

Executive Summary

Transformations are well established globally in the energy, transportation, food, and labour sectors. Each of these sector transformations is anticipated to be so significant in isolation that it will have an impact comparable to that of a new industrial age. As all four transformations are occurring concurrently, the impact on humanity and civilisation will be profound and unprecedented. The Accord Interim Report has passing references to the transformation of the energy system and essentially has no discussion of the transformations of the transportation, food, and labour sectors.

Some of the most significant documents with the greatest global impact are the periodic Intergovernmental Panel on Climate Change assessment reports. The Carbon Tracker organisation has recently published a report authored by the distinguished Professor of Economics Steve Keen, which argues that economic Integrated Assessment Models are incorrect due to scientifically false assumptions. There is an alarmingly small body of climate change economic research. It can be simply shown that the quadratic damage function employed by economists is mathematically incapable of representing an acceleration in damage costs after climate change tipping points. Further, it is understood that the economic Integrated Assessment Models have only modelled temperature change and have not yet incorporated rainfall. It is emphasised that Professor Keen asserts only that the economic research is incorrect and not being a climate scientist makes no conclusion on the natural sciences. It is noted that the Accord Interim Report mentions climate change six times, but does not emphasise that this recent research casts significant doubt on the time frame and costs of the economic impact of climate change in the public record. The Universities Accord was intended to provide a vision for the Australian education sector in thirty years and beyond. The Final Report may need to consider the accuracy of the economics research in the IPCC Sixth Assessment Report and the Carbon Tracker report and prioritise research accordingly.

This submission focuses on climate change, which has been recognised by several authorities as the gravest challenge facing humanity due to its urgency, scale and impacts. However, a recent report reviewing all societal scale challenges, published by the Institution of Electrical and Electronic Engineers Control Systems Society, presents a hierarchy of the most significant global Societal Scale Challenges. The Interim Report discusses wicked or complex problems thirteen times, but the only Societal Scale Challenge which is specifically identified is climate change. It is considered that the Final Report would be enhanced by a review of the resources that will need to be allocated to all Societal Scale Challenges.

It is noted that the Interim Report states an objective to improve Australia's Global Innovation Index ranking by 2035. To increase the diversity of the economy, Australia would need to enhance its manufacturing economy to the baseline that our peers in the OECD have maintained for decades. Further, it is considered that it is particularly critical to consider in the Accord Report the future innovation environment of the next few decades. As will be emphasised several times in this submission, transformations in the energy, transportation, food and labour sectors are well established and happening concurrently. Consequently, Australia will need to be at the leading edge of innovation in energy, transportation, food, and labour transformations. To perform better than our peers and improve Australia's Global Innovation Index ranking, the country will need to innovate, entrepreneur and commercialise faster, smarter, and more successfully than our peers in the OECD. If Australia is not competitive, our relative productivity will fall and increasing the diversity and performance of the economy will be even harder.

In previous Industrial Revolutions, some of the newly unemployed retrained and performed new jobs. This time, artificial intelligence, automation, and robotics are anticipated to cause adult human unemployment of more than 50 percent. This submission mentions that many commercialisation transformations in modern history had a duration of 10 to 20 years. The Interim Report has a review of the entrenched disadvantage that constrains the ambitions of students from low socioeconomic backgrounds, but does not consider the paradigm shift in unemployment that could be caused by artificial intelligence, automation, robotics, and transportation-as-a-service. Although the Interim Report has a vision narrative for 2035 and mentions the year 2050 nine times, it is not apparent that the Accord has truly considered and articulated how Australia should best prepare and respond to this and other challenges.

It is anticipated that the Universities Accord Report will not remain relevant for very long if it does not articulate the environment in which its initiatives will attempt to be implemented and maintained into the future. Significant elements of this environment are considered to be four future defining transformations in the energy, transportation, food, and labour sectors, all Societal Scale Challenges and the true costs and time frame of climate change.

Interim Report review submission

There are probably several futurists worldwide, but the analysis and projections of the RethinkX Group, which includes Stanford University lecturer Tony Seba, are considered representative. The RethinkX group asserts that a transformation is well established globally in the four sectors of energy, transportation, food, and labour. Each of these sector transformations is anticipated to be so significant in isolation that it will have an impact comparable to that of a new industrial age. As all four transformations are occurring concurrently, the impact on humanity and civilisation will be profound and unprecedented.¹⁰⁶ The pace of change due to the combined impact of these four transformations concurrently is anticipated to be confronting and disconcerting for many Australians. Each of these sector transformations is well established, and neither the Australian federal government, the global fossil fuel industry, nor the sensationalist populist media can stop these four transformations from playing out.³⁴

In 2021 renewables generated 12.6% of global total final energy consumption and 30% of total electricity consumption.²⁶ In 2021 the global wind and solar generation capacity was 1675 GW.⁷² Accelerated by the Russian invasion of Ukraine, renewable generation capacity is projected to increase an additional 2400 GW by 2027.¹ Global financial investment in 2023 in renewable energy was 1.7Tn, for the first time more investment than the fossil fuel industry's 1.0Tn.⁵⁴ The battery electric proportion of all vehicles purchased globally exceeded 10 percent in 2022.²⁴ The proportion of battery electric vehicles purchased in the world's largest car market and the country with the largest car manufacturing industry is projected to increase from 25 percent in 2022 and exceed 80 percent by the end of 2025.¹⁰⁷ Australian researchers made mammoth meatballs from the DNA of extinct mammoths in 2023.²² The cost of precision fermentation decreased from a million dollars a kilogram in 2005 to 100 dollars a kilogram in 2020.¹⁰⁵ What happens when the cost of protein continues on its current trajectory and gets to 10 cents per kilogram?²⁵ Tesla and Boston Dynamics have each developed humanoid robots that can perform simple tasks.¹⁹ The consternation engendered by the downsides that artificial intelligence might cause to humanity and the proposed six month pause in development as a suggested mitigation was so intense it was recently even widely reported in the mainstream media.

