Final Report on

Market Diversification and Access Project Mining and Renewable Energy Technologies

for Department of Industry, Tourism and Resources

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Executive summary

The Advanced Manufacturing Action Agenda (AMAA) was launched by the Hon. Ian McFarlane, Federal Minister for Industry, Tourismand Resources, in June 2006. The Action Agenda is an industry-led strategic framework that provides a roadmap and set of actions to achieve sustainability and growth of the industry. Three key market access and development actions contained in the Agenda are: identification of global driver industries and technologies; identification of strategies to capture opportunities in domestic and international supply chains; and the promotion of specific opportunities in new and emerging industries. The Department of Industry, Tourism and Resources has commissioned this research to address these issues.

Traditionally, Australian advanced manufacturers (AAM) have relied on the automotive sector as a key driver of production. However, due to increasing competition from global supply chains and low-wage-cost countries, AAM must seek to diversify into new markets. As such, this report assesses and identifies industry level and company specific opportunities for AAM to expand into two new markets identified in the AMAA that appear to offer growth potential: the renewable energy and mining sectors. This report has three aims:

- identify domestic and global market potential in the renewable energy and mining sectors
- identify company level market demand relevant to opportunities for AAM companies
- develop market strategies for AAM industry to promote company access to identified opportunities.

The methodology for this research adopted a marketing orientation framework where each market was segmented into homogenous groups, the needs and attractiveness of each segment were identified, and individual segments were matched to advanced manufacturers' capabilities. Information was collected from websites, company and industry publications, government reports, and company visits and interviews with senior staff. Finally, strategies at the industry and company level are recommended to take advantage of identified opportunities.

The renewable energy and mining industries were analysed to identify the sectors with most potential for growth. Within the renewable energy industry, solar photovoltaiac (PV) and wind energy were assessed as commercially viable with significant growth potential due to governments' concern to minimise the effects of climate change resulting from fossil fuel dependence. The mining industry is currently in a worldwide boom and Australia is positioned as a world-class and world-scale producer. The mining technology services (MTS) sector services earn most of their revenue from mining companies in return for goods and services based upon specialist technology, intellectual property or knowledge intensive engineering applications.

Grid-connected solar PV was the fastest expanding renewable energy source during 2004–2005, with capacity increasing from 2.0 GW to 3.1 GW, an increase of 55%. Leading producers of solar PV in 2005 were identified as Japan (830 MW), Europe (470 MW), China (200 MW), and the United States (150 GW). Australia's strength in research and development of solar PV cell and PV concentrator technology research is internationally recognised. BP Solar, Origin Energy and Solar Systems are examples of Australian companies with significant production and R&D capabilities.

Wind energy currently provides the largest growth in supply of any energy both in Australia and internationally, with total world wide wind generation capacity estimated at 59 GW in 2005. In 2006, Australia installed 563 wind turbines in 42 wind farms, delivering wind energy capacity of 817 MW. Wind energy contributes 0.5% of Australia's electricity requirements with 85% of production grid-connected. A further 765 MW is now approved for development and over 1,000 MW is in the investigation or planning stage. Despite less than 1% of Australia's electricity being derived from wind power, the existing networked infrastructure has the potential to accommodate up to 10%.

In the mining industry in the 2003–2004 period, gross sales revenue for the Australia's MTS was estimated at $4.75 billion, with exports valued at $1.1 billion. Australia is described as a leader in the export of mining equipment, services and technologies with key export markets in East and South-East Asian regions worth $791 million. Of particular interest to AAM is the contract mining, materials and equipment supplies, and engineering and construction services. Exports in this sector in 2003–2004 were estimated at $271 million or 24% of total exports. China ($83 million), North America ($29 million) and South Africa ($26 million) are seen as the most important markets for mining related machining and equipment manufacturing.

The framework used for assessing industry opportunities has identified three major categories of new industry engagement activities with potential to deliver real industry growth

- new capital investment projects
- import replacements
- generation of specialist product exports.

Within this framework, the report has successfully identified opportunities for AAM industry diversification and growth in the renewable energy and mining industries at the industry and company level. A number of these opportunities are current and accessible to industry participants in a near term time-frame. The report explores trends and issues within each target industry in detail, to provide a context for the various opportunities to be appropriately analysed.

Renewable energy opportunities

Three main areas of opportunity have been identified at the industry level for the renewable energy sector: the automated manufacturing of photovoltaic solar cells; the development of heliostat systems for solar concentrator system technologies; and the application of AAM industry capabilities to both large and medium-sized wind turbine component manufacturing. Each opportunity has the attraction of a significant domestic market that is able to support product development activities and thus give opportunities to leverage domestic market experience for entry into high value international supply chains. In addition, there is potential for Australian firms to develop and commercialise their own protected IP where AAM engineering capabilities are applied.

Within each industry, specific company opportunities are identified:

<u>Photovoltaic solar cell manufacturing</u>

- Development of high volume automated manufacturing systems for BP Solar, with potential to lead to a suite of standardised equipment systems with substantial international market scope throughout the solar PV manufacturing industry

- Early stage participation with Origin Energy and the Australian National University (ANU) in development of cost-efficient manufacturing processes for Australian developed "next-generation" Sliver Cell PV Systems. These have successfully reached early stage commercialisation and have the potential to deliver a major advance in solar PV cost and performance

Solar concentrator systems

- Design and/or manufacture of advanced heliostat systems, needed to meet the needs of the Solar Systems 154 MW pilot plant that is currently being planned for construction in Victoria and which will incorporate 246 receiver towers

- Development and manufacturing of cost effective heliostatic dish collector systems for future commercial applications of ANU developed Solar Thermal Energy technology

Wind energy

- Development of engineering services and facilities to meet the critical support needs of the growing local base of wind turbine installations.

- Supply partnership with Vestas and RePower wind turbine manufacturers for the local manufacture of large wind turbine components for upcoming local projects, and industry capability positioning to increase local content of the estimated $6,000 million industry investment over the next decade

- Participation in the development and manufacturing of new technology wind turbine systems being commercialised by Windflow Technologies in New Zealand

- Manufacturing support of the $600,000 pilot plant investment being undertaken by Dynamic Systems in NSW to prototype a new design of vertical axis wind turbine

- Development partnership with Nexxtdrive for the commercialisation of IP-protected variable speed generator drive systems that have high potential to increase wind turbine efficiencies

- Specialisation in the manufacture and support of medium sized remote area wind turbine systems for the high potential market existing in the Asia-Pacific region.

Mining industry opportunities

The AAM are currently engaged to a limited extent in supply to the mining industry, primarily through contract machining and some specialist mining equipment. Three strategic activities are recommended for facilitating the expansion of AAM opportunities:

- The development of improved supplier awareness and access mechanisms to allow the mining industry to engage AAM more effectively;

- The development of supply opportunities through companies operating in the MTS sector that fit AAM capabilities but are not presently identified within the Action Agenda process; and

- The involvement of qualified AAM companies in commercialisation of matched new product technologies emerging from the extensive mining technology research community. Specific opportunities at the industry and company level are identified:

Enhanced supplier awareness and access mechanisms

- Creation of effective industry directory tools by AAM industry bodies for the use of mining engineers and purchasing personnel to more readily engage with the industry on a national scale
- Providing access to the AM industry's existing mining specific capabilities through the mining industry's Quadrem internet supplier management system
- Listing of individual companies on the many existing print and internet-based directory services that have been identified for the mining sector
- Collaborative industry representation at major mining shows
- Company level membership of Austmine and MESCA organisations to develop mining industry linkages
- Presentation of detailed industry capabilities for listing on the ICN database for import replacement sources for mining projects
- Identification and engagement of AAM companies operating within the MTS sector that fit industry definitions but are not engaged in the Action Agenda process to build industry cohesiveness, better integrate market access points into the industry and leverage market opportunities

MTS sector advanced manufacturers

- Waratah Waracar product export development and supply partnership opportunities for sub assemblies and specialised components.
- CME supply chain development for local replacement part and new part sourcing
- Russel Mineral Equipment Hella equipment manufacturing for export markets
- Supply of AAM components to support DBT Australia local manufacturing of diesel haulers and material loaders
- Provision of manufacturing capacity to meet high production requirements of Caterpillar Australia
- Supply of high value precision drive components to Inbye Mining Services for longwall conveyor drive systems
- Wescone ore crusher component manufacturing and new product commercialisation

New product opportunities

- Commercialisation of the Oscillating Disk Rock Cutting Technology developed and prototyped by CRC Mining, Qld
- Commercialisation of the Tight Radius Drilling Technology prototyped by CRC Mining for methane gas extraction.
- Manufacture of Ore Characterisation Machinery developed by JKMRC, Qld and designed by RME
- Undertaking a detailed industry level project to identify suitable emerging new product opportunities in cooperation with the major industry research organisations
- Collaboration with research organisations, including undertaking embedded research activities, to gain early access to new product developments.

A number of proposed industry initiatives and industry level recommendations arise from this study to promote and support company access to specific new opportunities. These include the undertaking of market development research and market access development, promotion and facilitation of industry clusters for high value opportunities, adoption of Team Australia branding in export markets, strategic broadening of the AM industry umbrella and the institution of ongoing research mechanisms to continue to identify new opportunities for industry growth through diversification.

1. Introduction

Advanced manufacturers are recognised as key players in developing the competitiveness of the Australian industry. Australian advanced manufacturers (AAM) include several industry sectors: precision machining; die and mould manufacturing; cutting tool manufacture; robotic and other automated equipment for manufacture; and design for manufacture[1]. AAM provides tools, technologies and processes for a range of industries, such as aerospace, automotive, building technologies, defence, electronics, food and beverage, medical devices, mining, packaging, rail, renewable energy, ship building and whitegoods[2].

The Australian advanced manufacturing industry, with estimated annual revenue of A$2.84 billion in 2004–2005[3], is small compared with other countries. AAM face increasing competition from low wage-cost nations and larger globalised supply chains. Despite these challenges, globalised supply chains also present an opportunity for Australian manufacturers to develop new markets in Australia and overseas.

As a response to the dynamic market, the Advanced Manufacturing Action Agenda (AMAA) was developed to provide a strategic framework for the growth and sustainability of Australian advanced manufacturers[4]. The AMAA is a government initiative, led and developed by industry, which identifies the vision, goals and scope of the advanced manufacturing industry, and outlines actions seen as critical for its development. Advanced manufacturers have traditionally relied on the automotive industry as a key driver of demand. However, the AMAA recognises the need to diversify into sustainable industries. This diversification could involve engaging with new and emerging industries and technologies, niche markets, or access points to global supply chains, while taking account of how global trends impact on Australian suppliers' performance and sustainability. A key area of action is market development, whereby market opportunities are captured by identifying key driver industries and developing specific tactics for entering into global supply chains. This report is therefore aligned to the following three market access and development actions[5].

- *Identify and monitor global trends in key driver industries and develop strategies to position Australian advanced manufacturers as suppliers to these industries*
- *Identify specific opportunities in domestic and global supply chain markets, and develop and promote strategies for the industry to capture these opportunities*
- *Identify and promote sustainable opportunities for the Australian advanced manufacturing industry arising from the diverse range of new and emerging industries and technologies*

2. Aim

This report assesses and identifies opportunities for AAM to provide products and services to the renewable energy and mining sector.

3. Research objectives

- Identify domestic and global market potential in the mining and renewable energy sectors
- Identify company level market demand relevant to opportunities for AAM companies
- Develop market development strategies for AAM industry to promote company access to identified opportunities.

4. Key deliverables

- Concise market intelligence report on the local and international mining and renewable energy sectors. This identifies market trends, the capabilities required by the target sectors, the issues and key barriers to entry, the mechanisms needed to overcome potential barriers, and key contacts to facilitate the opportunities identified
- A list of quantified viable market opportunities for AAM industry companies to pursue, based upon a market access analysis
- A set of recommended strategies to allow AAM companies to engage the market opportunities
- Advancement of the AAM industry profile in the target sectors.

5. Report outline

This report comprises five sections. First, an outline of the project methodology details the research and screening process that was used to identify and evaluate the opportunities within each sector. The second section identifies and quantifies global and local markets for the renewable energy and mining industry sectors. Third, the Australian advanced manufacturers' capabilities are described. Fourth, market opportunities and industry capabilities are matched to identify potential cross-over of demand and supply. Fifth, specific market opportunities are highlighted in terms of the scope and access requirements.

6. Delimitations

This research will specifically analyse the mining and renewable energy sectors. Within these sectors, only areas that are recognised to have commercial potential in respect to short and medium term demand are evaluated and reported.

The target industries are large and highly diverse, and hence the specific market opportunities arising out of this report are by no means exhaustive. They represent a subset of possible opportunities able to be identified by limited research in a limited timeframe. Apart from their specific potential, these opportunities should be viewed as a representative sample of further, yet unidentified, opportunities available to advanced manufacturing industry participants.

In the case of renewable energy, only a cursory investigation has been conducted in regard to a range of embryonic technologies – including wave and tidal power, clean coal technology, geothermal energy, and biofuel – irrespective of their future potential. Nuclear power is recognised by some industry commentators as a renewable energy source and has not been analysed in this report in any detail due to the current level of uncertainty in predicting its uptake in Australia, if at all.

7. Research method

This research adopts a demand-driven market orientation where the target market is segmented into identifiable homogeneous groups based upon their needs and characteristics. Each segment is analysed to determine the potential for market attractiveness. The AAM industry capabilities are identified and market segment needs and capabilities are matched. From this analysis specific opportunities are recommended. Figure 1 schematically depicts this process.

Identifying individual industry segments enable their size, scope, potential for growth and their particular needs and nuances to be analysed. Each segment must have the potential to be a commercially viable target market for the Australian advanced manufacturers. Selected key target markets were identified and analysed in greater detail; this provided the basis for matching the demand side, that is, the target market requirement, with supply, that is, Australian advanced manufacturers' capabilities.

