Australia After Paris: Will we use our potential to be the energy superpower of the low-carbon world?

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1. The Great Energy Transformation

Modern economic development over the past quarter of a millennium has transformed for the better the lives of most people. It has lifted about a third of humanity to standards of comfort, knowledge, health and longevity that are way beyond those known to the elites of earlier times. It has provided another half of the people on earth with material standards of living that are far above the poverty that had once been the general human condition. It has placed this middle half on paths towards enjoying the high living standards of the developed countries within this century, so long as development is not blocked by a breakdown in political or ecological order. The remaining sixth of humanity lives in desperately poor countries and aspires to high living standards; there will be no stable resting place for humanity until that aspiration has been realised.

Modern economic development was built on intensive use of fossil fuels.

Fossil resources are finite, so a transition to other forms of energy would have been necessary at some time. Without concern for climate change, there would have been an extended period of rising fossil fuel prices, leading to investments in alternative technologies and a gradual phasing out of coal, oil and gas.

It has been increasingly clear over the last several decades that the inevitable transition from fossil fuels to other forms of energy must occur sooner rather than later if we are to avoid changes in climate blocking the spread of the fruits of modern economic growth to people everywhere. The good news is that the costs of the non-carbon energy technologies have fallen dramatically in response to greatly expanded deployment in recent years, so that the transition away from fossil fuels can now be seen as imposing costs that are small compared with the likely increases in global incomes over the years ahead. Once the transition to low-carbo energy has been completed, the cost of the new energy technologies can be expected to continue to fall for a considerable period.

When all of the Governments of Australia—Commonwealth, State and Territory—gave me the task of advising on climate change policy eight years ago, I described it as a diabolical policy problem with a saving grace.

The central policy problem and solution is familiar: for the operation of markets to generate good outcomes for society, external costs that some people's decisions impose on others must be compensated by a tax equal to those external costs, or regulation blocking the activities that impose costs on others.

Not to tax an activity that imposes costs on others is to subsidy to the harmful activity. That is why a 2015 paper from the International Monetary Fund refers to the absence of taxes or other restrictions on carbon emissions as a subsidy to the fossil fuel industries. A carbon tax at an appropriate level does not subsidise low carbon activities; the absence of carbon restrictions subsidises the use of fossil fuels.

Four characteristics of reduction of emissions to avoid dangerous climate change make it diabolical. First, while the atmospheric physics has for many years demonstrated that increased concentrations of greenhouse gases increase global temperatures, there has been uncertainty about the extent of the increase and its impact on human activity. The mean of the

possible outcomes would be highly damaging, and the bad end of the possibilities catastrophic. But the presence of uncertainty encourages some people to hope that something will turn up. Second, the costs of reducing emissions come long before the benefits, introducing into policy-making unfamiliar comparisons of the economic welfare of people living at different times. Third, the external costs of greenhouse gas emissions are similar wherever in the world they occur, while decisions on mitigation are taken by national governments. This incongruence means that effective climate change mitigation requires unprecedented degrees of cooperation across the international community. Fourth, effective action against climate change requires interventions that damage the interests of large concentrations of corporate power that are accustomed to advancing their sectoral interests by investment in the policy-making process. Supporters of Senator Palmer's use of corporate funds to secure the abolition of carbon pricing is an unusually explicit acknowledgement of this source of opposition to the public interest.

The saving grace to which I referred in 2008 is that there is more community interest in this issue, in Australia and many other countries, than in any other economic policy issue of modern times. If governments seek to avoid dealing with climate change because it is too hard or to placate vested interests, they are dragged back to the issue by many concerned members of the community.

The first steps along the path towards a low-carbon economy have been difficult everywhere and especially difficult in Australia. But the international community and its major national components have groped their ways towards understanding the implications of uncertainty in the climate change context; begun to think analytically about how to value benefits in the long term future against current cost; have adopted a workable approach to international cooperation that I call "concerted unilateral mitigation"; and are at least aware of the challenge to the public interest posed by the influence of private interests. The outcome of the December 2015 United Nations conference in Paris and a marked downward shift in the trajectory of global emissions growth reflect that progress.

