

Australian Economic Recovery Strategy

21st Century Australian Sovereign Capability
Creating Sustainable Advanced Technology

August 2020



FOREWORD	3
Executive summary	6
1. Australian ESG Advanced Green Technology Innovation Private/Public Fund	8
2. An Australian Advanced Technology Mineral Resource Plan	12
3. Establishment of an Australian Green Metal Manufacturing Industry	17
3.1 Rare Earth & Titanium Metal Production	18
3.2 Green Steel Production for Export	24
3.3 Creating a waste repurpose value chain for viable recycling	26
3.4 Hydrogen storage and containment	27
4. Turbocharging industry’s adoption of STEM within a digital 4.0 environment	29
Recommendation	31
Conclusion	32
ABOUT TITOMIC LIMITED	33
APPENDICIES	34
Appendix A - Initiatives Undertaken Overseas	34
Appendix B - Critical Rare-Earth Minerals Strategy	36
Appendix C - The Global ESG Movement for Australia	40
Appendix D - Key Advisers, Contributors, and Supporters of Titomic’s Initiatives ..	41
Appendix E - Waste Management and Waste Repurpose Value Chain	45
Appendix F - Hydrogen Storage	49

FOREWORD

A roadmap to deliver Australia's new advanced technology industry

Titomic Limited is a proud Australian SME, at the forefront of additive manufacturing and advanced technology solutions for clients around the world.

More than this; we are inspired to help harness our technology discoveries, strong academic, science and global industry networks, to help turbocharge Australia's economy out from under this unprecedented health and economic crisis.

We believe we can deliver, for the Government, important immediate solutions to drive Australia's recovery from its financially ravished COVID-19 economic situation. We stand ready to help create new advanced technology industries, spurring thousands of new Australian jobs and sustainable economic stimulus, harnessing our underutilised sovereign capabilities.

Across the globe, the COVID-19 virus has left a shocking path of illness, death, social and familial disconnection and massive unemployment on a scale never before conceived. Entire global supply chains into Australia and other five-eye countries have been crippled, industries shut down overnight, hospital emergency department's overflowing and in every town, there are unprecedented queues of the newly unemployed outside Centrelink.

Australians are shaken by the emerging realisation of our economic fragility and deep reliance on the stability of other major trading partners, predominantly China.

In these times of uncertainty and economic disruption, a cohesive approach is needed to reset Australia's sovereign development goals to create sustainable industries in Australia on the back of our natural resources and pioneering spirit to initiate and implement advanced manufacturing technologies, secure rare-earth mineral security, an ESG driven public private partnership and introduce sovereign trade protections for Australia and its other five-eye nations.

Australia has an opportunity to be pro-active and create a global leading supply chain for titanium metal, produced with green energies from our abundant natural resources of minerals, wind and solar.

Titanium is a critical material used in aerospace, defence, nuclear, marine and medical industries. However, the current titanium supply poses national security risks for the United States and the Western world. Japan, Russia and China are the largest suppliers of titanium metal to the United States and other developed nations.

Australia has an untapped role to play in offsetting those national security risks. We have the largest reserves of raw input titanium feedstock mineral sands in the world, a 280 million tonne resource that can create a commercially high value and sustainable value chain of pre-production input and post-production output.

The US Government recognised this and in 2019, Prime Minister, the Hon Scott Morrison and President Donald Trump agreed to develop a "US-Australia Critical Minerals Action Plan". At its heart, is the improved security and supply of rare earths and other critical minerals in the US and Australia. With China controlling at least 80 per cent of global trade in rare earths, both countries have been increasingly determined to develop alternative rare earths and critical minerals assets for the benefit of Australia and the US and our respective technology-driven industries.

Titomic Limited is one such company, at the leading edge of delivering such an outcome, through advanced multiple multi-metal technology and advanced manufacturing industry-based initiatives.

These initiatives will deliver significant advancements across Higher Education, resource management, mining, emerging advanced technologies, rare earth industry development, hydrogen, space industry development, plastic repurposing, start-up and early-stage SMEs, grants and government funding, and mostly importantly jobs.

Within the industry of early-stage medical research, the Government successfully broken down the silos between early-stage medical researchers and front-line health professionals with its globally respected and well-funded \$20 billion Medical Research Future Fund. We believe a similar strategic approach is required for our early-stage technology and advanced manufacturing sector led by government but funded through Australian Superannuation funds, foreign Green-Tech and Ethical wealth funds and foreign investment funds.

We also know the return on this investment will be significant; in terms of sovereign independence, economic prosperity, new value-add export opportunities and importantly job security for the next generation of young Australians.

We look forward to working with the Australian Government to demonstrate how Titomic can help it build truly global-leading advanced technology industries employing thousands of skilled, industry-ready employees.

We know we can emerge from this terrible crisis as a genuinely transformed nation that will ensure our children not only have steady, skilled employment, but that the country in which they live has implemented sustainable industry and resource management practises for the future.

Titomic has approached a number of key economic, manufacturing, industry and policy leaders and organisations to seek their advice and contribution for these initiatives we are putting forward to drive Australian's economic recovery. All of these parties and individuals have provided their resounding support for each initiative we are presenting and are keen to be involved and contribute to this nation-building endeavour, wherever they can.

We commit this post COVID-19 recovery implementation strategy for your consideration and look forward to working with the Government to achieve its goals of making Australia a true global leader in this exciting and yet to be fully realised sector.



Jeffrey Lang - Managing Director
TITOMIC LIMITED



Executive summary

Globally, Australia is well recognised for our abundant natural resources and early-stage technologies. However, it is widely accepted, that Australia only ever captures a very small part of the returns within the entire mining and manufacturing value chain.

Further, Australia has long been short-changing itself by accepting a low value for its exported materials for a fraction of their market worth and squandering precious taxpayer funds on worthy but repetitive or poorly structured R&D projects that were not focused on delivering large scale, nation building endeavours.

This proposal is aimed at resolving both of these missed opportunities. We will always need to foster a productive, mutually prosperous relationship with other trading countries but there is now a unique opportunity for Australia to do more than just recover economically.

We believe Australia can become its own **sovereign powerhouse**, and a **global leader of a new world of advanced digital technologies** and developments that require very different resources and skill sets to those currently being offered to truly deliver a 21st century industry policy for Australia.

If we can develop a long-term strategy for rare earths and titanium metal production, Australia can break the supply chain strangle hold that Russia and China both have over the five-eyes' countries¹ whilst returning significant and long-term economic benefits to the Australian economy.

We know that companies, such as Boeing, Airbus, BAE and Thales (as major customers of the end product of titanium), will support this initiative, as they too harbour concerns over the Russia-China duopoly.

Australia now has the perfect opportunity to counter its current vulnerabilities and adopt our proposal for a clear post COVID-19 recovery implementation strategy leveraging our advanced technologies and vast titanium and rare earth resources to become a truly dominant international player.

¹ The **Five Eyes** (FVEY) is an intelligence alliance comprising Australia, Canada, New Zealand, the United Kingdom and the United States. These **countries** are parties to the multilateral UKUSA Agreement, a treaty for joint cooperation in signals intelligence.

By developing genuine STEM based skills and training programs to support specific technology focused hubs across Australia, these technology industries will be able to scale against foreign competitive advantage back by training, jobs, resource & energy policies, and private & Government funding.

Our proposal

Our four-pronged approach is to work with the Australian governments (federal and state), scientists and key global industry leaders to develop an:

1. Australian ESG Advanced Green Technology Innovation Private/Public Partnership;
2. Australian Mineral Resource Management Plan;
3. Australian Green Metal Manufacturing Industry
 - 3a) Titanium production using Hydrogen
 - 3b) Green steel production for export
 - 3c) Creating a waste repurpose value chain for viable recycling;
 - 3d) Hydrogen storage and containment
4. Turbocharging industry's adoption of STEM within a Digital 4.0 environment

If implemented as intended, this multi-level implementation strategy will:

1. **create** the opportunity for Australia to build a sovereign private-public partnership around advancing green technology and access the global asset funds;
2. **provide** a strategic plan for sustainable management of Australia's abundant natural resources and
3. **develop** and implement value chains around Australia's key export trading commodities by utilising advanced technologies.

Titomic commits this post COVID-19 strategy to help urgently reboot our economy, to the Government and we look forward to working with it to create a strong and prosperous future for our children, our communities, our workforce and the industries of the future.

1. Australian ESG Advanced Green Technology Innovation Private/Public Fund

The Issue

Australia is in a precarious position due to its significant sovereign dependency on export of coal, LNG, mineral resources and agriculture, where greater transparency is urgently needed to create sustainable value chains for Australia's future strategic growth sustainability.

Global financial firms, responsible for assets in excess of \$118 trillion, are evaluating their investments in fossil fuels and mining resources and are now diversifying their investments towards sustainable green advanced technology assets. There is now over \$22 trillion¹ in assets now invested in environmental, social, and governance (ESG) strategies globally. This impressive figure confirms the sector has shifted out of its infancy and into the mainstream investment landscape.

While the adoption of ESG by institutions has been the main driver of this growth, a broader set of investors are now wanting their investments not only to satisfy their financial objectives but also to express their values.

Key strategies are urgently needed for the Federal Government to foster in a resilient future for Australia that secures sustainable management of our natural assets by creating new value chains that strategically positions Australia as the global leader in advancing technology as a viable solution to economic independence creating a new 21st century industrial policy for the country.

Why does Australia need a Private/Public Fund?

Globally, Australia has always been recognised for its resources and early-stage technologies. However, it is widely accepted, that Australia only ever captured a very small part of the returns within the value chain from its natural resources and creation of global-leading technologies.

Australia has long been short-changing itself by accepting a low-value for its exports and squandering precious taxpayer funded R&D development programs spent on worthy but repetitive or poorly-structured projects that were not focused on delivering large scale nation building endeavours.

The distribution of the R&D tax concession refunds is based on paying out based on the trial and error process of 'giving something a go', rather than true R&D outcome success. Any successful early-stage technologies, supported by these programs, cannot be expanded to commercial levels in Australia and are either licensed or sold to larger overseas owned multi-national conglomerates.

Despite this historic economic pattern, Australia now has the perfect opportunity to break this trend with a clear post Covid-19 recovery blueprint is an opportunity to map out the overarching opportunity for Australian companies and governments to band together and harness this chance to become a truly dominant international player.

Our initiative to deliver an implementation strategy for the establishment of an Australian ESG Advanced Technology Private/Public Partnership, will see significant advancements across emerging advanced technologies, rare earth industry development, mining, hydrogen, space industry development, plastic repurposing, higher education, vocational education, resource management, start-up and early-stage SMEs, grants, private and public sector contributed funding, and mostly importantly jobs.

