Solar PV and wind – the heart of an energy technology roadmap

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6th July 2020

Australia is leading the world in the deployment of solar and wind and is realizing the benefit in emission reductions in the electricity sector AND reducing prices. The Technology Investment Roadmap Discussion Paper highlights wind and solar as the largest potential for emissions reductions in the medium term. Australia can lead the world in developing the systems to support high fractions of wind and solar with associated knowledge export benefits. Australian research has underpinned the world's development of silicon PV and is driving next-generation tandem silicon improvements helping further reduce energy costs.

Recommendations:

- Continued rapid deployment of solar photovoltaics (PV) and wind in Australia's electricity systems to further support further cost reductions (learning by doing) and decarbonization of electricity generation
- Policy support for deployment of transmission, demand management, storage (batteries and pumped hydro) and energy efficiency to integrate wind and PV generation
- Prioritise ongoing solar cell and module research and development leading to large-scale solar cost reductions for Australia, through improvements such as to improved conversion efficiency
- Fund the continuation of the Australian Renewable Energy Agency (ARENA) and the Australian Centre for Advanced PV (ACAP) to support the innovation needed to accelerate the low emissions transition
- Support electrification of transport and low temperature heat (heat pumps) to drive down emissions through expanded use of renewable electricity

Solar PV and wind energy

1. Electricity is the easiest and cheapest energy sector to decarbonize. Low emissions electricity unlocks near term emission reductions in other sectors including heat (via electric heat pumps) and transport (via electric vehicles). Renewable electrification must be central to an energy technology roadmap.
2. Solar photovoltaics (PV) and wind comprehensively won the electricity supply race. They account for two thirds of global net annual capacity additions, and 99% in Australia.
3. Other low emission generation technologies cannot catch PV and wind within several decades, because they would require extravagantly unrealistic growth rates to catch PV and wind, which are both growing quickly with rapidly shrinking prices.

4. Renewable electricity (mostly PV and wind with support from hydro) has now passed gas and brown coal in the National Electricity Market (NEM), and will pass black coal in 2023 when Liddell closes (Figure 1).

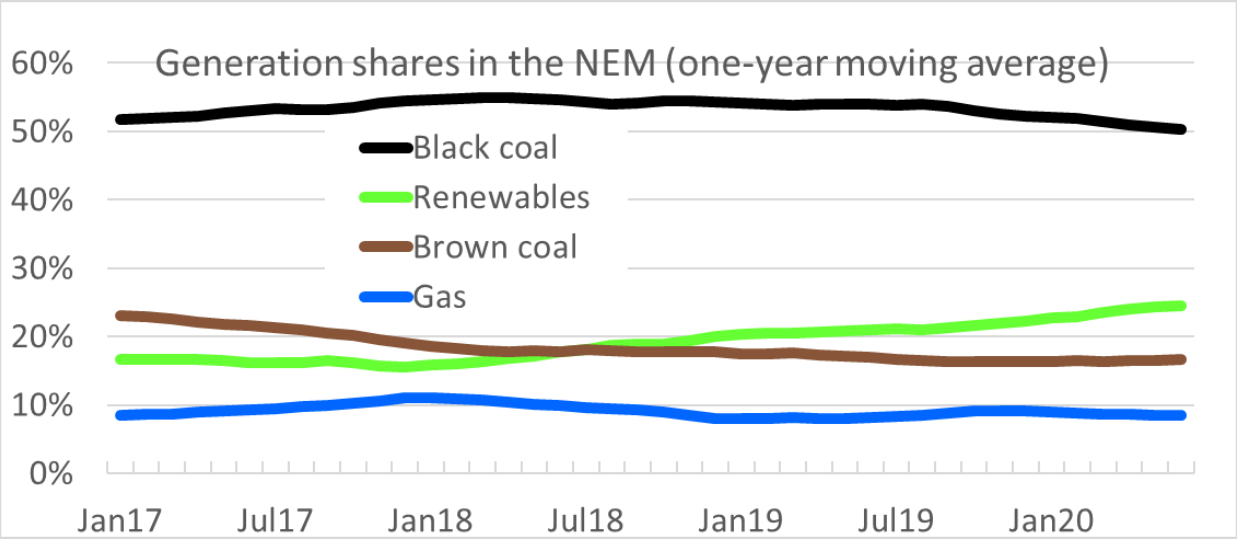

Figure 1: Renewable electricity (mostly PV and wind with support from hydro) has now passed gas and brown coal in the NEM, and will pass black coal in 2023 when Liddell closes

5. Silicon solar cells account for 95% of the global solar market. They are being installed faster than the combined net new electricity generation capacity from non-silicon PV, coal, oil, gas, nuclear, bioenergy, geothermal, solar thermal and waves (Figure 2).

