Arjun Flora, Analyst
Gerard Wynn, Energy Finance Consultant, IEEFA
Simon Nicholas, Energy Finance Analyst, IEEFA
Christian Kunze, Senior Energy Researcher, Smart Innovation Norway
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IEEFA.org

Steering by the Southern Sun

Australians Are Missing a Trick on Solar-Powered Electric Vehicles

Executive Summary

In this report, we investigate the potential for Australian citizens to capitalise on the country's exceptional solar resources and surging residential solar rooftop market to drive growth in electric vehicles (EVs). Australia has seen rapid growth in roof-top solar power, as households have seized the opportunity to cut relatively high electricity bills, by developed country standards, by exploiting some of the world's best solar irradiation, assisted by rapid falls in global solar module and battery prices. We explore whether they can go a step further, and capitalise on cheap solar and battery power to drive down motoring costs, by tapping into a growing global electric vehicle market, where the country so far has lagged.

As of September 2019, a fifth of Australian households, or 2.2 million, had installed some 10 gigawatts (GW) of roof-top solar, making it a world leader by market share.[1] Lately, Australia has also seen strong growth in residential batteries, cumulatively at tens of thousands. However, Australia has lagged in the uptake of another emerging digital energy technology, EVs. In 2018, Australia achieved just 1,800 new EV sales, or a miniscule 0.21% market share.[2] That is far below peer countries by economic size or region, such as Korea (29,630 new EV sales last year), the Netherlands (25,070), Canada (22,660), or New Zealand (4,360).

Solar power can be used to charge EVs via a stationary battery. Given the availability of low-cost solar power, and high domestic electricity prices, we investigated the potential for Australians to save money on a conventional gasoline car, by buying instead an EV coupled with residential solar power and battery. We estimated the number of years it takes to pay off the cost of a combined new EV, rooftop solar system and residential battery, through the savings generated by on-site power generation and from avoiding the cost of buying and fuelling a conventional car. We estimate payback periods both today, and through 2030, taking into account expected cost reductions in EVs, solar power and batteries.

We also investigated whether Australia could benefit from the experience of Norway, the world leader by EV market share. In 2018, Norwegians bought 46,140 new EVs, a 29% annual market share, far ahead of second-placed Netherlands, at 6%. Norway has achieved rapid EV growth through both taxes on conventional cars, which may be unpalatable in Australia, and incentives including exemptions on road tolls and value added tax (VAT).

[1] Australian Renewable Energy Agency, n.d., Solar PV R&D in Australia.
[2] IEA, Global EV Outlook 2019.

Main Findings

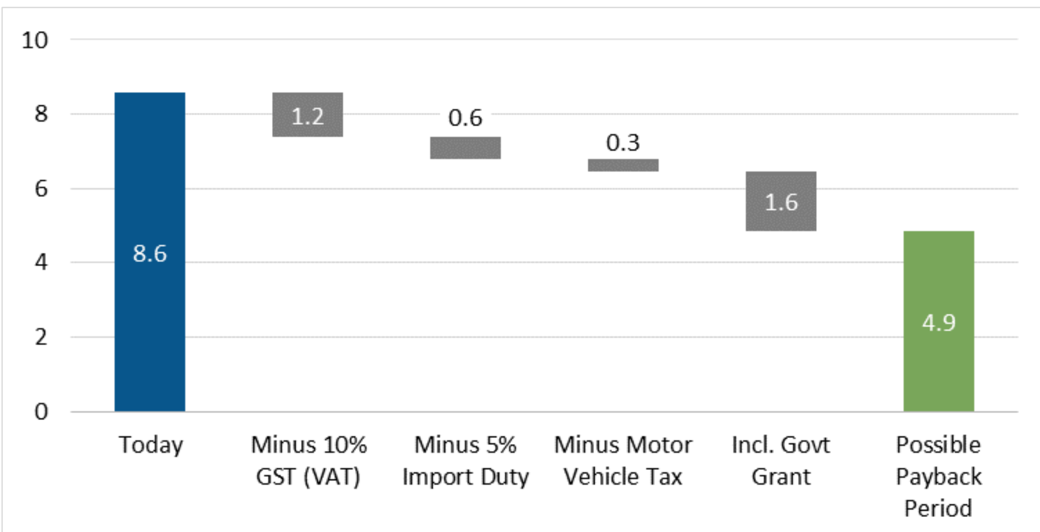
- Standalone rooftop solar systems are already achieving payback periods of five years or less in Australia. Such payback periods are short and attractive enough to drive mass adoption. Rooftop solar in Australia today is where many countries around the world will be over the next decade.
  - For a typical 8kW system in Sydney, we estimate payback periods in Australia of 4.2 years, dropping to less than 2 years in 2030
  - Households that install solar power today will thus pay off the initial investment in a handful of years, and then benefit from a further 20 to 25 years of free electricity.
- The economics of solar plus battery in Australia lags more developed markets, such as Germany. We find that residential batteries are significantly more expensive in Australia than in Germany, and additional ("balance of system") installation costs are also more expensive.[3] We attribute these higher costs to a far less developed market. In Germany, some 150,000 households have solar-battery systems.[4] Also, in Germany and Britain, consumers can earn a fee recognising the service of aggregated small-scale batteries to stabilise the grid.
  - We estimate a payback period for solar-battery systems (8kWp solar/8kWh battery) of nine years today, falling to less than three years in 2030. Some states have announced interest free loans and/or capital grants, which reduce these payback periods further.[5]
- Australia lacks a support regime for EVs. As a result, solar plus battery and EVs have a rather unattractive payback period of nine years today. However, this situation changes rapidly as EVs and batteries become cheaper. And if we borrow some examples of EV incentives as used today in Norway, Australians can benefit from cheap, solar-powered charging even sooner.
  - We estimate a payback period today for combined solar-battery-EV systems of 8.6 years today, falling to 4.1 years in 2025, and less than 2 years in 2030.
  - We then apply some incentives as applied in Norway and other European countries. As in Norway, we remove VAT/GST on EVs (@ 10% in Australia). As in Norway, we remove a 5% tariff on imported cars. As in Britain, we remove vehicle excise (@ c. AUD 250 per year). And as in Britain and Germany, we add a grant of AUD 6,500 for new EV