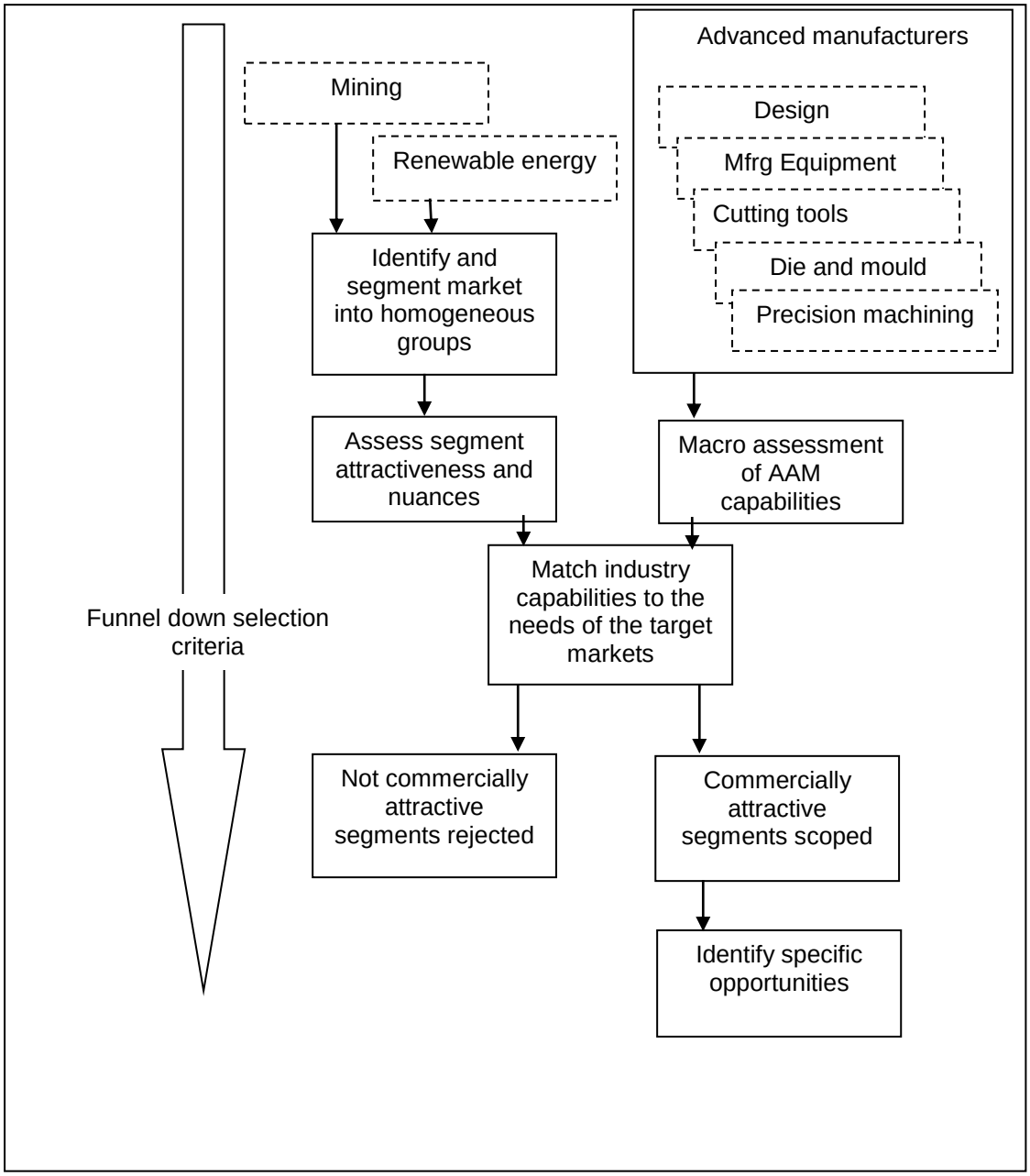
The Advanced Manufacturing Action Agenda[6] identifies five segments of Australian advanced manufacturers (AAM). These segments were analysed in terms of their supply capabilities to determine potential opportunities for the whole industry, rather than for individual organisations.

Strategic issues affecting the whole AAM industry are the lack of integrated marketing, development and leveraging on intellectual property (IP), and the lack of knowledge on how to integrate them into the value chain. This report describes methods to overcome the strategic issues and change mechanisms.

Demand of the niche markets was compared with the supply of goods and services by AAM using a criterion match. The funnel down selection criteria incorporated the following attributes:

- Market scope:
    - Scale of opportunity
    - Degree of certainty
- Implementation time frame engagement potential:
    - Number of identifiable modes of engagement
    - Quality of access potential

Figure 1: Analysis methodology



This match identified industry-wide and specific opportunities. Several potential opportunities were rejected if the match was not seen to warrant further investigation and thus the opportunities were rejected. Industry wide opportunities are identified in section 10. Specific opportunities are identified in section 11. Modes of engagement at nodes of the value chain are reported to meet these opportunities.

Modes of engagement for the renewable energy industry

- Asia Pacific Eng. Hubbing
- Capability clustering
- Consortium participation
- Engineering support
- Export
- International supply chain access
- IP opportunities
- Local content drivers
- New major projects
- New technologies
- Pilot projects
- Creation of defined products
- Special capabilities
- Strategic localisation
- Strategic partnerships

Modes of engagement for the mining industry

- Capability clustering
- Commercialisation opportunities
- Customer access mechanisms
- Export opportunities
- Import replacements
- Industry promotion activities
- International S/C access
- Local content drivers
- Major investments
- New product opportunities
- Product representation
- Replacement parts
- Sector specific marketing activities
- Specialist capabilities
- Strategic partnerships
- Supply partnerships

The research findings have been derived by the triangulation of information from various sources. The current literature was used as background material and provided leads into potential opportunities. Further investigation used the internet to specifically collect data. Finally, company visits and interviews with senior personnel collected in-depth data used to test and elaborate the propositions developed in this research. Due to the synthesis of data from numerous sources that presented often incongruent information, the researchers have made recommendations based upon their best consideration of a productive overall view with reference to the research objectives. In reflecting a diversity of valuable industry inputs a few discrepancies may be evident in this report.

8. Target markets

Traditional geographical and national boundaries have been eroded by competitive market forces, reduction in tariffs and trade barriers[7]. The liberalisation of world financial markets has facilitated the free flow of capital investments. Supply chains are being rationalised through the development of world-scale and world-class global sourcing networks as buyers seek to improve supply chain efficiencies. Advances in information technology and communications allow for seamless coordination of global supply chains.

Emerging producers with lower labour costs, such as India and China, compete with established producers such as Germany, the United Kingdom and the United States, resulting in the commoditisation of manufactured goods. Commoditisation has been credited with shrinking demand for advanced manufacturers in developed countries with resulting shifts of production facilities to low-cost countries, while activity within the advanced economies undergoes a reorientation to focus on knowledge intensive industry inputs.

Despite Australia's remote geographical location, AAM are not immune to global pressures. Reduction in tariffs, competition from lower labour cost countries, a stronger Australian dollar, and increasing numbers of multinational companies that control global supply networks put pressure on Australian manufacturers[8]. Relying on reduction in manufacturing costs is unsustainable in the long-term due to competition from countries with lower cost bases. Furthermore, AAM face increased competition from global supply chains that concentrate buyers' powers. Low-cost international suppliers actively compete in a shrinking domestic market. These pressures require AAM to refocus their attention, including exploration of new markets with significant long term potential aligned to sustainable globally competitive capabilities of the industry. The renewable energy and mining sectors may offer such potential.

8.1. Renewable energy

Renewable energy has been defined as "energy derived from resources that are regenerative or for all practical purposes cannot be depleted"[9]. Renewable energy sectors include wind, solar, biomass, wave, hydro, geothermal, biomass and biofuel. Investment in renewable energy in 2005 was estimated at US$38 billion, a significant increase from the US$30 billion in 2004. Germany and China are leaders in investment, with US$7 billion each, followed by the United States, Spain and India[10]. Table 1 compares the characteristics of the various renewable sectors.

Table 1: Indicators of the worldwide renewable energy markets

Category	2004	2005	Growth 2004–2005	Comments
World investment in renewable capacity	US$30 billion	US$38 billion	27%	Increase mostly due to solar PV (26%) and wind power (37%)
Renewable energy capacity ex. Hydro power	160 GW	182 GW	14%	
Wind	48	59 GW	24%	Fastest growing energy source with an average 32% growth during1998–2002[11]
Solar – PV	2.0	3.1 GW Investment of US$6 billion	55%	Fastest growing power generation technology Estimated investment 2006 US$ 8–9 billion
Solar – thermal hot water	75	88 GWth	14%	China accounted for 88% of new installations
Total solar	4.0 GW	5.4 GW		
Hydro				Reliant on suitable geographic areas and therefore reduces overall adoption levels
Tidal	0.3 GW	0.3 GW	---	In early stages of development
Geothermal power	9.0 GW	9.3 GW	3%	In early stages of development
Biomass power	41.5	44 GW		
Biofuel Ethanol (litres) Biodiesel (litres)	 30.5 billion 1.8 billion	 33 billion 3.9 billion	 8% 85%	

Adapted from: http://www.ren21.net/globalstatusreport/download/RE_GSR_2006_Update.pdf

Industry estimates are that world solar photovoltaic (PV) and wind energy sectors will each grow to US$50 billion by 2015[12]. Others estimate global growth per annum for wind and solar PV at 25% and 30%, respectively[13]. Presently the focus of renewable energy developments is

on the core markets in Europe and the United States. However, future markets are forecast to be China, Brazil and India, as they move from emerging markets to core markets.

In Australia, it is estimated that $257 million has been invested annually over the past three years and it is anticipated annual investments will grow to $369 million over the next three years[14]. Although Australia's renewable energy capacity has increased since 1998, the contribution of renewable energy to overall electricity needs had fallen from approximately 11.5% in 1998 to 8% in 2005[15], comprising 7% hydro power and 0.5% from wind[16], due to growth in total energy production. Australian manufacturing exports related to renewable energy are estimated at less that 0.2% of Australia's manufacturing output and employment[17].

Despite these conditions in the Australian market, the Australian Bureau of Agriculture and Resource Economics (ABARE) predicts that the renewable energy market in Australia will grow over the next 25 years, with an average annual growth of 7.9% for wind energy and 2.4% for solar PV over this period[18].

Within Australia, the solar PV and wind manufacturing sectors are valued at $102 million and $126 million, respectively[19]. Renewable energy exports have increased over the past few years, with an average of 50% of Australian manufactured solar PV products being exported[20].

8.1.1 Australian exports

Australia exports renewable energy technologies to over 70 countries, mainly located in the Asia–Pacific region. India, China, the Philippines, Thailand and Malaysia have been identified as potential attractive markets due to their diverse and widespread agricultural villages that have limited reliable electricity supplies[21]. China, for example, has mandated an increase from the 3% renewable energy in 2005 to 10% renewable energy in 2020[22]. Island communities throughout the Asia–Pacific region represent attractive markets due to the high cost of fuel transportation.

8.1.2. Drivers of adoption of renewable energy

The drivers for the adoption of renewable energy are government policy[23], improvements to efficiencies through research and development, end-user supply choices, security in energy supply, the high cost of remote area power and the rapid growth of emerging markets.

Government support for the increased use of renewable energy is the result of environmental climate change and energy security concerns. Accordingly, the adoption of renewable energy

is highly dependent the policy of individual countries. China is aiming for 10% renewable energy by 2020, and India for 10% by 2012. The United States and Canada have policy targets for renewable energy in 31 states and provinces. The European Union is targeting 9% renewable energy by 2010.

The Australian Government funds several renewable energy projects and programs[24] [25]:

- Mandatory Renewable Energy Target (MRET)
- Photovoltaic rebate program (PVRP)
- Renewable Energy Equity Fund (REEF)
- Renewable Remote Power Generation Program (RRPGP)
- Renewable Energy Development Initiative (REDI)
- Low Emissions Technology Demonstrations Fund (LETDF)
- Advanced Electrical Storage Technologies (AEST)
- Low Emissions Technology and Abatement (LETA)
- $75 million for the Solar City trials to demonstrate decentralised energy systems to households and business
- $14 million to develop long range weather forecasts for wind output
- $18 million to develop electrical storage technologies[26].

The main driver of renewable investment in Australia has been the Mandatory Renewable Energy Target (MRET) scheme[27], which has ensured that the adoption of renewable energy in Australia is in line with global trends. The scheme provides quotas to increase the adoption of renewable energy[28], with targets of 9,500 GWh or about 4,000 MW capacity to be installed by 2010[29]. Industry commentators suggest that retailers and wholesalers already have the capacity to meet MRET targets and thus, without an extension of this program, MRET will not stimulate further new investments.

Australian states and territories have their own targets and schemes, for example:

- NSW is proposing a NSW Renewable Energy Target (NRET) scheme that will enforce mandatory renewable targets for all NSW electricity retailers. The renewable

energy target levels will be 10% of NSW end use consumption by 2010 and 15% by 2020[30].

- Northern Territory funds a $46 million Renewable Remote Power Generation Program to increase the uptake of renewable energy, and is developing an Energy Policy that address renewable energy as an alternate fuel[31].

- Queensland has several rebate schemes that include the Queensland Sustainable Energy Innovation Fund (QSEIF) and Photovoltaic Rebate Program (PVRP).

- South Australia is targeting 20% of electricity to be produced from sustainable energy sources by 2015 and a reduction of 60% of greenhouse gas emission by 2050.

- Tasmania already has 96% of it electricity needs met by 29 hydro-electric power plants[32]. Other States use this electricity complement their gas and coal fired power plants.

- Victoria has a commitment to 10% renewable energy by 2016[33].

- Western Australia has numerous grants that include the Photovoltaic Rebate Program, Rural Renewable Energy Program, and Sustainable Energy Research Grants[34].

Additionally, the Australian Wind Energy Association (AusWea) and Greenpeaceare targeting 5 GW capacity by 2010, which would require an estimated $10 billion in investment.

Presently, new renewable energy sources are more expensive than fossil fuels for large-scale energy generation. Technological improvements through research and development are required to increase the efficiencies of wind farms and solar PV or thermal systems. Further developments in renewable technologies and investment in local projects will facilitate scale economies that will, in turn, reduce the cost of electricity generation and provide a base for expansion into export markets.

The developed world relies on fossil fuels for its energy needs. These resources are controlled by only a few countries, some of which are politically and economically unstable. The development of renewable energy sources will reduce the dependence on imported fossil fuels. For example, Denmark, with few fossil fuel resources, has developed wind power to supply 20% of the country's needs, and plans to expand this to 50% by 2025.

Emerging markets (particularly Asian countries) need access to new energy sources to support their increases in population and industrialisation. Many Asia–Pacific countries have small agricultural villages that require a reliable electricity supply, yet often it is not cost effective to connect them to their national grid. Similarly, many island nations face particularly

high power costs from diesel-driven generators. Remote off-grid power plants such as solar PV and wind turbine units are well matched for these applications.

In summary, the renewable energy industry faces strong long-term global growth potential to meet the increased energy needs of developing Asia and ongoing implementation in major developed economies. This strong growth has been and will continue to be driven largely by government policies to deal with greenhouse emissions and reduce dependency on fossil fuels. Niche markets within our region provide a potential competitive spearhead for small scale systems where fuel and energy distribution costs are particularly high.

8.1.3. Barriers to adoption of renewable energy

Barriers to adoption of renewable energy are identified as cost competitiveness, local environmental impacts, early stages of technology development, intermittent supply of wind and solar energy, source distance from loads and limitations of existing power distribution infrastructure. Renewable energy is still more expensive than fossil fuel sources (see Table 3). While Australia has an abundance of renewable energy resources, the country has a particularly cost-efficient coal-based power generation capability. However, real costs of renewable energy have been falling consistently over the last two decades[35]. Research and development in new technologies is improving efficiencies for renewable power plants and thus making renewable energy more competitive. Simultaneously, increased economies of scale related to substantial ongoing manufacturing growth in the industry enable cost per unit output to be reduced.

