Solar PV and Battery Capacities and Costs

Accompanying Appendix Five to

Understanding the value of residential solar PV and storage in New Zealand

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Contents

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1 Introduction

This appendix sets out the detail of solar capital costs used in the EECA residential solar study. It also sets out the battery costs used in the study. All costs given in this appendix are New Zealand dollars and include GST.

2 PV solar and battery capacities and costs

2.1 Capacities

A range of PV inverter capacities was used in the model, with PV array capacities matched to the inverter capacity such that the DC:AC ratios were either 1.0 or 1.2. Terms used when referring to PV system capacities and costs are given in Table 1.

Table 1: Terms used when referring to PV system capacities and costs. In this analysis all capacities and costs are referred to the PV system's AC output (inverter capacity) to ensure consistency. .

Term	Symbol	Units	Explanation
PV system AC capacity	cac	kWp-ac or kW-ac	The inverter's maximum AC capacity (active power, with units of kW), which in this analysis, also equals the inverter's kVA rating (the apparent power rating). This analysis does not consider the operation of inverter power quality response to control local voltage, which may result in the actual active power (kW) output being below the inverter's kVA rating.[1]
PV system AC unit cost	pv_ac_unit_cost	$/Wp-ac or $/W-ac	This cost includes all components and overheads that depend on PC system capacity, such as PV panels, racking, wiring, inverter, and installation. The system AC unit cost is used throughout for consistency. In the model this is specified for an inverter loading ratio of 1.0 to also provide consistent comparison of unit cost across different systems and capacities. This excludes the electrical inspection fee, even though most quotes include that fee. It also excludes the export meter cost and distributor fee.
Inverter loading ratio, or DC:AC ratio	ilr	none	Ratio of nominal DC PV array capacity (total PV panel capacity at manufacture without any degradation) to inverter capacity (cac). This is included in the analysis, because oversizing the PV array DC capacity compared to the inverter AC capacity is considered. Oversizing the PV array capacity can have the effect of loading the inverter closer to its capacity for a greater proportion of a day, allowing more capture of the sun's energy throughout the day, as well as offsetting PV panel light induced degradation.
Total PV system cost	total_pv_cap_cost	$	This is the PV system's total cost, equal to the 'PV system AC unit cost' multiplied by the 'PV system AC capacity', plus fixed overhead costs such as export meter, inspection fee, distributor fee, and diverter or timer cost if a diverter or timer are used. Importantly, this includes the cost of additional PV panels when the inverter loading ratio is greater than 1.0.
PV panel DC unit cost	pv_panel_unit_cost	$/Wp-dc	The unit cost of additional PV panels, racking and wiring. This is required when the inverter loading ratio is greater than 1.0.
Total PV system AC unit cost		$/Wp-ac	The total PV system cost (including overheads) divided by the PV system capacity. This is used to understand the effect of overheads on unit cost. It is always considered alongside the inverter loading ratio.
Total PV system DC unit cost		$/Wp-dc	The total PV system cost (including overheads) divided by the PV system DC capacity. This is used to show how the cost expressed as units of the DC capacity can vary compared to the AC cost.

The inverter capacities used are given in the following table. These capacities were selected to cover a number of inverter manufacturers and models available in New Zealand, with and without battery capability. They were also selected to give a range of capacities from small systems up to a larger 10 kW system. The 10 kW system was included later as it appeared to be increasing in popularity, especially combined with a 10 kWh battery.

Table 2: PV capacities modelled. A capacity of 0 kW was included specifically to understand the performance of a battery on its own.

Inverter capacity (kWp-ac)
0
3
5
6
8.2
10

Specific PV panel types were not selected, but annual light induced degradation details are based on the Hanwha Q Cells Q.Peak Duo ML-G10 415 Wp-dc PV module. This gives 2% degradation in the first year, and 0.5% per annum in subsequent years. Solar generation data was modelled by ANSA©, with details given in the main report.