A study of more than one hundred transformations, from car tyres, Model T Ford, to mobile phones, in the modern era determined that the transformation occurs in a duration of less than 10 to 20 years. In particular, the introduction of the Model T Ford occurred despite no fuel station infrastructure, no surfaced roads, limited supply chain and no trained mechanics, in contrast to the much more developed infrastructure that existed at the start of the electrify everything energy and transport transformations.³² There is no reason to expect transformations in the energy, transportation, food, and labour sectors could not also occur within twenty years. It is inferred that fossil fuel companies are vulnerable at the first and every subsequent time that they need to downgrade their proven reserves for any reason. If the incumbent industries collapse like a dynamited cliff in the near future, it is suggested that it is in each country's national interest to have progressed adoption of new technologies as far as practical before that happens.

These four transformations will define the future of human civilisation. The Higher Education Review requested feedback on a vision for the Australian education sector in thirty years time and beyond. Although the Higher Education Review should not reflect a dystopian nightmare, it is advocated that it should be cognisant of these four future defining sector transformations. It is anticipated that there are at least four broad categories of potential outcomes to this most consequential change of civilisation in history;

- human civilisation in some and possibly all countries will collapse by 2050, or;
- Australia, despite its wealth of resources, will fail to make the most of its potential in this transformation, or;
- A wealthy, powerful small minority will increase their dominance of, and at the expense of, the majority of humanity which may be very vulnerable if more than half the adult population does not work in the sense of work in the last century, or;
- there is a slim possibility that these transformations will facilitate a sustainable and democratic distribution of the "... largest transfer of wealth in human history, from the traditional suppliers of energy to the traditional consumers of energy."²³

In light of events in both developed and developing economies since the Global Financial Crisis, it is anticipated that human civilisation could collapse in some and possibly all countries due to two causes independently or in combination. In the past, the world has struggled to respond to natural disasters with more than a million refugees. Globally in less than three years, COVID was determined to be a factor in the death of nearly seven million people. However, the loss of employment in a proportion of the adult population during transformations in energy, transportation, food, and labour could result in civil unrest and a loss of trust between global financial institutions. Secondly, a single natural disaster event in one region that is, or is perceived to be, associated with climate change that causes dislocation or deaths in excess of 10 million people in one year could also result in a collapse of human civilisation in the region. It does not appear that the government has released a declassified copy of the Office of National Intelligence report³⁶ which analyses the impact of risks of climate change in Australia.⁵¹ A recent report reviewing all societal scale challenges, published by the Institution of Electrical and Electronic Engineers Control Systems Society, states that due to the urgency, scale and impacts of climate change it is the gravest challenge facing humanity³

It is advocated that there are two significant deficiencies, among others, in current Australian education. To maximise Australia's potential to respond to these four sector transformations, it is advocated that Australia needs to improve economics and renewable energy education. A rigorous mathematical and scientific basis to enhance economics teaching and research is critical both for a better understanding of finance and of humanity's climate change mitigation, adaptation, and restoration initiatives in the context of these four transformations.⁶⁶ It might be suggested that the contribution of economists to anticipating and recovering from the economic crises of the last two centuries has been underwhelming.¹¹⁷ Most mainstream economists have a poor record in predicting a national economic crisis because there are no widely accepted economic distress criteria.⁵⁷ Professor of Economics Steve Keen was awarded the third annual Friede Gard Prize for Sustainable Economics by the University of Trier in 2022 and published an accessible critique of mainstream economics.⁶⁰ Thirteen short lectures provide an introduction to the fallacies and limitations of contemporary mainstream economics to be able to realistically analyse real world economics.⁶¹ Professor Keen has given a speech on the limitations of mainstream economic analysis of climate change, which has evolved slowly over time from an audience of economics students in Amsterdam,⁵⁸ to faculty at the Institute for New Economic Thinking at Oxford University⁶⁸ and most recently to an audience in Scotland.⁶³

What are the deficiencies of mainstream economics? Critically, most mainstream economists cannot apply calculus to economics correctly. Most mainstream economists have not significantly changed their approach despite a coherent comprehensive critique of the mathematics employed by economists by a distinguished University of New South Wales professor forty years ago.¹⁴ Second, the treatment of environmental pollution as an externality could be construed as having a history of inadequate environmental conservation.³⁹ In addition, economic students are unlikely to receive an introduction to the laws of thermodynamics. Lastly, economics, in particular perhaps the treatment of pollution as an externality, appears to have inculcated an inadequate ethical culture in the profession.⁹⁹

Climate change is apparently not an attractive research topic for approximately 65000 academic economists worldwide. Climate change is apparently an economic backwater which can potentially stunt an academic's career progression. The most prestigious and oldest English language economics journal has not published a single article on climate change since it was founded in 1886.⁶⁴ A literature review in August 2019 identified a total of only 57 papers on climate change in the entire English language canon of eight leading economics journals.⁸⁸ Even within the small group of less than 80 mainstream economists in total who have published on climate change, some of the authors themselves have acknowledged that they may be subject to group think, peer pressure, and self censoring.

There is a dichotomy between the conclusions of mainstream economists and natural scientists on climate change, including

"... the risk that a 2°C warming could activate important tipping elements, raising the temperature further to activate other tipping elements in a domino-like cascade that could take the Earth system to even higher temperatures (Tipping Cascades) ... conditions that would be inhospitable to current human societies and to many other contemporary species"¹¹⁰

For many people in many countries the conclusions of the natural scientists of climate change are already reflected in their lived experience. If the natural science is representative, or conservative, it would go a long way to simply resolve this dichotomy if the way mainstream economists have projected climate change future costs in Integrated Assessment Models could be proven to be unrepresentative.