[3] This cost differential varies by brand, but for example LG Chem RESU batteries cost c.34% more in Australia than Germany, under current exchange rates at the time of writing this report.
[4] Energy Storage, 2019. Battery storage systems at "the edge of profitability" as German households reach 1GWh capacity. September 10, 2019.
[5] One Step off the Grid, 2019. Battery storage can get where it's going with incentives and VPPs. July 31, 2019.

purchases, which we halve every year, falling to AUD 102 in 2025. The motives for these incentives are various, and include to recognise that EVs are cleaner, quieter, and less carbon-emitting than conventional cars.

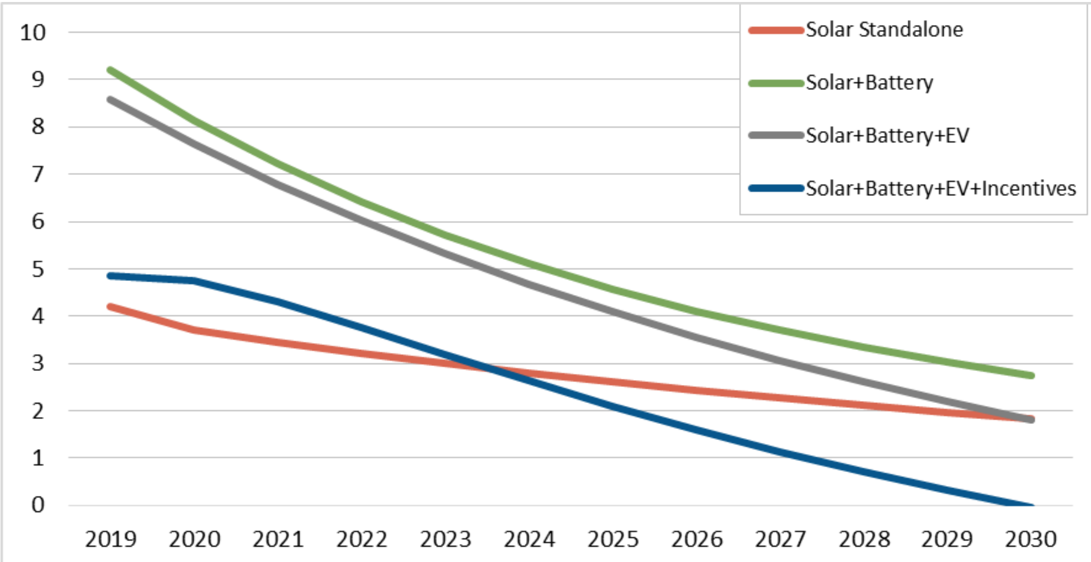
- Applying these combined incentives, the payback period on solar plus battery plus EV falls dramatically to about five years today, and zero by 2030. By 2024, it is cheaper for a household to invest in solar, storage and an EV in combination, than in a solar system alone, demonstrating the synergistic nature of these emerging technologies.

Figure 1: Combined Solar, Battery and EV Today— Impact of Policy Incentives on Payback Period (Years)



Source: IEEFA.

Figure 2: Comparison of Payback Periods for Different Combinations of Technologies (8kW Solar, 8kwh Battery, Small EV), Years



Source: IEEFA.