In a similar vein that the Government achieved enormous success in breaking down the silos between medical researchers and front-line health professionals with its globally respected and well-funded \$20 billion Medical Research Future Fund, we believe a similar strategic approach is required to better fund Australia's emerging technology and advanced manufacturing sector with patient private capital if the fund is structured correctly.

We also know the returns on this investment will be significant in terms of sovereign independence, economic prosperity for our country, export opportunities and job security for the next generation of young Australians.

We look forward to working with the Australian Government to show how Titomic can help build a truly global-leading advanced technology industries employing thousands of skilled, industry-ready employees.

We will demonstrate how we are can emerge from this terrible crisis, pushing Australia forward as a genuinely transformation nation to ensure our children, for generations to come, not only have steady skilled employment, but that the country in which they live has implemented sustainable industry and resource management practises for the future.

We commit this post-Covid-19 recovery blueprint for your consideration and look forward to working with the Government to achieve its goals of making Australia a true global leader in this exciting and yet to be fully realised sector.

The Solution

Australia is in a strong position to harness its sovereign capabilities and build industries for sustainable employment and environmentally beneficial opportunities for future generations utilising its existing and established advanced technology and resources sectors.

Our initiative is to deliver an implementation strategy for the establishment of an Australian ESG Advanced Green Technology Private-Public Partnership initiative.

This world class funding vehicle will trigger significant advancements across emerging advanced technologies, rare earth industry development, mining, hydrogen, space industry development, plastic repurposing, higher education, vocational education, resource management, start-up and early-stage SMEs, grants, private and public sector contributed funding, and mostly importantly jobs.

How will the funds required be raised?

- Australian Government
- State Governments
- Foreign Sovereign wealth funds
- Superannuation funds (domestic and international)
- Private wealth funds
- ESG wealth funds

In 2019, European funds devoted to sustainable investing pulled in a record €120 billion (USD\$132 billion) from clients as demand for green and ethical options surged. The number of sustainable investment funds based in Europe rose to 2,405 last year.

Assets managed by funds in Europe that incorporate environmental, social and governance criteria into their strategies swelled by 56% in 2019 to €668 billion with more than 50 of the 360 funds started in 2019 had a climate-oriented mandate.

Europe is crafting a €750 billion recovery package in response to the economic impact of the coronavirus pandemic. It will devote more than €200 billion directly to low-carbon infrastructure projects. That could enable hundreds of billions more for renewables, efficiency, clean public transport and hydrogen. Investment firms around the world, including giants such as BlackRock and Amundi, are responding to the fast-growing demand for ESG funds. BlackRock, manages assets worth USD\$6.9 Trillion (£5.3 Trillion) including big holdings in major oil producers such as BP, Shell and ExxonMobil.

In January 2020, BlackRock, the world's largest fund manager, said it would divest from any company earning more than 25% of revenue from thermal coal with BlackRock CEO Laurence D. Fink publicly pledging to incorporate environmental concerns into the firm's investment process for both active and passive products.

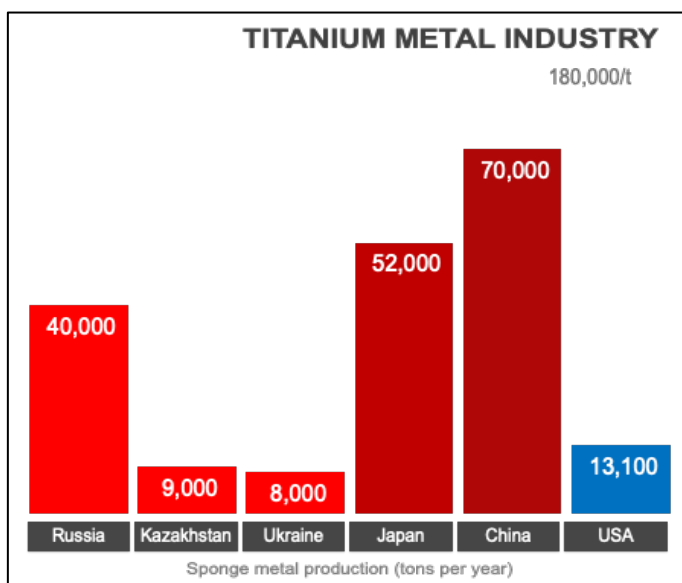
In May 2020, Norway's Norges Bank dropped mining majors Glencore PLC and Anglo American PLC, among others, from the country's US\$1T sovereign wealth fund and placed BHP Group under observation for its production of coal or coal-based energy. The bank also blacklisted Vale SA for causing severe environmental damage.

Australia is in a strong position to harness its sovereign capabilities and build industries for sustainable employment and environmentally beneficial opportunities for future generations utilising its existing and established advanced technology and resources sectors.

2. An Australian Advanced Technology Mineral Resource Plan

The Issue

Despite having the largest global reserve feedstock of titanium, Australia does not currently produce titanium in any metal form and only exports mineral resources. The titanium metal market is currently dominated by Russia, Ukraine, Kazakhstan, Japan and China.



In 2018, Australia exported 1.35 million tonnes of titanium mineral sands, the precursor feedstock to produce titanium, which had a total export value of just \$535 million.

Thus, securing a supply chain of titanium and other critical metals is a key requirement for building Australia's defence and aerospace sovereign industrial capabilities but despite having the largest natural reserves in the world, Australia exports its raw material realising just a fraction of its finished-product sale value and accordingly is not utilising the full benefits of abundant natural resources.

The titanium mineral sand feedstock is exported now to produce titanium dioxide being the white additive colouring pigment found in many products, foods and paints.

Whilst the mining industry is one of the main contributors to the Australian economy, at the current rate of growth of the titanium dioxide market, being at a CAGR of 5.8%, Australia will run out of titanium feedstock reserves altogether within the next 95 years without having harnessed the true value of the resource as commercial titanium.

The Australian critical minerals and rare earths sub-sector would benefit from closer engagement with US end-users. The US increasingly requires critical minerals to serve its growing high-tech industries and Australia possesses the raw materials to meet this need.

Given US end-users of refined rare-earth elements are dependent on concentrated offshore global supply chains, the US government has taken the decision to diversify import sources.

This has opened a new opportunity for Australian companies to supply a growing US specialist manufacturing industry with the required raw or semi-processed materials.

Geoscience Australia estimates China had 38 per cent of world economic resources and 72 per cent of global production of rare-earth elements in 2018. However, this is based on documented production. Some industry analysts estimates China could hold up to 50 per cent of known global resources and 80 per cent of global production of rare-earth elements. China is also the world's largest consumer of rare earths. It is an economic and industry priority for the Chinese government to support development of its own, hi-tech manufacturing industry.

The United States accounts for about 4 per cent of the total world production of titanium minerals and is heavily dependent on imports of titanium mineral concentrates to meet its domestic needs. The lack of downstream processing capability at scale in the US presents both a challenge and an opportunity for the Australian critical minerals sector.

US interest in Australia, as a potential supplier of critical minerals, is in line with Australia's position as a significant trading partner. Australia further stands out as a safe, ethical and reliable supplier in a strategically significant region.

In 2018, Australia exported 1.35 million tonnes of ilmenite and rutile, the precursor to titanium metal, reaping just \$535 million in revenues for Australian mining companies. By adding just one more stage in production process to the mineral sands prior to export, Australia could have generated \$13.5 billion in revenue just in 2018 alone, that's \$13 billion in lost revenue opportunity.

There is an enormous untapped potential in the research earths and metals of military importance that can, and must, be realised.

The Solution

We know – even now in this strange pandemic world - we can redefine Australia's global branding from selling dirt, white beaches and great start-up ideas which can be acquired, to being a land of highly skilled individuals, building world leading advanced digital technology industries to capture more of an industries intrinsic vertical value.

Post virus, it would make Australia a destination high tech and advanced manufacturing hub for international investors across the sectors of space, rare earths, hydrogen, defence, environment and mining.

Our job-ready, university and TAFE graduates will be in high demand and our children (and their children) will be assured of strong and successful futures in the industries of tomorrow.

The **Australian Advanced Technology Mineral Resource Plan** will focus on four critical areas:

- 1) capture increased return from mineral resources through a vertically integrated value-chain in Australia to create future education, skills, employment and export opportunities;
- 2) create a stockpile of critical minerals for Australia and five-eye allied countries to secure defence supply chains;
- 3) work with native title land holders to create employment and education opportunities from community hubs to unlock unrealised returns and development from Australian resources (in particular titanium) to ensure value is maximised and returned to the traditional landowners; and
- 4) breaking the duopoly of Russia and China over global supply chain of rare-earth and titanium supplies to Five-eye countries for defence and aerospace applications.

Why Titanium?

Titanium is the fourth most abundant mineral resource for structural metal after aluminium, iron and magnesium. It presents in the Earth’s crust at a level of about 0.6%.

According to U.S. Geological Survey (USGS,2019), Australia is estimated to have 29 million tonnes rutile (TiO₂) reserves (47% of the world total) and 250 million tonnes ilmenite (FeTiO₃) reserves (28% of the world total). A snapshot of the critical minerals industry is captured in Appendix B.