The estimation of the economic impact of climate change by contemporary mainstream economists was formulated and first published in 1991 and has remained largely unchanged since. This first seminal paper assumed that activities that could not reasonably or economically be protected by being conducted underground, in a building, or under a roof were vulnerable to climate change.

"The most sensitive sectors are likely to be those, such as agriculture and forestry, in which output depends in a significant way upon climatic variables. Our estimate is that approximately 3% of United States national output is produced in highly sensitive sectors, another 10% in moderately sensitive sectors, and about 87% in sectors that are negligibly affected by climate change."⁸⁴

In addition, for thirty years economists have not yet incorporated changes in rain patterns in their projections of the future.

"AMOC slowdown is expected to have physical effects other than temperature change, for instance effects on precipitation and regional sea levels ..., but these have yet to be incorporated in economic studies"³⁰

Fundamentally, mainstream economists have not understood the natural scientist's distinction between climate change and weather. The academic economist methodology has remained largely unchanged for thirty years, so the economic conclusions in the 2014 and 2022 Intergovernmental Panel on Climate Change assessment reports are largely similar.

"With historically observed levels of adaption, warming of 4°C may cause a 10-23% decline in annual global GDP by 2100 relative to global GDP without warming, due to temperature impacts alone".⁵

In contrast a recent report⁶ identifies significant climate change tipping points.³⁹ A recent article reviewed the tipping points of climate change and determined that there are indications that some tipping points are starting sooner than previously predicted.¹²³

The Carbon Tracker organisation has recently published a report authored by Professor Keen, which focuses on pension funds in England and the climate change risk advice they have received, to which ultimately the 57 academic articles by mainstream economists mentioned above are a significant contribution. The conclusion of the report is that pension funds in England do not fulfil their fiduciary duties to their investors by indirectly relying on climate change risk advice, which is in large measure based on the vast majority of climate change economic papers which have scientifically false assumptions.⁶² Although the report focuses on English pension funds, Australian superannuation funds receive advice that is also ultimately informed by these mainstream economic articles. UniSuper for example concludes that the overall risk to its portfolio is acceptable even in the worst case scenario of a global temperature increase of 4.3°C by 2100.⁹⁵

"Each layer in the process of assessing the risks of climate change has assumed that the previous layer has done its job adequately, and relied upon the previous layer's reputation, rather than scrutiny of the work undertaken. At both the national and international level financial regulators have accepted the refereed economic literature as providing realistic estimates of the economic damages from climate change"⁶²

One of the strategies adopted by mainstream economists is to extrapolate future damage costs from historical damage costs;

"The damage function used in the Nordhaus DICE model, for example, is a simple inverse quadratic relationship ... this damage function is made up out of thin air. It isn't based on any economic (or other) theory, or any data. Furthermore, even if this inverse quadratic function were somehow the true damage function, there is no theory or data that can tell us the values for the parameters ... or the correct probability distributions for those parameters, or even the correct means and variances."⁹⁶

In order to refute the damage function thesis of mainstream economists, Professor Keen fitted a quadratic, exponential, and logistic s-curve function to the National Oceanic and Atmospheric Administration Billion-Dollar Weather and Climate Disasters database. It is noted that as the third derivative of a quadratic is zero, the quadratic damage function cannot reflect the acceleration in future damage costs of climate change after tipping points. The economists also appear to propose the same damage function for an increase or hypothetical reduction in temperature. A hypothetical decrease in global temperature of five degrees Celsius would cause a kilometre of ice over all of Canada and Scandinavia, which would have a greater effect on GDP than that estimated in the quadratic function proposed by economists. There may be no scientifically valid method to select a representative damage function or to extrapolate from past damage to project future costs, but the Carbon Tracker report analysis casts significant doubt

on the validity of the quadratic damage function.

"The logistic and exponential functions, on the other hand, imply complete destruction of the global economy by the mid to late 21st century".⁶⁴

If a future climate change tipping point impact was so extreme that humanity chose to dramatically reduce its global fossil fuel energy consumption by a certain percentage reduction, the corresponding reduction in GDP is, as a first approximation, estimated to be the same percentage reduction.⁶⁷

The natural science summarised in the Sixth Assessment of the Intergovernmental Panel on Climate Change is collated by hundreds of authors and has tens of thousands of citations.⁵⁵ The Carbon Tracker Report provides references to the growing body of dissenting voices, from both natural scientists and heterodox economists, to mainstream climate change economic research. The entire 100 trillion dollar global economy is to a greater or lesser extent significantly dependent on 57 climate change articles by a total of less than 80 academic economist authors.⁸⁰

"Consequently, the approach that has dominated the economic analysis of global warming has led to governments, central banks, regulators, and financial stakeholders, all the way down to pension/saving advisors, operating under a false sense of security in the face of what, according to climate scientists, could be an existential threat".⁷³

For example, the Reserve Bank Act states, and this is also embossed on the building, in part that "... duty of the Reserve Bank Board, ... ensure that the monetary and banking policy of the Bank is directed to the greatest advantage of the people of Australia ... maintenance of full employment in Australia; and ... the economic prosperity and welfare of the people of Australia".⁸⁷ It is not clear how the RBA can now fulfil this obligation without dynamic system economic models, and a closer consideration of climate change time frame and costs. It is expected that due to the publication of this Carbon Tracker report many of the natural scientists and activists who are invested in the Intergovernmental Panel on Climate Change process will be closely scrutinising academic economic research in the lead up to the Seventh Assessment report.

The 2023 Intergenerational Report uses the same medium-term projection methodology for population, participation, productivity, and prices as the 2023-24 Budget, and extends the projection horizon to 2062-63.¹¹⁵ A cursory review of the 2023-24 Budget was not instructive in additional elaboration of its methodology.