Recommendations

We find that Australians already benefit today from exceptionally rapid payback periods when installing standalone rooftop solar power. We find that with modest EV incentives, Australians could make similar annual savings on the annual cost of motoring. Savings on the cost of road fuel and grid power would pay off the upfront costs of a combined solar, battery and EV system in around five years, falling to zero by 2030. Without EV incentives, the payback period today is nine years, falling to two years in 2030.

We note social benefits from supporting EVs, in particular reduced urban air pollution, lower carbon emissions, and national as well as individual energy independence. And there are softer benefits, such as a quieter driving experience and, for the driver, instant torque. We recommend that Australians are encouraged to transition to EVs, to exploit the country's natural solar advantages, far less than be penalised, as discussed under mooted road user charges. We highlight the following incentives, as modelled under our accelerated EV scenario:

- Exempt EVs from 10% GST and a 5% import tariff
- Exempt EVs from motor vehicle tax (e.g. AUD 236 per year in NSW)
- Provide a capital grant for the purchase of new EVs, starting at AUD 6,500, and halving annually thereafter, falling to about 100 AUD in 2025.
- Introduce softer incentives, such as free public parking, to increase the convenience of transitioning to EVs.

Table of Contents

Table of Figures

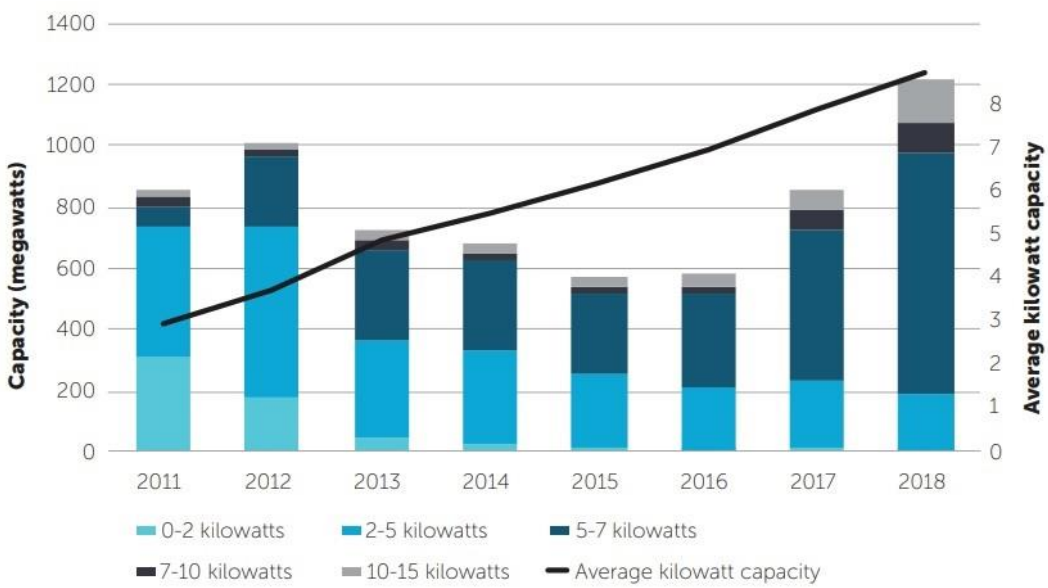
Introduction: Status of Australia's Installed Residential Solar, Batteries and EVs

Australia has excellent solar resources, with an average solar power output of about 1.8 MWh/kWp per year, compared with European market leader, Germany, at 1.1 MWh/kWp per year).[6] Australia also has a world-leading roof-top solar market: as of September 2019, a fifth of Australian households, or 2.2 million, had installed some 10 gigawatts (GW) of roof-top solar.[7] That compares with around 1.6 million solar installations in Germany.[8]

Early rooftop installations in Australia were driven primarily by a solar credits incentive (STC) scheme, introduced in 2009. Today, good solar resources and high retail power prices are the main drivers, with the STC scheme to be phased out linearly over the coming decade.[9]

Annual small-scale renewables capacity additions show that, on average, rooftop solar systems are getting larger, as the technology continues to become more cost-effective (see Figure 3).

Figure 3: Australian Annual Small-Scale Renewables Capacity Additions, 2011-2018



Source: Australian Government Clean Energy Regulator; The Renewable Energy Target 2018 Administrative Report, July 2019.

