



Firm solar in the NEM context

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Agenda

- The case for firm solar in the NEM
- Potential avenues for implementation
- Benefits of firm solar
- Outlook

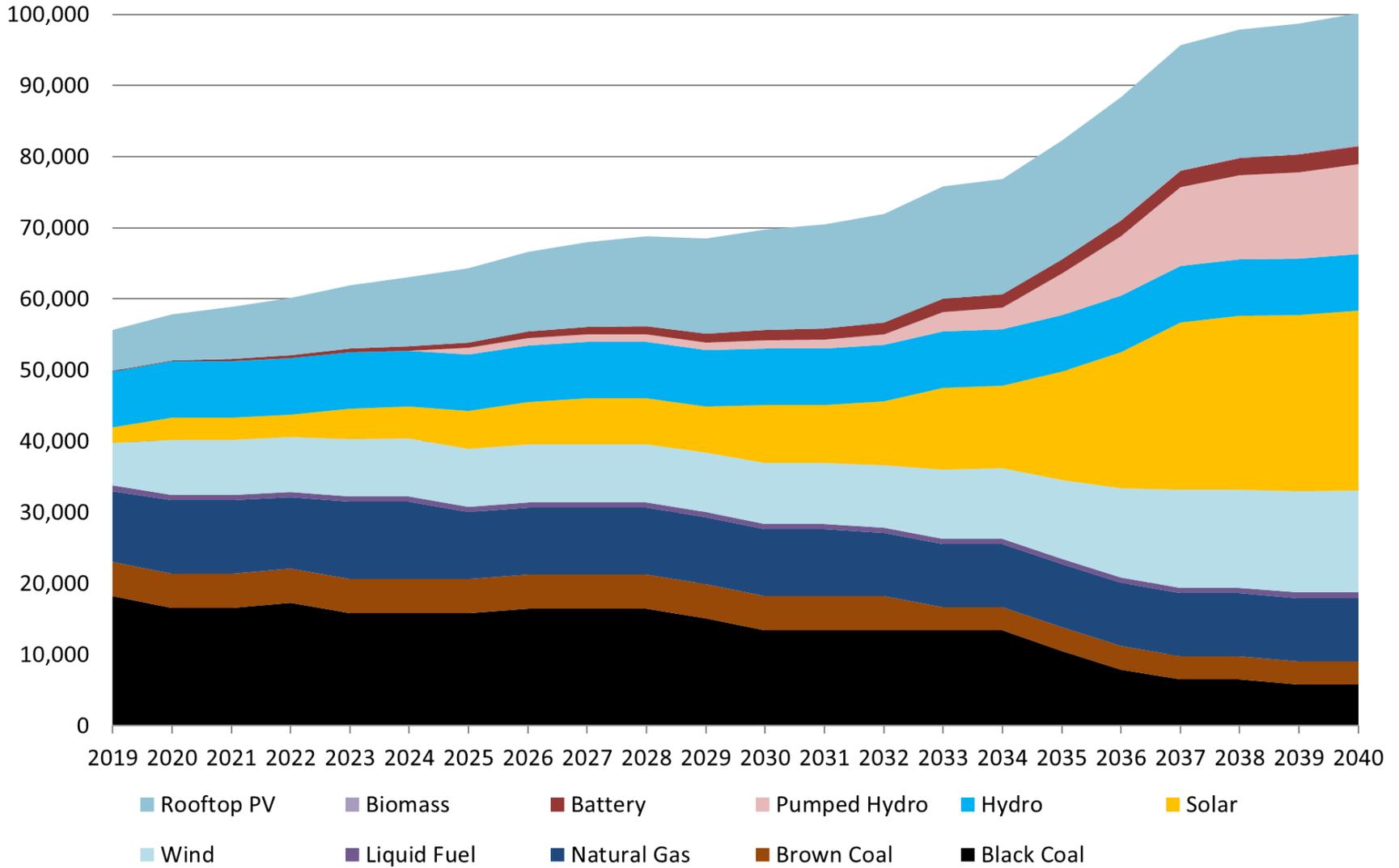
The case for firm solar in the NEM

- Definition of firming for solar:
 - Ability to supply an energy contract with a firm quantum of energy to a counterparty where solar is a key contributor to the energy supply
- Why is firming solar important?
 - Presently about 80% of demand in the NEM is traded through the forward contract market
 - Historically solar (and wind for that matter) could not compete in this market due to the variable nature of their output
 - Contracting capability is a key risk management strategy in the volatile electricity market
 - Also, if the NEG reliability obligation is passed this will impose a higher level of contract coverage on the market