"Key export commodity prices are assumed to track in line with long-term fundamentals. The population projections do not account for the effects of climate change. Underlying productivity growth is assumed to converge over a 10-year period to 1.2 per cent per year, around the average growth rate in labour productivity over the last 20 years. The aggregate fiscal projections in this Report are produced using Treasury's Model of Fiscal Aggregates and Scenario Analysis (MFASA). MFASA brings together the outputs of separate but consistent models that project economic parameters, tax receipts, balance sheet items, and payments. The financing task, the level of AGS [Australian Government Securities] on issue at the end of the forward estimates, and the yield curve in each year are inputted into a separate model, the Public Debt Interest Simulator (PDI Sim). PDI Sim calculates interest payments and the level of AGS. This is inputted back into MFASA to generate the fiscal aggregates."

The Intergenerational Report explicitly states that its population projections do not account for the effects of climate change.

This is perhaps not surprising since the climate change mainstream economic research considers both population and GDP to be exogenous variables.

"These are factors that customers of this research would rightly expect to be outputs of these models - in other words, that they should be endogenous variables, which are determined in large part by the future impacts of climate change. Instead, these models show climate change as damaging part of the output of the production system, but the system itself is assumed to sail through unscathed. Similarly, global population, though it is distributed differently between regions in some models because of climate change, is assumed to continue growing regardless of climate change in both DICE and the SSP".⁶⁴

Ultimately, rather than transferring data back and forth between MFASA and PDI Sim it is considered that a more representative projection for the Intergenerational Report could have been obtained with a single comprehensive dynamic system model.

It is advocated that Australia should change the minimum requirement to be recognised and accredited as an economist. Professor of Economics Steve Keen recommends that economics students should be taught a Bachelor of Systems Engineering with a major in economics.⁵⁹ None of the Australian universities recognised for excellence in Systems Engineering offer the option of a major in economics.¹²² It is advocated that existing economic lecturers who wish to continue research or teaching or both should be transitioned out of social science faculty and into STEM faculties where the academic management hierarchy is innately competent in system engineering. The following concepts, to express employment rate as a function of economic, labour productivity and population growth, and rate of wages share growth as a function of wage and labour productivity growth, were proposed in Marx's publication of 1867.⁷⁶

$$\frac{d\lambda}{dt} = \lambda \left(\left(\frac{1-\omega}{\nu} - \delta_K \right) - \alpha + \beta \right) \qquad \frac{d\omega}{dt} = \omega (S_\lambda \cdot (\lambda - Z_\lambda) - \alpha)$$

I am not an economist but they look like two ordinary differential equations to me. Professor Keen asserts that system dynamic economic models can be developed from incontrovertible macroeconomic definitions. The most sophisticated system dynamics economic model in 2019 was a model of the Portuguese economy that is claimed to be more accurate than the corresponding models of the Portuguese Treasury or the Central Bank.⁶⁵ This is apparently, surprisingly, a relatively virgin field of economic research with at least the following potential topics;

- system dynamics economic model of each country;
- system dynamics economic model of G20, G50, and G100 group countries;
- system dynamics economic model of each country integrated with a climate change model;
- system dynamics economic model of G20, G50, and G100 integrated with a climate change model;
- labour sector transformation projection with large scale commercialisation of artificial intelligence, automation and robots;
- agriculture and food sector transformation projection with large scale commercialisation of precision fermentation and cellular agriculture;
- optimise intervention alternatives to influence inflation;⁵²
- optimise and validate tax reform alternatives;
- compare economic intervention efficiency between countries that provided COVID stimulus;
- optimise energy-emissions-money-savings-contingent-loan incentives for Australian residences and businesses to install insulation, buy renewable energy equipment and transport;⁴¹
- mineral or chemical compound, or possibly even fresh water, resource depletion projections.

This is settled science. The STEM disciplines have sixty years of experience in analysing systems of differential equations with which economists could exploit their understanding of dynamic economic systems. In contrast, after several decades, the Integrated Assessment Models developed by economists, in an attempt to interface economic and climate change models, still omit modelling rainfall. The relatively cheap investment of enhancing economics teaching from the current three year degree to a four year bachelor of systems engineering degree not only attenuates the incidence of poor decisions, it also enables experienced professionals to identify additional sources of funding for national priorities. Prospective students who are interested in a career in economics are suggested to consider doing a degree in Systems Engineering if a specific economics-focused degree is not available. The engineering industry has Bachelor of Engineering and Bachelor of Technology degrees. Do students need the choice of Systems Engineering degrees and an alternate poor cousin three year Bachelor of Economic Science degree, which would be similar except that it would exclude partial differential equations? In the interim, some thought leaders consider that the best economics degree currently available in Australia is the Master of Economics of Sustainability from Torrens University.⁴⁵

The Universities Accord discussion paper emphasises that a significant portion of Australia's export revenue is derived from fossil fuel extraction.⁸⁵ Indicative figures for years 2020²¹ and 2023¹¹⁴ are summarised in Table 1.³⁸ With the fossil fuel industry in decline, it would be in Australia's national interest to develop

additional sources of export revenue. It is noted that some thought leaders have asserted that Australia could derive significantly more export revenue than the fossil fuel industry, from sustainably processing metals and critical minerals.⁴² Numerous reviews have confirmed that fossil fuel companies pay very little income tax⁷ and employ relatively few people.²⁷ Precision fermentation and cellular agriculture may also cause a decline in Australian agricultural revenue.

The Interim Report does not emphasise that in recent years Australia has derived an export revenue of more than 130 billion dollars from fossil fuels and industrial agriculture. The Interim Report does not emphasise that more than a quarter of Australia’s contemporary export revenue is at risk due to the transformations of the energy, transportation, food, and labour sectors. Although the Interim Report mentions entrepreneurship twice and states an objective to improve Australia’s Global Innovation Index there is no discussion of university spin out venture start-up funding which might be an effective strategy for this objective. The Interim Report does not emphasise that if Australia does not diversify its economy and find alternative sources of income, there will be much less funding available for the education industry.

