An Industrial Strategy for Domestic Manufacturing of Onshore and Offshore Wind Energy Towers and Equipment

By Phil Toner

The Centre for Future Work at the Australia Institute

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1. Introduction

The purpose of this study is to first, outline the scale of potential domestic demand and supply for onshore and offshore wind-towers used in electricity generation; second, determine the barriers to and benefits from increased domestically produced wind towers and equipment; and finally, identify feasible and efficient industry policies to reduce these barriers to increased local supply of wind towers and other components of wind turbines.[1]

The paper is structured as follows. Chapter 2 briefly describes the international public policy context for this study. Sparked by disillusion with outcomes from 40 years of neoliberal economic policy, there has been a resurgence of active industry policy as a legitimate field of government activity. Chapter 3 provides a concise overview of the factors driving global wind turbine demand, describes the global wind generation equipment making industry and details the policy instruments employed by nations to foster their local industry and successfully participate in the global wind turbine supply chain. Chapter 4 quantifies the scale of current and prospective Australian demand for wind turbines, the drivers of this demand, and current local wind tower and related equipment supply capacity. Chapter 5 identifies the major barriers to increasing local tower production to satisfy this enormous demand. These barriers arise mainly from changed market and engineering requirements for towers and deficient renewable energy industry policy. The benefits to multiple industries and the economy from expanded domestic supply capacity are considered in Chapter 6. The final chapter makes recommendations to redress these barriers.

The principal findings of this study are first, there is a powerful renaissance in global industry policy driven by a number of self-reinforcing developments. These include disillusionment within government and the electorate with outcomes from the neoliberal 'experiment' over the last 40 years, especially declining living standards, rising inequality and deindustrialisation which has driven many adverse changes, including the rise of populism. In Australia's case, the loss of national industrial capacity has exposed supply chain risks in key technologies and essential inputs, especially worrisome in light of rising geopolitical conflicts. The self-evident success of aggressive industry policy in nations such as China and South Korea has also called into

[1] The discussion focuses mainly on the prospects and feasibility of domestic manufacture of towers. These constitute a key and financially valuable input into wind turbines that is compatible with Australia's current technology, skills and local inputs to production. Potential scope for and benefits from Australian production of blades, machinery, and other wind turbine components are also briefly explored.

question dominant economic orthodoxy of unrestrained globalisation of capital and trade.

Second, all of these factors are in confluence with the rapid decarbonisation of the energy system and the need to dramatically increase renewable energy generation, storage and transmission equipment making. Globally, this will require public and private investment in manufacturing capacity in the trillions of dollars. Wind turbines will form an integral and increasing role in decarbonisation and in this manufacturing investment. However, the International Energy Agency (2023b: Figure 1.10) is forecasting a large 'capacity shortfall' between demand and supply of renewable generation equipment manufacturing, with the production deficit for wind turbines and towers reaching 70% of demand by 2030. In response, the IEA forcefully argues the level of investment and co-ordination required to effect this enormous expansion in renewable energy equipment making necessitates comprehensive national industrial policies.

> 'The energy world is in the early phase of a new industrial age – the age of clean energy technology manufacturing...Every country needs to identify how it can benefit from the opportunities of the new energy economy, defining its industrial strategy according to its strengths and weaknesses… Countries are trying to increase the resilience and diversity of clean energy supply chains while also competing for the huge economic opportunities. Major economies are acting to combine their climate, energy security and industrial policies… There are big dividends for countries that get their clean energy industrial strategies right' (IEA 2023b: 20-21).

Third, the scale of required investment in decarbonisation presents the possibility of a multigenerational renaissance in Australian manufacturing and related advanced services. Demand for onshore wind towers alone to satisfy base case AEMO projections of wind generation capacity to 2040-41 will exceed $1bn per annum. If complete turbines are locally manufactured the value of local production increases dramatically, as towers comprise only about 12% of the manufacturing cost of a wind turbine. Moreover, these figures exclude offshore wind generation equipment, the cost of which further multiplies these figures. Given current policy settings, essentially all of this demand will be met by imports.

Four, efficient wind tower production is scale intensive. However, it is concluded that the level of projected demand is sufficient to support the establishment of factories, operating at a scale to deliver world equivalent productivity, in the east coast wind energy generation growth states of Queensland and NSW. Similarly, the scale of demand for offshore wind towers is also projected to be sufficient to support efficient local manufacture. Industry estimates suggest the current price difference between imported and locally produced onshore wind towers is around 15%-20%. This price difference could be significantly reduced or eliminated with the establishment of large-scale plants closer to wind farm development, and by addressing other barriers. Under current policy settings these investments are extremely unlikely to occur due to excessive and unnecessary investment uncertainty and risk.

Five, local industry is constrained by a number of barriers from participating in the local production and supply of wind towers. Current local supply capacity in the growth states of Queensland and NSW is effectively zero. Some barriers to expansion of local production include: the small scale and location of current plants; the market structure and behaviour of major international producers; non-enforcement of engineering and quality standards on imported towers; skill shortages; restricted local plate steel production; and deficient industry policies.

Six, there are multiple benefits to local industry and the broader economy in developing wind tower manufacturing. Given the high intensity of steel use in wind tower manufacture a major beneficiary of increased domestic wind tower supply will be the Australian steel industry, which has suffered from low and uncertain demand. Even a relatively modest lift in local supply of wind towers will represent a significant and stable source of demand for the local steel industry. Demand from a local onshore and offshore wind tower and turbine industry for steel will also contribute substantially to generating a level of output necessary to validate investment by steel producers in 'green steel' technologies. The production of green steel will in turn offer flow-on benefits to all other steel users. Locating tower and parts of turbine manufacturing close to wind farms reduces logistics costs and has the benefit of creating regional based jobs which can also offer alternative employment to those displaced by phase down of fossil fuels extraction and processing and use in electricity generation. Estimates are also provided showing domestic tower production makes a material reduction in CO_2 emissions by displacing sea transport of millions of tonnes of imported steel towers.

Seven, wind tower manufacture satisfies key criteria to justify both government intervention and increase the likelihood of the intervention's success. These criteria include:

- Renewable energy policy implies the demand for wind towers and, therefore, output of wind equipment factories, will be very large and of long duration.
- The pace and scale of demand for wind towers is directly under the control of government through national electricity generation plans, public investment in generation and incentives for private investment in generation.

- Wind energy generation and wind generation manufacturing are a proven, mature technology that is unlikely to be subject to medium term technological redundancy.
- Given Australia's comparatively unsophisticated manufacturing base, fabrication of wind towers, as a mature low-medium technology activity, is well within domestic capability.

  (These four attributes reduce the risk to government in supporting indigenous tower production.)

- There are strong input-output linkages with existing industries conferring a cumulative growth impetus to employment and incomes.
- Wind tower and turbine manufacture are subject to consistent and above average productivity gains which aids macro productivity performance.
- Once established, this activity offers the real prospect of entry into higher-value and technologically advanced products such as generators, blades and voltage control systems.
- International trade in wind towers and turbines is both extensive and subject to intensive national industrial policies. In orthodox economic terms, international trade is distorted by a variety of incentives and subsidies and requires countervailing intervention by the Australian government to correct these 'market failures'.

Finally, this report recommends several specific measures to address some of the key barriers to investment in domestic wind tower manufacturing, including:

Recommendation 1: The federal government in co-operation with state governments and industry commission an engineering and financial study into the optimal location, plant size, plant layout, advanced production equipment and minimum scale of output required to establish competitive tower manufacturing on the east coast of Australia where onshore and offshore wind farm activity will be intense for decades. This study should also examine the optimal risk-sharing arrangements between private industry and the public sector to ensure public funds are efficiently spent to maximise public benefit. For example, the study could examine the relative merits of up-front subsidies for capital investment versus a production subsidy per tower. Such a study should also consider the scope and feasibility of full or partial turbine manufacture through an audit of local supply chain capability and gaps.

Recommendation 2: The government should implement key recommendations of the 2017 Senate Inquiry into the Australian steel industry relating first to import of sub-standard steel and fabricated structures and second, to ensure consistency across the states in the application of engineering standards.

<u>Recommendation 3</u>: A carbon price be imposed on the Scope 3 emissions of wind farm developers due to the substantial carbon emissions arising from sea-transport of imported towers. This carbon price should be part of a wider and more powerful carbon pricing system in Australia to reinforce (and help pay for) the transition to renewable energy systems. Local wind tower manufacturers (along with other manufacturers of equipment used in renewable energy systems) could then be supported with these revenues help defray establishment and production costs.

<u>Recommendation 4</u>: State based local content schemes should be harmonised to reduce the scope for gaming and prevent perverse incentives such as duplication of tower factories resulting in a loss of scale economies and lower productive efficiency. Second, state and federal government local content plans for renewable energy generation should be altered to prescribe specific proportions of local inputs into private and public procurement. These proportions should be set so as to generate the level of demand needed to satisfy the minimum scale of wind tower plant output to be identified from the study suggested in Recommendation 1.

<u>Recommendation 5</u>: A joint public and private sector authority should be established to co-ordinate and sequence investment in renewable energy generation and transmission and steel and green steel production to maximise supply and demand linkages between these sectors, promote investment and reduce investment risk. To improve the efficiency of this task the authority should have input into setting the level and timing of local content requirements.

The economic benefits of a major expansion in domestic manufacturing of wind towers and equipment are large, on top of the environmental benefits resulting from the accelerated transition to renewable energy. In the cases simulated in this report, these benefits could include:

- Over 4,350 ongoing jobs in wind tower manufacturing, and thousands more in input industries (especially steel).
- Output of over 800 towers per year, with cumulative value of up to $15 billion over the next 17 years.
- Incremental demand for up to 700,000 tonnes of Australian-made steel per year, creating a foundation for the recapitalization of Australian steel plants with carbon-free technologies.
- Avoiding 2.6 million tonnes of CO2 emissions thanks to reduced sea shipping of imported wind towers.

In sum, an active industrial strategy aimed at carving out a proportionate foothold for Australia in this important, growing sector should be a key feature of the country's overall plan for the energy transition and associated industrial and manufacturing linkages.

2. Global Resurgence of Industry Policy

It is important to place the current position of the domestic wind turbine and tower industry and discussion of measures to promote its development in a broader international context. The key development is mounting disappointment with outcomes from the dominant neoliberal economic policy instituted over the last 40 years.

> ‘Many of the policies which have been implemented across the OECD, not just over the last decade but over the last forty years or so, appear no longer able to improve economic and social outcomes in the ways they once promised’ (OECD 2019a: 4).

In response economic policy over the last half decade or so has undergone a radical shift, with the most important change being ‘industrial policy is experiencing a global resurgence’ (Mazzucato and Rodrik 2023: 4). Industry policy entails purposeful government action to shape and direct private investment decisions along with complementary investments in public assets such as infrastructure and research. The objective of industry policy is to shape the industrial structure and improve the performance of firms and industry typically directed at multiple objectives of lifting productivity, innovation, employment, investment and exports. Increasing the share of manufacturing industry in total output and improving the performance of manufacturing are central objectives of industry policy historically and currently.[2]

Underpinning the resurgence of industrial policy is a dramatic shift in perception of the legitimate role of government in economic development. The most transparent examples of this fundamental shift are the industry policies embodied in the US Infrastructure Investment and Jobs Act, the CHIPS and Science Act, and the Inflation Reduction Act, which have driven a renaissance in US manufacturing industry (Joyce and Stanford 2023). These actions are being emulated in the European Union, Canada, South Korea, and elsewhere.

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[2] Modern industry policy has a broad conception of ‘manufacturing industry’, in recognition of the inherent linkages of inputs, outputs and ideas between manufacturing activity and advanced services such as ICT, logistics marketing, and engineering consulting.

The locus of the new industry policy has been renewable energy generation (and storage) equipment manufacturing especially solar, wind, hydrogen and batteries. This is due first, to the diversity of technologies used for renewable generation, and the diversity of manufacturing and services inputs required to make this equipment. Second, this diversity combined with the monumental scale of investment in transforming national energy systems offers multi-generational opportunities for technological upgrade of manufacturing bases and to grow jobs, often in regional locations. Finally, control over supply of renewable energy generation and storage equipment making is a driving force in geopolitical and strategic concerns and a driving force in the renaissance of industry policy. Chapter 3 details the industry policies used to promote domestic wind energy equipment manufacture in the US and EU which, to a large extent, are an exercise in emulating and 'catching up' with highly successful Chinese strategies.

These huge global shifts are of direct relevance to Australia and the local wind tower industry. Despite the historic re-orientation of global economic policy this study finds there is little evidence that Australian policy has adapted; rather, with a few exceptions it remains fused to the previous neoliberal order with continued political and bureaucratic opposition to coherent national industrial strategies, including those applying to domestic wind tower manufacture.

2.1 NEOLIBERALISM'S ABANDONMENT OF INDUSTRY POLICY

Before considering in more detail what is behind this global policy reversal, we need to briefly consider the general history and impact of neoliberalism. Since the 1980s economic policy in almost all advanced economies has been informed by neoliberalism.[3] This economic and political philosophy is marked first, by the central priority it gives to 'markets' both in the allocation of economic resources and as superior to all other institutions especially, government, in generating, expressing and delivering the social and political preferences of individuals. Second, despite its methodological individualism and absolute focus on individual preferences, neoliberalism promotes a strong state to, in effect, impose 'market discipline' on a potentially recalcitrant population.[4] Finally, the central objective of neoliberalism is to

[3] For an excellent account of the historical origins, varieties in and objectives of neoliberalism see Plehwe, Slobodian and Mirowski (2020).

[4] For example, since the 1980s the quite draconian legislation in Australia to restrain the operation of labour unions (Jericho and Stanford 2024).

defend and extend the right of capital to be freely deployed with the singular objective of profit maximisation.[5]

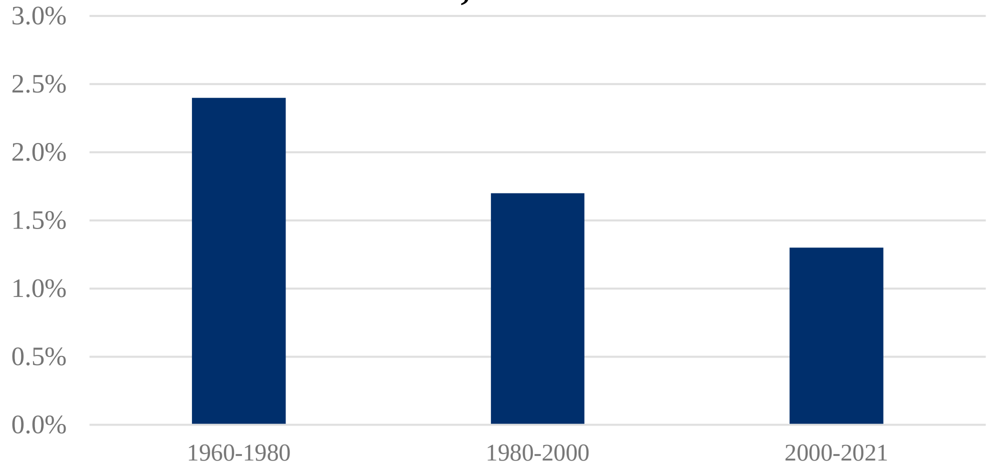
In practice, neoliberalism has entailed deregulation of international trade and capital markets and domestic labour markets; preferentially lowering taxes on corporate earnings and personal income derived from capital; lowering capital gains taxes; extending and creating markets by privatising profitable state assets and contracting-out remaining public services to the private sector (Cahill and Toner 2018).

Economic 'reform' under neoliberalism was supposed to deliver increased productivity, innovation and incomes (Treasury 2018). Over the last half-century, the actual outcomes of this neoliberal 'experiment' are both clear and disappointing:

Declining productivity and growth

Prior to implementation of neoliberal policy, the annual rate of productivity growth (measured as real output per hour worked) in the period 1960 to 1980 in Australia was 2.4%. This rate declined in the subsequent neoliberal era (Figure 1). From 2000 to 2021 the annual rate of increase was just 1.4%; a 42% decline from the earlier period. This matters since productivity growth is the principal contributor to growth of incomes.[6]

Figure 1. Annual Labour Productvity Growth Australia, 1960-2021



Source: Derived from Productvity Commission (2023) 5-year ProductivityInquiry: Keys to growth, Vol. 2, Figure 2.2. Financial year data

[5] Neoliberalism has not been associated with a reduction in the 'size of the state' as measured for example by expenditure, employment or rate of legislating new statutes.

[6] Whilst productivity is the main driver of long-term income growth, Stanford (2018) demonstrated the link between productivity growth and wages has over the last 20 years been broken. This is attributed to a range of factors but most important has been deregulation of labour markets and changes to industrial relations systems discouraging collective bargaining.

The pre-neoliberal period, 1960-1980, was marked by centralised wage fixing; high levels of public ownership of core infrastructure; active industry policies and capital controls. These are the very policies argued by neoliberals to constrain productivity. Most OECD countries have experienced a similar productivity slowdown (Productivity Commission 2023: 32).

Many causes of declining growth in output and productivity have been advanced. Most explanations centre on the sustained decline in inputs to growth such as investment in productive capital equipment, human capital and R&D over the last 15 years in advanced nations. This decline in inputs is attributed first, to financialisation, or growth of the finance sector in GDP and investment in financial assets. Since the 1980s major corporations have diverted profits from investing in the business, to instead use retained earnings or borrowing to transfer profits into higher shareholder dividends and share buy-backs. Companies have shifted from a strategy of 'retain and reinvest' to 'downsize and redistribute' (Lazonick 2018). Financialisation is a central outcome of neoliberalism and arose in an environment of globalisation of capital markets; extensive use of tax havens; financial innovation such as securitisation; preferential tax treatment of capital gains; sustained low interest rates and 'quantitative easing' and changes in corporate objectives, especially the prioritising 'shareholder value' over all other stakeholders (Lavoie 2012). Second, the growth of income and wealth inequality, also associated with neoliberal economic policies, is adverse for productivity and growth. One link in the causal chain between inequality and lower growth is diminished educational participation and attainment of a large proportion of the population.[7] Reduced acquisition of human capital limits the generation and diffusion of new technologies and restricts productivity (OECD 2014).

Another important cause of long-term retarded productivity growth across advanced nations, and especially in Australia, is the changing industrial structure over the last half century and its links with manufacturing industry and neoliberal policies. The Productivity Commission (2023: 37) neatly summed up this issue:

> 'As Australia continues to become a more services-centric economy, real wages and national welfare will be increasingly dependent on services sector productivity. But driving productivity growth in (at least parts of) the services sector has, on average, been more difficult compared with the goods sector, which includes agriculture, manufacturing and mining.'

[7] Although not associated with neoliberalism, the theory of 'secular stagnation', which draws on broader ideas about cycles in technological innovation, suggests the decline is associated with a slow-down in the rate at which 'investable' innovations are being generated (Rawdanowicz, et al. 2014).

A key driver of this decline in productivity performance has been the continuous fall in the share of manufacturing industry in total GDP from around 30% in 1960 to 5% currently (Productivity Commission 2021: Figure 1). This reduces overall productivity growth given that the average rate of productivity growth is faster in manufacturing than for GDP as a whole. The reasons for manufacturing industry's historical disproportionate contribution to productivity growth have been widely investigated. [8]

Whilst some decline in the share of manufacturing industry in total national output is historically associated with rising income levels over time,[9] Australia is an absolute outlier among advanced nations as it 'has the smallest manufacturing sector relative to GDP, and the greatest net reliance on imported manufactures, of any OECD country' (Stanford 2020).

