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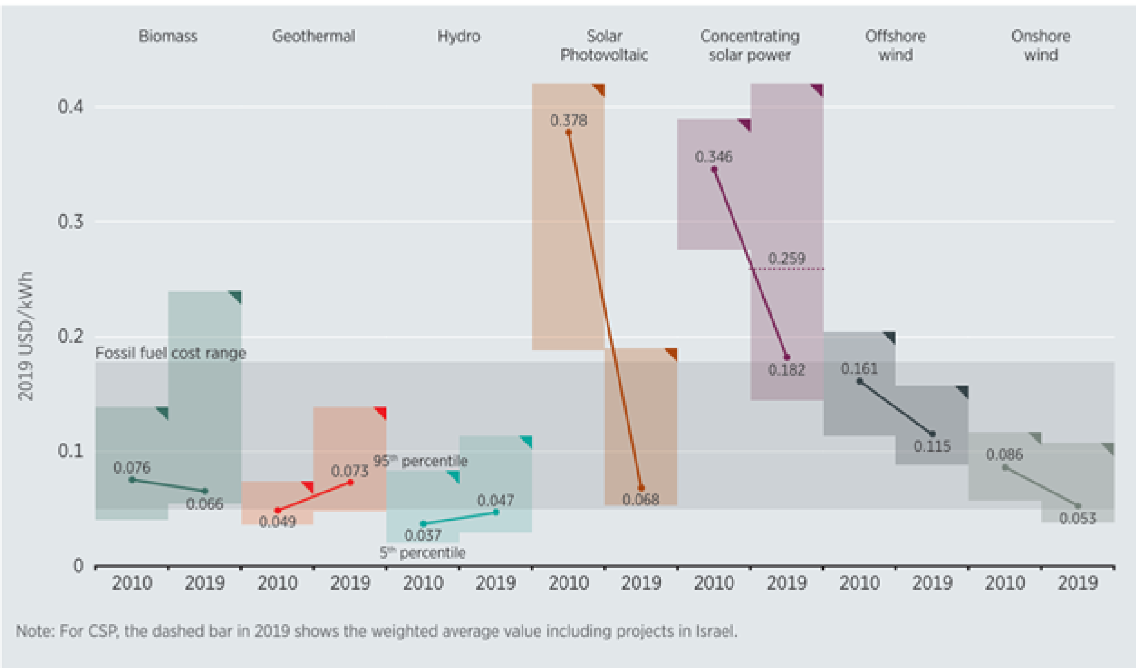
RENEWABLE ENERGY GENERATION

BY CRAIG PICKUP

Over the past decade electricity from renewable energy generation has drastically decreased in cost due to technology improvements, economies of scale, increased supply chain competition and improved developer experience (IRENA, 2019b).

These factors have culminated in renewable power generation technologies becoming the least-cost option for new generation capacity, surpassing fossil fuel plants such as coal and gas.

The market reflects this transition where globally in 2019, renewable generation technologies accounted for 72% of all new capacity addition and is trending to increase in market share (IRENA, 2019b). **Figure 1** demonstrates how technologies, such as solar photovoltaics (solar PV), have gone from almost twice as expensive as fossil fuels per kWh (2010) to be cheaper than nearly all fossil fuel plants, with further cost reductions expected.



Note: This data is for the year of commissioning. The thick lines are the global weighted-average LCOE value derived from the individual plants commissioned in each year. The project-level LCOE is calculated with a real weighted average cost of capital (WACC) is 7.5% for OECD countries and China and 10% for the rest of the world. The single band represents the fossil fuel-fired power generation cost range, while the bands for each technology and year represent the 5th and 95th percentile bands for renewable projects.

Figure 1: Global weighted average levelized cost of electricity from utility-scale renewable power generation technologies from 2010 to 2019

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According to the Department of Environment and Energy Australia, over the next ten years, solar PV is expected to grow at a rate of 58.7% annually with small scale rooftop solar such as residential and industrial to make up 90% of that growth (Australian Government, 2019).

