

Australia: 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 unknown to the elites of earlier times. It has placed another half of the people on earth on paths towards enjoying those living standards comfortably within this century, so long as development is not blocked by a breakdown in political or ecological order. The remaining sixth of humanity aspires to be on one of those paths and there will be no stable resting place for humanity until they have achieved that goal.

Modern economic development was built on intensive use of fossil fuels. Solar energy had been converted by photosynthesis and natural storage processes into coal, oil and gas over hundreds of millions of years. It was then drawn down at a much faster rate than it was ever deposited, to drive the machines of the newly industrial world and meet the expanding demands of the households enriched by economic growth. Coal dominated the mix of fossil fuels at first, and was joined by oil from early and natural gas from late in the twentieth century. The availability of this concentrated energy was important to the burst of incomes growth that revealed the tendency for human fertility to fall when living standards became higher and more secure. The decline in fertility, in turn, allowed us to climb out of the Malthusian trap that had blocked large and sustained increases in standards of living for ordinary people from the beginnings of human civilisation.

So take a bow coal, oil and gas, and all of the people who have worked in producing and distributing them from the beginnings of the industrial age. Humanity's ascent from poverty and ignorance would not have happened without you.

The economists and other social scientists of the nineteenth century worried that the finite nature of fossil energy reserves would eventually bring modern economic development to an end. One of the founders of the neo-classical economics that is dominant today, William Stanley Jevons, wrote about Britain's choice, between a glorious several decades of high prosperity and power while coal reserves were depleted without restraint, and a longer period of modest prosperity. Weber ended a famous book with speculation that the industrial age would end with the combustion of the last tonne of coal.

The Australian economist Colin Clark—the global pioneer of national income accounting and development economics—had his initial training in chemistry and considerable knowledge of biological systems. This gave him confidence that humanity would find a successor to fossil fuels in meeting the needs of economic development. Three quarters of a century ago he noted that we can calculate the likely amount of undiscovered fossil fuel from the carbon that was once in the atmosphere.

“However, we must not set out to burn them up too fast, even if we do find them, at any rate not faster than the carbon dioxide can be converted by photosynthesis...”. Clark assures us that keeping the use of fossil fuels within the limits of what can be absorbed by photosynthesis need not be the end of economic growth. There is an abundance of solar energy falling on the earth, if we know how to tap it. The best method at present, he said, is the proven process of photosynthesis in trees. He calculated that the eucalypt is the most productive known agent for conversion of solar energy into useable energy. Algae had the potential to do better. “The silicon battery and other recent discoveries,” he said, “may do better still one day” (Clark 1940: 488-9).

While fossil resources are finite, this does not mean that reserves will be exhausted at any early date. But 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 the fruits of modern economic growth are to continue to be open to most of humanity. Just as the stone age did not end because we ran out of stones, or the bronze age because we ran out of copper and tin, the fossil energy age will not end because we run out of coal.

This lecture discusses the global transition from coal, oil and gas to forms of energy with low emissions of carbon dioxide, and its implications for Australia.

The climate change policy challenge is the most complex and difficult to come before our polity in living memory. When all of the Governments of Australia—Commonwealth, State and Territory—gave me the task of advising on policy eight years ago, I described it as a diabolical policy problem with a saving grace.

Four characteristics of the problem make it diabolical. 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 of others impose on others must be compensated by a tax equal to those external costs, or regulation blocking the activities that impose costs on others. The most enthusiastic supporters of the market economy from John Stuart Mill to Hayek and Friedman all recognised the importance of such interventions specifically in relation to the natural environment.

Not to tax an activity that imposes costs on others is to subsidise the harmful activity. That is why a recent 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.

The first steps along the path towards a low-carbon economy have been difficult, especially 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; adopted a workable approach to international cooperation that I call "concerted unilateral mitigation"; begun to think analytically about how to value benefits in the long term future against current costs; and are at least aware of the challenge to the public interest posed by the influence of private interests.

