hub, and with Rio Tinto, to develop low-emissions steelmaking processes at Port Kembla, including hydrogen direction reduction and an iron melter.

Recently, expectations about the rate of transition that Australia might achieve have begun to change. This is especially evident in the Australian Electricity Market Operator (AEMO)'s draft 2022 Integrated System Plan (ISP) for the National Electricity Market.[60] AEMO considered five scenarios for the development of Australia's electricity market with different rates of decarbonisation. The 'steady progress' scenario was discarded as "no longer relevant" in light of the national commitment to net zero emissions by 2050. The remaining four scenarios in order of ambition are: slow change, step change, progressive change, and hydrogen superpower. The feedback AEMO has received is that 'progressive change' is the most likely scenario, while conversely 'slow change' the least likely. The 'hydrogen superpower' scenario was seen as less likely than 'step change' yet hitherto scarcely contemplated. It involves developing an enormous hydrogen export industry, which runs the risk of pricing our domestic industry out of access to their primary low-emissions fuel. If Australia were to decarbonise iron reduction using hydrogen technologies, that would fit under a hydrogen superpower scenario. But decarbonising the steel industry is part of both progressive change and step change. Under both of these scenarios, AEMO expects Australia to require around 270 GW of installed renewable energy capacity by 2050 (almost triple the currently installed capacity). The hydrogen superpower scenario is considerably more ambitious, reaching 270 GW as early as 2035 and continuing up to 800 GW by 2050. The majority of the extra 525 GW of installed capacity would be expected to be utility-scale renewables mainly used for hydrogen production (Figure 6).

Figure 6. AEMO scenarios for Australia's renewable electricity requirements (2023-2050)[61]



AEMO's draft 2022 ISP provides a well-modelled context within which the decarbonisation of the steel industry can be expected to progress. Because harder to abate emissions are drawn from primary steel production and because Australia's primary steel industry is so concentrated (with two major producers each filling a different industry niche and each operating in a different geographical region of Australia) we are able to examine each of the two major primary steel producers individually. There are also significant related opportunities from carbon-free iron ore reduction which will be scrutinised in the next section.

BlueScope Steel: Port Kembla

BlueScope's blast furnace operation located at Port Kembla, south of Sydney, is the largest single plant for steelmaking in Australia. Because of that fact, the Climate Action Report that BlueScope released on 1 September 2021 (the first time BlueScope has released such a report) is incredibly important.[62] BlueScope has adopted a net zero target for 2050 with interim targets for 2030 of reducing emissions intensity of their steelmaking processes by 12 per cent from their 2018 levels and reducing the emissions intensity of all their other operations by 30 per cent with $150 million over five years budgeted for climate projects. They have appointed a Chief Executive of Climate Change (Gretta Stephens), established a corporate climate team, and linked executive remuneration to performance on climate targets. However, they do not expect significant emissions reduction before 2030 and decisions that must be made within the next year or two will significantly impact how ready the company is to begin realising serious emissions reductions even after 2030.

The company is currently undergoing feasibility assessments on relining the No.6 blast furnace at Port Kembla. Refurbishment is expected to take three years with a figure of around $1 billion capital invested. This includes technologies that will be key enablers of medium to longer-term opportunities to reduce Port Kembla Steelworks' greenhouse gas intensity. These opportunities are part of a broader suite of climate-related projects at Port Kembla that have the potential to reduce GHG emissions intensity by up to 20 per cent.[63]

BlueScope has also stated publicly that it has the financial flexibility to rapidly adopt breakthrough technology once it is commercially viable and available at scale, and it would not need to operate a relined No.6 blast furnace for a full 20-year campaign in order to be viable. It has described the reline as a "bridge" to get to low emissions steelmaking, where it can transition to the new technology when it is commercially available.

The company has indicated that it intends the refurbishment to be done in a way that allows integrating hydrogen fuel as it becomes available at commercial scale, yet the manner in which that is expected to work has not been made publicly clear to date. Whether these plans amount to fast enough action depends on what else is done. The company has repeatedly described their plans as critically contingent upon five "enablers":

1. Commerciality of emerging and breakthrough technologies;
2. Availability of affordable and reliable renewable energy;
3. Sufficient affordable hydrogen made from renewables;
4. Availability of other quality raw materials; and
5. Appropriate policies to support investment and prevent carbon leakage.