So why such considerable growth? It is due to the combination of environmental awareness from consumers, rebates such as the Solar Trading Credits (STC), increasing electricity prices and reduced solar PV installation costs. Solar PV installation costs are driving the uptake of renewable generation as payback periods (ROI) for systems have gone from 10-15 years to as little as two years.

Renewable energy generation technologies are commonly known as net zero CO2 generation, meaning the CO2 required to manufacture a solar panel or wind turbine parts is off set by the electricity generation over the life of the plant. I.e. if it requires 1 TONGn of CO2 to manufacture a solar panel of 1kw capacity, it will need to produce approx. 1000kWh of electricity to offset the CO2 required to manufacture it.

In 2017-2018 the total percentage of renewable energy generation in Australia was 17.1%, including hydro, wind, bioenergy and solar PV (Australian Government, 2019). This share grew in 2018 to 19% and is set to rise year on year.

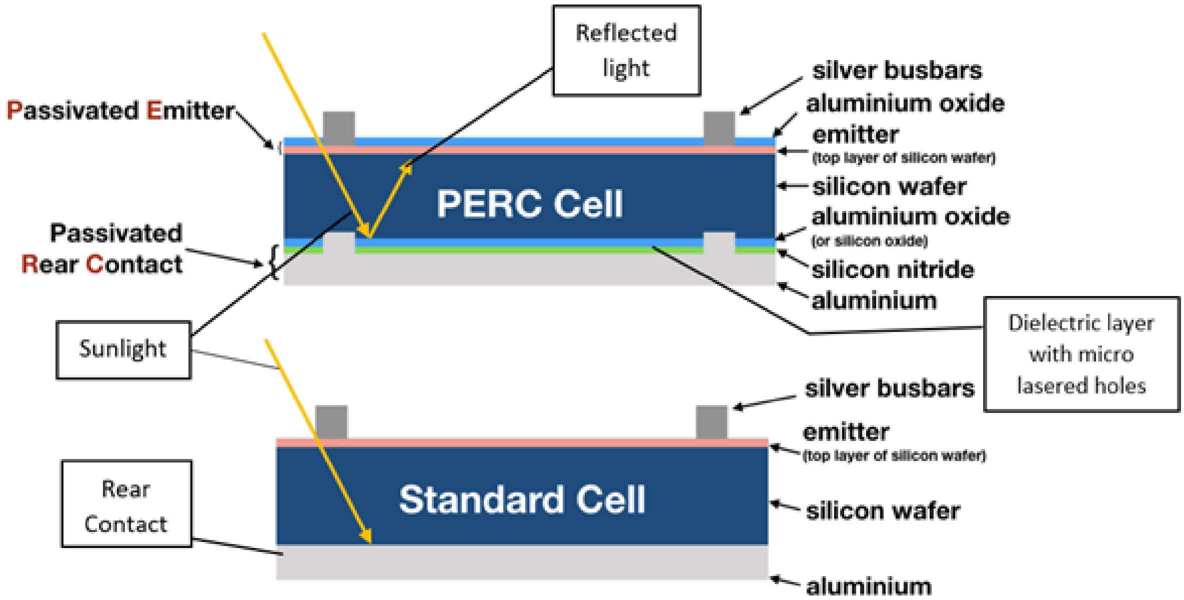

Figure 2 PERC vs Standard silicon cell (PERC vs Standard Cell, 2018)

TECHNOLOGICAL IMPROVEMENTS

Some of the technological improvements include the meteoric rise in adoption of PERC monocrystalline cells. This comes at the expense of polycrystalline cells that have traditionally been cheaper to manufacture (Cherradi, 2019; International Renewable Energy Agency - IRENA, 2019; IRENA, 2019b).

PERC or Passivated Emitter Rear Contact (Figure 2) acts as a mirror reflecting light that does not get absorbed by the silicon wafer (doped layer), giving the light a 2nd chance to be absorbed and generate current. PERC is particularly appropriate for manufacturers as it requires minor change to production lines to incorporate, providing a low-cost solution to improve conversion efficiency (Cherradi, 2019; IRENA, 2019a).