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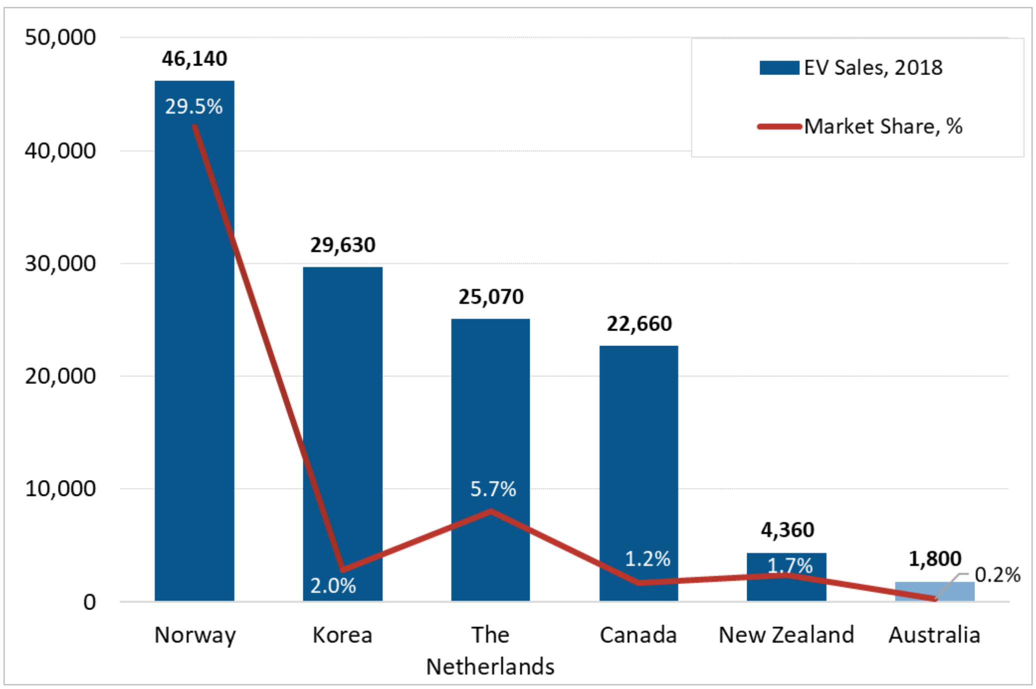
[6] Global Solar Atlas.
[7] Australian Renewable Energy Agency, n.d., Solar PV R&D in Australia.
[8] Fraunhofer Institute, 2019. *Photovoltaics Report*. October 25, 2019.
[9] Australia has higher retail power prices than many OECD countries, for example 25% above UK levels, while still substantially below Germany, one of the most expensive.

Australia is also seeing growth in residential battery systems. Cumulative battery installations have reached tens of thousands, but this is far behind uptake in market leader Germany, with more than 100,000 solar-battery systems. Batteries enable consumers to make additional savings, by increasing self-consumption of their rooftop-generated solar power, storing it during the daytime for use when needed. Australian residential power prices are more than 30 AUD-cents/kWh, compared with solar export tariffs of less than 10 AUD-cents, implying a net saving potential of more than 20 AUD-cents per kWh, from using solar power versus exporting it to the grid.

This rapid growth in roof-top solar makes all the bigger contrast with Australia's lagging uptake of another globally significant digital energy technology, the electric vehicle. In 2018, Australia achieved just 1,800 new EV sales, a tiny 0.21% annual market share, far below peer countries by economic size or region (see Figure 4).

Figure 4: Selected 2018 New EV Sales and Market Share, by Country



Source: IEA Global EV Outlook 2019.

The Economics of Solar, Batteries and EVs

We see three key factors affecting revenues for new residential solar, batteries and EVs: energy bill savings, financial support and annual cost reductions. We note a fourth factor, access to grid services markets, which could increase battery storage revenues in future. At present, grid services markets are in their infancy for small-scale generation, and we have excluded this from our analysis. Following are our modelling assumptions for each of these three factors.

Savings on Energy Bills

Energy bill savings are generated by substituting grid electricity with solar power. Savings will increase, the higher the domestic energy prices.

- In terms of electricity bill savings, a key measure is the solar self-consumption rate. The higher the self-consumption rate, the more solar generation is being used by the household instead of being exported to the grid, and the greater the energy bill savings. We assume that stand-alone solar has a self-consumption rate of 30%.

- Another key metric in electricity bill savings is total consumption, as this sets the effective ceiling on potential savings: the higher the annual consumption, the greater the potential energy bill savings from investing in solar.

- We make various other assumptions relevant to energy savings, such as residential electricity tariffs and tariff inflation (see Appendix).

Government-Backed Financial Support

Solar Power

Government support for solar in Australia includes a solar export feed-in-tariff (FiT) and a capex rebate, which is facilitated under the small-scale technology certificate (STC) scheme.

- The solar export FiT is provided by retailers for energy exported from households to the grid and varies, both within and across territories in Australia. In NSW, the government guides retailers to its benchmark rate range which is currently 8.5-10.5 AUD-cents per kWh. This is based on what it would cost retailers to buy electricity from large generators and so tracks the wholesale electricity price over time. We have assumed an export FiT of 9.5 AUD-cents per kWh. As this is lower than the average domestic retail price of electricity, it is still cheaper for households to save on their bill by self-consuming their electricity, vs exporting it to the grid.

