Massively expanding behind-the-meter battery-backed photovoltaics (PV) on business properties

A policy proposal that offers a rare combination of potentially huge upside and easily managed downside risk

2 October 2024
C4C Webinar

Victoria Energy Policy Centre

VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

Outline

1. Why this paper?
2. Rooftop solar to-date
3. Economics: is policy needed ?
4. Policy options
5. Discussion
6. Implementation and next steps

Why this paper?

The energy transition, it turns out, is hard: Social and local environmental costs of distant wind/solar farms + transmission have been under-estimated.

And so:

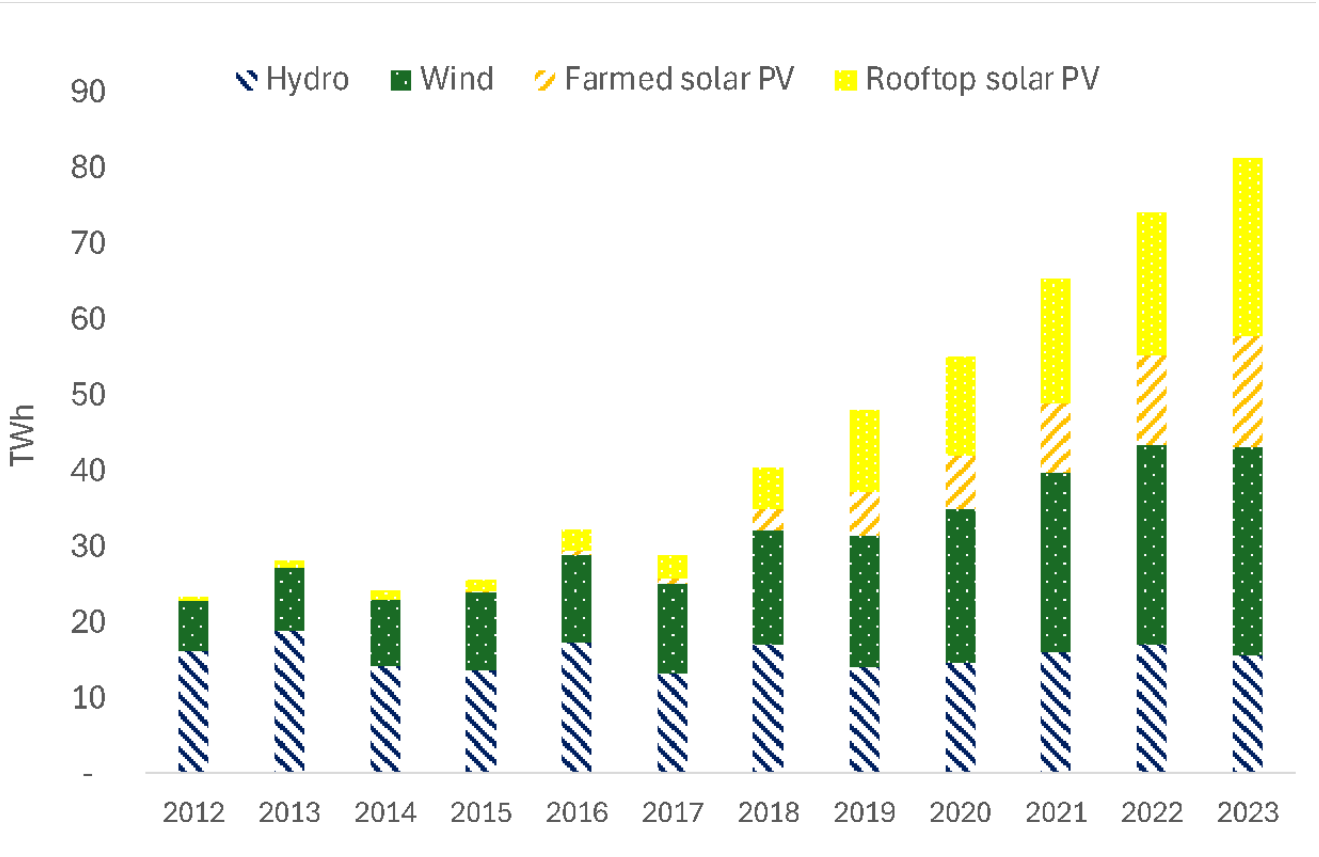
1. Can grid-focused battery-backed solar on business properties be part of the solution?

2. Is policy support needed? If so, would this be in the public interest?

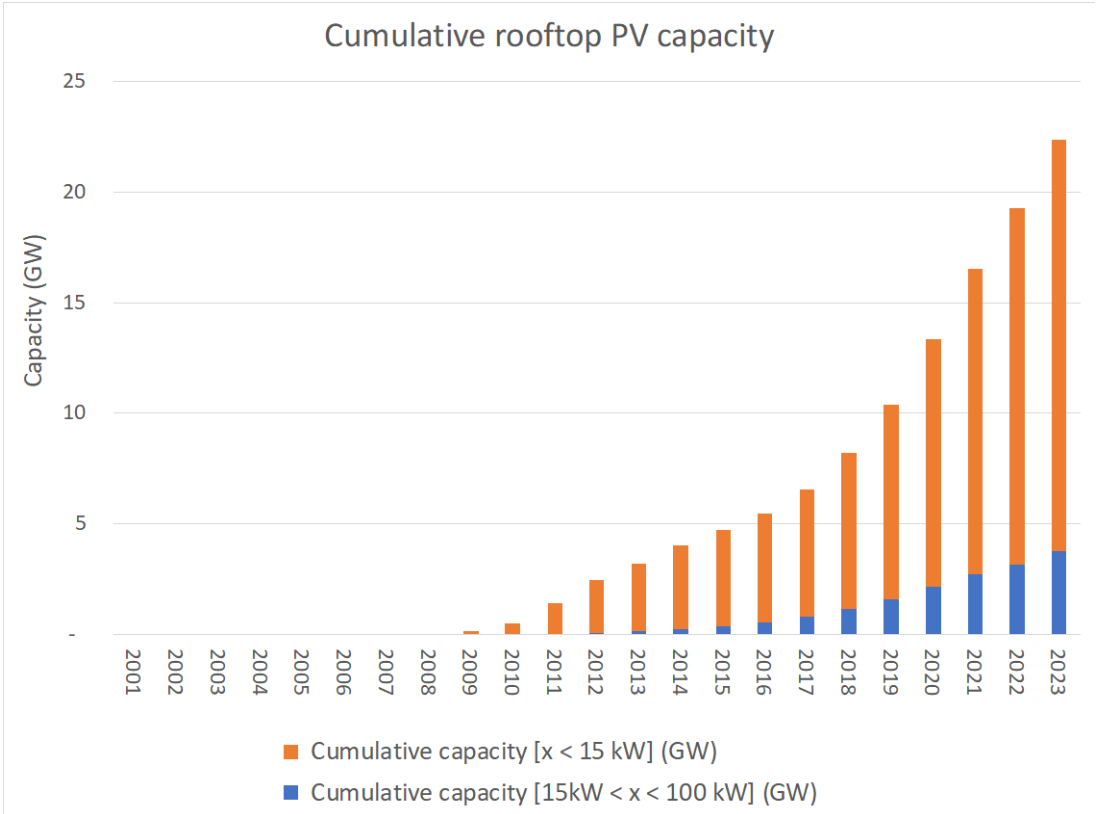
3. What would effective policy look like?