Table 2: Estimated costs of producing electricity from various energy sources

Technology to produce electricity	Comparative cost per mWh[36] in Australia	Cents per kWh[37] in USA	Cents per kWh[38] in UK
Coal	31–40		6–7.7
Nuclear		8	5.5
Natural gas (combined cycle)	37–44	6	4.3
Small hydro	40–70*		
Large hydro	10–81		
Landfill gas/sewage gas	40–60		
Bagasse	30–100*		
Wind	60–80	4.2–6.6	8.9–12
Geothermal hot rocks	40–130		
Tidal power	80–175		16
Solar PV	400–800		

* Low cost/risk hydro and bagasse projects have already been exploited under the Commonwealth's MRET scheme

The local environmental impact of new renewable energy sources is a major issue for new developments. Consequently, no significant new hydro-electric capacity is likely to become available in Australia, and the siting of potential wind farms and solar arrays is significantly constrained, particularly in regard to tapping coastal wind resources, by community acceptance and/or attaining cost-effective plant locations in proximity to large populations.

A substantial proportion of Australia's renewable resources is located distant from populations and are not aligned to existing centralised power distribution networks. The infrastructure costs associated with remotely located large scale renewable energy sources may significantly add to their direct generation costs.

Intermittent supply of solar and wind energy has the result that reliance beyond a threshold level of supply depends on the future development of economical storage technologies. Industry experts suggest solar and wind will not be able to replace fossil fuels due to the inconsistent wind and solar outputs and the inability to cope with demand fluctuation. Power production is independent of demand schedules. Current electricity storage solutions are highly expensive.

8.1.4. Summary

In Australia, electricity is produced cheaply from coal. As a result, government policy will need to support the ongoing implementation of new renewable energy production for substantially longer than in most other countries where fossil fuel costs are higher. Siting of renewable energy plants, affected by local environmental impact and availability of distribution networks, will increasingly influence the industry as "easy" locations are locked up by early projects. The fundamental cost barrier will be eroded by ongoing technological developments and scale of manufacturing gains that continue to improve cost competitiveness towards parity with fossil fuels. This may be achieved on a broad scale within one to two decades. Potential exists for efficiency breakthroughs in either wind or solar energy costs, or the implementation of carbon cost accounting, to create a more radical shift in viability.

Based upon the assessment of the current development and future potential of the various renewable sectors, solar and wind power are recognised as having close compatibility with the AAM needs and capabilities. Australia's growth in solar PV and wind is around 30% per annum, in line with global rates[39]. Excluding hydro, wind contributed 30% to renewable capacity in 2005[40].

This study has selected three renewable technologies to consider more closely for Advanced Manufacturing opportunities. The chosen areas include photovoltaic solar system manufacturing, solar concentrator system technology and wind energy. These three areas

have been selected on the basis of i) the potential for application of existing or reasonably attainable AM capabilities to meet identified requirements within these sectors, and ii) evidence of significant current and prospective short term investment levels in each sector.

Longer term and potentially large opportunities exist in several other identified energy technologies that may align with Advanced Manufacturing capabilities. However, these are at an embryonic stage of development and their potential for industry engagement cannot be ascertained at this stage.

Of these technology areas, wave and tidal power sources are subject to extensive research worldwide. A number of highly promising technologies are now reaching commercial prototype testing stages; two designs are being actively developed in Australia (Portland and Port Kembla). Research by the UK Renewable Energy Association suggests that this energy source is roughly at the stage of development of wind energy 25 years ago, and is likely to follow a similarly steep growth path. The systems currently being tested utilise highly diverse generating principles and it is likely that a dominant technology will emerge over the next five years.

Notably, the potential for establishing a nuclear energy industry in Australia has been raised. Based on overseas experience, this industry requires a high level of Advanced Manufacturing activity in plant construction, sophisticated custom designed automated and remotely controlled system actuation, and material handling systems.

Clean coal technologies that are currently at an early stage of research and development in Australia may also present a source of Advanced Manufacturing opportunities in the future, depending on the success of the ideas that are being proposed.

8.2. Solar energy collecting devices

Solar energy can be collected by several types of devices:

- Photovoltaic (PV) systems, where solar cells directly convert sunlight to electricity, can be used at the “off-grid” applications (such as residential homes) or fed into the electrical grid. Off-grid systems make up the majority of the market[41].

- Solar PV concentrators use lenses or reflectors to concentrate the sunlight on solar cells, modules and arrays[42].

- Direct solar thermal panels heat fluid or air for residential or light industrial applications. Solar thermal (such as solar hot water systems) has the advantage that heat can be stored for later use.

- Solar thermal concentrators focus the energy of sunlight on a receiver where the resulting high temperatures may be used to produce electricity using a gas cycle in a similar manner to traditional power stations.

- Solar updraft towers generate electricity by channelling rising, less dense hot air to turn turbines.

- Passive solar systems control heat through architectural design.

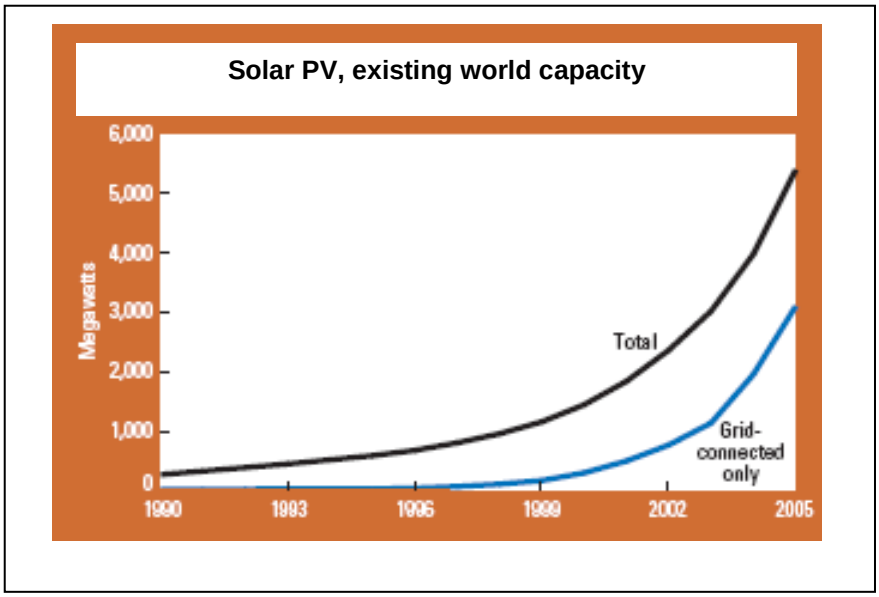
- Solar ovens trap solar energy to heat food.

The photovoltaic (PV) industry is credited as containing the fastest growing and most profitable companies in the renewable energy sectors[43]. Solar PV and solar thermal are recognised as having significant potential for future growth; significantly, the manufacturing processes and growing manufacturing volumes of solar PV match the capabilities of Australian advanced manufacturers.

8.2.1. World trends

Grid-connected solar PV was the fastest growing renewable energy source during 2004–2005, with capacity increasing from 2.0 GW to 3.1 GW, an increase of 55%. Global production capacity increased from 1.15 GW in 2004 to 1.7 GW in 2005. The countries with the largest increase in grid-connected solar PV in 2004–2005 were Germany at 600 MW, Japan 300 MW, and the United States 70 MW. Figure 2 schematically depicts the trend of installed solar PV capacity[44].

Figure 2: Solar PV capacity trends 1990–2005



Source: http://www.ren21.net/globalstatusreport/download/RE_GSR_2006_Update.pdf

Japan and Germany are the leaders in solar PV exports. Their success has been attributed to strong government support to build economies of scale that were leveraged to grow their export markets. Leading producers of solar PV in 2005 were identified as Japan (830 MW; companies include Sharp, Sanyo and Kyocera), Europe (470 MW), China (200 MW; companies include Nanjing CEEG PV Tech, Yingli Solar and Suntech Power), and the United States (150 GW)[45]. Australia's primary use of solar PV is for light industry and residential homes. Due to the high cost of solar PV cells, niche or remote applications are the most common[46], with an estimated 87% of Australia's total solar PV output used in off-grid applications.

8.2.2. Australian manufacturers

In Australia, BP Solar employs 300 people and is the largest solar PV panel manufacturer in the southern hemisphere. The plant has annual total capacity of 50 MW, servicing professional customers requiring complete solar electricity systems. The plant exports 75% of production[47]. Worldwide, BP Solar is a major manufacturer of solar PV cells. Employing over 2,000 people, BP Solar operates five plants in the United States, Spain, India and Australia. Completed projects include Burstadt, Germany (5 MW), Springvale, USA (4.6 MW) and Geiseltalsee, Germany (4 MW). Manufacturing plants are located in Spain and India; current annual manufacturing capacity is being increased from 55 MW to 300 MW[48], with a target of reaching five 200 MW capacity plants by 2010. The relatively small Australian plant is a used as a technology test-bed for the whole company, with new process being developed and trialled here then shipped to the other plants.

Solar Systems has implemented four PV concentrator systems for remote area applications and is now developing a $420 million Heliostat Concentrator Photovoltaic solar power plant in Victoria, with the objective of demonstrating large scale solar electricity generation that is cost competitive with fossil fuels. The project is enabled by $125 million in state and federal grants, and will deliver on-grid capacity of 154 MW. The company's strategic plan is the global implementation of 5,000 MW of concentrated solar generating capacity by 2030.

Origin Energy manufactures solar panels using sliver technology developed by the Centre for Sustainable Energy Systems at the Australian National University. Manufacturing capacity of solar PV modules is 7 MW per annum and is able to expand to 25 MW per annum[49].

Australia's strength in research and development of solar PV cell and PV concentrator technology research is internationally recognised[50]. Research institutions include the University of New South Wales, Australian National University, University of Newcastle, CSIRO, Research Institute for Sustainable Energy Centre, BP Solar and Origin Energy.

8.2.3. Components

Photovoltaic (PV) solar cells covert sunlight into electricity. Multiple PV cells are connected to form PV modules; a collection of PV modules is called a PV array. Combining PV modules and arrays in parallel or in series can create the desired electrical output.

Types of PV applications include:

- fixed panel mounts with tilt: the tilt angle of the PV arrays is set to maximise electrical output throughout the season
- solar tracker: motors and software vary the tilt angle to follow the sun to maximise the electrical output. Motors require drive train and gears
- multi-mirror reflective units: heliostats (typically mirrors) concentrate sunlight into a PV module. Advanced designs in heliostats use algorithms to continuously calculate the sun's position to determine the optimum angle for the PV module.

Typically PV cells have a 25-year life span and are affected by extreme heat. Their use has been limited due to their high manufacturing costs and a worldwide shortage of silicon wafers. However, manufacturing costs are estimated to be reducing by 3–5% annually[51].

8.2.4. Barriers to adoption of solar PV

Manufacturing costs of solar PV cells have been kept high due to worldwide shortages of silicon wafers. This material input represents 60–70% of the total product cost, and its limited availability directly affects PV production capacity[52]. This has reduced the dispersion of solar PV technologies, resulting in relatively low adoption of solar PV cells[53]. However, the industry anticipates a substantial improvement in the cost and availability of silicon wafers by 2008. Within the same time-frame, the rapid increase in production volumes and technological improvements will ameliorate currently high manufacturing costs for solar PV cells and ancillary equipment[54], delivering ongoing reductions in comparative energy production costs.

The cost structure for solar systems involves funding large up-front capital expenditure, followed by energy production with minimal operational costs over an effective payback period of approximately seven years.

The inherently intermittent diurnal cycle of solar availability caps its estimated maximum production to 20% of grid needs. For off-grid applications, the additional expense of either an extensive battery storage system or backup generation capacity adds substantially to total implementation costs.

8.2.5. Drivers of solar PV

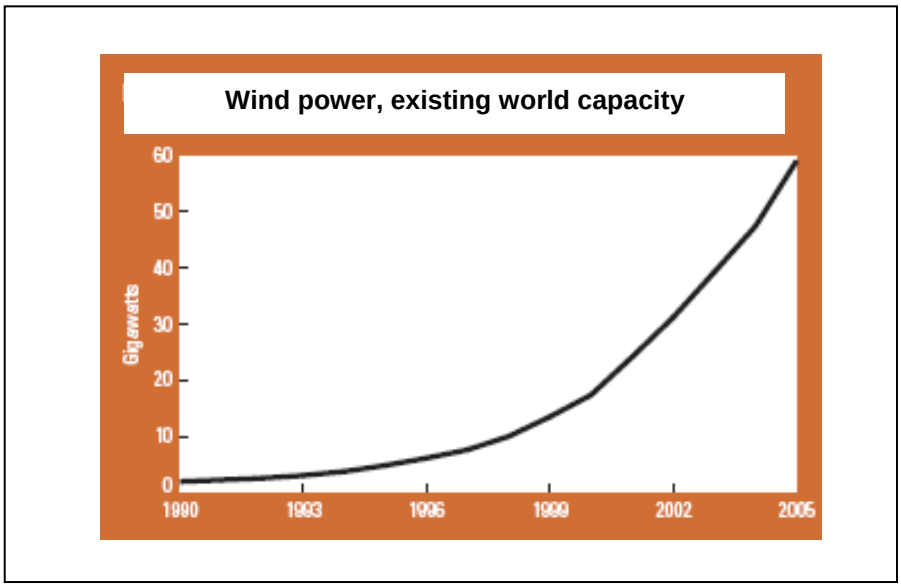
Technology improvements through research and development increase the efficiency of panels, lower unit production costs and lower the installation costs of new projects. This results in improvements to the comparative affordability of solar PV against other energy sources. Developed by ANU, sliver technology is an example of a new technology that promises to substantially improve efficiency and reduce manufacturing costs.

Scale economies are credited with low unit manufacturing costs. Countries such as Japan and Germany have developed significant domestic production capacity and thus used this capacity for leverage into international markets. Small scale specialist manufacturers may find difficulty in competing in competitive global supply chains.

8.3. Wind energy

Wind energy is the fastest growing renewable energy source both in Australia and internationally in absolute terms, with total world wide wind generation capacity estimated at 59 GW in 2005[55], roughly equivalent to Australia's total electricity generating capacity. The exponential rise from 1990 to 2005 in the world wind power capacity is illustrated in Figure 3.

Figure 3: World wind power capacity, 1990–2005



Source: http://www.ren21.net/globalstatusreport/download/RE_GSR_2006_Update.pdf

The 24% increase in generating capacity from 2004 to 2005, on top of average annual growth of around 30% over ten years, is testament to the potential of wind power. Ten countries accounted for 87% of new capacity installations in 2005, as shown in Table 3. The potential for wind power generation has been estimated at 20% of the total electricity demand[56].