These enablers are largely outside the control of BlueScope alone, which is part of the reason decarbonising steel must be a national, not just a company priority. Regarding ensuring the availability of affordable hydrogen that can be integrated into their production processes, BlueScope has estimated that to decarbonise the steel output from its Port Kembla blast furnace using hydrogen-based processes will require up to 300MW of hydrogen electrolysers (about 100MW/million t). Initially, they have announced intentions to pilot a 10MW renewable hydrogen electrolyser, with two crucial reasons for starting small.

First, there is a lot to learn: how hydrogen is best produced and stored safely on site, how it should be handled, and most importantly, how hydrogen behaves in the blast furnace. Both making hydrogen and using it to make steel are technologies that are yet to be commercially demonstrated. Although a 10MW pilot is small relative to the anticipated ultimate requirements of around 300MW, it is not relative to existing commercial experience. Today, the biggest operating electrolyser in existence is 1.2MW, with three 10MW electrolysers expected to begin production in Australia next year. Most existing hydrogen production is from methane steam reforming of oil or gas[64] but emissions must be captured and stored to ensure a zero-emissions product. There is even less experience available for using hydrogen in blast furnaces. Safety issues need to be resolved, especially when managing large amounts of gas around equipment operating at extremely high temperatures. There are many practical matters arising from the different chemistry of hydrogen from coal. Skills need to be developed, including around safely and productively operating and maintaining new processes and equipment. Many issues have to be learned through experience, and ideally, working closely with employee representatives. This inevitably takes time, which is why it is urgent to begin now if we intend to meet goals by 2030 or 2050.

The second reason to start small is cost. Operating 300MW of hydrogen electrolysers requires a significant amount of electricity. The costs of hydrogen are likely to fall significantly as the industry increases in scale, but that has not happened yet. BlueScope's 10MW pilot electrolyser will also incur significant annual operating costs (separate from upfront capital investment). Although this is a significant operational cost, it is small by comparison to their annual electricity bill (which runs into the tens of millions of dollars). To deploy hydrogen at scale, renewable electricity generation needs to be multiples of its current level.

Several potential government funding sources for the development of renewable hydrogen projects are available, including the NSW Government's hydrogen hubs and hydrogen roadmap funds. The government's Renewable Energy Zones policy is designed to drive an increase in firmed renewable generation capacity in the State, and it will also drive demand for renewable energy components. BlueScope and its partners recently secured a $55.4 million grant under the Federal Government's Modern Manufacturing Initiative, to create an Advanced Steel Manufacturing Precinct at Port Kembla Steelworks, which will see the building of a new fabrication facility to manufacture components for the renewable energy, defence and other sectors, as well as upgrades and modernisation of BlueScope's Plate Mill. Decarbonising steel production in Port Kembla presents a significant task, but BlueScope is increasingly demonstrating its commitment. While there remains a huge amount of work to do, it will be essential to ensure that decisions made now are compatible with decarbonisation plans.

In the context of significant technological uncertainty, it is ideal to have multiple candidate technologies. Just as is the case with COVID-19 vaccines, investing in one prototype and not simultaneously exploring other options is an extreme risk. BlueScope has stated publicly that it is also examining the role of technologies such as biochar, which could potentially replace a proportion of the pulverised coal injection used in the blast furnace, with resulting reductions in GHG emissions. In the mid-2000s, BlueScope undertook research & development with industry partners and CSIRO, including to examine the use of renewable carbon sources as fuels and reductants. This work included piloting pyrolysis-based biochar production. Ensuring this work continues will be both economically and environmentally worthwhile.

GFG Alliance

GFG Alliance consists of Liberty Steel and InfraBuild among other entities. Liberty Steel was formerly called Arrium until the company was purchased by GFG Alliance in 2017.[65] GFG Alliance is well positioned to take advantage of emerging clean steel technologies. InfraBuild (the smaller of GFG Alliance's two major steelmakers in Australia) is already fully electric and Liberty has plans to introduce fully clean hydrogen and electric processes. Yet the best thought-out plans and good intentions are undermined if they cannot be converted into tangible, commercially viable results.