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.

At Cancun in 2010, the United Nations Framework Convention on Climate Change committed to limiting human-induced warming to 2 degrees.

Since then, there has been tension between the announced goal of the world's governments, and resistance by large corporations producing fossil fuels and the ecosystem of institutions supported by them. The major coal, oil and gas companies have continued to invest in exploration and development of reserves the use of which would be inconsistent with the achievement of the 2 degree objective. They have reported reserves of fossil fuels in their accounts that would have no value if the agreed international objective on containment of greenhouse gases were to be met. Some have defended this contradiction over the last year by asserting that governments would not achieve their objective of reducing emissions to levels consistent with holding warming to 2

degrees. While carbon capture and storage would preserve the value of some reserves of fossil fuel in a low carbon world, the major producers of coal, oil and gas have made invested little in its development and commercialisation.

The major coal companies have taken comfort over the years from selective use of International Energy Agency projections of demand. They have purported to rely on scenarios based on expectations that internationally agreed objectives would not be met—and which the Agency declared were deeply unsatisfactory for that reason. Coal companies have asserted the importance of fossil energy to lifting living standards in developing countries—in itself a welcome focus on global development as a moral issue.

Developments over the past year show that these great tensions are in the process of being resolved in favour of effective action to build a low-carbon world economy. The two biggest emitters of greenhouse gases, China and the United States, have dramatically lowered their carbon emissions trajectories. This was symbolised in the joint statements by Presidents Xi and Obama at the time of the Beijing APEC meeting in November 2014. The Australian Prime Minister sought to stand against the tide of international opinion on climate change mitigation as host of the G20 heads of government meeting in November 2014, and learned much about the strength of the tide. The G7 heads of government meeting in Germany in June 2015 emphasised the importance of a strong outcome from the UN meeting on climate change scheduled for Paris in December 2015. It said that it would be necessary completely to decarbonise economic activity by the end of the century and electricity supply a long time before that.

Two statements last week reveal the extent of change.

The International Energy Agency (IEA) published the *World Economic Outlook Special Report 2015: Energy and Climate Change* to assist in preparation for the Paris Summit. Its clarity on the importance and feasibility of the 2 degrees objective marks the end of coal industry use of the IEA's authority on the future of coal. The IEA noted that the provision of electricity for all people who lack it now would add only one percent to total coal use and emissions.

The IEA notes that 2014 was the first year in which global greenhouse emissions fell in the absence of recession in major countries. Amongst the developed countries in 2014, carbon emissions fell 1.8 percent while GDP increased 1.8 percent. Emissions fell 6 percent in the EU and 3 percent in Japan. They rose by 1 percent in the US but remained 10 percent below 2005.

In China, emissions fell 1.5 percent and coal use 3 percent despite over 7 percent growth in the economy. Chinese zero-carbon electricity—renewables plus nuclear—rose from one fifth of the total in 2013 to one quarter in 2015.

The main mention of Australia was as the country which, against the international flow, had abolished carbon pricing. For the record, electricity emissions have risen significantly in Australia after the end of carbon pricing in mid-2014 despite a fall in electricity demand, after falling significantly through the two previous years.

The IEA notes that national commitments to reduce emissions that have been announced so far do not put the world on a path that would hold warming to 2 degrees. It suggests the adoption of five-yearly commitments to successively tighter emission reduction targets until we are on such a path.

