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The science and politics of climate change

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Abstract

The scientific evidence of climate change has developed rapidly over the past 30 years, with an overwhelming array of scientific data supporting the view that human activity, in particular greenhouse gas emissions from burning fossil fuels, has a measurable and accelerating influence on Earth's climate. The scientific process underpinning climate science is no different to any other peer-reviewed field of science. Scientists are sceptical by training and continually challenge ideas, revise theories and subject their work to critical peer review, in a continual loop that drives scientific understanding. Despite what we hear in the popular press, there is very little disagreement among climate scientists on the broad trends in climate change and mankind's influence, or on what needs to be done about it. Why then do climate change deniers have such a strong voice in the media? This paper will attempt to unravel the science from the politics, describe typical emotional responses, and discuss the importance of, and barriers to, achieving an international agreement on reducing emissions.

Introduction

Why does the topic of climate change provoke such polarised and antagonistic responses in much of the population and across politics? Ross Garnaut in his 2008 review referred to climate change as a "diabolical problem", where doing nothing is not an option and yet policy responses must include most of the world's governments. Harvard economist Daniel Gilbert states "A psychologist could barely dream up a better scenario for paralysis than climate change" (Halstead, 2014). Mark Carney, Chair of the Bank of England, famously described climate change as "a tragedy of horizons, the longer you leave it, the more costly it will become". Nicholas Stern, Former Chief Economist of the World Bank, argues that climate change is the biggest example of market failure the world has ever seen.

In Australia, political response to climate policy has seen the overthrow of leaders of the two major political parties and change of government. The tortuous evolution of Australian climate policy since 1972 is summarised by the Parliamentary Library (Talberg et al., 2016) who comment, "Australia's commitment to climate action over the past three decades could be seen as inconsistent and lacking in direction."

This paper will first describe the process of science as a discipline, the current state of understanding of climate science and why the public at large, as well as politicians, are so divided in their beliefs. The paper then summarises the workings of the Intergovernmental Panel on Climate Change (IPCC), climate projections and recent climate data, implications of the 2015 Paris Climate Agreement and steps required to limit global warming to 2°C through rapid decarbonisation of the economy. As demonstrated in many overseas jurisdictions, visionary governments and reasoned public discourse can largely overcome vested interests to create business and employment opportunities to transform the economy and improve health and social outcomes, but this goal appears elusive in Australia.

Is science a belief?

The oft-asked question "Do you believe in climate change?" reflects a fundamental misunderstanding of the scientific process. Religious dogma dominated belief systems until the 18th century, when the Enlightenment, or the Age of Reason, and the scientific method brought rigour and academic processes as the key source of authority and legitimacy. The Enlightenment built upon the scientific revolution sparked by the publication of Nicholas Copernicus' *De revolutionibus orbium coelestium* (On the Revolutions of the Heavenly Spheres) in 1543, followed by the seminal works of René Descartes, Galileo Galilei and Isaac Newton.

Karl Popper, one of the most influential philosophers of the 20th century, described criteria to distinguish scientific theories from metaphysical or mythological claim. Popper's techniques (Popper, 1959) are based on the methodology of falsification, whereby scientific theories are characterised by entailing predictions that future observations might reveal to be false. Einstein's general theory of relativity, for instance, predicted that light rays would be bent by gravity, and was later shown to account for discrepancies in observations of the transit of Mercury over the Sun that could not be explained by Newtonian physics. Thomas Kuhn (1962) challenged the prevailing view of incremental progress of science, and argued for an episodic process of revolutions in scientific theory as, for instance, Copernicus overturned the Ptolemaic model of Earth as the centre of the cosmos and Dalton's atomic theory explained the formation of chemical compounds, developments Kuhn referred to as "paradigm shifts".

The origins of climate science can be dated back to Joseph Fourier in the 1820s, who posited that the earth's atmosphere played a pivotal role in preventing the earth from freezing into a ball of ice. John Tyndall's laboratory experiments in 1861 demonstrated that gases such as methane and carbon dioxide absorbed infrared radiation, and could trap heat within the atmosphere. Svante Arrhenius, a Swedish chemist, provided the first numerical estimates of "climate sensitivity" — defined as the temperature change corresponding to a doubling of carbon dioxide in the atmosphere. He suggested a value around 4°C in 1896, which is within the range of current estimates. Weart (2008) gives an excellent overview of the early theoretical and experimental work that underpins climate science and more recent climate change research.

