THE WORLD ENERGY MARKET AND AUSTRALIAN ENERGY: ECONOMIC AND BUSINESS PERSPECTIVES

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This article is a selective treatment of the world global market and Australian policy scenarios/trends in the energy discussion. Even though emissions of carbon dioxide (CO2) are mainly derived from the combustion of fossil fuels to produce energy, the focus of this article is energy from an economic and business perspective. As such, this article does not address the climate change debate.

World Energy Market

What does the world energy market look like from 2016 to 2040?

The U.S. Energy Information Administration (2016) *International Energy Outlook 2016* identifies the following fuel types: liquid fuels, natural gas, coal and electricity. The total world energy consumption is set to rise from 549 quadrillion British Thermal Units (Btu) in 2012 to 815 quadrillion Btu in 2040, an increase of 48%.

Renewables are the world's fastest-growing energy source growing by an average 2.6%/year between 2012 and 2040. Nuclear power is the world's second fastest-growing energy source, with consumption increasing by 2.3%/year over that period. Non Fossil fuel is expected to grow faster than consumption of fossil fuels, fossil fuels accounting for 78% of energy use in 2040.

Liquid Fuels

World use of petroleum and other liquid fuels grows from 90 million barrels per day (b/d) in 2012 to 100 million b/d in 2020 and to 121 million b/d in 2040. Most of the growth in liquid fuels consumption is in the transportation and industrial sectors.

Natural Gas

Worldwide natural gas consumption is projected to increase from 120 trillion cubic feet (Tcf) in 2012 to 203 Tcf. By energy source, natural gas accounts for the largest increase in world primary energy consumption. Natural gas remains a main fuel in the electric power sector and in the industrial sector.

Coal

Coal is the world's slowest-growing energy, rising by an average 0.6%/year, from 153 quadrillion Btu in 2012 to 180 quadrillion Btu in 2040. Throughout the projection, the top three coal-consuming countries are China, the United States, and India, which together account for more than 70% of world coal use.

Electricity

World net electricity generation is projected to increase by 69% from 21.6 trillion kilowatt hours (kWh) in 2012 to 25.8 trillion kWh in 2020 and to 36.5 trillion kWh in 2040.

While coal continues to be the fuel most widely used in electricity generation, renewables are the fastest-growing source of energy for electricity generation, followed by natural gas and nuclear power. Electricity generation from nuclear power worldwide increases from 2.3 trillion kWh in 2012 to 3.1 trillion kWh in 2020 and to 4.5 trillion kWh in 2040 as concerns about energy security and greenhouse gas emissions support the development of new nuclear generating capacity.

Energy related C02 Emissions

The report includes a factual outline of world carbon emissions. Figure 1 indicates the regional and country trends. World energy-related CO2 emissions are expected to rise from 32.2 billion metric tons in 2012 to 35.6 billion metric tons in 2020 and 43.2 billion metric tons in 2040. Growth in emissions is attributed to developing Non- OECD nations, many of which continue to rely heavily on fossil fuels to meet the fast-paced growth of energy demand.

Coal became the leading source of world energy-related CO2 emissions in 2006, and it remains the leading source through 2040. Although coal accounted for 39% of total emissions in 1990 and 43% in 2012, its share is projected to stabilize and then decline to 38% in 2040, only slightly higher than the liquids share.

The natural gas share of CO2 emissions, which was a relatively small 19% of total energy-related CO2 emissions in 1990 and 20% in 2012, increases over the projection to 26% of total fossil fuel emissions in 2040.

In 1990, CO2 emissions associated with the consumption of liquid fuels accounted for the largest portion (43%) of global emissions. In 2012, they had fallen to 36% of total emissions, and they remain at that level through 2040.

The net result of both the reduced share of fossil-fuel energy and the shift in the fossil-fuel mix is that projected energy-related CO2 emissions in 2040 are 10% lower in 2040 than they would have been without the changes.