Neoliberal economic policies have encouraged this retreat of manufacturing. One key factor here is the international trade agreements entered into over the last 40 years.

> 'The specific objectives of Australian trade policy have been to obtain increased market access for agricultural and services exports. In practice...this has meant trading away tariffs and all other forms of support for manufacturing industry' (Ranald 2018: 312).

Development of Australia's mining industry has also been actively encouraged in the neoliberal era, in part, through large subsidies and public sector infrastructure support (Armistead et al 2022). For orthodox economic policy makers in Australia, primary industries (especially mining and agriculture) have a privileged place in development, as their growth is claimed to conform to the principle of 'comparative advantage'. The rapid growth of mining has directly and adversely affected manufacturing through prolonged periods of exchange rate appreciation caused by mining investment and commodity price booms. In summary:

> 'The strong resources sector raises the value of the Australian dollar and reduces the relative competitiveness of the manufacturing sector' (Productivity Commission 2023: 35).[10]

Regular cycles of currency appreciation associated with resource booms have also created a significant 'risk-premium' for investment in non-commodity tradables such

[8] Toner (2000) and Stanford (2020) provide a summary of the literature on this topic and Australian data.

[9] Since demand for services grows proportionately faster than incomes, they are relatively income elastic and will tend to increase as a share of GDP as economies progress.

[10] Modelling by the Reserve Bank of Australia (Tulip 2014) shows the large effect of mining and commodity price booms in reducing manufacturing output. These negative effects more than offset any growth in domestic manufactured inputs to mining.

as manufactures. The key point is that resource booms are cyclical but the structural changes they induce in manufacturing are permanent.

Neoliberal economic policy has caused a retreat from active industry policy which could have offset, to some extent, continued de-industrialisation. For example, following the large reduction in tariffs a series of successful development strategies for the steel, auto, heavy engineering, pharmaceuticals, electronics and shipbuilding industries were created in the 1980s. However, these so-called 'Button Plans' were abolished in the 1990s (Sheehan et al 2004). Indeed, the last forty years or so of public policy in Australia have been marked by continuing political and bureaucratic hostility to industry policy (Jones 2024). Representative of this hostility is one former head of the Productivity Commission, who acknowledged resource-boom-induced decline of manufacturing industry, politely referred to as 'structural adjustment', but argued this is to be celebrated as 'these economy-wide impacts unambiguously raise our national wealth' (Banks 2011: 2).

Finally, contrary to the stated objectives of neoliberal 'reform', there has been increased industry concentration or growth of oligopoly in Australia. Measures of industry concentration and 'market power' (ability to set prices above costs of production) have increased. Since 2000, a 'range of metrics point towards declining competitive pressures in Australia' (Treasury 2022: 19). Treasury (2022: 19) concludes that 'the decline in competitive pressure appears to have weighed on aggregate productivity growth'.

Increased income and wealth inequality

Neoliberal policies have also exacerbated income and wealth inequality:

> Income inequality in OECD countries is at its highest level for the past half century. The average income of the richest 10% of the population is about nine times that of the poorest 10% across the OECD, up from seven times 25 years ago (OECD 2023).
>
> 'In most countries, households at the lower half of the wealth distribution have little to no net wealth. Around 2018, across the OECD on average, the 40% of households with the lowest private net wealth held only 3% of total household wealth. In some countries, these households even owned negative net wealth, meaning that their debt exceeded the total value of their assets. Instead, wealth is highly concentrated at the top. Over half (52%) of the wealth "pie" was held by the wealthiest 10% of households' (OECD 2021: 2).

This matters since '[t]here is now strong evidence that inequality can significantly lower both the level and the durability of growth' (Ostry et al 2016).

Neoliberal policies have been identified as contributing to these perverse outcomes. These include:

- Financialisation and long periods of historically low interest rates, which dramatically boosted capital gains over labour income.
- Tax policies favouring capital gains over other income sources.
- Changes to wage bargaining systems and restrictions on unions that contributed both to a shift in the distribution of national incomes from labour to capital (profits) and widening the disparity between high and low pay.
- Bifurcation between 'good' well-paid secure jobs and 'bad' insecure, low-pay jobs that has accompanied major changes in industrial structure.
- Large reduction in the share of manufacturing, and large increase in low-wage services in total employment, which is argued to be a major factor in 'labour market polarisation' (OECD 2019b: 7).

One key driver of the decline of both manufacturing and economic equality has been the adoption of free trade policies:

> 'It has become clear that the increasing liberalisation of international trade does not have the widespread economic benefits formerly assumed, particularly for already open economies. Although greater trade may raise GDP, it frequently results in a highly uneven distribution of the benefits, with significant net economic costs being borne by particular industrial sectors and the geographic communities dependent on them' (OECD 2019: 14).

Not only is inequality undermining growth, but it is also a major cause of rising populism, declining trust in government and business and diminishing support for democracy.

Over the last five years international supply-chain disruptions caused by COVID and geopolitical conflict exposed sizeable gaps in nations' domestic manufacturing production in a broad range of commodities: pharmaceuticals, diagnostic and protective equipment, refined rare earths, and computer chips. Restrictions to global energy supplies following Russia's invasion of Ukraine in March 2022 have stimulated investment in domestic energy supply, especially renewables. In response many nations have responded by boosting 'sovereign capacity' or production capabilities in these key products.

Increased sovereign risk

Australia's unusual industrial and trade structure accentuates vulnerability to chain supply shocks. The nation's merchandise trade is overwhelmingly inter-industry, exporting mining and agricultural commodities and importing things we do not make, especially sophisticated manufactures. In contrast, the international merchandise trade of other high-income nations is overwhelmingly intra-industry – that is, making and selling similar items (OECD 2010). Intra-industry trade is based on international specialisation of finished goods and components within industries. A concrete example is autos: Germany exports Mercedes cars to France, which in turn exports Peugeots to Germany.

One measure of Australia's unusual industrial and trade structure and greatly diminished sovereign capacity is the high import penetration of manufactures measured as the share of imports in net turnover of manufacturing industries (Table 1).

Table 1
Manufacturing Industry Turnover and Import Shares
Australia, 2018-19

	Manufacturing Industry Turnover Minus imports $bn	Imports as % of Domestic Turnover
Food Products	78.1	16.2%
Primary Metal and Metal Products	44.3	21%
Fabricated Metal Products	22.1	33%
Non-Metallic Mineral Products	18.1	16%
Beverage and Tobacco	12.6	26%
Wood Products	11.9	17%
Printing	7.1	11%
Pulp, Paper	7.0	33%
Basic Chemical and Chemicals	5.9	82%
Polymer Product and Rubber Products	3.9	75%
Furniture and Other Manufacturing	-3.2	143%
Petroleum and Coal Products	-8.1	145%
Textile, Leather, Clothing and Footwear	-10.9	241%
Transport Equipment	-16.0	155%
Machinery and Equipment	-51.1	227%
Total Manufacturing	121.7	70%

Source: Imports data derived from ABS *International Trade in Goods and Services, Australia* Cat. No. 5368.0 Table 35a. Merchandise Imports, Industry (ANZSIC 2006), Customs Value. Manufacturing turnover data derived from *Australian Industry, 2018-19* Cat No. 5155.0

For manufacturing as a whole, imports are the equivalent of 70% of domestic supply. For 7 of the 15 industries listed in Table 1, imports are the equivalent of 75% or more of local supply. [11]

The key policy implication of Australia's depleted industrial structure for participation of local industry in meeting the enormous demand for manufactured inputs into decarbonising local power systems is summarised as follows:

> 'The painful legacy of decades of policy neglect for domestic manufacturing has left Australia's industrial base in poor shape to seize the opportunities being opened up by the global energy transition. Without strong support to quickly enhance domestic manufacturing production, skills, and technological capabilities, the main industrial outcome of the energy revolution for Australia may be simply replacing one set of unprocessed exports (coal, oil and gas) with another (raw lithium and related critical minerals). Most of the spinoff benefits of the renewable energy revolution for industry, technology, value-added and diversification will pass Australia by' (Joyce and Stanford 2023: 4).

Success of industry policy in developing nations

There is increasing recognition in government, business and academia that the obvious success of active industrial strategies, especially in North Asia, represents a legitimate counter-factual to neoliberal economic strategy of liberalising trade and retreat from active industry policy.

> '[Compared to] … increasing liberalisation of international trade…Actual experience in a variety of countries suggests that a non-liberalised, more government-directed approach to trade and industrial policy may have a much stronger impact on growth and its distribution' (OECD 2019: 14).

This follows from the indisputable success of activist industrial policies in post-war Japan and, since the 1970s China, South Korea, Vietnam and Singapore, which now dominate global supply of many key commodities and industries from low to high technology. Of particular relevance here is their leading position in renewable power generation, transmission and storage such as batteries, solar panels, wind turbines and 'green' products like EVs. As argued by the International Energy Association (2023b: 107):

> 'China's dominance in supply chains today is not a coincidence. Its clean energy technology industry has been over a decade in the making,

[11] As we will show later, concerns over global supply shortages and sovereign capacity also applies to some important renewables including wind towers.

driven by industrial policy focused on several key technologies' (IEA 2023b: 107).

Academic work[12] has collated and analysed the relatively simple but highly effective strategies used by these nations. Their success flows from an explicit repudiation of the orthodox case for trade liberalisation founded on the notion of 'comparative advantage'.[13]

In response to the obvious success of North Asian industrial development strategies, governments of advanced economies and their major corporations have sought to learn from and adapt these strategies to their own circumstances and needs. The most outstanding example is US Inflation Reduction Act (IRA). (Measures used in the US and elsewhere to promote industries producing inputs to renewable power generation, notably wind towers and equipment, are described in Chapter 3.)

Decarbonisation

Another factor driving the growth of industrial policy is recognition that existing neoliberal policy could not deliver the required pace of decarbonisation. Achieving net zero requires nothing less than a new industrial revolution to replace the fossil fuel energy production system and all other capital and consumption goods that rely directly or indirectly on fossil fuels.[14] To achieve this monumental rate of transformation, the OECD (2021: 132) has concluded 'it seems clear that governments will need to engage in much deeper forms of sectoral planning, social partnership and public consultation than most have practised in the recent past'.[15] Moreover, industrial and other policies will be required to ensure a 'just transition' or an 'equitable restructuring of carbon-intensive sectors' (OECD 2021: 131). This is especially the case for Australia given its unusual industrial structure for a developed nation – with the uniquely high penetration of fossil fuels in energy generation and extraction through mining and processing. Industry policies must ensure the costs and benefits of decarbonisation are fairly distributed. It is also essential that industry policies are paired with meaningful and reliable climate policies, to ensure that the phase-out of fossil fuels is genuine and steady – not token commitments without real back-up.

[12] Wade (1990); Toner and Butler (2009); Mazzucato and Rodrik (2023); Rodrik et al (2023).

[13] Chapter 5 of Green (2008) provides an accessible account of the principle of comparative advantage, its underlying assumptions and how these violate the real world of production and consumption.

[14] Massively increased renewable electrical generation capacity will be required for example to produce hydrogen as a substitute for fossil fuels in steelmaking ('green steel'), concrete (reducing limestone), and fertilizers (ammonia NH3), and as a heat source for industrial activities as diverse as food processing and pulp and paper.

[15] Joyce and Stanford (2023) provide a comprehensive analysis of the drivers of 'climate industrial policy' and the major international schemes enacted for its implementation.

Geopolitical tensions

A confluence of all these concerns which further legitimates industry policy is the rising geopolitical tension between the US (and 'the west' more broadly) and China (Rodrik 2023). Prolonged economic stagnation, low productivity growth, increased inequity in the distribution of the economic surplus and concerns over security of supply are putting the western economic and political model in direct competition with authoritarian, but also economically successful, regimes. Moreover, given the monumental scale of demand for renewable energy generation equipment any nation which controls this technology, and its supply, will absorb much of the world's income and receive an enormous boost to their strategic influence. Competition for global domination of renewable energy generation equipment and carbon neutral consumer goods has also seared into the minds of western governments that manufacturing industry is the locus of science and technology.

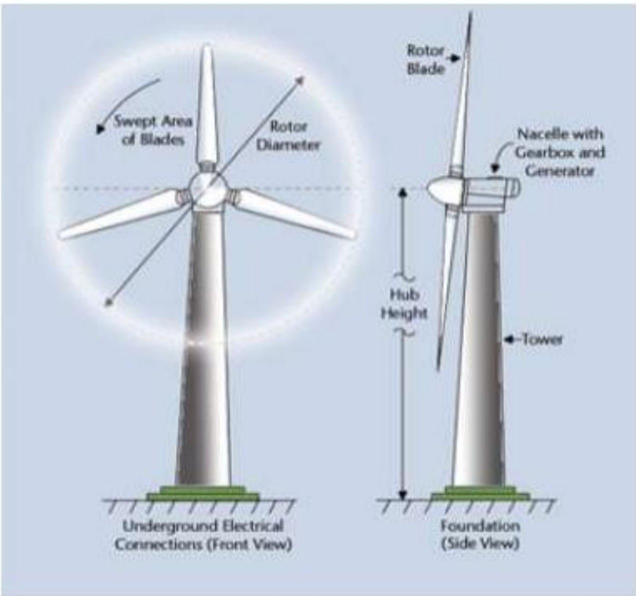
3. Global Wind Tower Demand and Supply

This chapter provides a concise overview of the factors driving global wind turbine demand, describes the global wind generation equipment making industry, and details the policy instruments employed by nations to foster their local industries and successfully enter the global wind turbine supply chain.

3.1 WHAT IS A WIND TOWER?

Most wind towers are made from tubular steel and support the other principal components of a wind turbine.[16] Wind turbines convert kinetic energy of air in motion into rotational energy via blades, which is then transferred by a shaft to a generator producing electrical energy. [17] The main elements of a wind turbine are shown in Figure 2.

Figure 2. Main Components of a Wind Tower



Source: Rehman et al 2013

[16] Towers can also be concrete, a hybrid of both concrete and steel or other materials including even wood. The main focus of this paper is on opportunities for manufacturing towers in Australia, but we also consider the potential for domestic sourcing of other turbine components.

[17] For a simple explanation of wind turbine operation and physics see Office of Renewable Energy and Energy Efficiency (n.d.).

Steel towers are fabricated in 3 to 6 sections and are assembled on-site. Because wind speed increases with height, taller towers enable turbines to capture more energy and generate more electricity. Winds at elevations of 30 meters or higher are also less turbulent.

Wind turbines operate on land ‘onshore,’ or ‘offshore’ with floating or fixed foundations. Offshore wind towers are in general much larger than onshore towers with correspondingly longer blades, as offshore towers are not subject to the same size restriction as onshore towers. Importantly the mass of a tower increases exponentially (not linearly) with height. For example, a 50 metre 1.2MW turbine requires a tower with 60 tonnes of steel, but a 150 metre 6KW tower requires 500 tonnes of steel (Keppel Prince 2023). This relationship between tower height and mass is very important for estimating the quantity of steel required for domestic manufacture and the scale of a wind tower factory.

A simplified description of the manufacturing process within a dedicated wind tower factory is provided below:

1. Plate steel 40-60mm is used for onshore towers and ≥ 80mm for offshore. This is cut into rectangles several metres long and wide.
2. High pressure rollers curve the plate into circular or conical shapes and edges are bevelled for internal and external welding.
3. These formed plates are welded horizontally and vertically and are known as ‘cans’. Several stacked cans form a 'section'. There are 3 to 6 sections in a tower. As towers increase in weight and height more sections are required since transport and logistical factors limit maximum section length to around 30 metres.
4. Circular flanges are welded to the ends of each section to enable bolting of sections together forming the wind tower. Flanges are also attached to the base and top of the tower to connect to the foundation and nacelle.
5. Internal components like stairs, cabling guides and lift apparatus are added.
6. Sections are sand blasted to remove rust and scale, and paint or other coating applied to extend life of the tower.
7. Testing of material inputs and welding is conducted to ensure conformity with engineering standards.
8. Sections are placed in storage and readied for transport to site.

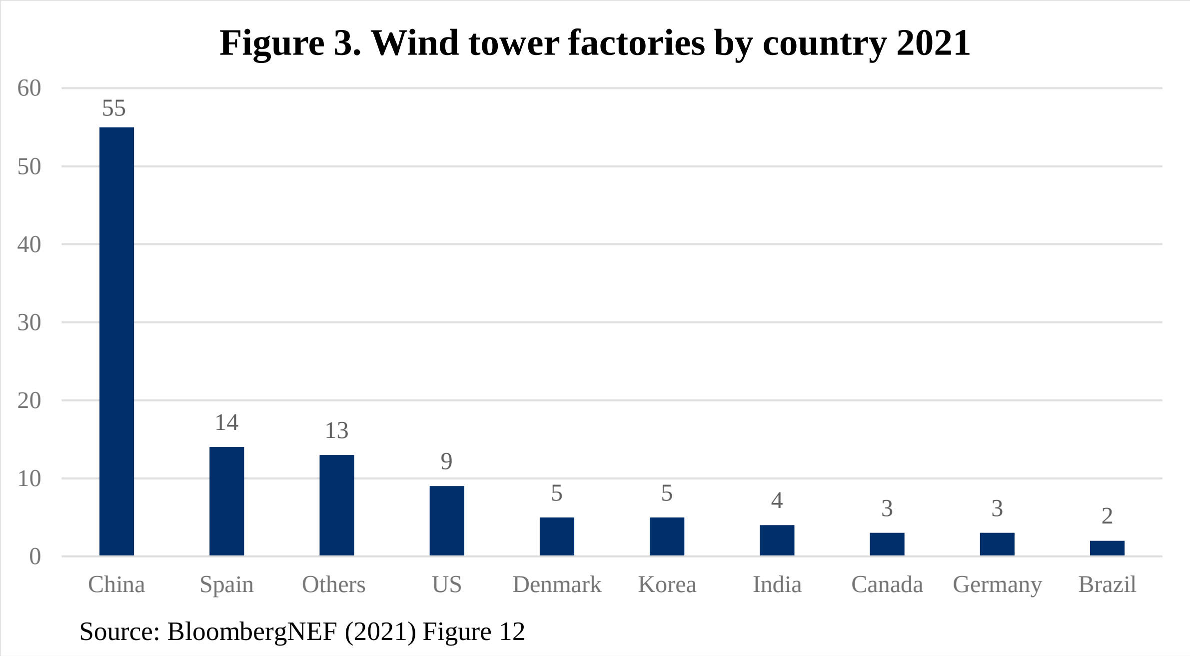
3.2 GLOBAL WIND TOWER PRODUCTION

Wind tower production is widely distributed across the globe, in developed and developing nations, with well over 110 factories spread over a minimum of 15 nations. The largest share of factories is in China (Figure 3).[18]

The fact that onshore and offshore wind tower manufacturing plants are widely distributed across nations reflects the engineering requirements and economics of tower production and markets. Wind towers are widely tradable commodities, based on a mature design and production technology, they are built to international engineering rules and have standardised characteristics. Each major OEM has specific design requirements, but these are, in the main, readily accommodated in modern tower plants. Reflecting their commodity status, many wind turbine manufacturers outsource production of towers and purchase them through tendering with established local and global tower producers.