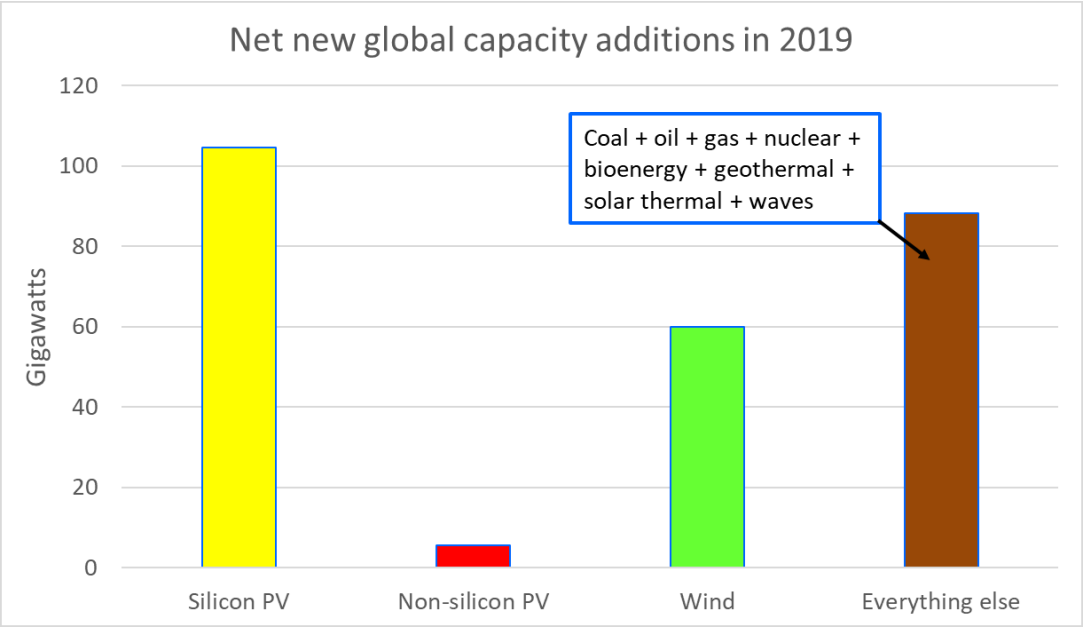

Figure 2: Silicon PV is being installed faster than everything else combined except wind [IRENA]

6. Australia's overall Greenhouse emissions are falling. Emissions from the electricity sector (due to solar PV and wind displacing generation from coal) are falling more quickly than emissions are rising in all other sectors combined (heating, transport, industry and fugitive emissions from coal and gas mining). PV and wind are the only credible path to deep emissions reductions. Their cost is now so low and falling continuously such that the net cost of pushing coal out of the electricity sector to allow deep cuts in emissions is around zero (including the cost of storage and transmission) Australia is tracking towards deep emissions reductions through the deployment of 6 Gigawatts per year of new PV and wind. In the longer term, PV and wind and strong renewable electrification can push all fossil fuels out of the Australian economy and thereby remove 85% of Australia's emissions. To reach this target in 2050 we need to double the annual deployment rate to 12 Gigawatts per year. This is not so hard considering that Australia tripled its deployment rate since 2017 and prices continue to fall.
7. Deployment of more solar PV and wind is correlated with reducing electricity prices (Figure 3). Although price trends over the last 2 years are not conclusive, this indicates the likely future trend, that PV and wind allow Australia to reduce emissions AND prices!

