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Discussion between Andrew Blakers and Peter Rez

Abstract

The two authors respond to each other's articles, above.

Andrew Blakers responds to Peter Rez's article

To undertake this kind of analysis you need to include the following:

- Hour-by-hour solar, wind and demand data over 5–10 years for many places in each state. This represents what is actually happening
- Both PV and wind are cheaper than one alone
- Add in legacy hydro and bio
- Additional high voltage DC (HVDC) and AC transmission to even out supply and demand between states (a "copperplate"). We find a 5× reduction in storage needs when we do this rather than try to balance state-by-state. The cost of the transmission is modest but the effect is large.
- Storage (0.5 TWh). We chose to model off-river pumped hydro, of which there are 3000 good sites in Australia — look at our atlas at http://re100.eng.anu.edu.au/global/index.php. This sets an upper bound on storage cost. If batteries and demand management reduce the overall cost, then good.

Our 2017 paper did all these things (Blakers et al. 2017), which represent what is actually happening.

Prof. Rez did not. His comment is wrong: "The development of hydro and pumped hydro-electric is predicated on climate and topography. In most countries hydro-electric power has been fully developed. Furthermore pumped hydro requires not just one, but two reservoirs at different elevations."

Our results are clear and reproducible: the cost of balancing a 100% grid (over and above the cost of PV/wind energy supply) is low (<A$25/MWh). This is far below the cost of gas generation.

Gas is only supplying 8% of generation in the national electricity market (and declining). Facts on the ground show that PV, wind and storage is squeezing gas.

See Blakers et al. (2020).

Peter Rez responds

Ideally I would have used hour-by-hour data for many years. I grabbed what was available and did what I could in the limited time available. I've looked at the Blakers paper (Blakers et al. 2017) again and have now come to the conclusion that there are serious problems.

Prof. Blakers claims that he can get by with a total storage of somewhere between 225 and 750 GWh; let's call it about 500 GWh. The reason I went through those detailed analyses on mismatch between demand and solar and demand and wind is to establish what could be considered as minimum storage necessary. Let's take solar. Just looking at the shape of the peak and how it slots between the demand peaks shows that as a minimum one would need to store approximately the amount of electrical energy used in a day. For the 4 states that's about 600–700 GWh. Taking account that not every day is sunny would only increase this amount. For wind the problem is different: it's the need to allow for long periods (up to a week or more) with low wind velocities and minimal outputs. Don't think that taking wind from widely separated areas is that much help: the correlation between wind in S. Australia and Victoria is 0.72, and even when one compares New South Wales (where there isn't much wind) with S. Australia it's as high as 0.4. In other words wind is mainly determined by the passage of weather systems (you'll see the same elsewhere in the world).

HVDC buys one a factor of about 2 (see Rez 2017, Chapter 5); maybe it's cheaper to put in one HVDC line rather than 2 equivalent AC lines. The real advantage of long-distance transmission is using solar generation at points 2000 miles west to match an evening peak. But that's not what we're talking about: these states are on a North–South axis. When I played with my crude program, I found that amalgamating the states brought the storage down from about 11TWh to 9TWh either with 5.0× wind 10.4× solar or 7.6× wind and 6.4× solar. To be honest, the notion that the 4 eastern states of Australia can manage off 0.5 TWh storage seems implausible, so I think there's something wrong with his code.

If anything, my crude analysis underestimates the storage required, as it takes each day as a block rather than following supply and demand on an hourly basis (very important for solar as shown above).

As for costs, one doesn't know what they will be until someone actually goes out and asks for bids (preferably on a fixed-price contract).

If Prof. Blakers is right, then Australia should be able to manage on Snowy 2 with a few extra transmission lines. So what's stopping you? (Though I'd check his code carefully first: as I said, I think the estimates for storage required are implausibly low.)

As for the wonders of all the solar that has already been installed, see Fig. 1D showing the effect on Australian CO_2 emissions. It's precisely zero. Until Australia gets off coal, nothing is going to change.