Rooftop solar to-date

23 GW of rooftop PV operational in 2023. Rooftop PV now almost as large as wind as the main sources of clean electricity in the NEM

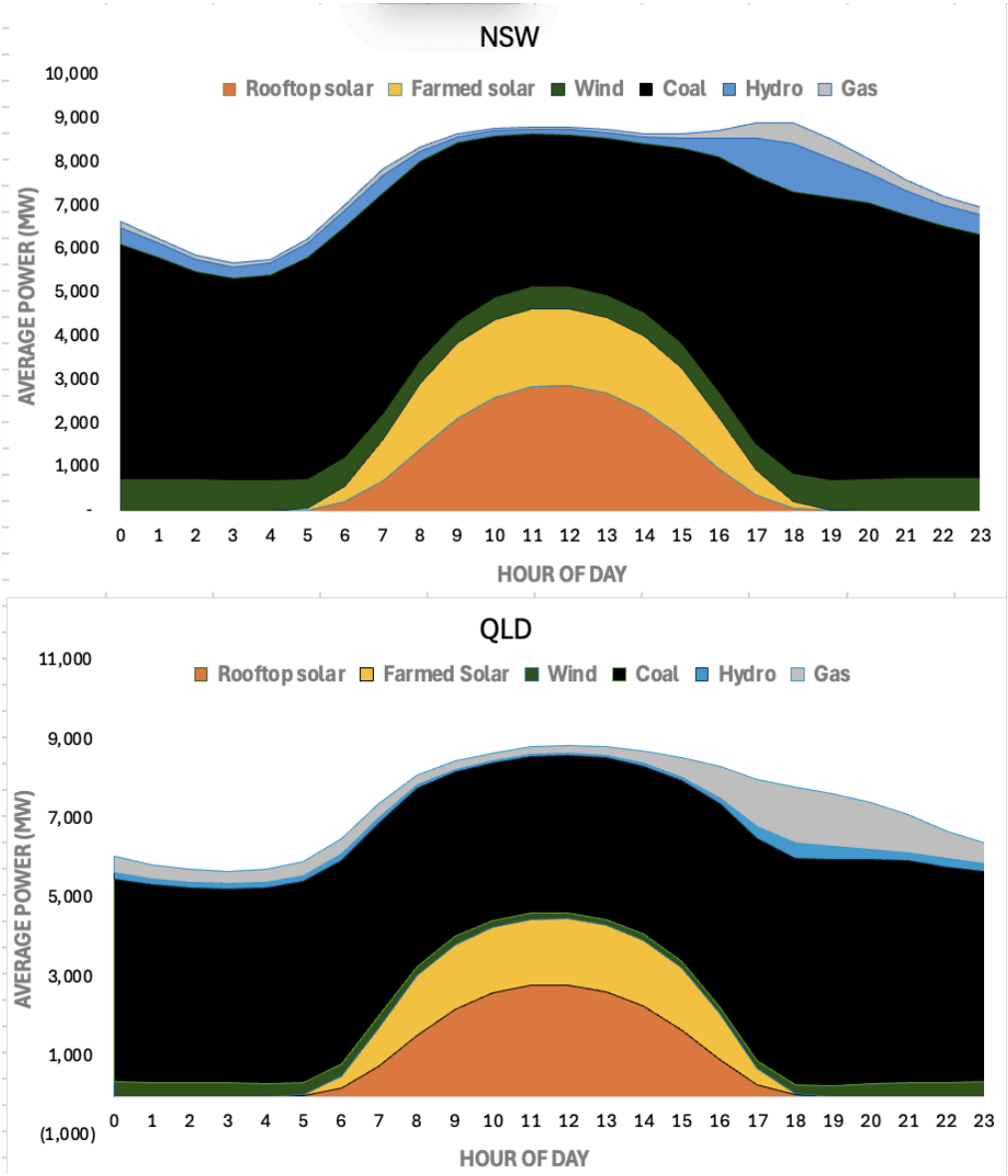


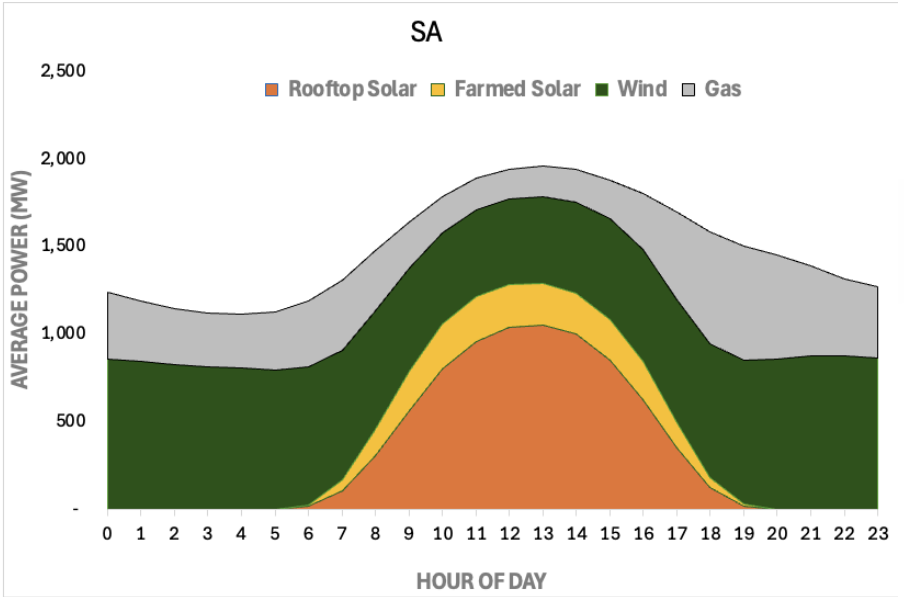