The case for firm solar in the NEM

- In addition:
 - Expectations of large build out of solar PV renewable capacity in coming decades for following reasons:
 - Help meet 26% emission reduction target by 2030
 - and any targets beyond this timeframe
 - It comprises an important component of the least-cost new entrant mix
 - It will be an important component of the replacement capacity for the NEM's coal fleet as many of these plant reach the end of their technical lives

The case for firm solar in the NEM



Potential avenues of implementation

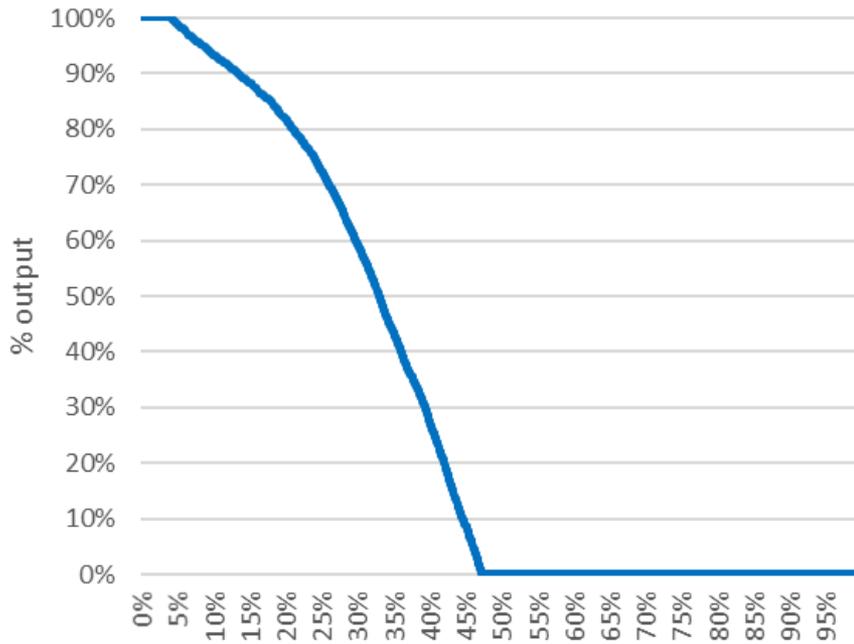
- What are some solutions for firming up solar?
 - Portfolio approach for firming capacity
 - Residual is supplied by a portfolio of dispatchable generation sources
 - e.g. hydro, coal, gas
 - An effective option using existing capacity and technology
 - C.f. inverse solar financial product developed by ERM Energy
 - Over the longer term the dispatchable supply mix would change with more coal retirements
 - Would expect storage to play a larger role

Potential avenues of implementation

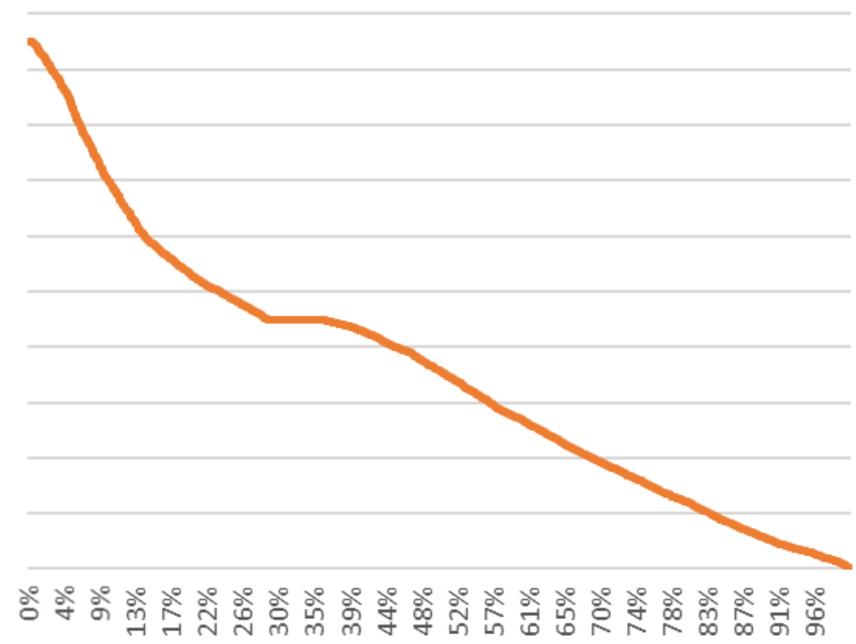
- What are some solutions for firming up solar?
 - Renewable portfolio approach
 - Variable renewable generation profile to be firming is diversified by coupling solar output with wind output
 - Firming costs can potentially be reduced via diversity in generation output profiles which aggregate to a flatter overall profile
 - Complementarity of wind/solar output profiles or wind/wind profiles would be ideal
 - e.g. average wind output increasing in evening would complement the decline in solar output
 - Off-shore wind may have some potential here
 - Geographical diversity between multiple wind locations may also offer benefits