Figure 1 World Energy related Co2 emissions by region figures without US Clean Power Plan

Region Country	1990 (%)	2012 (%)	2020 (%)	2030 (%)	2040 (%)
OECD	11.6	12.8	13	13.3	13.8
USA	5.0	5.3	5.5	5.5	5.5
Australia & NZ	0.3	0.4	0.5	0.5	0.6
Non-OECD	9.9	19.5	22.6	25.8	29.4
China	2.3	8.5	9.9	10.8	11.1

U.S. Energy Information Administration (2016) *International Energy Outlook 2016*

Australian Energy Market

To gather evidence, I have limited the scope of data collection to the business and economic articles in *The Australian* newspaper and a report on electricity policy scenarios. I have done this because, from my experience, the go to resources in the geography classroom are often from sources like *The Sydney Morning Herald, The Guardian* and *The Conversation.*

The Australian articles are behind a paywall and as such not everyone would have access to them. There is a potential inherent bias in this approach, however, I aim to provide my students another perspective from which they can build their arguments and potentially refute with evidence counter arguments to their viewpoints.

My methodology was to collect articles in 2018. I collected and processed dozens of articles on the energy, specifically the National Energy Guarantee (NEG) in 2018 which I used as the basis of early drafts and were quickly shelved as soon as the NEG was put on the back burner.

So, I decided to wait till after the 2019 elections and only collected articles for 2019. I specifically sourced articles relevant to energy demand in January and the resultant impact on supply with high summer temperatures and then monitored articles up to and just after the 2019 elections.

Policy Scenarios and Electricity

Where does the Australian energy market fit into the worldwide picture?

Brian Fisher (2019) authored the report on *Economic Consequences of Alternative Australian Climate Policy Approaches* which in part give indications of trends for electricity generation in Australia in relation to six policy positions.Scenarios 1–3 impose an emission target representing a 27 per cent reduction off 2005 levels consistent with the countries announced Paris contribution of a reduction in emissions to 26 to 28 per cent by 2030. Scenarios 4–6 impose a more stringent emissions target representing a reduction of 45 per cent compared to 2005 levels.

To break down the scenarios further:

- Scenario 1: -27% from 2005 by 2030
- Scenario 2: -27% from 2005 by 2030 with use of Kyoto carryover

- Scenario 3: -27% from 2005 by 2030 with use of carryover and permit trading
- Scenario 4: -45% from 2005 by 2030 and 50% renewables
- Scenario 5: -45% from 2005 by 2030 and 50% renewables with use of carryover
- Scenario 6: -45% from 2005 by 2030 and 50% renewables with carryover and trading

Fisher, B.S. (2019) *Economic Consequences of Alternative Australian Climate Policy Approaches.*

Here we examine the electricity section of the report in the context of electricity generation in Australia and the different policy scenarios.

Electricity generation in Australia is projected to reach around 300 TWh by 2030. This is equivalent to a growth rate from 2021 to 2030 of around 1.6 per cent a year, accompanied by projected higher consumption by electric vehicles. The share of renewable energy, including hydroelectricity, is projected to increase from around 13 per cent in 2013 to around 36 per cent by 2030.

The report investigates six policy scenarios in which a significant amount of coal is removed from the fuel mix. Results for other fuel types vary substantially depending on the scenario under consideration. The projected electricity generation mix in 2030 is summarised in Figure 2. The first column indicates the reference point and the numbers of the different fuel types for the different scenarios need to be read in the context of the reference point.

For example, in Scenario 1 in 2030 there is a near halving of the use of coal in relation to the reference point with Scenario 1 at 23 and reference point 40. There is a rapid uptake in natural gas with S1 at 38 compared to reference point of 23. Also, it seems that 75% coal fire generation must be retired by 2030 and gas penetration needs to increase by 15%. Also note electricity demand is less for S4–6 compared to S1–3.

Figure 2 Scenario and Electricity Generation Mix in 2030, Australia (%)

	Reference	S1	S2	S3	S4	S5	S6
Coal	40	23	32	34	12	18	26
Gas	23	38	30	29	37	31	22
Renewables	36	36	36	36	50	50	50
Other	2	1	2	2	1	1	2
Total	100	100	100	100	100	100	100

Fisher, B.S. (2019) *Economic Consequences of Alternative Australian Climate Policy Approaches.*

Another factor that plays into the energy discussion in Australia is the price of energy. The wholesale price is impacted upon by existing generation capacity, intermittency, the integration costs of wind and solar technologies and the supply and demand of electricity. Figure 3 indicates how the price factor is related to the scenarios.