- The STC rebate scheme allocates a number of STCs to a consumer, based on various factors (geographic 'zonal' location, solar system size in kW, and number of years remaining until year 2031). These STCs can then be sold and are bought by electricity retailers looking to meet their renewable energy obligations. Thus the scheme effectively provides households with a rebate on a portion of the initial cost of a solar PV system. We have assumed an STC value of AUD 37 per certificate (including goods and sales tax (GST)) throughout our analysis.[10]

[10] Goods and sales tax. 37 = $40 capped STC price minus $3 tax.

Batteries

Government support for residential storage is state-led, and some states have announced schemes to subsidise capex, through capital grants and/or, zero- or low-interest loans.

- Given the variability of these schemes, both by state and installation parameters, and the inherent variability of residential storage costs by battery size, brand, installation requirements, etc, we have not included capital grants in our modelling of payback period and ROI. However, we have indicated, for reference, the sensitivity of our outputs to a +/- AUD 2,000 swing in total system cost (see Figure 5)

- In October, Australia published its first installation performance standard for domestic battery energy storage systems.[11] The standard requires that a cement wall should separate the battery from habitable rooms, regardless of the fire safety specification of the battery installed. Battery industry representatives estimated that the additional materials and labour could add an average AUD 1,000 to installation costs.

- We note anecdotal evidence that at present in Australia renewable energy installers are focused on rooftop solar, given attractive economics and strong demand, where training of staff for battery installations may be viewed as a costly distraction.

Electric Vehicles

There is no government support for electric vehicles in Australia. Indeed, legacy import tariffs originally designed to protect the Australian domestic car industry can add to prices, while mooted road user charging which would increase EV costs.[12] We investigate the potential impact of several policies, drawn from Norway and other European countries:

- Remove 10% GST from EV purchases (as in Norway where EVs are exempt from 25% VAT).

- Remove the 5% import tariff on cars (as in Norway, where there are no import tariffs on EVs).

- Remove vehicle excise duty / road tax of c. AUD 250 (as in Britain). Road tax is charged differently in different states in Australia, and in NSW it is calculated by weight, with no exemption for EVs.

- Provide a capital grant for the purchase of new EVs, starting at AUD 6,500 in 2019, and halving every year going forwards (equivalent to grant schemes applied in Britain and Germany).

[11] https://onestepoffthegrid.com.au/what_battery_installation_standard_mean/
[12] Infrastructure Partnerships Australia, 2019. Report: Road User Charging for EVs. November 21, 2019.

- In addition, in Norway we are seeing the rollout of so-called "peak taiffs" which reward EV owners and electricity consumers in general to consume power at off-peak times, thus providing incentives to make EVs work, both for consumers and the wider electricity system.

Annual Cost Reductions

- We use various published market prices for solar in 2019 (see Appendix for full details). We assume wholesale module prices of 41 AUD-cents per watt; developer margins of 15%; balance of system (BoS) costs of 49 AUD-cents per watt; labour costs at 25% of full installed cost; and annual solar operational expenditure of AUD 81.

- We then apply annual reductions to these numbers, from 2020 to 2030, to take into account expected improvements in technology and manufacturing economies of scale. Our cost reduction assumptions include: solar modules at minus 5% annually; solar BoS minus 2.5%; and solar developer margins minus 5%.

Our Method

Our analytical approach was to estimate how many years it would take (the "payback period") for energy bill and other savings to recoup investment outlay on various combinations of solar, batteries and EVs, as well as to calculate an initial annualised return on investment (ROI). Where regional assumptions were required we based our analysis on the most populous territory, New South Wales (NSW). We made various cost reduction assumptions to calculate the payback periods for new projects through 2030.

For calculating the payback period, we calculated the number of years it takes for total cumulative income to pay off upfront and cumulative costs, using Excel "What-if Analysis." Costs include capital cost, debt financing and operational costs. For the financing cost, we assume solar is 50% debt-funded, where the cost of debt is 6.79% and cost of equity is zero (see Appendix). Income includes government-backed financial support and energy bill savings as described in the previous sections.

For calculating ROI, we divided initial net annual income by the upfront capex. Net income includes the variables as described above, such as financial support plus energy bill savings (year 1) minus costs including operational costs, financing costs and depreciation (see Appendix). Upfront capex includes full installed cost of the installation, including GST.