Source: www.n-nem.org, data from NEMWeb

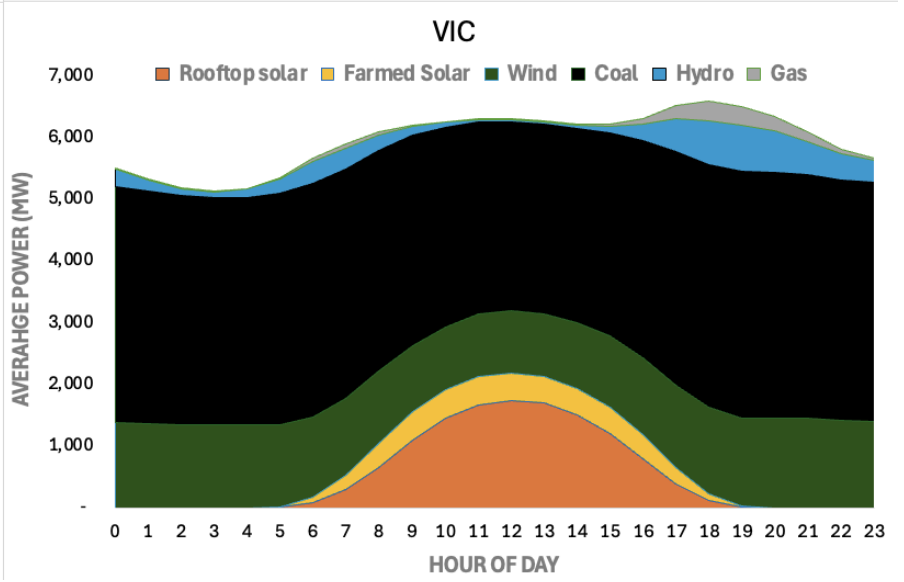


Source: Data from Clean Energy Regulator's analysis, author's analysis

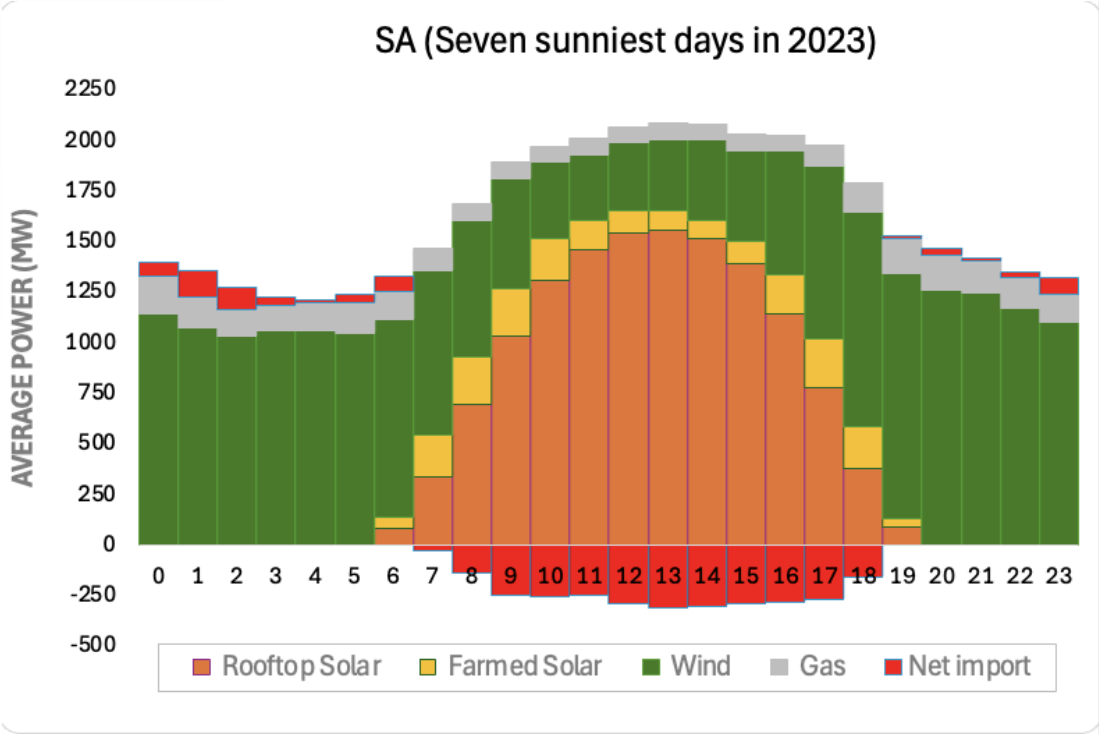
Rooftop PV now a big part of daytime supply