At right: Transporting a wind turbine blade, Atherton QLD

Figure 3 Impacts on the wholesale Electricity price in Australia in 2030, $/month Wh

	References	S1	S2	S3	S4	S5	S6
Wholesale Electricity Price	81	112	93	91	157	128	111

Fisher, B.S. (2019) *Economic Consequences of Alternative Australian Climate Policy Approaches.*

A final factor to examine is the electricity industry output projections for a whole range of industries. These industries include crops, livestock, forestry, fishing, thermal coal, metallurgical coal, oil and gas, oil refinery, iron ore, food processing, chemical rubber and plastic, non-metallic mining products, iron and steel, non-ferrous metal electricity, land transport, construction, water and air transport and services.

Some of these industries are compared to the scenarios in Figure 4. Though the sample in Figure 4 is selective all other industries mentioned above were in the negative territory as well. Scenario 4 and 5 appears to have the greatest impact on price.

ESA's deep-space ground station at New Norcia, Western Australia, is now powered in part by sunlight, from a new solar power 'farm' completed in August 2017. The farm has 840 photovoltaic panels arranged in five double rows with a rated capacity of 250 kW. Source: https://commons.wikimedia.org/wiki/File:New_Norcia_solar_ESA387214.jpg

Figure 4 Industry output projection, percentage variation from reference case, 2030.

	S1	S2	S3	S4	S5	S6
Thermal Coal	-37.3	-21.2	-19.0	-63.8	-44.0	-26.4
Oil refinery	-13.1	-4.3	-3.4	-36.7	-17.0	-5.2
Electricity	-11.3	-3.9	-3.0	-23.8	-14	-7.7
Land Transport	-6.2	-1.4	-1.0	-20.5	-9.1	-2.8

Fisher, B.S. (2019) *Economic Consequences of Alternative Australian Climate Policy Approaches.*

By necessity this examination of global and Australian trends is from two sources and can be complemented with references and cross checking. Notwithstanding the material should provide teachers a good foundation to work with students in developing evidence-based knowledge for their decision making and future actions

Australian Energy: classroom discussion points and ideas for resource collation

These different Australian energy situations can be unpacked in the classroom through group work, individual research, interviews and even worksheets. As much as possible the intention is to steer a middle path based on evidence collected from the sources identified. Below I have pooled together issues which could be used to generate classroom discussion, activities and resource development. The reference for each issue is in the body of the article.

1. There is evidence of a lack of power supply in January for the past couple of years.

One of the key issues at the beginning of each year is the reliability of the energy supply in summer when hundreds of thousands of people turn on their air conditioner units.

In the week before 28 January 2019, the wind generators in Victoria and South Australia worked at around 20 percent of capacity in the crisis periods because the "wind didn't blow enough". It was a repeat of the events on February 10, 2017 when the NSW system had 2080MW in renewable capacity, excluding the Snowy, but only generated 707MW from that capacity at the peak demand time because the wind did not blow and at 5pm the sun had lost the capacity to generate power. In 2016, South Australia was not as lucky and suffered a week-long blackout made worse by cable failures.

Gottliebsen, R (2019) "Close shave as southern states once again spin climate roulette" *The Australian* 28 January.

2. Is there an impact of closing down on coal fired power plants while renewable energy is still building capacity to meet the demand for electricity?

For example, the Snowy Hydro Snowy Hydro has called for urgent investment in NSW's electricity transmission network to unlock an extra 1000 megawatts of generation and dodge a supply shortfall when AGL's ageing Liddell coal plant retires in 2022. AGL plans to replace the lost capacity with a mixture of solar, wind, gas, pumped hydro and battery power.

Williams, P (2019) "Invest Now to Unlock Power" *The Australian* 28 January.

3. The capacity of the transmission lines even if the nation had the energy supply.

For example:

"Transmission upgrades would integrate future renewables into the shared network and unlock

up to 1000MW of existing capacity from the Snowy Scheme which we can't get into the market due to constraints on the transmission lines."

This can be achieved by boosting the state's inter-connections with Victoria, South Australia and Queensland in a bid to unlock more power from the Snowy scheme and better manage peak demand on hot days.

Williams, P (2019) Call for new coal plants as grid feels the heat" ***The Australian*** 21 January.

4. The creation of new thermal coal/gas fired power stations or suitable alternatives.

For example, firstly, Australia's big three "gentailers" — AGL Energy, Origin Energy and Energy Australia — operate the nation's biggest coal power stations. All three have ruled out building new plants given high construction costs and cheaper renewable alternatives. Secondly, in NSW a $2 billion high efficiency, low emission (HELE) coal plant with 660MW is planned. This could either be built at AGL's Liddell facility in the Hunter Valley or at the site of the old Vales Point A power station.