Table 1: Australian Export Revenue

Export Category	2019-2020 (billion)	2022-2023 (billion)
Liquefied Natural Gas	47.525	92
Thermal Coal	20.400	64
Metallurgical Coal	34.200	60
Crude Petroleum	8.568	NA
Total Fossil Fuel Revenue	110.713	216 plus petrol
Beef, other Meat, Wheat	20.625	NA
Total Export Revenue	475.240	NA

I read the Australian Universities Accord Interim Report looking, mainly, for references to the transformations of the energy, transportation, food and labour sectors and to see whether the Report had adopted an alternative phrase instead of Societal Scale Challenges.⁸⁶ The Interim Report has passing references to the transformation of the energy system and essentially no discussion of the transformations of the transportation, food and labour sectors. The Report does not adopt the phrase Societal Scale Challenge but perhaps the various phrases used, including problems, complex or wicked problems, are on occasion intended to refer to Societal Scale Challenges. The Control Systems Society has recently published the first edition of a hierarchy of Societal Scale Challenges considered to be the most challenging globally.³

Table 2: Australian Universities Accord Interim Report Literature Review

Concept	Australian Universities Accord Interim Report
Climate Change	pages 23, 31, 76, 82, 93, 95
Sector Transformations	pages 31, 42, 46, 48, 49, 57, 74, 82, 95, 103, 111, 112
Societal Scale Challenge	pages 70, 79, 82, 85, 91, 93, 96, 98, 99, 101, 104, 111, 112
Knowledge Economy	pages 18, 23, 24, 48, 59, 77, 78, 82, 92, 95, 97, 100, 112, 124
Innovation	pages 18, 70, 76, 79, 92, 95, 100, 105, 108, 109, 112, 113
United Nations Development Goals	Nil
Year 2050	pages 1, 5, 9, 22, 33, 36, 37, 38, 40
Venture start-up funding	Nil
Interdisciplinary	Nil
Entrepreneurship	pages 95, 99

It is considered that the Accord Final Report might be enhanced if its objectives were reviewed against

the United Nations Development Goals. The Accord Interim Report reviews the entrenched disadvantage in accommodation,¹⁰⁸ commuting, and employment that constrains the ambitions of students and prospective students.¹¹²

This requires the higher education system to grow by at least 300,000 Commonwealth supported students by 2035 and an additional 900,000 Commonwealth supported students by 2050. ...

Enrolling more students will also require substantial growth in participation from groups currently under represented in Australian higher education. Given the increase needed in 2035, and to meet population parity, around 60% of the additional students in the system will need to be from low [socio-economic status] backgrounds, around 53% from regional and remote areas, and around 11% would need to be First Nations students. ... This will mean addressing a greater divide between rich and poor, and an ongoing inability to close the gap on Indigenous disadvantage. The equity targets that were set in the 2008 Bradley Review have still not been met 15 years after they were first proposed. ... This inequity is unsustainable in a fast-evolving, knowledge-based global economy and society.

The Accord Interim Report does not appear to reach the definitive conclusion that achieving the goal of an innovative knowledge economy will require substantially addressing the cost of living pressures that constrain the ambitions of Australian students and prospective students.¹⁰⁹

It is noted that the Review has commissioned an analysis from BIS Oxford Economics to explore the number of higher education graduates required to meet the workforce and economic needs over the next 30 years.⁸⁶ From a cursory review of the BIS Oxford Economic website and two recent reports, the organisation does not claim to be an expert in system dynamics, system engineering, or Monte Carlo analysis. One of the recent BIS Oxford Economic reports is interpreted as relying on the Cobb-Douglas Production Function.⁷¹ However, Professor Keen has proven that the standard Cobb-Douglas production function⁶¹ is incorrect.⁶⁷ In advance of reading the BIS Oxford Economic methodology in the Final Report, will it include a Monte Carlo analysis with a spectrum of different input values? How does the methodology analyse the transformations that are well established and anticipated to play out in the next thirty years in the energy, transport, food and labour sectors? How does the methodology analyse the impact, in particular, of labour resources required for Societal Scale Challenges?

Some thought leaders have asserted that the quickest, most efficient and economical strategy to mitigate climate change is the rapid implementation of the four sector transformations of energy, transport, food, and labour. It has been estimated that a predominately wind and solar renewable energy generation system will require approximately 70TW¹¹⁸ to 80TW¹³ of global electrical generation capacity. It is estimated the pace of installation of renewable energy generation needs to increase five times from the current 0.3TW each year to 1.5TW per year by 2030.⁴⁰ Although Adam Dorr expresses some opinions that might be considered heterodox to some audiences, his assertion that the only viable solution to climate change is large scale implementation of better technology is considered realistic.³⁴ Several reports have determined that a rapid mitigation of climate change would have a cheaper total capital cost⁹ than a slow transition.⁹⁷ Australia is projected to need at least 500 GW of wind and solar electricity generation capacity to support its domestic and export, including significant energy intensive materials processing, economy.⁵⁰ A recent study determined that Australia is projected to need only 12 hours¹¹³ (6 to 12TWh) of energy storage for a predominantly wind and solar electricity system.⁷⁴ Using somewhat unrealistic limits, if the contemporary car population of 20 million were all electric or if the future car population of 8 million were all electric, that would be a battery storage capacity of 1.2TWh or 0.7TWh, respectively.

There are many aspects to climate change adaption; however, one aspect that particularly affects the Australian community is the impact of climate change on housing. It is anticipated that mortgages or insurance or both industries in combination will soon need to provide mortgages or insurance only to those regions that are less risky.⁵³ The industry will need to mature and maintain its risk assessment of bush fire, cyclone, flood, sea level rise, and wet bulb temperature in excess of the human survival limit prone regions. Are there current research priorities to refine these regional risk assessments and are there research priorities for how these communities can best adapt?