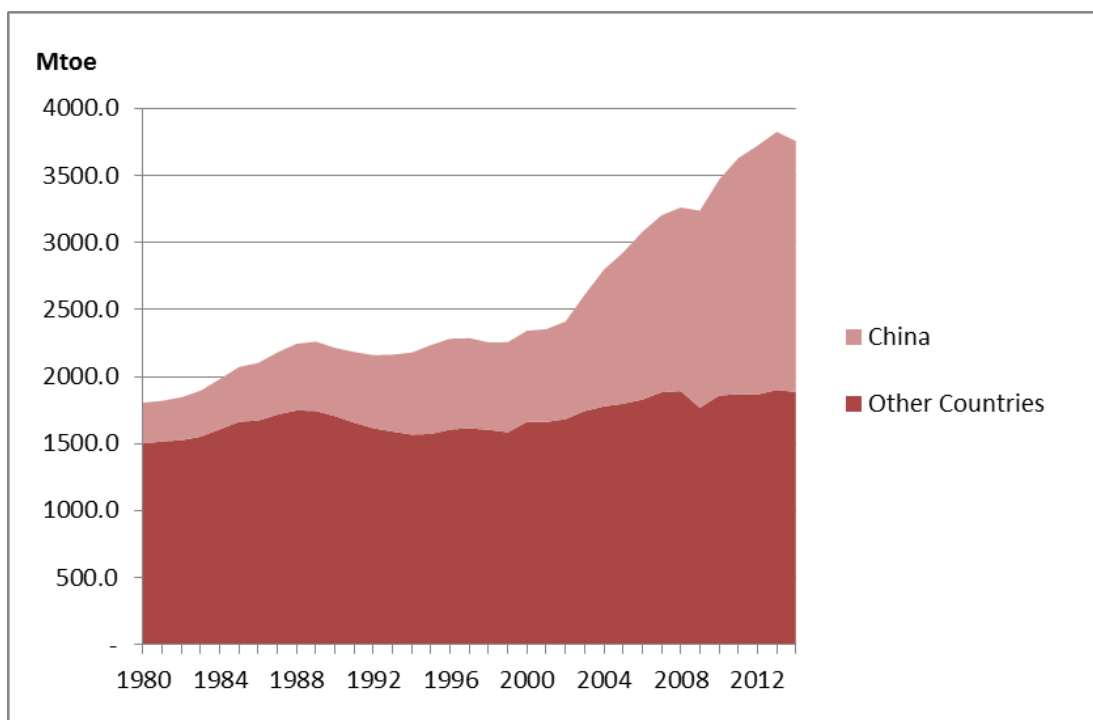
Even currently announced targets—the IEA's "Nationally Determined Contributions" scenario—sees little growth in coal demand before a peak in 2030. The 2 degrees scenario would see a peaking of global coal demand before 2020. The IEA stresses the importance of carbon pricing to

achieve strong emissions reduction outcomes at moderate cost. Carbon pricing is critical for the success of carbon capture and storage and therefore for the future of coal. Sound policies that support carbon capture and storage would see the preservation of an important role for coal, supplying one fifth of electricity requirements in 2030 and 12 percent in 2040. In this scenario, with carbon pricing and carbon capture and storage preserving a role for coal, the intermittent renewables, solar and wind, would increase their share of global electricity supply nearly 7-fold from 3 percent in 2013 to 20 percent in 2030 and increasing proportions after that. Without carbon pricing and carbon capture and storage, the role of coal would be much smaller and of solar and wind larger.

Large increases in supply of electricity from intermittent renewables requires stronger management of the timing of demand. It also requires expansion of energy storage—both at grid level, where pumped hydro storage already offers low costs, and at user level, where costs of battery storage are falling rapidly.

The IEA's expectations on carbon emissions reduction have lagged behind reality in recent years, most importantly in relation to China. That continues in the June 2015 Report, although the lag is now shorter than it was. Two charts, together with other information and analysis, suggest that Chinese use of coal has reached its peak under current policies (Chart 1). Recent increases in electricity have come entirely from zero-emissions sources (Table 1). Note that thermal electricity in Table 1 comprises gas and biomass as well as the dominant coal, with the biomass and gas share rising strongly in recent years.

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.

Table 1: Chinese Electricity Generation by Source 2010-2014

Year	Quantity (million Mwh)						Rise over previous 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	74
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	156

Source: National Bureau of Statistics of China and China's National Energy Administration.