At Cancun in 2010, the United Nations Framework Convention on Climate Change committed to limiting human-induced warming to 2 degrees. That objective was extended in Paris to holding temperature increase to as far as possible below 2 degrees and as close as possible to 1.5 degrees. Most importantly, the Paris meeting consolidated support across all members of the United Nations for purposeful and effective "concerted unilateral mitigation".

Within "concerted unilateral mitigation" as developed at Paris, each country assesses the reduction in emissions over the 5 or 10 years ahead that it judges to represent a fair contribution to the international mitigation objective. The appropriateness of the contribution is subject to both international and domestic political review and pressure. National targets are reviewed at 5-yearly intervals in response to those pressures.

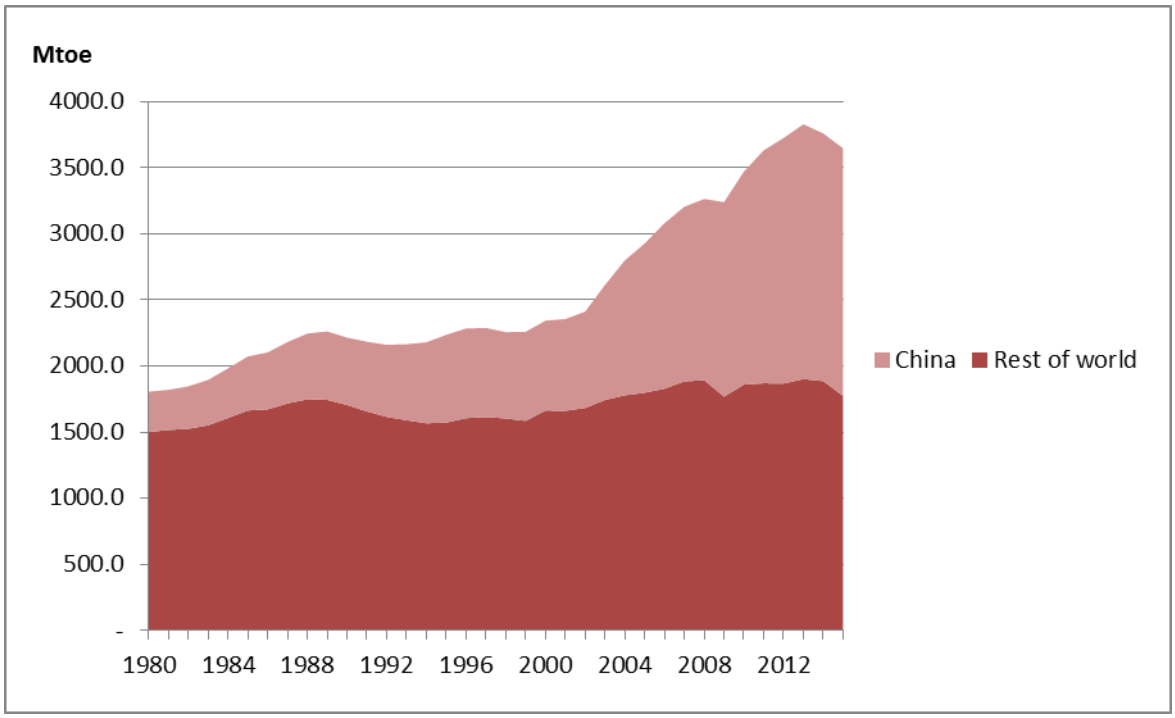
This approach emerged from the diplomatic fiasco in Copenhagen in 2009. The pledges from the early application of "concerted unilateral mitigation" add up to a radical change in trajectory of greenhouse gas emissions. The early years of the new approach have seen the pledges met in practice by the world as a whole and its major national members.

Preliminary data for 2015 suggest that we have had had two years of falling global greenhouse emissions—the first such years in modern times in the absence of major recession.