Other technology advancements of note are; half-cut cell, multi-busbars, bifacial solar cells, increased wafer size, Heterojunction and Tandem design.

SOLAR PV STILL THE FRONT RUNNER

All these technological advancements are significant, but what sets solar PV apart from technologies such as wind and concentrating solar power is the relative ease of installation for new and existing buildings. For a strongly built roof, the modifications required to install solar PV on industrial warehousing is minimal. For structurally 'light' roofs, thin-film technology provides a solution with, albeit, with some compromise.

Thin-film has approximately half the conversion efficiency of silicon PV, but also a lower again installation costs. Solar PV can also be incorporated into the building structure with Building Integrated Solar PhotoVoltaics (BIPV) providing generation capabilities on more surfaces than the rooftop while providing secondary functions such as shading or exterior wall lining.

The installation statistics of solar PV are promising with the Australian Energy Council reporting in the first quarter of 2020 over 56,000 rooftop installation for a combined generation capacity of 408 MW, averaging 136 MW a month of new capacity or 453 kW per day (Australian Energy Council, 2020).

With the ever-increasing uptake, lowering costs and flexibility of solar installation, there is little reason not to install solar PV. Subsequent articles will discuss the economics of solar PV such as the levelized cost of electricity, degradation rate costs, the balance of system and paybacks.

WHY STILL INVEST IN FOSSIL FUELS?

With renewable power generation continuing to decrease in cost, why would anyone build fossil fuel plants? In Australia, there are not only several political complexities that exist but a public perception that renewables cannot provide baseload generation.
That assumption is only partially correct as solar PV, and wind generators do not generate power while the sun is not shining wind is not blowing.

However, solar PV and wind are complementary technologies that generate power at different times of the day.

For example, solar PV will generate power from the morning to the late afternoon, peaking production in the middle of the day.

Wind power, when positioned correctly, will produce electricity primarily in the mornings and evenings. In Australia, the Asian renewable energy hub (AREH) that has received approval in the Pilbara region of Western Australia for the first phase of a 15 GW renewable generation power plant should help to prove the large scale balancing of wind and solar.

AREH is planned to be the largest power generation plant in the world, renewable or not and comprises of 78 km2 of solar panels, 1,600 wind turbines and 14 GW of hydrogen electrolysers to produce green hydrogen (About the Asian Renewable Energy Hub – Asian Renewable Energy Hub, n.d.).

Figure 3 shows that the predicted daily output of the AREH for each hour of the site, noting how the combination of solar and wind can provide a minimum baseload generation for all hours of the day.