The cost of wind energy production has decreased by 75% over the past three decades and it is expected that within 15–20 years coal and wind generation costs will converge[57]. In 2006, costs were approximately twice that of coal produced energy[58]. At an annual growth rate of 28%, wind power could potentially deliver 29% or the world's electrical energy by 2030[59]. Denmark has the highest penetration of wind power, contributing 20% of national electricity demands[60]. In Spain and Germany, wind power contributes 8% and 5% of national demand, respectively[61], and the EEC is targeting 12% wind power to meet their Kyoto Protocol requirements.

Table 3: Changes in wind generation capacity

Country	Total MW capacity (2005)	New MW capacity installed Jan–Dec 2005	% of new world installations (2005)	Plans
USA	9,100	2,431	21.1	expected additional 3,000 MW to be installed in 2006
Germany	18,400	1,808	15.7	
Spain	10,000	1,764	15.3	
India	4,400	1,430	12.4	estimated to grow 1,500 to 1,800 turbines p.a. for 3 years
Portugal		500	4.3	
China	1,200	498	4.3	goal of 30,000 MW by 2020
Italy		452	3.9	
UK		446	3.9	
France		367	3.2	
Australia	800	328	2.8	6 GW in various stages of site identification and pre-construction
Top 10 total		**10,024**	**86.9**	
Rest of world		1,507	13.1	
Denmark	3,100			
Japan	1,000			
Canada	700			expected 500 turbines for 2006
World total		**11,531**	**100**	

Adapted from: "Global Wind Energy Outlook 2006" Global Wind Energy Council

In Australia in 2002, the cost of installing wind power farms was estimated to be A$1.3–2 million per MW of capacity[62] . In 2004, the Lake Bonny Wind Farm project was estimated at A$1.4m per MW installed capacity[63]. Installation costs for wind power projects are decreasing in real terms due to improved technology and efficiency.

In 2006, Australia installed 563 wind turbines in 42 wind farms, delivering wind energy capacity of 817 MW. Wind energy contributes 0.5% of Australia's electricity requirements[64] with 85% of production grid-connected[65]. A further 765 MW is approved for development and over 1,000 MW of projects are in the investigation or planning stage in Victoria alone[66]. Despite less than 1% of Australia's electricity being derived from wind power, the existing networked infrastructure has the potential to deliver up to 10%[67].

8.3.1. Industry players

Denmark is the global leader in wind turbine manufacture, holding 40% of the wind turbine market, of which 90% is exported. In 2002, the total Danish manufacturing industry was estimated to be worth A$5.15 billion[68]. Vestas of Denmark control 28% of the global market for the installation of large wind turbines[69].

The international wind power market is dominated by five companies that supply 75% of the wind turbines. Vestas, Nordex, Gamesa, Acciona and GE Energy are leading global players with manufacturing plants around the world. Recognising the pressures of supply chain efficiencies, Vestas (Denmark), Suzlon (India) and Nordex (Germany) are expanding their nacelles, hubs and blades manufacturing plants to China.

China is the leading manufacturer of small wind turbines, accounting for 29% of turbines installed in 2005. Chinese manufacturing companies are trialling larger turbines. For example, Harbin Electric Machinery Co. is a new entrant testing 1.2 MW turbines and Dongfang Steam Turbine Works a new entrant testing 1.5 MW turbines. Some major international industry players are listed in Table 4.

Table 4: International wind energy component manufacturers and installers

Company	Size	Country/contact details	Manufactured component
Accionia Energy[70]	Managing 3,133 GW capacity	Spain www.ehn.es	Turnkey global services
Enercon	11.4 GW capacity installed to date	Germany www.enercon.de	Turnkey global services
Gamesa [71]Eolica	13.4% market share	Spain hwww.gamesa.es	Turnkey global services 28 plants world wide
GE Wind	9,100 turbines installed to date	US www.gepower.com	Turnkey global services
Nordex Energy	3,000 turbines installed to date	Germany www.nordex-online.com	Turnkey global services
Notus Energy	Not available	Germany www.notus.de	Planning, developing and maintaining wind farm projects
REPower	10% German market share	Germany www.repower.de	Turnkey global services Office in Australia Suzlon is currently mounting a takeover
Siemens		Germany www.siemens.com	Research and development, manufacturer of wind turbines
Suzlon Energy	Largest Indian 2 KW turbine manu.	India www.suzlon.com	Turnkey global services in Asia and India
Vestas Wind Systems	28% world market share 12,300 FTE[72]	Denmark http://www.vestas.com	Turnkey global services Offices in Australia

8.3.2. Technology

The major design considerations for drive wind turbine design are:

- capital cost per kWh generation capacity, dependent variously on machine cost, capacity, efficiency and low wind performance
- long term reliability under 24-hour operation with minimum maintenance requirements
- resistance to extreme weather including dust, rain, high winds, snow, ice and lightning
- low noise emission.

Subsequent to early development of wind turbine technology in the US in the 1970s, European machines from Denmark, Germany and Holland gained dominance in the industry, based largely on the high level of reliability achieved by their machine design. Initially small by today's standards, with capacities around 50 KW, the design of these machines has been progressively upscaled, with capacities of 500–750 KW being widely utilised by 2000, and most installations today comprising machines with a capacity of 1000–2000 KW.

Machines over 2000 kW have been commercialised, initially in off-shore wind farms, and the largest machines now reach a size of 5000 kW. A typical 1650KW machine has a rotating diameter of approximately 80 metres and a 50 ton nacelle mounted on a tower up to 80 metres high.

The predominant design currently in use is a horizontal axis, 3-bladed up-wind machine utilising a high ratio step-up gearbox between the slowly rotating blade hub and a high speed generator. This machine configuration is offered by all major manufacturers with individual variations. The most advanced systems incorporate independent servo-controlled blade pitch adjustment. Synchronous generators connected to variable frequency power inverters have entered the market in competition to well proven constant speed asynchronous systems, providing the ability for variable speed operation and potential improvements in both efficiency and noise reduction.

An alternative electrical design using a directly driven large diameter ring generator has been successfully implemented by several leading companies (including 10 750kw units built by Siemens in Latrobe, Victoria in 2001 for the Dutch company Largerway, and installed in Japan). This design eliminates the expense and unreliability associated with step-up gearboxes, but has the disadvantages of a large nacelle diameter and weight, high generator cost and problems with contamination.

Advances in blade design include incorporating highly effective lightning conductors, increased blade diameter and hence swept volume, improved efficiency and reduction in aerodynamic noise. Companies around the world are researching alternative system and component designs with the aim of delivering lower costs. The Wind Turbine Company in the US is working on a lighter and simpler flexible 2-bladed down-wind design. Windflow Technologies in New Zealand has developed a 2-bladed machine utilising patented gear technology to reduce system shock loads. Terra Moya Aqua Inc. in the US and Dynamic Systems P/L in Australia are working on high capacity vertical axis machines. Nexxtdrive in the UK holds patents for an electronic variable ratio gearbox.

8.3.3. Australian manufacturers

Current local content for Australian wind farms is estimated at 50%[73] of total project requirements, with the balance from German and Danish manufacturers. Australian components of wind farms typically make-up 44-40% of project costs, mainly in tower and civil engineering construction[74]. Small turbines (under 30 kW) are manufactured in Australia from imported and local parts.

Australian firms specialising in site monitoring, design, installation, maintenance and operation include Pacific Power International, Pacific Hydro, Western Power Corporation Ltd, and Hydro Tasmania[75]. Local manufacturing and installation companies active in the local industry are illustrated in Table 5. Australia has been proposed as an ideal centre of wind generation technology, exporting turbines and machinery to wind farms in the Asia–Pacific region[76]. However, there are presently no large scale turbine manufacturers in Australia and the majority of locally manufactured products are destined for local markets[77].

Table 5: Domestic wind energy component manufacturers and installers

Company	Size est.	State/contact details	Manufactured component
Air-Ride Technology	100 FTE	South Australia	Wind towers and other steel fabrication
Areogenous Australia	Start-up	www.aerogenesis.com.au	Developing 1.5 kW and 5 kW turbines
Aus-tech Composites	30 FTE	Tasmania www.atcomposites.com.au	Nacelle components for Vestas
Bolwell Corporation	unknown	Vic www.bolwell.com.au	Blade manufacturer and other composite product manufacturers
Eliott Engineering	unknown	Vic www.eliottgroup.com.au	Wind tower and medium to heavy engineering
Flowtrack	Unknown	www.flowtrack.com.au	5kW wind turbines, design and manufacture using University of Newcastle designs
Gridlink Wind Turbines	5	Victoria www.gridlink.com.au	Manufacturers of small wind electric turbines and control systems including assembly plants, towers and micro wind turbines
Haywards Engineering	20 FTE	PO Box 47 Kings Meadow Tas 7258 (03) 6391 8508	Wind towers and general steel fabrication services
Keppel Prince Engineering	75	PO Box 515 Portland, Vic 3305 (03) 5523 3944	Wind towers, steel fabrication and crane hire
Powercorp	unknown	NT www.pcorp.com.au	Represents Enercon in Australia wind/diesel/energy storage technology
PowerCorp	40	NT www.pcorp.com.au	Microprocessor and automation controls and management systems for wind diesel power stations
Siemens		Vic	Direct drive generators
Soma Power trading as Sunrise Solar	2	NSW www.somapower.com.au	Manufacturers of small wind electric turbines and control systems including assembly plants, towers and micro wind turbines
Sterling Wind	unknown	Vic www.wind.com.au	Install wind turbines from 150 kW to 3,000 kW Represents Nordex in Australia
Vestas Wind	70 FTE	Vic and SA	Blades, capacity of 225 blades

Systems		www.vestas.com	per annum[78] in Vic and blade plant in SA
WestWind	15	WA www.westwind.com.au Recently sold to firm in Northern Ireland	Manufacturers of small wind electric turbines and control systems, including assembly plants, towers and micro wind turbines

8.3.4 Components

Major components in typical wind generators include blades, hub, pitch control system, main shaft and bearings, step-up gearbox, generator, chassis, yaw bearing, yaw drive and braking system, nacelle housing, towers, hydraulics, power electronics and electrical control systems. A typical life expectancy of a Megawatt class turbine is 20 years with rebuilding of the generator and gearbox two or three times within this period.

Locally made towers contribute approximately 14% of projects costs. Towers are manufactured in Australia due to high freight costs[79] and are generally 50–80 metres high. Wind turbines account for approximately 56% of project costs. Technologies include Danish gearbox turbine and the gearless or ring generator turbine, of which a highly successful design was manufactured by Siemens in the Latrobe Valley in Victoria for an export contract. Blades up to 40m long are currently being both locally manufactured (Vestas, VIC) and imported with high freight cost.

Historically, wind energy manufacturing in Australia has been closely tied to the local requirements of specific projects, primarily related to wind farm developers seeking to provide benefits to win the approval of local communities. These projects are driven by government policy targeting minimum renewable electricity requirements for retailers and wholesalers. These targets make wind power an economically viable alternative to other forms of renewable energy.

Opportunities exist for advanced manufacturers to supply wind farm equipment in the areas of towers, blades, blade hubs and nacelle equipment. A competitive strategy could initially focus on specific components that are of a weight or size that incur high freight costs and associated logistical difficulties, or on providing essential local support, such as electrical maintenance and gearbox rebuilds.

Innovative construction techniques developed by Australian tower manufacturers are being implemented in Europe and are successfully achieving export orders. Similarly, engineering companies that have gained experience in the local wind industry have subsequently won significant work developing projects in overseas markets, including China.

Another opportunity exists for smaller stand alone generation systems required for remote areas that use combined wind/diesel systems. This smaller capacity 20–25 kW equipment and sub-assemblies are required in remote areas to reduce dependence on diesel. The smaller turbine sizes are more feasible for remote mining, farming and indigenous communities[80] and have the potential to match export requirements in Asian and island market.

At current costs, the implementation of 5% of wind energy generating capacity across Australia by 2015, representing a medium level scenario estimate, would equate to an approximate total capital investment of A$5,000 million, estimated to be a sufficient level of activity to support the development of extended local manufacturing capabilities.

8.4. Mining

This report adopts the definition by ABARE (2005:6) "*Mining (excluding petroleum) includes mineral exploration, mining (extraction), quarrying, and coal, and mineral processing including smelting and refining of metals and minerals)*". Mining products are regarded as commodities that are traded in a global market, with purchase decision made largely on specification and price considerations[81]. The mining industry contributed 5% to the world's GDP and 5.5% of Australian GDP in 2006[82]. The demand and supply for mining goods and services is a global marketplace with intense competition from suppliers around the world.

The cyclical nature of the mining industry follows the broad economic cycles. Presently, the world is experiencing a worldwide boom in resources that is expected to continue to 2011[83]. Net profits from mining companies increased 59% from 2004 to 2005. Mining firms increased their investment activities by 41% to US$38 billion during this period, the focus of mine operators being mine supply and maximising production[84]. Similarly, Australia has followed this boom period with new capital investment rising 70% in the year ending June 2006[85] .

The mining industry is dominated by large conglomerates that are well integrated into the supply chain[86]. Mergers and acquisitions of large miners continued throughout 2005 and 2006[87] such as BHP Billiton acquisition of WMC Resources for US$7.2 billion. The largest ten mining companies in the world by capitalisation in December 2005 were BHP Biliton, Rio Tinto, CVRD, Anglo American, Newmont, China Shenhua, MMC Norilsk, Anglo Platinum, Xstrata and Barrick Gold[88]. These companies control the world's largest deposits of aluminium, coal, copper, gold, iron ore, manganese, nickel, palatinum group metals, silver, zinc and industrial metals[89].

Australian mining industry contains world-scale and world-class companies[90]. ABARE[91] reports record export earnings by Australian mineral resources in the December quarter of A$27.1 billion as a result of increased prices and volumes. Commodity mineral exports account for 30% of Australia's total exports of goods and services each year[92]. Mineral and commodity exports include coal, bauxite, iron ore, alumina, uranium, gold, silver and diamonds.

The mining technology services (MTS) sector relies on the mining industry as it provides contract, subcontract and commissioned work[93].The MTS sector receives a substantial portion of their revenue from mining companies in return for goods and services based upon specialist technology, intellectual property or knowledge[94]. MTS supports the mining industry by providing[95]:

- mining software and equipment
- scientific analysis
- exploration assessment technology
- mineral processing technology
- environmental and consulting services and
- health and safety services and equipment.

The Mining Technology Services Action Agenda developed in 2001 targets $6 billion sales from the MTS sector by 2010. In the 2003–2004 period, gross sales revenue for the Australia's MTS were estimated at $4.75 billion, with exports valued at $1.1 billion. The key markets in East and South-East Asian regions were worth $791 million. Individually, Indonesia contributed $382 million, China $90, and other remaining regional countries $319 million. Exports to the United States were valued at $109 million[96].