China had been the major locus of global growth in emissions from the beginning of the twenty first century, with compound average increases in double digits from the turn of the century until 2011. Its Paris pledges, following the detail of the joint statement from the Presidents of China and the United States in November 2014, represent a major change from earlier tendencies: for Chinese emissions to reach a peak by 2030 and if possible before then.

The Chinese practice seems likely dramatically to exceed the Paris commitment. Chinese emissions growth slowed dramatically in 2012 and 2013 as the new model of Chinese economic growth began to transform the energy intensity of economic activity and the emissions intensity of energy use. In China in 2014, emissions fell 1.5 percent and coal use 3 percent despite over 7 percent growth in the economy. In 2015, with growth in real output a touch below 7 percent, preliminary data suggest a second year of falls in coal use and emissions (Chart 1). Chinese zero-carbon electricity—renewables plus nuclear—rose dramatically as thermal power generation fell (Table 1).

Chart 1: Coal consumption of China compared to other countries



Source: BP statistical review online database http://www.bp.com/en/global/corporate/about-bp/energy-economics/energy-charting-tool.html and author's estimation.

Substantial as the changes in emissions trajectories are, they are only the beginning. The meeting of the G7 heads of government in Germany in July 2015 recognised that achievement of the 2 degrees objective requires zero net emissions for the world as a whole before the end of the century. It requires zero net emissions in the developed countries from around mid-century. The increase in mitigation ambition embodied in the Paris agreement brings forward these timelines.

Table 1: Chinese Electricity Generation by Source 2010-2015

Quantity (million Mwh)							Rise over previous year %					
Year	Total	Thermal	Hydro	Nuclear	Wind	Solar	Total	Thermal	Hydro	Nuclear	Wind	Solar
2010	4228	3416	687	75	49	0	14.9	13.4	20.1	6.7	78.9	73.7
2011	4731	3900	668	87	74	1	11.9	14.2	-2.7	16.7	49.9	459
2012	4986	3925	856	98	103	4	5.4	0.6	28.1	12.7	39.1	412
2013	5372	4222	892	112	138	9	7.7	7.6	4.2	14.3	34	125
2014	5550	4205	1070	126	156	23	3.3	-0.4	20	12.5	13	155.6
2015	5592	4171	1010	169	181	38	0.7	-0.8	-5.6	34.1	16	65.2

Source: National Bureau of Statistics of China and China's National Energy Administration.
Note: Thermal includes coal, gas and biomass. The coal proportion of thermal energy has been falling over the period covered by the table. 2015 estimate based on real data for the first eleven months.

Such challenging objectives are gradually being absorbed into discussion of global economic development. They are being reinforced by leaders of the great religions. They are being reinforced in the diplomacy of the major developed states. They are gradually being embedded in valuations of emissions-intensive activities in global financial markets. There is still a long journey to the reconciliation of continued global development with climate stability. But it is now clear that the world is headed towards a low-carbon economy. The costs will be lower in countries that move early and establish clear and stable policies.

2. Australia in the Fossil Fuel Economy: the Injured Superpower

Australia enters an era of global emissions reductions with a challenging starting point. We begin with distinctly the highest emissions per person in the developed world. The original emissions reduction targets for 2020, reported formally to the United Nations at Cancun in 2010 with the support of the then Opposition, were to reduce emissions by 5% unconditionally (that is, if the rest of the world did nothing), and up to 25% proportionately with other developed countries if there was substantial action in other countries. The most limited reading of Australia's commitment points to a minimum 15% reduction by 2020. I have followed the progress of the 2020 targets with close interest, as the conditional and unconditional elements follow my recommendations in the 2008 review (Garnaut 2008). I consider the current focus on the 5 percent reduction to be a breach of the formal commitment to the United Nation—albeit a breach for which there is no legal remedy.