The RethinkX group advocate that there two effective strategies for a reduction in atmospheric carbon dioxide concentration or climate change restoration, planting trees, and ocean alkalinity enhancement.³⁷ In both, human intervention accelerates a naturally occurring process.³³ Australia has lost 40 percent of the forest cover it had before European settlement.¹⁷ In 2019 the Crowther Lab of ETH Zurich published in the journal Science a summary of an analysis that identified approximately 10 million square kilometres of land that could be reforested predominately in six countries Russia, United States, Canada,

Australia, Brazil, and China.⁸ If precision fermentation is successful and can provide food cheaper than contemporary industrial agriculture, the land available for reforestation is expected to exceed 20 million square kilometres. Are there contemporary research priorities to manage and finance reforestation and the potential decline of industrial agriculture in Australia in this paradigm shift transformation? The significance of agriculture livestock may transition from a food source to a spreader of fertiliser.⁷⁷ Perhaps there would be less damaging floods if there were more trees.¹⁰⁴

It is inferred that the fossil fuel industry is promoting hydrogen as a code for the possibility for the industry to make hydrogen in the future through grey, brown, or black hydrogen and storage of the carbon dioxide primarily as a gas. Hydrogen storage in electricity systems is not considered effective, efficient, sustainable, or economical because the thermodynamic limits of combustion and fuel cells ensure that these technologies will consume at least twice the energy of the same process supplied directly with electricity. Unless a direct or catalysed process can be commercialised, electrolysis will require half¹⁶ of current global electricity consumption to generate a significant amount of hydrogen.¹⁵ Hydrogen is obviously a reactive and volatile gas. Hydrogen has a propensity to leak and several recent reports⁴⁸ emphasise that it would be important to keep hydrogen leaks¹⁰³ to a minimum to achieve the benefits of switching to a hydrogen economy.¹²¹ It would be confidence inspiring to know that a definitive review has assessed how large a hydrogen economy can be developed with the resources of catalysts that are economically available. It is expected that countries that currently have an advanced manufacturing economy, but that have poor renewable resources of wind and solar, will have ongoing tension to obtain sustainable energy. Unless these countries can develop a renewable energy resource economically, they may have to settle for paying a premium to import energy intensive commodities. In some sense I feel like I have wasted a paragraph on hydrogen hopium, but I would like to emphasise that some thought leaders project that hydrogen will be the energy transport conduit for approximately five percent⁴² of future energy.⁴³

Saul Griffith is also scathing in a pragmatic assessment of the true unsubsidised future potential of carbon dioxide capture and storage:⁴²

"In its most recent report, the Intergovernmental Panel on Climate Change (IPCC) outlined the best-case scenario for CCS. It assumed burying huge amounts - 10 billion tonnes - a year of CO₂. That is as many gigatonnes of stuff as the entire fossil-fuel industry currently rips out of the ground. It imagines an industry as large as the *entire* fossil-fuel industry to transport, process and bury CO₂, and that this industry will somehow magically spring into being by 2050."

The largest systematic study² to date of operating or proposed carbon capture and storage infrastructure in America concluded that more than 80% ended in failure.¹¹⁶ Similarly, another report provides a history of the Australian experience.¹⁰⁰

One technology that has been in the commercialisation doldrums in recent years is geothermal energy,¹⁰ but it could potentially compete against wind and solar in the supply of sustainable renewable energy.⁴ The potential compelling value proposition of geothermal energy is that its dispatch power generation could be less variable than that of wind and solar, which could facilitate a reduction in the amount of excess generation capacity necessary. Historically, geothermal has been economically viable in specific tectonic plate regions such as New Zealand and Iceland, but the proposed technologies are claimed to be feasible in most countries.¹⁰¹ If nascent geothermal technologies can be successfully commercialised, they are expected to be widely installed in existing thermal power stations in Australia and throughout the world.

One persistent debate is about critical resource depletion projections. Tesla⁸² and others advocate that there is no issue with mineral availability in the transition to renewable energy.²⁹ The International Energy Agency and the Geological Survey of Finland have suggested that the transition to a completely renewable energy system could be constrained by available mineral resources.⁶⁹ Independent of the transition to renewable energy, some experts suggest that there is a serious threat in the next 100 years of dwindling resources of some chemical elements.⁷⁹ These diametrically opposed positions may be due to the question of whether it is possible to recycle minerals indefinitely. Humanity has created about 90000 synthetic compounds in the last 75 years.⁸³ It is advocated that additional research is necessary to definitively determine which of these compounds are toxic and which are not being adequately managed. Additional research is expected to also be required for recycling.

It is advocated that Australia's industrial policy should prioritise responding to the four future defining transformations of energy, transportation, food, and labour. It would be in Australia's national interest

that higher education evolve and be optimised to support Australia's response to these four sector transformations. It is expected that an emphasis on nuclear power submarine industry could result in more Australians with skills and experience in Science, Technology, Engineering, and Mathematics in several decades time. It is considered that a nuclear powered submarine industry without a civil nuclear power generation industry or a nuclear weapons industry is about as useful as a one-legged broken stool without the other two elements.⁴⁴ It is noted that the New South Wales Government expects to award future auctions at lower floor prices than were recently awarded in a renewable energy auction of 35 and 50 dollars per megawatt hour for solar and wind, respectively. It is noted that only a small number of politicians continue to advocate for a civil nuclear power generation industry and that the Australian government has explicitly stated that it does not seek to obtain nuclear weapons. It is noted that the life of the current global economic proven resource of uranium is less than one hundred years.³¹ The nuclear powered submarine and nuclear regulatory industry is anticipated to be a distraction which detracts from Australia's ability to respond to these four sector transformations, climate change, other societal scale challenges, and transition to a prosperous economy in the future.⁵⁶ The Collins class submarine project increased the quality of engineering in Australia. However, it is emphasised that defence infrastructure should normally be the by-product, not the foundation stone for maintaining or, in Australia's case, developing an innovative advanced manufacturing and digital¹⁸ economy.¹¹