Wind tower manufacture is a low-medium technology activity with low-medium barriers to entry due to mature production technology, standardised designs, and reliance on existing pools of skilled labour. There is a low level of product differentiation – such as an absence of unique intellectual property, which can create a competitive 'moat' around a particular wind tower company or plant. An important exception is that given the increased size and weight of towers over time, plants have also had to invest in scaling up production capacity. For some plants this may not be possible due to cost or lack of factory space to expand. More importantly, progressively larger towers create progressively higher logistical barriers for plants more remote from wind farms. 'Transportation challenges and low technical barriers to entry to have led to relatively quick build-outs of tower-making plants in markets where demand has spiked' (BloombergNEF 2021: 9).

[18] 'Other' includes the Czech Republic, Vietnam, Indonesia, Malaysia and Mexico. The number of nations and factories will have increased since this data was published in 2021 (BloombergNEF 2021).



Modern large wind tower plants are capital intensive, costing many tens of millions of dollars to establish. The cost is due to factors such as the large land area required to fabricate, assemble and store long tower sections, and the enormous weight of towers and production equipment (which necessitates especially thick reinforced factory floors and heavy, large-scale fabrication and materials handling equipment). Tower factory lay-out, which is essentially a tower production line, and product-specific production equipment, precludes production of products other than wind towers. There may be some scope for products such as monopole transmission towers, hydro-electric power penstocks and similar conical products.[19] Wind tower factories are also critically dependent on plentiful and low-cost supply of steel, as this is by far the largest single input into tower production. Efficient wind tower production is scale intensive, with world class plants producing towers using a high-volume production line model. This requires a high rate of throughput to generate the income and achieve the required rate of return on investor funds. (Chapter 4 considers in more detail the scale intensity of tower production in the context of the Australian market.)

This combination of low-medium technology, few barriers to entry, a commodity-based competitive market, capital intensity, product-specific production technology, critical dependence on affordable and ready steel supply, and scale-intensive production, makes investment in tower factories risky. In addition, demand for towers is critically dependent on continuity of government renewable energy targets, as these are the fundamental driver of investment in wind farms and thus wind turbine and

[19] This contrasts with a standard engineering jobbing shop which is intended by design to produce a variety of machined and fabricated products, often with design input from jobbing shop staff.

tower factories. Despite the risks, it is self-evident from the wide global distribution of tower plants these risks can be redressed. This chapter details the central role of government policy in redressing these risks and creating the historical competitive advantage of the leading tower producers, especially China, and more recent policies in the US and EU to promote renewable energy generation equipment manufacture (of which towers are an essential part).

3.3 GROWTH OF WIND POWER

Since the early 1990s there has been enormous growth in the cumulative rate of wind energy generation in total electricity generation. In many nations, including Australia, it accounts for over 10% of total global electricity supply, and in some nations much more.

Two key factors are driving the growth of wind-turbine generation. First, government stimulus through subsidies to lower electricity generation carbon emissions.

> 'Policy support remains the principal driver of wind deployment in the majority of the world. Various types of policy are driving capacity growth, including auctions, feed-in tariffs, contracts for difference and renewable energy portfolio standards.' (International Energy Agency 2023a)

Government stimulus also applies to solar generation, but increasingly policy makers are viewing wind and solar as complementary power sources with one offsetting the inherent deficiencies in energy production of the other. Energy storage such as batteries is also increasingly being added to these 'hybrid' power sources not just for improved energy continuity but also for grid stabilisation.

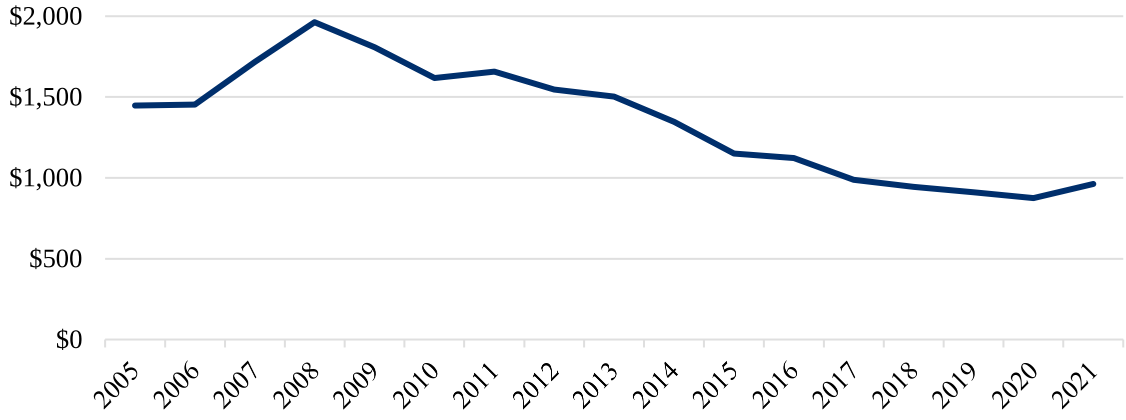
The second factor driving wind power growth is its comparatively low lifetime capital and operational costs. The typical operating lifetime of onshore and offshore wind turbines is 25 years (IEA 2023b: Figure 1.18). The standard measure for comparing the cost per unit input and output of electricity generation technologies is the levelised cost of electricity (LCOE). This measures 'the total unit costs a generator must recover to meet all its costs including a return on investment', excluding subsidies (Graham et al 2023: 50). LCOE is the cost of energy production from the perspective of an investor, as it encompasses capital costs, fuel, maintenance, expected utilisation rates and discount rates. According to the International Renewable Energy Agency:

> 'In 2010, the global weighted average LCOE of onshore wind was 95% higher than the lowest fossil fuel-fired cost; in 2022, the global weighted average LCOE of new onshore wind projects was 52% lower than the

cheapest fossil fuel-fired solutions. However, this improvement was surpassed by that of solar PV. This renewable power source was 710% more expensive than the cheapest fossil fuel-fired solution in 2010 but cost 29% less than the cheapest fossil fuel-fired solution in 2022'[20] (IRENA 2022).

Many factors enter into this phenomenal improvement in competitiveness of wind, including relative price movements of fossil fuels and increases in the efficiency of wind turbines – both in their operational design and cost of manufacture. These improvements in engineering design efficiency and incremental improvements in production efficiency are reflected in declining absolute real cost of wind turbines per unit output. For example, from 2005 to 2021 the real price of Vestas turbines, a leading global manufacturer, declined by 34% or a compound annual rate of -2.4% p.a. (Figure 4).

Figure 4. Vestas global average wind turbine price $/kW 2021 prices ($US)



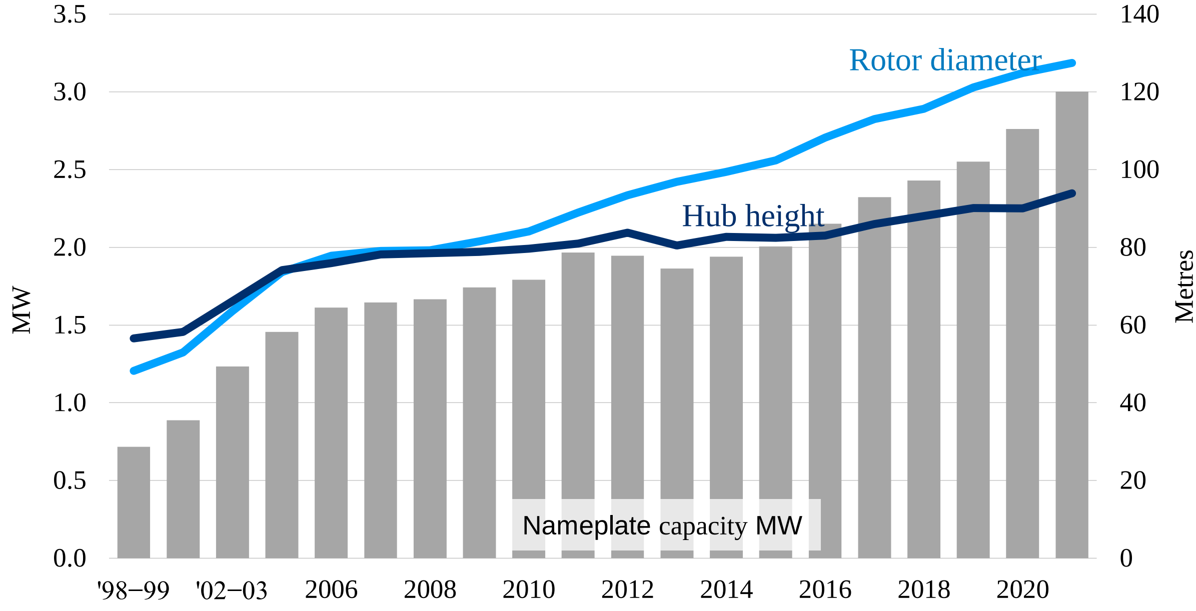
Source: US Department of Energy 2022

An important contributor to this drop in turbine cost per unit output is growth in tower height and rotor (blade) diameter (Figure 5). In simple terms power output of a turbine is a function of wind speed and swept area of the blades. Wind speed increases with height and, in theory, wind power (kinetic energy per unit time) increases by the cube

[20] This very large reduction in wind LCOE occurs despite the fact that wind turbine 'capacity factor', or proportion of operational life producing energy, is low compared to fossil fuel technologies like coal fired generators or even some renewables such as geothermal. 'On average wind farms in south-east Australia operate at a capacity factor of around 30-35%' (Aneroid Energy 2023). Wind turbines do not operate at very low or high wind speeds.

so that a doubling of wind speed increases wind power by a factor of eight (IRENA 2023).[21]

Figure 5. Average turbine nameplate capacity, hub height, and rotor diameter for land-based wind



Source: US Department of Energy 2022

3.4 GLOBAL WIND POWER MANUFACTURING SUPPLY CONSTRAINTS

Achieving the required carbon emission reduction under agreed international protocols to meet Net Zero Emissions (NZE) by 2050 and intermediate targets by 2030 will require a huge increase in the supply of renewable energy generation including wind.[22] Crucially, for this study, it also necessitates an equivalent parallel expansion of renewable generation equipment manufacturing and installation capacity (IEA 2023b: 211). The magnitude of the task is clear from the current high dependence of global energy demand on fossil fuels:

[21] The relation between wind speed and tower (hub) height is complex but increases at a decreasing rate with height. If there is 10 metres per second of wind at a height of 10 metres above the ground at a height of 100 metres the wind speed increases to 15 metres per second (Wind Profile Calculator https://wind-data.ch/tools/profile.php?h=10&v=10&z0=0.1&abfrage=Refresh. Default setting for roughness class and length).

[22] The IEA 2023b modelled the required growth of renewable energy and least-cost technologies required to achieve two different scenarios: NZE and a less ambitious Announced Pledges Scenario (APS).

> ‘Despite the rapid recent growth in clean energy technologies, the world still relies predominantly on fossil fuels for its energy supply. In fact, growth in clean energy supply since 2000 has been dwarfed by that of oil, gas and coal, especially in the emerging and developing economies...As a result, the overall share of fossil energy in the global energy mix has remained almost constant at about 80%’. (IEA 2023b: 38)

However, aligning known announced increases in wind turbine and wind tower manufacturing production capacity against the required increase in wind power generation to achieve NZE reveals a very large ‘capacity shortfall’ in future global manufacturing production (IEA 2023b: 212). The IEA (2023b: Figure 4.1) anticipates a shortfall of around 70% between current and announced increases in manufacturing production capacity by 2030 for onshore and offshore wind turbines.[23] All three major components of wind turbines (towers, nacelles and blades) are identified as being in shortage and by approximately the same proportion (IEA 2023b: Figure 1.10).

> ‘Realisation of announced projects would bring global wind manufacturing capacity to only about one-third of what is required in 2030 to meet demand envisaged in the NZE Scenario. A rapid increase in co-ordinated efforts from both government and private stakeholders is needed to accelerate wind power deployment and manufacturing capacity investments’ (IEA 2023a).

Whilst there is, of course, some uncertainty around this estimate given that new, as yet unannounced investments can occur, ‘our assessment provides an indication of which technologies are most likely to be subject to supply shortfalls’ (IEA 2023b: 2012). The capacity shortfall for wind turbines is the largest of 12 mass-produced technologies required for NZE aside from fuel cell stacks. This contrasts with other key technologies such as solar modules, cells and wafers which are in balance by 2030 and EV batteries and components which are in or close to balance of supply and demand by 2030 (IEA 2023b: Figure 4.1).

Compounding this gap between current, announced and required production capacity is that the ‘lead-time’ to build an onshore or offshore wind tower plant is 1.5-2.5 years. This lead time for towers is similar to the lead time for the other main components of a wind turbine, the nacelle and blades (IEA 2023b: 451).

[23] Even under the less stringent APS there is a 30-40% gap between required global wind turbine manufacturing output and planned capacity (IEA 2023b: Figure 6.6).

Moreover, any expansion in wind tower production capacity itself requires a simultaneous increase in global production capacity of the capital goods manufacturing sector – that is, plants that make the equipment used to make wind towers and other wind turbine components. These capital goods include laser cutting equipment; automatic and manual welding machines, and large industrial-scale steel rolling equipment and materials handling equipment to move steel plate and formed tower segments around the factory and for final installation on site. A large increase in global steel making capacity will also be required to provide the necessary inputs for towers and fixed and floating foundations. (The issue of the potential Australian steel making capacity shortfall is taken up is Chapter 5).

These projected shortages in wind tower supply-chains will occur in the context of an even larger simultaneous increase in production of all other renewable energy sources such as solar, hydrogen, and biomass, as well as more energy-efficient consumer goods such as heat pumps and EVs (IEA 2023b: Figure 1.6). The monumental scale of the energy transformation will severely test raw material, labour and industrial supply chains.

In sum, the key implication of these results is that 'the considerable gap between current expansion plans and that needed to be on track for the net zero trajectory means that a significant near-term boost in manufacturing investment is needed' (IEA 2023b: 223).

3.5 GLOBAL WIND TURBINE AND TOWER MANUFACTURING SUPPLY CHAIN RISKS

Compounding the shortfall in manufacturing capacity, the IEA (2023a) identifies a number of risks to future wind energy manufacturing supply. These risks are of direct relevance to Australia's plans for deployment of wind generation and to the case for increased domestic supply of turbines.

Geographic concentration

Manufacturing of all wind turbine components is heavily concentrated geographically. China accounts for well over half of all tower manufacturing capacity, with the remainder spread reasonably evenly between Europe, North America and the Asia Pacific (Table 2). China accounts for an even higher share of global nacelle and blade production.

Table 2 Global Manufacturing capacity for wind technology components, 2021						
	Tower (GW)		Nacelle (GW)		Blade (GW)	
	Onshore	Offshore	Onshore	Offshore	Onshore	Offshore
China	55%	53%	62%	73%	61%	83%
Europe	15%	41%	13%	26%	18%	12%
Nth America	11%	0%	10%	0%	10%	0%
Asia Pacific	12%	6%	8%	2%	6%	4%
Other	7%	0%	7%	-1%	5%	1%
Total	100%	100%	100%	100%	100%	100%
Source: IEA 21023b: 451						

Market concentration

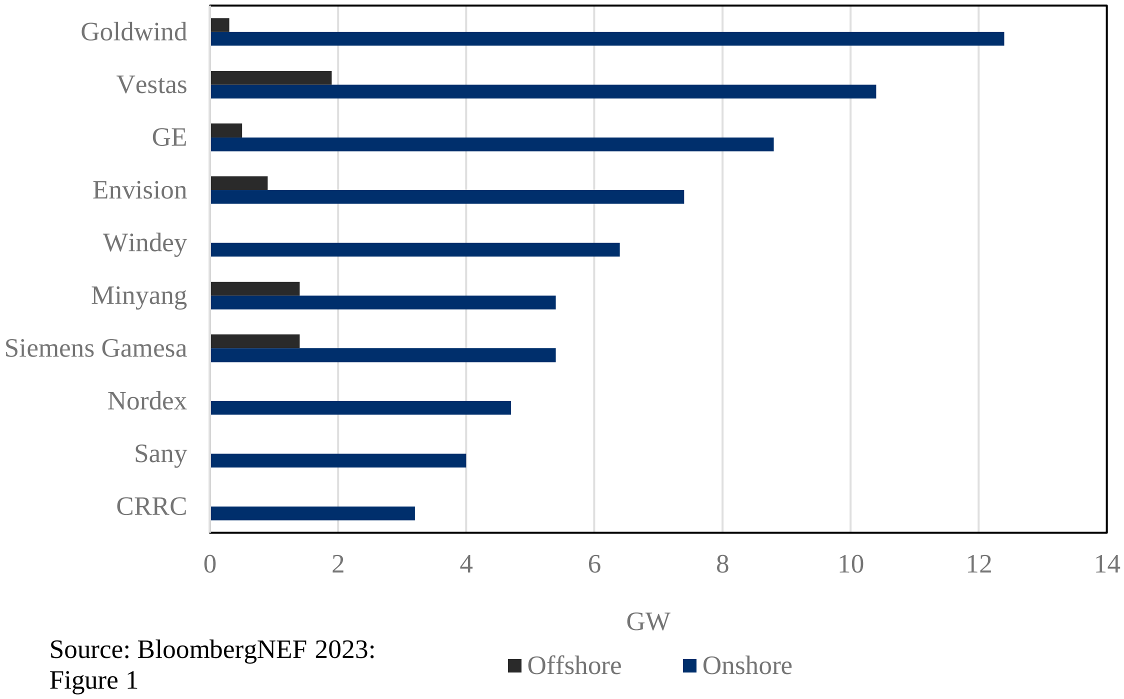
Global wind turbine production is highly concentrated within a limited number of firms (Figure 6) as the top 5 manufacturers account for over half (53%) of total GW of wind power commissioned in 2022; the top 10 firms supply 79% of total new capacity (derived from BloombergNEF 2023: Figure 1). 'If unchecked, a high degree of market concentration – overreliance on a small number of companies for the supply of a given good – can lead to supply chain fragility' (IEA 2023b: 399).

Six of the top ten manufacturers (Goldwind, Envision, Windey, Sany, CRRC, and Minyang) are Chinese headquartered, and several are either wholly owned state-owned enterprises (SOEs) or are publicly listed with a majority effective government ownership. For example, Goldwind is publicly listed with 40% of its shares owned by Chinese government entities, and CRRC is an SOE. In addition, most are industrial and financial conglomerates with wind energy generation either a minor or major part of an overall heavy industry and finance business. For example, Sany is the world's largest concrete machinery manufacturer, and CRRC is the world's largest rail rolling stock manufacturer. This conglomerate and often vertically integrated structure affords Chinese wind manufacturers considerable cost advantages in terms of scale economies and ability to cross-subsidise business units during temporary slowdowns.

The European Union has identified the power of vertical integration, conglomerate business structure and close relations with government as characterising Chinese wind equipment manufacture, and argues it confers an 'unfair' competitive advantage – an advantage the EU is committed to reducing through countervailing industrial policy interventions:

‘While competition stimulates innovation and product improvements, an unlevel playing field could negatively affect EU wind equipment manufacturers and could even reduce their competitiveness on the EU market. Chinese manufacturers have also benefited from vertically integrated business models with shorter supply chains owing to China’s dominance in steel production and raw materials, as well as possibly from highly attractive financial conditions. All this severely undermines EU companies’ ability to compete on a level playing field’ (European Union 2023: 4).

Figure 6. Top 10 Global Wind Turbine Makers 2022 GW Commissioned



Source: BloombergNEF 2023: Figure 1

The combination of market and geographic concentration contributes to rising geopolitical and supply chain risks.

