ADVANCED FIBRE CLUSTER GEELONG

SUBMISSION TO THE TECHNOLOGY INVESTMENT ROADMAP: Carbon Fibre

21 JUNE 2020

ADVANCED FIBRE CLUSTER

The Advanced Fibre Cluster is a group of highly innovative companies and organisations manufacturing products for global markets and developing world-leading advanced fibre and composite technologies.

This submission emphasises the value of these technologies in reducing emissions, in strengthening Australia's economy and in supporting jobs and businesses.

High pressure hydrogen and gas storage tanks represent one of the fastest growing markets for advanced fibre materials, particularly for filament-wound carbon fibre composites. These include self-contained breathing apparatus and oxygen and gas storage on aerospace vehicles, but the primary market for high pressure carbon fibre vessels is in bulk transportation of compressed natural gas and fuel storage for low-emission vehicles, including hydrogen alternatives.

Light passenger and commercial vehicles account for an estimated 10 per cent of Australia's total emissions, according to the Climate Change Authority[1].

[1] http://www.climatechangeauthority.gov.au/reviews/light-vehicle-emissions-standards-australia/opportunities-reduce-light-vehicle-emissions

OVERVIEW

The Advanced Fibre Cluster respectfully submits the following:

01 Australia's low-emissions future depends on the supply of cutting-edge lightweight advanced fibre composite materials and the technologies and capabilities to manufacture these.

02 Carbon fibre material exhibits outstanding specific strength and modulus, almost four times that of steel, making it one of the strongest and lightest materials on the planet today.

03 Global demand for these products and technologies is growing, notably including in the development of:

- more efficient blades for wind turbines
- lightweighting for battery electric vehicles (BEVs)
- carbon fibre pressure vessels for onboard hydrogen storage
- fuel cell plates for fuel cell electric vehicles (FCEVs).

04 Australia's technology investments should build new export-facing industries in the global low emissions economy.

05 Australia already supplies world-leading composite products, especially into the global aerospace and mobility industries, both in the defence and commercial sectors.

06 Greater cost efficient access to carbon fibre and a secure supply would enhance the global competitiveness of our existing and future local manufacturers.

ECONOMIC STRETCH GOAL

In response to the Government's request for suggestions for economic stretch goals that could help establish pathways for the cost-effective deployment of priority technologies, we submit the following:

- Australian demand for carbon fibre could easily exceed 2000 tonnes annually within five years[2].
- With that level of demand, local manufacture of precursor and carbon fibre (CF) have the potential to be globally competitive, producing CF at a cost of less than US$15 per kilo. (Current estimates of costs are between US$15 to US$33)[3]

[2] AFCG research, June 2019 -May 2020
[3] S. Nunna, P. Blanchard, D. Buckmaster, S. Davis, M. Naebe, Development of a cost model for the production of carbon fibres, Heliyon, 23 October 2019 - https://www.cell.com/action/showPdf?pii=S2405-8440%2819%2936358-3

GROWING DEMAND

Global demand for industrial, consumer and engineering grade applications of carbon fibre is growing across a broad range of industries and supporting a low-emissions future.

ENERGY

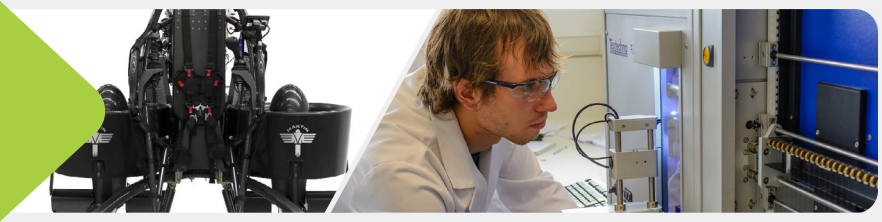
Wind Turbines

AEROSPACE

Aircraft Fuselage
Wing Components

INDUSTRIAL

Rapid Prototyping



AUTOMOTIVE

Automotive Components
Vehicle Chassis / Monocoque /
Hydrogen Storage Tanks

SPORTS

High performance cycle
wheels / racing rowing boats /
components

THE OPPORTUNITY: GROWING DEMAND

ENERGY AND WIND

Growing demand for increased energy output from wind turbines has led to an increasing use of carbon fibre in the manufacture of turbines and rotor blades.