Battery capacities modelled are shown in the following table.

Table 3: Battery capacities modelled. A capacity of 0 kWh was included specifically to understand the performance of PV only. The battery capacity given is after a 70% depth of discharge, so for a 10 kWh battery the actual capacity is 14.3 kWh, with only 10 kWh of that capacity used. When the PV capacity is zero (i.e. there is only a battery with no PV), the discharge and charge rates default to 5 kW.

Battery capacity (kWh)	Discharge rate (kW)	Charge rate (kW)	Round trip efficiency
0			
5	PV inverter AC capacity	PV inverter AC capacity	90%
10	PV inverter AC capacity	PV inverter AC capacity	90%
30 (Vehicle to Grid[2])	10	10	

[1] Due to the operation of the inverter's power quality response when voltage becomes excessive, the inverter's active power (MW) output may be reduced by up to 20% of the inverter's apparent power (kVA) rating within the nominal voltage range due to the Volt-VAr response. It may be further reduced by up to 80% of the inverter's apparent power (kVA) rating when outside the nominal voltage range due to the Volt-Watt response, assuming it is set. This analysis does not consider either of these responses, and instead assumes sufficient export capacity, up to the export limit, on the distribution network. The parameters for these power quality responses are set out in the AS/NZS 4777.2 standard, or by the relevant distributor in their Connection and Operation Standard.
[2] Modelled as a special case, not in the main simulations.

2.2 Costs

PV system and component costs used in the modelling were developed from the following sources, and are shown in Table 4 and Table 5.

- Quotes and published costs from New Zealand solar suppliers, assumed to be the 'Total PV system cost' less overheads but including the inspection fee.
- EECA Gen Less Solar Tool default costs, assumed to be the 'Total PV system cost' less overheads.
- Schedule fees from Part 6 of the Electricity Industry Participation Code.
- Experience from installing solar systems for such items as the import-export meter cost and inspection cost.
- Survey's by SEANZ from 2024

The operating and maintenance cost used is the same as that used in previous modelling, at 20 $/kW per annum. The units of kW are assumed to be kW-ac. It is assumed that this covers replacement of faulty panels, wiring issues, and inverter replacement.

Table 4: PV system capital costs. The values used throughout the model are 'Total PV system AC unit cost', multiplied by the 'PV system AC capacity' to give the total capital cost.

PV system AC capacity	Total cost with no overheads* ('PV system AC capacity' x 'PV system AC unit cost')	PV system AC unit cost	PV panel, additional racking and wiring DC unit cost	DC:AC ratio	Total PV system cost	Total PV system AC unit cost(1)	Total PV system DC unit cost(2)	Source of Column 2 'Total costs with no overheads*'. Overheads are the export meter cost, inspection fee, and distributor application fee.
cac		pv_ac_unit_cost		ilr	total_pv_cap_cost	total_pv_ac_unit_cost	(not used in the model)	
kW-ac	$	$/W-ac	$/Wp-dc		$	$/W-ac	$/Wp-dc	
3.0	$7,500	2.50	1.00	1.0	$7,810	$2.60	$2.60	SEANZ survey in 2024
4.0	$9,500	2.38	1.00	1.0	$9,810	$2.45	$2.45	Interpolated between 3 kW-ac and 5 kW-ac
5.0	$11,250	2.25	1.00	1.0	$11,560	$2.31	$2.31	SEANZ survey in 2024 and installer websites, with inspection fee subtracted(3)
6.0	$13,200	2.20	0.95	1.0	$13,510	$2.25	$2.25	Interpolated between 5 kW-ac and 10 kW-ac
8.2	$17,138	2.09	0.79	1.0	$17,448	$2.13	$2.13	SEANZ survey in 2024 interpolated between 5 kW-ac and 10 kW-ac and quotes, modified to ilr=1.0, with inspection fee subtracted(3)
10.0	$20,000	2.00	0.75	1.0	$20,310	$2.03	$2.03	SEANZ survey in 2024
3.0	$7,500	2.50	1.00	1.2	$8,410	$2.80	$2.34	Based on PV panel prices calculated form the SEANZ survey in 2024
4.0	$9,500	2.38	1.00	1.2	$10,610	$2.65	$2.21	As above
5.0	$11,250	2.25	1.00	1.2	$12,560	$2.51	$2.09	As above
6.0	$13,200	2.20	0.95	1.2	$14,650	$2.44	$2.03	As above
8.2	$17,138	2.09	0.79	1.2	$18,744	$2.29	$1.90	As above
10.0	$20,000	2.00	0.75	1.2	$21,810	$2.18	$1.82	As above

