Calculating The Cost of Solar Power

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Long-term financial calculations rely on a number of factors and assumptions. Calculating the cost of solar power is no different. This paper outlines a method of calculating the cost of solar power and the results obtained using the stated assumptions. I've used prices, interest rates and solar generation data relevant to Melbourne, Australia, but the same approach can be used anywhere. And importantly, I've left out all government subsidies for solar power. These are the real costs based on paying the full price for the respective systems.

Basics

Inputs to the calculations include the system size, how long it lasts, the installed cost, its location and the interest rate payable on the funds required to buy the system.

Let's start with basics. Generally, the larger the system you install, the less it costs per watt of generation capacity. So a larger system will generate cheaper power. Provided you have room for it, of course. I therefore looked at a range of systems, from 2.2 kW (around the average size of systems being installed these days) to just over 10 kW.

How long will the system last?

There is a good chance that solar panels installed today will still be pushing out useful amounts of power in 40 or 50 years' time. Panel efficiency does drop over time, but typically manufacturers guarantee that a panel will still produce at least 80% of its initial power after 25 years. Based on this figure, my calculations allow for panel output to fall by 0.925% each year. This is probably being conservative, and I have been told that panel output does stabilise over time.

Then there is the question of how long the inverter will last. This is a key component of the system. I chose systems based around a well-respected brand of German inverters with design lives of 20 years. System prices were obtained from a local solar power company without any attempt at haggling. I ran the numbers over 20 years, with no inverter replacement (a "poor" scenario), and 40 years, including the cost of replacing the inverter after 20 years (a "reasonable" scenario).

The cost of money

A couple of really important assumptions are the cost of financing the system and the rate of inflation. If you borrow $100 today and pay it off over 20 years, then the $5 you pay off in the last year won't have anything like the same value as the $5 you pay off in the first year. So we need to subtract the inflation rate from the borrowing costs (or your investment returns if you use your own money) to come up with the real cost of funds. If you have money sitting in the bank earning 3% interest, and inflation is also running at 3%, then the effective funding cost of the system is 0%. If you borrow at 8% with 3% inflation, the real cost of money is 5%. My calculations assume that the initial cost of the system is financed over 20 years (to match the inverter life), and that the replacement inverter is also financed over 20 years. I've given figures for a range of funding costs with the highest (5% real rate) equivalent to borrowing at a mortgage rate of 8% pa (higher than current levels) then subtracting inflation of 3%.

I've also assumed that the system is for "personal use". No allowance has been made for tax deductions of interest payments, depreciation or other costs.

Don't forget the sunshine

Rather obviously, the amount of sunshine that falls on the solar panels is going to have a big bearing on the final result. For this I used data from my own solar power system. Melbourne's eastern suburbs are hardly Australia's sunniest spot, but my panels have a clear northern aspect with no shading from trees or chimneys. The output figures from my system also take account of the fact that the panels don't get cleaned very often - usually only when flying foxes have been feasting in a nearby Lilly Pilly tree. (They seem to "unload" just after take-off.)

Again to be conservative, I averaged the output over two years. The second year was the wettest on record, and power production was down 8.7% compared with the first year. The annual production per kW of system size was1,291 kWh. If you live in sunnier parts of Australia, your solar power costs will be less than I've shown below.

Still with me?

Great. We're nearly there.

The various assumptions were fed into a spreadsheet to come up with the cost per kWh spread over the assumed life of the system. See the last page for the example of a 2.2 kW system paid for by "borrowing" at a real rate of interest of 2.5% pa. This is equivalent to withdrawing funds from a high interest bank account to pay for the system. At this rate of interest, the "repayments" over 20 years for the initial cost of the system would be $762.84 per year. In the 21st year the inverter is replaced at a cost of $2,700 in today's dollars, and the "repayments" drop to $173.20 per year.

Over 20 years the system is estimated to generate 53,973 kWh for a total cost of $15,256.75 (20 x $762.84), giving a cost of $0.283 per kWh (28.3 cents per kWh).

Over 40 years the system is estimated to generate 98,791 kWh for a total cost of $18,721.80 ((20 x $762.84) + (20 * 173.20)), giving a cost of 18.9 cents per kWh.

The real cost of solar power

The calculations were repeated for systems of different sizes, at real funding rates of 0%, 2.5% and 5% pa, and for lifespans of 20 and 40 years.

For comparison, major electricity retailers are currently quoting prices in the range of 19-29 cents per kWh for power from the grid. For customers with dual rate or "smart" meters, a lower rate of 10-12 cents per kWh applies to power used between 11 pm and 7 am or at weekends, not times when solar panels are doing much.

2.28 KW system

Initial cost: $11,892 installed, new inverter after 20 years: $2,700 (today's dollars)

Real finance rate	20 years	40 years
0%	22.0 c/kWh	14.8 c/kWh
2.5%	28.3 c/kWh	18.9 c/kWh
5.0%	35.4 c/kWh	23.7 c/kWh

4.94 KW system

Initial cost: $23,750 installed, new inverter after 20 years: $3,700 (today's dollars)

Real finance rate	20 years	40 years
0%	20.3 c/kWh	12.8 c/kWh
2.5%	26.1 c/kWh	16.5 c/kWh
5.0%	32.6 c/kWh	20.6 c/kWh

10.26 KW system

Initial cost: $45,000 installed, new inverter after 20 years: $6,500 (today's dollars)

Real finance rate	20 years	40 years
0%	18.5 c/kWh	11.6 c/kWh
2.5%	23.8 c/kWh	14.9 c/kWh
5.0%	29.7 c/kWh	18.6 c/kWh

It should be noted that in the case of the 40 year lifespan, with the main cost of the initial system being paid off over the first 20 years, the costs are much higher over that period. They then fall dramatically for subsequent years.