Liberty

Liberty's main operations produce steel long products at their facility in Whyalla in South Australia.[66] Currently, Whyalla uses an emissions-intensive blast furnace, however the company has adopted a target of achieving carbon neutrality by 2030, which they call "CN30". Plans were announced in 2020 to replace their blast furnace with an electric arc furnace (EAF) facility using hydrogen fed direct reduced iron (DRI) in the iron ore reduction processes. The Whyalla blast furnace is rated at 1.2m tons per year but the planned EAF facility is expected to have the capacity to produce 2m tons per year. This increase in production capacity alone would represent a 15 per cent increase in Australian steel production. The main constraint on this transition is the supply of renewable hydrogen and the company is currently assessing options for either buying renewable electricity or building their own generating capacity. Ensuring that progress materialises is a critical task.

InfraBuild

InfraBuild is a low-carbon steel maker that uses 100 per cent recycled scrap metal and has two EAFs: one in Sydney at Rooty Hill and the other in Melbourne at Laverton plus four rolling mills which include reheat furnaces that consume gas. They describe their process as GREENSTEEL™. In essence, scrap steel is used instead of iron ore, meaning there is no need to reduce iron ore. The steel is melted for recycling using an EAF, which consumes significant amounts of electricity – the NSW government describes InfraBuild's Rooty Hill plant as "one of the largest electricity users in NSW" using 310 GWh per year.[67] Although this much electricity consumption can produce significant emissions when the electricity is generated from coal, it is also not complicated to transition to renewables.[68] InfraBuild have plans to largely eliminate their Scope 2 emissions from their EAF within two years by transitioning their electricity supply to 100 per cent renewables, describing "existing contracts" as the only source of delay. Emissions from the second stage in their process is slightly more challenging to abate. However, the gas used in the reheat furnaces to prepare the steel for rolling into products can potentially be replaced with hydrogen. InfraBuild have indicated interest in becoming base customers for hydrogen hubs in Victoria or the Hunter Valley in NSW. As with Liberty, the challenge is converting good intentions and aspirations into commercially successful results.

Pilbara

Because iron ore and renewable electricity are the main ingredients for clean steel, and because Australia has some of the most abundant endowments of each, we cannot ignore the potential for upgrading Australia's iron ore exports into clean iron. If Australia is to decarbonise our steel industry, we need to invest in large quantities of renewable electricity and hydrogen as well as develop the skills and capability to reduce iron ore without producing GHG emissions. The question then follows; why not apply it to all the iron ore we produce? Australia has the potential to demonstrate emissions-free iron-ore reduction using renewable energy and hydrogen processes in the Pilbara, a region known for its vast mineral deposits in northern Western Australia. If Australia could produce emissions-free reduced iron for export, it could become an even bigger supplier of iron than it already is. Conversely, missing this opportunity risks providing that market position to Brazil or Africa, each of which also have major iron ore reserves and significant renewable energy potential.

The Australian steel and manufacturing industries would benefit from lower costs due to economies of scale if Australia can develop very large clean energy and hydrogen production. Some producers may also potentially benefit from lower relative costs of reduced iron compared with international competitors. Transporting DRI requires strict safety measures to prevent explosions, including treatment before transport and close monitoring while in transit.