It is advocated that Australia's industrial policy should prioritise value add and manufacturing specifically in technologies in these four future defining transformations of energy, transportation, food, and labour. Process lithium. Process critical minerals. Make pig iron, smelt steel, copper, gold, nickel, and aluminium. Make batteries. Manufacture terawatts of photovoltaic solar. Rather than submarines, it is advocated Australia should manufacture or rebuild vehicles in several locations throughout Australia. In particular, the robotic manufacturing technologies employed by contemporary manufacturers would develop and maintain an Australian skill base in both electric mobility, artificial intelligence, automation, and robotics. Electric vehicles in aggregate are anticipated to be the largest single electrical storage in national electrical systems. Build renewable energy infrastructure. Many thought leaders advocate that renewable energy infrastructure is the most viable and pragmatic strategy to rejuvenate regional Australia. Lord⁷⁴ asserts that there are alternative technologies that are potentially cheaper and more efficient than legacy processes for many industrial processes. Heat pumps have applications in beer, milk and food processing, infrared for paper, induction elements for aluminium casting, microwave ovens for brick kilns, and electrical resistance elements for glass and plastic manufacture. Rather than using hydrogen to make green steel, research is in an advanced stage of development to make steel with an electrochemical process.¹⁰² Australia is projected to need one billion solar cell panels. At its current production rate, the only Australian solar manufacturing facility is projected to require more than 1600 years to manufacture one billion solar panels.

Australia needs a workforce with skills and experience in Science, Technology, Engineering, and Mathematics for the following;

- Climate Change mitigation, adaption, and restoration;
- Transitioning away from the current fossil fuel dependent economy and developing a sustainable economy of the future;⁹⁹
- Developing Australia's contribution as a good global citizen to all societal scale challenges;
- Installing, managing, and maintaining 500GW of renewable energy generation infrastructure;
- Transportation sector transformation;
- Potential decline of industrial agricultural due to precision fermentation and cellular agricultural transformation;
- Artificial intelligence, automation, and robotic transformation and potential decline in net human employment.

It is anticipated that nuclear powered submarines may be a bridge too far.

In its vision narrative for 2035 the Accord Interim Report states an ambition to be ranked in the top ten in the Global Innovation Index. While the Report emphasises that Australia is ranked nineteenth for inputs, it appears to omit that Australia is ranked thirty second for outputs and twenty fifth overall.³⁵ Additionally, after decades of decline in manufacturing activity, Australia is ranked ninety third in the

Economic Complexity Index, the lowest of any OECD nation, by Harvard College.⁴⁷ To achieve this ambition, it is considered that Australia would need to be much more strategic, entrepreneurial, and purposeful than, arguably, it has ever been before. Diversifying the Australian economy is considered a commendable ambition. It is considered that the Accord Interim Report has collated or proposed many encouraging concepts for the journey including the Tertiary Education Commission, Cooperative Skills Centres, industry salaried placements for PhD candidates, and more university sector diversity between research only and teaching institutions. To optimise these initiatives, will an additional accreditation be required, a Habilitation degree perhaps? However, as the Accord Interim Report is considered to have only a superficial articulation of transformations in the energy, transport, food, and labour sectors, climate change, and other Societal Scale Challenges its consideration of the environment in which it is intended to reform the Australian higher education sector is considered to be inadequate. Without a sophisticated and nuanced articulation of the environment, there is a concern that the implementation of the Australian Universities Accord will be essentially directionless.

Australia is last in the OECD in the Economic Complexity Index.¹¹¹ To increase the diversity of the economy, Australia would need to improve its manufacturing economy to the baseline that our peers in the OECD have maintained for decades. Further, it is considered that it is particularly critical to consider in the Accord Report the future innovation environment of the next few decades. As has been emphasised several times in this submission, transformations in the energy, transportation, food, and labour sectors are well established and happening concurrently. Consequently, Australia will need to be at the leading edge of innovation in the transformations of energy, transportation, food, and labour. To perform better than our peers and improve Australia's Global Innovation Index ranking, the country will need to innovate, entrepreneur, and commercialise faster and smarter than our peers in the OECD.¹⁸ If Australia is not competitive, our relative productivity will fall and increasing the diversity and performance of the economy will be even harder. Ironically, the single best bang-for-buck initiative may be to mandate a Bachelor's degree in System Engineering as the minimum requirement to be accredited as an economist. However, it is expected that the relative advantage will not last for very long before other countries follow suit.

The cost of renewable energy is already cheaper than that of nonrenewable energy and is decreasing rapidly. If Australia does not have competitive energy costs, its productivity will fall. Cars have been manufactured in much the same way since the mass production of the monocoque chassis in the 1934 Citroën Traction Avant. Tesla has been able to lower its prices due to pioneering modular production; gigapress components, seats on structural battery pack, paint one side, and assemble once innovations.⁸¹ The cost of precision fermentation and cellular agriculture is approaching cost parity with that of industrial agriculture.²⁵ Australia's current globally competitive agricultural prices may no longer be competitive if other countries can produce protein in the country at a lower price, with lower land, water, and transport resource requirements. In previous Industrial Revolutions, some of the newly unemployed retrained and performed new jobs. This time, artificial intelligence, automation, and robotics are expected to cause adult human unemployment of more than 50 percent. If this labour transformation is cheaper and Australia is not competitive, productivity will fall relative to countries that are competitive. Energy and transport transformations have both exceeded ten percent penetration of their respective markets. Humanity is about to experience the really steep gradient of the energy and transport technology commercialisation disruption s-curves. Each sub optimal decision made in Australia will have an opportunity cost.