Potential avenues of implementation

100% solar GDC



50% solar / 50% wind GDC



Potential avenues of implementation

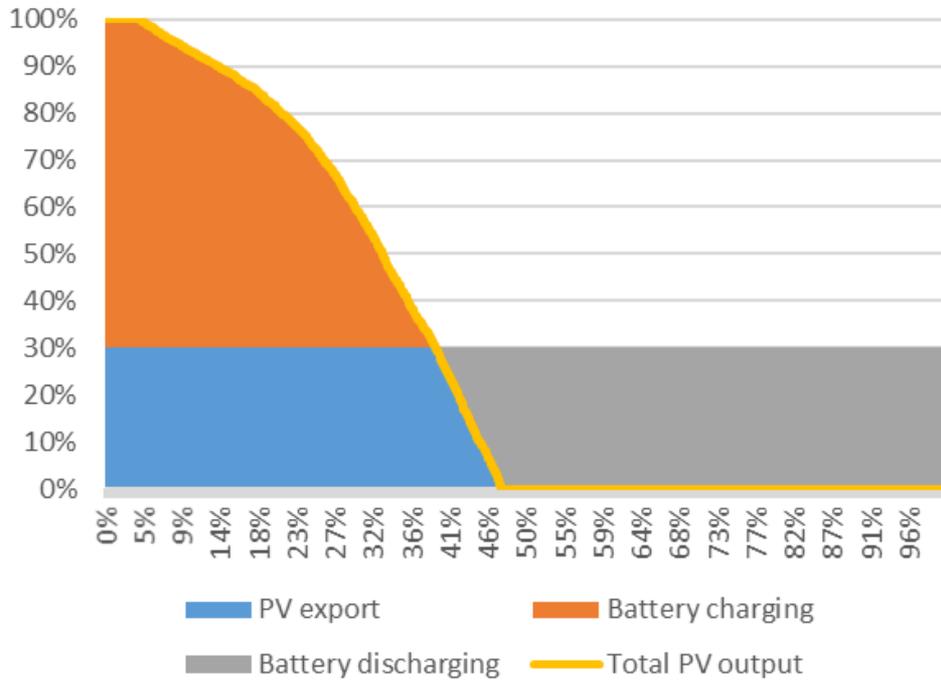
- What are some solutions for firming up solar?
 - Energy storage capacity
 - Battery or pump hydro
 - Currently a relatively costly option if using battery storage
 - Capital costs are expected to continue declining rapidly into the next decade
 - Pump storage costs can be relatively low but are very dependent on the specific site
 - E.g. low cost sites include old mines that already have a substantial amount of the required earthworks completed