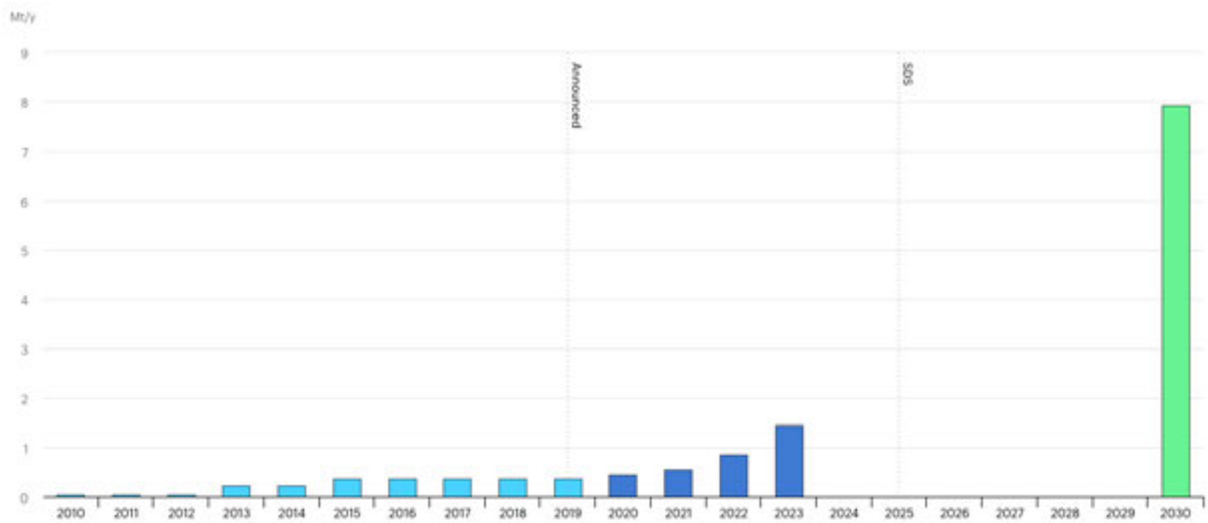
As there are already major renewable energy projects under development in the Pilbara (such as the 26 GW 'Asian Renewable Energy Hub'[69]), the missing links in this supply chain are building the DRI capacity. This is likely best done in collaboration with steelmakers who already have decades of experience in reducing iron ore.

Another hurdle that will need to be overcome is to develop and implement the technology to cost-effectively manufacture direct reduced iron from the hematite ores that predominate in areas such as the Pilbara. To date, magnetite ores have been more suitable for hydrogen DRI production worldwide due to their higher grade once processed and lower impurities. Using hematite ores in DRI production is a focus of BlueScope's MoU with Rio Tinto.

Fortescue Metals Group and Fortescue Future Industries

Fortescue is primarily an iron-ore mining firm but has begun investing strongly into hydrogen and other renewable energy technology. Emissions from steel made from Fortescue's iron ore are considered "Scope 3 emissions" from the perspective of the firm. They estimate their annual Scope 3 emissions from crude steel manufacturing are equivalent to around 250 million tons of CO2.[70] Fortescue's subsidiary, Fortescue Future Industries (FFI) have set a target of producing 15 million tons of renewable hydrogen per year by 2030, increasing to 50 million tons. The company has also "secured exclusive access" to over 300 GW of renewables capacity.[71] By contrast, in 2020 the IEA estimated that the total announced low-carbon hydrogen production for this year was 0.55 million tons, and that almost 8 million tons/year would be needed by 2030 under their "sustainable development scenario" (Figure 7). FFI are planning to meet that goal twice over.

Figure 7. Low-carbon hydrogen production (2010-2030)[72]



FFI's stated commitments to renewable energy are massive: equivalent to 15 times the annual electricity consumption from all sources on the National Electricity Market (NEM).[73] Within that ambition is a 60 percent stake in HyET Group, which is developing a 1 GW "Powerfoil factory". HyET's is a Dutch company and their Powerfoil solar panels are flexible and light weight modules.[74] The 1 GW Powerfoil factory would be producing 1 GW of solar film per year for large-scale users, such as utility solar or to power FFI's hydrogen electrolysers. Currently, the only solar PV manufacturer in Australia is Tindo Solar, which produces 150 MW of solar panels per year.[75] HyET also producer hydrogen compression systems (compression is a required part of the hydrogen storage process).[76] In its most recent full year results, FMG announced they expect to ship 180-185 million tons of iron ore this financial year.[77] While FMG's stated plans are ambitious, were they able to reduce their iron ore locally with clean hydrogen, the impact on global emissions would be tremendous, as would be the impact on developing an Australian hydrogen industry and providing low cost material inputs to the steel and manufacturing sectors.