America has enacted the Inflation Reduction Act of 2022¹²⁴ which is considered to provide the most generous funding in history for sustainable greenhouse gas constrained energy transition.¹² Europe responded with the Green Deal Industrial Plan,⁹² Net Zero Industry⁹⁴ and Critical Raw Materials Resilience⁹³ Acts. Canada responded with 83 billion through to 2035.²⁸ There was not a single solar or wind renewable energy project in Australia that reached financial closure in the first quarter of 2023.⁹¹ Australia appears to be waiting for other countries to propose installing infrastructure in Australia.⁹⁸ It is inferred that Australia is sliding down the renewable energy investment attractiveness ranking.¹²⁰ The data from the August 2023 release of the greenhouse gas emission data by the Australian government indicates that emissions have increased slightly.⁴⁹ An industry insider indicates that a consistent stable guaranteed order book of more than 1GW electrical generation capacity per year is required to establish a renewable energy industry factory. Despite the interest in reestablishing a manufacturing industry and concerns about global supply chains it is not clear that a consistent demand of that magnitude exists in Australia.⁹⁰

The global best postgraduate qualification in wind turbine design is considered to be the European Wind Energy Masters alliance offered, depending on the specialisation, by Delft University of Technology,

Danish Technical University, Norwegian University of Science and Technology, and the University of Oldenburg. The last known substantial review of the sustainable energy curriculum in Australia is almost ten years old.⁷⁵ The Queensland Government, which has belatedly pledged to try to catch up with the transition to renewable energy, recently announced that it intends to manufacture wind turbine components.¹¹⁹ The University of Technology Sydney has recently published the Australian Electricity Workforce for the 2022 Integrated System Plan Projections to 2050 in which the Step Change scenario is forecast to require an average of 8000 professionals and 7000 managers per year. The Hydrogen Superpower scenario is forecast to have correspondingly higher requirements for resources and personnel.

It is considered that there are not enough and there are gaps in the scope of renewable energy science and engineering education available in Australia. It is advocated that Australian universities should offer more renewable energy degrees and, in particular, that some degrees be offered completely online so that to expedite the transition experienced professionals are facilitated to study part time while continuing to work in their current job. To truly acknowledge the climate emergency, it is suggested that the Australian Government would permit a Higher Education Contribution Scheme tax debt for renewable energy degrees from any country which is a party to the Washington Accord or is recognised as having a similar quality of engineering or science professionalism. It is suggested that this would be economical to attenuate the need to encourage experienced professionals to immigrate to Australia. The Accord Interim Report emphasises that Australia played a leading role in the development of the new Global Convention on the Recognition of Qualifications concerning Higher Education. If American education continues to be even more expensive than Australian and if Australia continues to be under resourced in renewable energy education, it is recommended that prospective students consider Europe as a potential option.

The Australian academic sector is currently considered to offer more teaching in fossil fuels than in renewable energy. It is anticipated that many Australian universities should offer an enhanced diversity of renewable energy degrees, but perhaps there should be a coordinated strategy for some institutions to specialise in particular technologies. Does Australia intend to have the following facilities for wind turbine commissioning and research; rotor blade fatigue test, wind tunnel, wind tunnel integrated with a wave model test basin, roller bearing facility, generator dynamic test, and foundation soil mechanics? Does Australia intend to have a living laboratory research facility of several prototypes of large modern contemporary wind turbines?

If Australia establishes centres of excellence in renewable energy technology, it is anticipated that it will be in only a small number of locations. Is it necessary or desirable for Australian universities to collaborate more between themselves and with renewable energy centres of excellence to offer renewable energy degrees? Europe is actively engaged in collaborating within Europe and internationally to continuously improve renewable energy research and education.⁷⁸ Do Australian universities need to collaborate among themselves and internationally for continuous improvement of renewable energy research and education? Should there be arrangements to increase the portability and modularity of learning?²⁰

The Accord Interim Report does not include the word interdisciplinary and in particular makes no mention of prioritising interdisciplinary research. The submission by the University of Technology Sydney Transdisciplinary School to the Accord Terms of Reference is considered representative.⁷⁰ Transitioning economics from social science to system engineering expertise could be construed as an extreme example of the benefits of an interdisciplinary perspective. Although this submission has focused on STEM disciplines, it is recognised that a truly resilient education system would place an equal priority on other disciplines.

In light of at least three recent incidents in the information technology industry in Australia, it could be advocated that Australian universities collaborate with universities or governments of Ukraine or Estonia⁸⁹ or both on digital governance research and education.⁴⁶ It is suggested that due to recent advances in automation, artificial intelligence, and robotics, labour will be transformed in the next few decades. In the past industrial ages, some jobs declined and new professions were created. However, it is anticipated that this time transformations in artificial intelligence, automation, and robotics concurrently with transformations in energy, transportation, and food, are expected to lead to a net decrease in human employment. As the purpose of the Higher Education Review was socialised as refining the sector to be suitable for thirty years and beyond in the future, it is advocated that the labour sector transformation should be a critical consideration. Most of the adult human population is expected to not work in the sense of work in the past century. This is another reason for reform to enhance economic teaching and research. How will this probable majority of future generations of the adult human population live a

dignified life? Whilst some may recommend Universal Basic Income, my question on UBI is it intended to pay millionaires a UBI? In addition, it is advocated that the Higher Education Review should prepare to refine education for a future where the majority of the adult human population has no work as part of their identity. Although lifelong learning is expected to be necessary in that future, are there other cultural changes required?

One of the questions asked on the Accord Interim Report consultation website was what measures of success could the Panel propose to track the outcomes of Accord recommendations? It is considered that the Accord Interim Report has not articulated the environment of transportation, food and labour sector transformation, Societal Scale Challenges, and the true costs and time frame of Climate Change in which it is intended to implement Accord recommendations. As BIS Oxford Economics do not claim to be experts in systems engineering, it is anticipated that the Accord Final Report will not include a dynamic system model. It is considered that a dynamic system model would be necessary to make a realistic projection of the next few decades in an environment of energy, transportation, food, and labour sector transformations, and all Societal Scale Challenges including climate change. Without a realistic and pragmatic baseline, it is not clear how the success of Accord recommendation outcomes can be measured.

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