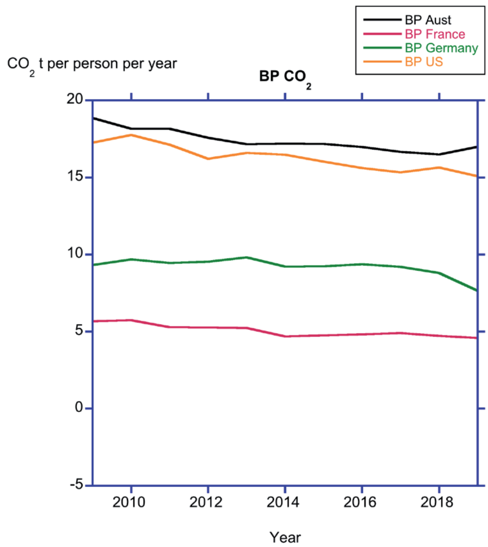

Figure 1D CO_2 emissions

Peter Rez continues

Let me summarise where we are at:

I agree in principle it would be possible for Australia to live entirely off renewables; where we differ is the magnitude of pumped hydro required (I think it's 10 to 15 times more than Prof. Blakers' estimate). I don't know whether the topography allows for the 9–15 TWh of pumped hydro that I think is more likely to be necessary. I'm a bit confused by Prof. Blakers' 2017 paper. The critical number, the amount of pumped storage in GWh or TWh, is not clearly spelled out. In the text there's vague talk of numbers between 225 GWh and 750 GWh, in his Fig 4 16 TWh per year (what does that mean?) is mentioned.

If the objective is to lower CO_2 emissions, then the increased adoption of solar PV, despite Prof. Blakers' cheerleading, hasn't done much (if anything). (See attached graph, Fig. 1D). It didn't do anything in Germany either. The most important thing is to eliminate coal from power generation. That hasn't happened in Australia, which is why Australia's CO_2 emissions per person remain high. Australia also has a high contribution from transportation. It would be interesting to see how much the extractive industries contribute.

It's very easy to get into a situation where the widespread adoption of rooftop PV actually increases CO_2 emissions when it displaces nuclear power or combined-cycle gas from the baseload.

The one thing that is guaranteed to work is to substitute nuclear power for coal. The position really hasn't changed that much from when I wrote my book (Rez 2017): the French CO_2 per person per year is substantially less than the German CO_2 per person per year. The British Petroleum data show a fall in German CO_2 for 2019 (Fig. 1D, BP 2020), but I'm going to wait for the more rigorous U.S. Energy Information Agency data to try and understand what's going on.

The costs of renewables are all up-front capital costs. I wouldn't take any notice of numbers for costs produced by me, Prof. Blakers or anyone else who lives in an ivory tower. Take a concrete proposal and send it out for bid with real contractors and companies who have "skin in the game."

In many countries there are various individuals promoting the view that reducing or even eliminating CO_2 emissions in a modern industrial society is going to be cheap, with the painless substitution of renewables for fossil fuels. Any reduction in CO_2 emissions is going to be hard, potentially costly and time-consuming, and these costs have to be weighed against potential benefits. I think the Chief Scientist understands this, and I would urge him to consider all the options and not accept what Prof. Blakers says.

Andrew Blakers responds

Robert, one difference between us is that my colleagues and I have actually done the hard yards: a detailed hour-by-hour analysis taking all key parameters into account.

Another is that we look at facts on the ground: PV and wind are rapidly taking over the AU electricity grid — far faster than in the USA and elsewhere — because they are cheap.

As I said, Prof. Rez needs to include the following, and until he does so then he will get an inflated answer for storage needs:

- Hour-by-hour solar, wind and demand data over 5–10 years for many places in each state. This represents what is actually happening with widely distributed solar & wind
- Both PV and wind are cheaper than one alone
- Add in legacy hydro and bio
- Additional HVDC and AC transmission to even out supply and demand between states (a "copperplate"). We find a 5× reduction in storage needs when we do this rather than try to balance state by state. The cost of the transmission is modest but the effect is large

- Storage (0.5 TWh). We chose to model off-river pumped hydro, of which there are 3000 good sites in Australia — look at our atlas at http://re100.eng.anu.edu.au/global/index.php. This sets an upper bound on storage cost. If batteries and demand management reduce the overall cost, then good.

Table 3 in our 2017 paper clearly sets out storage needs for 17 scenarios. All around 0.5 TWh. None is around 9–15 TWh (Blakers et al. 2017).

With respect to Snowy 2.0: this system has nearly enough energy storage (350 GWh, compared to the 500 GWh requirement) but not nearly enough power (2 GW, compared to 20 GW). In other words, we can't get the water out fast enough.[1] It would be unwise to put too many eggs in this basket by adding many more tunnels and gensets — better to spread the storage power around.