Potential avenues of implementation

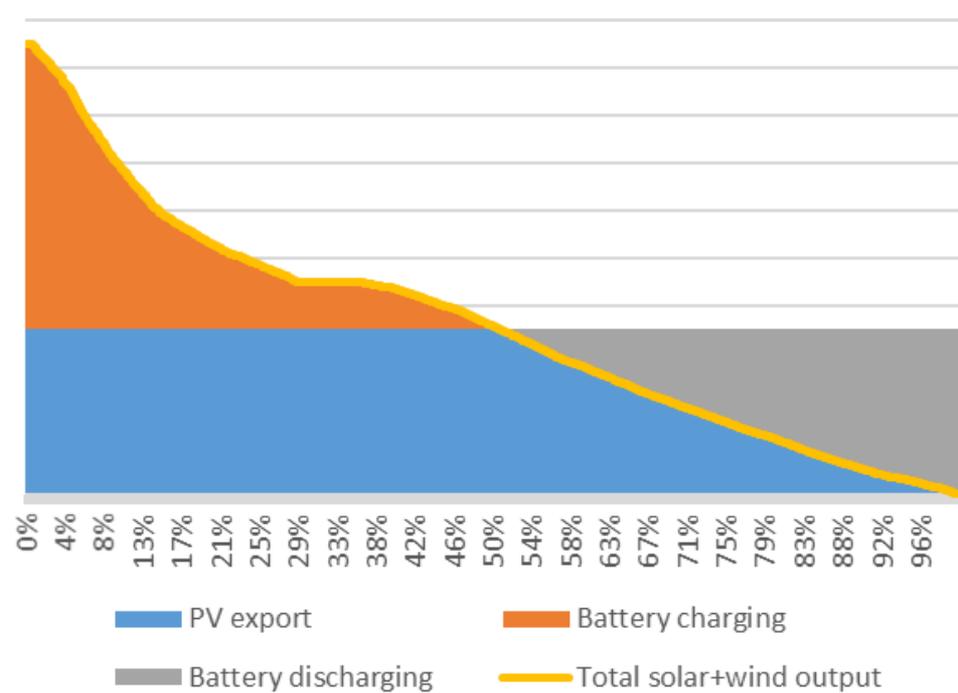
- What are some solutions for firming up solar?
 - Energy storage capacity
 - Larger penetration of solar capacity provides an arbitrage opportunity for energy storage -> duck curve effect
 - This is also amplified by uptake of rooftop PV, which is expected to continue rolling out for at least the next decade
 - The signal becomes stronger with the retirement of coal-fired capacity as this enhances price support in non-daylight periods
 - Sizing of storage capacity for firming does not necessarily have to be one on one if solar profile is coupled with a wind profile

Potential avenues of implementation

100% solar GDC



50% solar / 50% wind GDC



Benefits of firmed solar

- Maximises utilisation and rollout of the least-cost new entrant technology
 - Allows solar proponents to more easily compete in the forward contract market
 - Increases competition, reduces barriers to entry faced by variable renewable supply
- Provides a revenue source to flexible dispatchable generators and storage that physically cover the gaps left by solar
- Provides ongoing reliability benefits to the system through the presence of the dispatchable capacity providing the firming
- Provides potential ancillary services capabilities
 - Batteries in particular provide high quality FCAS services as evidenced by the performance of the Hornsdale Power Reserve in South Australia

Benefits of firmed solar

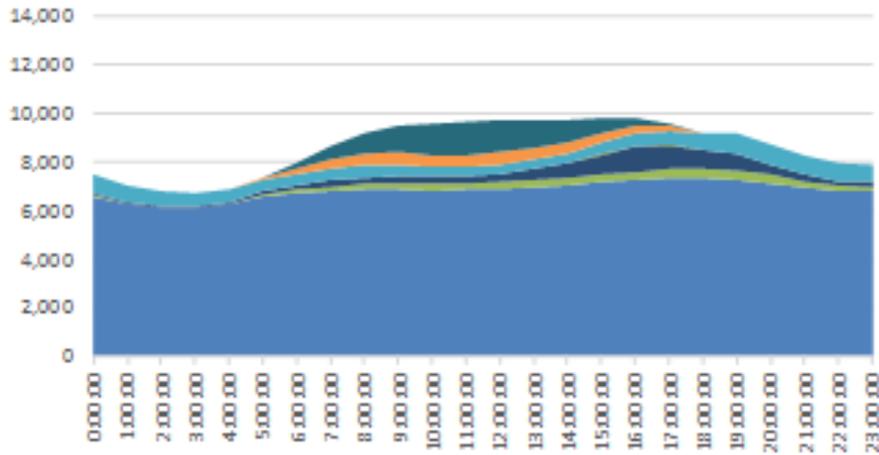
- May provide an MLF benefit for solar plant coupled with battery used to shift its output
 - Reduce peak output in middle of the day when all other solar plants are also at full output
 - Results in less congestion in transmission system at peak times and lowers transmission losses