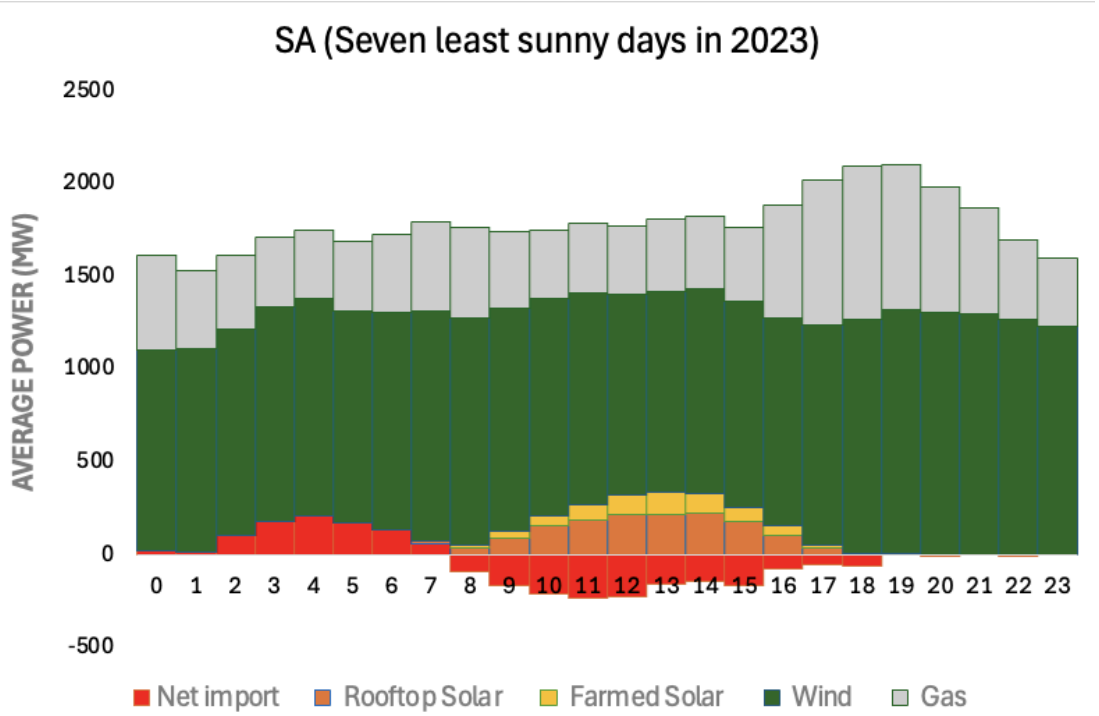




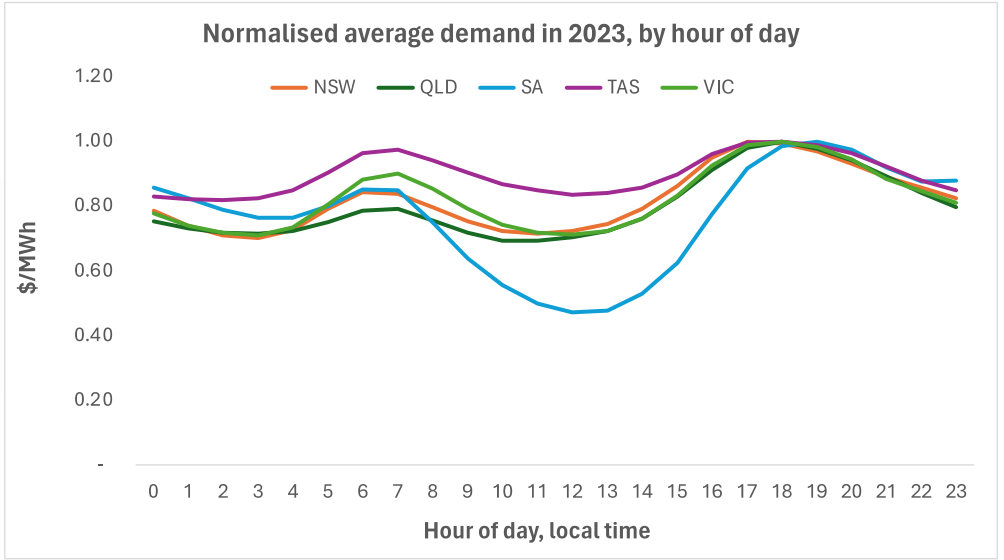


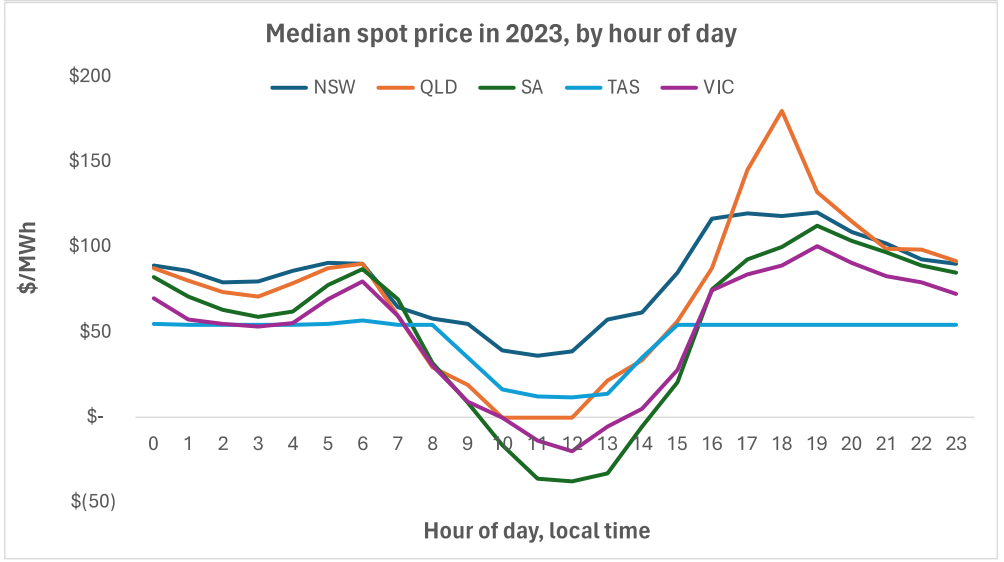
But big disparity between most sunny and least sunny days