One of the aims of science is to develop models that account for as many observations as possible within a coherent framework. Climate models, first developed in the 1950s, have steadily improved as increased computational power has enabled more parameters to be included in models of increasing complexity and resolution. By the late 1990s climate predictions could be reliably matched with observed data, and the resulting improved understanding of uncertainties in data and models increased confidence in climate projections into the future under a range of scenarios.

There has been no "paradigm shift" in the understanding of climate science — instead, a continual, relentless and dedicated effort by thousands of scientists around the world to improve the certainty and accuracy of climate modelling, supported by the collection of vast quantities of climatological data across the globe, the atmosphere and the oceans.

Climate science is like any other branch of experimental science — a process of painstaking and careful observation, the development of hypotheses and theories to explain the data, testing predictions from physical, chemical and numerical models, and the forging of scientific consensus through rigorous peer review and publication. Scientists are sceptical people by training, and are constantly trying to test and improve scientific understanding. The scientific process is designed, as far as is possible, to objectively understand how the world works, without the burden or constraint of ideology and dogma.

Asking "do you believe in climate change?" is akin to the questions "do you believe in gravity?" or "do you believe in cancer?" More logical questions would be "What causes climate to change, do humans play a role and can anything be done to mitigate those changes?" Extending the questions to "is the cost worth the effort?" and "who are the winners and losers?" extends the debate away from science into economics and sociology.

Belief systems

There is a disjunct between views of scientists and the general public, and between conservative and progressive sides of politics. In an American survey (Figure 1), around half of the public said that they believe that "human activity is a significant contributing factor in global warming" and they thought about half of scientists held the same views. In reality, around 97% of climate scientists have no doubt about anthropogenic climate change (Cook et al, 2013). The authors did note, however, a lower level of acceptance among scientists without expertise in climate science, particularly economic geologists.

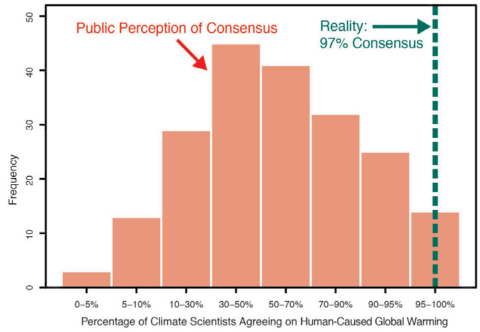

Figure 1: Public and scientific consensus on human induced climate change (data from Doran and Zimmerman, 2009, and Cook et al, 2013).

They go on to say, "The challenge appears to be how to effectively communicate to policy makers and to a public that continues to mistakenly perceive debate among scientists."

Politically, Democrats and Republicans in the USA have grown further apart in their attitudes and beliefs about climate change over the past few decades, although there was bipartisan support for climate action in the 1980s (Cook, 2016). The difference in opinion is strongly related to belief systems — conservatives (right-wing) tend to favour small government and resist actions to limit individual freedom and impose regulations. Liberals (left-wing) support government regulation to achieve social, environmental and economic outcomes that benefit society as a whole. The partisan influence on climate change views, referred to as the "liberal consensus gap" can be up to 40 percent. If a person doesn't want to believe that humans are causing climate change, they will ignore the hundreds of studies that support that conclusion, but latch onto the one study they can find that casts doubt on this view (Macdonald 2017). Among Republicans, higher levels of education correlate with higher levels of rejection of scientific consensus (Oreskes, 2017).

There is deep-rooted belief in US culture that "government that governs least governs best", and that accepting climate change science will inevitably lead to an expansion of government and constriction of personal freedoms (Oreskes and Conway, 2010). Those who don't want government action, for either economic or philosophical reasons, are likely to reject the science and attack the scientists.

Differentials between the left and right sides of politics are also seen in Australia. Taylor (2015) explores the factors involved in the evolution of Australia's political attitudes, including carbon-intensive industries combining their lobbying effort, sections of the media supporting a new narrative describing the essential role of coal and an open scepticism of the science, regulatory capture and cultural change, primarily the rise in neoliberal economics.

Media, too, play an important role in influencing public opinion; with some media outlets promoting clearly biased views on climate science, as well as misinformation, to the public. Dissent (whether real or imagined) sells newspapers.