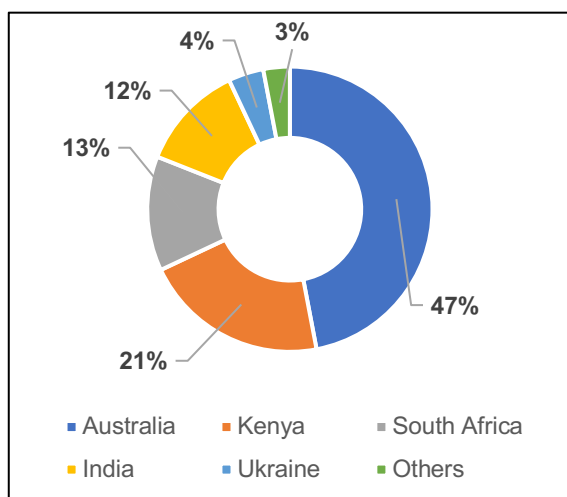


Figure 1 - The total world reserves of ilmenite

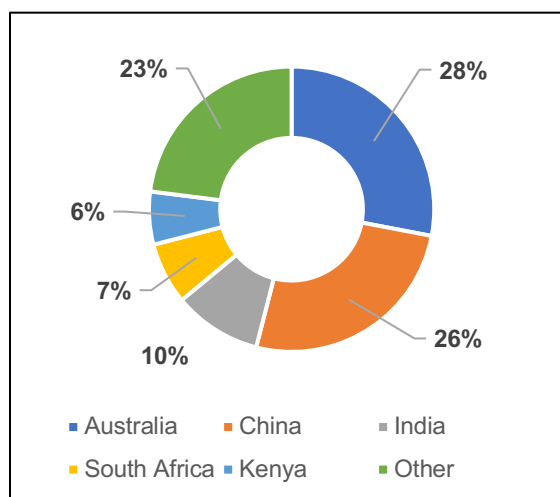
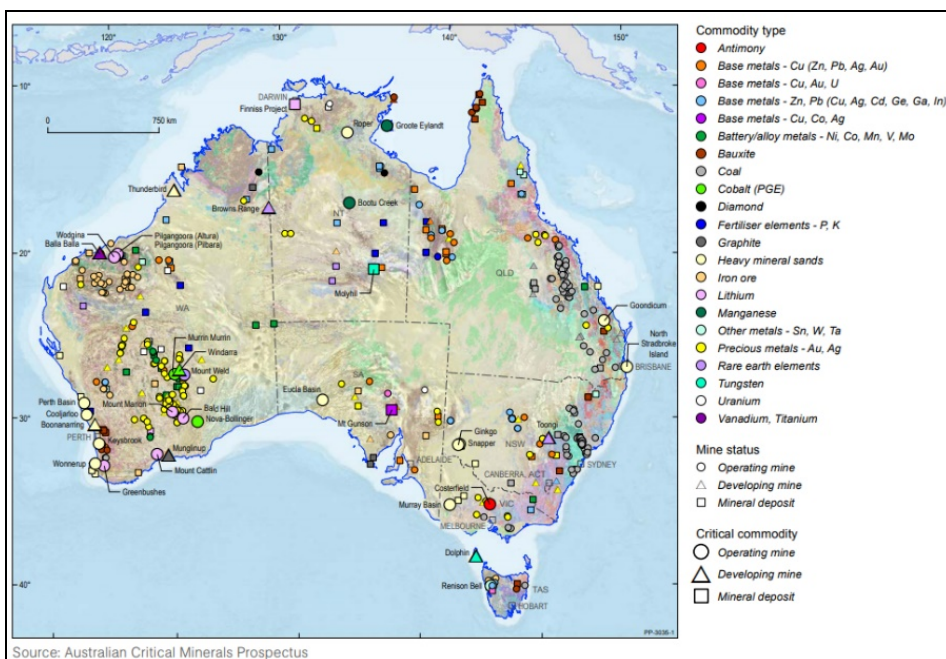
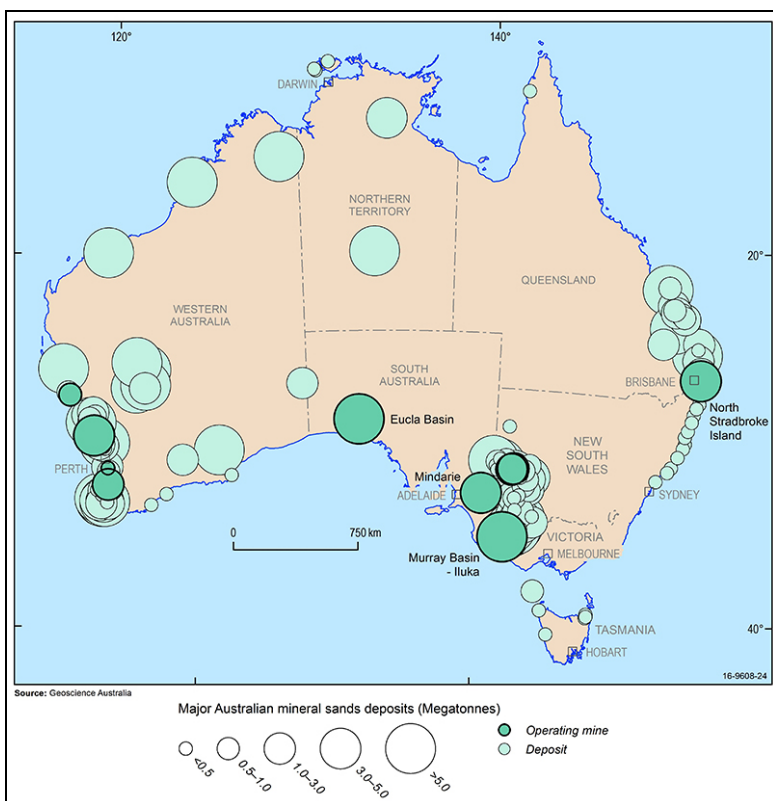


Figure 2 - The total world reserves of rutile

Australia's suitability as a valuable partner is supported by several key attributes:

- a) political stability and cooperation across state and federal governments;
- b) almost three decades of uninterrupted economic growth and
- c) a highly skilled and educated workforce that contributes to the mining industry and related research.



This new increased value chain will also develop an entirely new capability for many Australian industries which will ultimately lead to better living standards within these communities, improved resources and education, many more local jobs, higher skilled local labour leading to higher employment in their traditionally higher unemployment and lower skilled labour areas. It will empower our first nation people and it will be nation building - economically and socially.

This was the case when this proposal was first recommended to Government, as a pre-Budget submission 2020-21. It is even more vitally important now.

We know this is a significant focus of the Morrison Government and we stand ready to help deliver on its economic recovery objectives.

Recommendation

We recommend the Australian Government to work with Titomic to design and establish the **Advanced Green Technology Public-Private Partnership** and the **Mineral Resource Management Plan**.

We estimate the cost to the Government would be \$14 million for these initiatives over the next two years.

The initial \$8 million of funds for 2020-21, would be allocated to the development of a sovereign **Advanced Green Technology Fund**, co-ordinated and managed by a government-held trust, with Titomic and other industry leaders as key board advisers. We anticipate the fund will attract significant private and public investment to eventually become a self-sufficient billion-dollar entity.

The fund could be cost neutral to taxpayers by charging annual memberships for industry participants and then award co-contribution grants for projects based on their submissions.

3. Establishment of an Australian Green Metal Manufacturing Industry

Australia has the capability to create a global leading hydrogen industry utilising multiple advanced technology providing future energy security for Australia.

The implementation of a Hydrogen industry will create jobs and build an export industry valued in the billions to supply both clean hydrogen and provide sustainable green tech manufactured products to the world.

As part of the recommended **Australian Green Metal Manufacturing Industry** plan; Titomic has identified the opportunity to establish an innovative Green Titanium STP™ and Green Steel production and Hydrogen industry for struggling fossil fuel funded regional areas such as the LaTrobe Valley (VIC), Hunter Valley (NSW) or Bowen Basin (Qld). There is a significant and worrying lack of new industry and job opportunities across regional Australia. The situation worsened dramatically with the impact of bushfires and COVID-19.

As an example, Latrobe Valley is home to Victoria's coal-fired power stations and is one of the hardest hit regions. Rationalisation and privatisation of the state's power industry in the 1990's has seen thousands of jobs being lost, business closures, a drop in house prices and an exodus of residents.

As the Grattan Institute observed recently, the future of Australia's carbon-intensive industries, particularly coal mining, will be determined primarily in Beijing and New Delhi, not in Canberra. This is not in Australia's national security interest.

A better approach is economic diversification, particularly into new industries based on zero-emissions energy.²

This new industry could create hundreds of jobs, develop a bold new export opportunities and solve a national security risk for Australia, the US and other members of the 'five-eye' nations particularly surrounding securing Titanium metals for the aerospace and defence industries.

² <https://reneweconomy.com.au/how-green-steel-could-replace-australias-coal-industry-and-end-climate-wars-50875/>

3.1 *Rare Earth & Titanium Metal Production*

The issue

Australia has an opportunity to be pro-active and create a global leading supply chain for Titanium metal produced with green energies from our abundant natural resources of minerals, wind and solar.

Titanium is a critical material used in Aerospace, Defence, Nuclear, Marine and Medical industries however the current Titanium supply represent national security risks for the United States and Western world. Japan, Russia & China are the largest suppliers of Titanium metal to United States & Western world.

Australia has largest reserves of raw input titanium feedstock mineral sands in the world, a 280 million tonne resource that can create a commercially high value and sustainable value chain of pre-production input and post-production output.

A December 2017 US Presidential Executive Order - No. 13817, 'A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals' directs US Government agencies to develop an inter-agency strategy to ensure how they procure rare earths and critical minerals, and to ensure a safe, ethical and reliable supply of critical minerals for the future as a way to insure that, in urgent situations and times of war, the United States will have access to critical items needed to ensure national security.

In 2019, the Australian Government said it wanted to make funds available for rare earths and other critical minerals projects, as it collaborates with the United States on ways to reduce China's near stranglehold on supply.

The Australian and US governments are aiming to develop a "US-Australia Critical Minerals Action Plan" that will improve the security and supply of rare earths and other critical minerals in the US and Australia. With China controlling at least 80 per cent of global trade in rare earths, Australian and American defence and security officials have been in talks for months about developing alternative deposits both in Australia and the US.

This was reiterated in the Australia Government's 2019 Critical minerals strategy which highlighted:

"The Australian Government has been strengthening links with the United States (U.S.) since President Trump released an Executive Order in December 2017 directing the development of a United States Critical Minerals Strategy."

In the United States, Congress introduced the Berry Amendment (USC, Title 10, Section 2533a), which requires the Department of Defence (DOD) to give preference in procurement to domestically produced, manufactured, or home-grown products, notably specialty metals, in order to protect the domestic industrial base in the time of war. The specialty metals provision requires that specialty metals incorporated in products delivered under US DOD contracts must be melted in the United States or a “qualifying country” including Australia.

This was reaffirmed by US President Donald Trump in September 2019, when he described Australian Prime Minister Scott Morrison as a “Man of Titanium”. This moniker was delivered during a White House meeting that canvassed stronger military action against Iran, rising tariffs against China and joint defence work in Afghanistan. Mr Trump spoke of the “eternal ties” between Australia and the United States during talks that cemented the positive relationship of the two allies on defence and trade.

The Australian Government AusTrade Report “Critical Minerals Supply Chain in the United States” also released in September 2019 highlighted: “US Congress has determined that reliance on foreign sources of supply for materials such as titanium and specialty metal poses a heightened risk.”

Following the issuing of an interim rule amending the Defense Federal Acquisition Regulation Supplement to implement a section of the National Defense Authorization Act for Fiscal Year 2019, the US Department of Defense is prohibited from purchasing devices that contain certain magnets or tungsten from North Korea, China, Russia and Iran. This has opened a new opportunity for Australian companies to supply a growing US specialist manufacturing industry with the required raw or semi-processed materials

The Australian critical minerals and rare earths sub-sector would benefit from closer engagement with US end-users. The US increasingly requires critical minerals to serve its growing high-tech industries, and Australia possesses the raw materials to meet this need.

