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DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Being green and spending green - the trouble with rooftop solar

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*This is a guest post by **kiashu**, who also blogs at GWAG.*

This article looks at domestic solar power in Australia, asking: *is it worth it?*

It does not talk about large-scale solar systems, but focuses on *grid-connected solar photovoltaic cells on a home's rooftop*. The article looks at it from the perspective of the one who actually decides whether or not to install it: the homeowner. It may or may not be worthwhile from the point of view of society as a whole, but at present the decision is up to the person who owns the house. This article came about from my own research as my household, here in Melbourne, considered getting a rooftop solar photovoltaic system. In the end we've decided not to.

There are several things to consider: vanity, society, systemic, security, environmental, and financial. But first some background.

BACKGROUND

Photovoltaic cells convert light to electricity. Obviously, they produce electricity only when there's sunlight, and more or less depending how high the sun is in the sky and how overcast it is.

Photovoltaics produce a direct current which can go straight to recharging batteries, or to devices which use direct current like any battery-driven device, some specially-designed refrigerators, etc. Most household appliances use alternating current. Thus, with the solar PV must come an inverter, which changes the direct current to alternating so that the household appliances can use it.

In a stand-alone system, such as is found in outback Australia, the house isn't connected to the electricity grid, and so they have banks of batteries to store the energy generated during the sunny days. In a grid-connected system, the house draws power from the grid normally, but the electricity from the cells goes to the grid, too. In practice, the cells generate more electricity than the household uses during hot afternoons, and the house draws from the grid the rest of the time. The standard installation for a grid-connected system includes the solar panels, the inverter, and a new electricity meter; it does not include batteries.

The major obstacle to widespread use of photovoltaics is the cost. A grid-connected 1kW system might be around A$17,000 all-up. Various federal and state governments have offered rebates and encouragement to lower this cost; these will be discussed in the "finances" section. Apart

from ordinary politics, the purpose of these is to ease the peak load. If a region normally uses at most (say) 1,000MW of power, but then on a hot summer's afternoon uses 1,500MW, the region must have 1,500MW of capacity in its power plants, or buy the energy in from another region. As well as the expense of new power plants or energy importing, the various power lines have to be tougher, too, so this means more infrastructure and maintenance, etc. That's a lot of expense and hassle for what might only be 7 days a year when that peak capacity is needed. Enter photovoltaics - they produce the most power at the same time as the peak demand.

There are some rebates for wind and other forms of generation at the domestic level, but since most of Australia's population lives in relatively sunny and dry areas, the focus of efforts so far has been on solar.

VANITY

If you're a person with a greenish tint around the edges, it'll feel good to have solar panels on your roof. What the SUV or iPhone is to the yuppie, solar panels are to the greenish middle-class. I don't see anything wrong with this, if we did nothing for ego and image, we'd be a much grubbier-looking people. It's a statement of who you are and what you believe is important, and it feels good. Part of making a statement is having somebody listen - society.

SOCIETY

Between fossil fuels running short and their extraction and burning causing various kinds of harm to the world we live in, whether civil war in Nigeria and Iraq or global warming, it's plain that we can't keep burning so much of the stuff forever, and eventually we must burn none at all. However, people are reluctant to accept this. In physics, inertia is the tendency of an object to keep moving at the same speed and in the same direction as it was going unless it's acted on by an outside force. Societies have a kind of inertia, it can take quite a bit to make them change.

We ought not to overestimate this, however. As Solnit writes in "Revolutions per minute",

"Sex before marriage. Bob and his boyfriend. Madame Speaker. Do those words make your hair stand on end or your eyes widen? Their flatness is the register of successful revolution. Many of the changes are so incremental that you adjust without realizing something has changed until suddenly one day you realize everything is different. [...]

"Although we typically associate revolution with the sudden overthrow of a regime, the Industrial Revolution was an incremental change in everyday life and production that began a little over two centuries ago and never ended. [...]

"The fantasy of a revolution is that it will make everything different?and regime-changing revolutions generally make a difference, sometimes a significantly positive one?but the making of differences in everyday practices is a more protracted and incremental and ultimately more revolutionary process."

The idea that we must burn less fossil fuels today, and one day we will not burn *any fossil fuels at all* is a radical idea. It's so radical that many people say it's impossible, insisting that easy oil reserves are sitting around waiting to be discovered, that we must await some technological breakthrough to use renewables in any significant way, that we'd have to "live in caves" to do it, or that if we even *try* to do without fossil fuels there'll be a "dieoff", or that it can be done in principle but we don't have enough time and the attempt to build the infrastructure will be the final burst of carbon dioxide that pushes us over the edge into catastrophic global warming.