Ideology against action on climate change has evolved in what the *New York Times* refers to as the Culture Wars. The attack on science is relentless and dangerous. Conservative commentators, fossil-fuel companies and well-funded lobby groups have led the attack to subvert the public understanding of the science. The Heartland Institute, for example, spent $100,000 in spreading the message in K-12 schools that "the topic of climate change is controversial and uncertain — two key points that are effective at dissuading teachers from teaching science." In Australia, climate change deniers have been appointed to chair government enquiries into energy policy, and at least one Government Minister consulted Wikipedia for a view on climate change rather than experts in CSIRO and the Bureau of Meteorology.

Denial and confusionists

Why do people respond so differently to the science and implications of climate change? Part of the answer lies in the worldview and ideological preferences of the individual, as discussed above, but the roots go far deeper.

Not surprisingly, psychologists have taken a keen interest in the human and behavioural aspects of the challenge of climate change. One segment of the population readily accepts the science and is ready to address the problem. For others, the threat posed by climate change elicits a wide range of feelings, which may include sadness, distress, shame, guilt, despair, loss and grief (The Australian Psychological Society, APS, 2010, 2014), Doherty and Clayton (2011), Reser, et al. (2011) and Härtel and Pearman (2010).

People may react to these feelings by:

- Minimising or denying that there is a problem,
- Avoiding thinking about the problem,
- Being sceptical about the problem, or
- Become desensitised to information.

If people feel they can't change a situation, they may become:

- Resigned ("if it happens, it happens"),
- Cynical ("there's no way we can change things"),
- Dependent on others (eg government) to act, or
- Become "fed up" with the topic.

Given the broad range of personality types, worldviews and ideologies, is it any wonder that climate change policy has become such a divisive issue? (Jones, B, 2010, Pearman and Härtel, 2010, Garnaut, 2011).

The IPCC — The best summary of climate science

The Intergovernmental Panel on Climate Change (IPCC) is a scientific and intergovernmental body, set up in 1988 under the auspices of the United Nations, with the task of providing the world's governments with an objective, scientific view of climate change and its political and economic impacts.

IPCC reports cover the scientific, technical and socio-economic information relevant to understanding of climate change, its potential impacts and options for adaptation and mitigation. The IPCC does not carry out its own original research, but bases its reports on the vast array of published literature.

Thousands of scientists and other experts contribute to writing and reviewing reports, which are then reviewed by governments. IPCC reports contain a "Summary for Policymakers", which is subject to line-by-line approval by delegates from all participating governments. Typically, this involves the governments of more than 120 countries. The IPCC provides an internationally accepted authority on climate change, producing reports that have the agreement of leading climate scientists and the consensus of participating governments.

The IPCC's first assessment report was completed in the 1990s, and the most recent (5^{th}) report in 2014. The IPCC also issues special reports on topics such as emission scenarios, renewable energy, extreme events, mitigation and adaptation. With each edition, as more data are collected and models improve, the evidence for anthropogenic global warming becomes more compelling. The 2007 report concludes "Global warming *very likely* shows a significant anthropogenic contribution over the past 50 years" and the 2014 report "It is *extremely likely* that human influence has been the dominant cause of the observed warming since the mid-20th century" (my emphasis).

Since over 2,000 peer-reviewed papers on climate science are published every year, no one person is able to absorb and understand the vast array of information available. The IPCC is arguably the most robust system in the world for summarising a science — yet all too often, "climate-deniers" choose one or two papers, carefully cherry-picking graphs and statements to support their views.

Globally, leading scientific organisations and academies have issued position statements supporting the consensus on human-induced climate change, e.g. https://climate.nasa.gov/scientific-consensus/ .

In Australia, regular summaries of climate science, observations and projections are published by the country's premier science organisations. The CSIRO and Bureau of Meteorology publish *State of the Climate Reports* every two years, most recently in 2016. The Australian Academy of Science publishes *The Science of Climate Change — Questions and Answers* (the 2015 edition has 370 references!). The reader is referred to these reports as well as the IPPC web site, NOAA (climate.gov) and NASA (climate.nasa.gov) for a plethora of expert coverage of climate science.[1]

[1] Note that in January 2017, the Trump administration began restricting public access to climate data, e.g. mandating that scientific data published by the EPA (Environmental Protection Agency) undergo review

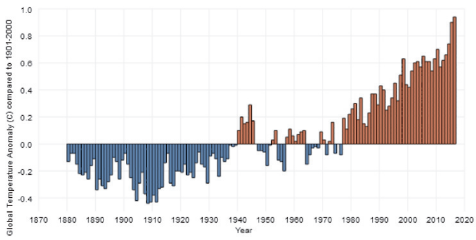

Figure 2: Global temperature anomalies from 1880 to the present compared to the long-term average (1901–2000). Blended land and ocean data (NOAA https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature).