The June 2019 release of the US Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals to boost domestic production of minerals, and continue and expand cooperation and collaboration with partners, including Australia.

Given US end-users of refined rare-earth elements are dependent on concentrated offshore global supply chains, the US government has taken the decision to diversify import sources. In the case of purchasing by the US Department of Defense, this policy is now mandatory.

Cooperation between the US and Australian governments over the past 18 months has fostered ideal conditions to position Australian raw materials as part of the solution to the US's critical minerals supply chain needs.

Geoscience Australia estimates China had 38 per cent of world economic resources and 72 per cent of global production of rare-earth elements in 2018. However, this is based on documented production. Some industry analysts estimates China could hold up to 50 per cent of known global resources and 80 per cent of global production of rare-earth elements. China is also the world's largest consumer of rare earths. It is an economic and industry priority for the Chinese government to support development of its own, hi-tech manufacturing industry.

The United States accounts for about 4 percent of the total world production of titanium minerals and is heavily dependent on imports of titanium mineral concentrates to meet its domestic needs. About 2.5 percent of the world's titanium is used for the production of corrosion-resistant titanium metal (Murphy and Frick, 2006). Titanium metal alloys are desirable for their high strength-to-weight ratio and corrosion resistance. The lack of downstream processing capability at scale in the US presents both a challenge and an opportunity for the Australian critical minerals sector.

US interest in Australia, as a potential supplier of critical minerals ,is in line with Australia's position as a significant trading partner. Australia further stands out as a safe, ethical and reliable supplier in a strategically significant region.

Production methodologies

There are two very viable production methods for rare-earth and titanium mineral powder production:

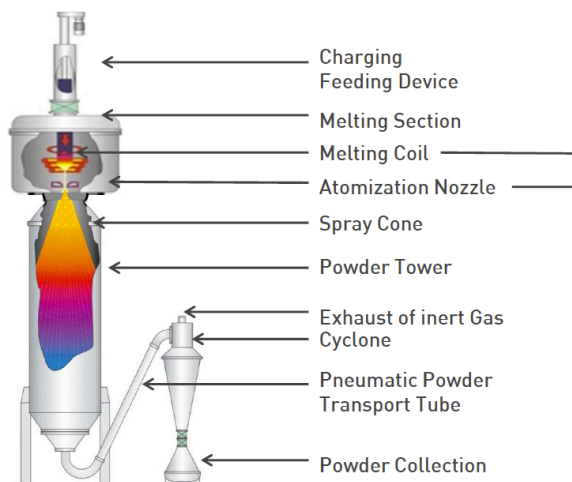
a) A Gas Atomisation Production Plant

Titomic has fully costed and quoted a Gas Atomiser Production Plant capable of delivering:

- a) Gas Atomisation of Rare-Earth Minerals Production Plant
- b) Titomic Kinetic Fusion (TKF) Additive Manufacturing Centre
- c) Material Science Laboratory
- d) Advanced Material Science Technical Advisory Board

The Gas Atomiser capable of atomising many other rare-earth minerals enabling exploration works to be undertaken to develop new metals and metal alloys for use in the Defence, Medical, Aerospace,

Medical and Construction industries. The Gas Atomiser is capable of being powered by fully renewable and sustainable green energy initiatives.



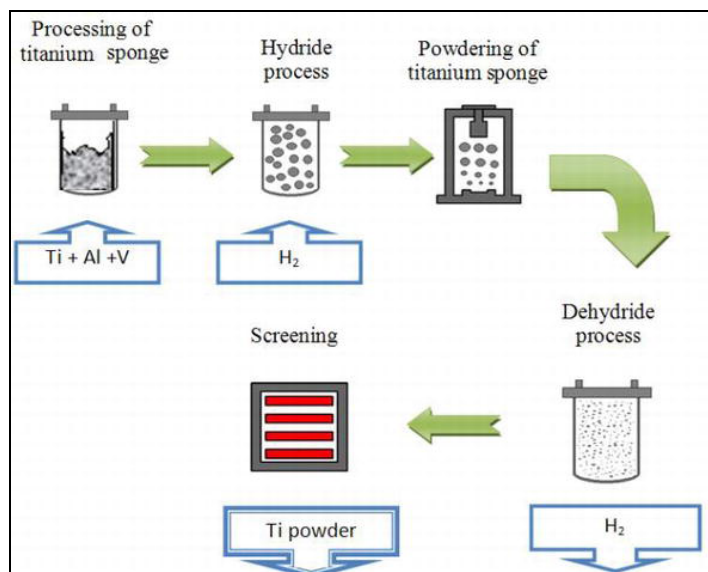
b) A Green Titanium STP™ Production Plant

Titomic has fully costed a Green Titanium STP™ Production Plant capable of delivering:

- a) Hydrogen Atomisation of Titanium Minerals Production Plant
- b) Titomic Kinetic Fusion (TKF) Additive Manufacturing Centre
- c) Material Science Laboratory
- d) Advanced Material Science Technical Advisory Board

The Green Titanium STP™ hydrogenation process, illustrated below, is used to produce titanium powder from titanium sponge or titanium scrap as the raw material.

This is achieved using a batch furnace that is usually operated in vacuum and/or hydrogen atmospheric conditions.

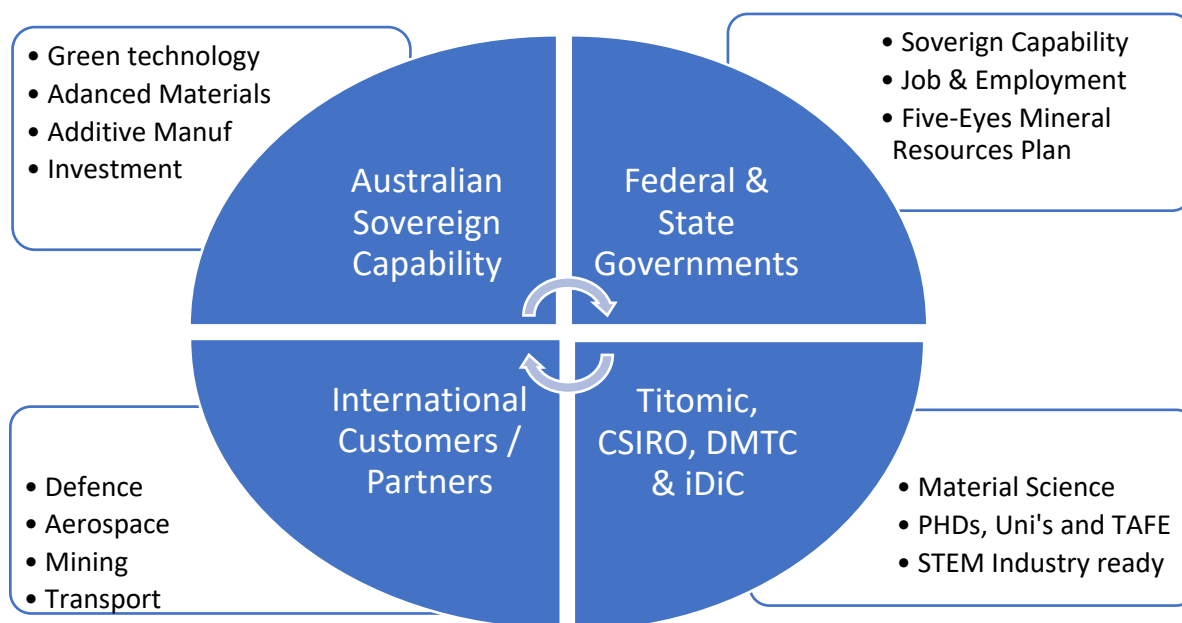


The hydride-dehydride process is relatively inexpensive and further efficiencies can be found from the Green Titanium STP™ manufacturing process using recycled hydrogen and argon gas.

Titomic has fully costed and quoted a Green Titanium STP™ Atomisation Production Plant capable of delivering a Titanium Production Plant, Titomic Kinetic Fusion (TKF) Defence Centre STEM Advanced Technology Hub, supported by a Titanium Material Science Technical Advisory Board.

We believe this can be achieved with an investment using sustainable green hydrogen energy.

Potential Funding Breakdown and Ownership



Benefits of the initiative:

- 1) It will break the duopolisation by China and Russia of the titanium and rare-earth supply chain
- 2) Secures 'five-eye' countries' access to critical rare-earth metals
- 3) Each Atomisation Production Plant can employ up to 50 employees with hundreds of more jobs created through indirect upstream mining, and downstream defence and aerospace manufacturing jobs.
- 4) The Atomisation Production Plant can be located in self-supporting remote community hubs to bring jobs to rural and disadvantaged communities
- 5) Will create STEM advance technology education & training centres for high-value jobs
- 6) Will create significant high-value export opportunities for Australia

It will lead to significant Australian technology advancements through research and development collaboration opportunities between Titomic, CSIRO, AMRC, iDiC and major international aerospace and defence industry primes.

3.2 *Green Steel Production for Export*

The Issue

As we begin a debate about reinvigorating Australian manufacturing, an opportunity is emerging that could do just that.

Globally competitive renewable energy, matched with our major mineral resources, has the potential to create thousands of jobs in regions likely to be in trouble as the world turns away from fossil fuels in coming decades. These are the same regions struggling, economically, to recover from the COVID-19 crisis.