Other hydrogen commitments

Developing a clean steel industry demands commercially available renewable energy and clean hydrogen, each still underdeveloped. There has been a huge number of hydrogen related announcements over the last two years which will only increase further. Developments in hydrogen technology and costs have spurred commitments and investments from governments and the private sector around the world, not least from Australian states and territories. However there remains a daunting schedule of work. According to ARENA, ATCO Australia's Clean Energy Innovation Park (CEIP) aims to "create Australia's first commercial scale green hydrogen supply chain". Hydrogen will be trucked to gas network injection points. The Park will build a 10 MW electrolyser that can produce 4 tonnes of hydrogen per day.[78] ARENA is also supporting two other 10 MW electrolysers – among the largest renewable hydrogen demonstration projects in the world.[79]

Recommendations

1. **Develop and implement a National Clean Steel Roadmap**

The Commonwealth Government working in tandem with state governments, steelmaking companies and employee stakeholders, including, but not limited to, the Australian Workers' Union, should establish a Clean Steel Taskforce with the specific aim of creating a National Clean Steel Roadmap. The taskforce should be established and funded in the 2022-23 Commonwealth budget and begin operations no later than 1 July 2023. The taskforce should take submissions from relevant parties, be informed by overseas best-practice, notably the case of Sweden, and deliver the Clean Steel Roadmap to the Commonwealth Government no later than December 2022. The Roadmap should enunciate clear parameters around decarbonising steelmaking and other industrial heat sources such as concrete and a range of chemicals, support a range of technologies in order to reduce risk given current technological uncertainties, detail precise steps for interlinking the developing hydrogen industry into the steel and iron production process, and set clearly defined and monitored targets for transitioning to clean steel production. In addition, the Roadmap must make funding provision for and outline the ways in which the existing steel and iron workforce will be retrained and/or redeployed, as well as clearly establishing Occupational Health and Safety guidelines to account for new workplace settings.

The National Clean Steel Roadmap should include clear awareness that central to the challenge is the need to develop and deploy commercially and at scale multiple new, unproven technologies within a narrow timeframe. The plan must facilitate scheduled progress for technological development and deployment in three areas (linked to activity targets elaborated adjacent):

1. Utility-scale renewable energy generation, storage, transmission and distribution
2. Large scale clean hydrogen production, transmission, storage, and
3. Low or zero emissions iron reduction and steelmaking.

The National Clean Steel Roadmap should include scheduled National Interim Activity Targets in recognition that several years of progress will be required before any "results" can be expected. Steelmakers and other producers of difficult to abate emissions are putting forward plans to reduce their emissions by 2050, but these tend to rely on technology that is not yet proven. Interim milestones are needed to ensure the foundational work is being done as early as possible. Importantly, these should not be focused solely on medium and long term outputs, like a 2030 emissions reduction target; they need to focus on the activity that longer-term targets depend on. For instance, targets to ensure producers have contracted access to sufficient renewable hydrogen supplies within the timeframe needed. Targets to ensure producers are trialling the technology that they will eventually need to work with. And targets to ensure they are developing the local skills required. The precise details of such plans should be left to the companies themselves, but they should commit to the intermediate steps that will credibly make their long-term plans viable. The tasks where short-term progress is required include building sufficient renewable energy at the appropriate locations; building hydrogen electrolysis at scale, ensuring the hydrogen can be stored safely, piloting the use of hydrogen in iron reduction, demonstrating steel production with iron made from renewable hydrogen, and ensuring the entire production process is well integrated. Progress should be made on each of these fronts in parallel, and the Commonwealth should legislate short-term targets on each of the above.

2. Establish national accreditations for clean hydrogen and clean steel

The federal government should establish a national zero-emissions accreditation scheme for hydrogen and other industrial products. The accreditation process should allow the market to distinguish between zero-emissions products and those that are not zero-emissions. Market discrimination will help facilitate an economic return on emissions reduction investments, while reducing 'carbon leakage', whereby supply shifts to producers that are not part of emissions reduction efforts.

The Commonwealth Government should codify a zero-emissions accreditation scheme for hydrogen and related industrial products and mandate clearly enunciated short-term targets for building infrastructure and production. It is intended that these two steps be integrated with the development and implementation of the proposed National Clean Steel Plan outlined above. A clean steel accreditation should also be developed. It should be graded and have a forward-scheduled tightening of standards set in line with expectations of the international frontier. Governments should commit to procurement policies that demand high levels of clean steel accreditation as well as minimum standards set in building codes. Both procurement-standards and minimum standards should be indicated as much in advance as possible – ideally several years. Accredited clean steel will be a premium product relative to other steel products. For this reason, the economics of exporting steel should become more attractive. Therefore, the national accreditation scheme should be constructed so as to ensure international buyers can have confidence in clean certification.