Findings

Solar Standalone and Solar Plus Battery Storage

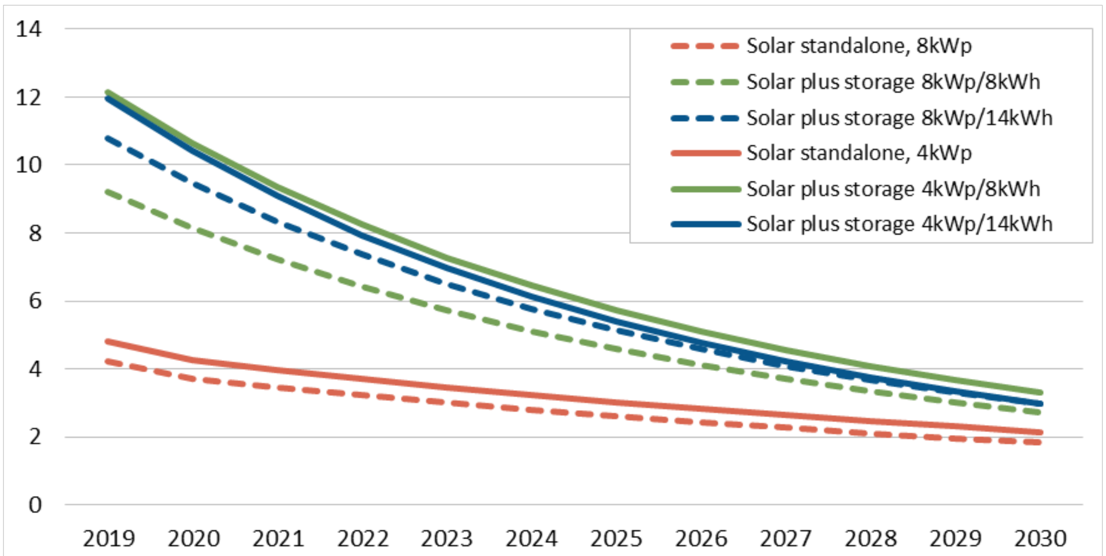
We looked at both a "typical" 8kW solar installation in Australia, and a smaller 4kW solar system, which is a more typical size for countries in Western Europe. We calculated the payback period for such a system, both with and without a battery.

We considered two battery sizes; 8kWh and 14kWh, taking an average cost from various providers.

We find standalone solar with a capacity of 4kW to 8kW presently has a payback period of four to five years in Australia. Falling solar panel and other costs will see these payback periods fall to around two years in 2030 (red lines in Figure 5).

Adding an 8kWh battery to an 8kW solar system increases the payback period to nine years, and to almost eleven years for a 14kWh battery (blue and green lines in Figure 5). These results are broadly similar to adding batteries to a smaller, 4kW solar system. Falling costs see the payback period for solar plus battery systems fall to around three years in 2030.

Figure 5: Solar vs. Solar Plus Storage— Payback Period

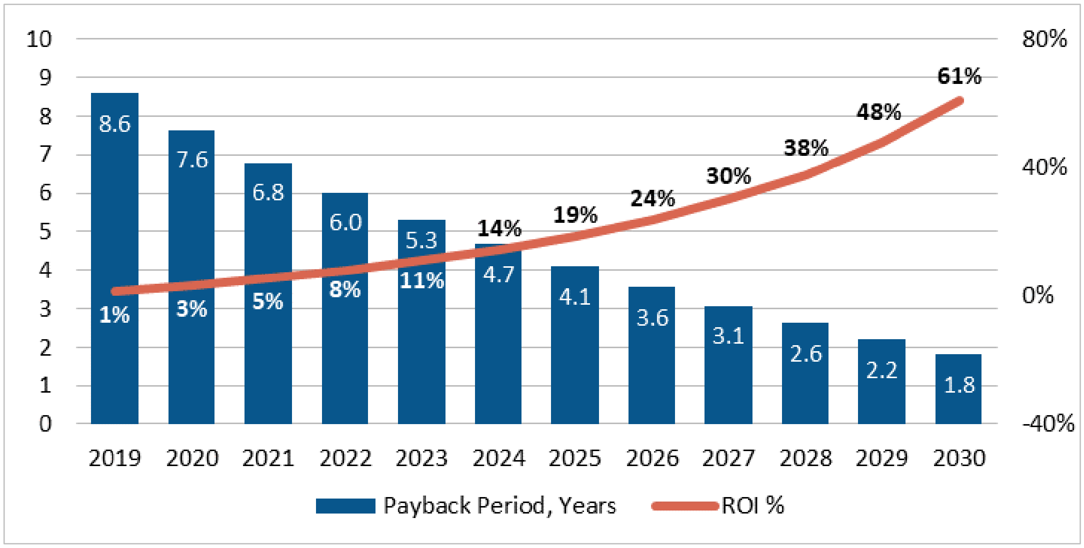


Source: IEEFA.

Solar Plus Battery Storage Plus EV

We next investigated the impact on payback period and ROI of adding an EV to a combined 8kW solar and 8kWh battery system. In this case, the EV can be charged directly from the battery, in turn charged by the rooftop solar panels. The household thus further increases self-consumption of their solar power, avoiding grid electricity, by adding a new source of demand for their solar power (the EV). And they now make additional road fuel savings by eliminating petrol consumption. We find a payback period of 8.6 years today, falling to 1.8 years in 2030 (Figure 6).