Weather and climate

Weather describes short-term changes in the atmosphere over time periods of minutes to months, whereas climate describes how the atmosphere behaves over longer periods of seasons to millennia.

What's happening to the Earth's climate?

This paper cannot hope to comprehensively cover climate science — the reader is referred to the sources listed above. The key evidence for climate change is compelling:

The Earth is warming

Figure 2 shows annual global land and ocean temperatures since 1870. Yearly fluctuations are caused by El Niño and La Niña and other weather events, volcanic eruption, etc.

The long-term trend is clear (though climate change deniers often select particular years or geographic locations to demonstrate that the world is cooling.) Since 1976, every year has had an average global temperature warmer than the long-term average. Most of the warming has occurred in the past 35 years, with 15 of the 16 warmest years on record occurring since 2001. The three most recent years, 2014, 2015 and 2016 were the hottest years on record (World Meteorological Organisation).

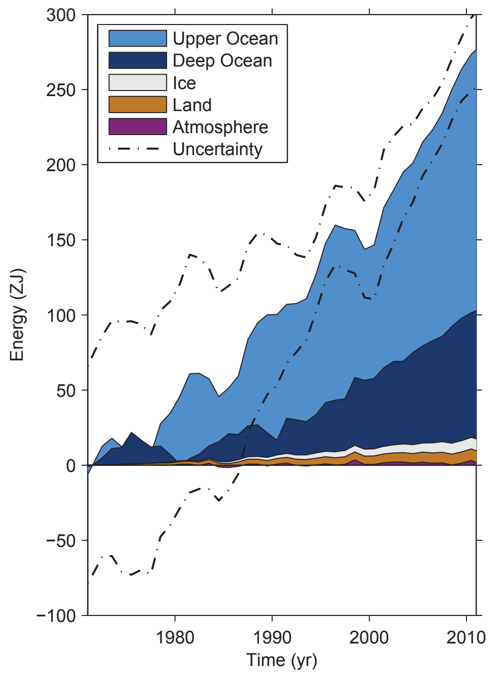

Figure 3: Changes in ocean heat content since 1970. Most of the excess heat from global warming is stored in the ocean. The heat capacity of the top metre of the ocean is the same as the entire atmosphere (IPCC 5th Assessment Report).

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by political appointees before publication. Activists in the USA and Canada immediately began an archiving program in a "race" to save U.S. government's climate data Science, Jan 25 2017 http://www.sciencemag.org/news/2017/01/trump-officials-suspend-plan-delete-epa-climate-web-page; *New York Times*, Jan 25 2017 https://www.nytimes.com/2017/01/25/us/politics/some-agencies-told-to-halt-communications-as-trump-administration-moves-in.html. Australia's Chief Scientist observed "Science is literally under attack" http://www.smh.com.au/technology/sci-tech/donald-trump-like-stalin-says-chief-scientist-alan-finkel-as-science--literally-under-attack-20170206-gu6f5w.html.

Where does the heat go?

Since 1955, over 90% of the excess heat trapped by greenhouse gases has been stored in the oceans (Figure 3). The top 700 m of ocean warmed 0.16 degrees C since 1969. The remainder of this energy goes into melting sea ice, ice caps and glaciers, and warming the continents' land mass.

Global sea levels rose about 17 cm in the last century, and the rate is accelerating. Half of the sea level rise is caused by thermal expansion of the oceans, and half by melting ice caps and glaciers currently grounded on land.

Only a small fraction of the thermal energy goes into warming the atmosphere. Humans, living at the interface of the land, ocean and atmosphere, only feel a sliver of the true warming cost of fossil fuel emissions. Ocean Scientists for Informed Policy (www.oceanscientists.org) is a good resource for ocean science.