3. Strategic Government Investment to support steelmakers in decarbonising

a. New South Wales: Decarbonise Port Kembla steel operations

Australia's largest steelmaking facility is BlueScope's Port Kembla Steelworks. The NSW and federal governments should collaborate with BlueScope to decarbonise that operation at speed. There are four initial steps that require financial and logistical government support:

1. Build and secure local dedicated renewable energy supply at scale (with storage).
2. Maximise and secure hydrogen production capacity.
3. Piloting hydrogen integration with the blast furnace.
4. Policies to prevent 'leakage'.

These have been identified by the company as essential conditions that will need to be met in order for their decarbonisation plans to succeed. Progress has begun, but it remains insufficient and dependent upon conditions that are not guaranteed, with no interim targets or clear accountability for reaching critical milestones. The region around the Port Kembla blast furnace has been designated as a renewable energy zone by the NSW government. Incremental targets at one to two years for installing renewable energy would ensure we stay on track to install sufficient capacity to supply the necessary clean hydrogen in the required timeframe. Support should be provided for pilot projects and trials, such as the pilot renewable hydrogen electrolyser at the Steelworks and trials to produce iron and steel more cleanly using hydrogen and other reductants such as biochar.

Port Kembla gas terminal

There are plans to upgrade the port to facilitate natural gas imports to help supply the gas facility that will be built adjacent to the port and blast furnace. But if the area is to become a major hydrogen production area, it will need to become an exporter of hydrogen, not an importer of LNG. This demands that the Commonwealth and NSW government ensure the Port Kembla Gas Terminal is fitted for hydrogen, and capable of operating as an export terminal. The Port Kembla Gas Terminal is a 'Critical State Significant Infrastructure' (CSSI) project since 2018. It received planning approval in 2019.[80] The federal government announced $30 million support for the $250 million project in October "as it progresses to Final Investment Decision". The terminal is intended primarily as an import terminal to ensure an economical supply of gas to the eastern seaboard. Ensuring the terminal is constructed to specifications that enable handling hydrogen will be essential for linking BlueScope's steel facility to reliable hydrogen supplies. The port should also have the capacity to operate as an export terminal. The economics of hydrogen will be made far better if major production areas are able to sell excess supply to national or international markets.

Blast furnace hydrogen trials
BlueScope should include specific planning for integrating the No.6 blast furnace with hydrogen technology. This needs to include a timeline as well as clear estimates of the amount of hydrogen required and any early steps that will best be managed at the beginning of the no.6 blast furnace relining process. Trials should proceed with hydrogen from whatever source is available. Developing multiple technologies should proceed with parallel processes, not sequential processes – meaning that current proposed trials should be advanced as quickly as possible. Should trials of hydrogen use in steelmaking begin only when there are abundant supplies of renewable energy and affordable clean hydrogen, progress on decarbonising steel would not begin until it was too late for a national financial and manufacturing dividend.

b. *South Australia: Make Whyalla Australia's first clean steel demonstration project*

GFG Alliance's Whyalla facility is well placed to become the first producer of clean primary steel in Australia. Whyalla are planning to replace its aging blast furnace with Electric Arc Furnace (EAF) technology using iron from a Direct Reduced Iron (DRI) facility. Their planned DRI will source iron ore from GFG's on iron ore mines in South Australia and will initially reduce the iron using natural gas. The company plans to transition to clean hydrogen production over time. The EAF will run directly on electricity produced from renewables, while the DRI will need clean hydrogen as early as possible. The first large scale commercial production of clean steel will be a significant milestone.

c. *Explore the potential of a futures market for clean steel*

Part of the challenge is the difficulty in finding demand for a product that does not exist, and finding willing investors for a product that has no proven consumers. One solution could be to create a futures market for clean steel. A futures market would allow buyers to contract for clean steel deliveries after a certain date, such as 2030. Payment would be conditional upon delivery, reducing the risk to buyers. The ability for producers to demonstrate to investors that a market exists could reduce the risk to investors, facilitating the early progress future production depends on.

d. *Grow the industry with a new small facility producing only premium clean steel*