Rooftop solar is the main explanation for lower day-time spot prices



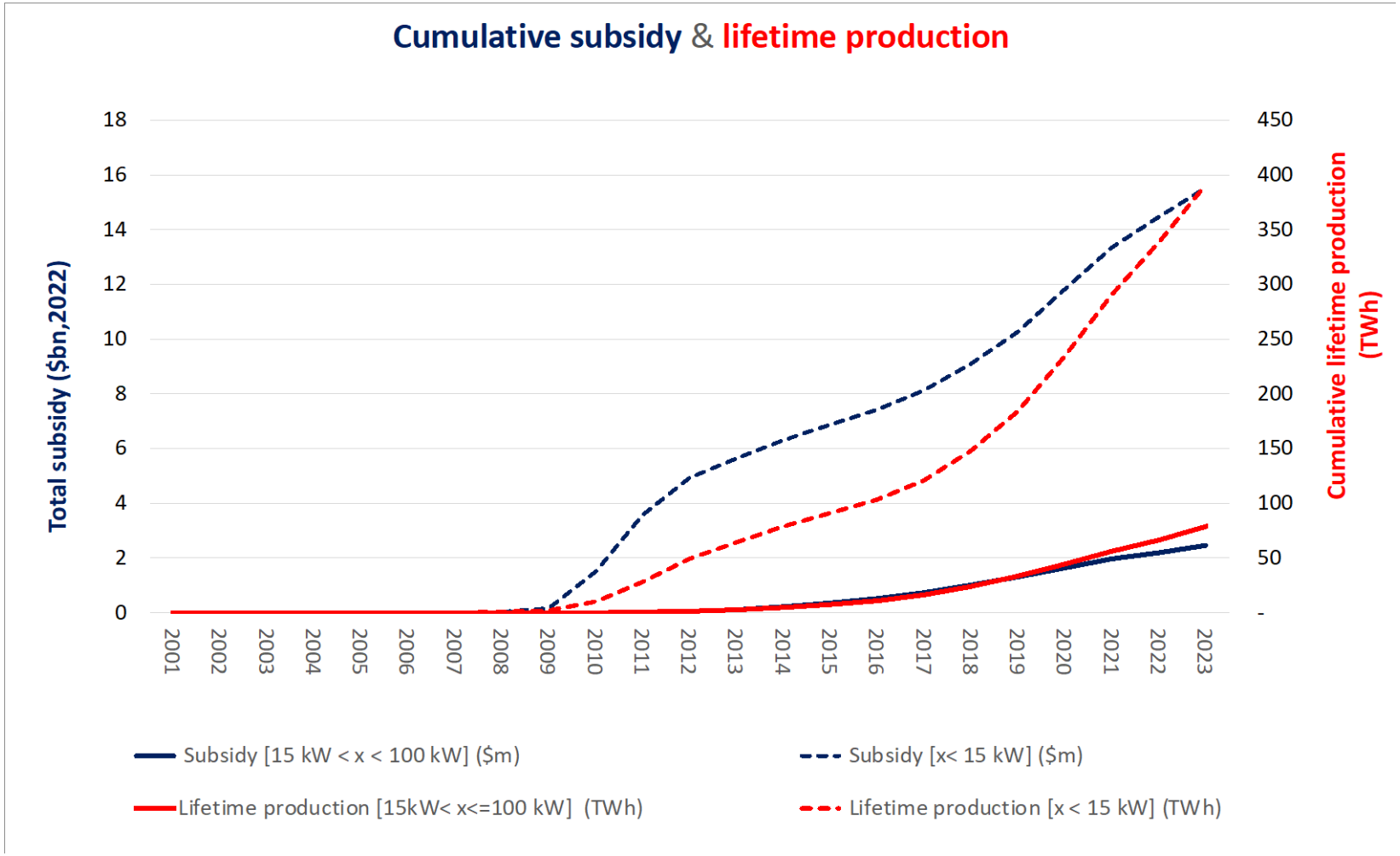


Rooftop solar reduces day-time prices in two ways:

- It substitutes grid supplied electricity and so reduces demand for grid supplied electricity and so depresses prices. This effect is not large however (only around 25% of rooftop solar is self-consumed at the premises).
- The remaining 75% is exported to the grid, greatly reducing the demand for much more expensive generation during the day. This is the main source of the (downward) price impact on the grid.

Source: Data from www.v-NEM.org, author's analysis

So far federal policy support of $17.2bn has been paid for RTS. Rooftop solar currently operational is likely to deliver 460 TWh over its life

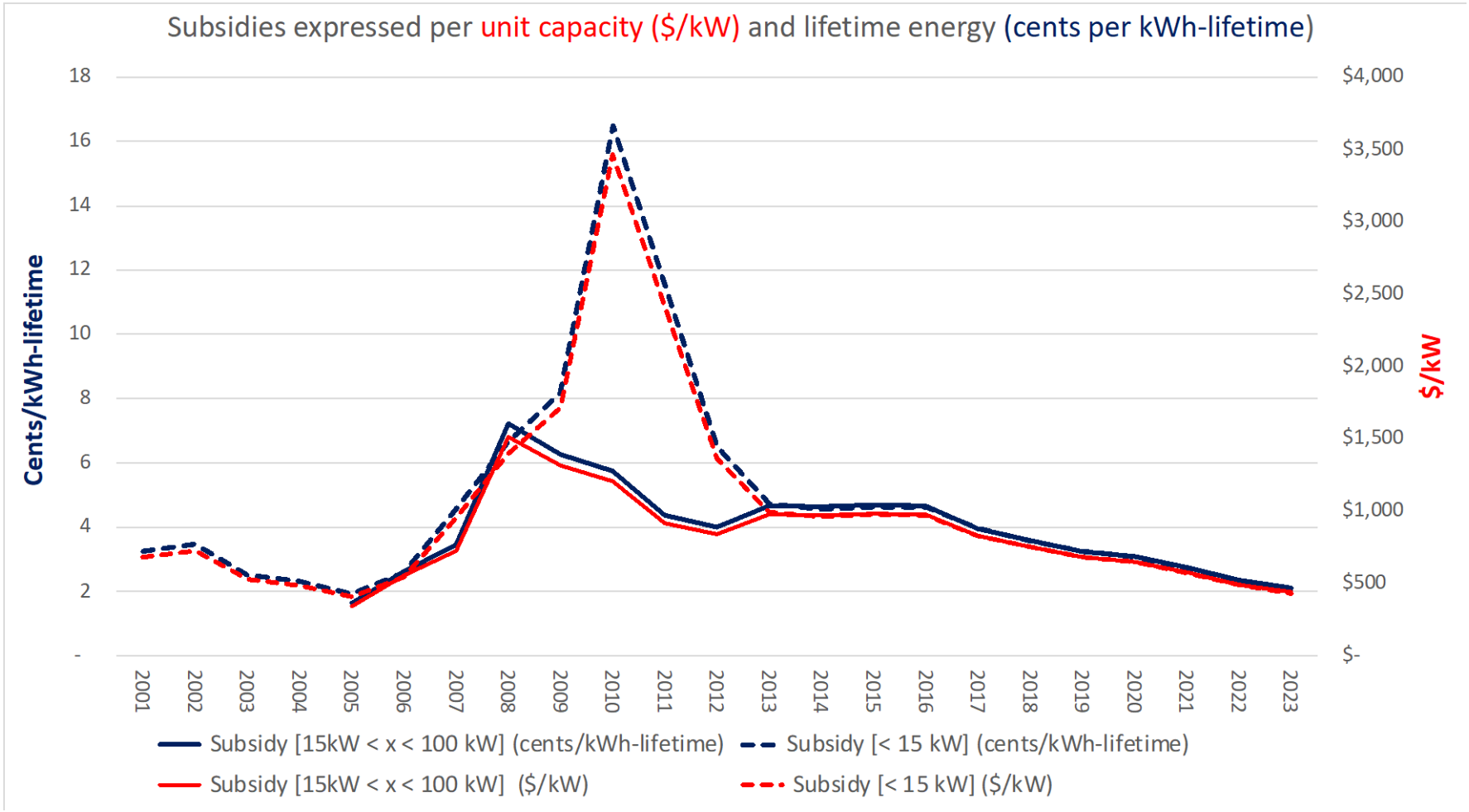


$17.2bn policy support has delivered 23 GW of capacity at average (pre-subsidy) installed price over the period from 2009-2023 of circa $3000/kW.