[Model_Design.xlsx]PV Capital Cost Details

(1) Total PV system AC unit cost is used throughout the model
(2) Total PV system DC unit cost is not used in the model, but is shown to illustrate how DC unit cost can vary from 'PC system AC unit cost'
(3) since most installers quote including the inspection fee

Table 5: Other costs. Total fixed costs contribute to the 'Total PV system AC unit cost' in the model, and are included in 'Total PV system AC unit cost' column of Table 4. Diverter cost and Timer cost are included only if a diverter or timer are modelled.

Item	Symbol	Cost	Units	Source
Export meter	export_meter_cost	$150	$	Based on actual observed costs
Inspection cost	inspection_cost	$60	$	Set out in the Electricity Industry Participation Code 2010, Part 6, Schedule 6.5
Distributor application fee	dx_fee	$100	$	Set out in the Electricity Industry Participation Code 2010, Part 6, Schedule 6.5
Total fixed costs (meter, distributor, inspection)	pv_other_costs	$310	$	Total of the above costs
Battery capable inverter cost with no PV but with batteries. The above fixed costs also apply in this case.		1,500	$/Wp-dc	Estimated
Diverter cost	diverter_cost	$1,200	$	Based on observed costs (20% higher than that used by the EECA solar calculator)
Timer cost	timer_cost	$400	$	Assumed
PV operating and maintenance cost	om_cost	$20	$/kWp-ac/pa	Previous modelling, covers panel replacement and inverter replacement

[Model_Design.xlsx]PV Capital Cost Details

2.2.1 Battery costs and operation and maintenance

The installed and commissioned battery cost used is 500 $/kWh, with the actual cost being adjusted by the depth of discharge to give 714 $/kWh. So, for example, the cost of the 10 kWh battery used in the model is $7,143. Where PV capacity is zero, an inverter cost of $1,500 and one-off fixed costs of $310, covering the meter, inspection, and distributor fee, are added to the battery cost (as set out in Table 5).

Historical retail battery costs have been roughly double the battery cost used at over 1,000 $/kWh. However, there have been reported sharp reductions in battery costs between 2022 and 2024, with assumed ongoing reductions since then. Hence the historical retail cost has been halved for use in this study.

In the case of vehicle-to-grid (V2G), modelled as a special case only, no battery cost is included as the electric vehicle's battery is assumed to be a sunk cost. However, a cost of $6,000 for a V2G charger/inverter is added to the model.

The battery is assumed to have a cycle limit of 11,000 cycles, close to 365 days over the 29 years that the model is run. In the majority of cases the battery is cycled once per day or less, and remains within this limit. The battery operating and maintenance cost model adds cost as the cycle limit is exceeded in each year, if it is exceeded. The cost added is at a rate based on the battery's capital cost and pro-rated by the number of cycles exceeded. This acts as a cost penalty as the battery's cycle limit is exceeded, rather than adds the cost of an entirely new battery. In cases where the battery cycle limit is exceeded, it is usually well into the 29 years of operation. This operation and maintenance and battery replacement model was adopted on the basis that battery technology and costs are changing at such a rate that adding the full cost of a new battery based on today's prices is likely to be incorrect. The same cost penalty model is applied to V2G, despite the EV battery being considered a sunk cost.