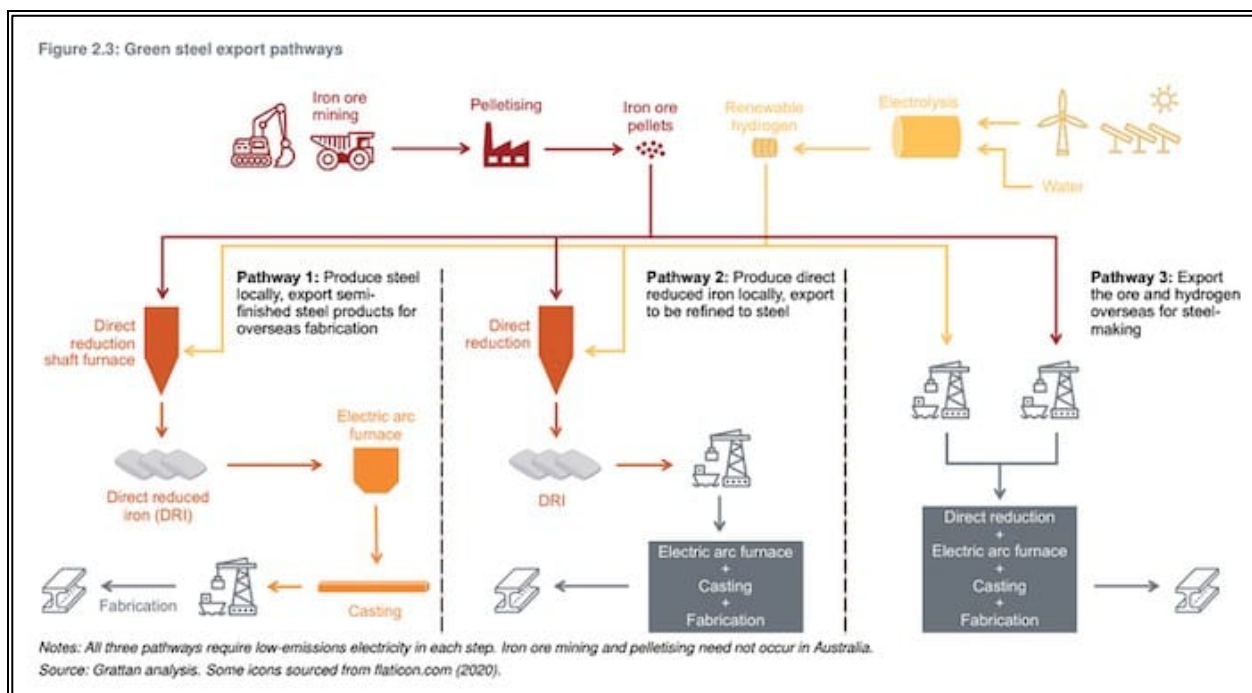
Over the past few years, Australian industry achieved annual exports of about \$70 billion of iron ore, \$40 billion of metallurgical coal to turn that ore into steel, and \$20 billion of thermal coal for generating electricity. These figures will undoubtedly be dented by the economic impacts of COVID-19 in the short term.

In the longer term, there is a strategic risk, with significant consequences, as the world begins to seriously tackle climate change. We need a strategic response, whether these changes emerge over 10, 20 or 30 years.

Australia has close to 100,000 “carbon workers” – those in coal mining, oil and gas extraction, fossil-fuel generation and integrated steelmaking. About half of these workers are concentrated in a few geographic areas, notably central Queensland and the Hunter region of NSW.

Building on the recent work of experts, such as Chief Scientist, Mr Alan Finkel, and renowned economist, Mr Ross Garnaut; the Grattan Institute has published a report *Start with Steel* which charts an economically viable alternative path through.

Demand for low-emissions industrial commodities is emerging and will grow over coming decades. We analysed several emissions-intensive sectors, including aluminium, cement, aviation fuel, ammonia and steel. The Grattan Institute concluded that “green steel” is the best opportunity for large-scale exports and job creation in key regions – benefits beyond the reach of simply investing in large-scale renewable energy.



The Solution

Green metal product is produced using hydrogen, rather than coal, to strip the oxygen out of iron ore. The by product is water rather than carbon dioxide.

It is easy to put coking coal on a ship, but much harder to ship hydrogen. The difference decisively shifts the economics. It will make sense to manufacture green steel here in Australia rather than in the energy-poor countries of Asia.

It is built on Australia's unique combination: extensive and competitive iron ore and renewable energy resources, to be matched with emerging hydrogen production. It is consistent with the federal government's priority for technology-led investment to lower emissions.

This opportunity will not happen overnight. But the Grattan analysis³ shows that capturing about 6.5 per cent of the global steel market would generate about \$65 billion in annual export revenue and could create 25,000 manufacturing jobs in Queensland and NSW.

Moving Australian steelmaking towards lower-emissions technologies in the next decade would build the domestic skills and capabilities needed to create an export-oriented green steel industry in the following decades. In that context, federal funding for a steel "flagship" project would be a worthwhile investment, given the size of the opportunity.

³ <https://grattan.edu.au/report/start-with-steel>

While the export opportunity is the longer-term prize, a flagship project in the near term and using gas in the interim, could also help sustain existing steelmaking jobs in Whyalla in South Australia or Port Kembla in NSW.

The Australian government is rightly committed to driving down the cost of producing renewable hydrogen, through the National Hydrogen Strategy and it is to be applauded for its \$300 million Advancing Hydrogen Fund.

Now we have the real opportunity to add value to Australia's energy and minerals resources and create sustainable jobs through manufacturing and exporting.

Green steel combines minerals and energy resources in an eyes-wide-open opportunity, based on credible underlying economics in a changing world. Such opportunities do not come along every day and are always hard to realise. This one is worth the effort.

3.3 *Creating a waste repurpose value chain for viable recycling*

The Issue

What will Australia do with its commercial, household and industrial waste, particularly plastics? bury it, burn it? or repurpose it?

Now that China has now closed its borders to Australia's waste, the problem surrounding what to do with our waste, in particular plastics, is mounting daily.

Our municipalities are struggling to find avenues to process and dispose of household waste from recycling bins particularly in light of the collapse of many recycling plants.

Whilst these companies could repurpose or reuse many of the materials there was no market demand for the down-stream output product of these repurposed materials.

There needs to be a fundamental mentality shift within all of Australia's stakeholders from recycling, to repurposing waste products for which strong down-stream value chains can be created.

The Solution

Titomic can work with the Government to create a new Value Chain surrounding the repurposing of waste management and other materials. This will:

- Create a framework for the lifecycle management of plastic and other industry and household waste. This will lead to genuine waste management solutions for municipalities and their rate

payers. Currently municipalities are struggling to find a solution to their problem of what to do with the waste;

- Develop new early-stage vortex milling processes to break waste down into nano particle powder elements for repurposing.
- By alleviating waste management issues through the repurposing of waste by breaking it down to its nano-powder state, 3D metal, plastic, and fibre printing technologies can utilise these nano-powder feedstocks to produce new products. This closes the entire value chain loop of a product life-cycle from powder, to product, to powder to product and so on.
- Create industry driven feedstock value chain for nano-particle milled waste utilising automated robotic plastic and metal additive manufacturing printing technologies within a digital 4.0 smart factory facilities;
- Repurpose waste for biofuels and other green energy production capabilities.

A snapshot of two of these key technologies is outlined in Appendix E.

3.4 ***Hydrogen storage and containment***

The Issue

The global market for hydrogen is expected to reach USD\$155 billion by 2022.⁴

Hydrogen too is identified as the energy source of the future. Within 20 years; Australia could be exporting more than \$10 billion p/a worth of this low emissions energy each year.⁵

The direct economic contribution (value-add) embodied in the value of hydrogen production for export is estimated to be AUD\$200 million – AUD\$900 million by 2030. In the high scenario they are comparable to the numbers employed in the LNG industry (55,000 – 65,000 people) and direct supply chain.⁶

Although various hydrogen storage technologies are presently available, none completely satisfies all of the auto industry requirements. In fact, finding a solution to the hydrogen storage problem is considered by many to be the foremost challenge for the hydrogen economy.

To meet the storage challenge, basic research is needed to identify new materials and to address a host of associated performance and system issues.

⁴ International Energy Agency Hydrogen Technology Collaboration Program 2017, Global Trends and Outlooks for Hydrogen

⁵ Australian Renewable Energy Agency (ARENA) Hydrogen Grant Summary Report

⁶ McKinsey Australia 2016- Sustaining Impact from Australian LNG Operations

Further background on **hydrogen storage** can be found as Appendix F.

The solution

Titomic is advancing a new program centred around producing hydrogen storage tanks in the form of Titanium coated aluminium tank liner instead of carbon fibre wrapped aluminium tank liner.

The titanium coated tanks will far exceed the pressure rating of a carbon fibre wrapped tank and also provides a safer and less explosive outcome from any potential tank failure compared to a carbon fibre failure.⁷

This capability will help deliver on the following economic outcomes and can bring forward the Government's own hydrogen roadmap by 10-15 years.:

- Natural Gas Supply: Gas prices remain high and hydrogen could replace gas as a low emission source of heat and feedstock for a number of industrial processes
- Electricity Sector: A Hydrogen Fuel Mixture can help manage the transition to a higher proportion of variable renewable electricity in the electricity network by overcoming challenges with energy intermittency. *NB*: Titomic has a lower cost solution here to be discussed later.
- Liquid Fuels Security: Australia has long been dependant on imported liquid fuels and a Hydrogen Fuel Mixture can play a role in localising liquid fuel supplies with a clean option.
- Skilled Workforce: Australia has a technically skilled workforce with deep expertise across the energy sector and in the high value or advanced manufacturing production processes. These skills can be transitioned by this workforce to a growth market.

⁷ <http://www.fsec.ucf.edu/en/consumer/hydrogen/basics/storage.htm>

4. Turbocharging industry's adoption of STEM within a digital 4.0 environment

The Issue

Are we ready?

The transition to Industry 4.0 is well underway in many countries - being helped, in no small part, by governments funding national programs to promote the uptake of additive manufacturing.

These organisations offer funding, collaboration opportunities and other financial and commercial incentives to promising additive manufacturing businesses. In many countries, for the most part, the programs work with established large organisations to help smaller organisations enter the market through collaborative efforts.

Deloitte's 2020 annual survey on business's preparedness for Industry 4.0;⁸ highlights the need for a sharper focus on the uptake of transformational technologies. In surveying over 2000 executives across 19 countries, it was found that two thirds of respondents have no formal strategies or are taking ad-hoc approaches to Industry 4.0 advancements.

They also revealed that only 10% of executives had long term strategies to leverage new Industry 4.0 technologies.

This highlights the importance of government and industry groups promoting collaboration and consultation in preparing for a transition to Industry 4.0. In a study of Australian business preparedness for Industry 4.0, undertaken by PWC,⁹ the transition to digitalisation and advanced automation was poised to add 14% or \$1.5 trillion to global GDP gains by 2030.

In order to take advantage of these gains, business and workforce transformation is essential. This will ultimately lend on the labour force sectors of education and training to deliver properly skilled people we will need for this exciting but challenging phase.

⁸ Deloitte 2020 *Leadership in the Fourth Industrial Revolution: Faces of progress*

⁹

Transforming Australian Manufacturing: Preparing businesses and workplaces for Industry 4.0

<https://www.pwc.com.au/education/industry-proposal-13may2019.pdf>

Globally, many countries have designed and implemented dedicated national programs focussed purely on transitioning traditional manufacturing processes to advanced manufacturing and Industry 4.0. The leading countries undertaking such initiatives in this area are the USA, Canada, UK and Singapore. Appendix A has a detailed snapshot of initiatives undertaken overseas.

With an economy significantly weakened, this closer collaboration between the Australian Government and industry is absolutely needed now.