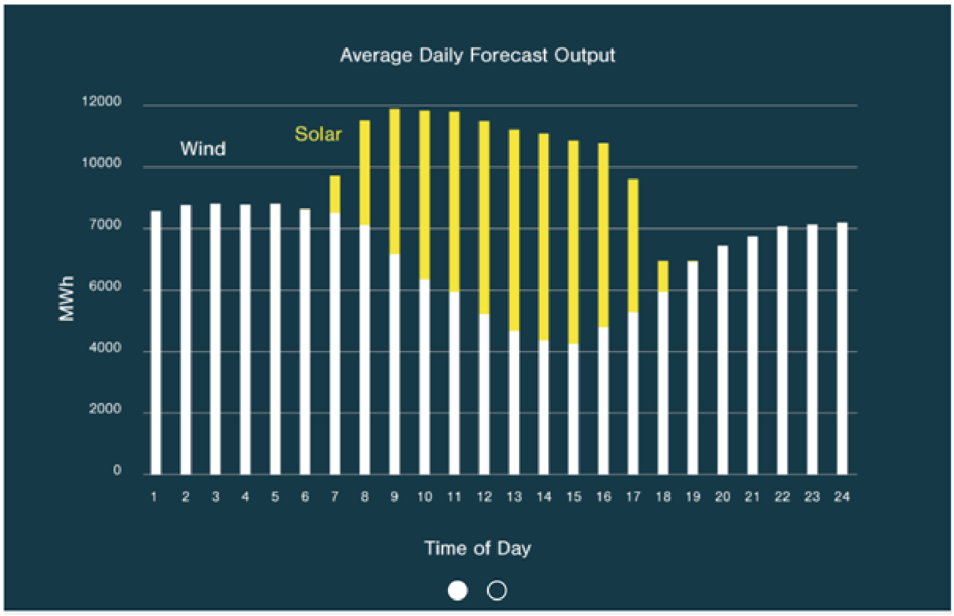

Figure 3 Average daily generation output forecast for Asian Renewable Energy Hub (About the Asian Renewable Energy Hub – Asian Renewable Energy Hub, n.d.)

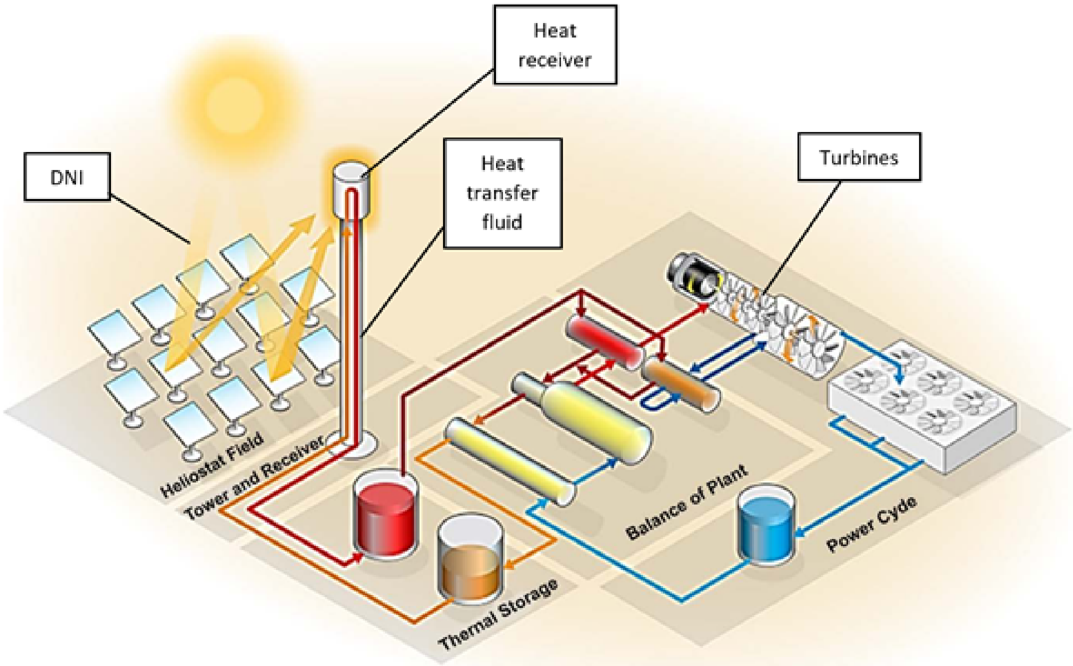

Figure 4 Solar Tower CSP plant

While it is technically feasible to produce baseload generation with just wind and solar, other complementary technologies significantly help this transition. These include hydropower like the snowy hydro 2.0 project, which plays a vital role in variable output for grid stabilisation and concentrated solar power (CSP).

Hydropower is an excellent and currently unmatched technology when it comes to large scale energy storage and has the cheapest generation rate of any renewable energy storage with a globally weighted average in 2019 of $0.066/ kWh (IRENA, 2019b).

The primary issue with hydro is the long construction time and extensive capital expenditure relegating the construction of hydro plants, mainly to governments. By comparison, concentrated solar power is far more accessible for businesses and can be constructed from small kW to high MW scale.