Lighter and stiffer carbon fibre reinforcement means larger dimensions are possible for both land-based and offshore wind systems. In the mid-1990s, typical blades were around 50m long – now they are closer to 100m. Next generation blades could be up to 160m in length, making light-weighting increasingly important from a structural perspective and increasing the attractiveness of carbon fibre composites. Such large blades could also be manufactured locally, reducing transportation costs and emissions, and enabling circular-economy material design and production.

The wind energy industry is the fastest growing renewable energy source in many countries and is expected to continue to grow rapidly over the period to 2030.

Production of wind energy is largely concentrated in Europe and the United States. However, there has also been rapid growth in the wind energy industries in China and India. At the end of 2018, there were 94 wind farms in Australia, delivering nearly 16 GW of wind generation capacity, according to the Australian Renewable Energy Agency.[4]

The proliferation of intermittent generation technologies and micro-grid systems calls for improvements in energy storage and frequency regulation technologies. Grid-scale flywheels enabled by high-tensile carbon fibre composites offer a potential solution.

AEROSPACE AND SPACE

The aerospace and defence industry makes up 14 per cent of the total composites market by value, and this is estimated to grow to around 16 per cent of the market by 2021. Aerostructures, or components of an aircraft's airframe, including all or part of the fuselage, wings, or flight control surfaces, may be manufactured from composite materials and increasingly advanced fibres are being used to strengthen and reduce weight in space and aerospace applications.

Space launch vehicles require light-weight materials such as carbon fibre, and high-pressure tanks for storing propellants and life-support gases and liquids are often manufactured with carbon-reinforced composites. 3D-printed carbon composites offer new design possibilities for low-cost and light-weight cube-sat structures.

[4] https://arena.gov.au/renewable-energy/wind/#:~:text=Wind%20energy%20in%20Australia,GW%20of%20wind%20generation%20capacity

THE OPPORTUNITY: GROWING DEMAND

AUTOMOTIVE

Advanced fibre composite materials have contributed to the development of vehicles for more than 50 years, making more and more things possible in terms of design, durability, and light weighting.

Today, advanced fibre and composite materials bring new benefits and applications that are becoming even more relevant in the context of an increasingly diverse and fast-evolving mobility.

Reducing the weight in the unsprung mass of a car – in the wheels, for example - has vastly improved fuel efficiency and vehicle performance overall.

The development of new fuels and energies is also bringing new opportunities for advanced fibre applications, particularly for carbon-fibre reinforced battery housings, lightweight structural integration in battery electric vehicles (BEVs), and carbon fibre pressure vessels for on-board hydrogen storage and carbon fibre fuel cell plates for fuel cell electric vehicle (FCEVs).

CONSTRUCTION AND INDUSTRIAL

Architects and engineers around the world are applying composites in a variety of ways, ranging from curtain wall panels to roofing systems and bridge structures which are almost maintenance-free for decades.

Advanced fibre composite solutions are improving sustainability and design across the construction and infrastructure sector, where lighter weight and durability lends itself to bridges and other structures to ends itself to bridges and other structures that do not rust, are faster to erect and are longer lasting.

In Melbourne, the award-winning extension of the Westgate Bridge by John Holland incorporated the largest application of carbon fibre to a bridge structure anywhere in the world.

THE OPPORTUNITY: GROWING DEMAND

HIGH PERFORMANCE SPORT

Design is at the centre of all composite development - and excellent design is critical to the development of high performance sporting equipment. From the world's best rowing racing boats to performance-centric road-cycling wheels, carbon fibre composites offer a wide range of light-weighting, structural and functionality benefits. Carbon and other advanced fibre-reinforced composites are found in products used for 7 of the 10 most popular outdoor sports and recreational activities.

Carbon fibre leads the way in this market because of its high rigidity, tensile strength and chemical resistance with low weight. At least 10,000 metric tonnes of carbon fibre is estimated globally to go into sports equipment each year, replacing traditional materials like wood, steel and aluminium.

ASSISTIVE TECHNOLOGIES

New assistive and wearable technologies that augment the body's natural physical abilities are being made possible because of advanced fibre composite design and innovation. Carbon fibre is being used in the design of exoskeletons for factory workers in heavy industries and for new generation devices and mobility solutions to make life easier for people with disabilities. Advanced fibre technologies open the door to innovative solutions because they are lightweight, strong and adaptable.