The high starting point and the constrained 2020 commitment have been followed by an initial commitment to 2030 that is at the least ambitious end of the range of developed countries: minus 26-28 percent by 2030. A commitment to 26-28 percent reduction by 2025—5 years earlier-in line with the United States—would place Australia acceptably within the range of developed countries. The Australian Government has sought to focus on this country's greater relative effort on a per capita basis, in the light of faster population increase in Australia. Per capita emissions are relevant to international comparisons. So is the higher Australian starting point per person, which requires faster per capita reductions than in other countries. I take both these considerations into account in my assessment that we are at the low end of the range developed countries' ambition.

That domestic political circumstances at the time of the decisions on a 2030 target in mid-2015 could have led to an even more constrained outcome is hardly a comfort: a high starting point

and a slow start means that the rate of reduction of emissions in Australia will have to accelerate more rapidly than in other countries if, with others, we are to achieve near zero net emissions around the middle of the century.

Australia's actual emissions and emissions reduction policies stand out since the end of carbon pricing in 2014. The IEA noted the unusual position of Australia in a major report in 2015: the only country which had abolished carbon pricing as a number of countries and regions within countries adopted it as a low-cost way of reducing emissions. When carbon pricing was in place between mid-2012 and mid-2014, Australia experienced large falls in emissions in covered sectors, including electricity. Total emissions have increased since the end of June 2014, led by sectors including electricity once covered by carbon pricing.

Australia's high emissions starting point is the result of high energy-intensity of economic activity and high emissions intensity of energy in an economy in which coal is abundant. It is a consequence of Australia being a global superpower in energy supply. Australia has the highest per person endowments of coal and gas (both natural and unconventional) in the developed world. Australia is the world's largest exporter of coal and uranium and probably soon and for a while the largest exporter of liquefied natural gas. Energy exports have contributed significantly to Australia's standard of living in the past.

For many years, the fossil energy endowments have also contributed to Australians' high standard of living as sources of relatively low-cost electricity and heat for households and as inputs into production and exports of manufactured goods. Investments through the 1980s led Australia to become the major exporter of aluminium—the most electricity-intensive manufactured product that is important in international trade. Australia also has much manufacturing industry based on low-cost natural gas, established prior to the establishment of the Gladstone LNG processing plants shifting Australia to export parity pricing for gas.

The coal, oil and gas industries will remain large and important in Australia for several decades, but have been subtracting from growth in national income over the past two years and will continue to do so for the foreseeable future.

Global energy markets have received four large shocks since the turn of the century. Not sudden shifts as in the two oil shocks of the 1970s, but longer-lasting change, the effects of which accumulate to something that is larger on a durable basis. First, unexpected and unprecedentedly strong growth in demand for energy driven by rapid and energy-intensive economic growth in China took markets by surprise and forced a big lift in oil, coal and gas prices. Second, high energy prices and concern for climate change and other environmental impacts of fossil energy use led to higher energy efficiency and lower energy intensity of economic growth, most powerfully after 2008. Third, high energy prices and incentives to reduce greenhouse gas emissions in the developed countries led to rapidly increased use of renewable energy, radically reducing costs as the scale of deployment increased. Fourth, high energy prices encouraged deployment of unconventional gas technologies which increased supply from about 2008.

At first these shocks gave us unprecedentedly high incomes, until a new model of Chinese economic growth brought the China resources boom to an end from 2011. Now they are delivering to us a massive decline in Australia's terms of trade and the beginnings of what seems set to become the longest period of stagnation and decline in national income per

person that Australians have known. The first shock gave us what I described in my 2013 book as Australia's salad days (Garnaut 2013). The others have brought Australia's Dog Days after the boom.

Energy costs everywhere have internationally tradeable and non-tradeable components.

The tradeable component of energy costs—the cost of energy raw materials—are lower in countries with abundant domestic energy resources, which tend to be net exporters of energy. The domestic cost advantage is lower in energy commodities in which international transport costs are low. Prices in the exporting country are lower still if exports are restrained.