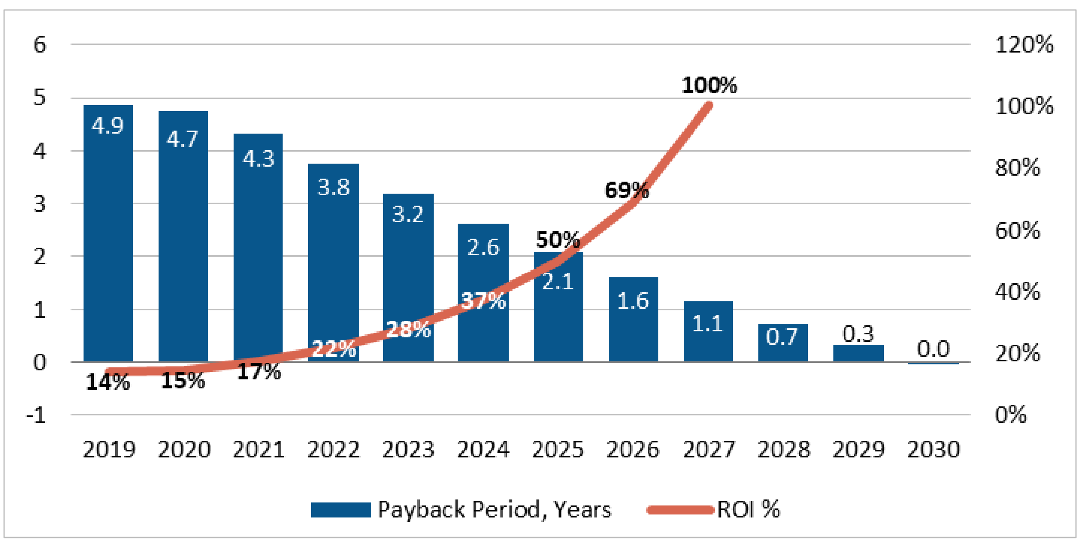
Figure 6: Combined EV-Solar-Storage— Base Case



Source: IEEFA.

We find payback periods can be dramatically reduced, to 4.9 years today and zero in 2030, if Australia were to implement certain regulatory policies to support uptake of EVs (Figure 7). These incentives were: to remove a 10% GST and 5% import tariff for EVs; make EVs exempt from road tax; and to provide a capital grant for the purchase of new EVs, starting at AUD 6,500, and halving annually thereafter, falling to about 100 AUD in 2025.

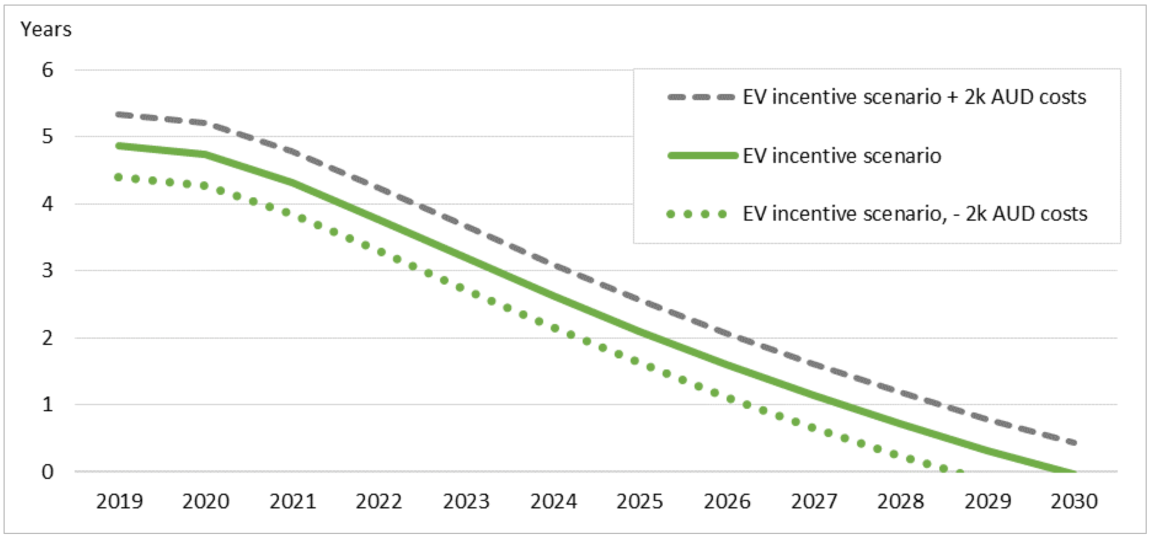
Figure 7: Combined EV-Solar-Storage— Additional EV Incentives



Source: IEEFA.

Finally, we investigated the impact on our additional EV incentives scenario, of changing battery storage costs. We made this extra analysis because of some uncertainty at present regarding the impact of changing installation requirements nationally, and the impact of more or less generous battery installation capital grants regionally. Figure 8 shows that varying installed battery cost by AUD 4,000 has a relatively modest impact on combined EV-solar-battery payback period, which varies between four and five years today, and between zero and one year in 2027.