The second historic intervention last week was the Pope's Encyclical Letter *Laudato Si: On Care for Our Common Home*. The Pope speaks of the problems with "a model of development based on the intensive use of fossil fuels, which is the heart of the worldwide energy system.....If present trends continue, this Century will witness extraordinary climate change and an unprecedented destruction of ecosystems with serious consequences for all of us." The Pope stresses the importance of reducing fossil fuel use for the welfare of the poor, who would suffer disproportionately from unmitigated climate change.

The Papal encyclical is the most powerful and influential manifestation of an increasing tendency to see personal contributions to reducing emissions as a moral issue. Scholars of ethics remind economists who analyse human behaviour primarily in terms of individual response to external incentives, that many of the practices that are essential to human civilisation depend on social and internal constraints on self-centred behaviour. John Broome, Professor of Moral Philosophy at Oxford University, has argued in a recent book that each individual contribution to greenhouse gas emissions hurts someone at the margin of vulnerability to climate change. The fact that we do not know when or to whom the damage occurs does not change moral responsibility, any more than distance from and anonymity of victims removes moral responsibility for death or injury from firing a rifle into a crowd. The Pope's intervention may affect emissions through its influence on personal behaviour as well as on policy.

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 has been a global superpower in energy supply. It 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, especially in the decade of the China resources boom.

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. Australia is a major exporter of aluminium—the most electricity-intensive manufactured product that is important in international trade. It also has much manufacturing industry based on low-cost natural gas.

The coal, oil and gas industries will remain large and important in Australia for several decades, but will detract from rather than enhance Australian incomes growth from now on.

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.

Australian domestic policy has interacted with the four big global shocks.

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. Coal has been internationally tradeable for a long time, so that domestic coal prices 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 process of shifting from being readily available in Australia at extremely low prices by international standards, to having 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.

Under free trade, these economic imperatives would move Australia towards using at home those sources of energy with relatively high international transport costs (renewables, fossil fuels using low-cost sequestration sites) and exporting energy that has relatively low international transport costs (uranium and coal).

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.

Relative costs of the tradeable component of energy costs in Australia have increased because export barriers for gas have fallen in Australia and risen in the United States.

The internationalisation of Australian energy markets has a sound economic rationale. The United States export restrictions will gradually be corroded through several mechanisms, but for the time being distort investment in gas-using manufacturing industries in ways that damage Australia.

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 increase 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 costs remain out of line with the rest of the world, and further real exchange rate depreciation is required before Australia has completed its adjustment to the end of the China resources boom.

New institutional arrangements introduced in the 1990s and early 2000s separated eastern Australian wholesale, transmission, distribution and retail electricity markets. The reforms established successfully a competitive wholesale market for power.

Transmission and distribution are not working well. Transmission and distribution are natural monopolies requiring price regulation. Investment and therefore electricity prices increased at rates far beyond past Australian experience and experience of other developed countries. Increases in network charges dominate total electricity price increases since the current regulatory approach was introduced.

A new Chair of The Australian Energy Regulator has taken a first step in correction of errors in Australian energy network regulation over the past year. However, there is a massive overhang of excessive investment, the recovery and return on which raises the cost of electricity and gas to Australian 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.

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. And costs of sequestration are likely to be lower per unit of energy, especially for geological sequestration. Carbon pricing assists gas to make use of its advantages in a low-carbon world.

The futures of the Australian coal and gas export industries depend on developments in carbon sequestration. Carbon capture and storage in geological structures uses a large amount of energy so will be economically viable only where primary energy costs are low. It needs favourable and tested sites near major sources of emissions. Biological sequestration in algae is a promising path

to low-cost production of bio-energy. Chemical capture may generate commercially attractive building and road-making materials.

Some manufacturing processes hold the carbon in the final product. These are not affected by the 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.

Despite the future prospects for Australian exports of coal and gas being closely related to sequestration, little effort has been allocated so far by coal and gas producers to developing these technologies.