This give “policy leverage” of 4 ($17bn of policy support has delivered $69bn of spending in total).

Source: Data from Clean Energy Regulator’s analysis, author’s analysis

Federal subsidies for rooftop PV are now $500/kW or about 3 cents per kWh. This is about 40% of rooftop solar cost or 70% of RTS spot market revenues



Though policy support is a high proportion of cost, PV costs are low.

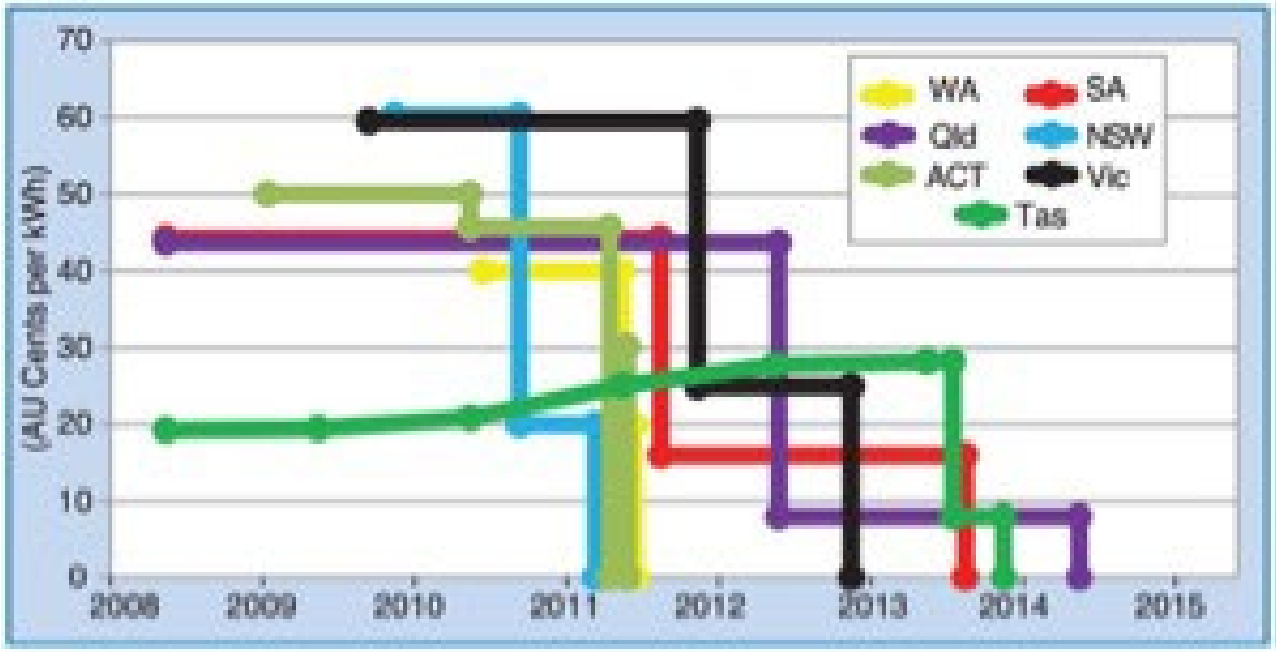
Though policy support is a high proportion of spot revenues, these revenues have been depressed by abundant rooftop solar production.

Though a variable (albeit forecastable) source of electricity, rooftop solar is currently the cheapest source of GHG abatement in the electricity sector.

Source: Data from Clean Energy Regulator's analysis, author's analysis

In the early years, substantial feed-in tariff policy support from state governments was also paid, but this has now largely died away

Feed-in tariffs



Value of feed-in tariffs

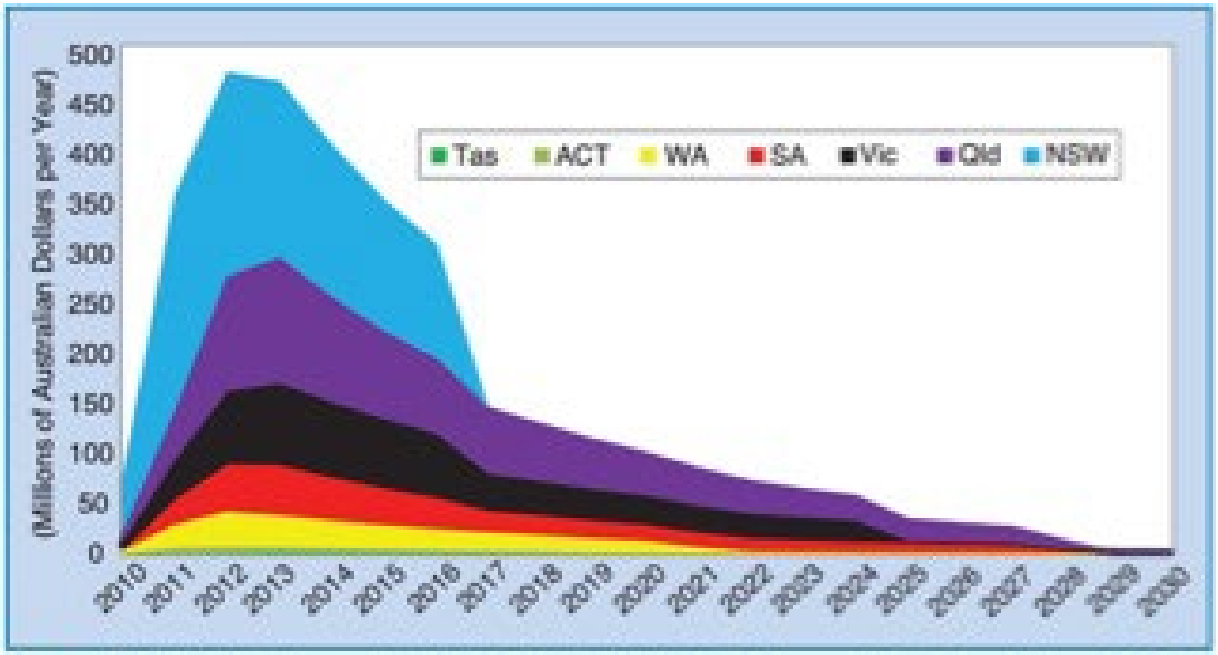


figure 7. Jurisdictional mandated FiTs, 2010 to 2030, in millions of Australian dollars (2014).