Outlook

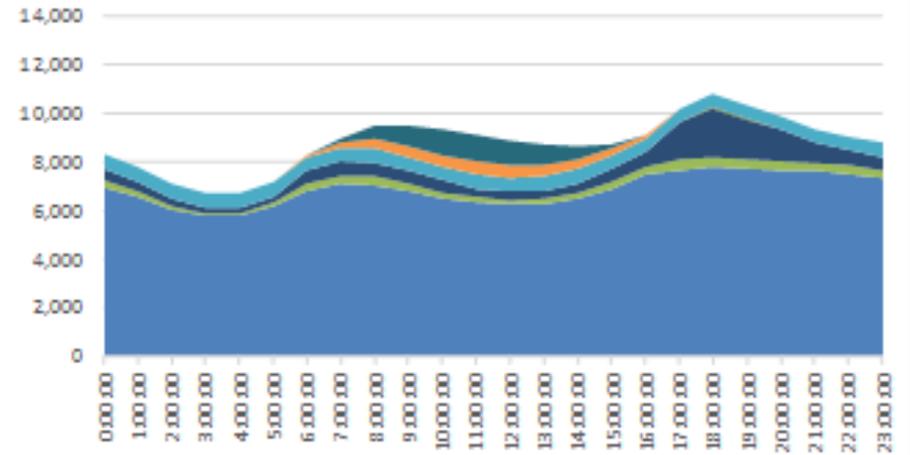
- The low cost of solar and further expected cost reductions means that it will play a larger role in supplying energy in the NEM
- There are at present a myriad of potential options for firming solar given the ratio of dispatchable capacity in the system to renewable capacity
- This will tighten over time as incumbent coal-fired generation retires when it reaches its end of life
- Energy storage is expected to play a key role in firming solar
- The timeframe for this transformation is expected to span the next two to three decades

Outlook

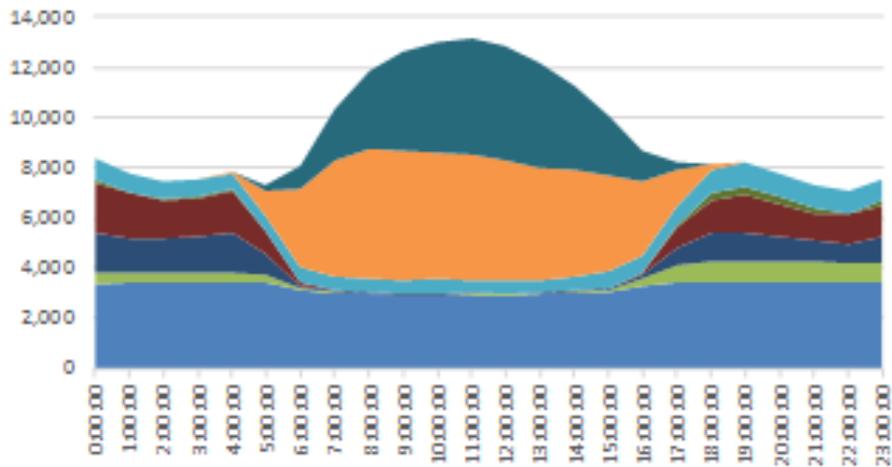
2020 Summer



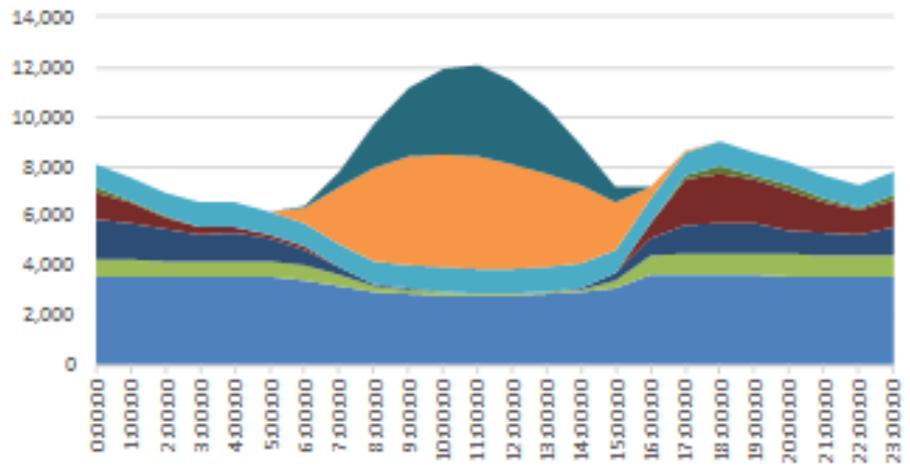
2020 Winter



2035 Summer



2035 Winter



- Black Coal
- Natural Gas
- Hydro
- Pumped Hydro
- Battery
- Biomass
- Wind
- Solar
- Rooftop PV

Thank you!

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