5. What can we do with the closed down fire powered coal power stations?

For example, a Chinese businessman and sole shareholder of privately-owned CU- River Mining, wants to transform the site of South Australia's last coal-fired power station into a bulk commodity port facility that ships high-grade iron ore from his company's local mining operations to China. This involves a 1068-hectare Spencer Gulf site in Port Augusta, 310km north of Adelaide. This would not progress until rehabilitation works have been finalised by current owner Flinders Power, an offshoot of Alinta Energy, in April.

Williams, (2019) "Gas guru stays ahead of the game" *The Australian* 21 January.

6. What is the impact of high level corporate and government decision making?

For example, Glencore is to abandon large coal acquisitions, freeze production over investor climate change concerns.

The Swiss-based resources giant will cap its global thermal and coking coal production at the current level of about 145 million tonnes after holding talks with the Climate Action 100+ initiative. Glencore's Australian mines account for nearly 100m tonnes of its global volumes, underlining the impact it may have on Queensland and NSW. Such decisions are taken seriously by Climate Action 100+ members in Australia including Australian Super, AMP Capital, Cbus, IFM Investors, QSuper and BT Financial Group reflecting ethical investment decision making.

Further examples include RioTinto exiting from NSW thermal coal mines due to climate change concerns, stating the decision was influenced by the implications of climate change on coal supply and demand and because it had better investment options in iron ore and copper.

In addition, the NSW Land and Environment Court earlier this month upheld a decision by the NSW government to block the development of Gloucester Coal's proposed Rocky Hill coking coal mine, with judge Brian Preston citing the mine's potential contribution to climate change as a reason for the decision.

Williams, P (2019) "Glencore to abandon large coal acquisitions, freeze production over investor climate change concerns" *The Australian* February 20.

7. The relationship between Federal and State Governments

Policy decisions are made at a federal government level for implementation at the state level

On February 1 2019 the government indicated it will consider 10 new power generation projects. Including coal after energy was cut to 200 000 homes in Victoria in the week prior to when the article was written. Outage cost VIC and SA 1.1b in less than 48 hours. Seventy investors "seized on the chance to compete for federal government backing". Including two clean coal plants (HELE) aiming to reduce power bills and shore up their reliability. The breakdown of the 66 submissions include projects in NSW (26), VIC (17), SA (15), QLD (12), TAS (3) and WA (3).

Kelly, J (2019) "New coal projects to secure power supply" *The Australian* February 1.

Below: Murujuga National Park, WA. The bright flame tower of the North West Shelf LNG gas plant lights the night time landscape, as the moon rises over the rocky terrain Source: https://commons.wikimedia.org/wiki/File:LNG_Flare_turns_night_into_day.jpg

Coal freight train travels through the northern Sydney suburb of Pennant Hills

8. What is the story with batteries?

Tesla recently said SA's giant Hornsdale battery bringing worldwide interest. In 2018 it deployed 1.04 GWh (gigawatt hours) of energy storage and 2GWh in 2019 providing $US 140m profit in last quarter in 2018. SA Virtual Power Plant Program aims to install 50 000 interconnected Powerwall units. The Hornsdale battery project is located at Hornsdale wind farm near Jamestown run by French group Neoen

Jenkins, C (2019) "Tesla says SA's giant Hornsdale battery bringing worldwide interest" *The Australian* 31 January.

9. Supplies of some energy resources will eventually run out.

For example, AGL chief executive Brett Redman suggested gas on the east coast is going to go into shortage over the next few years.

"We're not seeing development coming on quickly and the new drilling going on in the Bass Strait is coming up dry so we're not seeing big, new reserves necessarily poised to enter the market."

Williams, P (2019) "AGL signals full steam ahead with LNG terminal plan" *The Australian* 15 February.

10. Impact of government changing policy and indecision.

For example, businesses have threatened to pull $2 billion of planned investments from NSW as frustrations mount that delays approving Santos's Narrabri project will cripple the viability of their operations.

Indian-Australian industrial company Perdaman Group, Australia's largest brickmaker Brickworks and gas wholesaler Weston Energy are calling on the Berejiklian government to make a final decision on Santos's project this year. Perdaman is considering developing a $US1bn ($1.44bn) ammonium nitrate plant near the town, 520km northwest of Sydney, which could supply fertiliser for agribusiness or explosives for the state's mining industry.