Uranium has very low international transport costs, so prices in Australia are indistinguishable from those in importing countries. Most coal outside Victoria has been internationally tradeable since the structural changes in the Queensland and New South Wales electricity industries in the 1990s, so that domestic coal prices outside Victoria are not far below those in developed countries. Eastern Australian gas was non-tradeable until the huge new coal seam gas reserves provided the volume to support export facilities. Gas is in the later stages of shifting from being readily available in Australia at extremely low prices by international standards, to having constrained availability for domestic use and export parity prices.

For Australia, with current technology, renewables are effectively non-tradeable. Unlike uranium, coal and now gas, if it is much cheaper to produce wind or solar power in Australia than in Germany, the full difference will be felt in lower prices to Australian users. It follows that Australia's advantages from low domestic energy costs from abundant energy resources—for example, as a location for energy-intensive metals processing—are greater in a world in which renewable energy plays a major role.

The non-tradeable component of costs includes the cost of turning energy into useable forms and distributing it to users. The cost of the non-tradeable component varies with the real exchange rate (the general cost level in Australia compared with other countries when both are expressed in the same currency) and the relative technical efficiency of Australian production in the energy sector (which is affected by the quality of the regulatory environment).

Tradeable and non-tradeable components of energy costs both increased much more rapidly in Australia than in the rest of the world from the turn of the century until 2011. Over this period, we lost our comparative advantage in energy-intensive industries. We can get it back as our unusually rich renewable energy resources become more influential in a world in which all countries have major components of renewable energy generation, so long as the other non-tradeable components of supplying are more or less globally competitive.

The increase in the non-tradeable component of energy costs arises from two sources: the large appreciation of the real exchange rate through the resources boom; and a much larger increases in distribution costs for electricity and gas than in any other developed country after a new regulatory regime came into full effect in 2006.

There has been a substantial correction of the real exchange rate since early 2013. However Australian—and I could add especially West Australian—costs remain a long way out of line with the rest of the world. Large, additional real exchange rate depreciation is required before

Australia has completed its adjustment to the end of the China resources boom. With low inflation in the rest of the world, the increase in Australian competitiveness must come mainly from exchange rate depreciation. Stronger productivity growth in Australia would help—but only if Australian total factor productivity growth shifted from being lower to much higher than other developed countries. In any case, any superiority of Australian over other countries' productivity performance would take several decades to correct contemporary weakness in Australian competitiveness.

The exchange rate cannot do all or even the major part of the job in supporting the effective use of our rich renewable energy resources in restoring Australia's historic strength in energy-intensive industries. Huge cost-increasing distortions in the supply of electricity transmission and distribution services must be corrected.

New institutional arrangements introduced in the 1990s and early 2000s separated eastern Australian wholesale, transmission, distribution and retail electricity markets. In the other Australian States and the Australian Capital Territory, a National Electricity Market (NEM) has been established. Within the NEM, the wholesale market is operating effectively, with a reasonably high level of competition and historically low prices. The retail end is challenged by inadequate competition, with high and rising margins leading to high costs for to power users. There is some prospects of new entrants increasing competition and eventually lowering prices. Western Australia and the Northern territory remained outside the NEM.

Transmission and distribution are not working well in the NEM or in the jurisdictions that remained on their own. Transmission and distribution are natural monopolies requiring price regulation. After 2006, investment and therefore electricity prices increased at rates far beyond either past Australian experience or the modern experience of other developed countries. Increases in network charges have dominated total electricity price increases since the current regulatory approach was introduced in 2006.

Since late 2014, the Australian Energy Regulator has taken some steps towards correction of errors in Australian energy network regulation in the NEM. However, there is a massive overhang of excessive investment, the recovery and return on which raises the cost of electricity and gas to users. The manner in which this legacy is corrected will have a large effect on the success of Australia in using its potential energy cost advantages in a low-carbon world.

Western Australia is in some ways similar and in some ways different from the National Electricity Market. I know much less than our Chair today, WA Energy Minister and Treasurer Mike Nahan, but I will hazard some general rather than finely detailed comments on the WA situation.

There would be advantages in WA making both the wholesale and retail ends of the electricity market more contestable by private competitors. Once there is effective competition, the case is weak for keeping established suppliers in public ownership.