Of particular interest to AAM are the contract mining, materials and equipment supplies, and engineering and construction services. Austmine claim that 80 members are part of the MTS sector. Their complete membership database can be examined at www.austmine.com.au Individual areas of expertise (as defined by Austmine[97]) of interest to AAM are differentiated in Table 6.

Table 6: Areas of potential interest to AAM

Contract mining	Materials & equipment supplies	Engineering & construction services
Mining and process R&D	Exploring equipment and consumables	Mine infrastructure
Fine coal beneficiation and process control	Underground and above ground mining equipment and vehicles	Mineral processing and beneficiation plants
Strata reinforcement technology	Rock bolting and strata reinforcing equipment	Liquid and gas pipelines
Hazardous mining environmental technology	Drills and drilling supplies	Material handling facilities
Alluvial mining and mineral sands operations	Beneficiation equipment and supplies	Ship loader and port facilities
Materials handling systems	Pumps, pipes, valves and fittings	
Mining maintenance and technology	Conveyor systems and components	

Australia is described as a leader in the export of mining equipment, services and technologies[98]. The size of the MTS machinery and equipment manufacturing sector in 2003–2004 by gross sales was $1,110 million or 18% of total gross revenues. Exports in the sector were estimated at $271 million or 24% of total exports[99]. China ($83 million), North America ($29 million) and South Africa ($26 million) are seen as the most important markets for machining and equipment manufacturing[100]. Canada and South Africa are recognised as key competitors in mining technology services (MTS), the substantial domestic mining industries underpin their MTS sectors[101].

8.4.1 Supply chain

Demands for mining goods and services are from integrated producers, producers, exploration companies, small scale operators and prospectors[102]; primary buyers are mining conglomerates. Trends[103] in mining operations are: increased scale in equipment deployed; decreased staffing levels, with operators being multi-skilled and being able to operate new technologies; and innovation through research and development to maintain cost competitiveness and facilitate cost reductions. Critical technologies employed in mining operation[104] are identified as information and communications technologies for process optimisation, remote control and automation, operations and maintenance, and unit operations capabilities. Mining companies are concerned with increasing efficiency and effectiveness of operations, and want to buy a complete package from MTS suppliers who are perceived as trustworthy and innovative. The nexus between quality, cost, service and reliability of goods and services are key considerations for buyers[105].

In contrast to the concentration of large mining conglomerates, the Australian MTS sector in 2003–2004[106] was fragmented and dominated by a number of small firms, as suggested by the following characteristics:

- 16,800 FTE employed in the sector
- 52.7% employ less than 10 FTE
- 51.9% have gross sales of less than $1 million per annum
- 26.1 % have gross export revenue more than $1 million per annum
- 29.6% own patents that are registrable.

However, despite the numerous small MTS firms who employ most of the FTEs, the larger companies account for the majority of turnover and export sales (Table 7).

With few intermediaries in the supply chain, MTS suppliers often sell directly to the mining industry. It is estimated that MTS suppliers sell 77.3% of goods and services directly to mining companies, 16.8% to contractors, and make insignificant sales to manufacturers or wholesalers. An alternative approach to entering the supply chain is through global Engineering, Procurement, Construction and Manufacturing (EPCM) firms[107].

In 2000, Quadrem.com was established as a global e-market supply portal to facilitate world-wide sourcing for the mining industry. In 2006, Quadrem[108] reported in excess of 50,000 buyers and sellers, an annualised US$13.4 billion in online transactions, 9.3 million catalogue items and maintenance of over 5 million documents per month. This portal is particularly suited to MRO suppliers whose commoditised products are ideal for online catalogue sales.

Table 7: MTS sector analysis by company size

Business size by full-time employee (FTE)	% labour force for the MTS sector	Gross sales 2003–2004		Gross export sales revenue 2003–2004		Gross sales by internet channel 2003–2004	
		$m sales turnover	% total gross sales revenue	$m sales turnover	% of gross export revenue	$m sales turnover	% of gross sales
Small 0.001–10 FTE	53	180	4	38	3	6	3
Medium 10.1–50 FTE	24	307	6	84	8	4	1
Large >50 FTE	21	4,270	90	991	89	17	0.4
Total						**27***	

Note* Total $27 million gross sales via the internet channel with $17 million from large MTS firms. Adapted from: ABARE (2005) "*Mining Technology Services: A Review of the Sector in Australia*", Australian Government Department of Industry, Tourism and Resources, Canberra. p.30-42

In 2003–2004, an estimated $27 million of gross sales revenue was generated online for the MTS in Australia, equating to less than 0.5% of gross sales[109].

8.4.2 Drivers in mining sector investment[110]

Drivers in the mining sectors are identified as:

- economic cycles. Broad economic cycles create the 'pull' for mined materials. China, Russia and India have been recognised as 'sleeping giants' in the global mining industry. China's rising investment in fixed capital, urbanisation and industrialisation will drive demand for several more years[111]; in 2005 China was suggested to account for 30% of the world growth in mining[112]. India may 'pull' demand in the future as the country industrialises

- lowering production costs to maximise profitability

- enhanced productivity of workers and equipment to maximise profitability and to counter the effects of upward pressure to share the profits by contractors, employees and governments[113].

- opening new mines and extending the life of ore bodies. Existing operations are at full production with few new projects coming on line, as a result of under investment in

the late 1990s and access to prospective land becoming more difficult. Mining is a long-term investment as lead times for new mines can be ten years[114].

- meeting increasingly sophisticated environmental requirements and ensuring best practice in meeting environmental standards

- Increasing global standards for mine safety and the application of new technologies to address the safety challenges of the hostile mine environment, and increasing mine automation

- growth in the resources demands and mine investments in developing South-Eastern Asian markets, for which Australia represents a recognised world mining industry leader, in efficiency and technology, located within geographical proximity.

8.4.3 Barriers to entry into mining opportunities

Barriers to entry into the MTS sector include:

- new projects being harder to deliver due to their size and complexity[115]. Thus SMEs have difficulty in meeting demands in large scale mining projects[116] and therefore must work collaboratively to form supply networks

- entry into the mining industry global supply chains where existing knowledge and reputation are regarded as important prerequisites. ICN experience indicated that Australian suppliers were given token participation in major contracts with the majority of work allocated to contractors who had prequalified on the Engineering Procurement Construction and Management global chain[117]

- tyranny of distance. Although abating, Australia's distance from European and North American markets increases response times and adds freight costs. Historically, Australian manufacturers have not had sufficient local market size to sustain the development of competitive machinery technologies. Distance also provides a competitive barrier for imports in fields where world leading technology developments are occurring in the Australian industry and are providing a global spring-board for specialist local MTS companies.

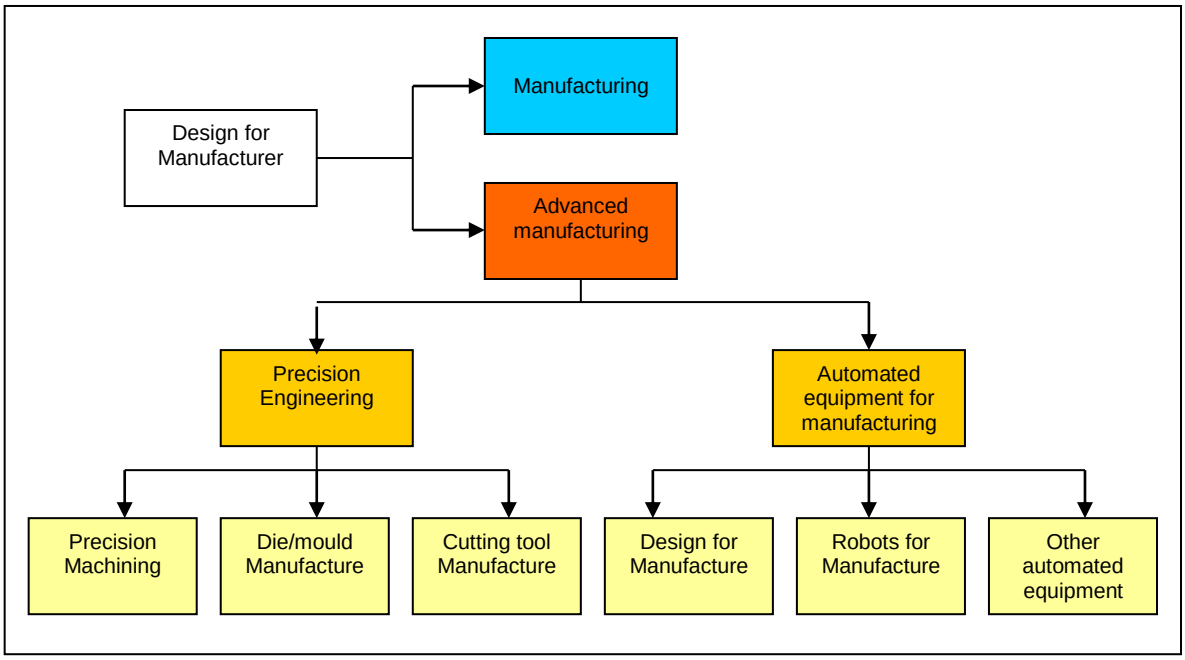
9. Australian Advanced Manufacturers' capabilities

A detailed statistical review of the AM industry was presented by the AMAA in August 2005, in its paper "Measuring the Industry Statistics and Performance".

Briefly, the AAM industry in 2004 was estimated to have a total turnover of $2.84 billion, with value added of $1.36 billion and exports of $537 million. The industry employed around 12,000 people and had an annual growth rate of 2–3%.

The industry consists of two major segments with different categories of products and different market applications (figure 4). The Precision Engineering segment represents a wide range of manufacturing activities that require a high level of engineering and manufacturing precision, while the Automated Equipment for Manufacture segment concentrates on applying smart technologies and equipment to manufacturing processes.

Figure 4: Arrangement of the seven industry sectors



Source: Advanced Manufacturing Action Agenda, June 2006

The size of each sector, indicated by total revenue and value added in 2004, is shown in Table 8.

Table 8: Revenue and value added for industry sectors, 2004

Sector	Total revenue $ million	Value added $ million
Precision Machining	400	136
Tooling	1000	560
Cutting Tools	158	32
Machine Tools	309	170
Robotics	191	76
Other Automated Equipment	650	293
Design for Manufacture	130	91
Industry Total	**2,838**	**1,357**

Source: Advanced Manufacturing Action Agenda, June 2006

9.1 Capabilities by sector

The definition of each AM sector is based on a generic categorisation of industry products or outputs. However, the broad capabilities of each sector are more effectively indicated by the particular processes and activities that are applied. Market opportunities in the target industries of this research can be gauged from the constituent activities and technologies generating the sectors' outputs, and the technical capabilities that enable those outputs.

The capability sets in each sector are also analysed to differentiate between skills and capabilities specific to existing customer industry products, and underlying or broader capabilities that can potentially be applied to new industries, technologies or products.

9.1.1 Precision Machining

The Precision Machining (PM) sector can manufacture components not achievable by common machining facilities. Sophisticated software and equipment is used to generate highly complex forms with great accuracy and make components with requirements towards the limits of machining technology, including very large parts, very small features, highly delicate components and those using exotic materials.

Size of companies ranges from very small to those with over 100 FTE's. Large precision machining companies are able to apply a wide range of specialist processes and provide important supporting activities such as CAD design, automated metrology and project

management. Many companies that specialise in other AM sectors offer a Precision Machining capability to the market.

The advanced capabilities of the PM sector are not market sector specific and therefore they have wide potential for application in any customer industry with requirements for machined components.

9.1.2 Die and Mould Manufacturing

Die and Mould (D&M) Manufacturers in Australia produce formed tools with complex shapes, fine detail and intricate internal mechanisms, using a range of difficult-to-machine steels. Their products incorporate detailed specialist knowledge of the repetitious manufacturing processes to which their tools are applied.

The sector comprises a significant number of medium-sized companies employing 25–60 people, as well as a large number of small and very small companies.

Companies are typically specialised in the design and manufacture of particular types and sizes of tools (eg: medium sized plastic injection moulds), and mostly do not engage substantially in other AM sectors.

High levels of international competitive pressure have resulted in companies developing very lean operating structures throughout the sector. Company numbers have declined; many companies have changed their business model to incorporate tool manufacture in low-cost countries, with local inputs shifting towards providing tool design expertise and tool support facilities. Larger companies are developing export opportunities using this structure to provide cost effective proposals for international automotive projects.

A few larger companies have recently gained considerable experience in the specialised area of large aerospace composite moulding tools through the TIFA Aerospace collaboration project, and they are now actively pursuing export markets.

Advanced capabilities of the D&M sector include the design and manufacturing of highly specific types of tools, which are not readily applied to other industry needs. Strong capabilities exist in the processes needed to realise complex machined geometries, include CAM, 5-axis machining, EDM and precision hand fitting.

9.1.3 Cutting Tools

The cutting tool (CT) sector produces accurate, complex, intricately shaped tools using a range of very hard metals and exotic materials, and applies sophisticated surface treatment technologies to achieve hard wearing properties.

Local manufacturers make a variety of types of tools, mostly geared towards industries with high tool consumption, particularly high volume automotive component manufacturing. A number of manufacturing facilities are allied to large international cutting tool technology companies, and provide specialist tools and tool regrinding capabilities to complement a range of imported standard tooling.

CT sector products are used in machining processes that are applicable across many industries. Large cutting tool technology companies are active in many industries and offer catalogue listed products for a very wide range of applications.

The applied nature of cutting tool demand, based on catalogue selection, and the high profile of large international brand-name suppliers, have generally saturated potential CT market opportunities in all industries. However, Australian capabilities could find applications in development of tooling for new processes or technologies.

9.1.4 Machine Tools

Machine Tool manufacturers in Australia design and build either specially conceived equipment or highly optimised standard machines for specific processes. Typically, highly accurate mechanical motion systems are integrated with a specialised material removal technology and sophisticated computer controlled drive electronics, as well as hydraulic and pneumatic sub-systems and material handling devices.

Activity in the sector is dominated by a small number of larger companies with broad ranging in-house capabilities covering the multiple sub-system technologies incorporated in a modern machine tool. The sector holds considerable product Intellectual Property and has well developed export markets in specialised types of machines.

The diverse capabilities in the sector have potential application in the design and manufacture of other complex electro-mechanical systems, particularly where sophisticated motion control may be required, where different technologies must be amalgamated, and where the importance of system dynamics is of a high order.

The sector has a high level of international business experience that provides strong capabilities in international marketing, integrating with global supply chains in both markets and supply base, and in the management of export projects. The sector also incorporates global technical support infrastructures.