Unless a decision is made the company could redirect the investment to other international destinations including New Zealand, Indonesia or the Middle East, and drew a comparison with a $4bn urea project on the Burrup Peninsula in the Pilbara where it is working with Woodside Petroleum and the state government.

Williams, P (2019) "Investment to walk out the door over gas delays" *The Australian* May 28.

11. The links between energy providers and retail distributors of energy.

Andrew Forrest's planned LNG terminal in NSW has struck a five-year, $500 million-plus supply deal with Energy Australia as it works to lock in customers for the nation's first gas import plant. Energy Australia, one of Australia's big three power retailers, reached a preliminary agreement to buy 15 petajoules of gas from January 1, 2021. Gas from the Port Kembla terminal will be supplied to Energy Australia's residential and industrial customers on the east coast.

Utility AGL Energy and big gas producer ExxonMobil have flagged potential import terminals in Victoria while Japanese conglomerate Mitsubishi is backing a plan to import LNG at Pelican Point in South Australia.

William, P (2019) "Port Kembla LNG terminal strikes $500m deal with Energy Australia" *The Australian* May 23.

This scenario is best summed up by the following quote:

The big three generator retailers — AGL Energy, Origin Energy and Energy Australia — may still lack sufficient certainty to proceed with looming investment decisions.

Williams, P (2019) "Power players push for certainty" *The Australian* May 21.

12. There is a need for visionary strategy

A commodity tycoon, who rescued South Australia's Whyalla steelworks from administration, believes the government could play a critical role in backing the development of cheap but intermittent solar and wind supplies supported by firming up generation sources like pumped hydro or gas.

Solar is wonderful but it is not a 24/7 solution. You need pumped hydro and gas to smooth the supply curve and they require substantial investment.

While power plants could run for 30 years or even 50 or 60 years if they were hydro- powered, they cannot be financed at normal market rates and may require additional government assistance to get off the ground:

We know renewables is economically viable, but the security of supply is even more important. So, with that in mind, we need to ensure the transition occurs in an orderly manner.

Coal continues to prop up about 70 percent of the national power grid but with many of the east coast's ageing plants nearing the end of their life the government faces a test to ensure the grid can handle a boom of renewable supply into the system.

Williams, P (2019) "Sanjeev Gupta's powerful vision for reliable energy" *The Australian* 22 May.

13. The nuclear option

It's embarrassing to tell people in the US that nuclear energy is banned in Australia. "But don't you export uranium?"

Australia could learn for overseas projects. As part of its "carbon-free power project", Oregon-based Nuscale is already building a set of small modular reactors for the state of Utah, which should be operational by the mid-2020s. The new designs eliminate two-thirds of previously required safety systems and components found in today's large reactors. Three of these, at about $US250 million ($350m) each, would provide more energy than Australia's biggest wind farm.

It is argued that nuclear power should be a natural complement to wind and solar as the world moves away from fossil fuels.

The development of massive storage capacity at low cost is of benefit to nuclear too, because when there is abundant wind, for example, you don't need all (of a) nuclear plant's production, so you can store it and release it later."

There is a cost advantage for example, in Illinois, with just under 13 million people, there are six nuclear power stations. In Chicago the average price of electricity in January was around US12c a kW/H. Energy Australia charges me 29.4c a kW/H for electricity in Sydney. In nearby Ontario, where nuclear energy provides 60 per cent of the electricity needs of Canada's biggest province, it was less than C13c a kW/h.

It has two major benefits — low operating costs and virtually none of the emissions that lead to smog, acid rain or global warming," says Ontario Power Generation. "These benefits make nuclear a very attractive option for meeting the province's electricity needs well into the future.

Adam Creighton suggests Australia offers a safer geography for nuclear power. As the closure of the giant Liddell coal power station nears in 2022, small modular imported nuclear reactors might be one option worth investigating, providing reliable, carbon-free power cheaply.

Creighton, A (2019) "No logic in our nuclear allergy" ***The Australian*** 23 April.

Conclusion

Although this article is focused economic and business perspectives it should provide useful insights and ideas for classroom application and lead to the development of resources which may be of used for a balanced discussion, when used with other resources. Most probably, by the time of publication, of the article there will be further developments in this evolving global and national issue.

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Wind Farm, Challicum Hills Vic. Source: https://www.flickr.com/photos/jlascar/4613875666/in/photostream/