On the networks, there is much discussion about whether WA should follow Victoria, South Australia and New South wales into privatisation of the natural monopolies.

Here the lessons of other state's experience is clear: efficient pricing for the services of a natural monopoly are more important than ownership. If privatisation is to be contemplated, make sure that you first put in place an efficient price regulation regime.

The experience of the NEM underlines the truth in an old proposition from economics: in regulating prices in a natural monopoly, avoid setting prices primarily by reference to the rate of return on investment (Averch and Johnson 1962). With rate of return regulation, the combination of caution to avoid underinvestment and the inevitable tendency to regulatory capture will lead to rates of return being set above the supply price of investment, leading to wasteful over-investment.

WA's public ownership of the transmission and distribution networks introduces greater freedom for productivity-raising reform of network pricing, whether or not the networks remain in public hands. Here I will outline a few principles that the WA Government could take into account in network pricing reform.

As in the NEM, a number of technological and economic changes in recent years have caused the current capacity of the grid to exceed the requirements of WA electricity users. They have also caused the distribution of capacity across the grid to diverge from economically optimal patterns. Increased opportunities and interest in opportunities for energy efficiency have contributed to falling demand for power through the networks. So has the falling cost of decentralised solar power generation. Technological change and falling cost of capital have introduced opportunities for decentralised solar power generation and storage in batteries to reduce peak demand by electricity users—and therefore reduce demand for investment in increased network capacity. The falling cost of renewable energy generation and storage also allows communities away from the main lines of the established grid to be serviced much more cheaply by locally sourced electricity than from centrally generated power distributed through the grid.

The falling costs of decentralised power and storage open up the possibility of reducing costs of power supply to users of power throughout the State. But only if the pricing of network infrastructure allows economically efficient use of the existing grid, and provides incentives for efficient allocation of investment between centralised and decentralised power in future.

The first step towards rational pricing is to write down the value of redundant grid capacity—of some investments that have been made redundant by technological and economic change, and others that were redundant when they were made. This is what the market economy forces in other sectors of the economy where there has been investment in supply capacity beyond demand.

Any attempt to recoup the value of redundant investment through network charges introduces incentives for underutilisation of sunk investments. The State will have to meet the costs of past investments that have been funded by debt in one way or another, but higher prices for electricity is an especially inefficient means to this end. To the extent that it raises the cost of power to business users, it unnecessarily inhibits the emergence of exports from energy-intensive industries in which WA has comparative advantage. And to the extent that it raises the cost of electricity to households, it reduces the standard of living more than comparable amounts of revenue raised from taxes on carbon externalities, on payrolls or on consumption more generally. With the prices of fossil fuels having fallen dramatically in recent years, and

with growing awareness of Australians' responsibility to do their fair shares in a global mitigation effort, a tax on fossil fuel use may be more attractive electorally than the most frequently canvassed alternatives: a higher tax on payrolls or on consumption in general.

Once the capital value of the grid has been written down to its contemporary economic value, it is important that the network pricing structure introduces incentives for efficient investment in the grid in future.

An economically efficient pricing structure would charge mainly for the use of peak capacity used by firms and households, and avoid purely fixed charges for access to the grid. Over time, this would lead to more even use of the grid through the hours of the day and the seasons of the year. It would encourage efficient use of decentralised power generation and storage to minimise overall costs of providing power.

An economically efficient pricing structure would lead over time to the emergence of a new balance between centralised and decentralised power supply that reduced overall costs. It would encourage use of power for energy-intensive industry where the State had comparative advantage.

3. Opportunities in the Low-Carbon Economy

Australian opportunities in the energy sector will be radically different in a low-carbon world.

The old fossil fuel industries no longer provide opportunities for incomes growth. Export markets for coal are unlikely to support remunerative prices without closure of a substantial amount of the world's established capacity. Some of that withdrawal will be in Australia. If new mines are established, more old ones will be closed. After a few decades, the surviving coal exports will supply processes and industries and locations endowed with favourable carbon sequestration opportunities.