9.1.5 Robotics

The Robotics sector primarily integrates standard industrial robots into automated systems to undertake specific manufacturing tasks, requiring design, manufacture and integration of specialised end-effector tooling and devices, mechanical handling and location systems, advanced sensing and guidance technologies, and system control software.

Several larger high profile businesses in the sector are distributors of leading brands of imported robots, while a larger number of smaller robot integrators operate either locally or with expertise in specific fields of application (eg: welding, assembly, packing, and food industry).

As the range of applications for robotic automation is highly diverse, companies in the sector are highly adept at applying their core robotics capabilities to meet individual industry or company needs and creating special solutions for different applications, very commonly requiring the integration of new advanced technologies.

9.1.6 Other automated equipment for manufacture

This sector applies technologies allied to the Machine Tools and Robotics sectors to the highly diverse needs of high volume manufacturing and processing industries for application-specific automated processes.

Companies of widely varying sizes operate in this diverse sector, with many also working in Robotics and some in the area of Machine Tools. Companies commonly have a high level of knowledge in the design of specialist systems for specific industries. Capabilities within the industry are equally as diverse as the broad range of equipment types that are constructed, from high speed automated pharmaceutical production systems to rock crushing plants.

In general the sector has a high level of capability in the field of electrical control system design and programming, and often utilises third party AAM companies to separately undertake mechanical system design and construction.

The breadth of the definition of this sector potentially includes many companies that do not perceive themselves as part of the Advanced Manufacturing industry, but define their capabilities more in terms of their customer industries.

9.1.7 Design for manufacture

As a sector, Design for Manufacture (DFM) is engaged as a critical support resource to potentially all product manufacturing industries, with deliverable capabilities in product engineering, analysis, 3D modelling, reverse engineering, detailed CAD design and CAM outputs for automated manufacture.

The sector is partially embodied by the in-house design facilities of product manufacturers, which have high levels of expertise in specific design areas and are a critical resource in the creation and retention of companies' product IP. The sector also includes independent design and engineering organisations that contract product development to manufacturers to supplement in-house design resources at times of peak activity.

A summary of the advanced product-enabling technical capabilities identified in each sector at an industry level are listed in Table 9.

Table 9: Advanced technical capabilities of industry sectors

Advanced Technical Capabilities	AAM Sector						
	PM	**D&M**	**CT**	**MT**	**RO**	**OAM**	**DFM**
Precision machining	H	H	H	M	-	-	-
Specialist machining processes	H	H	H	M	-	L	-
High precision machining	H	M	H	M	-	-	-
Large machining	M	M	-	M	-	-	-
CAD design	L	H	M	M	M	M	H
Machining of complex forms	H	H	M	L	-	-	-
Design engineering and analysis	-	M	L	H	M	M	H
Machining of difficult materials	H	H	L	M	-	-	-
Research and development	L	L	M	H	M	M	M
Electrical control system integration	-	-	-	H	H	H	-
Electrical systems	-	L	-	H	H	H	-
Hydraulic systems	-	L	-	H	L	M	M
Pneumatic systems	-	L	-	H	H	H	M
Advanced control & sensing technologies	-	L	-	M	H	H	H
Automation Engineering	-	L	-	M	H	H	H
International technical support	-	L	-	M	-	L	-

Legend: PM, Precision Machining; D&M, Die and Mould; CT, Cutting Tools; MT, Machine Tools; RO, Robotics; OAM, Other Automated Manufacture; DFM, Design for Manufacturing.

H, high; M, medium; L, Low; -, insignificant.

A summary of commercial capabilities that are relevant to the generic capacity of companies with each sector to engage with new industry opportunities is listed in Table 10.

Table 10: Commercial capabilities of industry sectors

Advanced Commercial Capabilities	AAM Sector						
	PM	D&M	CT	MT	RO	OAM	DFM
Strategic business planning	L	L	M	H	M	M	L
Sophisticated marketing techniques	L	L	M	M	L	L	-
Engagement of supply chains	L	M	M	M	L	L	-
Management of complex contracts	L	M	L	M	M	M	-
New product development	L	L	M	H	L	L	H
Research and development	L	L	M	H	L	L	H
International marketing	-	L	-	H	-	L	-
Project management	L	M	L	M	H	H	-
Project financing	-	M	L	M	L	L	-

Legend: PM, Precision Machining; D&M, Die and Mould; CT, Cutting Tools; MT, Machine Tools; RO, Robotics; OAM, Other Automated Manufacture; DFM, Design for Manufacturing.

H, high; M, medium; L, Low; -, insignificant.

9.2 Industry-based market segmentation

The Advanced Manufacturing industry is overwhelmingly geared to servicing the needs of the automotive industry. Industry sources suggest automotive work accounts for more than half of the total activity of the industry.

Limited data are available on market segmentation in other sectors, but significant business areas identified by industry participants include white goods, defence and aerospace, electronics, medical and pharmaceutical and other process industries. Table 11 for the Machine Tool sector indicates relative activity levels in different industries.

Table 11: Relative activity levels of Machine Tool sector in different industries

Market Segment	Share
Metal Product Manufacturers	30%
Motor Vehicles and Transport Equip	30%
General Construction	20%
Mining Industry	10%
Machinery and Equipment Manufacturers	10%

Source: 2000 data IBIS Machine Tool and Parts Manufacturing in Australia

Table 11 does not represent the market segmentation of the overall industry because the machine tool sector is small and other large sectors, such as Die and Mould Manufacturing, dominate automotive activity.

However, mining accounts for only a small percentage of the industry's overall activity, and while the activity of the AAM industry in the Renewable Energy sector is not well documented, it is presumed to be negligible in percentage terms.

The AAM industry is currently engaged with mining in two main areas. The first is the precision machining of components for both replacement parts and new equipment. Mining work is undertaken on a jobbing basis as a small percentage of business; it represents a high level of activity for a small number of companies located mostly in Perth, Newcastle and Queensland and for those with the equipment capability to machine very large components.

The market for this work is driven by customers in the mining technology sector sourcing specialist components requirements. Due party to the wide geographic separation and low level of engagement of the majority of the AAM industry with the mining industry, few companies in the AM industry actively market their capabilities to the mining industry beyond direct contact with either established customers or locally based potential customers.

The second significant area of mining manufacturing activity is for precision machining companies with unique capabilities in the manufacture of special components, notably including gears and slew bearings, and particularly those able to manufacture parts for high power transmissions and large diameter machinery drives. Companies active in this field are located in Perth, Brisbane and Townsville and are closely engaged with the mining industry as a major customer base. These companies undertake extensive market contact into the mining industry and have high levels of market specific knowledge. These companies are currently experiencing very strong business conditions meeting the needs of mining industry investment.

10 Market opportunities

The identification of specific company level opportunities in each of the above industries is a major objective of this study. The study methodology to identify opportunities was defined in section 7. First, a framework of potential participation at an industry level was based upon the matching of Advanced Manufacturing capabilities and identified customer industry needs. This framework was then combined with identifying specific modes of engagement whereby Advanced Manufacturing industry participants may initiate effective mechanisms to gain access to customer industry supply chains.

At the customer industry level, three broad categories of opportunity are exhibited from the perspective of potential new Advanced Manufacturing engagements.

10.1 New capital investment projects

Both the renewable and mining industry sectors are experiencing sustained growth in activity in the local market. Supporting this growth creates new supply opportunities that may not be met by existing supply capabilities or existing industry capacity. Hence meeting investment needs of these growing markets has excellent potential for driving overall industry development.

Large scale investment to meet growth in business activity is predominantly concentrated in specific project-based expenditure cycles, ranging from funded pilot commercialisation projects to establishing major new production sites or facilities, with investment typically ranging from hundreds of million to multi-billion dollar expenditures.

Timing of market engagement is critical when supplying major projects. Limited opportunity is provided very early in the project for determining and costing supply strategies, including the setting of detailed expenditure budgets based on known supply base structures and often pre-selecting potential supply sources. Budget allocations often become closely aligned to the capabilities, nomenclature and cost structure of previous suppliers or those that become engaged early in the process.

10.2 Import replacement

Growth opportunities for any recurring local investment at an industry level are related to successfully competing with sources of imported equipment. A number of modes of engagement detailed below relate to import replacement mechanisms, which fall into two categories: i) direct customer industry product level competition and ii) specialist supply integration into international supply chains.

Potential contribution to local industry growth depends on how well the opportunities compete with imported products. Often this cannot readily be discerned within complex supply structures.

10.3 Export of specialist products

The export market provides opportunity for large sales growth; markets are far broader than those available domestically, and have potential for direct industry growth. At the company level, potential international sales volumes for specialist products are sufficient to justify high levels of development expenditures, and having a low market share in large diverse markets provides for increased sales stability.

Export potential for Advanced Manufacturers often stems from the development of a highly competitive product, service or capability in the local market, where close interaction with local customers provides a cost effective development platform in a less hostile business environment. Fertile opportunities for ensuing international success may be indentified in fields where the demands of local customers are in advance of their international counterparts and/or fields where advanced technologies are being generated by the local research community.

To meet global market demands a threshold of international competitiveness must be reached in regard to technical features and capabilities and/or manufacturing process efficiencies. Successful international marketing is attained when a competitive product is packaged to highlight its strategic competitive advantage; conveys a high level of credibility of the manufacturer as an international supplier; and meets the strategic sourcing requirements of customers' international supply chains.

With the diversity in levels of specialisation, product orientation, size and depth that exist within AAM companies, the opportunities for export business range between two alternative strategies. Companies that are able to develop and market identifiable internationally competitive products have the opportunity to directly address international markets either individually or in collaboration with others to package either niche products or supply chain solutions.

On the other hand, companies with internationally competitive capabilities, rather than an internationally competitive product, have the opportunity of matching those capabilities to the manufacturing needs of other companies that have potential for international customer industry product engagement. Support of the marketing efforts of lead companies will promote indirect export opportunities for their supply partners, as will mechanisms that optimise matching of capabilities on a national basis that promote reaching thresholds of international competitiveness within the industry.

11. Specific market opportunities

The potential for involvement in market opportunities at a technical level depends on matching specific capabilities within the industry with market opportunity requirements. However, this level of analysis does not account for demands placed upon the structural business capabilities of companies in meeting specific commercial demands and providing a complete offering that is well aligned to customer needs. There are a wide range of different business structures within the Advanced Manufacturing industry. Equally there are a multiplicity of identifiable modes in which AM industry participants may be able to participate in specific market opportunities depending on their individual business structure and

objectives. These have been termed Modes of Engagement for the purpose of this study, and are used for evaluating the accessibility of opportunities to the industry on a commercial basis at the company level, and as a descriptor to assist companies consider the demands of the opportunities that are presented.

High potential modes of industry engagement are identified for each market sector being considered, and specific potential modes of engagement for each identified company level opportunity are proposed.

- **Asia Pacific Engineering Hubbing:** provision of engineering services to support regional requirements for dispersed installations or manufacturing sources
- **Capability Clustering:** achieving combined supply capabilities or capacity through industry collaboration of two or more organisations
- **Consortium Participation:** creating a contracting entity through formal collaboration of multiple partner companies
- **Cross Fertilisation of Technology:** adapting and applying industry or application know-how and capabilities to other industry sectors
- **Customer Access Mechanisms:** systems or tools that provide supply entry opportunities to new customers
- **Engineering Support:** augmenting a supply capability with engineering resources or services in an advantageous manner for the customer
- **Export Opportunities:** involving direct export activities
- **Import Replacement:** supply in competition to existing imported supply lines
- **Industry Promotional Activities:** where industry level activities will enhance opportunity access
- **International Supply Chain Access:** contact or opportunity providing a conduit into wider international markets
- **IP Opportunities:** associated with development and ownership of intellectual property
- **Local Content Drivers:** where an impetus exists to promote the competitiveness of local supply capabilities

- **Major Investment Project:** where direct engagement with a specific large project is required
- **Product Packaging:** the development of market-oriented product from existing capabilities
- **New Product Development Opportunities:** an identified need aligned to capabilities that allow the development of a new identifiable product
- **New Technology Development:** undertaking primary research and development activities at a pre-commercialisation stage
- **Pilot Project Support:** proactive involvement in early commercialization activities
- **Product Representation:** where manufacturing capabilities may be augmented by representation of third party products
- **Reverse Engineering:** requiring a supply capability to be developed from analysis of an existing product or process
- **Supply of Replacement Parts:** involving spare parts requirements that may provide significant proportion of ongoing business
- **Supplier Access Mechanisms:** systems or tools that provide supply entry opportunities to new customers
- **Sector Specific Marketing:** requiring development of sector targeted marketing material or activities
- **Provision of Specialist Capabilities:** where specialized supply of niche capabilities provides an effective market access opportunity
- **Research Commercialisation Opportunities:** where there is an opening to take on a commercialisation process for a new technology arising from a research institution
- **Strategic Localisation of Manufacturing:** addressing a global supply chain requirement to establish localised capabilities
- **Strategic Partnership:** development of a relationship with other organisations for mutual benefit, such as an international support partner or an IP provider
- **Supply Partnership:** establishment of a customer relationship beyond competitive supply, which may include product development or provision of prototyping services.

11.1 Renewable energy

Sustained strong growth in the development of the renewable energy industry, both locally and globally, has been outlined in Section 8.1, providing for conservative forecasts of multi-billion dollar investment in sophisticated equipment over the coming decade.

Excellent alignments of the existing and potential capabilities of the Australian Advanced Manufacturing industry with the investment needs of specific renewable energy sectors have been identified.

11.1.1 Solar PV manufacturing

As outlined in Section 8.1.6, the Solar PV market is presently the world's fastest expanding energy supply sector, with incipient gains in cell efficiency and material cost that will ensure increasing competitiveness and increasingly rapid expansion of production volumes.

Rapid increases in production volumes need to be met by appropriate upgrading of manufacturing and material handling processes that will concomitantly deliver further reductions in unit manufacturing costs.

The processes currently utilised by the majority of silicon wafer PV cell manufacturers are largely common and utilise automation system equipment and technologies similar to other manufacturing industries. Automation equipment suppliers around the world are developing turnkey systems to cover the variety of automated tasks within a PV plant and have developed competitive advantages through capturing repeat sales to the international market However, current processes are not fully automated, and a typical plant arrangement has a discontinuous array of islands of automation built around specific processes, possibly a legacy of rapid production increases from relatively low levels. A high level of manufacturing labour is used in the industry.

Leading machine tool, automation and robotics companies within the AAM industry appear to have the required capabilities to design and manufacture competitive manufacturing solutions for this industry, with the opportunity to collaborate in developing the next generation of integrated manufacturing, automation and testing systems required to meet future production volumes, and in globally marketing an international turnkey capability.

BP Solar's test-bed facility in Australia and commercialisation of the highly promising ANU Sliver Cell Technology by Origin Energy provide unique opportunities for effectively undertaking manufacturing process development in close cooperation with end users.