Intimately, Australian industry needs such a plan now to stay relevant in, and re-enter, the competitive global market:

- Academic institutions need to return on quality education focused deliverables, not profits;
- educate students proficiently such that they are industry ready from day one;
- fill industry skill gaps with newly trained students to champion transition;
- retain Australian-educated local and foreign students to increase the skilled labour workforce; and
- take advantage of the significant opportunity Australia has to own the Industry 4.0 digital advanced technology and manufacturing sectors implemented using smart factory processes.

The Solution

Titomic would work with our academic partners and industry colleagues to review the gaps and barriers and present a roadmap to develop the Australian Advanced Technology Fund.

This will – by Q4 2020:

1. establish sustainable funding channels through investment, grants and tax incentives to truly support emerging technologies and companies through their foundation set-up years;
2. create incubator hubs to foster co-development and collaboration between advanced technologies to mature technology advancements faster
3. develop practical advanced technology curriculum programs for students to propagate a workforce of highly skilled digital robotics, AI and material science engineers (Industry 4.0);
4. assess and redesign university curriculums to ensure students receive fundamental basic lateral-thinking and concept training to break a current pattern of one-dimensional thinking;

5. reinvigorate Universities and Education Institutes to be skill, knowledge and industry outcome focussed instead and offset the need to rely on foreign students and government funding;
6. better align the student academic outcomes to the needs of industry to enable students to truly be job-ready when completing higher-education; and
7. develop career and support pathways to retain the significant number of international students studying in Australia. Many of these studies complete their studies only to struggle to find a job in an industry within their field of study, or who choose to move overseas to explore job opportunities.

Recommendation

We recommend the Australian Government work with Titomic to design and establish the **Australian Advanced Technology Fund** and **Mineral Resource Management Plan**.

We estimate the cost to the Government would be \$20 million for both of these initiatives over the next two years.

These initial \$10 million of funds for 2020-21 would go into the sovereign **Australian Advanced Technology Fund which will be a private-public investment vehicle**. It can be co-ordinated and managed by a Government-held trust with Titomic and other industry leaders as key board advisers.

We anticipate the fund will attract significant domestic and international private investment to eventually become a self-sufficient \$2 billion entity.

The fund could be initially cost neutral by charging annual memberships for industry participants and then awarding co-contribution grants for projects based on their submissions.

Conclusion

This strategy underscores Australia's much needed confidence and readiness to take risks, define big, long-term goals, and have the audacity to do it 'the Aussie way' and 'to have a go'. We need this more now than ever. It is empowering, recovery and necessary. This strategy is a hand up for industry, not a hand-out.

Titomic's strategic vision roadmap and commercial endeavours has defined the whole commercial value chain of Australia's 280 million tonnes of titanium mineral sands stemming from the Government's "Ore to More" program in 2008 gained the interest of other country Governments and major industries.

It also highlights that global leading advanced technologies, created by a co-operative partnership between research (CSIRO) and industry (Titomic) and creates a diverse skillset symbiosis that is both respected and accepted as representative of Australian sovereign capability.

In establishing this **Australian Advanced Technology Fund** and **Mineral Resource Management Plan**, the Australian government may also gain access to seek sustained funding from the Task Force on Climate-related Financial Disclosures (TCFD) which has International held funding available in the trillions of dollars.

<https://www.fsb-tcfid.org/wp-content/uploads/2019/06/2019-TCFD-Status-Report-FINAL-053119.pdf>

This fund will also complement the Government's recently announced development of a \$500 million Business Growth Fund for SMEs that is being funded by co contributions of the major banks, superannuation companies and the Government.¹⁰ This in turn follows the success of the United Kingdom's Business Growth Fund, which has now invested \$2.7 billion in a range of sectors across the economy.

It could also replicate the success of the USD\$100 trillion asset funds¹¹ being redistributed from mining and oil and gas to green advanced technology.

¹⁰ <https://treasury.gov.au/small-business/bgf>

¹¹ <https://www.fsb-tcfid.org/wp-content/uploads/2019/06/2019-TCFD-Status-Report-FINAL-053119.pdf>

Titomic commits this post COVID-19 strategy to help urgently reboot our economy, to the government and we look forward to working with it to create a strong and prosperous future for our children, our communities, our workforce and the industries of the future.

ABOUT TITOMIC LIMITED

Titomic Limited (ASX:TTT), headquartered in Melbourne, Australia, is a pioneer in advanced manufacturing. The company's proprietary system of robotics, patented process and material science produce goods at industrial scale, faster and cheaper. The Titomic Kinetic Fusion™ process creates superior products at lowered production costs, using less resources for a more sustainable future.

Multiple robots can be utilised to build larger parts, competing with traditional manufacturing solutions for industries such as aerospace and defence, sporting goods, medical, automotive, industrial equipment, construction and marine.

APPENDICIES

Appendix A - Initiatives Undertaken Overseas

USA

America Makes is the USA's national accelerator for additive manufacturing and 3D printing. It was established in 2012 and is the flagship organisation for Manufacturing USA, the National Network for Manufacturing Innovation. America Makes is managed by the National Center for Defense Manufacturing and Machining and in 2018 received a budget of US\$115 million.

The organisation is structured as a public-private partnership with member organisations including industry, academia, government, non-government agencies, and workforce and economic development resources. The goal of the organisation is to increase the USA's global manufacturing competitiveness.

America Makes enables collaboration between AM organisations through several projects focussed on elements within the overall roadmap. In addition, there are challenges available to undertake which could see participants being awarded large grants to develop their solutions.

<https://www.americamakes.us/about/>

Canada

The government of Canada has funded many programs which promote the progression of the manufacturing industry. The country has focussed mainly on the development of materials production for Additive Manufacturing, with metal powders production appearing to be a high priority. This sets up the country's manufacturing industry with a secure local supply chain for advanced materials.

The Quebec Economic Development Program supports the development and economic diversification of regions and helps them seize promising economic development opportunities for the future. The organisation offers interest free loans to companies for up to 50% of the cost of equipment, inventory, long term assets, real estate, short term assets and other eligible items.

Companies involved in advanced manufacturing in the country include AP&C (GE), PyroGenesis and Tekna, all of which have benefited from the Governments of Canada and Quebec as funding

partners. Quebec appears to fund the organisations through the Quebec Economic Development Program.

For example, in 2018, Tekna received investments from the Governments' of Canada and Quebec respectively. This investment came as a part of a project worth over CAD\$100 million. The amount contributed by the governments was funded more than one fifth of the total project value.

United Kingdom

The UK Government has a number of programs which it has funded with the goal of promoting the adoption of additive manufacturing. The Department for Business, Energy and Industrial Strategy funds a non-governmental body known as UK Research and Innovation, which in turn funds Innovate UK which funds a number of AM related R&D projects. Since its inception in 2007 Innovate UK has invested £2.5 billion into projects worth £4.3 billion.

In addition, the UK Government has also promoted AM through AM UK (Additive Manufacturing UK) an independent government supported collaboration with an aim to promote acceptance of additive manufacturing in the UK through workshops and industry consultation. The organisation is led by representatives from leading manufacturing companies.

Through a process of industry consultation AM UK has come up with a series of recommendations for the manufacturing industry to collaboratively promote AM and to work towards a digitalisation of industry. There are further recommendations made in the specific areas of design, materials and processes, inspection, IP, skills, supply chain, and implementation.

Outside of formal organisations the UK government has funded projects such as the Advanced Manufacturing Supply Chain Initiative (AMSCI) and the CASCADE project. The Cascade project was run by a consortium of 11 companies with a view to develop metal powders for AM and refine AM processes. These advanced manufacturing projects received over £235 million from the UK government and show the ongoing commitment by this government to industrial transformation.

Singapore

The Singaporean government has a number of organisations operating under the Ministry of Trade and Industry, which are helping to promote a move to advanced manufacturing.

The Singapore Economic Development Board offers grants, and tax assistance to companies which they hope to attract to the country. A*STAR (\$25.2 billion from 2015 onwards) is a research organisation set up to bring scientific discoveries to market through spinning off research into commercially successful businesses. SIMTech is an organisation focused on collaboration with industry to improve skills and increase the value of manufacturing and falls under A*STAR.

Finally, NAMIC is an AM focussed organisation focussing on accelerating AM startups' development. NAMIC has collaborated with a great number of start-up companies involved in AM, having reported that 1700 companies have been engaged, with 222 projects being initiated.

Appendix B - Critical Rare-Earth Minerals Strategy

Australia's Department of Development – Bureau of Mineral Resources, Geology and Geophysics

A 1968 report commissioned by the Australian Government through the Department of National Development and Bureau of Mineral Resources, Geology and Geophysics concluded:

"It has been suggested from time to time that Australian mineral sands producers should further extend the vertical integration of their industry with culmination in the domestic production of titanium metal.

Australia is pre-eminent as a world producer of titaniferous ores and hence the domestic production of titanium pigment, from the chloride process, and of titanium metal would be a logical development of the Australian mineral sands industry.

The difficulties lie in markets and cost of production rather than in capital requirements or technical knowhow; these difficulties should become less formidable as domestic demand grows, with greater population and the establishment of a supersonic aircraft industry, and as world needs for titanium products increase."

https://d28rz98at9flks.cloudfront.net/12250/Rec1968_138.pdf

This was reiterated in the Australia Government's 2019 Critical Minerals Strategy which highlighted:

The Australian Government has been strengthening links with the United States (U.S.) since President Trump released an Executive Order in December 2017 directing the development of a United States Critical Minerals Strategy.

In the United States, Congress introduced the Berry Amendment (USC, Title 10, Section 2533a), which requires the Department of Defence (DOD) to give preference in procurement to domestically produced, manufactured, or home-grown products, notably specialty metals, in order to protect the domestic industrial base in the time of war.

The specialty metals provision requires that specialty metals incorporated in products delivered under US DOD contracts must be melted in the United States or a "qualifying country" including Australia.

This was reaffirmed by US President Donald Trump in September 2019 when he described Australian Prime Minister Scott Morrison as a “man of titanium” in a White House meeting that canvassed stronger military action against Iran, rising tariffs against China and joint defence work in Afghanistan. Mr Trump spoke of the “eternal ties” between Australia and the United States during talks that cemented the positive relationship of the two allies on defence and trade.

In a contrast with his glowing remarks about Mr Morrison and Australia, Mr Trump, also in September 2019 prior to the COVID-19 outbreak, warned that China was a “threat” to the world and would continue to suffer a hit to economic growth unless it settled its trade dispute with his administration.

In 2019, the former Resources Minister, Senator Matthew Canavan, said Australian companies would be able to maximise their access to government support to expedite new on-shore rare earths and critical minerals processing.

"We are determined to develop our rare earths and critical minerals assets for the benefit of Australia and our technology-driven industries," he said.