Further evidence

Other observations, summarised from NASA's Global Climate Change information service, include

- Shrinking ice sheets — The Greenland and Antarctic ice sheets have decreased in mass. Greenland lost 150 to 250 cubic km of ice per year between 2002 and 2006, while Antarctica lost about 152 cubic km of ice between 2002 and 2005.
- Declining Arctic sea ice — Both the extent and thickness of Arctic sea ice have declined rapidly over the last several decades. If current trends continue, the summer Arctic could be ice-free by mid- century, for the first time in 125,000 years.
- Glacial retreat — Glaciers are retreating almost everywhere around the world, including in the Alps, Himalayas, Andes, Rockies, Alaska and Africa.
- Extreme events — The magnitudes of extreme events such as hurricanes, temperature extremes and intense rainfall event are increasing.
- Ocean acidification — Since the beginning of the Industrial Revolution, the oceans have absorbed one-third of the carbon dioxide we have produced. This has caused an increase of 30% in surface ocean acidity. The last time the oceans were this acidic was 53 million years ago.
- Decreased snow cover — Satellite observations reveal that the amount of spring snow cover has decreased over the past five decades and that the snow is melting earlier.

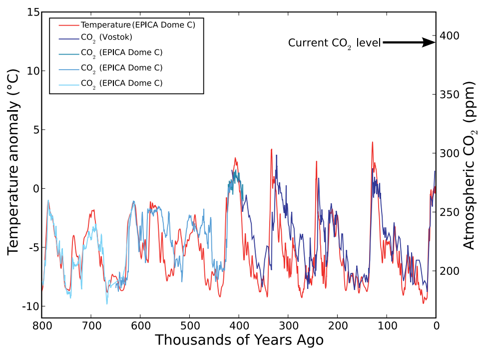

Figure 4: Temperature and CO_2 levels for the last 800,000 years, based on data from Antarctic and Greenland ice cores. Current CO_2 levels are over 400 ppm, and rising at an accelerating rate of 3.3 ppm/year (IPCC).

Long-term records

Data from isotopic analysis of deep ice cores show that CO_2 levels are now higher than at any time over the past 800,000 years (Figure 4).

During ice ages, atmospheric CO_2 levels were around 200 ppm, and during the warmer interglacial periods, they hovered around 280 ppm.

Most of the past climate changes are attributed to very small variations in Earth's orbit that change the amount of solar energy our planet receives. In 2013, CO_2 levels surpassed 400 ppm for the first time in recorded history.

Climate modelling

Massive computer models, known as General Circulation Models or GCMs representing physical processes in the atmosphere, ocean, cryosphere and land surface, are the most advanced tools available for simulating the response of the global climate system to increasing greenhouse gas concentrations. Dozens of research agencies around the world develop, improve and compare model outputs in each IPCC round; differences in model runs are used to assess uncertainty in climate projections.

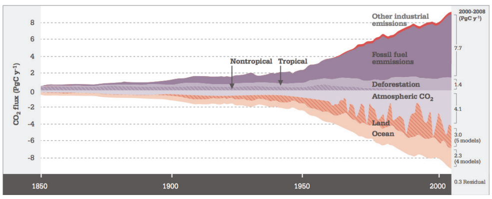

Figure 5: Global CO_2 budget, 1850 to 2008. Note the rapid increase of CO_2 emissions since 1950, most of which is then stored in the atmosphere and oceans (Raupach and Canadell, 2010).

Using climate models, it is possible to separate the effects of natural and human-induced influences on climate. Models successfully reproduce the observed warming over the last 150 years, when both natural and human influences are included, but not when natural influences act alone. Modelling clearly shows that most of the observed recent global warming results from human activities rather than natural influences on climate.

Greenhouse gas trajectories

Global greenhouse gas emissions have risen rapidly since the 1950s, primarily from fossil fuels, industry and land use change. They end up in the atmosphere and carbon sinks on land and in the ocean (Figure 5). If it were not for the substantial uptake of carbon by the terrestrial biosphere, the accumulation of CO_2 in the atmosphere would have been much more rapid.

With continued strong growth in CO_2 emissions under the "business as usual" scenario, much more warming is expected. Figure 6 shows two future scenarios for fossil fuel emissions — a high-emission pathway if the world continues to burn fossil fuels at present rates (red lines) and a low-emission pathway with deep, immediate deep emission cuts (blue).