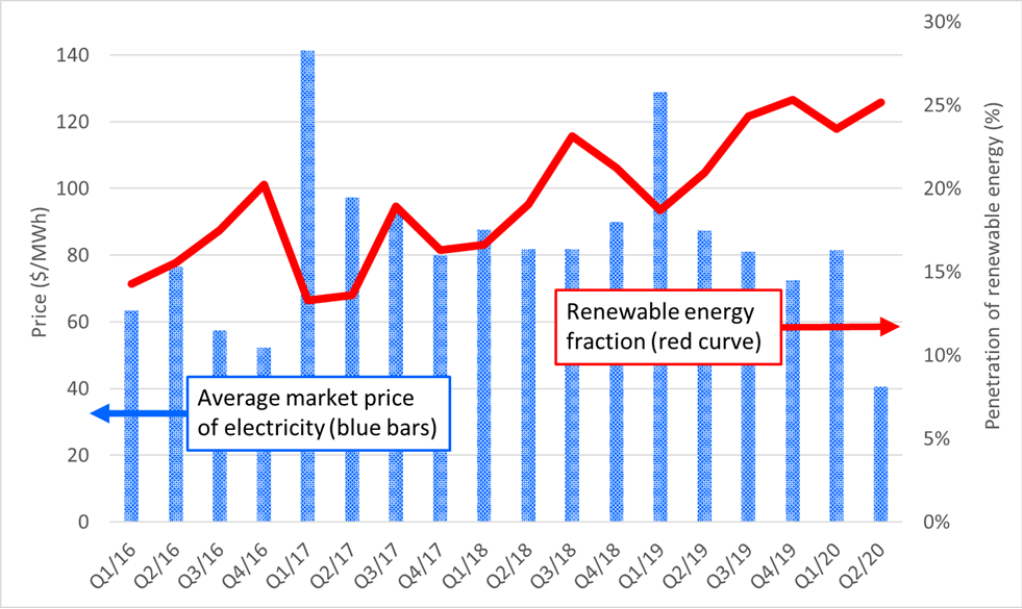

Figure 3: Deployment of more solar PV and wind is correlated with reducing electricity prices.

8. PV and wind in Australia is an $8 billion per year business. Australia is deploying about 6 Gigawatts per year of new solar PV and wind energy systems, including roof-mounted PV and ground-mounted PV and wind. The renewable energy industry employs about 27,000 people. The renewable energy fraction of the National Electricity market has increased from 16% in 2017 to 25% in 2020 and on track to pass 35% in 2022.
9. Balancing 50-100% variable PV and wind is straightforward using off-the-shelf techniques: stronger long distance transmission (to smooth out local weather), storage and demand management. These techniques are being deployed at Gigawatt scale to manage Australia's rapidly increasing PV and wind. An Australian-developed global survey of off-river pumped hydro energy storage found 100 times more sites than required to support a 100% renewable global electricity system. In combination with batteries and demand management, this solves the problem of low-cost storage to balance 50-100% renewable electricity.
10. Australia is the global renewable energy pathfinder: Australia is deploying new renewable energy 10 times faster per capita than the global average and 4 times faster per capita than in Europe, China, Japan or the

USA. The Australian experience is highly replicable in other countries. Australia is a pathfinder for the three quarters of humanity who live in the sunbelt (lower than 35 degrees of latitude) where there is high and consistent solar insolation and no cold winters. This is where most of the growth in population, energy use and Greenhouse emissions are occurring. Australia's rapid deployment of PV and wind is an important reference point for other countries to also adopt this path and thereby reduce electricity costs and mitigate large amounts of future emissions. Data from the International Renewable Energy Agency IRENA (Figure 4) shows that Australia has the:

1. Most installed solar PV (PV) per capita (625 Watts per person)
2. Fastest deployment speed of solar PV per capita (168 Watts per person per year)
3. Fastest combined deployment speed of solar PV and wind per capita (216 Watts per person per year).

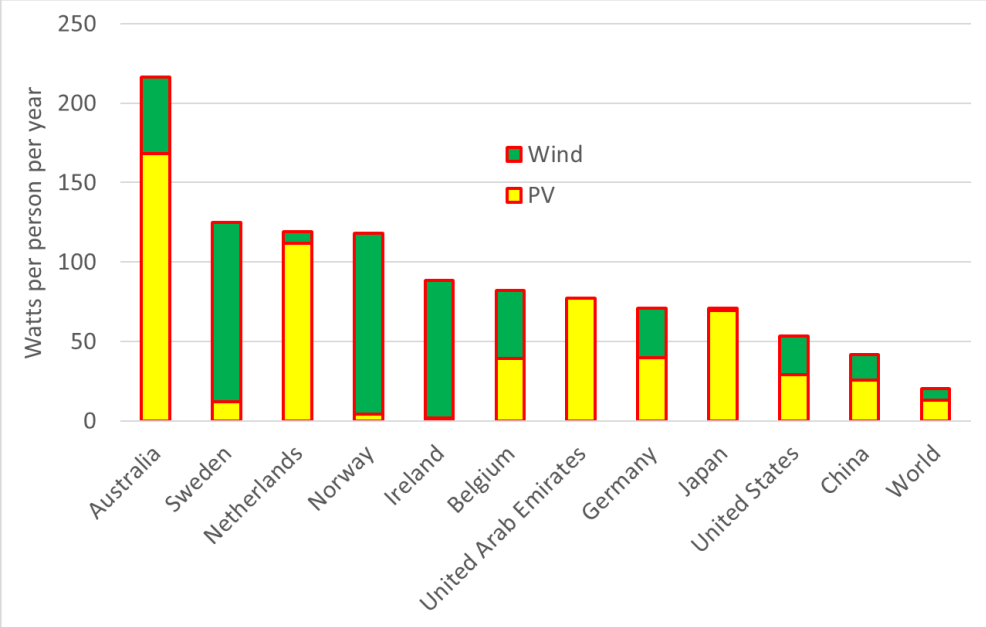

Figure 4: Deployment speed (average 2018-2019) of PV and wind in terms of Watts per person per year [IRENA]