The Australian Government AusTrade Report “Critical Minerals Supply Chain In The United States” from September 2019 highlighted:

US Congress has determined that reliance on foreign sources of supply for materials such as titanium and specialty metal poses a heightened risk.

The December 2017 US Presidential Executive Order No. 13817, ‘A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals’ directs US Government agencies to develop an inter-agency strategy to ensure how they procure rare earths and critical minerals, and to ensure a safe, ethical and reliable supply of critical minerals for the future as a way to insure that, in urgent situations and times of war, the United States will have access to critical items needed to ensure national security.

Those who advocate for maintaining a robust capability among the domestic sources for titanium, as an example, argue that these companies will ensure that, should a global shortage of titanium develop or if the United States loses a key trading partner, the United States will not become unduly dependent on another country for a critical item. Furthermore, having domestic suppliers who have the protection of the specialty metal clause may ensure that domestic production lines remaining open and viable.

US Consumption of Critical Minerals in 2017

Critical Mineral	US Consumption, reliance and value (2017 figures, in USD\$)	Uses in the US
Titanium	1.1 mt of titanium mineral concentrates (ilmenite and rutile) valued at USD\$561M and 37 kt of titanium sponge (metal) valued at USD\$318M	About 90%: used by titanium dioxide pigment producers
	91% reliant on imports of titanium mineral concentrates and 53% reliant on titanium sponge imports	Remainder: used in welding-rod coatings and for manufacturing carbides, chemicals and metal
		Around 80% of titanium metal is used in aerospace applications
		Around 20% of titanium metal is used in armour, chemical processing, marine hardware, medical implants, power generation, and consumer and other applications

US Aerospace and Defence sectors – The Demand for Titanium

Company	Reason for interest / Value Proposition
BAE Systems	Defence-oriented transnational that designs, develops, produces and upgrades platforms and systems that include armoured combat vehicles, wheeled vehicles, naval guns, surface ship combatants, commercial vessels, and missile artillery systems.
Boeing	Manufactures commercial airplanes and provides defence equipment
	User of super alloys and ultralight metals
GE	Known for its digital industrial offerings and massive installed base spread across various products and services.
	New primary focus will be on aviation, power and renewable energy.
Honeywell	Operates four business segments: aerospace, building technologies, performance materials and technologies, and safety and productivity solutions.
	Transforming into a software-industrial company serving end markets like the US defence, e-commerce, and oil and gas industries.
Lockheed Martin	User of super alloys, lasers and ultralight metals.
	Largest business segment is aeronautics, accounting for 40% of sales.
	Remaining sales are generated by rotary and mission systems, space systems, and missiles and fire control.
MTU America, Inc (Subsidiary of Rolls Royce)	Core products include MTU diesel engines and MTU onsite distributed energy systems.
	Products are found in applications such as mine haul trucks, military vehicles and marine vessels.

Company	Reason for interest / Value Proposition
Northrop Grumman Corporation	Designs, manufactures and integrates space deployable products.
	Products use super alloys, lasers and ultralight metals.
Pratt & Whitney	Designs, manufactures and services aircraft engines and auxiliary power units.
Raytheon	User of super alloys, lasers and ultralight metals.
	Operates through five segments: integrated defence systems; intelligence and information; missile systems; space and airborne systems; and a cyber security business branded Forcepoint.
Safran USA, Inc	Designs, manufactures and services engines, and mechanical and electrical systems for military and civil aircraft.
	Defence segment specialises in navigation, optronic and avionics systems.

The global titanium metal production, in its primary form of sponge, has a total global market capacity currently of just 180,000 tonnes which due to the high demand for titanium is generating as much as \$1.8 billion (\$1,800,000,000), or 10,000 per tonne, in revenue per annum.

Taking these revenue metrics from just 180,000 tonnes, should we take Australia's total 2018 mineral titanium feedstock sand export capacity of 1.35 million tonnes at the same pricing, this could have generated \$13.5 billion in revenue by adding just one more stage in production to the mineral sands prior to export. This means in just 2018 alone the Australian industry missed out on \$12.97 billion.

Titanium Application	Mineral Sands		Base Material	Metal Form		Advanced Manufacturing	Aerospace and Defence
Life Cycle Stage	Ilmenite	Rutile	Sponge	Ingot	Wrought	Powder	Final Parts
Country	Australia Exports		Russia, China, Kazakhstan, Ukraine, Japan, USA			Five Eyes	Five Eyes
Price per Tonne (\$)	\$ 170	\$ 640	\$ 9,840	\$ 16,200	\$ 47,800	\$200,000	\$1,500,000

Revenue potential by creating value chain for Australia's 280M tonnes of titanium mineral sands:

Life Cycle Stage	Ilmenite	Rutile	Sponge	Ingot	Wrought	Powder	Final Parts
Revenue received exporting 1.35M* tonnes mineral sands	\$535M*		\$NIL	\$NIL	\$NIL	\$NIL	\$NIL
Revenue potential exporting 1.35M* tonnes of Titanium	Sovereign value chain processing mineral sands to Titanium metal		\$13.3B	\$21.9B	\$64.5B	\$270B	\$2.025T

* Australia's 2018 Mineral Sand Exports of 1.35 Million tonnes

The above table not only shows the revenue potential being lost by the Australian mining industry from exporting base product in comparison to just one further stage added to the value chain prior to export.

Building a sustainable value chain around Australia's access to critical metals, resulting in the export of a much higher valued product, will dramatically enhance Australia's sovereign capability ensuring that the resources last for centuries to come.

Significant parcels of native title land have been exploited by large mining companies who, even themselves, have not captured the true value locked up and contained within these mineral reserves.

It's time that the true value of these resources be realised for the benefit of all Australians with additional process steps to be completed within Australia to add further value to the exported materials benefitting indigenous and regional communities.

Appendix C - The Global ESG Movement for Australia

There is now over \$22 trillion in assets now invested in environmental, social, and governance (ESG) strategies globally¹². This impressive figure confirms the sector has shifted out of its infancy and into the mainstream investment landscape.

While the adoption of ESG by institutions has been the main driver of this growth, a broader set of investors are now wanting their investments not only to satisfy their financial objectives but also to express their values.

Studies have revealed the ESG sector holds great appeal for two large and important demographics - millennials and women. Demographic shifts support ESG growth, particularly for millennials and women.¹³

In 2019, European funds devoted to sustainable investing pulled in a record €120 billion (USD\$132 billion) from clients as demand for green and ethical options surged.

Assets managed by funds in Europe that incorporate environmental, social and governance criteria into their strategies swelled by 56% in 2019 to €668 billion, according to research firm Morningstar Inc. more than 50 of the 360 funds started in 2019 had a climate-oriented mandate.

¹² <https://www.mckinsey.com/industries/private-equity-and-principal-investors/our-insights/from-why-to-why-not-sustainable-investing-as-the-new-normal#>

¹³ <https://www.vanguardinvestments.com.au/retail/ret/investments/ESG-investing.jsp##vanguard-esg>

Europe is crafting a €750 billion recovery package in response to the economic impact of the coronavirus pandemic. It will devote more than €200 billion directly to low-carbon infrastructure projects including renewables, efficient and clean public transport and hydrogen.

Investment firms around the world, including giants such as BlackRock and Amundi, are responding to the fast-growing demand for ESG funds.¹⁴

The number of sustainable investment funds based in Europe rose to 2,405 last year, with 105 new offerings launched in the fourth quarter.¹⁵

Appendix D - Key Advisers, Contributors, and Supporters of Titomic's Initiatives

Andrew Liveris – Manufacturing & Trade

Mr Andrew Liveris is a recognised global business leader with more than 42 years. The former Dow Chemical chief helped write manufacturing policy for Barack Obama and Donald Trump and is now a key advisor to Australian Prime Minister Scott Morrison. He is the author of 'Make It in America'. Mr Liveris is a Director of Saudi Aramco, IMB and special adviser to the Crown Prince of the Kingdom of Saudi Arabia. Mr Liveris is also an advisor to the Australia National COVID-19 Coordination Commission.

Dr Alan Finkel AO – Scientific Expert

As Chief Scientist for Australia, Dr Alan Finkel led the development of the 2019 National Hydrogen Strategy, which was adopted in November 2019.

He also led the 2016 National Research Infrastructure Roadmap, the 2017 Review into the National Electricity Market ("Finkel Review"), and the 2018 STEM Industry Partnership Forum report. Dr Finkel serves as the Deputy Chair of Innovation and Science Australia.

The Hon Andrew Robb AO – Foreign Trade & Investment

Until his recent retirement from politics, Mr Andrew Robb was Australia's Minister for Trade and Investment.

In this role, Mr Robb negotiated Free Trade Agreements with South Korea, Japan and China, as well as the 12 country Trans-Pacific Partnership (TPP) free trade agreement and the Comprehensive Strategic Partnership with Singapore. Additionally, he conducted 85 investment roundtables with 28 countries.

¹⁴ <https://www.greentechmedia.com/articles/read/america-uses-its-stimulus-to-push-the-status-quo-while-europe-goes-big-on-green-investments>

¹⁵ <https://Bloomberg.com>. European-esg-funds-pulled-record-085653775.html

Jeffrey Lang – Advanced Technology & SME Start-ups

Mr Lang is an experienced SME professional in composite manufacturing and advanced materials technologies with 30 years' experience in manufacturing in Australia, Europe and Asia. Jeff is an experienced Managing Director and Chief Financial Officer for over 15 years and has worked on the joint venture between Force Industries and Heli Group China to set up Matrix Sports Co Ltd.

Jeffrey has many years of business experience across multiple industries and working with international brands, manufacturers, research institutes and government agencies.

Jeff is the current Managing Director of Metal industrial-scale Additive Manufacturing company Titomic Limited.

Adam Goodes – Indigenous Affairs

Adam Goodes is a name synonymous with great Australian athletes. A professional football career that spans more than 16 years, he holds an elite place in AFL/VFL history. In 2014, Mr Goodes was named the 2014 Australian of the Year; recognition for empowering the next generation of Indigenous role models and as an advocate for the fight against racism. Now CEO of Indigenous Defence & Infrastructure Consortium (iDiC), Mr Goodes works closely with federal and state governments, captains of corporate industry and prime contractors. His commitment to invigorate support pathways for communities, lead to the creation of The Goodes-O'Loughlin Foundation (GO Foundation) with fellow Indigenous teammate Michael O'Loughlin. Adam also joined the National Indigenous Council, as well as the board of Supply Nation.