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), rare earths (batteries), 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.

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—starting with but extending well beyond uranium oxide. Complementing its advantages in mining uranium and potentially in enriching it, Australia has perhaps the world's safest geology for safely storing nuclear wastes from power generation.

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.

The advantages in the low-carbon economy are shared across all Australian states, but are disproportionately located in South Australia.

Whether these inherent strengths are converted into success 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. Massive expansion of gas liquefaction and coal export supply capacity has coincided with an historic slowing of global demand growth for fossil fuels. That means low profitability and attrition of productive capacity, especially for coal, and weak government revenue and employment. The emergence of a gas export industry in eastern Australia is lifting domestic wholesale gas prices by large amounts to export parity. Massive investment in electricity transmission and distribution has accompanied an historic decline in domestic demand for electricity. The regulatory system that generated this outcome passes the costs to users. Technological improvements in solar energy and batteries are increasing use of decentralised power and causing more of the poles and wires investments of recent times to be redundant, leading to higher grid prices and discouraging use of the grid. Australia has removed an efficient mechanism for reducing emissions just as international developments demand deeper cuts in emissions. Australia has drastically reduced funding for research, development and commercialisation of new, low-emissions technologies just when its exceptional strengths in applied science and engineering have greatest value. Investment in production of old and new forms of energy from nuclear to unconventional gas to coal hydro-electric to wind is contested fiercely on grounds that have little connection to reality.

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 have 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 next week, 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 supplement to carbon pricing while market prices are low.

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. The Californian emissions trading scheme has been a useful partner for Canadian Province Quebec and is soon to be joined by other US states and Ontario. British Columbia's carbon tax with proceeds remitted to taxpayers—along the lines proposed by Tony Abbott from Opposition prior to becoming Leader in 2009—has proven to be popular and effective at rates higher than Australia's old "carbon tax".

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. Current regulatory arrangements block full utilisation of the potential for the grid. Reform requires users to integrate greater use of decentralised power and storage opportunities with economically priced access to the grid. Fundamental changes in pricing are required, focussing on charging for the actual use of peak capacity rather than for access to the grid itself. Efficient outcomes would require write-

downs of historical investments, with the distribution of costs among State and federal governments, users and owners of grid assets a matter for discussion.

Reform of pricing and provision for decentralised elements of the distribution system to be owned by local interests could lead to greatly increased overall use of electricity. Use of the central transmission system could expand despite large increases in decentralised provision of power.

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.

A majority of the costs of electricity to South Australian and many Australian households comprise payments for use of the network. The old electricity supply system was built around a small number of mostly coal-based generators in favourable locations in each state. These were connected to almost all businesses and households in the state through an elaborate and expensive grid. The costs of supplying power outside the main centres of population by this method are high, sometimes amazingly so.

Seventy percent of the costs of the SA electricity grid are said to be outside Adelaide, but only 30 percent of the revenues. The price for using the grid in Adelaide would be nearly 60 percent lower and the overall household cost of electricity around 30 percent lower if there were no need to support the grid outside the metropolitan area. Today, with low-cost decentralised supply of power from renewables and falling costs of storage, many provincial and rural communities could meet their own requirements locally at much lower costs. Finding mechanisms to allow decentralisation where it is economically efficient would reduce everyone's costs of power.

This is a big topic and I won't go further tonight. Let's just keep in mind that the established pattern of regulation unnecessarily increases the costs of power to all users; introduces artificial incentives for users to depart the grid, and reduces the chances of Australia again providing low-cost energy to households and energy-intensive industries.

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 considered 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.

This holds for the whole of Australia. It holds most strongly for South Australia. This state did not do as well as any of its mainland sisters when the creator handed out the world's best fossil fuel resources. South Australia leads them all in the sun, wind, geo-thermal, nuclear, bio-sequestration and new mineral resources that will build the low carbon economy of the future.

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