11. Continued research and development: Australian Universities work closely with manufacturing and deployment companies and help them achieve efficiency gains and cost reductions, both directly through R&D and also through the training of highly skilled scientists and engineers. Small gains in solar cell efficiency lead to large reductions in the cost of PV energy. Most of this relates to area costs (cells, modules, transport, land, module-mounting). An increase in module efficiency translates to a reduction in required PV module area, corresponding to a large annual saving. The Australian PV industry is worth about $5 billion per year. For example, if module efficiency increases from 19.8% to 20.0% (a gain of 1% relative) then savings approaching $50 million per year accrue to Australia. This far exceeds Australian expenditure on solar R&D.
12. Education, training and outreach: for 40 years, Australian Universities have been at the global forefront of renewable energy research, development and education. University courses and postgraduate training (PhD/Masters) provide scientists, engineers and other energy professionals with deep knowledge that they can take into senior positions in companies, research and public service. Outreach contributes to "energy change literacy" by way of TV, radio, newspapers, magazines, public lectures and advice to Government.

Australian-trained scientists and engineers made a profound contribution to the growth of PV manufacturing by taking their Australian experience and knowledge to found companies in China. This led to rapid growth in PV manufacturing in China, rapid reductions in prices and rapid growth in global PV deployment. Without the creation of the opportunity for cheap solar power, the world would be facing a much greater challenge in dealing with global warming today. This contribution continues.

13. ARENA: Australia's global technology impact has been achieved through the nearly continuous existence over 40 years of Government agencies that specialize in supporting renewable energy, including research & development at Australian Universities. Currently, the Australian Renewable Energy Agency (ARENA) provides strong support for R&D (and indirectly, education and outreach) through the Australian Centre for Advanced PV (ACAP) and direct grants. However, ARENA has nearly exhausted its funding. The future of Australian University renewable energy R&D, education and outreach is uncertain, along with the beneficial impact of on-going involvement of Australian Universities in the global renewable energy industry.
14. Investment in supporting technologies for wind and PV is important. These include transmission, storage (pumped hydro and batteries), demand management, Minimum Energy Performance Standards (including for buildings and vehicles) and integration of rooftop solar PV.
15. The PERC silicon solar cell, which was invented in Australia, now has **three quarters** of the global solar market. Australia's research and development has fundamentally changed the solar industry. PERC has achieved cumulative global module sales of about $70 billion to date. PERC modules are being deployed at a similar global rate (net new Gigawatts per year, Figure 5) to coal, gas and nuclear generation capacity combined, and sales are growing rapidly. PERC is currently mitigating about 0.5% of global Greenhouse emissions due to displacement of coal.

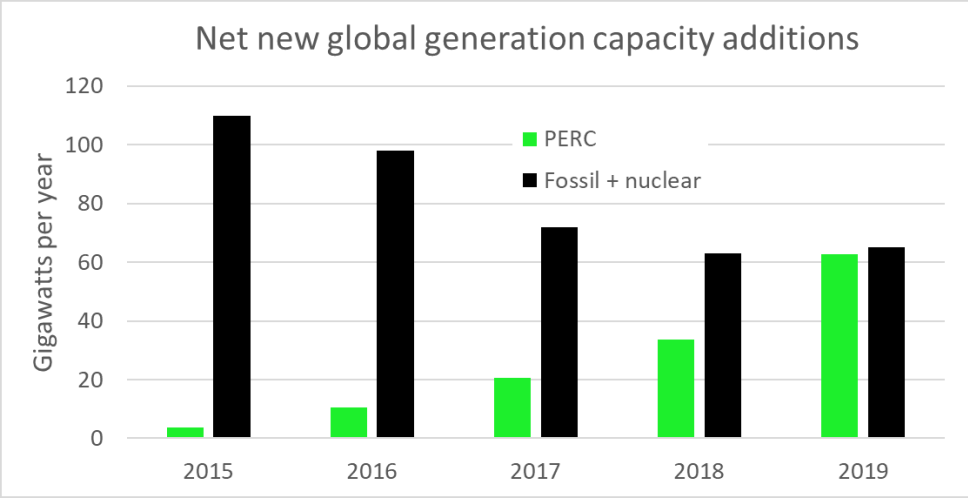

Figure 5: PERC silicon PV modules are being deployed at a similar rate to net new coal, oil, gas and nuclear generation capacity combined