Large scale CSP has seen a slow uptake when compared to solar PV and wind with the technology still considered to be in the developing stage.

However, this also means there are significant cost reductions possible for the technology as it develops further and is more widely produced, with power generation costs halving from a global average of $0.49/ kWh in 2010 to $0.26/ kWh in 2019.

THE QUESTION OF CONCENTRATED SOLAR POWER (CSP)

One question you might be asking is how does CSP work and how can it generate baseload power? Figure 5 shows a diagram of a simplified Solar Tower (ST) CSP. The basic premise works by reflecting the suns Direct Normal Irradiance (DNI) (sunlight that comes directly from the sun and is not diffused or reflected by clouds) from a farm of mirrors called a heliostat field. These mirrors track the suns movement throughout the day to provide the highest possible efficiency. All the mirrors in this field are focused on the heat receiver at the top of the ST, where depending on technology can reach in excess of 1,000˚C.

This heat is absorbed by a heat transfer fluid, commonly a high-temperature oil and is either stored as thermal energy in molten salt tanks or used to generate high-temperature steam. From this point, CSP works the same as gas and coal power plants where high-temperature steam drives turbines and generates power.

Where CSP has a crucial advantage over solar PV and wind is the thermal storage tanks. This gives CSP the ability to store hours of generation capacity and is highly scalable to suit the application. Therefore, CSP can generate power during the day using DNI and at night utilise the heat from molten salt tanks to provide 24hr power generation.

Evidence of successful applications on the utility generation scale for CSP is Vast Solar's CSP demonstration power station in Jemalong, New South Wales (Figure 6)completed in 2018.

It provides 1.1 MW electricity and 6 MW of thermal energy. This is a scalable design CSP system that comprises of 5 ST's with the concept of providing additional generation capacity by adding more ST's as desired.

Figure 5 Vast Solar's CSP demonstration power station in Jemalong, New South Wales (Lovegrove et al., 2018)