Skill shortages

Globally, it has been estimated that by 2025 demand for skilled labour to manufacture and instal all renewable energy projects will exceed supply by more than 3:1. These shortages, especially for trades and engineers ‘are already limiting the pace and extent of new projects in several key regions, raising doubts about the speed of the transition in the near to medium term’ (IEA 2023b: 72).

3.6 GLOBAL RENEWABLE ENERGY GENERATION EQUIPMENT POLICY AND INSTRUMENTS

In response to growing opportunities and risks governments around the globe are employing industry policies to promote domestic manufacture of renewable energy generation equipment.

Box 1. 'There are big dividends for countries that get their clean energy industrial strategies right' (IEA 2023)

The energy world is in the early phase of a new industrial age – the age of clean energy technology manufacturing...Every country needs to identify how it can benefit from the opportunities of the new energy economy, defining its industrial strategy according to its strengths and weaknesses…Countries are trying to increase the resilience and diversity of clean energy supply chains while also competing for the huge economic opportunities. Major economies are acting to combine their climate, energy security and industrial policies…There are big dividends for countries that get their clean energy industrial strategies right (IEA 2023b: 20-21)

This section briefly describes some of the most common industry policy instruments identified by the IEA and other sources. Unsurprisingly, the list of successful policies employed in developed and developing nations for wind energy equipment production follows closely the long-established developmental strategies used by governments in promoting other manufacturing and related service industries (Wade 1991).

At the most general level effective industry policies work on both the demand-side ('pull' factors) and supply side ('push' factors). In renewable energy equipment manufacture, four important demand side measures can be catalogued:

- Mandating the scale and timing of renewable energy generation in total national energy supply.
- Mandating technology-specific targets such as the share of wind, solar and biomass in total renewable supply.
- Mandating local content requirements for the supply of wind towers.
- Providing financial incentives to private and public investors to achieve the required rates of investment.

These demand-side measures are critical to ensuring manufacturing investors' confidence that there will be a market for the products they make. Keynes' intuition that the level of current and expected demand is the dominant variable explaining the scale and rate of investment in capital equipment and training has been confirmed in multiple empirical studies.[24]

Complementary supply-side measures are also important in ensuring that an industry or technology targeted for growth has the inputs required for its expansion. The most obvious inputs for the wind tower sector are steel and skilled fabrication and engineering labour; ensuring long-term competitiveness through an expansion of public and private R&D and product and process innovation in wind towers is also important. [25] In some nations such as China, which had no local wind turbine manufacturing industry at the commencement of its 'big push' into renewables, attracting foreign investment was crucial to boosting both advanced manufacturing capacity and technology. (The Chinese model of development is examined later).

A wind tower manufacturing plant operating at globally efficient cost is capital intensive, requiring many tens of millions of dollars in investment, and therefore requires a high through-put to validate the investment. The level of demand should be sufficient to achieve globally efficient economies of scale and accelerate learning-by-doing. Like all manufacturing activities, production of renewable energy generation equipment is subject to quantifiable productivity increases which are directly related to increases in the time-rate of output (Hayward and Graham 2011). A summary of key industry policy measures to support wind tower manufacturing is provided in Table 3.

[24] Toner (1988) provides a succinct overview of the literature on equipment investment determinants and explanation of why expected demand is key. McCombie and Thirlwall (1994) provide a detailed description of the 'demand-side' economic growth model.

[25] Grubb et al (2021) undertook an exhaustive meta review of studies into government innovation policies related to renewable energy generation and low-carbon products and found that demand-side policies for innovation are highly effective at 'inducing' innovations and diffusing them across firms and industries. Further, gains accumulate as a novel product, process or service is incrementally improved upon through learning in production and by users. In sum, for demand-side innovation policies, 'The challenge is not whether to do it, but how to do it well' (Grubb et al 2021: 35).

Table 3 Global demand and supply-side industry policies for wind tower manufacturing	
Example of industry policy	**Description**
Demand-side	
Investigate barriers to local participation in wind tower supply chains	Domestic firms can face a number of barriers to entry and/or expansion supplying wind towers. These arise from multiple sources including inappropriate application of engineering standards by Original Equipment Manufacturers (OEMs); vertical integration of production by OEMs who supply all wind turbine components as a 'turnkey' contract; OEMs can also be wind farm developers preferencing their own supply; and unfamiliarity of wind farm developers with local production capability. The first step to lift local participation is a joint government and industry inquiry into the barriers and solutions to lifting local participation.
Market signaling	'Governments should prioritise efforts to stimulate private investment in clean energy technologies within the framework of domestic industrial policies by signalling activities, areas or regions of interest for technology supply chains. For example, development of strategic roadmaps for a given region or technology can incentivise investments in new… processing facilities and factories' (IEA 2023b: 405).
Local content requirements	Local content requirements (LCRs) mandate specific levels and types of domestic inputs for wind farm developers. Alternatively, developers can be encouraged to meet LCRs through generous incentives as in the US Inflation Reduction Act.
Production subsidies	A payment for each unit of output can be paid to the equipment producer. This can enable local producers to compete against subsidised imports and lowers any potential cost burden on purchasers while plants achieve efficiencies from scale economies and learning. The US Inflation Reduction Act makes extensive use of production subsidies for renewables, and also has provision to temporarily offset a cost differential between imported and locally made goods and services.
Export subsidies	Incentives to export take many forms and are designed to increase the scale of production and expose producers to international competition to stimulate improvements in efficiency and quality. Incentives include lower tax rates on income derived from exports, production subsidies for exports, and subsidized advertising.
Anti-dumping measures	Protect local manufacturers against predatory pricing on imports where wind towers are supplied at marginal variable cost or below, at scale and for an extended period of time.
Efficient windfarm approval and scheduling	Ensure a sufficient quantity of onshore and offshore windfarms are developed to justify investment in tower production. The scheduling of their approval and construction minimises potential supply bottlenecks.

Table 3 (cont'd) **Supply-side**	
Co-ordinating input supply	Ensure simultaneous expansion in production of key inputs, such as steel, required for expanded wind tower production. Simultaneous expansion is also essential for skills training. Co-ordinated expansion of production capacity and inputs that enter into this production lowers investment risk and avoids supply constraints or 'bottlenecks'.
Innovation support	Assist wind tower manufacturers to identify and access the most advanced global production and design technologies. This would include, for example, advances in metallurgy, materials science such as composites, metal forming and welding. Tax support for R&D and expanded public research is critical to the competitiveness of local industry.
Benchmarking studies	A complement to innovation support is international benchmarking of local wind tower manufacturing performance against world leaders in design, research and manufacture.
Subsidised loans, accelerated tax write-off on investment	Financial assistance for investment by manufacturers and wind farm developers lowers the 'hurdle' rate of return required by private investors and mitigates investment risk. 'Low-cost loans, insurance and loan guarantees can be effective instruments for projects that cannot attract adequate financing from commercial banks, which is often the case for clean energy technologies and their supply chains' (IEA 2023b: 405).
Testing and certification	Wind tower manufacture and the inputs that enter into their production are subject to strict engineering and performance standards. Efficient and low-cost testing and certification against these standards is important to the competitiveness of local supply, and ensures imports comply with or exceed local standards for materials and quality of production.

The IEA sums up the centrality of industrial policy to meeting both climate and industrial goals:

> 'The energy system transformation needed to achieve net zero emissions, involving a broad portfolio of technologies, will not happen at the necessary scale or speed without clearly formulated long-term government strategies, integrated into overall energy, climate and industrial policy and system planning, to guide and reduce the risks of investment decisions'. (IEA 2023b: 366)

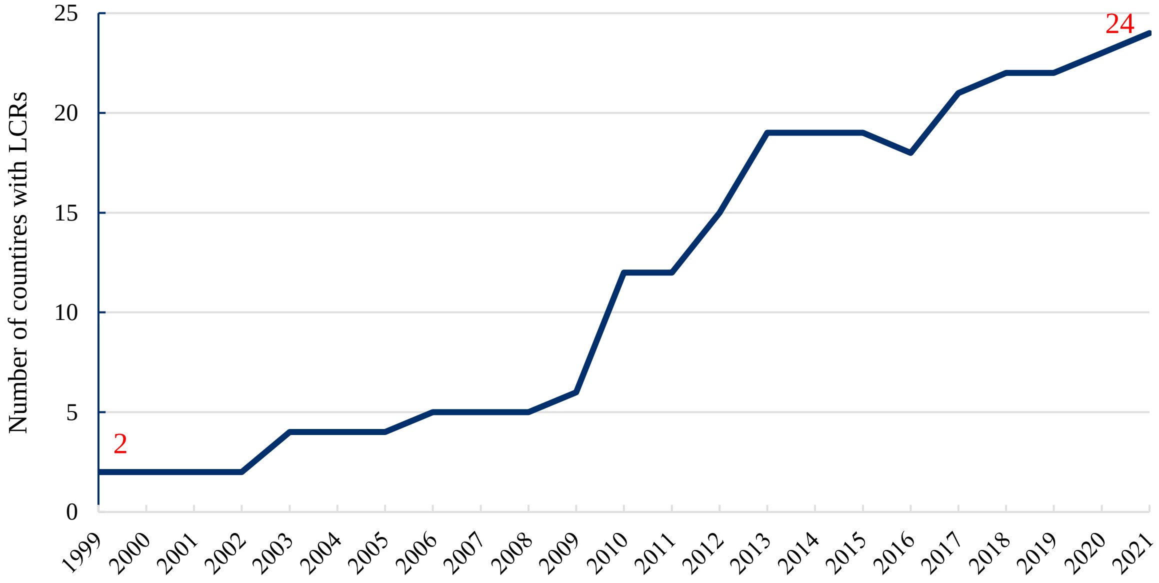
3.7 WIND GENERATION EQUIPMENT INDUSTRY POLICY: COUNTRY CASE STUDIES

The following briefly describes some industry policies applied to wind turbines and towers across several nations. Best-practice wind equipment manufacturing industry policy, such as that employed in China, employs a sequenced, integrated and self-reinforcing set of demand side and supply-side assistance measures to kick-start and accelerate development of indigenous wind turbine manufacture. There were three principal features of successful industry policy. First, assistance was directed at industry on the basis of objectively measured performance benchmarks – including requiring local products and production methods to attain equivalence with imported products in terms of technology, quality and productivity and/or export performance. Second, assistance was time limited: once benchmarks were met, assistance was reduced or withdrawn. Third, policies were adaptive, changing over time to meet evolving industry benchmarks, competitive pressures and government objectives.

Central to initiating and maintaining wind equipment manufacture has been the imposition of local content requirements (LCRs). Also known as 'localisation', LCRs are 'policies imposed by governments that require firms to use domestically manufactured goods or domestically supplied services in order to operate in an economy' (OECD nd). LCRs are widely imposed around the globe, though each nation adapts provisions to its own industrial capabilities and ambitions.

The US free-trade think tank, the Peterson Institute (2021), identified and detailed local content requirements for wind and solar equipment manufacture in 24 nations (Figure 7). These include seven OECD countries: Canada, France, Greece, Italy, Spain, Turkey, and the United States. Non-OECD countries with LCRs include Argentina, Brazil, China, Croatia, India, Indonesia, Jordan, Malaysia, Morocco, Russia, Saudi Arabia, South Africa, Ukraine, and Uruguay. This list is not complete; the Taiwan based firm InfoLink Consulting (2023) recently identified Japan, South Korea and Taiwan as also imposing LCRs for wind manufacturing, and provided a detailed comparison of their policies with those in the United States.

Figure 7. Number of countries with Local Content Requirements in wind and solar industries. 1999-2021



Source: Peterson Institute 2021: Figure 1b

China

> 'China's dominance in supply chains today is not a coincidence. Its clean energy technology industry has been over a decade in the making, driven by industrial policy focused on several key technologies'. (IEA 2023b: 107)

Comprehensive accounts of Chinese wind turbine manufacturing industry policy and its evolution are provided in Ecobusiness (2023), Li et al (2023), and Urban and Nordensvard (2013). Development occurred in three broad stages. First, the "Ride the Wind" programme started in 1997 and continued to around 2009. It focussed on boosting the 'quantity' of output by heavily subsidised wind farm development; imposed mandatory joint ventures on advanced overseas producers, and set LCRs at progressively higher rates as local capacity and technology grew. LCRs started at 20% in 1997; lifted to 50% in 2003 and peaked at 70% in 2004. With the second stage from 2009 to 2015, the focus shifted to quality and product and production process innovation. LCRs were officially terminated in 2009 'after many foreign players left the market due to the high LCR and more competitive local suppliers' (Ecobusiness: 2023). In 2008, an R&D Special Fund was established to enhance innovative technology and lift quality for the export market. During the second phase the government introduced but did not enforce product standards for wind towers and turbines. The third stage from 2015 and continuing to the present, saw producer consolidation and quality standards legislated and enforced with testing and certification systems established.[26]

An example of Chinese wind equipment policy applied to a major foreign global producer is in provided in Box 2.

Box 2 'To Conquer Wind Power, China Writes the Rules' (NY Times, 2010)

'Gamesa has learned the hard way, as other foreign manufacturers have, that competing for China's lucrative business means playing by strict house rules that are often stacked in Beijing's favor.

Nearly all the components that Gamesa assembles into million-dollar turbines [in China], for example, are made by local supplier companies Gamesa trained to meet onerous local content requirements. And these same suppliers undermine Gamesa by selling parts to its Chinese competitors wind turbine makers that barely existed in 2005, when Gamesa controlled more than a third of the Chinese market.

But in the five years since, the upstarts have grabbed more than 85 percent of the wind turbine market, aided by low-interest loans and cheap land from the government, as well as preferential contracts from the state-owned power companies that are the main buyers of the equipment.

The story of Gamesa in China follows an industrial arc traced in other businesses, like desktop computers and solar panels. Chinese companies acquire the latest Western technology by various means and then take advantage of government policies to become the world's dominant, low-cost suppliers.

On July 4, 2005, China's top economic policy agency, the National Development and Reform Commission, declared that wind farms had to buy equipment in which at least 70 percent of the value was domestically manufactured.

But the Chinese government bet correctly that Gamesa, as well as G.E. and other multinationals, would not dare risk losing a piece of China's booming wind farm business by complaining to trade officials in their home countries.

Rather than fight, Gamesa and the other leading multinational wind turbine makers all opted to open factories in China and train local suppliers to meet the 70 percent threshold.' Bradsher (2010)

These policies were so successful that, as noted earlier, China now accounts for the largest share of global wind tower production capacity, and Chinese manufacturers account for more than 95% of turbine capacity deployed domestically (IEA 2023b: 399).

[26] Yuan et al (2015) provides an excellent description of the problems created by the first and second growth stages, especially the low quality and minimal innovation due to an absence of engineering standards and policy priority given to reducing costs by expanding the scale of production.

United States

The US Inflation Reduction Act (2022) provides very large incentives to wind farm developers and strongly encourages use of locally made wind energy equipment. Incentives to renewable project developers are remarkably generous and 'stackable' or additive. Subsidies for the cost of wind farm inputs include:

- 10% for meeting certain domestic content thresholds.
- 100% of applicable iron and steel components if domestically manufactured.
- 40% of costs for manufactured products and components for land-based wind if domestically manufactured.
- 20% of costs for manufactured products and components for offshore wind if domestically manufactured.
- 10% for locating facilities in fossil-fuel-powered communities or brownfield sites (US Department of Energy 2023).

European Union

In September 2023 the European Union announced a European Wind Power Action Plan declaring wind manufacturing a 'strategic sector' and a number of measures to operate on the demand and supply side including but not limited to:

- Indexing auction prices and tariffs for onshore and offshore wind farms to inflation. (Inadequate indexation exposes windfarm developers to wind equipment and installation cost inflation risk. Given the lengthy time gap between winning an auction to develop a farm and installing the equipment).
- Finance for investments in new wind factories, infrastructure and the wind energy workforce. It proposes to double the money available for wind manufacturing under the next call of the EU Innovation Fund to €1.4bn.
- The European Investment Bank (EIB) will also 'provide de-risking tools and counter-guarantees by the end of 2023 to cover the exposure of private banks when they lend money to the wind industry'. The EIB has also changed its lending policy to finance wind power manufacturing in addition to financing wind farms.
- EU member states will have to outline 10-year plans for wind energy deployment, including a 2040 outlook.
- 'The Commission will also make full use of the trade instruments at its disposal to ensure a level-playing with non-European competitors'. (European Union 2023)

3.8 ANTI-DUMPING MEASURES

International trade law has long permitted governments to impose countervailing penalties on firms in other nations which 'dump' exported products in their markets. The main requirements to prove dumping are: first, the dumping persists for a 'substantial' period of time; second, the exports are priced in the receiving market below the 'normal cost of production'; and third, it can be shown the imports cause 'injury to domestic industry' competing against these dumped commodities in the importing nation (World Trade Organisation, nd).[27] 'Below the normal cost of production' means selling at a price which does not recover fixed and variable costs of production, plus other standard transport, administrative and selling costs.

Countervailing or anti-dumping measures typically include a tax or duty imposed on imports set to be equivalent to the 'margin of dumping' or weighted average difference in price between the dumped and normal prices over the period of time the dumping or injury to local firms occurred. (This duty on imports is known as the 'dumping rate'.)

It is important to note that proved cases of dumping are strong evidence for the wide gap between the simple textbook model of international trade, which has informed public policy in Australia for half a century, and the political-economic reality of international production and exchange. Dumping can arise from temporary over-production in the exporting nation, but more importantly occurs when a firm seeks to gain a long-term strategic advantage in an overseas market for its products, by supplying them at a price and for a period of time which will economically injure a domestic competitor. Having reduced the degree of competition in the export market, the dumping firm can then lift prices and impose other conditions on customers. The most common ground for anti-dumping cases is retaliation to overseas governments subsidising their firm's exports.

Anti-dumping cases involving international trade in wind towers are common. Moreover, publicly available reports by state agencies responsible for administering anti-dumping laws furnish important insights into the scale of anti-competitive pricing and level of assistance provided by governments to their exporting wind tower manufactures. For example, in 2021 the European Commission found steel wind towers were being dumped in the EU by Chinese firms and imposed anti-dumping duties to offset the difference between the dumped and 'normal' price, ranging from 7.2% to 19.2%. The investigation revealed that Chinese towers valued at around €300

[27] The scope for injury is large and encompasses 'actual and potential decline in sales, profits, output, market share, productivity, return on investments, or utilization of capacity… cash flow, inventories, employment, wages, growth, ability to raise capital or investments' (World Trade Organisation, nd).

million were being imported at dumped prices into a market where annual domestic production was €1 billion (European Commission, 2021). The rationale for imposing the anti-dumping measure was:

> ‘These measures serve to protect and defend EU producers and workers from trade distortive practices that harm EU manufacturing.
>
> The investigation has confirmed that imports of steel wind towers from China at an annual value of €300 million were taking place at dumped prices, causing economic damage to EU producers. Steel wind towers are an important component of wind turbines, which are essential for wind energy production and for the transition to green energy. These anti-dumping measures will also help protect the steel value chain and over 3600 direct jobs in the EU.
>
> The imposition of anti-dumping duties will ensure fair competitive conditions for sales of steel wind towers in the EU market’. (European Commission, 2021)

The US has been particularly prolific in the application of anti-dumping action against wind tower imports (Table 4). The data is not exhaustive but is useful in indicating the range of nations and firms and the scale of price discrimination caused by dumping as reflected in the countervailing dumping rate imposed on imports.