Clean steel will be a premium product for at least the next twenty years. Because of this, clean steel has the potential to be successfully exported in large quantities. A new DRI-EAF facility producing in the range of 1 million tons per year would be a small facility relative to the Port Kembla operations, but could be established in a shorter time than is required to fully transition Australia's entire steel industry. An additional 1 million tons per year of steel production would represent around 20 per cent growth for the industry and could directly employ in the region of an additional 1,200 permanent full time workers after the initial construction phase finished (using the Whyalla steelworks as a rough benchmark).[81] The federal government should work with industry, other levels of government and employee representatives to establish a commercial clean steel demonstration project as a premium product. Existing producers may be involved, but the project can also encourage new market entrants, helping reduce the high degree of market concentration. Choosing a relatively small production volume will make it possible to establish the necessary renewable electricity and clean hydrogen production within a relatively short time frame. The government should be ambitious, aiming for commercial operations to begin as early as 2028. To expedite the process, the right location will be essential. Strong potential for rapidly establishing local renewable energy and hydrogen production will be necessary as well as access to suitable port facilities. A location such as the Hunter Valley could be ideal given the advanced plans for clean hydrogen production.

e. Western Australia – Establish pilot-at-scale decarbonised iron-metal production in the Pilbara

Western Australia has a unique opportunity to decarbonise a major portion of the global iron industry at the source. Doing so would require enormous investment in renewable energy and hydrogen production as well as introducing a new export-dedicated iron reduction industry to WA. Fortescue Future Industries has demonstrated a desire to lead on this front. The WA and federal governments should collaborate, helping match funding and ensure appropriate policy settings are in place. The WA and federal government should invite international collaborators. Japan, Korea and Indian firms should be encouraged to participate in early-stage processes to ensure a diverse market. The scale of renewable electricity production required to achieve this vision is tremendous. Estimating the amount of renewable electricity needed to reduce all of Australia's iron ore production (about 900 million tons each year) using hydrogen made from electrolysers powered by renewables is impossible to do precisely, since there have not been any large-scale demonstrations of the technology. But estimates of the relevant order of magnitude are in the region of seven times greater than Australia's current total electricity production.[82] To produce that much hydrogen from renewable electricity, it needs to be done where the best large scale renewable resources are. Australia happens to have those resources where they're needed. We should not hold back.
policy that supports investment in decarbonisation and avoids risk of carbon leakage.

The opportunity for Australia

This report has outlined what we believe governments, working hand in hand with business and labour, has to do to secure the future of Australia's steel industry. Yet this plan goes beyond protecting what we already have: we have the opportunity to create a serious economic boon for Australia. Decarbonising Australian steelmaking could grow the industry in several ways. If Australian construction standards and government procurement requirements demanded certified low-carbon or carbon-neutral steel, we could expect to see a shift in domestic consumption towards locally-made steel rather than imported steel if competitors had not decarbonised in line with Australian producers. Clean steel will be a premium product and, accordingly, be suitable and highly lucrative as an export. Major steel users in our region such as Japan, Korea, India, China and others all have decarbonisation obligations that mean they are potential importers of certified clean steel. The same imperative also makes them highly attractive investors, especially in a country such as Australia with a stable investment environment and regulatory system. All that is missing is a federal government that is committed to decarbonisation and committed to the long-term future of the steel industry and its workers. As we suggested earlier Australia can potentially increase its production of steel and steel products by an achievable 1 million tonnes to an overall 6.5 million tonnes a year, which would be a fantastic a win-win outcome for business and workers by increasing industry revenue to over $30 billion a year and adding around 1200 jobs in steel manufacturing and many more downstream – good, secure, and well-paying jobs.

The opportunity for Australia from decarbonising steel is not limited to just the steel industry. Competitive Australian certified clean steel would be the anchor customer for major investments in renewable energy and hydrogen production as well as the basis for a growing market for fabricated products, including the fabricated renewable energy components that themselves will be needed as inputs to the industry. It would help Australia diversify our economy and our exports, making the country more resilient. And it would help deal with the hardest to abate nine per cent of global emissions; an imperative if we want a future not impoverished by climate change. There is much work to coordinate and time is of the essence. If we shy away from this task, we risk losing a great deal. But if we roll up our sleeves, work together, and get it done, there is so much more to gain.

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ISBN: 978-0-6489886-3-2

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