The social benefit of having solar panels on your roof thus becomes clear: *it makes the radical seem ordinary*. If you walk along a street and half the houses have the blue shiny panels on them, it's hard to keep thinking change is impossible. They start to seem rather mundane - boring, in

fact. When the radical seems ordinary, we stop objecting to it and standing in its way, and usually claim we supported the idea all along. If I want to effect social change in the direction of *let's burn less stuff*, solar panels on my roof seems good.

SYSTEMIC

As noted earlier, power generation and grid capacity must be kept at a level which can match the highest demand placed on it, even if that demand only shows up a few days a year and is normally much less than that. That's a lot of expense and hassle. Here in Melbourne we've experienced a failure of generation and grid capacity to meet demand, suffering blackouts of a few days as large supply lines or power substations went down from overheating, leading to mass train cancellations and many other disruptions.

In Australia, peak demand happens at the same time as peak generation of rooftop solar. Thus domestic rooftop solar seems a good solution to the problem of our hot days, as it lessens the demand on the large power stations and the grid as a whole. It has a systemic benefit - helping prevent the system from breaking. Of course there is a cost to this, but already we pay taxes to help the system as a whole avoid breaking, at least in this case we'd be choosing exactly what our money goes on.

SECURITY

In 1998 alone, Melbourne lost natural gas supplies for about two weeks, the Auckland CBD lost electricity for some five weeks, and Sydney's water supply became undrinkable. There are many other cases of interruptions to supply due to poor maintenance of infrastructure in our region. It seems reasonable to expect that in a decade of living in a home, we may lose supply of a single utility for up to 28 days, and of all three utilities for 2-7 days. Thus, it seems prudent to have your own gas bottles, water tanks and electricity supply that can keep you going for one to four weeks, though obviously at much reduced consumption.

Unfortunately, a *grid-connected* system on its own does not improve our electricity security. We have to have a battery system for that, and it's not a standard installation, costing about another $2,000. More in the "finances" system.

ENVIRONMENTAL

The greenish Westerner wants to live relatively lightly on the Earth, to have the least impact they can while still having a decent standard of living. Here in Victoria, we have the dubious distinction of having the dirtiest power station in the industrialised world at Hazelwood, built from 1959 onwards.; it emits about 1.58kg CO_{2e} per kWh [source: *Hazelwood West Field EES La Trobe Planning Scheme Amendment C32*, Independent Planning Panel (2005)], compared to more typical numbers of 0.8-1.3 kg CO_{2e}/kWh for other coal-fired stations. In Melbourne in 2003 the average household consumed about 6,265 kWh of electricity, which would thus cause about 9.9t of emissions if all got from Hazelwood.

However, we're not obliged in our households to buy this power. We can put up solar panels, or we can buy renewably-generated electricity from our retailers.

The federal government has set up a Greenpower accreditation system. Basically, any renewable power created since 1997, and not involving the burning of native forest or reduction of environmental flows to rivers is counted. We have a privatised electricity system - one company

will own a power station, another will buy wholesale electricity from it, and a third will retail sell that electricity to industry, commerce and households. Households can ask their electricity retailer for renewable electricity.

Now, if the household buys renewable energy, that does not mean the company sets up a special power line from the wind turbine to the home. It just means that if during the year the household buys (say) 6,000kWh of electricity from the retailer, the retailer must buy 6,000kWh of electricity from the owners of the wind turbine. The particular electrons you get may have come from Hazelwood, from the Snowy hydroelectric project, from your neighbour's rooftop solar, or some mixture of those; but your money goes to support the renewable energy generation.

Naturally, if more people ask for renewable than is being produced, the price of renewably-generated electricity will rise, and more companies will build renewable energy. That is, if say 20% of generation is renewable but 25% of consumption is from people buying GreenPower, they'd have to build another 5% of generation. Currently, this is not the case; demand for GreenPower is less than supply, as I wrote in green states and brown. The most recent Greenpower report [2Mb pdf of 2008-Q4] tells us that there were 476,762MWh of GreenPower sales in 2008-Q4; if this were annual, it would be 1,907,048MWh, or 1.9 billion kWh. The federal government's Mandatory Renewable Energy Target includes 9.5 billion kWh generated by 2010 and 45 billion kWh by 2020, compared to total 2007 consumption of about 240 billion kWh. So the household demand is considerably less than the current supply of renewable energy; this is probably because it costs more.