Source: Mountain B.R and Szuster, P. 2014 "**Solar, Solar Everywhere: Opportunities and Challenges for Australia's Rooftop PV Systems". IEEE Power and Energy, Vol 13, Issue 4, p.53-60**

Economics: is policy support needed?

Rooftop solar is now cheaper than grid-purchased electricity in SME & C&I

- The LCOE of rooftop solar is below the variable consumption rate for grid-supplied electricity to C&I customers.

Table 1. Levelised cost of electricity of rooftop solar PV ($/MWh)

	NSW	QLD	SA	TAS	VIC
Levelised cost of electricity (S/MWh)	$88	$81	$81	$99	$95

Rooftop solar likely to continue to grow organically (even without policy support) as a substitute for grid-supplied electricity in the C&I/SME market.

(Appendix A for calculation)

But VWAP (PV) < LCOE, so rooftop PV focused on grid export not likely to be viable

Table 1. Levelised cost of electricity of rooftop solar PV ($/MWh)

	NSW	QLD	SA	TAS	VIC
Levelised cost of electricity (S/MWh)	$88	$81	$81	$99	$95

Table 2. Volume-weighted average spot price of rooftop solar ($/MWh)

	Volume-weighted average spot price value of rooftop PV ($/MWh)				
	NSW	QLD	SA	TAS	VIC
2018	$84	$74	$91	$83	$99
2019	$77	$56	$43	$94	$104
2020	$65	$30	$25	$44	$43
2021	$41	$38	$25	$29	$14
2022	$103	$93	$51	$95	$50
2023	$47	$24	$2	$40	$ (4)
To 30 April 2024	$56	$51	$1	$45	$18
Average	$68	$52	$31	$61	$46

Batteries viable? BTM battery evaluated at spot prices not likely to be commercially viable unless battery operators can accurately foresee prices

Table 3. Average trading margin assuming passive operation and perfect foresight operation in each NEM region ($/MWh)

	Trading margins ($/MWh) using 2020-2023 spot prices				
Battery operating assumptions	**SA**	**VIC**	**NSW**	**QLD**	**TAS**
Passive: charge each day at average price between 11am & 2pm; discharge at average price between 6pm & 9pm	$160	$112	$107	$191	$34
Perfect foresight: charge each day at average of 24 lowest 5-minute prices; discharge at average of 24 highest 5-minute prices	$596	$275	$400	$709	$210

LCOE (battery, grid charged) = $395/MWh
LCOE (battery, BTM solar charged) = $325/MWh

In QLD, NSW & SA assuming perfect foresight, BTM storage valued at spot prices will be profitable. But assuming passive operation, BTM storage is not profitable in any NEM region

So, “Business Power” will not happen without policy support. Why consider it?

1. Almost all generation (or storage) in the NEM relies on policy support.
2. Political consensus on GHG reduction but refusal to bring GHG cost into economy. So, policy needed.
3. Social and environmental costs of distant generation not fully priced. So, policy needed.
4. Spot market does not fully compensate generation expansion or storage. So, policy needed.
5. Business power will improve distribution network utilisation to improve D productivity, but no mechanism for value capture. So, policy needed.
6. Business power will reduce spot prices particularly evening peak prices.
7. Business Power will reduce network losses. Some value capture, but incomplete. Policy needed.
8. Business Power will reduce curtailment on feeders (by expanding storage). No mechanism for value capture. Policy needed.
9. Business Power will create possible co-benefit with EV charger installation at places of work.
10. If its not working you can pull the plug with exposing customers to a large stranded cost.

Policy options ?

Scope, type and form are the three main choices

Q: Scope? Roof top solar only / battery only / rooftop solar+battery?

A: Both clean energy and storage are valuable: all three options should be on the table.

Q: Type? Capital subsidy or production subsidy ?

A: Production subsidy to provide incentives for asset operation in customers' interests.

Q: Form? If production subsidy: flat rate or time-varying (for solar)?

A: Time-varying to avoid incentives for production when supply is plentiful; and to encourage batteries to discharge when supply is scarce.

Recommendation

1. Floor price ($/MWh) for rooftop solar production before 11am or after 2pm
2. Floor price ($/MWh) for battery discharge between 6pm and 9pm

We examine three possible (not mutually exclusive) policy support options

- Rooftop PV-only :
  - Feed-in price floor for injection to grid before 11am or after 2pm, for 20 years.
- Battery-only:
  - Feed-in floor price for battery discharge to the grid between 6pm and 9pm, for 10 years. Floor price applies to the daily discharge volumes obtainable from a two-hour battery.
- Rooftop PV+battery:
  - Battery floor price applies to the daily discharge volumes obtainable from a two-hour battery (i.e. 1 kW of solar must be matched by 2 kWh of storage). This means that typically about half the solar system's daily production in summer and more than all of the solar system's daily production in winter, is likely to be shifted to the period from 6pm to 9pm.

Policy evaluation

Policy support is evaluated on four measures

- **Net Present Value (NPV):** is the present value of revenues less costs likely to be positive, and so factory power will be attractive to investors?
- **Policy support as a percentage of revenues**: how much of the revenue is explained by policy support?
- **Policy support as a percentage of cost:** what proportion of the cost is absorbed by policy support?
- **Implied GHG abatement cost:** what is the value of the policy support per tonne of GHG emissions abated as a result of the policy?

PV-only policy support evaluation

Table 4. PV-only floor price evaluation

Average sales price ($/MWh)					
Floor	**NSW**	**QLD**	**SA**	**TAS**	**VIC**
No floor	59	30	26	43	17
$100	88	73	77	77	65
$130	103	89	92	94	80
$150	114	101	103	105	91
NPV ($m)					
Floor	**NSW**	**QLD**	**SA**	**TAS**	**VIC**
No floor	$0.20	$0.39	$0.42	$0.35	$0.51
$100	$0.00	$0.06	$0.04	$0.14	$0.20
$130	$0.10	$0.06	$0.08	$0.03	$0.10
$150	$0.18	$0.15	$0.16	$0.04	$0.03
Policy support as % of revenue					
	NSW	**QLD**	**SA**	**TAS**	**VIC**
$100	33%	59%	66%	45%	74%
$130	43%	67%	71%	54%	79%
$150	48%	71%	74%	59%	82%
Policy support as % of levelised cost					
	NSW	**QLD**	**SA**	**TAS**	**VIC**
$100	32%	53%	62%	35%	51%
$130	50%	73%	80%	51%	66%
$150	62%	88%	93%	63%	78%
Implied carbon price ($/tonne$CO_{2\text{-}e}$)					
Floor	**NSW**	**QLD**	**SA**	**TAS**	**VIC**
$100	$29	$43	$39	$27	$37
$130	$44	$60	$51	$39	$49
$150	$55	$71	$59	$48	$57

A feed-in floor of $100/MWh rooftop PV grid export before 11am and after 2pm means:

- close to zero NPV in all states;
- policy support accounts for 33% to 74% of spot market revenues;
- policy support accounts for 32% to 62% of costs;
- an implied $CO_{2\text{-}e}$ abatement price of $27 to $43 per tonne $CO_{2\text{-}e}$.