It's a tie

The take home message is that, over its lifetime and without subsidy, even a relatively small solar power system can deliver electricity that is competitive with the cost of grid power. Also bear in mind is that the cost of the solar power is locked in for the life of the system. The cost of grid power, on the other hand, is rising by substantially more than the inflation rate. In a very short time solar power looks set to go from "competitive" with the grid to "cheaper than the grid".

Extracting full value

If you can generate your own electricity for, say, 20 c/kWh instead of buying it from the grid at 25 c/kWh, then you're ahead. But what if you can't use all the power you generate? Extracting full value from your system then depends on how much your electricity company pays you for power you export to the grid (the feed-in tariff), and the proportion of power you use yourself.

Feed-in tariffs are a political hot potato at the moment. The amount varies from state to state, retailer to retailer, and many programs that pay a premium feed-in tariff are ending or under review. If you use most of the power you generate, or if you can get paid at least the generation cost of the power that you export, then solar will come out on top.

Another thing that influences the economics of solar power is how long you own the system. These calculations show the cheapest power comes over longer periods, but 40 years is much longer than the average length of home occupancy. In Australia this is around seven years. The question then becomes, can you get the buyer of your house to pay for the value of the solar power system? And how to you value it? Technically it is the net present value of the discounted future cash flows that it generates. Getting a buyer to agree to what that value is may be a challenge, but with solar power systems becoming commonplace, they may well become a factor in a home's marketability.

Just a reminder. These calculations were done using the full costs of quality systems. No reduction has been applied in relation to Small Technology Certificates that currently reduce out of pocket costs. Cheaper systems are also available and, if they go the distance, will provide cheaper power.

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Solar Power Actual Cost Calculator

System Size (kWp)		2.28
Initial cost		$11,892
Inverter replacement		$2,700
Initial cost per watt		$5.22
kWh pa per kWp		1,291
Annual panel efficiency loss		0.93%
Loan interest rate (% pa)		5.50%
Inflation rate		3.00%
Real interest rate (after inflation)		2.50%
Loan period (years)		20
System "life" (years)	***20***	***40***
Total power produced (kWh)	53,973	98,791
Total cost	$15,257	$18,721
Cost per kWh	**$0.283**	**$0.189**

Year	Output relative to year 1	kWh for the year	Loan repayment (initial system)	Loan repayment (inverter replacement)	Total annual cost	Cost per kWh for the year
1	100.0%	2,943	$763	$0	$763	$0.259
2	99.1%	2,916	$763	$0	$763	$0.262
3	98.2%	2,889	$763	$0	$763	$0.264
4	97.3%	2,863	$763	$0	$763	$0.266
5	96.4%	2,836	$763	$0	$763	$0.269
6	95.5%	2,810	$763	$0	$763	$0.271
7	94.6%	2,784	$763	$0	$763	$0.274
8	93.7%	2,758	$763	$0	$763	$0.277
9	92.8%	2,733	$763	$0	$763	$0.279
10	92.0%	2,707	$763	$0	$763	$0.282
11	91.1%	2,682	$763	$0	$763	$0.284
12	90.3%	2,657	$763	$0	$763	$0.287
13	89.4%	2,633	$763	$0	$763	$0.290
14	88.6%	2,609	$763	$0	$763	$0.292
15	87.8%	2,584	$763	$0	$763	$0.295
16	87.0%	2,560	$763	$0	$763	$0.298
17	86.2%	2,537	$763	$0	$763	$0.301
18	85.4%	2,513	$763	$0	$763	$0.304
19	84.6%	2,490	$763	$0	$763	$0.306
20	83.8%	2,467	$763	$0	$763	$0.309
21	83.0%	2,444	$0	$173	$173	$0.071
22	82.3%	2,422	$0	$173	$173	$0.072
23	81.5%	2,399	$0	$173	$173	$0.072
24	80.8%	2,377	$0	$173	$173	$0.073
25	80.0%	2,355	$0	$173	$173	$0.074
26	79.3%	2,333	$0	$173	$173	$0.074
27	78.5%	2,312	$0	$173	$173	$0.075
28	77.8%	2,290	$0	$173	$173	$0.076
29	77.1%	2,269	$0	$173	$173	$0.076
30	76.4%	2,248	$0	$173	$173	$0.077
31	75.7%	2,227	$0	$173	$173	$0.078
32	75.0%	2,207	$0	$173	$173	$0.078
33	74.3%	2,186	$0	$173	$173	$0.079
34	73.6%	2,166	$0	$173	$173	$0.080
35	72.9%	2,146	$0	$173	$173	$0.081
36	72.2%	2,126	$0	$173	$173	$0.081
37	71.6%	2,107	$0	$173	$173	$0.082
38	70.9%	2,087	$0	$173	$173	$0.083
39	70.2%	2,068	$0	$173	$173	$0.084
40	69.6%	2,049	$0	$173	$173	$0.085