Recent overinvestment in Australia and elsewhere will keep international gas prices low for a while. There is an opportunity for gas to fare better than coal for two reasons. Its combustion generates substantially lower amounts of greenhouse gases per unit of energy, and it is therefore favoured as a transitional fuel in the period prior to the emergence of a zero emissions energy sector around the middle of the century. And costs of sequestration are likely to be lower per unit of energy, especially for geological sequestration. Using carbon pricing as the principal instrument for reducing emissions would support the emergence of carbon capture and storage and assist gas to make use of its advantages on a sustainable basis in a low-carbon world.

Some manufacturing processes hold the carbon in the final product. These are not affected by constraints on carbon emissions. Other manufacturing processes will come under competitive pressure. In some industrial processes including blast furnace production of steel, geological capture is likely to be expensive. Others, also including blast furnace steel, are well suited to biological sequestration, because of the tolerance of algae to accompanying waste materials.

The low-carbon economy will vastly expand opportunities for Australian mining to supply inputs to processes and products that are used in low-emissions energy. Australia is home to a high proportion of the world's high grade uranium reserves—a much larger proportion than

for coal or gas. Demand for uranium oxide (nuclear power), lithium and rare earths (batteries), natural graphite (the batteries of the future), high grade silicon oxide (photovoltaic panels), carbon fibre (energy-efficient vehicles) and special metals (wind and hydro-electric turbines) will all expand prodigiously in the low-carbon economy. These all use minerals in which Australia is well endowed. The processing of all of these materials for final application uses electricity intensively. The combination of internationally competitive domestic mineral reserves and low-cost electricity would make Australia the natural locus of processing.

Petroleum-based transport fuels will give way to some combination of low-emissions alternatives. Electricity-, ammonia- and hydrogen-based technologies will compete for supply of road transport. All require electricity as the source of energy. Low-cost electricity would give Australia a role in energy for transport vastly beyond that which it has with liquid petroleum. Low-cost low-emissions electricity would make Australia a major source of internationally tradeable ammonia and hydrogen should these technologies become important in road transport. Renewable ammonia, based on electrolysis applying electricity from renewable sources, is likely to replace ammonia from traditional fossil hydrocarbon sources in the low carbon global economy of the future.

Which will win out of electricity, hydrogen and ammonia as a fuel for road transport? It would be wise for Australians to participate in the early experimentation with each. Early establishment of domestic demand would be helpful to creation of domestic production of ammonia or hydrogen for international markets.

At the margin, the low-carbon economy is likely to favour electrified rail over road transport. This, the substitution of electricity for gas as a source of heat for households and industrial processes, the expansion of electricity-based minerals processing and the use of electricity-based energy sources for road transport are all likely to increase demand for electricity. Low-cost generation, transmission and distribution of low-emissions energy is therefore of central importance to the energy transition.

Australia has the potential to be even more important in global energy in a low carbon world. Amongst the world's developed countries, Australia has by far the greatest per capita potential for low-cost production of energy from most of the promising renewable sources: solar, wind, deep geothermal, wave and tidal. While endowed less richly than many countries with hydro-electric capacity, it has two developed sources, in Tasmania and the Snowy Mountains, that are considerable by world standards and which are able to contribute a great deal in the balancing of intermittent renewable generation. There is large potential as well for balancing intermittent renewable energy in potential for pumped hydro-electric storage capacity. Australia has excellent geo-sequestration potential in a few locations. At least amongst the developed countries, Australia has the greatest potential for biological sequestration of carbon wastes. It has the richest opportunities for production of biomass as a base for biofuels. At least amongst the developed countries, it is the most richly endowed in minerals that will be used in much greater quantities in the low-carbon economy.

Australia happens to be disproportionately strong in the applied physical and biological sciences and engineering that are important to turning opportunity in low-carbon energy into competitive advantage.

Whether these inherent strengths are converted into success in the various Australian States and in Australia as a whole depends on our being able to transform what in the recent past has been a dysfunctional policy-making and institutional framework.