Australia has no nuclear and is not going to get any.

Gas is only 8% of annual generation in the NEM and declining (OpenNEM). Renewables are tracking towards 50% in 2025.

Facts on the ground (Blakers et al. 2020):

- Solar and wind are 99% of new capacity in Australia because they are cheap
- Emissions in the electricity sector are falling rapidly. Overall emissions are also falling
- Australia is installing renewables 4× faster per capita than EU, USA, China or Japan and 10× the global average. USA has a great deal to learn from Australia
- So far in 2020, Tasmania (100% hydro & wind) and South Australia (60% wind & solar) have the cheapest electricity in Australia. See this at https://opennem.org.au/energy/nem/?range=7d&interval=30m

"In the year to June 2020, emissions per capita and the emissions intensity of the [Australian] economy were at their lowest levels in 30 years. Emissions per capita were lower than 1990 by 44.7 per cent while the emissions intensity of the economy [CO_2 per $] was 64.7 per cent lower than in 1990." (AG 2020, p. 3)

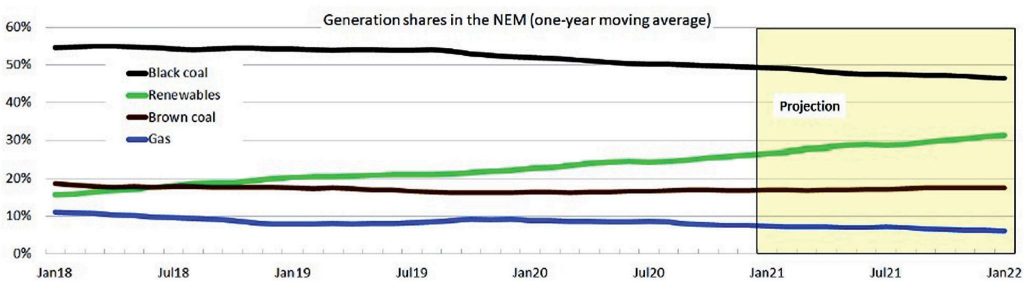

Figure 2D Australian energy shares

1 This is a distinction between energy (measured in GWh) and power (measured in GW): in the economist's language, almost enough stock but not enough flow. [Ed.]

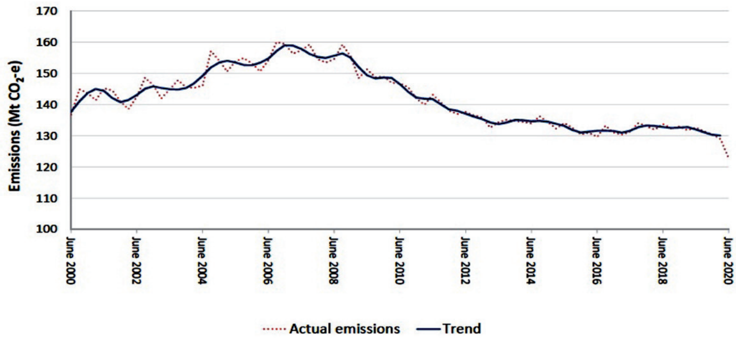

Figure 3D CO2 emissions — AU

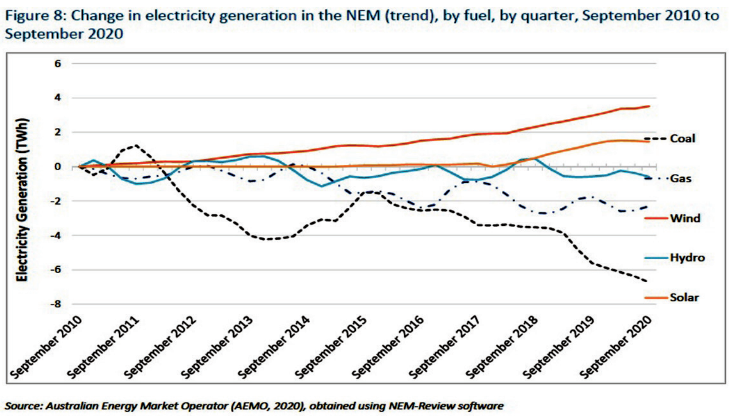

Figure 4D Electricity fuel changes — AU

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