Modes of engagement with the solar PV manufacturing opportunity include Capability Clustering, New Product Development, International Supply Chain Access, Sector Specific Marketing and the development of Supply Partnerships.

See Appendix 1 for the specific solar PV opportunity details.

11.1.2 Solar concentrator systems

As described in Section 8.1, two promising solar concentrator energy systems are under development in Australia, and the industry has the potential to deliver energy costs competitive with fossil fuel within the medium term.

Large scale solar concentrator systems incorporate substantially sized heliostat devices that require a precisely engineered and constructed structure and incorporate 2-axis positioning systems that, depending upon system configuration, may need to be highly accurately controlled. On a global basis the manufacturing of large heliostatic devices has been done only on a relatively modest scale for prototype systems. The development of lower cost heliostats for commercially competitive solar systems is yet at an immature stage and is critical to the achievable energy production costs.

Specific opportunity to participate in Solar System's 154 MW commercial prototype system proposed for Victoria and to become involved with commercial development of the ANU's solar thermal system are further described below.

Key modes of engagement for AAM in the field of solar concentrator systems include New Product Opportunities and development of Supply Partnerships.

See Appendix 2 for the specific solar concentrator opportunity details.

11.1.3 Wind energy industry

The wind energy industry currently provides the single largest source of growth in global energy supplies. Sustained global growth of around 30% p.a. over ten years is widely expected to continue unabated as ambitious targets for implementation of renewable energy in leading developed and developing countries are fulfilled, wind energy costs continue to fall and global electricity demand faces substantial long term expansion.

The industry is primarily driven by government policy in relation to greenhouse emissions and energy security. Because wind is able to produce energy at only approximately twice the cost of Australian coal and is closer to par where fossil fuel costs are higher, it has dominated

investments to meet renewable targets and is likely to continue to contribute strongly over the next decade.

The Australian Advanced Manufacturing industry began significant advances in localisation in recent years in anticipation of expansion of the federal MRET initiative. While this increase was not finally enacted, Australian engineering companies and wind turbine manufacturers held discussions to consider the manufacture and assembly of major parts of turbine machinery. Interest in localisation has dropped with a slow-down in new projects associated with the saturation of the MRET scheme, and the opening of larger opportunities for wind turbine manufacturers in Asia. Investment has shown signs of being somewhat re-energised by current renewable target schemes in VIC, NSW and SA.

In evaluating supply opportunities, the industry's dependence on government policy is an important consideration. Internationally there is a well documented history of policy reversals, notoriously in the US in the early development of the industry and most recently in Spain, which have destabilised the investment environment and seriously impacted manufacturing companies.

The scale of capital expenditure opportunity in Australia is difficult to predict, but based on the range of targets and estimates put forward by different stakeholders, a reasonably conservative estimate would exceed a total capacity of 5,000 MW by 2015, with an approximate total investment level of $6,000 million during that time. Continuation of current levels of localisation would result in approximately 40% of that investment flowing to Australian companies. Further localisation of larger hub, blade and nacelle mechanical components could increase this percentage substantially, delivering hundreds of millions of dollars of additional local work.

Specific market opportunities that are matched to strong capabilities within AAM are mostly associated with the major components of the blades and wind turbine itself. Progress in this direction has been slow because these are subject respectively to core IP and identified in-house retained processes by the turbine manufacturers. A countervailing influence is an identified world-wide shortage in turbine manufacturing capacity. The preoccupation of the large manufacturers with accessing massive market potential in China and India by meeting government localisation demands has, on the one hand, circumvented possible investments in Australia as an Asian supply hub, but on the other hand, has a deeper potential impact of forcing the European industry to adapt a more open localisation model that may in turn facilitate new opportunities for Australian manufacturers.

11.1.4 Localisation of precision manufactured elements

The bulky and heavy nature of wind turbine equipment, ranging from the extremes of 80m towers and 40m blades to the still rather massive turbine hub and nacelle is likely to create increased competitiveness for localised production alternatives as the size and weight of the machines steadily increase.

As machine design becomes increasingly commodified through industry coalescence upon dominant mechanical and electrical technologies and a global supply chain for key sub-assemblies, the impetus towards providing for increased local manufacture and assembly is enhanced.

Whether the local industry is able to integrate into developing supply chains through increased localisation of sophisticated system components depends on ongoing development of specialist capabilities. These include large volume 5-axis machining capacity, large precision assembly facilities and possibly tooling technologies to support emerging blade manufacturing processes, as well as the application of high level business processes.

Specifically in relation to blade manufacturing, a strong and growing body of knowledge in Australia for tooling and manufacturing of slender advanced composite components for Aerospace and Marine applications is developing.

The core modes of engagement relevant to localisation of turbine components include Local Content Drivers for Import Replacement, Engineering Support, involvement in Major Investment Projects, Provision of Specialised Capabilities and the development of Supply Partnerships.

11.1.5 Maintenance and refurbishment

As substantial numbers of turbines begin to come out of their initial warranty coverage period, an industry opportunity in machine maintenance and refurbishment will emerge. This will provide an opportunity for AM companies with precision mechanical assembly and control systems knowledge, as well as specialists in the high-power gear systems that require regular major overhauls under demands for minimum system down-time.

The growing turbine maintenance industry provides valuable opportunities for technology familiarisation that could be used to enhance local manufacturing know-how.

Considerable knowledge in high-power and large precision gear design and manufacturing is held by several AM companies around Australia, with leading companies such as Hofmann having the capability to refurbish turbine gear boxes stronger, more accurate and more

reliable than their new condition. The possibility that this high level capability could be adapted either by individual companies or collaboratively to join the small number of successful high-power transmission gearbox manufacturers in the world is raised.

The maintenance and refurbishment opportunity involves modes of engagement that include Engineering Support, Provision of Specialised Capabilities, Sector Specific Marketing and Reverse Engineering.

11.1.6 Emerging technologies

The dominant wind energy technology of the large 3-bladed horizontal axis upwind step-up geared machine is the basis of the product offering of all major industry suppliers, and accounts for virtually all current large wind farm projects. While the design is highly successful, a number of inherent design constraints present significant barriers in the quest for further improved competitiveness with fossil fuels. These include the expense and multiple rebuilds associated with high cyclical loads on the step-up gearbox, the necessity of using laterally stiff blades and the difficultly of mounting and maintaining the complex and heavy turbine assembly, weighing 40 to 80 tons, on top of a tall tower.

A number of alternative machine designs being developed around the world propose to deliver a significantly lower system cost, two of which are being actively researched and prototyped in Australia and New Zealand. High potential long-term opportunities for suitable Advanced Manufacturing companies appear to exist in supporting these developments, with the possibility of delivering a stake in valuable protected IP.

Involvement in new wind technologies potentially requires Capability Clustering and the Cross Fertilisation of Technologies to achieve New Technology and New Product Development involving Research Commercialisation.

11.1.7 Remote area systems

The high cost of fuel in remote and island locations makes renewable energy sources highly economically attractive. Because of its competitiveness in this scenario, a high growth market for remote energy systems is emerging across Australia’s remote regions and the island nations of the Asia–Pacific region. This market is not highly dependent on policy drivers once optimised system configurations are established, that is, when the industry has moved past pilot project verification stages, with the proviso that capital investment funding requirements can be met.

The required scale of energy solutions is substantially smaller than the scale of even single elements of systems designed for large grid-connected systems. The furnishing of medium scale wind (and combined solar) plants may present an industry opportunity that does not directly compete with the interests of large wind turbine industry players, and which is manageable on a turn-key basis by Australian SME companies. Potential engagement of AAM could include licensed medium-sized turbine manufacture, system design and integration and technical support services.

Modes of engagement activities potentially include sector specific marketing, new product development, strategic partnerships and engineering support.

See Appendix 3 for the specific wind energy opportunity details.

11.2 Mining

As described in Section 8.2, the global mining industry is currently undergoing a capital investment boom, facilitated by high levels of profitability within the industry, which underpins growth in output to meet strong global markets for material inputs.

The unique structure and culture of the mining industry, related to its specialised industry requirements, present supply chain entry constraints and strategies that are very different to the current predominant customer industries for Advanced Manufacturing.

Australian mining is a world leader in scale, export focus, technology and production efficiency. As major global players and global industry leaders, Australian mining companies are strongly integrated into global supply chains, including many specialist Australian suppliers to the industry, including in the Mining Technical Services sector.

Australian based manufacturers have competitive advantages arising from the vital requirement for highly responsive support of industry users and from import tariffs on industry inputs where local manufacturing capabilities exist. Large overseas based suppliers have enjoyed massive market dominance with relatively static product offerings that now face competition from the introduction of new technology by more agile and innovative companies.

Currently the identified AM sector has a low level of engagement with the mining industry and a limited understanding of the mining supply chains. A small number of companies in the sector work directly in the mining industry, while a wider range of companies sporadically manufacture components and assemblies on a sub-contract basis for miners or mining engineering firms.

Characteristic of the current engagement of AM with Mining is a largely arms length relationship with end users, and reactive rather than proactive sales mechanisms. A commonly expressed interest in developing business in Mining is countered by a limited understanding of the supply chain and a scarcity of identifiable products marketed to the sector.

Three streams of actions to potentially increase activity in the Mining sector have been identified in this project.

11.2.1 Enhanced supplier access mechanisms

The mining industry uses a number of sourcing portals and directories to find suppliers, and is increasing its use of web, including advanced end-to-end integrated web-based supply management systems such as Quadrem. Strong networks of mining supply companies are supported by organisations such as Austmine.

The industry currently has low visibility to mining companies that source relevant products. Few AM companies are listed on mining sourcing directories or have links into the existing mining engineering networks.

Mining equipment suppliers face high levels of international competition and the ensuing need to enhance their cost effectiveness. While expressing concern at the cost of subcontracted manufacture in Australia, these companies typically work with a small number of historically convenient, local AM suppliers to meet their needs for machined or other specialised components. It is evident that among mining companies there is a limited knowledge of the wider AM supply base. Therefore, they are not effectively tapping the depth of specialist capabilities, manufacturing quality and efficiencies available within the broader Australian AM industry that could enhance the international competitiveness of their own manufacturing operations.

A high level of decision making conservatism is common within the mining industry. The use of sequenced lines of equipment under 24 hour operation in remote or underground locations results in a particularly high cost penalty for any stoppage or equipment unavailability, while logistical constraints multiply the time and cost impact of any breakdown. The hazardous mining environment leads to a strong consideration of personnel safety, both in terms of the regulatory environment that sets stringent requirements, and in the operating ethos of the industry. For these reasons, sourcing decisions in the industry may often place a particularly high emphasis on suppliers known to have experience in the industry, and hence an understanding of its demands.

Consequently, the industry does not readily look outside itself for new suppliers. The emerging opportunity to increase AM activity in mining is the development of a range of mechanisms to facilitate AM supplier access by the mining industry supply chain, both at an industry and at a company level.

At an industry level, the extensive capabilities of AAM need to be presented to mining decision-makers in a coherent framework structured according to mining requirements, so as to provide a logical and efficient capability matching tool for the purchasing user.

At a company level, it is essential for potential suppliers to gain maximum exposure to industry conditions and to use the knowledge gained to generate industry specific marketing strategies with the dual aims of promoting their brand perception as an industry insider and framing their strategic competitive advantages in specific terms that are relevant to miners' priority concerns. Tools to promote entry into the industry include mining industry directories, web portals and sourcing platforms.

Enhancement of supplier access mechanisms will require sector specific marketing at an industry level and industry promotion activities and has the potential to provide import replacement opportunities and provide openings for access to international supply chains.

See Appendix 4 for enhanced supplier access opportunity details.

11.2.2 Mining industry technology sector advanced manufacturers

A large component of the existing engagements of the AAM industry with the mining industry occurs through mining industry-based companies that manufacture specific technology, equipment or systems, mostly with associated in-house developed IP. These companies source varying degrees of their manufactured content from third party suppliers, including many AM companies; common supply items include general machining, large machined parts and specialist precision components such as shafts, gears and complex special purpose proprietary components requiring specialised manufacturing processes.

Some mining industry equipment suppliers also have their own in-house capabilities for undertaking advanced manufacturing processes in competition with the potential supply base. To meet expanding operations, several companies have undertaken or are in the process of making investments in machinery to increase their in-house advance manufacturing capacity. Common sourcing strategies include the tendency to keep processes in-house where they relate closely to core intellectual property and to outsource less sensitive parts. Deliberate strategies of widely distributing outsourced components on a piecemeal basis are also used to control IP risks. A survey of companies consulted in this regard showed 30–70% of total

manufactured value is outsourced. It is estimated that over 50% of this content may be flowing to AAM companies.

The main factor differentiating these companies from other sophisticated industrial equipment manufacturers is their high level of immersion in the mining industry, with an associated deep of industry knowledge and close contact to their mining customer companies. As expressed in company literature and discussion with executives, such companies generally perceive themselves as part of the mining industry. However, viewed from the perspective of their design and manufacturing processes and product characteristics, an interesting fit with the profile of AAM companies is clearly evident.

Such companies do not, however, have close fit to mining industry bodies. Their business, personnel and technical issues relate more to AAM companies. Consequently, AMM activity in the mining industry can be strengthened in several ways:

- Build closer industry level linkages with Mining Technology companies that also belong to the AAM community, strengthening the overall AM industry's capabilities, market knowledge and market linkages in the mining sector, and gaining an informed voice in industry strategy development relevant to this industry.

- Strengthen the marketing activities of MTS Advanced Manufacturers through Advanced Manufacturing Industry Body initiatives, including international marketing activities, from which benefits will flow to the extended AM supply chain supporting the manufacture of sophisticated mining products.

- Seek synergies and cross-fertilisation of capabilities between MTS AM companies and other AAM companies and organisations, including improved costing and performance of system components through improved matching of supplier capabilities, partnering to undertake product development activities and financial support of marketing initiatives.

- Collaborate to provide manufacturing capacity to meet the requirements of large individual projects both domestically and internationally.

11.2.3 New product technologies

The large extent of the Australian mining industry has generated substantial mining technology research activities in universities and government- and industry-sponsored research organisations. The high level of well funded activity in applied industry research provides a pipeline of new technologies to improve mine extraction and mineral processing efficiencies.

The outputs of the research sector are often taken through to the stage of early commercial prototypes by the commercialisation arms of the large research bodies, from which point full commercialisation partners are sought. This process may facilitate the direct involvement of technology-based companies able to undertake the required product development, which potentially includes AAM companies or networks of companies that would then tap into protected IP market advantages.

Alternatively, initial commercialisation partners may be drawn from potential industry customers seeking to apply new technologies and who are prepared to fund commercialisation activities in return for captured competitive benefits. In this case, potential exists for suitably capable AAM companies to provide product development and engineering functions as a third party, with the possibility of capturing IP benefits.

The core modes of engagement with new product technologies include research commercialisaton and new product development with the potential to deliver the development of protected IP and open export markets.