Table 4
Finalised Anti-Dumping Cases Against Wind Tower Imports to the US

Date	Nation	Number of firms covered by the anti-dumping determination	Dumping rate
June 2020	Canada	1	4.9%
	Indonesia	1	8.5%
	South Korea	1	5.4%
	Vietnam[28]	1	65.9%
June 2021	Spain	6	73%
October 2021	India	6	54%
	Malaysia	1	3.2%

Source: US International Trade Administration (2020; 2021a, b).

[28] Vietnam recently investigated imposing huge anti-dumping duties against China, in the order of 94% (Reuters 2023).

4. Australian Wind Tower Demand and Supply

This chapter describes current and future demand for onshore and offshore wind generation, and by implication the demand for wind towers. It compares this likely future demand to current supply of wind towers and local production capacity.

4.1 SCALE OF CURRENT AND FUTURE DEMAND IN AUSTRALIA FOR ONSHORE AND OFFSHORE WIND TOWERS

The demand for wind towers is derived from demand for wind turbines. In turn, the demand for wind turbines is a function of the rate of growth of renewable energy share in total electricity generation, and within that the share of wind in total renewable supply. The following data offers three perspectives on the relative contribution of current wind energy to Australian energy supply which, in turn, provides a base for examining growth prospects for wind tower manufacturing. The first examines the wind contribution to electricity supply; the second, to total domestic energy supply; and the third, to total domestic energy supply plus energy exports.

Table 5 shows the composition of energy sources for electricity generation in Australia divided into non-renewable and renewable sources, and the change in these sources between 2015 and 2022.

Total non-renewable generation measured in GWh declined at an annual compound rate of 2.3% over this period. Coal constitutes over half of the non-renewable energy source for electricity generation. By contrast renewable generation increased at an annual compound rate of 13.7% in an overall context where total electricity generation rose by just 1.1% per year over the period.[29] Because the rate of growth of wind generation at 14.1% closely matched the overall rate of renewable energy generation, the share of wind in total renewable energy generation remained relatively constant at

[29] This low rate of electricity generation growth reflects a long-term decline in energy intensity of GDP, or quantity of energy per unit GDP, due to improved energy efficiency and the decline of energy intensive industries such as manufacturing (and rise of less energy intensive activities like services). This trend will reverse as electricity, and especially renewably generated electricity, becomes the dominant source of energy under decarbonisation strategies.

around one-third. Solar generation, in particular large scale (or 'utility scale') PV generation, experienced rapid growth of close to 75% each year between 2015 and 2022. This rapid growth rate reflects the low base at the start of the period (with minimal utility PV in 2015), as well as the rapid decline in PV costs. Utility and residential PV combined now account for 43% of total renewable electricity generation. (Evaluating the likely future demand for wind towers requires an assessment of the relative growth of onshore and offshore wind turbines, as none of the latter are yet installed in Australia, and the relative growth of wind alternatives, especially PV. Section 4.3 provides a brief discussion of these matters.)

Table 5
Electricity Generation in Australia, 2015-2022 (GWh)

Non-renewable fuels	2015 Share of non-renewable generation	2022 Share of non-renewable generation	Annual Compound Growth (GWh) 2015-2022
Black coal	51.2%	52.7%	-1.9%
Brown coal	23.2%	17.0%	-6.6%
Natural gas	22.8%	27.8%	0.5%
Oil products	2.8%	2.5%	-4.1%
Total non-renewable	*100%*	*100%*	*-2.3%*
Renewable fuels	2015 Share of renewable generation	2022 Share of renewable generation	Annual Compound Growth (GWh) 2015-2022
Bioenergy	10.2%	3.5%	-2.4%
Wind	32.9%	33.8%	14.1%
Hydro	39.6%	19.7%	2.9%
Large-scale solar PV	0.8%	15.9%	74.6%
Small-scale solar PV	16.5%	27.1%	22.1%
Geothermal	0.001%	0.0%	
Total renewable	*100.0%*	*100.0%*	*13.7%*
Total generation all sources			1.1%

Source: Derived from Department of Climate Change, Energy, the Environment and Water (2023) *Australian Energy Statistics 2023*: Table 01.2

Table 6 shows the latest data on the contribution of energy sources to total electricity generation in Australia. As of 2022, fossil fuels still supplied over two-thirds (67.7%) of energy for electricity generation, with wind contributing 10.9% and all forms of PV 13.8%.

Table 6 Electricity Generation in Australia by Energy Source, 2022	
Non-renewable fuels	**Percent of Total**
Black coal	35.7%
Brown coal	11.5%
Natural gas	18.8%
Oil products	1.7%
Total non-renewable	*67.7%*
Renewable fuels	**Percent of Total**
Bioenergy	1.1%
Wind	10.9%
Hydro	6.4%
Large-scale solar PV	5.1%
Small-scale solar PV	8.7%
Geothermal	0.0%
Total renewable	*32.3%*
Total Generation	100%
Source: Derived from Department of Climate Change, Energy, the Environment and Water (2023) *Australian Energy Statistics 2023*: Table 01.2	

Demand for new wind energy has been very strong, growing at 14.1% per year over the last 7 years. Moreover, there is considerable scope for an expansion in the rate of growth of wind energy in total Australian electricity supply, implying even faster growth of turbine installation. Later we will examine official projections of potential growth rates under various scenarios.

But electricity generation comprises only one use of total energy supply in Australia; indeed, energy used in all forms of electricity generation comprised only 23% of total energy supply for domestic production and consumption (derived from Department of Climate Change, Energy, the Environment and Water 2023: Table A). This is formally known as 'primary energy supply'. Aside from electricity generation, other uses of energy include transport; mining and agriculture (internal combustion engines using petrol and diesel); manufacturing (coal for steel, LNG for cement making and food processing); and residential (heating). Across all these uses, renewables contribute just 8.9% of total energy supply used for domestic purposes; within that, wind contributes just 1.8% (Table 7).

Viewed from the perspective of the total domestic energy supply system, substituting renewables for current fossil fuel use (which account for over 90% of total energy supply) implies a truly phenomenal scope for increasing renewable generation, including wind.

Table 7 Australian total primary energy supply (PJ) X source 2021-2022			
	Fuel Source	Petajoules	% of total supply
Fossil fuels	Coal	1586.8	27.5%
	LNG	1559.3	27.1%
	Oil, LPG, Refined products	2103.4	36.5%
	Total Fossil Fuels	*5249.5*	*91.1%*
Renewables	Biofuels, wood, biomass	200.3	3.5%
	Wind	104.8	1.8%
	Solar	124.9	2.2%
	Hydro	61.2	1.1%
	Solar hot water	21.3	0.40%
	Total renewables	*512.5*	*8.9%*
	Total primary energy supply	5762.1	100%
Source: Derived from Department of Climate Change, Energy, the Environment and Water (2023) *Australian Energy Statistics 2023*: Table A2 Australian energy supply and consumption, 2021-22, energy units. Total primary energy supply is a measure of the total energy supplied within the economy. It is equal to indigenous production plus imports minus exports, plus stock changes and statistical discrepancies.			

Finally, total primary energy supply, by definition, excludes exports but includes imports. Australia is a net energy exporter, with this energy trade surplus generated overwhelmingly by coal and LNG. Both of these sources must be substituted by renewable energy if Australia is to fully decarbonise its economy. The idea that Australia could maintain and even increase its exports of energy, but sourced from renewable sources, underpins the vision of Australia becoming a ‘renewable energy superpower’.

In 2021-22 Australia exported 15,623.2 (PJ) of fossil fuels, which is 2.7 times larger than primary energy supply for domestic purposes of 5762.1 PJ (Table 8). Total

Australian energy supply in 2021-22 is thus 21,385.3 PJ. Renewable energy supply was just 512.5 PJ or 2.4% of total supply, and wind was only 0.5% of total supply.

Table 8 Total Australian energy supply 2021-22	
	PJ
Primary indigenous supply (a)	19,111.2
plus all imports (b)	2,129.0
less all exports (c)	15,623.2
less stock changes (d)	-199.2
less discrepancies (e)	54.1
Total primary energy supply (a+b+d+e)-c	***5,762.1***
Total Australian energy supply (a+b+d+e)	**21,385.3**
Source: Derived from Department of Climate Change, Energy, the Environment and Water (2023) *Australian Energy Statistics 2023*: Table A2 Australian energy supply and consumption, 2021-22, energy units.	

The key implication of this analysis is that even a relatively modest increase in the share of wind energy in total Australian energy supply would require a gargantuan increase in wind turbine installations and by implication the number and production of wind towers.

Having briefly described the current supply of wind energy in the electricity and total energy system, we now turn to examine long-term projections of the growth of wind generation and its implications for tower demand and production.

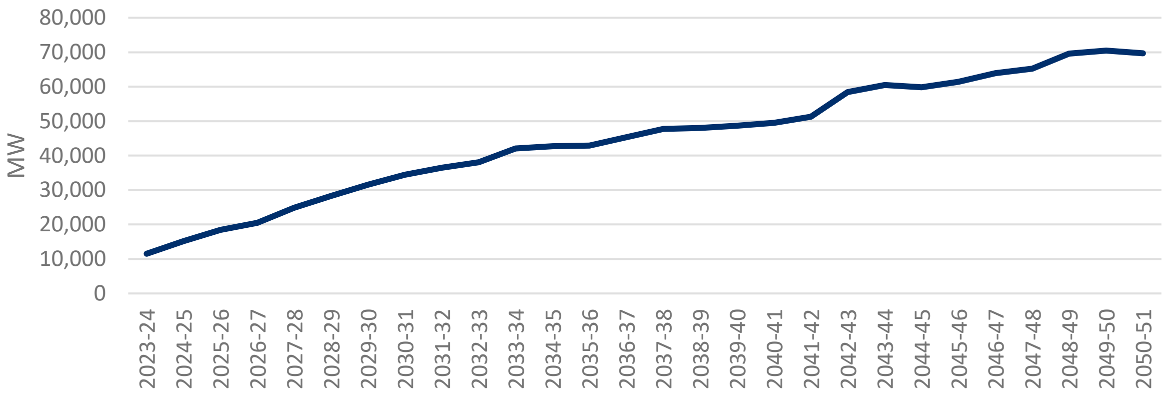
Projections of future demand for wind energy and towers

The Australian Energy Market Operator (AEMO) publishes projections of total electricity demand and supply using a number of scenarios. Each scenario assumes differing rates of change in electrification of existing energy use, and differing trends in capacity of various generation technologies to meet supply. These projections are thus critically dependent on the validity of their assumptions, such as changes in the relative price of various renewable generators, the degree of 'social license' granted to energy developments, and potential new alternative technologies.

AEMO identifies wind and solar as critical clean energy generation technologies, but both must be complemented with various forms of storage. Storage is critical given that 'on average wind farms in south-east Australia operate at a capacity factor of around 30-35%' (Aneroid Energy 2022), due to the wind being too slow or fast for efficient or safe operation. Aside from storage, a wide spread of wind farms is needed as wind energy is quite variable across geographic expanses -- requiring installation of many turbines in different locations to 'smooth' the flow of wind-generated electricity.

AEMO identifies several different scenarios of future renewable electricity supply, with the central case being its 'Step Change' scenario.[30] Under the Step Change scenario, additional wind capacity is required to rise from 11,525MW in 2023-24 to 34,415MW by 2030-31 – an increase of 22,890MW (Figure 8). By 2040-41 additional capacity of 37,944MW is required: an incremental increase of 329%.

Figure 8. AEMO Step Change Scenario wind generation capacity (MW) NEM 2023-24 to 2050-51



Source: AEMO 2022(b) ISP Results workbook. CDP 2 Step Change least-cost

This growth in wind generation capacity has major implications for wind tower demand. The following estimates assume an average 4MW capacity per onshore tower.[31] Between 2023-24 and 2030-31, an additional 5723 towers are required to meet this growth in wind generation capacity, an increase of 199% over the estimated existing stock of towers in 2023-24 (Table 9). This equates to an additional 818 towers per year. By 2049-50 an additional 14737 onshore towers will be required above the stock in 2023-24.[32] (Appendix 1 presents the data from which these estimates are derived.)

It took nearly 40 years, since installation of the first onshore wind tower in Australia in 1987, for the stock of towers to reach close to 3000, but in 6 years from 2023-24

[30] It is important to note AEMO has to date excluded offshore wind from its analysis, due to the degree of uncertainty regarding its deployment, but due to more definite planning in NSW and Victoria especially, it is proposing to incorporate offshore generation in future studies.

[31] The International Renewable Energy Agency (2023) states that current onshore turbines have average capacity of 3-4 MW each.

[32] To this demand must be added tower depreciation as the economic life of a tower is on average 26 years (AEMO 2023:114), implying an increasing absolute number of towers be replaced each year.

nearly 6000 additional towers will have to be installed to achieve the Step Change target.

It is also important to note that the most demanding AEMO scenario, the so-called 'Green Energy Exports' model, envisages a much larger increase in onshore wind generation which is required to substitute 'green energy' for current fossil fuel exports. The Green Energy Exports scenario requires 75% more energy by 2040 than the Step Change model (AEMO 2023: Table 1).

There are at present no offshore wind turbines operating in Australia, but the technology is mature and widely implemented overseas. Plans to implement offshore wind are well advanced and it is anticipated installation will occur in a number of states, especially NSW and Victoria. The following provides indicative data on the scale of demand from offshore generation.

Offshore developer Oceanex (2023) is proposing a 2000MW (2GW) windfarm off Newcastle with 15MW turbines and requiring 130 towers. In total Oceanex is proposing 8000MW across 4 locations in Australia. Assuming a similar configuration across all sites, this equates to 520 towers. Oceanex is proposing that installation of the Newcastle farm be finalised by 2031. In addition, the Victorian government is proposing 9GW (9000MW) of offshore wind power by 2040, with the first 2GW operating by 2032.[33] Assuming a similar configuration to the Newcastle site, this implies around 600 offshore turbines in Vicotria. Combined this leads to 1120 offshore turbines installed by 2040-41.

In sum, based on the available data from AEMO and Oceanex it is estimated that by 2040-41 a total of 10,606 additional onshore and offshore towers will be needed to effect the required rate of decarbonisation of the energy system equivalent. This implies an average of 624 new towers per year.[34] Combining onshore and offshore demand, an additional 15837 towers will need to be fabricated by 2049-50 (Table 9). This assumes onshore and offshore generation are not substitutes.

[33] According to the Victorian Offshore Wind Policy Directions Paper and Implementation Strategy Statements One and Two (AEMO 2023: Table 2).

[34] Welding Technology Institute of Australia (2022b: 3) estimates that from 2022 an additional 12,545 towers will be required by 2050 compared to 15800 based on the assumptions above. The variance would be attributable to differences in the assumed average tower generation capacity.

Table 9
Demand for new onshore and offshore towers

	Onshore towers*			
	Base year (stock)*	Cumulative net additional towers required from base year[35]		
Year	**2023-24**	**2030-31**	**2040-41**	**2049-50**
Number of onshore towers	2881	5723	9486	14737
Average annual onshore increase		818	558	567
		Offshore towers**		
Offshore towers			1120	
		Total towers		
Total towers			10606	15857

Source: Data on wind generation capacity from AEMO (2022b) ISP Results Workbook Step Change (least cost DP (Candidate Development Path 2) https://aemo.com.au/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp/2022-isp-inputs-assumptions-and-scenarios *
*The current stock and future onshore wind generation output and assumes 4MW per turbine.
**Assumes 15MW per tower. Data on offshore generation (GW) derived from Oceanex (2023) and AEMO (2023: Table 2).

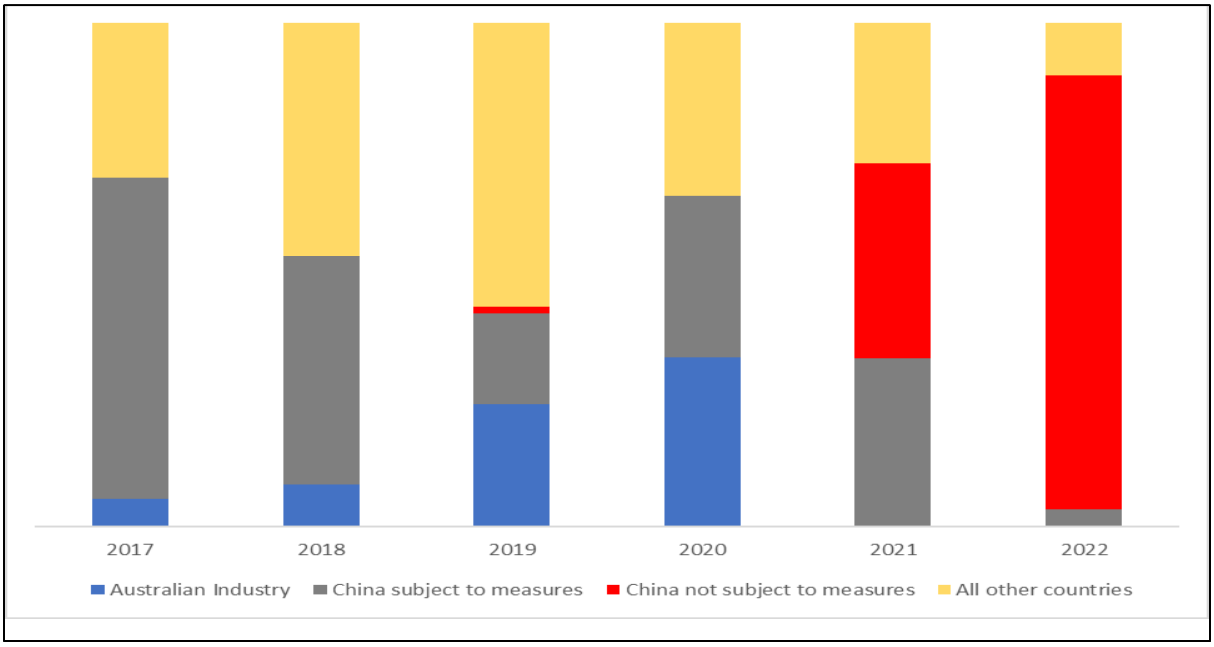
It is important to note offshore towers are much taller and thicker than onshore towers and also require large fixed or floating foundations. As a result, Australian fabrication of offshore towers will require not only a disproportionate increase in demand for steel compared to onshore towers, but also a number of dedicated offshore turbine manufacturing facilities separate to onshore fabrication facilities. These issues are taken up subsequently.

[35] Variation in the rate of annual installations reflects changes in wind MW capacity modelled by AEMO. This is due for example to renewable output adjusting to assumed future closure of major fossil fuel generators; growth of storage capacity and alternative renewable generation sources; and a faster tower build rate early in the forecast to achieve emissions targets.

4.2 CURRENT SUPPLY OF WIND TOWERS, LOCAL PRODUCTION CAPACITY AND GREENFIELD COST OF WORLD SCALE PLANT

Australia has a long history of wind turbine production. For example, the WA firm Westwind manufactured the very first utility scale turbine installed in Australia in 1987 (Vorrath 2012). Vestas operated blade manufacturing plants in Victoria and Tasmania until 2006 and 2007 respectively (AAP 2007). Closure of the Vestas plants was attributed first, to the small and intermittent local renewable energy market, largely due to inadequate renewable energy targets; and second, failure to adapt to rapid technological change as the market shifted to larger blades (Cowan 2007). In 2019 Vestas re-entered Australia, opening a turbine assembly factory in Victoria (Vorrath 2019). Also in Victoria, between 2001 and 2020 Keppel Prince manufactured 3000 wind tower sections (Keppel Prince 2023).

