Influence of household prosumage growth on utility generation and storage portfolios in Western Australia

Kelvin Say & Wolf-Peter Schill
Electricity customers are changing.

**The Sydney Morning Herald**

Too much of a good thing: Solar power surge is flooding the grid

By Cole Latimer
June 6, 2018 – 4:42pm

**Bloomberg**

Australians Love Rooftop Panels. That’s a Problem for Big Solar

By James Thorhill
December 16, 2019, 6:00 AM GMT+11
Updated on December 16, 2019, 10:00 PM GMT+11

- About one in four Australian households has solar panels
- Surge in residential uptake set to hurt profits of big plants

**ABC NEWS**

The rise of solar power is jeopardising the WA energy grid, and it’s a lesson for all of Australia

By Daniel Mercer
Updated 4 Dec 2019, 5:28pm

What could happen with household batteries?
Outline.

- Introduction
- Research question
- Context of the case study
- Methodology
- Results
- Conclusions
Derivation of customer value.

Retail usage charges/kWh:

- Usage: 29c
- FiT: 7c
- Self-consumption value
- Net-export value

Diminishing returns for additional PV capacity + eligibility considerations

7c/kWh

22c/kWh

Energy Transition Hub
The value **shifts** with PV-battery prosumage.

- Batteries revalue excess PV generation (minus losses)
- Prosumage adoption becomes a combined consideration of PV and battery capacity
- Interaction with FiT eligibility
- FiT incentives are “flipped”

* Assuming batteries only operate to maximise self-consumption
Changing shape of residual network demand.

1. Batteries incentivise additional PV capacity
2. Declining minimum demand
3. Declining late-afternoon peak
4. Emerging residual morning peak
5. Increased morning to midday down ramping
Changing shape of **residual network demand**.

6. Shifting into winter dominant demand
Research question.

With costs of battery systems declining and electricity prices rising, what impacts could household PV-battery adoption have on the optimal least-cost portfolio of the power sector?
Western Australia’s South-West Interconnected System (SWIS) Network

- Islanded network, currently unable to export elsewhere or curtail household PV
- Significant wind and solar resources
- Around 18 TWh of annual energy consumption (and 4.4 GW peak) with households consuming around 30%
- Over 1.5 GW of rooftop PV installed (2021) and growing
- Instantaneous contribution to underlying demand recorded above 60% (13 March 2021)
- In 2030 it is estimated that 50% of households will have PV installed
Household batteries only operate for “self-consumption”
## Input Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Source</th>
</tr>
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<tbody>
<tr>
<td>Household underlying demand and generation (heterogenous)</td>
<td>261 Sydney homes via half-hourly gross meter data 2012-13</td>
<td>(Ausgrid)</td>
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<tr>
<td>Residential/utility PV cost projection curves</td>
<td>Scaled by 0.78</td>
<td>(Solar Choice, GenCost 2018)</td>
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<tr>
<td>Residential/utility battery cost projection curves</td>
<td>Scaled by 0.73</td>
<td>(Solar Choice, Schmidt et al. 2017)</td>
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<tr>
<td>Retail usage charge projections</td>
<td>29c/kWh +4%pa</td>
<td>(Synergy, ABS)</td>
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<tr>
<td>Underlying network demand</td>
<td>SWIS operational demand 2012-13</td>
<td>(AEMO)</td>
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<tr>
<td>Number of investing households</td>
<td>500,000</td>
<td>Forecasted number of PV installations in 2030 (AEMO)</td>
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<td>Other technology costs</td>
<td>Conventional, wind, hydrogen, biomass</td>
<td>(GenCost 2018)</td>
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<td>Wind resource</td>
<td>Time-series</td>
<td>(AEMO)</td>
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<tr>
<td>Solar resource</td>
<td>Time-series average of household insolation data</td>
<td>(Ausgrid)</td>
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</table>
We compare scenarios with varying FiT and RES shares to a counterfactual setting without prosumage.

- FiTs at 0%, 25%, 50% of retail usage charge
- RES share (constrained) at 39%, 49%, 59%

The scenarios investigated.

Total of 12 scenarios
Various degrees of **prosumage**.

- 261 real household load and PV generation profiles
- Path dependency evaluated through a brownfield investment simulation
- Investment opportunities run annually using a 10-year financial horizon
- The PV-only, PV-battery, battery-only configuration with the highest NPV is selected, but only after a perceived risk check

![Diagram](image)
Various degrees of **prosumage**.

- Higher FiTs discourage battery adoption and keeps households at the eligibility limit (5 kW$_P$)
- Lowering FiTs encourages battery adoption
- Larger consumption households may exceed FiT eligibility limit

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**PV-only**
- Average = 5 kWp & 0 kWh

**PVB**
- Average = 5.3 kWp & 5.9 kWh

**PVB+**
- Average = 4.7 kWp & 8.7 kWh
Figure 23  Installed behind-the-meter PV capacity, 2018-19 to 2029-30 financial years

A. Cumulative installed capacity forecasts account for degradation of solar panel output over time. CSIRO applied a degradation rate of 0.5% per annum and GEM applied a degradation rate of 0.7% per annum.

B. Historical monthly behind-the-meter PV capacity data is provided in the 2020 WEM ESOO Data Register.

Source: CSIRO and GEM
**Capacity impacts.**

**Reference (counterfactual) scenario**
No PV battery investing households
- More wind than utility PV capacity
- Increased utility battery capacity as RES share rises
Capacity impacts.

**PV-only FiT₅₀ scenario**
Average 5 kW_p with no batteries

- Displacement in both utility PV and wind capacity
- Wind capacity recovers as RES increases
- Greater utility PV capacity displacement as RES increases
- Further utility battery capacity added
Capacity impacts.

**PVB FiT25 scenario**
Average 5.3 kW_p + 5.9 kWh

- Displacement in both utility PV and wind capacity
- Wind capacity recovers as RES increases
- Greater utility PV capacity displacement as RES increases
- Little effect on utility battery capacity
**Capacity impacts.**

**PVB+ FiT₀ scenario**
Average 4.7 kW_{p} + 8.7 kWh

- Reduced displacement of utility PV capacity
- Wind capacity recovers as RES increases
- Greater utility PV capacity displacement as RES increases
- Little effect on utility battery capacity
Generation impacts.

Reference (counterfactual) scenario

- No PV battery investing households
- Wind is an increasingly important resource, higher capacity factor of wind means that wind contributes more to the generation mix
- Coal has greatest reduction
- OCGT, CCGT generally unaffected
Generation impacts.

Slight coal enhancing effect
Wholesale price impacts.

Considering PVB FiT\textsubscript{25} and 49% RES share:

- Late-afternoon peak prices fall
- Mid-morning prices rise
- Wholesale prices for non-prosumage also falls slightly
- Cost of supply to C&I rises slightly
Overall **system cost effects**.

- Higher PV battery investment costs for customers leads to sub-optimal allocation of capital across the power sector.
Conclusions.

- Utility PV generally substituted by household PV capacity but less so as additional household batteries are installed.

- Wind power is less affected especially in scenarios with higher shares of renewables.

- Utility battery capacities are hardly substituted with household batteries operating to maximise self-consumption.

- Slight decrease in wholesale prices faced by non-prosumage households less so with prosumage households, while other consumers are slightly increased.

- Potential system benefits from more system oriented household battery operations that have near-zero marginal costs (from the consumer perspective).