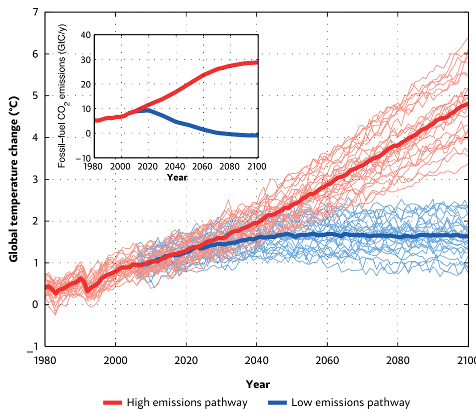

Figure 6: Projections of future changes in climate under low- and high-emission pathways. The inset shows the two scenarios for CO_2 pathways, and the main graph the resulting temperature changes. Individual model runs are shown as light lines, and the average as sold lines (graphic from Australian Academy of Science, 2015).

Half the CO_2 emitted stays in the atmosphere and lasts 50–100 years. Thus, even if emissions reduce markedly, warming due to the greenhouse effect is largely unchanged. According to a recent National Academy of Sciences report (Solomon et al., 2009), "the climate change that takes place due to increases in carbon dioxide concentration is largely irreversible for 1,000 years after emissions stop".

Rapid decarbonisation of the economy can slow global warming, but will not reverse it! Warming of 1 to 1.5°C is already locked into the system. Society can potentially adapt to a 2°C-warmer world, but 4 to 5°C degrees of warming would be catastrophic, with widespread famine, flooding, heat waves and much of the world's populations displaced (World Bank, 2014).

The Paris Climate Change Agreement

COP-21 (the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change), held in Paris in December 2015, was the most decisive of a series of international meetings attempting to reach agreement on policies to limit the impact of human activities on climate change. The journey has been slow and disjointed as developed countries most able to reduce emissions jostled with developing countries with growing populations demanding financial assistance before taking action.

The breakthrough in Paris was the establishment of a clear goal for containing global warming — reaffirming the intent to limit global temperature increase to below 2°C while urging efforts to limit the increase to 1.5°C, and the establishment of binding commitments for countries to reduce greenhouse gas emissions (which include CO_2, methane and nitrous oxide). Australia, for its part, agreed to implement an economy-wide target to reduce greenhouse gas emissions by 26% to 28% below 2005 levels by 2030. Countries also committed to submit new contribution targets every five years, with the clear expectation that they will "represent a progression" beyond previous ones.

The 2°C goal is feasible only with immediate and strong international action, especially by the major emitting countries. Current global commitments are insufficient. Australia's current reduction target for 2030 falls far short of that required to meet the 2°C goal — a "fair share" would be closer to 40% to 60% below 2005 levels by 2030 rather than 26% to 28%.[2]

Decarbonising the economy

The 2°C target will require most countries to cut their net greenhouse gas emissions to zero in the second half of the century.

[2] The Climate Change Authority (2014) concludes that Australia's reduction targets are inconsistent with a "fair" contribution to the long-term global goal, because 1) they won't keep pace with actions in many other countries, and 2) stronger targets are easier to achieve than previously thought. They suggest:

- 2020 target 15% below 2005 levels — carry-over from pre-Kyoto commitment gives 19% below 2000, and
- 2030 target of 40–60% below 2005 levels.

The corresponding national carbon budget would be:

- 4,193 Mt CO_2e 2013–2020 (580 Mt CO_2e in 2013 ramping down to 480 Mt CO_2e in 2020),
- 10,100 MtCO_2e 2013–2050 (ramping down from 480 Mt CO_2e in 2030 to ~270 Mt CO_2e in 2050),
- and zero net emissions by 2045.

Australia is on track to achieve its stated 2030 target, with projections for annual emissions of around 600 Mt CO_2e in 2030 (Dept Environment and Energy 2016b), but has no strategy to achieve the longer-term targets needed to meet the global goal of reducing warming to 2°C below pre-industrial levels.

Massive transformation of the world's energy mix will be required — more than 80% of the world's coal, 50% of gas and 30% of oil reserves are "unburnable" and must remain in the ground (Jakob & Hilaire, 2015; McGlade & Ekin, 2015).

Globally, US$348 billion was invested in clean energy in 2015, mostly in China, with a steadily declining investment in fossil fuels as industry moves to a more sustainable footing. The International Energy Agency predicts "Driven by continued policy support, renewables will account for half of additional global generation, overtaking coal by 2030 to become the largest power source." The cost of solar generation, in particular, is falling rapidly, and the amortised cost per GWh is now comparable with fossil fuel plants in many parts of the world, and battery storage costs are also decreasing at an astonishing rate.