4. Australia as a Superpower in the Low-carbon World Economy

The immediate future for the Australian energy sector is problematic.

At first sight, the problems are so large that we expect comprehensive failure to achieve Australia's potential as a superpower of the low-carbon economy.

Reflection reveals that overcoming the problems along the way to utilising Australia's potential are less painful than continued underperformance.

So what has to be done?

Most fundamentally, our recent political culture has to change. Success requires us to stop seeing energy policy and technology choice in partisan political and ideological terms. Success requires thinking on time scales that allow sound policy innovations to remain for long periods. Success requires independent citizens to reject government subordination of public to private interests, as powerful players from the old economy seek to block the emergence of the new.

A few particular policy reforms are more important than others.

First, on health. Independent Australians have to insist that participants in the recklessly contested policy debates on energy technologies allow a large role for scientific assessment of claims about effects on health. Questions about the effects on health of carbon particles released from coal combustion, or the vibrations caused by wind turbines, or the contamination of water by fracking for gas; let them all be examined by independent experts. And let the rest of us stand together against claims that have no scientific foundations.

Second, on the environment. As on health, we need to find space for independent, authoritative scientific assessment, and to respect the outcomes of soundly constituted processes. There is no path to utilisation of Australia's opportunity in the low-carbon economy that does not begin with acceptance of the authority of mainstream science on anthropogenic climate change. It is simply too costly to Australians' prosperity and standing in the international community to indulge the idiosyncratic obscurantism on climate science that has had a more influential role here than in any other country.

Once we accept that we have to reduce emissions in line with other developed countries, the task becomes to do it in a way that minimises costs and maximises the potential for Australian prosperity in a low carbon world. Yes, it is possible to achieve deep reductions in emissions through regulation of various kinds. But it would have to be deeply intrusive and costly regulation. Broadly based carbon pricing allows deep reduction of emissions without that intrusion. The old carbon pricing scheme, linked to Europe as it would have been from mid-2015, was capable of contributing efficiently to deep decarbonisation. Carbon pricing can contribute substantially to Australia's budget deficit challenge at the same time as it carries the weight of mitigation.

Carbon pricing can be supported by regulatory measures and buy-back schemes like the Emissions Reduction Fund in sectors not covered by the carbon price, and by supplementary regulatory measures in covered sectors until the linked carbon price is high enough to carry the load. Carbon pricing over most of the economy can fund offset schemes in what remains outside. The Renewable Energy Target has turned out to be a means to reducing electricity sector emissions by large amounts while reducing electricity costs to users. It reduces emissions reliably in the electricity sector, but, unlike carbon pricing, fails to discriminate between more and less emissions-intensive fossil sources of energy, and to recognise the carbon advantages of nuclear power and carbon capture and storage. It is a useful transitional instrument in the electricity sector along the way to effective carbon pricing.

Pending re-introduction of carbon pricing at a national level, it is worth considering the sub-national carbon pricing that has been successful in North America.

On innovation, the Australian Renewable Energy Agency (ARENA) has been operating effectively. It requires additional funding to cover the many areas in which Australians are able to contribute new ways of reducing emissions that are new to this country and in many cases to the world.

An efficient, low-cost electricity grid, designed to allow full use of the new technological opportunities in renewable energy and storage and the enhanced potential for low cost decentralised supply, has a centrally important role in a low-carbon economy.

There is potential for reductions in costs that could materially improve the prospects of Australia making good use of its extraordinary opportunities in the low-carbon economy.

As I worked my way into my first review of climate change policy eight years ago, I saw Australia's participation in a strong global effort to reduce risks of dangerous climate change being in Australia's interests despite some cost to Australian economic growth. As costs of the low-emissions technologies have fallen much more rapidly than once seemed possible, and as we have learned more about Australian opportunities in the low carbon world, that perspective has changed in response to new realities. I now see acceptance of the new as much more reliable economically than lingering embrace of an old energy system that the rest of the world is gradually but surely leaving behind.

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