Figure 9. Market Share for Installed Wind Towers in Australia, 2017-2022



Source: Anti-Dumping Commission (2023: Figure 3)

In the recent past Australian production capacity has been limited to just two facilities: Haywards in Tasmania and Keppel Prince in Victoria. The last locally produced wind tower was finished in 2020. Local output accounted for only a minority of total supply, peaking at around 30% in 2020 (Figure 9). Since then, all supply has been met from a variety of import sources, including Vietnam, Indonesia and Malaysia, but China dominates supply. The substantial but temporary rise in Australia production from 2017 to 2020 was attributed primarily to the large increase in demand from the

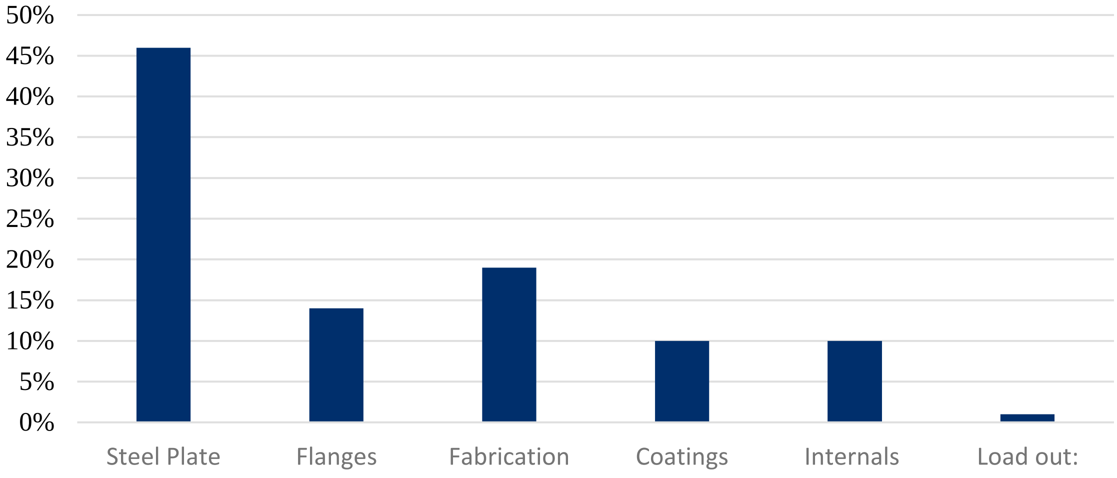
Victoria Renewable Energy Target (VRET) stage 1 wind tower projects. There were no domestic sales in 2021 and 2022. This decrease in sales volume is directly attributable to the ceasing of VRET wind tower projects, and the consequent increase of imports' (Anti- Dumping Commission 2023: 28-29). VRET was not only large in terms of total MW installations, but it also imposed significant local content requirements on wind farm developers. The causes of this collapse in local wind tower manufacturing are examined more fully in Chapter 5.

According to WTIA (2023: Figure 4), imported towers cost approximately $1.6 million each, equivalent to 12% of the total cost of an installed turbine. They reported the cost of Australian-fabricated towers at approximately $1.9 million each, representing 14.5% of the total cost.[36] By this estimate, the price differential between imported and locally made wind towers is therefore about 20%. In contrast, Keppel Prince (2023) suggests the price difference is smaller, around 15%. Differences in these estimates could reflect foreign exchange fluctuations (as imported towers are typically priced in $US dollar terms) and fluctuations in steel prices. Towers are thus an important component, but not the most significant cost for an onshore wind turbine.

A breakdown of tower manufacturing costs is provided in Figure 10. The most important cost is steel plate which, for most onshore towers, ranges from 40-60mm thick. Aside from material inputs, labour represents around 25% of total wind tower fabrication cost. This reflects comparatively high labour costs in Australia, as well as the labour intensity of the production process. This is especially true of welding: a large 6KW onshore tower requires nearly 7km of welding (Keppel Prince 2023). Optimising and automating tower fabrication processes is therefore important to ensuring competitiveness of local production. (Options for improving the competitiveness of local tower fabrication are taken up in Chapter 6).

[36] The WTIA (2023) suggests the price of an imported wind turbine is $13.2 million. Aurecon (2022: Tables 4-1 to 4-3) estimates a 6MW Siemens Gamesa onshore wind turbine in Australia costs $11.25 million, excluding construction and installation costs. The total turbine equipment cost for a 50-tower wind farm wind farm employing this model would thus equal over $560 million.

Figure 10. Component Shares of Onshore Wind Tower Manufacturing Cost



Source: Keppel Prince (2023)

Industry sources indicate that the optimal manufacturing process for making wind towers utilises a flexible production line with standardised inputs and equipment. However, each wind turbine OEM has their own specifications and variations. Allowance in factory equipment and plant layout is required not just for different OEMs, but also for different heights and other dimensions of towers. Many OEMs contract out wind tower manufacture, but the OEMs are responsible for wind tower design and engineering, not the wind tower manufacturer. Design capacity on the part of a wind tower manufacturer is thus not generally a source of competitive advantage.

Past production capacity

It is useful to examine how past local production capacity stands in relation to projected future demand. Data for total local Australian production capacity is derived from Keppel Prince (2023). The two facilities in Australia which produced utility scale wind towers were Keppel Prince Engineering in Victoria and Haywards in Tasmania. Their production capacity is stated at less than 8 sections each per week (Keppel Prince 2023). Assuming 4 sections per tower this translates into a total annual Australian tower production capacity of just 182 towers (Table 10).

Table 10 **Theoretical Australian Onshore Wind Tower Production Capacity**	
Sections per week	14
Sections per tower	3-4
Number of towers per week*	3.5
Annual Australian tower production	182
Source: Keppel Prince (2023). *Assumes 4MW towers.	

Based on the simulations in Table 9, on average 818 onshore towers are required per year from now to 2030-31 – exceeding past Australian production capacity by a minimum of 4.5 times. Over time the cumulative annual average demand moderates so that production capacity needs to increase by a minimum of 3.5 times from 2023-24 to meet projected 2040-41 demand of 624 onshore and offshore towers.

The barriers to local supply are examined in more detail later but it will serve to note the following. An industry respondent interviewed for this project stated since 2020, when the last wind tower was locally fabricated, one producer has experienced a loss of skilled labour due to turnover and lack of use, and equipment is being committed on other projects. Second, it is also not commercially feasible to supply wind towers into NSW and Queensland from Tasmania or Victoria. All towers in NSW and Queensland are supplied by imports. Victorian based Keppel Prince (2023) state the 'size, complexity and cost of transporting wind tower sections interstate places existing manufacturing capability at a significant competitive disadvantage in relation to landed overseas wind towers in NSW and Queensland markets'.

In conclusion, under current market conditions, and in the absence of policy interventions, local capacity to supply the major growth markets of NSW and Queensland and other states is effectively zero.

Scope for increasing production capacity

Based on the above data there is enormous scope to increase Australian wind tower production capacity. It is an important, but also perilous, task to quantify the scale of future wind tower demand in terms of sales. Combining the data on future tower requirements in Table 9 with the current WTIA (2023) estimate of imported tower prices provides a very approximate estimate of revenue that would theoretically be available to tower producers (Table 11). The data is really a 'thought experiment' to identify the potential scale of gross revenue available to producers given assumptions regarding growth in renewable energy, wind turbine share of this generation, tower prices and price deflators. It also assumes the existing production technology is not subject to rapid redundancy causing tower prices to fall significantly.

Table 11
Projected Revenue from Australian Onshore Wind Tower Sales ($m)

	Nominal Revenue Over the Period	Annual Revenue	Productivity Adjusted Revenue*	Annual Revenue
2023-24 to 2030-31	9,156	1,308	8,286	1,184
2023-24 to 2040-41	15,178	893	12,643	744

Source: Author's estimates as described in text.
* Assumes 2.4% annul price reduction due to productivity improvements.

In addition, as shown in Figure 3, wind turbines are subject to long run real price reductions, reflecting productivity gains in manufacture and competitive pressures leading these gains to be passed onto buyers. This annual compound rate of price decrease is 2.4%. Accordingly, an annual price reduction of 2.4% was imposed on the nominal revenue data to generate an estimate of 'productivity adjusted revenue'. (This assumes an identical rate of price reduction applies to all turbine components). Revenue estimates are essential to determine the viability of local manufacture under various cost and market share scenarios.

It is important to note these estimates likely underestimate the total value of tower production by a considerable margin. This is due to the fact that the unit tower price used to calculate revenue uses only onshore imported towers, but offshore towers are expected to comprise a much larger proportion of total demand beginning in the late 2020s, and these are considerably more expensive than smaller onshore towers.[37]

The key conclusion is that over the next few decades the value of towers supplied into the Australian market to meet projected wind generated electricity will be worth many billions of dollars.

Despite this large potential market, is the projected market big enough to support local production? It was noted earlier that tower manufacturing is a scale intensive activity, so it is important to determine if the local market meets the minimum efficient scale of output to justify the considerable investment in a new or significantly refurbished facilities. However, ascertaining the minimum efficient scale is not straightforward. For

[37] Lack of public data on the cost of offshore wind towers, given none have yet been installed in Australia, prevents a more accurate forecast from being generated.

example, industry respondents to Briggs et al's (2022: 75) examination of input requirements for an expansion in renewable energy generation suggest that 'the minimum viable scale for investment in a new [tower] factory is approximately 250MW per annum and the optimal scale around 350MW per annum for 6 years'. Based on 4MW per tower this is an annual output per factory of around 90 towers. But an earlier assessment in 2016, by then chairman and managing director of the Indian renewable energy equipment maker Suzlon Energy, suggested 'a minimum of 2GW a year of new development in Australia before companies could consider establishing a manufacturing base' (Schlink and Teo 2019). This is equivalent to production of 500 onshore towers per annum.

Even this latter high benchmark is met over the 17 years between 2024-25 and 2040-41 since the annual average increment of onshore wind power alone is 2.23GW, equivalent to an annual production of 558 towers. Including offshore generation, this jumps to an annual increase of 3.23GW.[38]

Finally, industry sources suggest the capital cost of establishing a world scale wind tower manufacturing plant in Australia is approximately $50m in a greenfield site (excluding land cost) fitted with the required number and quality of computerised plate cutting, bending, plate bevelling, automated welding, painting and materials handling equipment.

[38] Assuming, as noted earlier, that projected rise in onshore towers from AEMO and the offshore generation from Oceanex.

5. Barriers to Local Manufacture of Wind Towers

This chapter considers the barriers to increased local supply of wind towers, proposes policies to address these barriers; and discusses broader costs and benefits of enhanced local participation in wind tower supply.[39]

5.1 LOCATION OF PRESENT WIND TOWER FACTORIES

The location of present facilities in northern Tasmania and Melbourne are unsuited to serve demand in renewable energy growth markets outside Victoria, notably NSW and Queensland.

In a 2017 report into anti-dumping, it is recorded that 'KPE indicated that it is most competitive on transport costs within an identified radius of its production facilities in Portland and acknowledged that there are certain areas where it is not competitive on price due to the location of the wind farm. These areas are Western Australia, Queensland, the Northern Territory, and certain locations in northern New South Wales' (Department of Industry, Innovation and Science Anti-Dumping Commission 2017: 32).

Importing towers and trucking them directly from major ports to regional locations can thus incur significantly lower transport costs than inter-state transport.

Industry sources suggest the optimal location for new onshore wind turbine factories will be in NSW and Queensland close to declared wind energy production zones, which are generally located in regional and remote areas. In addition, given the large quantities of plate steel required for their manufacture location on or near a rail hub would potentially be more efficient that road transport of this essential input. Offshore tower factories need to be located on or near a port or harbour, due to the massive size and weight of offshore towers and associated blades and foundations.

[39] The Bureau of Industry Economics (1987) detailed similar problems with local firms winning major heavy engineering contracts in the context of an unprecedented investment boom in coal and minerals processing occurring on the east coast of Australia induced by the first oil price shock in 1974. The House of Representatives Standing Committee on Industry, Science and Technology (1998) reached similar conclusions regarding the early phase of the West Australian NW Shelf gas project.

5.2 SCALE OF CURRENT WIND TOWER FACTORIES

Industry advice is that current domestic plants are of inadequate physical size to efficiently produce the number and increased projected scale of future towers and attain the scale necessary to be price competitive against imports. Given the importance of scale to attaining local competitive supply, it is essential to understand how the current absence of large-scale production is a barrier to winning contracts.

The dimensions of utility onshore towers have increased prodigiously over the last two decades (Table 12). Compared to towers in 2001, current large onshore towers are 3 times taller, 8.3 times heavier and require 23.3 times more welding. Current Australian plants cannot efficiently supply this market.

Table 12
Increased Size of Onshore Towers

2001	2022
1.2MW Turbine	6MW Turbine
52m tower	150m tower
2 sections	6 sections
3.8m base diameter	6m base diameter
20mm plate	50mm plate
Weight 60tonne	Weight 500tonne
327m weld	6,977m weld

Source Keppel Prince (2023).

Scale is important not just from an engineering perspective but also an economic one. Large output creates economies in buying inputs of capital equipment and intermediate goods, especially steel. In addition, if the plants are of sufficient scale, it becomes possible to enter into long-term buying agreements with steel makers to reduce price fluctuations in this critical input. It is also possible to enter into long term supply contracts or negotiate options to supply agreements with wind turbine manufacturers and wind farm developers. A high annual throughput also makes it economically feasible to mechanise and/or automate processes and use more specialised equipment, management, engineering and trades labour. All of these factors are associated with sustained productivity growth.[40]

The latest CSIRO *Gen Cost 2022-23* study (Graham et al 2023) devotes considerable space to considering the effect of increasing scale on the prices of renewable energy

[40] A review of the engineering and market dynamics affecting wind turbine manufacturing costs is provided by Elia et al (2020).

equipment manufacture. It applies the well-established principle that long run increases in plant output give rise to sustained productivity rises known as 'learning by doing'. These productivity gains arise from gradual optimisation of plant processes with experience. 'Learning rates can be measured by examining the change in unit cost with cumulative capacity of a technology over time' (Graham et al 2023: 60).

Learning by doing creates a create a positive feedback loop from increases in the rate of output growth to increases in productivity and price competitiveness which further raises output growth. Graham et al (2023: 21) modelled this interdependence using simultaneous equations of learning related to increase in scale and learning induced cost reductions which stimulate further scale increases.[41]

The *Gen Cost 2022-23* report (Graham 2023: Table 3.3) modelled these effects for Australian production of onshore wind turbines and found a learning rate that is 2.6 times faster compared to established global producers. This was based on a rate of domestic production output identical to the increase in generation given by the IEA global central case scenario (Graham 2023: 21). It concluded that:

> 'The potential for local learning means that technology costs are different in different regions in the same time period… [the study] uses inputs from Aurecon (2023) to ensure costs represent Australian project costs. For technologies not commonly deployed in Australia, these costs can be higher than other regions. However, the inclusion of local learning assumptions… means that they can quickly catch up to other regions if deployment occurs' (Graham 2021: 21).[42]

To make the issue of scale concrete and show how it affects production methods and productivity consider the example of welders, who are the key skilled trade involved in wind tower manufacture.

> 'Currently, Australia's 70,000 welders spend approximately 2 hours on-arc time per shift, which is below international benchmarks (4 hours per shift in the US and Japan). The remainder of their time is spent

[41] Investigating this cumulative interaction between rate of output growth and rate of productivity growth for manufacturing industry is certainly not new. The most well-known version is Verdoorn's Law, after the Dutch economist who proposed it in 1949. Regressing manufacturing productivity growth on output growth (both in log form) across time and across nations suggests a coefficient of .5. In other words, a 1% increase in manufacturing output tends to produce a .5% rise in productivity (Toner 1999).

[42] The study also notes that the modelling of scale effects is focussed on equipment production, not installation and construction costs, and assumes identical quality of equipment across nations (Graham 2023: 21).

completing manual labour, including materials handling in warehouses and on site.

> 'Weld Australia is currently partnering with TAFE to train welding apprentices to program cobots,[43] which can then reduce the manual labour burden on welders in a variety of industrial settings. This program, at scale, has the capacity to double the on-arc time of Australian welders. By reducing the manual labour load, there is an opportunity to increase welder productivity and improve the capacity of the domestic welding industry to achieve the Government's priorities'. (Welding Technology Australia 2023)

Removing welders from non-welding tasks can be achieved when the scale of output increases to permit a firm to invest in specialised materials handling equipment, cobots, automated welding machines and employ more trades assistants for lesser skilled manual tasks.

The key implications of these results are that policies to promote increased use of Australian tower production will lower costs; the faster the rate of output growth, the faster the rate of cost reduction. Further, since the rate of output growth will be much faster than in mature markets, as new Australian plants are effectively starting from zero output, their rate of learning will also be much faster than in mature markets – accelerating the 'catch-up' to established producers.

5.3 NON PRE-QUALIFICATION OF LOCAL PRODUCERS

Certified compliance with international engineering and quality standards is a pre-requisite for wind tower manufacturers tendering to turbine OEMs. In addition, OEMs impose other standards relating to workplace safety, engineering capability and financial viability on tower suppliers. Prior to 2020 Keppel Prince Engineering was a pre-qualified supplier with major OEMs, but as explained by the Anti-Dumping Commission lost that status:

> 'The commission understands that currently KPE is not pre-qualified with any OEMs… The lack of pre-qualification limits KPE's ability to

[43] Cobots directly work with humans in the same job setting as opposed to robots, which due to their speed and size or use in dangerous and dirty functions, usually operate in job settings physically isolated from people.

> tender for and be responsive to upcoming projects'. (Anti-Dumping Commission 2023: 55)

The reasons for this lack of pre-qualification status, which effectively precludes Keppel Prince from being able to bid for tower projects, are not publicly known. Possibly the cost of compliance combined with other barriers to successful tendering create little incentive to pre-qualify for this class of work. This suggests a vicious circle whereby an initial loss of market share causes a loss of scale, profitability and investment which further precipitates continue loss of market share. This is the reverse process of the virtuous economic cycle of growth that is the objective of successful government industrial policy, as evidenced by China's domination of the global wind generation market.

5.4 GLOBAL WIND TURBINE MARKET

It was noted earlier that wind energy equipment making has been, and continues to be, the subject of active industry policy interventions in a growing number of nations. Without countervailing measures the price signals international trade in these goods sends to domestic producers distorts the local market and economic structure and results in a sub-optimal allocation of productive resources.

Other aspects of the global wind turbine market present a barrier to entry for local producers.[44] Local suppliers can be disadvantaged where:

- Turbine manufacturers are vertically integrated and produce all major wind turbine components, including towers. Some of the largest producers in China, India and Vietnam, encouraged by national industry policies, operate in this way.
- A variation on the above is where a major wind turbine and tower producer is also a wind farm developer. Such firms will preference intra-company inputs (WeMake 2023).
- Alternatively, inter-company shareholding, or even home government expectations, can favour sourcing inputs from home-nations.

Detailed information on market and supply conditions is commercially sensitive and difficult to publicly access but there is evidence that some of the market conditions identified above apply in Australia. The Anti-Dumping Commission (2023: 42) examined what it termed local 'distribution relationships with exporters from China…[and]…found that the same two importer OEMs were responsible for the

[44] For a simple typology of wind turbine manufacturers business models see Micelli (2017).

importation of over 85% of the total volume of imports from China in both calendar year 2018 and calendar year 2022'. At the very least this is evidence for a concentrated supply market or oligopsony, which may disadvantage local manufacturers.