Figure 8: Combined EV-Solar-Storage— Sensitivity to Battery Cost



Source: IEEFA.

Appendix

Our basic input assumptions, for modelling of ROI and payback periods follow.

INPUT VARIABLES (Nov 2019)		Australia		With Additional Incentives
HOUSEHOLD		**Units**	**Value**	
	Annual power consumption excl EV	kWh	5,548	
	Domestic tariff inflation	%	1.50%	
	Domestic tariff	AUD/kWh	0.374	
	National inflation (CPI)	%	1.50%	
SOLAR PV				
	Capacity	kWp	8	
	Average load factor	%	16.36%	
	Self-consumption rate	%	30%	
	PV Module cost, annual change	%	-10%	
	PV Module cost	AUD/watt	0.41	
	BoS materials cost, annual change	%	-5%	
	BoS materials cost	AUD/watt	0.49	
	Labour cost (% of installed cost)	%	25%	
	Opex (incl. any insurance & contingency)	AUD/year	-81.00	
	VAT	%	10%	
	Govt grant/incentive, annual change	AUD	-407	
	Government solar capex rebate (STC scheme)	AUD	4,884	
	Solar degradation rate	%	-0.40%	
	Solar export FiT annual change	AUD/kWh	0.001	
	Solar export FiT	AUD/kWh	0.095	
	Depreciation period	# years	20.00	
BATTERY				
	Battery system, rated capacity	kWh	8	
	Battery system, rated discharge power	kW	5	
	Battery system efficiency rate	%	98%	
	Battery system inverter loss impact	%	96%	
	Battery depth of discharge	%	90%	
	Battery cost, annual change	%	-15%	
	Battery cost	AUD/kWh	1093.50	
	BoS materials cost, annual change	%	-5%	
	BoS materials cost	AUD	2167.10	
	Labour, year 1 cost (% of battery system cost)	%	20%	
	GST (VAT)	%	10%	
	Depreciation period	# years	10.00	
SOLAR + BATTERY				
	Developer margin, annual change	%	-5%	
	Developer margin	%	15%	
	% debt funded	%	50%	
	Cost of debt	%	6.79%	
	Cost of equity	%	0%	
	WACC	%	3.40%	
	Borrowing term	# years	3.00	

INPUT VARIABLES (Nov 2019)		Australia		With Additional Incentives
EV				
	Battery system, rated capacity	kWh	28	
	Battery cost, annual change	%	-10%	
	Battery cost	AUD/kWh	325	
	EV price premium, annual reduction	AUD	500	
	EV price premium (incl battery pack)	AUD	11,488	***2,370***
	EV subsidy, annual change	%	-50%	
	EV subsidy (-ve)	AUD	0	***-6,500***
	Annual mileage	km/ year	15,000	
	Conventional veh efficiency, annual change		-2%	
	Conventional vehicle efficiency	litres/km	0.048	
	Conventional fuel price, annual change	%	1.50%	
	Conventional fuel price	AUD/litre	1.45	
	Annual conventional fuel savings	AUD/year	1,044	
	Annual road tax benefit, annual change	%	1.50%	
	Annual road tax benefit	AUD/year	0	***236***
	EV efficiency, annual change	%	-5%	
	EV efficiency	kWh/km	0.15	
	Annual EV charging consumption	kWh	2,250	
	WACC - EV		5.50%	
	Borrowing term - EV	# years	3.00	
	Depreciation period	# years	7.00	

Source: IEEFA.

About IEEFA

The Institute for Energy Economics and Financial Analysis conducts research and analyses on financial and economic issues related to energy and the environment. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy. www.ieefa.org

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About the Authors

Arjun Flora

Arjun Flora is an analyst with a particular focus on the new energy technology sector. He previously spent 5 years working on M&A and capital-raising transactions at Alexa Capital. He started his career in Technology investment banking at Jefferies and holds a MEng from the University of Cambridge.

Gerard Wynn

Gerard Wynn is an energy finance consultant at IEEFA. He has previously worked as an analyst, editor and writer, including a decade spent as a reporter and columnist at Reuters News Agency, covering energy and climate change. He holds a PhD in agricultural economics.

Simon Nicholas

Simon Nicholas is an energy finance analyst with IEEFA in Australia. Simon holds an honours degree from Imperial College, London and is a Fellow of the Institute of Chartered Accountants of England and Wales. He has 16 years' experience working within the finance sector in London and Sydney at ABN Amro, Macquarie Bank and Commonwealth Bank of Australia.

Christian Kunze

Christian Kunze is a senior energy management researcher at Smart Innovation Norway, specialising in the implementation of smart energy market projects. He has previously worked for a decade in the electricity trading industry and runs his own trading company. He started his career with a PhD in business administration.