Around two-thirds of Australia's emissions are from the energy sector, followed by agriculture and other forms of land use (Dept Environment and Energy, 2016a). The Climate Change Authority (2016a,b) has developed a toolkit to align Australia's climate goals and policies, including a detailed study for Australia's electricity supply sector. Detailed studies have also been produced by the CSIRO, ANU, Grattan Institute and The Climate Institute, among others.

The renewable energy target (RET), not without controversy, is one important mechanism for Australia's transition to a low-carbon economy. The Federal Government's renewable energy target for 2020 is ~23% (23,000 GWh), with no plans for increases beyond that date. The States and Territories, motivated by widespread public support, have led the charge on aggressive (and possibly aspirational) growth in renewable energy: 50% by 2030 for Queensland, 50% by 2025 for South Australia, and 40%/50% by 2025/2030 for Victoria. The ACT plans to be 100% renewable energy powered by 2020, and NSW and SA aim for zero net emissions by 2050. Australia's Chief Scientist, Alan Finkel, is chairing a review commissioned by the COAG Energy Council to recommend how to integrate the increasing proportion of renewable energy and maintain security and reliability of the National Electricity Market.

Regulation or market-based?

With any transformation, there will be winners and losers. Incumbents fiercely protecting the status quo, while entrepreneurs and nimble companies pursuing opportunities in transforming the economy. Australia, unlike Europe, has experienced much political turmoil over policy, most recently relating to carbon pricing and the renewable energy target (RET).

Policy levers can be broadly grouped into two categories:

- Market-based mechanisms with fixed or floating price, such as cap-and-trade, carbon tax, baseline intensity and emissions intensity schemes, and
- Regulation or direct action (incentives and penalties) such as mandated closures of high-emission electricity generators, emissions reduction funding (with or without safeguard mechanisms), RETs and energy efficiency mandates.

Economists broadly favour emissions trading (cap-and-trade) as being the lowest-cost approach, as industry has shown itself to be particularly adept at rapid innovation in technologies to drive down costs and exploit opportunities when given appropriate incentives to do so. In practice, a judicious combination of both approaches is optimal.

Opportunities and transformation

To a large extent, business understands the risks and opportunities posed by climate change, with initiatives such as the Carbon Disclosure Project (www.cdp.net/en) encouraging companies to publish their greenhouse gas emissions. The Financial Services Council and the Business Council of Australia stress the importance of assessing climate risk on business operations. AGL, Australia's largest greenhouse gas emitter, will close all its coal-fired power stations by 2050 and has launched the *Powering Australian Renewables Fund* to spur investment and development to support Australia's transition to a low-carbon economy. Royal Dutch Shell, among others, is pursuing opportunities in Australia to support what they term "the unstoppable transition to a cleaner economy." President Obama regards the trend towards clean energy as "irreversible" (Obama, 2017).

Paul Fisher, Chair, G20 Financial Stability Board, speaking in Sydney on 20 Oct 2016 said, "I saw climate change go from being an issue that was sociopolitical, ethical, moral, if you like, to being front and centre as a hard commercial issue. We need to sweep the politics to one side and say this is just a commercial business risk, like any other, that we need to take into account."

A myriad of sociological, economic and political barriers exist with respect to any change, particularly one so disruptive and revolutionary as needed to address climate change. Individuals have strong behavioural practices and belief structures but so too do institutions and companies, which are inherently conservative, and often governed to protect vested interests, and sometimes aiming to exploit the system through rent seeking.

Meeting Australia's ambitious emission reduction targets will be demanding of successive Australian governments. There is an urgent need for visionary leadership, both at the corporate and Governmental level. A de-carbonised world will be different from today and the transition presents large challenges and commercial opportunities.

In summing up, my conclusions cannot be expressed better than by Nicholas Stern, the author of the influential 2009 Stern Review on the economics of climate change.

> "We have the knowledge to act now, and that the outcome will be a cleaner, safer, more biodiverse and more prosperous world. The alternative — business as usual — will cost more, undermine growth and lead to immense conflict, dislocation and loss of life. Delay will greatly exacerbate the burden on society. The argument about whether we should act strongly and urgently is over — or should be."

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