Even where towers are sourced in the open market there will be a tendency, for risk minimisation reasons, for turbine makers and/or wind farm developers to deal with parties with whom they have previously contracted.

5.5 DEFICIENT INDUSTRY AND RENEWABLE ENERGY POLICY

Australian industry policy remains largely committed to the theoretically incoherent and empirically falsified notion of comparative advantage as the basis for trade and resource allocation. This consigns the nation to be primarily a producer of unprocessed raw materials. Hostility to coherent industrial policy is deeply rooted in Australian political parties and the leading economic bureaucracies in Canberra (Jones 2002; 2016; 2024).[45] To be sure, this long-standing opposition has been interspersed with short periods of successful and innovative policy activism, such as the Button Plans. Nevertheless, opposition to active industry policy represents a significant barrier to developing coherent policies for re-development of local tower and turbine manufacture.

In stark contrast, other major developed states have thoroughly re-oriented their economic policies to foster 'competitive advantage'. In this new economic order, issues of industrial structure and performance are once again paramount, with a focus on maximising domestic output in strategic industries and technological and workforce skills upgrading. This is underpinned by a central role for the state in identifying and promoting investment in key sectors (Joyce and Stanford 2023).[46]

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[45] A 1998 review by the House of Representatives Standing Committee on Industry, Science and Technology into the scope for lifting local content into the enormous northwest shelf oil and gas development concluded: 'Federal bureaucracies still do not appear to play a significant role in promoting and fostering local industry content in major projects. Indeed, the Committee believes they are indifferent to the real opportunities for domestic industry growth'. As recently as 2023 the Deputy Chairman of the Productivity Commission asserted that the 'optimal industry policy' response of Australia to overseas developments such as the US Inflation Reduction Act and assertive industry plans by China is 'to continue to focus on our comparative advantages and think carefully about new sources of comparative advantage that are likely to emerge' (Robson 2023).

[46] There are well-established principles for successful industrial policy that maximise public benefit, reduce waste and lower the risk of gaming and policy capture. These must inform measures to assist wind tower manufacture. Key elements are detailed in Wade (1990), Green (2008: Ch5), Joyce and Stanford (2023) and Mazzucato and Rodrick (2023).

Central to this new economic order and the resurgence of interest in manufacturing industry and industrial policy is renewable energy and more especially renewable energy equipment manufacture. 'Clean energy and technology supply chains are at the nexus of climate, energy and industrial policy, and so establishing them requires an all-of-government approach' (IEA 2023b: 361).

The opportunities for Australia in renewable energy equipment manufacture are huge, but current policy will ensure these opportunities continue to be lost. The case for domestic manufacturing of towers and turbines is compelling.

Industry estimates suggest the current price difference between imported and locally produced wind towers ranges from 15%-20%. Efficient wind tower production is scale intensive, but industry suggest the level of projected demand for onshore wind generation is sufficient to support the establishment of factories, especially in NSW and Queensland close to major wind farm developments, at a scale to deliver world-matching productivity. Similarly, the scale of demand for offshore wind towers is also projected to be sufficient to support efficient local manufacture.

However, under current policy settings these investments are may not occur due to excessive and unnecessary investment uncertainty and risk. The specific deficiencies in current renewable energy policy include the following.

First, government policy is highly intrusive and directive in driving renewable energy generation, but in contrast support for manufacturing renewable energy generation equipment has been a lower priority. Renewable energy generation is strongly supported through mechanisms such as the billions expended in the Capacity Investment Scheme (Department of Energy, Climate Change, Environment, and Water 2023); transmission (through the 'Rewiring the Nation' initiative); technology specific projects, like Snowy Hydro and hydrogen production. and research (such as the activities of the Australian Renewable Energy Agency). An exception that proves the rule is the relatively modest levels of government funding for production of the Hysata electrolyser in the Illawarra. As detailed by Parkinson (2023), this project has been accelerated thanks to ambitious and targeted government supports – an approach which has yet to be generalised.

Ironically, the absence of serious government support for local tower and turbine production is one reason given by the Anti-Dumping Commission for its decision to cease anti-dumping measures against imported towers:

> 'A lack of funding (whether through private or government means) has further constrained the Australian industry's ability to invest in facility upgrades in order to produce wind towers to the specifications that the market requires. The commission does not have evidence of future

> government funding or capital investments that may improve the Australian industry's ability to address these manufacturing capabilities.' Anti-Dumping Commission (2023: 9)

Second, despite the ambitious projections of massively increased renewable and wind energy production outlined earlier, political uncertainty over the agreed scale of renewable production and the technologies to be deployed remains unresolved. For example, nuclear energy is still seriously advanced by some politicians as one solution to climate change, as does debate over the continued use of gas fired generation and support to extend the operation of coal-fired base-load stations. Plans for expanded onshore and offshore turbines are also being challenged by local opponents in some regional and remote locations. Uncertainty from this instability in renewable energy policy compounds the potential risk to investors in expanding local supply capacity.

Finally, related to the last point, a lack of policy consensus at a national level has caused the states to pursue their own strategies. Numerous states are actively considering support for wind turbine manufacturing plants within their borders, including:

- Western Australia (Williamson 2022).
- Queensland (Vorrath 2022), and
- NSW (Smith and Fernandez 2020).

Whilst commendable, these uncoordinated actions have the potential to fragment production across sub-optimal size plants, or result in poorly located facilities in terms of proximity to wind farms in neighbouring states or key inputs such as steel. Australia has a lamentable history of sub-optimal scale plants established across states resulting from competing preferential state procurement schemes.[47]

[47] For example, a Senate inquiry into the rail industry found that 'the lack of standardisation (or harmonisation) is just one of the historical legacies that characterise the Australian rail manufacturing industry. A fragmented rail system – across a number of states and territories – means that each state also has its own rail manufacturing economy to service its particular needs and operations. This translates to smaller markets – less for manufacturers to supply to – and limits manufacturers' ability to expand and compete globally' (Senate Standing Committees on Rural and Regional Affairs and Transport (2017: 2.22).

5.6 ANTI-DUMPING MEASURES IN OTHER COUNTRIES

As noted previously the US and EU have for some years imposed punitive anti-dumping measures against China and others to protect domestic manufacturers and employment against subsidised imports. These measures result in trade diversion as Australia is now a more preferred export destination for surplus Chinese production, especially given the recent decision to remove Australian anti-dumping tariffs.

> 'The commission considers that the imposition of trade remedies and measures in other jurisdictions is a factor that influences global trade by altering access to markets. The commission considers that the expiry of measures may make Australia a comparatively more attractive and accessible market for exports from China, given the prevalence of trade measures against Chinese wind towers in other jurisdictions'. (Anti-Dumping Commission 2023: 45)

5.7 REMOVAL OF DOMESTIC ANTI-DUMPING MEASURES

Anti-dumping tariffs have been applied to some Chinese tower imports for a considerable time and indeed, the Anti-Dumping Commission (2023: 46) expects that into the future there will be 'a continuation of, or a recurrence of dumping of wind towers from China' into the Australian market. Nevertheless, it argues given the barriers against local tower production and the absence of local tower manufacture since October 2020 there is in effect no local industry and therefore no prospect of 'material injury' to local firms or the economy:

> 'The commission does not consider that the expiration of the measures would lead, or would be likely to lead, to a continuation of, or a recurrence of, the material injury that the measures are intended to prevent'. (Anti-Dumping Commission 2023: 58).

The anti-dumping tariff will be removed from Apil 2024. Absence of support for the local wind tower industry, and its resulting collapse, is consistent with the long-standing thrust of Australian international trade policy: namely, a willingness to open up the domestic market for manufactures to overseas producers in return for improved access by Australian agriculture and services to overseas markets. This interpretation is supported by *Australian Financial Review* analysis of the recent decision by the Australian government to lift anti-dumping penalties on imported

Chinese towers in return for China removing its ban on Australian wine and barley exports (Tiller and Smith 2023).

5.8 NON-ENFORCEMENT OF ENGINEERING AND QUALITY STANDARDS

Despite the great emphasis in the literature on the rigorous application of international engineering and quality standards by OEMs to their own operations and that of their suppliers, including towers, there is evidence that conformity of some imported towers with these specifications is breached.

The WTIA (2023) claims many imported towers do not comply with Australian or equivalent international engineering standards in their manufacture and this affords these products an unfair competitive edge:

> ‘In the area of fabricated steel it has been repeatedly proven that imports do not comply to Australian Standards, are not fit for purpose and rarely meet their design life… We note the well documented safety issues in Australia with overseas fabricated towers which reflects the situation in Europe and North America where failure is an equally as common and growing problem’ WTIA (2023).

WTIA (2023) was commissioned by a major Chinese wind turbine supplier to assess quality issues with their imported towers with the following result:

> ‘16 of these imported towers were condemned—classified as beyond economic repair prior to erection—and a further 450 towers failed to comply with Australian Standards and raise serious safety issues…As is so often the case, asset owners fail to factor whole of life costs and safety costs into their procurement strategies. We are not aware of any issues with Australian fabricated towers’. WTIA (2023)

All fabricated steel structures made in and imported into Australia are meant to comply with Australian or agreed international engineering standards established by organisations such as the International Standards Organisation (ISO). Compliance with standards increases the cost of production, not just because certifying compliance of a factory and its products is usually conducted by third parties and costs money, but the whole production process (including sourcing materials, processes for transforming inputs, qualifications of workers, storage and transport of finished products to site) is fully prescribed by standards.

There are a number of reasons for non-compliance of towers with Australian or international standards. First, the ISO only creates standards, but does not ‘enforce, regulate or certify compliance with standards’ (Standards Australia, n.d.). Second, for standards to be enforceable they must be incorporated into legislation or regulations by state or Commonwealth government, and resources must then be devoted to ensure compliance. Evidence by Standards Australia to a recent Senate Economics References Committee inquiry (2017: 4.17) into the steel and fabrication industry was that ‘different states have different standards and specifications, and some enforce them, and some do not'. Third, even when standards are legislated and mandatory, ‘legal loopholes in contracts and gaps in regulatory regimes in some instances may allow imported fabricated steel to avoid complying with the same standard as steel made in Australia’ (2017: 4.21). The main issue here is use of the phrase 'Australian standards or equivalent', which ‘according to some witnesses and submitters, allows room for certification to standards that may pose a safety risk’ (2017: 4.25). Fourth, ‘evidence that the inquiry received indicated that fraudulent standards certification was also a key area of concern for the Australian steel industry’ (2017: 4.35). Fifth, Australia is a signatory to the World Trade Organisation's Agreement on Technical Barriers to Trade (TBT), which includes the requirement that '[m]embers shall ensure that technical regulations are not prepared, adopted or applied with a view to or with the effect of creating unnecessary obstacles to international trade' (2017: 4.10). WTIA in evidence to the Senate inquiry suggested failure to legislate and enforce standards reflects bureaucratic and political interests favouring unrestricted international trade (2017: 4.18-4.19). This line of argument is consistent with the earlier observation that the pre-disposition of public policy over the last 50 years has been to trade-off international access to the Australian market for manufactures in return for improved access by Australian exports of agriculture and services. Finally, there may be a connection between non-compliance and the market conditions for trade in wind towers identified in section 5.4.

In sum, non-compliance of imported towers with local or international standards and the resulting unfair competitive position of imports represents a barrier to local participation.

5.9 CURRENT AND PROJECTED SKILLS SHORTAGES

Expansion of tower manufacturing will create many thousands of jobs directly and indirectly. Key trades such as welders have faced long-term labour shortages.

Instability in renewable energy public policy not only creates negative incentives for investment in renewable equipment manufacture ‘it is very hard for the industry to invest in training and development in the context of policy uncertainty… Coping strategies are often used (e.g., importing workers) which do little to build the skill base' (Briggs et al (2020: 15).

5.10 LOCAL PLATE STEEL SUPPLY

Although not currently a barrier since there is no local tower production any future expansion of the tower industry will be constrained by local steel supply. Even a modest share of tower growth supplied from local industry will likely exceed current plate steel supply capacity. (This issue is taken up in more detail in the next section on benefits of expanding tower production).

6. Benefits of Local Tower Manufacture

There are multiple benefits to be realised from redressing the barriers to wind tower manufacture in Australia.

6.1 FROM TOWERS TO TURBINES

Domestic tower production increases the probability of further local investment by OEMs in other turbine components, such as forged section rings, internals like ladders and lifts, nacelles, gearboxes, blades and generators. This is due not just to the 'demonstration effect' that local production proves capability. Manufacture in Australia also reduces the risk multi-national corporations face in losing valuable intellectual property to competitors. [48] Local supply simplifies supply chains such as parts supply, maintenance and eases communication between contracting parties. The case for additional component production becomes even more compelling if backed-up with supportive industry policies.

6.2 REDRESSING SOVEREIGN RISK

A related point is that nations seek security of energy supply which is threatened by prospective global manufacturing capacity shortfalls, as well as by sovereign risks arising from excessive dependence on overseas suppliers and geopolitical trade shocks (IEA 2023b: 226). 'Building up domestic clean energy technology manufacturing is a key opportunity to diversify supply chains, as well as boost economic growth' (IEA 2023b: 402).

6.3 OUTPUT AND EMPLOYMENT

Acil Allen (2022) was commissioned to investigate the cost and benefits of implementing local content requirements under the NSW Electricity Infrastructure Investment Act 2020. Using a variety of content and cost scenarios they found positive

[48] Industry policy in China for example is actively directed to acquiring such property from foreign MNC operations based in China. One court case involving wind turbines is detailed in US Department of Justice (2018).

benefits for GDP and incomes flowing form the increased investment and labour generated by the scheme.

Tower manufacture is classified to the sub-industry Fabricated metal product manufacturing.[49] Based on the projections in Table 11, which showed a potential increase in wind tower annual output of $1.3bn, for 2023-24 to 2030-31this would expand output of the Fabricated metal product industry by 4%. Assuming wind tower manufacture has a similar employment/output ratio to Fabricated metal product manufacturing as a whole this output translates into an additional 4,350 jobs sustained over the period. These estimates are of course only very approximate as they assume 100% local tower production. Against this, offshore tower production has not been factored into these output and employment estimates which, if included, would significantly increase the number of jobs and value of local tower manufacture.

If local tower production translates into additional component production or even complete turbines this will dramatically expand direct output and employment. Recall that towers comprise just 12% of total turbine value and that imported 6MW turbines are valued at between $11.25m to $13.2m each.

Fabrication facilities designed for wind towers may also, depending on their configuration and degree of spare capacity, be used to manufacture other related products such as pumped hydro pipes and piling for ports and bridges. This expands the scope for import substitution, output and jobs.

6.4 ENHANCING PRODUCTIVITY

Tower and turbine manufacturing, like other forms of metal fabrication, is subject to higher than average rates of productivity growth compared to many other industries: a feature common to manufacturing more generally (Stanford 2020). This is attractive to government seeking to promote higher productivity industries in a context where, due to factors explained in chapter 2, economies are experiencing long-term productivity slow-down.

[49] The five-year annual average output (sales and service income) of this industry between 2017-18 and 2021-22 was $34.94 bn (ABS 2023: Table Key data by industry subdivision, Manufacturing, 2021-22). Output from the industry has been volatile so a 5-year annual average was used to ‘smooth’ these results.

6.5 REGIONAL JOBS

To avoid logistical problems, especially as towers (and blades) get progressively larger, the optimal location for new land-based wind tower factories is close to wind farms. Establishment of wind tower manufacturing plants in regional locations will create a number of benefits. It will provide a large source of employment to regions and have the added benefit of providing alternative employment for regional workers currently engaged in fossil fuel extraction and processing and/or in industries supplying inputs to these sectors (such as maintenance services and transport). These fossil fuel linked jobs will reduce overtime as renewables gain a larger share of energy production. Moreover, at present there is a sentiment in some regional areas that the regions are incurring certain costs of renewable energy production, such as road disruption caused by construction of renewable energy facilities, but not sharing equally in the gains. Establishing renewable energy manufacturing plants in the regions, such as wind tower production, is an important means of distributing the gains from decarbonisation more equitably and will also assist to reduce public and political resistance to rapid decarbonisation. Supporting this claim is that a study by Briggs et al (2022: 61) found a high degree of transferability of skills and occupations from fossil fuel related sectors to renewable energy generation, installation, maintenance and manufacture.

6.6 STEEL AND GREEN STEEL

Steel is the most important physical input into the making of towers and other major tower-related components, such as flanges and foundations. Table 13 provides estimates of the steel required to manufacture the number of onshore towers necessary to satisfy the AEMO Step Change wind generation scenario.

Table 13 Steel requirements for AEMO 2023 Step Change Scenario Wind Generation	
2024-25 to 2030-31	
MW Increase	22,890MW
No. of 6MW towers	3815
Steel required	2,556,050 tonnes
Annual requirement	365,150 tonnes
2024-25 to 2040-41	
MW Increase	37,944MW
No. of 6MW towers	6324
Steel required	4,237,080 tonnes
Annual requirement	249,240 tonnes
*Source for steel requirements per 6MW tower Keppel Prince (2023). Assumes all onshore generation, 6MW tower and 670 tonnes complete (tower, bolts, cage, reinforcement and flange).	

This annual incremental demand for steel would absorb most of the total annual output of plate steel production into the mid-2030s, and over half till 2050, as currently Australia produces approximately 400,000 tonnes of plate steel per annum (WTIA 2022b: 4). This estimate of steel consumption is conservative as it assumes all wind power is generated via onshore towers. Even a small share of generation sourced from offshore structures would dramatically lift steel consumption, as each 15MW offshore wind turbine proposed by Oceanex (2023) for the NSW coast consumes 5600 tonnes of steel or over ten times a 6KW onshore structure.[50] Assuming one-quarter of additional wind generation capacity to 2040-41 is met by offshore structures, then the total offshore steel to 2040-41 would rise to over 3.5 m. tonnes (or over 500,000 tonnes per annum).[51] The remaining three-quarters of onshore wind output would require 3.2m tonnes to 2040-41 (or over 185,000 tonnes per annum). With this mix of offshore and onshore wind generation to 2040-41, annual incremental plate steel demand would be close to 700,000 tonnes – or 1.73 times Australia's current annual plate steel production.

Plate steel used for towers and related structures is presently produced by BlueScope in the Illawarra which has an annual output of 3m tonnes of crude steel (Australian

[50] Oceanex (2023) estimates each of the three projects proposed for the NSW coast will comprise 134 towers with each project consuming 750,000 tonnes of steel. Most of this steel is in the floating foundations (4000 tonnes) and tower (1000 tonnes).

[51] Oceanex expects the first offshore towers to be installed by the late 2020s or early 2030s.

Steel Institute 2023: 17).[52] Under the full onshore wind generation scenario production in Australia absorbs 8% of total steel output and in the mixed scenario of .25 offshore and .75 onshore 23% of total BlueScope steel is absorbed.

This additional demand is important to directly support investment and jobs in the Illawarra. The local steel industry has experienced difficult trading conditions due to subsidised imports; failure to properly enforce engineering standards on imported fabricated steel (as discussed) and a large reduction in domestic manufacturing which used to be a major purchaser of Australian steel. For example, the local car industry previously represented 14% of total BlueScope sales, but now no longer exists (BHP 2002: i). These developments have further exposed BlueScope to the highly cyclical construction industry, which is now its main customer (Australian Steel Institute 2023). Development of domestic manufacture of tower and related components would greatly assist in diversifying and stabilising its customer base for steel and hugely expand output of plate steel production in Australia.