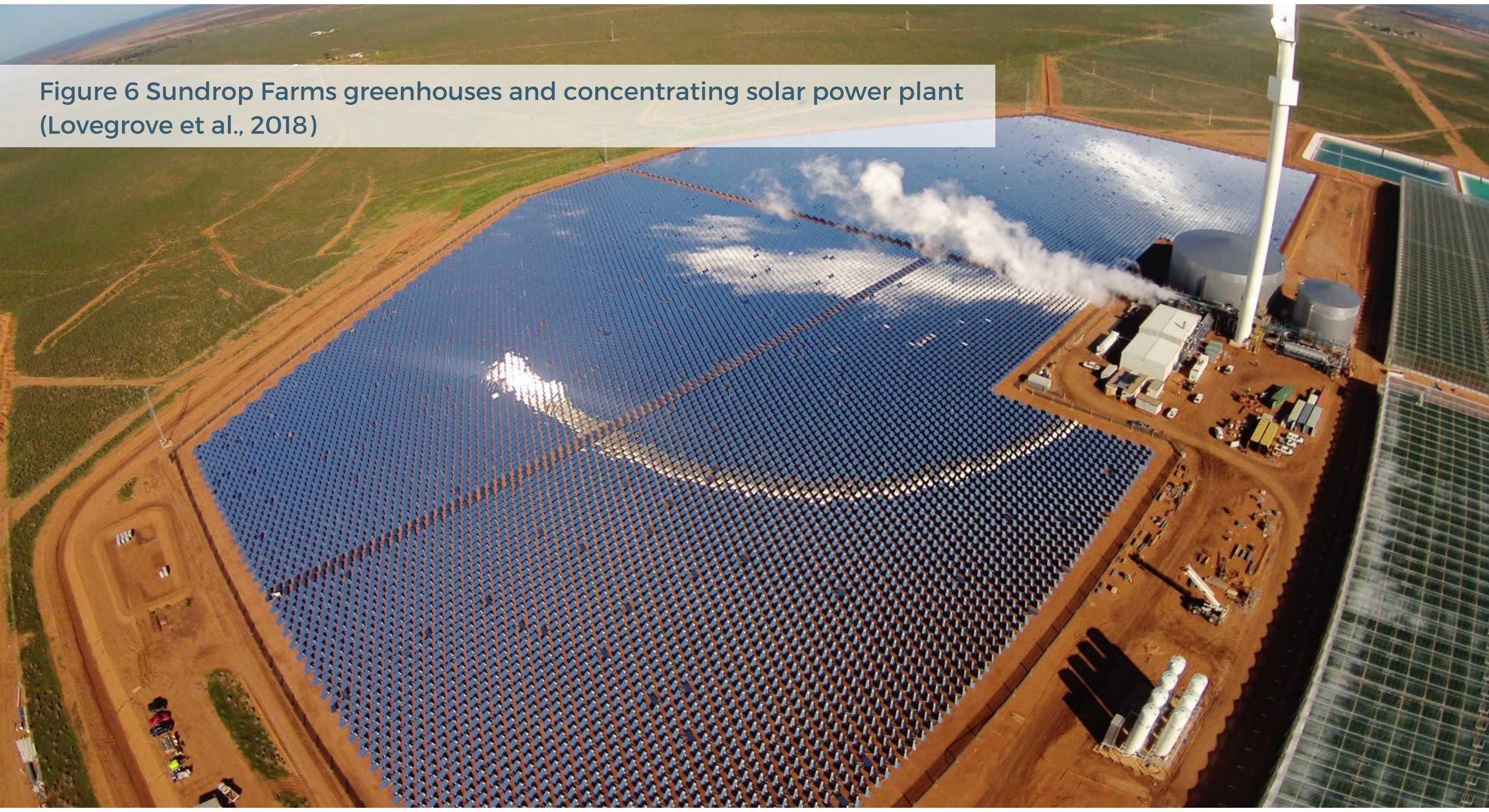

Figure 6 Sundrop Farms greenhouses and concentrating solar power plant (Lovegrove et al., 2018)

CSP is considered an important technology in Australia for several reasons:

1. For hydropower to be cost-effective large volumes of water needs to be stored at elevation, and Australia is a relatively flat continent with a scarcity of water.
2. CSP thrives in flat, sun-baked land that Australia has in abundance.
3. Capital investment in CSP is far lower than hydro and is vastly more flexible in ideal construction location.
4. Construction time is faster for CSP, and scaling of plant output is more straightforward for future growth.

An example of successful industrial CSP is the Sundrop Farms greenhouses in Port Augusta, South Australia, as shown in Figure 5. This is a tomato greenhouse farm that produces its own power through CSP and desalinates local seawater.

Currently, the electricity generation cost for CSP is higher than solar PV and wind, but this is an effect of developing technology and the low deployment in use. With more considerable interest and uptake, CSP has the potential to provide the baseload generation capacity required for many regional areas that currently operate on diesel generators and more importantly for industry and abundant source of heat and power.

IN CONCLUSION

When choosing between CSP, wind and solar PV, we must consider the benefits beyond electricity output.

For example, the quick, low modifications required for solar PV are idea for built-up areas and buildings with abundant roof space. Wind power increases in efficiency with larger blade diameters and is primarily suited for regional areas. CSP is excellent for industries that require thermal and electrical energy but requires large, flat ground to be installed in, which is not always available to a business.

Whichever technology is best suited for a business, it is essential to remember that every effort in decarbonising our power generation is a crucial step in lowering the impact of climate change.

Through my research, this phrase in the fight to decarbonise that resonated “winning slowly is the same as losing”. It is an impactful statement that illustrates our the potential impact of our sluggish progress and puts the onus of decarbonisation on each person to do their part.

With renewable power soon to be always cheaper than fossil fuel, there is no longer any financial incentive to continue with high carbon generation power plants.

Future articles will investigate energy storage technologies, what is available and the economics behind them.

“Winning slowly is the same as losing”

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