See Appendix 5 for the specific mining opportunity details.

12. Recommendations and conclusion

The examination made by this study of new business potential for AAM in the two customer industries of renewable energy and mining has identified both sizeable broad-level industry growth opportunities and an array of specific company level opportunities that are well aligned to AAM existing and potential capabilities.

This review of the size, structure and investment requirements of the two target industries has provided not only a basis for assessment of potential market opportunities for the industry, but also an introduction to the nature and trends within each industry for the consideration of interested AAM participants. Detail of the specific sectors of each industry that have been identified as having higher potential for engagement by Advanced Manufacturers has also been presented.

These two industries represent largely new markets for most of the AAM industry, and even in mining where some significant activity is currently undertaken, many supplying companies operate in the industry at arms length, and are not proactive participants in the supply chain. As the current level of AAM engagement with the Renewable Energy industry is negligible, considerable further industry familiarisation is clearly required.

Detailed customer industry knowledge is a vital ingredient for the successful marketing of enabling technologies, the purchase of which is justifiable through a value proposition that needs to be stated clearly in the terms of the customer market and its requirements.

Many of the opportunities identified in the report involve engagement in sophisticated marketing activities allied to product creation and technical and commercial development. The delicate task of working out mutually beneficial arrangements for instituting commercial partnerships and bringing together collaborative teams is also required. All these activities require high order business capabilities and present a significant challenge to the engagement of many elements within the Advanced Manufacturing industry. The development of capabilities in these areas is therefore a key need for the overall advancement of the industry into such new markets.

In concert with the pursuit by individual companies of the specific market opportunities that are identified in Section 11 of this report, and providing support for and coordination of those efforts, it is evident that a raft of industry level activities also needs to be undertaken. Specific activities that are proposed include the following initiatives, many of which may be furthered through the working groups of the Action Agenda and through high level activities undertaken on behalf of industry members by the industry representative bodies:

- incorporation of MTS companies in AM industry bodies
- building of linkages between AM and mining industry associations
- Team Australia umbrella branding
- promotion of collaborative approaches to meet large industry opportunities
- ongoing industry level opportunity research
- improved customer access mechanisms
    - targeted directories of industry capabilities
    - TA website development
- industry level activities to raise the profile of AAM capabilities
- building of connections with Industry based research organisations
- industry/market knowledge-building activities including improved data collection on target industries
- participation in mining shows

- use of industry sourcing tools
- engagement of specialist mining industry marketing services
- further systematic analysis of local customer industries to identify high potential export market springboard opportunities
- a detailed industry based project to identify suitable emerging new product opportunities in cooperation with the major industry research organisations

In consideration of the analysis of the opportunities identified in this report on the renewable energy and mining industries, recommendations are detailed below.

- Market development and access research provides valuable information and insight that address critical sustainability and growth requirements for the Australian Advanced Manufacturing industry. Unfortunately, due to the relatively small size of the majority of companies in the industry, few companies could afford to devote the necessary financial resources to complete such a project. Therefore, industry body and government research initiatives are highly valued as they benefit a wide spectrum of Australian companies and industry alike.
- Individual Advanced Manufacturing companies are able to target the company specific opportunities identified in this report. Opportunities should be viewed as an entrée into developing long-term strategic relationship with partner organisation in ancillary industries.
- Advanced manufacturers will need to proactively market themselves to integrate into global supply chains. This requires individual companies to develop long-term partner and/or collaborative relationships with organisations that offer synergistic value. Relationships need not be confined to traditional industry segments. The added value of these relationships will provide the competitive edge and scale economies to complete in a global supply chains.
- To exploit industry wide opportunities with medium and long-term time horizons, clusters may be better resourced and provide scale economies. These projects could be set-up using cluster models such as TIFA Aerospace or Joint Strike Fighter (JSF) Program.
- Developing strong domestic markets provide opportunities to ‘springboard’ into global supply chains. For renewable energy, the driving forces are government policy and development and management of IP. For mining, driving forces will be identifying

niches within the market and partnering with MTS vendors to develop more efficient and effective IP. Australia's mining industry is world-scale and presents significant opportunities for domestic industry. The use of the internet may provide an alternative channel to effectively develop and service new mining markets.

- The adoption of Brand Australia as a tangible symbol to differentiate Australian suppliers would advantage both Advanced Manufacturers and allied industries such as the Mining Technology Services sector. The unified approach to international marketing is required as typical Australia's suppliers lack scale economies.

- Due to the dynamic nature of the industries analysed and opportunities identified, further ongoing research will be required to monitor the changing landscape of each industry. This will allow a longitudinal analysis of Advanced Manufacturers' performance against the opportunities identified in this report. The research should be expanded to examine other industry segments or completely new industries.

Acronyms

AAM	Australian advanced manufacturers
AM	Advanced manufacturing
ABARE	Australian Bureau of Agricultural and Resources Economics
AMAA	Advanced Manufacturing Action Agenda
DITR	Department of Industry, Tourism and Resources
EPCM	Engineering, Procurement, Construction and Manufacturing
ICN	Industry Capability Network
IP	Intellectual property
IWTMA	Indian Wind Turbine, Manufacturers Association
kWh	Kilowatt-hour
GW	Gigawatts
GWEC	Global Wind Energy Council
GWth	Gigawatts- thermal
MNC	Multinational corporations
MRET	Mandatory Renewable Energy Target
MTS	Mining Technology Services
MW	Megawatt
MWh	Megawatt hours
PV	Photovoltaic
R&D	Research and development
SME	Small to medium sized enterprise

Disclaimer

This report represents an analysis of the views and opinions of the industry expert respondents and publicly available data. As such, discrepancies may arise due to the multiple sources of information therefore the figures are indicative not definitive in nature. In addition, due to the dynamic nature of the industry, careful assessment of the findings and recommendations needs to be considered with regard to the application of this report and its findings. It is therefore up to the reader to determine what information (if any) is valid, and how best to apply this research.

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Appendix 1

Solar PV specific opportunity details

BP Solar: PV Cell Automated Manufacturing Systems

Application: The production of PV cells is a mature process through the world industry with high levels of automation using turnkey systems. World production is rising strongly with continuous investment to upscale plant capacities. Drop in Silicon cost and increased availability from 2008 will spur more rapid expansion. BP Solar's small Australian plant is a manufacturing technology test-bed for their global operations. Current equipment is imported, but is fully within the capability of local industry. Local equipment costs provided to BP have previously not been competitive, and are presumed to be based on one-off design and manufacturing costs.

Scope for Engagement: Capability clustering, Import Replacement, New Export, Product Packaging, IP Opportunities

Engagement Activities:

- presentation to BP of a range of potentially matched AAM capabilities
- spread awareness of the opportunity to allow companies to make an approach
- research and report structure of world PV manufacturing industry
- collaboration to address hurdle of uncompetitive one-off machine costing
- potential "Commercial Ready" application
- a preliminary study of the international market is included in this project report (section 8.2.1).

Status: high potential for industry growth through the development of internationally competitive PV manufacturing systems.

Origin Energy/ANU: PV Sliver Cell Manufacturing

Application: Early stage participation with Origin Energy and the ANU in development of cost-efficient manufacturing processes for Australian developed “next-generation” Sliver Cell PV Systems which have successfully reached early stage commercialisation and have potential to deliver a major advance in PV cost and performance.

Scope for Engagement:

Engagement Activities:

Status:

Appendix 2

Specific solar concentrator opportunity details

ANU - Solar Thermal Heliostat Manufacturing

Application: Development and manufacturing of cost effective heliostatic dish collector systems for future commercial applications of ANU developed Solar Thermal Energy technology.

Scope for Engagement:

Engagement Activities:

Status:

Solar Systems: Concentrator PV System Commercial Pilot Project

Application: Design and/or manufacture of advanced heliostat systems, needed to meet the needs of Solar Systems 154MW pilot plant that is currently being planned for constructed in Victoria and will incorporate 246 receiver towers.

Engagement Activities:

Status:

Appendix 3

Wind energy opportunity details

Vestas, RePower: Wind Turbine Component Manufacturing

Application: Supply partnership with Vestas and RePower wind turbine manufacturers for the local manufacture of large wind turbine components for upcoming local projects, and industry capability positioning to increase local content of the estimated $6,000 million industry investment over 10 years.

Scope for Engagement:

Engagement Activities:

Status:

Windflow Technologies (NZ): Wind Turbine Development & Manufacturing

Application: Participation in the development and manufacturing of new technology wind turbine systems being commercialised by Windflow Technologies in New Zealand

Scope for Engagement:

Engagement Activities:

Status:

Dynamic Systems: Vertical Axis Wind Turbine Prototype

Application: Manufacturing support of the $600,000 pilot plant investment being made by Dynamic Systems in NSW to prototype a new design of vertical axis wind turbine.

Scope for Engagement:

Engagement Activities:

Status:

Nexxtdrive: Electronic Variable Ratio Generator Drive

Application: Development partnership with Nexxtdrive for the commercialisation of IP protected variable speed generator drive systems that have high potential to increase wind turbine efficiencies.

Scope for Engagement:

Engagement Activities:

Status:

Installed Wind Farms: Engineering Support

Application: Development of engineering services and facilities to meet the critical support needs of the growing local base of wind turbine installations

Scope for Engagement:

Engagement Activities:

Status:

Hofmann: Wind Turbine Gearbox Refurb. & Manufacturing

Application:

Scope for Engagement:

Engagement Activities:

Status:

Remote Areas: Wind Power System Manufacturing & Engineering

Application: Specialisation in the manufacture and support of medium sized remote area wind turbine systems for the identified high potential market in the Asia-Pacific region.

Scope for Engagement:

Engagement Activities:

Status:

Appendix 4

Enhanced supplier access mechanisms to the mining industry

AM Industry Bodies: Mining Industry Directory Tools

Application: Consultation with widespread industry sources indicates that the capabilities of the national AM industry are little known by mining engineers and sourcing personnel. Mining sourcing into the AAM industry are largely through local companies whose capabilities do not fully match all industry requirements resulting in issues with product performance and cost.

Scope for Engagement: replacement parts,

Engagement Activities: Creation of effective industry directory tools by AM industry bodies for the use of mining purchasing personnel to more readily engage with the industry at a national scale.

Status: Medium potential to increase the use of AAM suppliers for mining industry requirements.

Mining Directory Organisations: Creation of Industry Directory Listings

Application: RUI, Minebox

Scope for Engagement:

Engagement Activities: Listing by individual companies on existing print and internet based directory services that have been identified for the mining sector.

Status:

Quadrem: Participation in Mining Supplies Online Internet Market Place

Application: Access to the AM industry's existing Mining specific capabilities through the industry standard Quadrem purchasing system.

Scope for Engagement:

Engagement Activities:

Status:

AM Industry Bodies: Industry Representation at Mining Exhibitions

Application: Collaborative industry representation at major mining shows.

Scope for Engagement:

Engagement Activities:

Status:

MTS Industry Bodies: Development of Mining Industry Linkages

Application: Company level membership and participation in Austmine and MESCA organisations to develop mining industry linkages.

Scope for Engagement:

Engagement Activities:

Status:

ICN: Database Listing for Import Replacement on Mining Projects

Application: Presentation of detailed industry capabilities for listing on the ICN database for import replacement sources for mining projects.

Scope for Engagement:

Engagement Activities:

Status:

Appendix 5

Specific Mining Industry Opportunities

Waratah Engineering: Waracar Shuttlecar Supply Partnership & Export

Application: The Australian underground coal mining industry operates a fleet of approximately 300 shuttlecars with a typical working life of 5-10 years and replacement value of up to $1.0 million for each unit. An innovative Australian shuttlecar designed by Waratah Engineering has proven to be highly competitive with units from large international manufacturers, with total company sales to date of 36 units in Australia and NZ, and production plans for 24 cars p.a. The Waracar has over 50% local content including in-house manufacture and AM suppliers. It incorporates sophisticated servo electronics and hydraulic drive systems into a large fabricated structure, built to stringent underground mining requirements. The company is actively developing new IP in the vehicle and has an extensive list of future developments to enhance the international competitiveness of the product. Export potential for this product has not been tapped.

Scope for Engagement: Import Replacement, New Export, Strategic Partnership, Supply Partnership, International Supply Chain Access, IP Opportunity, Austrade

Engagement Activities:

- promote closer integration of Waratah with its AM industry colleagues
- research export potential and develop an export strategy with Austrade assistance
- presentation to Waratah of potentially matched AM capabilities to increase manufacturing competitiveness and provide additional manufacturing capacity
- sourcing of fully built up gearbox assemblies from specialist suppliers
- introduce high capability AM companies that may be interested in risk-sharing export development with Waratah with manufacturing participation and possible contribution of export sales and support infrastructure
- potential “Commercial Ready” application.

Status: high potential for providing industry growth and medium potential for the closer engagement of other AM companies.

Inbye Mining Services: Longwall Conveyor Drive Systems

Application: Supply of high value precision drive components to Inbye Mining Services for longwall conveyor drive systems

Scope for Engagement:

Engagement Activities:

Status:

CME: Sourcing of Replacement and New Parts

Application: CME supply chain development for local replacement part and new part sourcing. Crusher Replacement Components and Sourcing of Parts for Auspactor VSI

Scope for Engagement:

Engagement Activities:

Status:

Russell Mineral Equipment: Hella Mining Equipment Export

Application: to be outlined in site meeting on 140407

Scope for Engagement:

Engagement Activities:

Status:

DBT Australia: Diesel Haulers and Material Loaders

Application: Supply of AM components to support DBT Australia local manufacturing of diesel haulers and material loaders

Scope for Engagement:

Engagement Activities:

Status:

Caterpillar Australia: Large Component Sourcing

Application: Provision of manufacturing capacity to meet high production requirements of Caterpillar Australia.

Scope for Engagement:

Engagement Activities:

Status:

Wescone: Continuous Sampling Crusher Manufacture & Export

Application: Westcone ore crusher component manufacturing and new product commercialisation.

Scope for Engagement:

Engagement Activities:

Status:

CRC Mining: Tight Radius Drilling Commercialisation

Application: Commercialisation of the Tight Radius Drilling Technology prototyped by CRC Mining for methane gas extraction.

Scope for Engagement:

Engagement Activities:

Status:

CRC Mining: Oscillating Disk Rock Cutting Technology Commercialisation

Application: Commercialisation of the Oscillating Disk Rock Cutting Technology developed and prototyped by CRC Mining, Qld.

Scope for Engagement:

Engagement Activities:

Status:

JKMRC and RME: Ore Characterisation Equipment Mfr and Export

Application:. JKMRC is a mining research centre that is part of the University of Queensland. Manufacture of Ore Characterisation Machine developed by JKMRC, Qld and designed by RME.

Scope for Engagement:

Engagement Activities:

Status:

> I don't think this sits here as a' business opportunity' – the AM CRC if/when running can pursue this.

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