Battery-only policy support evaluation

Table 5. Battery-only floor price evaluation

Gross arbitrage margin ($/MWh)					
Floor	**NSW**	**QLD**	**SA**	**TAS**	**VIC**
No floor	$254	$351	$378	$122	$194
$100	$263	$458	$392	$148	$210
$200	$311	$495	$442	$219	$267
$300	$379	$558	$511	$304	$342
$400	$469	$642	$596	$398	$434
NPV ($m)					
Floor	**NSW**	**QLD**	**SA**	**TAS**	**VIC**
No floor	$0.08	$0.02	$0.04	$0.22	$0.15
$100	$0.07	$0.13	$0.06	$0.19	$0.13
$200	$0.03	$0.17	$0.11	$0.12	$0.07
$300	$0.05	$0.23	$0.18	$0.03	$0.01
$400	$0.14	$0.32	$0.27	$0.07	$0.10
Policy support as % of revenue					
Floor	**NSW**	**QLD**	**SA**	**TAS**	**VIC**
No floor	0	0	0	0	0
$100	4%	23%	4%	18%	8%
$200	15%	7%	11%	32%	21%
$300	18%	11%	14%	28%	22%
$400	19%	13%	14%	24%	21%

A feed-in floor of $200/MWh for grid injections after 6pm but before 9pm means:

- positive NPV in SA and QLD, close to zero in NSW, VIC and TAS;
- policy support accounts for 7%-32% of revenue

Battery-backed solar

Table 6. Battery-backed solar floor price evaluation

$200 Battery floor, $100 PV floor	NSW	QLD	SA	TAS	VIC
NPV	$0.03	$0.10	$0.08	$0.26	$0.27
Policy support as % of revenue	28%	45%	43%	52%	56%
Policy support as % of cost	27%	49%	46%	33%	40%
Implied carbon price	$19	$32	$23	$23	$23

A feed-in floor of $200/MWh for grid injections after 6pm but before 9pm means:

- positive NPV in SA and QLD, close to zero in NSW
- policy support accounts for 28%-56% of revenue
- policy support accounts for 27%-49% of revenue
- Implied carbon price of $19 - $32 / tonne $CO_{2\text{-e}}$

Discussion

Discussion: Policy support yield

For NSW, assuming $1bn of policy support and 3:1 policy leverage.

Table 7. Policy support yield

	Battery and solar	Battery only	PV only
Additional direct annual renewable generation (MWh)	2,679,002		4,816,097
Annual GHG emission reduction ($tCO_{2\text{-}e}$)	2,679,002		4,816,097
Additional storage (energy) capacity (MWh)	2,059	2,633	

So, think about this:

In 2023 total installed rooftop PV capacity of 5,6 GW produced 7,800 GWh. We estimate a total of $4.2bn of policy support was paid in getting to this.

With Business Power, our analysis suggests that $4.2bn of policy support would deliver 11.3 GW of additional rooftop PV capacity as well as 8,650 MWh of additional storage.

Discussion: average cost

- We estimate LCOE of battery-backed solar (with two sets of batteries so covering 20 years of solar backing) at $134/MWh.

- By comparison:

  - LCOE of OCGT $140-$240/MWh (CSIRO Gencost)
  - Stanwell Corporation (3300 MW coal and 700 MW OCGT and hydro) average production cost of $180/MWh
  - Hills of Gold windfarm, Energy Australia says LCOE is $110/MWh

Discussion: Impact on electricity prices

- Impossible to be sure, but:

1. This is likely to be one of the cheapest sources of new (substantially) firmed supply;
2. Much more efficient than existing RE policy;
3. Much higher evening supply (where supply curve is typically steep).

And so, even if Business Power policy support is fully recovered from consumers (rather than taxpayers) the policy may be expected to pay for itself in offsetting wholesale price reductions.

Discussion: Recovery of policy support costs

- Consumers or tax-payers?
  - The latter on the basis of GHG reduction; the former on the basis of electricity supply. Maybe a bit of both (like CIS is likely to turn out to be?)

- How?
  - Business Power Administrator makes floor price payments;
  - Recovers these payments through distribution network service providers (like FiTs)
  - Much scope for useful thought on how DNSPs then recover (if BPA charges become large)

Discussion: Uncertainty … is this really a go-er?

- Many, many uncertainties here:

  1. How will grid, battery and solar prices evolve?
  2. Will business customers really be interested in this even if its profitable?
  3. Will distributors drag their feet (they don't mind solar, but want batteries in front of the meter). Will regulators/governments do what it takes to overcome resistance?
  4. Will utilities see a business here that they want to promote (or will they try undermine it)?

- But if it fails it can easily be tweaked or closed to new customers. "*while success is not guaranteed, there is good reason to be optimistic, and that little will be lost by trying*"

Implementation

Feed-in floor price eligibility and conditions

1. Recipients in NEM-region; 3 phase (variations for SWIS and NWIS need to be considered separately).

2. Min. 15 kW PV; no upper limit.

3. Battery (kWh) storage capacity must be at least 2X continuous peak power (kW) rating, per day (i.e. “two-hour” battery). Minimum storage power/energy capacity of 15kW/30 kWh

4. Battery (power) capacity must be at least equal to rooftop PV DC inverter capacity.

5. Batteries must have a. No upper limit on battery power/energy capacity.

6. Business Power recipients required to forego RET subsidies.

Next steps

- Debate and scrutinize: get the discussion paper here: https://www.vepc.org.au/_files/ugd/92a2aa_22dc7eb8187c4e8ebe839970f099dfbe.pdf
- Community and political appetite ?
- It’s a “no-brainer”. So why then does it not already exist?

Thank you.