CASE STUDY: 100-YEAR BRIDGE

A collaborative project between Austeng Pty Ltd, Deakin University Carbon Nexus, and the City of Greater Geelong has resulted in an innovative new building material which is lower in CO2 emissions and solves the age-old problem of concrete cancer. The challenge was to design a bridge which could last 100 years without maintenance.

The material solution, proposed by Austeng and researched with Carbon Nexus Professor Russell Varley, was a geopolymer concrete reinforced with carbon fibre strands. The design solution was engineered and tested by the Deakin School of Engineering. Geopolymer concrete can be produced with 43% less carbon emissions than Portland cement.

THE OPPORTUNITY: GLOBAL CAPABILITY

We make carbon fibre composite products in Australia for export to the furthest reaches of the globe. The companies involved have achieved this by investment in automation and strict attention to the minutiae of the cost of conversion.

These are nation-leading businesses involved in high end manufacturing.

Unique carbon fibre automotive wheels made in Geelong, Victoria, for example, are supplying global automotive manufacturers because they are as much as 45 per cent lighter than aluminium wheels, reducing vehicle weight and therefore fuel consumption and CO_2 emissions.[5]

[5] Clean Energy Finance Corporation: https://www.cefc.com.au/case-studies/carbon-revolution-expands-innovative-wheel-technology-operations/

THE OPPORTUNITY: RAW MATERIALS ARE ABUNDANT IN AUSTRALIA

Greater market penetration of advanced fibre composites, especially into the automotive and alternative energy sectors, is limited by cost.

Currently, most carbon fibre is made from a "precursor" made from polyacrylonitrile (PAN) which is a petroleum-based polymer, contributing to more than 50 per cent of the cost.

Early-stage research points at opportunities to utilise agricultural or forestry waste or abundant coal resources as the material source for alternative "precursor" materials.

For example, Victorian brown coal or lignite, with its inherently low nitrogen, low sulfur and low ash content, is arguably the cleanest coal in the world. It has lower levels of these 'impurities' than most forms of biomass.

Victorian brown coal is a near ideal naturally-occurring precursor material for all sorts of carbon products. It is also comparatively cheap due to its massive accumulation in large deposits that are already operational and readily mined by open cut methods.[6]

Australian researchers have made significant breakthroughs in producing low cost and high quality carbon fibres using up to 40% lignite, with further research underway to increase the proportions of lignite. Wet-spinning of the precursor and subsequent thermal stabilisation and carbonisation have been conducted at pilot facilities.

[6] Institute of Frontier Materials, Deakin University, Annual Report 2019

THE OPPORTUNITY: RAW MATERIALS ARE ABUNDANT IN AUSTRALIA

CASE STUDY: LIGNITE

In a collaborative project between Deakin University and Monash University, led by Deakin's Associate Professor Minoo Naebe, researchers are investigating the production of low-cost carbon fibres using precursors derived from Victorian lignite. The project involves a team at the School of Chemistry at Monash University with expertise in chemical transformation and fractionation of Victorian lignite, and the Deakin team at Carbon Nexus, which houses an industrial pilot and research scale carbon fibre processing line, a precursor fibre spinning line and composite manufacturing capabilities.

Carbon fibres containing up to 40% lignite have been produced using two of the extract materials using the wet-spinning technique and subsequent thermal stabilisation and carbonisation.

Funding for this project is provided by Australian Carbon Innovation (ACI) and Australian National Low Emissions Coal Research and Development Ltd (ANLEC R&D).

CONCLUSION

01 Carbon fibre material exhibits outstanding specific strength and modulus, almost four times that of steel, making it one of the strongest and lightest materials on the planet today.

02 Light weighting of materials is catalysing a low emissions future.

03 Australia supplies world-leading composite products, especially into the aerospace and mobility industries, both in the defence and commercial sectors.

04 Australian capability is already high in carbon fibre component manufacture and carbon fibre materials research.

05 Widespread commercial use of advanced composites requires lower cost alternative precursors and faster, cheaper, processes for carbonisation.

06 Research in Australia in this area is world-leading. This includes automation and the application of artificial intelligence (AI) for reducing quality assurance costs, as well as lower cost alternative precursors and faster processes.

07 Driving investment in advanced fibre material production and composite product manufacturing technologies will drive fuel efficiencies, extend electric and other alternative vehicle range, improve high-value aerospace structures and applications in a growing number of sectors.

08 This will develop our comparative advantages in carbon fibre and composite technology and grow Australian jobs and exports.

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