Even better, developing a local wind generation equipment industry would provide an important source of demand to help justify major capital investments in shifting steel production toward non-carbon or 'green' steel-making technologies. Technology now exists to replace the use of coal and coke to reduce iron ore, with hydrogen as a direct energy source or else wind-generated energy for electric-arc furnaces. Either way, reductions in carbon dioxide emissions would make an important contribution to meeting Australia's climate targets as steel production accounts for over 8% of global CO2 emissions.

Put simply, there is a powerful and circular relationship between wind energy, expanding domestic manufacturing capability and climate goals. Wind energy equipment manufacturing makes intensive use of steel; a green steel industry could then make intensive use of green hydrogen (made with wind energy) and/or direct supplies of wind-generated electricity.[53] A coordinated and simultaneous expansion of all three sectors – wind energy, wind energy manufacturing, and steel-making – holds enormous potential to lead economic and industrial development in regions of Australia in need of future growth spurs.

There are important real-world examples of how these linkages have been exploited for mutual benefit in other countries. For example, the IEA (2023b: 401) cites a 2021

[52] In other words, of the annual 3m tonnes of crude steel produced in Illawarra only a fraction goes to plate steel as other uses of steel include structural beams and galvanised and Colourbond products for the construction industry and rod and bar steel used for example for concrete steel reinforcing.

[53] The vast quantities of steel necessary for onshore and offshore wind generation is itself, with current fossil fuel-based production technology, an important source of CO2 emissions (Li et al 2023).

agreement in Europe between a wind farm utility and a green steel company, worth EUR 2.3 billion. 'Such expansions might also allow companies to enter clean energy technology markets more quickly than if they invest individually'. This is a clear instance of redressing private inter-industry investment co-ordination failures.

6.7 LOCAL PRODUCTION REDUCES CO2 SEA TRANSPORT EMISSIONS

Another benefit of local production of towers and associated components is that it avoids the substantial CO2 emissions arising from transporting by sea millions of tonnes of fabricated steel from manufacturers overseas to Australia.

To estimate the significance of these emissions, consider the simulation described in Table 14. Assume all towers and components are imported from Vietnam (Ho Chi Minh City) to Brisbane port, a sea distance of 11,127 kms. We also assume other parameters such as tonnes of CO2/tonne/per km, and value these CO2 transport emissions conservatively at $35 per tonne (potentially reflecting payment of an abatement credit under some carbon price policy framework).[54]

Given these parameters, over the period to 2030-31, avoiding the sea transport associated with imported wind towers would avoid between 340,000 and 1.6 million tonnes of CO2 emissions – worth $12-$55m at that carbon price. Using the same assumptions but extending the analysis over a longer time period (to 2041), the savings in both emissions and costs are even larger: between 560,000 and 2.6 million tonnes of CO2 emissions valued at $20m to $91m.

[54] A wide variation in estimates of CO2 per tonne per km exists across vessel types and within the same vessel type. In addition, towers and related components can be carried on different ship types, for example Ro/Ro, container, break bulk or general cargo ships can and do carry towers and blades and within these ship types CO2 emissions vary greatly across ship sizes. For example, see carbon transport calculators such as https://tools.sinay.ai/co2_module/ and https://www.statista.com/statistics/1233482/carbon-footprint-of-cargo-ships-by-type-uk/.

Table 14 **CO2 Emissions Avoided from Domestic Manufacture of Onshore Towers 2024-25 to 2030-31**		
	CO2 55gm per km per tonne	CO2 12gm per km per tonne
Distance Ho Chi Minh port to Brisbane port***	11127 kms	11127 kms
Co2 gm per tonne transport	611985	133524gms
CO2 kg per tonne	612kgs	134kgs
CO2 1 tonne	0.612 tonnes	0.134 tonnes
2031-31 tonnes steel transported	2,556,050 tonnes	2,556,050 tonnes
CO2 2030-31 generated by sea transport	1,564,264 tonnes	341,294 tonnes
Value @$35 per tonne**	$55m.	$12m.
Source: *https://www.fluentcargo.com/routes/ho-chi-minh-city-vn/brisbane-au ** ACCU Figure 1.2 Generic Australian carbon credit unit (ACCU) reported spot price, July 2022 to July 2023 (https://www.cleanenergyregulator.gov.au/DocumentAssets/Pages/QCMR-data-workbook-June-Quarter-2023.aspx)		

This simulation underestimates the total CO2 avoided, since other key imported items (like blades and generators) are excluded. Assuming local turbine production occurs in the future, then even larger emissions reductions could be achieved. Moreover, only onshore towers and related components were included. If much larger and heavier offshore turbines and foundations are imported, emissions would increase substantially. (Recall that a 6MW tower and tower components weigh 670 tonnes but a 15MW offshore turbine and foundation weighs 5600 tonnes).

At present CO2 abatement schemes to reward producers for substituting imports with domestic production do not exist. However, a scheme which recognises the scale and value of abated CO2 emissions from domestic production of wind towers and components could substantially under-write the cost of establishing tower production facilities in Australia, so long as the value of those savings was incorporated within the business case for domestic production. Finally, as other nations and regions, such as the EU move towards carbon border adjustment trading schemes, the case for pricing embodied carbon dioxide content of imports into Australia (such as wind towers), will become increasingly compelling.

7. Conclusion and Policy Options

7.1 WIND TOWER PRODUCTION SATISFIES INDUSTRY POLICY CRITERIA

Before addressing specific policy options, it is important to recall that wind tower manufacture has a number of attributes that uniquely suit and justify industry policy interventions. These features legitimate government intervention and increase the likelihood of that intervention's success.

First, the demand for wind towers and, therefore, output of wind equipment factories, is very large and of long duration. Second, the pace and scale of demand for wind towers is directly under the control of government through national electricity plans, public investment generation and incentives for private investment in generation. Third, wind energy generation and wind generation manufacturing are a proven, mature technology that is unlikely to be subject to medium term technological redundancy. (These three attributes reduce the risk to government in supporting indigenous tower production). Fourth, there are strong input-output linkages with existing industries conferring a cumulative growth impetus to employment and incomes. Fifth, wind tower manufacture is subject to consistent and above average productivity gains. Sixth, given Australia's comparatively unsophisticated manufacturing base, fabrication of wind towers (as a mature low-medium technology activity) is well within domestic capability; moreover, once established, this activity offers the real prospect of entry into more high value and technologically advanced products such as generators, blades and voltage control systems. Finally, international trade in wind towers and turbines is both extensive and, as shown earlier, subject to intensive national industrial policies. In orthodox economic terms, international trade is distorted by a variety of incentives and subsidies and requires countervailing intervention by the Australian government to correct these 'market failures'.

7.2 SPECIFIC POLICY MEASURES

Specific measures that address some of the key barriers to assist investment in domestic wind tower manufacturing would include the following:

Commission a study into optimal plant locations, size and incentives

The WTIA (2023) has argued that domestic plants of feasible scale, incorporating the latest robotic welding; materials handling and painting technology, could achieve international price competitiveness for domestic sales, and could even be capable of exporting a share of output. The WTIA also proposes double- or treble-shifting of plants to adjust to peaks and troughs in demand.

The WA government, recognising this opportunity, in 2023 funded a full feasibility study into wind turbine and component manufacture, maintenance and end of life recycling in the state (Department of Jobs, Tourism, Science and Innovation 2024). In response, the WA Government has allocated $8m for an industry support program in collaboration with the Advanced Manufacturing Growth Centre. As WA is not part of the national electricity grid, and its distance from east coast factories probably precludes feasible tower supply from NSW or Queensland, the case for targeted manufacturing in that state is strong. Nevertheless, it is important that co-operative federalism applies to any assistance measures to avoid inter-state rivalry causing sub-optimal plant location and scale.

<u>Recommendation 1:</u> The federal government in co-operation with state governments and industry should commission an engineering and financial study into the optimal location, plant size, plant playout, advanced production equipment and minimum scale of output required to establish competitive tower manufacturing on the east coast of Australia where onshore and offshore wind farm activity will be intense for decades. This study should also examine the optimal risk-sharing arrangements between private industry and the public sector to ensure public funds are efficiently spent to maximise public benefit. For example, the study could examine the relative merits of up-front subsidies for capital investment or a production subsidy per tower. Such a study should also consider the scope and feasibility of full or partial turbine manufacture through an audit of local supply chain capability and gaps.

Regulate non-conforming imports

<u>Recommendation 2:</u> The government should implement key recommendations of the 2017 Senate Inquiry into the Australian steel industry relating first to import of sub-standard steel and fabricated structures and second, ensure consistency across the states in the application of engineering standards.

The Inquiries specific recommendations of interest to the present study are:

(Rec 4.85) The committee recommends that the Australian Government investigate the possibility of making third-party certification of steel compulsory for structural and fabricated steel used in Australia where relevant standards are available.

(Rec 4.87) The committee recommends that the Australian Government work with the states and territories to improve consistency in standards between different Australian jurisdictions and regulatory bodies, with a view to harmonising current standards requirements.

Regulate Scope 3 emissions to partially fund local tower manufacture

CO_2 emissions from the purchase of capital goods used in industry are covered under internationally agreed Scope 3 emissions (The Climate Leaders Coalition 2022:7). It was shown earlier that the domestic manufacture of wind towers could fully abate emissions from transporting millions of tons of fabricated steel by sea.

Recommendation 3: A carbon price should be imposed on the Scope 3 emissions of wind farm developers due to the substantial carbon emissions arising from sea-transport of imported towers. Ideally, this would be part of a broader carbon pricing system that created incentives for reducing emissions in all areas of energy use. Funds raised from a carbon pricing regime could be used to assist local tower manufacturers to partially defray establishment and production costs – as well as supporting investments in other renewable energy projects and technologies. In this way, policy will create fiscal disincentives for carbon-emitting activities (in this case, importing heavy wind towers from far-off production sites), while enhancing the cost appeal of investments in all varieties of renewable energy (including wind).

Local content policies

Local content policies prescribe that a proportion of inputs used by public and/or private entities be sourced from domestic production. Recent experience with some local content policies demonstrates their success in lifting local production. The Anti-Dumping Commission (2023: 64) analysed the Victorian Renewable Energy Target (VRET) which used auctions for wind farm developments and imposed a minimum 60% local content. It examined VRET and non-VRET wind farm tower supply from 2018-2020 and found that local content provisions were an important source of demand for local producers. However, as VRET auctions shifted to solar generation, demand for local towers declined markedly (Anti-Dumping Commission 2023: 53-54). The Commission (2023: 52) concluded that 'the absence of government led wind tower projects with local content requirements was a significant factor impacting the performance of the Australian industry'.

An evaluation by researchers at the University of Technology Sydney found that in renewable energy manufacture in Australia 'the level of local content and supply chain employment is low by international standards' (Briggs et al 2022: 70). Nevertheless, this research concludes that:

> '…reverse auctions with local content criteria are a proven mechanism for increasing local content. In Australia, reverse auctions in both the ACT and Victoria have increased local businesses and employment. In the VRET, proponents were required to submit a Local Industry Development Plan and Major Project Skill Plan which created 900 jobs, 600 on-going jobs and 270 apprentices and trainees. Local content targets of 64 per cent were set for bidders. The experience has been the same internationally, especially where there are repeat auctions as the project pipeline gives confidence for developers and businesses to invest and develop capability and competition leads to increased local content' (Briggs et al 2020: 70).

Local content provisions not only strengthen demand but make this demand more predictable. This is important in lowering the risk premium to private investors in renewable energy manufacturing. This works not just for investment in physical plant but also for skills development, as it 'is very hard for … industry to invest in training and development in the context of policy uncertainty' (Briggs et al 2022: 70).

Private wind farm developers, as profit maximisers, will likely object to local content policies or seek to evade their effects. One form this opposition could take is to delay informing organisations such as the Industry Capability Network of tender opportunities, reducing the time and opportunity of local suppliers to bid. In this context, a wind power manufacturing strategy needs to include feasible, strong and enforceable local content targets and ensure targets are met as a condition for receipt of publicly-subsidised wind power developments.

An important new local content opportunity is opened by the federal government's new Capacity Investment Scheme (CIS), introduced in 2022 and expanded in 2023. This will be the nation's primary mechanism for lifting investment in renewable energy generation. As with all federal government procurement contracts above a certain value threshold, tenderers will be required to submit an Australian Industry Participation (AIP) Plan. Developers will need to demonstrate how their proposal will:

> '…contribute to maximising the economic benefits of the transition to net zero, including local and indirect economic benefits and projects will be assessed against their contribution to achieving social licence and driving local benefits for the communities they operate in…. Local benefits will be assessed against a project's commitment to improve local and national economic development, including through the sourcing of materials and equipment. This can be demonstrated through commitments to employment and apprentice quotas and local procurement, engagement with First Nations businesses and

> subcontractors and contribution to workforce development, training and upskilling initiatives' (Department of Climate Change, Energy, the Environment and Water 2023: 20).

However, the effectiveness of the CIS in promoting domestic manufacturing of wind tower and wind turbine components will be limited as there appears to be no prescribed levels of local content. Second, state-based local content policies will continue to operate alongside federal government AIPs and it would appear that a developer can offset its AIP obligations under the CIS if it can demonstrate it also meets state based local content requirements.

> 'State-based policies on social licence may be taken into consideration during merit assessment of a project's social licence. This could include, for example, policies preferring or requiring projects to locate within a State-declared renewable energy zone' (Department of Climate Change, Energy, the Environment and Water 2023: 21).

In other words, it would seem that existing state-based local content obligations could negate, in part or in full, a developer's local content obligations established under the federal government's CIS. This could prove adverse for local industry if there are significant differences in the level of local content requirements across jurisdictions as this could promote 'jurisdiction shopping' by wind farm developers. (This logic applies to renewable energy sources).

In sum, local content schemes which prescribe minimum levels of domestic goods and services in procurement contracts can be effective. Equally it is self-evident that local wind tower manufacturers have not benefited from these schemes since 2020. Such schemes need to be strengthened and harmonised as a key part of an overarching industry strategy for wind tower manufacturing.

<u>Recommendation 4</u>. State-based local content schemes should be harmonised to reduce the scope for gaming and prevent perverse incentives which lower productive efficiency. Second, state and federal government local content plans for renewable energy generation be altered to prescribe specific proportions of local inputs into private and public procurement. These proportions should be sufficient to generate the level of demand needed to satisfy the minimum scale of wind tower plant output to be identified from the study suggested in Recommendation 1.

Steel and green steel

Co-ordinated and sequential investment in domestic onshore and offshore wind generation equipment manufacturing and steel production will overcome investment indivisibilities and risks. Further, such planned sequential investments can support the large investments required to manufacture Australian green steel. As more nations move towards carbon border adjustment schemes and Scope 3 emissions schemes, the availability of green steel will enhance the competitiveness not only of the Australian steel industry but also local steel tower manufacture and products that use wind generated electricity as an input. Such products can include energy intensive hydrogen, aluminium and battery components.

Recommendation 5. A joint public and private sector authority be established to co-ordinate and sequence investment in renewable energy generation and transmission and steel and green steel production to maximise supply and demand linkages between these sectors, promote investment and reduce investment risk. To improve the efficiency of this task the authority should have input into setting the level and timing of local content requirements.

7.3 A CALL TO ACTION

The rapid expansion of onshore and offshore wind energy generation in Australia carries enormous potential to help the country meet its emissions reduction commitments. Combining this with an integrated vision of a sustainable manufacturing industry that both contributes to, and uses, that renewable energy, it will spur important improvements in Australia's domestic manufacturing capability and prosperity.

There is a tendency in conventional economic circles to assume that Australia should stick to its so-called 'comparative advantage', in determining its role in the emerging net-zero global economy. But that would consign the country to a continued role as supplier of raw resources to other, more technologically sophisticated countries – that purchase Australian resources, transform them into innovative and expensive products, which are then sold back to Australians at a premium price. Merely replacing traditional mineral exports (such as coal) with new generations of unprocessed minerals essential in the net-zero economy (such as lithium and rare earths) would represent an enormous lost opportunity for Australia to attain a more balanced industrial structure and create good quality well paid jobs.

Faith in market forces to determine comparative advantage specialisation has been mostly abandoned in other countries. Instead, active and strategic industry policies have once again come to the fore, as countries seek to deliberately craft a competitive advantage in emerging strategic industries – including those associated with the production and use of renewable energy, The Biden Inflation Reduction Act in the U.S. is a prototype of this approach and is having a historic impact on the growth of manufacturing investment. Most other industrial countries have adopted similar or corresponding approaches. It is time for Australia to adopt a similar spirit of policy activism to maximise the industrial, technological and employment potential of the energy transition.

Active industrial policies to promote domestic production of manufactured products associated with the energy transition (such as wind towers and other components) must be paired with strong, consistent, and genuine policies to reduce fossil fuel production and use. Otherwise, the potential economic and environmental benefits of shifting toward a more sustainable industrial structure on one hand, will be squandered by continuing fossil fuel pollution (through both domestic consumption and exports) on the other.

To date, the potential for domestic wind power manufacturing has been largely overlooked in recent federal energy and manufacturing policies, but it should not be. The simulations described in this report indicate the potential for massive and ongoing economic and environmental gains, including:

- Over 4,350 ongoing jobs in wind tower manufacturing, and thousands more in input industries (especially steel).
- Output of over 800 towers per year, with cumulative value of up to $15 billion over the next 17 years.
- Incremental demand for up to 700,000 tonnes of Australian-made steel per year, creating a viable foundation for the recapitalization of Australian steel plants with carbon-free technologies.
- Avoiding 2.6 million tonnes of CO_2 emissions thanks to reduced sea shipping of imported wind towers.

Prudent economic policy must recognise these potential gains from the development of a domestic wind tower manufacturing industry and implement the same sorts of pro-active industrial strategies and incentives that are allowing other countries to make the most of the renewable energy transition.

Appendix 1

DATA AND ASSUMPTIONS FOR AEMO ISP ONSHORE WIND TOWER DEMAND. AUSTRALIA 2023-24 TO 2050-51

	Wind capacity MW	Annual Increment Wind Generation MW	No of new towers (assume 4MW per tower)	Cumulative total new towers from 2023-24	Cumulative % increase from 2023-24	Average annual new towers
2023-24	11,525	(2881) stock				
2024-25	15,164	3639	910			
2025-26	18,419	3255	814			
2026-27	20,462	2043	511			
2027-28	24,875	4413	1103			
2028-29	28,335	3460	865			
2029-30	31,523	3189	797			
2030-31	34,415	2892	723	5723	199%	818
2031-32	36,531	2116	529			
2032-33	38,112	1581	395			
2033-34	42,069	3957	989			
2034-35	42,697	627	157			
2035-36	42,931	235	59			
2036-37	45,376	2444	611			
2037-38	47,791	2415	604			
2038-39	47,986	195	49			
2039-40	48,713	727	182			
2040-41	49,469	756	189	9486	329%	558
2041-42	51,322	1853	463			
2042-43	58,456	7134	1783			
2043-44	60,500	2045	511			
2044-45	59,823	-677	-169			
2045-46	61,421	1598	400			
2046-47	63,950	2529	632			
2047-48	65,228	1278	320			
2048-49	69,624	4396	1099			
2049-50	70,473	849	212	14737	512%	567
2050-51	69,703	-770				

Source: Wind capacity AEMO 2022 ISP Results workbook. CDP 2 Step Change least-cost DP

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