John Hewson – Economics & Policy

Dr Hewson has had several careers in academia, bureaucracy, business, politics, and the media. He is currently a Professor in the Crawford School of Public Policy at ANU, and an Adjunct Professor at Curtin, UTS, Canberra and Griffith Universities, having been Professor and Head of the School of Economics at UNSW, and Professor of Management and Dean Macquarie Graduate School of Management at Macquarie University. He has worked for The Australian Treasury (Census and Statistics), the IMF, the Reserve Bank, the UN (UNESCAP), and the ADB, and often advises senior public servants.

A former Liberal leader, Dr Hewson is Chair, Business Council for Sustainable Development Australia, Chair, BioEnergy Australia, and a Patron of the Smart Energy Council and the Ocean Nourishment Foundation.

Supporting & Contributing Organisations

CSIRO

CSIRO is highly supportive of Titomic's efforts to establish a Gas Atomiser Plant capability in Australia capable of performing new innovative materials and additive manufacturing techniques for the Space, Defence and Medical Industries. CSIRO has provided in principle support to fund both the capital infrastructure required as well as ongoing funded research and development programs.

The Indigenous Defence & Infrastructure Consortium

As a supply chain aggregator, the Indigenous Defence & Infrastructure Consortium (iDiC) focuses on identifying business opportunities for indigenous communities and indigenous works throughout its indigenous business consortium partners. iDiC presents turnkey solutions providing a de-risked integrated offering to its clients. The iDiC is led by Adam Goodes.

The (iDiC) was established to assist Indigenous owned and controlled businesses to participate in the delivery of long-term Nation building projects.

Department of Defence

The Australian Government has announced the most significant changes to Defence policy and capability plans since the 2016 Defence White Paper. The government will invest about \$270 billion over the coming decade in new and upgraded Defence capabilities, including more potent and long-range combat systems and more secure supply chains.

Ministers Karen Andrews and Melissa Price are both aware of these Titomic-led initiatives.

Defence South Australia

Defence SA's mission is to maximise investment and jobs from the Australian Defence Force and defence industries. Working closely with Defence and industry, Defence SA targets investment and expansion opportunities, drives and supports the delivery of major defence projects and facilities, and pursues the location of additional Defence units and capabilities in the state.

Marubeni

Founded in 1858, Marubeni Corporation (TSE: 8002) is one of the largest Japanese trading companies. The company's operations encompass domestic, import/export, offshore trade and investment activities ranging from the development of natural resources to the retail marketing of finished products.

Titomic and Marubeni have a deep commercial relationship surrounding the supply and trading of titanium between Australia and Japan in conjunction with Marubeni's local Japanese partners.

Kingdom of Saudi Arabia

A Saudi-Japanese joint venture has started commercial production of titanium sponge at a plant in Yanbu, Saudi Arabia, targeting to provide cost-competitive supplies to the global market.

Advanced Metal Industries Cluster and Toho Titanium Metal is initially producing around 500 tonnes/month of titanium sponge at the Yanbu plant. It is targeting to reach its full 15,600 tonnes/year output within 18 months.

Titomic has deep ties into Saudi Arabia with access directly to the Saudi Arabian titanium sponge supply to create feedstock for an Australian-based gas atomisation titanium powder processing plant. Titomic has a Joint Venture partnership with Saudi Arabia's Science Technology for Development and Industrial Investment (STII) company to bring the Titomic Kinetic Fusion technology to SA, as well as a working relationship with SABIC, a subsidiary of Aramco, to explore different metal and plastic combination materials for defence and aerospace.

International Cyber Policy Centre - Australian Strategic Policy Institute (ASPI)

ASPI's International Cyber Policy Centre (ICPC) is a leading voice in global debates on cyber, emerging and critical technologies, issues related to information and foreign interference and focuses on the impact these issues have on broader strategic policy.

The centre has a growing mixture of expertise and skills with teams of researchers who concentrate on policy, technical analysis, information operations and disinformation, critical and emerging technologies, cyber capacity building, satellite analysis, surveillance and China-related issues.

The ICPC informs public debate in the Indo-Pacific region and supports public policy development by producing original, empirical, data-driven research. The ICPC enriches regional debates by collaborating with research institutes from around the world and by bringing leading global experts to Australia, including through fellowships. To develop capability in Australia and across the Indo-Pacific region, the ICPC has a capacity building team that conducts workshops, training programs and large-scale exercises for the public and private sectors.

Australian National University – Crawford School of Public Policy

Crawford School of Public Policy provides outstanding research to address key policy challenges in Australia, Asia and the Pacific. Our recent research demonstrates our expertise across the region and strengths in the international and comparative aspects of policy. Our cross-disciplinary research

environment brings together leading academics who share a commitment to scholarly excellence and policy-relevant research.

Advanced Manufacturing Research Centre (AMRC) UK – Sheffield University

The University of Sheffield Advanced Manufacturing Research Centre (AMRC) is a network of world-leading research and innovation centres working with manufacturing companies of any size from around the globe.

AMRC has provided a letter of support for these initiatives as they want both the research collaboration of advancing rare-earth material production and science, whilst also requiring the capability of access to then materials for their supporting partners such as BAE.

Thales

Thales operates in the key market segments of Defence and Security, Digital Identity and Security, Aerospace, Space, and Transport.

Titomic has an existing research program with Thales for defence products. Thales has confirmed to both Titomic as well as the Australian Federal Minister of Defence for their support of a capability within Australia that is able to produce and deliver locally made rare-earth and titanium metals for their production usage.

BAE Systems

BAE Systems, Inc. is the U.S. subsidiary of BAE Systems plc, an international defense, aerospace and security company which delivers a full range of products and services for air, land and naval forces, as well as advanced electronics, security, and information technology solutions.

BAE Systems are strong supporters of Titomic's materials programs for rare-earth and titanium metal supplies for their defence production supply chains.

Appendix E - Waste Management and Waste Repurpose Value Chain

There are two separate advanced technologies that Titomic is developing with other alliance partners and can achieve some extraordinary outcomes:

1. Converting Waste to Combustible Gas
2. The Resonant Vortex Milling

1. Converting Waste to Combustible Gas

This new Australian technology creates nearly 668,000 litres of natural gas per hour from approximately 300kg of black or brown coal mixed with a proprietary fuel mix and converted in a proprietary vapour chamber.

With ZERO CARBON EMISSIONS!

The mix can also include granulated plastic waste and rubber tyres offering the opportunity to dispose of this global waste problem without any detrimental effect to the environment. Waste to energy through repurposing not recycling.

With ZERO CARBON EMISSIONS!

The fuel mix has the ability to be modified for use in turbines and reciprocating engine drivers used in power plants.

Cost of production for the fuel mix is significantly less than current alternatives and requires minimal infrastructure.

The process takes black coal micronizes it mixes it with a fuel source (IP) then placing into a proprietary vapour chamber and converting it into gas. The output is a combination of Hydrogen, Methane and Oxygen.

A secondary proprietary process also exists to transfer brown coal to a black coal alternative to use in the same process. The brown coal is mixed with a combination of wood chips and an IP food source and biological agent.



2. The Resonant Vortex Milling

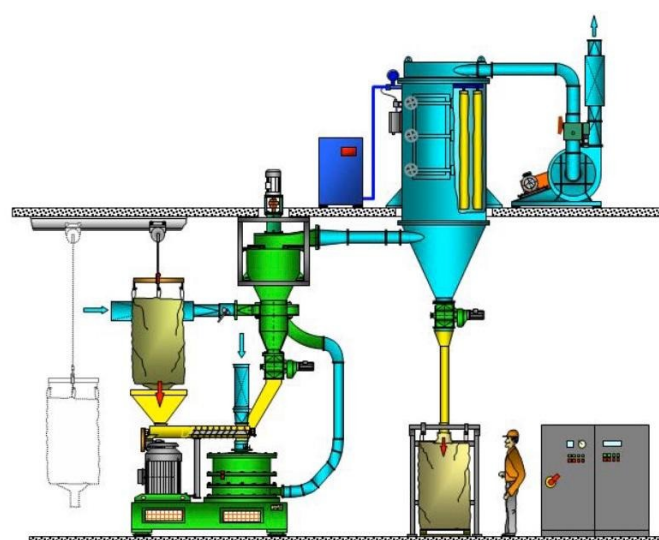
The resonant vortex mill is a new technology process for the contact-free milling of materials carried out by using an air vortex system which enables the milling of any waste material, from liquids to diamonds.

The destruction of materials of any hardness is performed by creating different zones of pressure gradients within the vortex mill pressurised up to hundreds of thousands of atmospheres. These materials break down as they go through the vortex milling process and the particles resonate and collide to continue breaking down to nano-particle level.

The second stage in the system is the resonance milling which is a system which generates wave oscillations with a frequency range from sonic to supersonic (100 MHz and above) within the mill. These vibrations determine different frequencies for different materials being milled and is able to separate the materials into different outputs based on the resonance feedback that particle provides from the vibrations. This mechanism is able to produce micronization measured in hundredths and thousandths parts of a micron (0.01-0.001 mm).

The third stage within the milling process is the impact vortex mill for the collision of particles. In the resonant vortex mill, the colliding of material particles to break them down to smaller particle size.

The resonant and vortex milling process is a gas-dynamic mill where the multicascade adiabatic resonant and impact milling is realised at various speeds for impact and destruction. For torsion (blast) mills, it is typical to use compressed air at pressures of 0.7-1.4 MPa, whereas a vortex mill is capable of reaching 0.2-0.6 MPa which substantially decreases running cost and makes possible to obtain fine powders outputs which can be reused using 3D Printing.



Appendix F - Hydrogen Storage

Hydrogen can be stored in three ways:

- As a compressed gas in high-pressure tanks.
- As a liquid in dewars or tanks (stored at -253°C).
- As a solid by either absorbing or reacting with metals or chemical compounds or storing in an alternative chemical form.

At present, only three systems for on-board hydrogen storage are close to commercialization. They are compressed gas at high pressures (5,000 to 10,000 psi in composite cylinders), liquid hydrogen which requires a cryogenic temperature of -253 °C, and materials-based storage in solids which involves the use of metal hydrides, carbon-based materials/high surface area sorbents, and/or chemical hydrogen storage.

The current status of various storage technologies in terms of weight, volume and cost.

Titomic is advancing a new program centred around producing hydrogen storage tanks in the form of titanium coated aluminium tank liner instead of carbon fibre wrapped aluminium tank liner. The titanium coated tanks will far exceed the pressure rating of a carbon fibre wrapped tank and also provides a safer and less explosive outcome from any potential tank failure compared to a carbon fibre failure.¹⁶

<http://www.fsec.ucf.edu/en/consumer/hydrogen/basics/storage.htm>

¹⁶ <http://www.fsec.ucf.edu/en/consumer/hydrogen/basics/storage.htm>