On the other hand, household electricity consumption as of 2006-7 is only about 231 PJ, or 64 billion kWh, and 2008-Q4's GreenPower consumption was a 37% rise on 2007-Q4.

The GreenPower-buying households are subsidising the non-green majority, but the GreenPower buyers are increasing rapidly. If renewables are installed quickly enough to meet the 2010 and 2020 targets (about 25% rise annually), and if demand continues rising as quickly as in the past few years (about 35% annually), demand for GreenPower will exceed supply in 2020. That is, government regulation and subsidy drive the growth in renewables to 2020, and the market drives it afterwards. I don't know if this is a fair assumption, but it seems to be the government assumption.

It's clear that either buying GreenPower or installing solar panels on your roof will have less environmental impact than simply buy standard coal-generated electricity. But it's not clear that having solar panels on your roof is any more or less environmentally-friendly than simply buying GreenPower from your retailer. In general, economies of scale will mean that a single large power station, whatever its power source, will have less emissions per kWh than many smaller power stations - for example on your roof. Would 1,000 1kW rooftop solar units have more or less impact than a single 1MW unit out in the countryside somewhere? Logically, they'd have more impact, needing more wires and inverters and maintenance and so on per kWh generated. However, I know of no formal study examining this in detail.

In sum, the environmental case for GreenPower *or* rooftop solar against conventional power is clear; which of the first two is better isn't clear.

FINANCIAL

We have established that a greenish person will want to get their electricity renewably, and will contribute to grid stability by having a rooftop solar photovoltaic installation, with the environmental case being strong for abandoning coal, but undecided for GreenPower, and that security of supply can't be had with a standard installation as it lacks batteries. But how much does all this stuff cost, and will it pay for itself?

Buying electricity retail

Conventional electricity retails at (including sales tax) A$0.18469/kWh, and wind-generated electricity adds a tariff to bring it to $A0.23969/kWh. There's also an A$174.90 service charge which we have to pay regardless of how much or little we use, so we can set it aside as a cost for the moment. The retail figures thus give us a baseline to judge the worth of the solar systems - how long before they generate enough electricity to pay for themselves?

If you have a rooftop solar system, each quarter they add up all the electricity you imported from the grid, and subtract all you exported into it. If you used more than you generated, you pay the same retail rate for the rest. In Victoria there exists a net feed-in tariff, so that if you generate more than you consume over a quarter, you are paid A$0.60/kWh for it.

A third consideration is that with fossil fuels peaking, countries considering various kinds of climate change avoiding/mitigating treaties, and a water shortage in Australia, we can expect that electricity will only get more expensive. Generating your own insures against retail consumption price rises, though does not insure against service charge rises.

The system and its retail cost

A typical household will be able to fit 1k-3kW of panels on the rooftop; a typical 175W panel is 1.3 x 1m and weighs about 16kg. Obviously a north-facing roof is needed to get a good output of power, and with the typical pitched roof this means only a quarter the area is available to use, so few people will be putting 5kW systems up there. I don't want to be seen as endorsing any particular company, but a websearch will show that the retail cost of solar panels in Australia is $10-$15 per Watt once you're in the kW range. So you're looking at $10,000 to $45,000 for the 1-3kW.

The inverter comes next; the larger the capacity of the panels, the tougher the inverter needs to be. This is not very big, around 60cm x 30cm x 20cm and a few kilograms, though bigger if it must be outside and waterproofed, or inside and silenced (they give out a "hum" like transformers in the street) and is usually another $2,000 or so.

Lastly there's the meter: conventional electricity meters are designed only to measure power going one way, so a "smart meter" must be installed. Typically the solar panel company has nothing to do with this, and the customer must get their electricity retailer to do it. Enquiries with my own retailer told me,

"The cost of a new electricity meter is approx $180 for single phase or $315 for poly phase meter. This is charged directly by your electricity distributor. There will also be a truck fee of $290. This will be passed through to you on your electricity bill from the electricity distributor. If your electricity box is not up to relevant electricity standards [ie is more than 25 years old], there will be a cost to upgrade. This cost could be up to $1500."

Thus, $500-$2,000 for the meter. It's notable that unless you spend $250 on a "site inspection fee", you cannot know exactly what it'll cost to change your meter over. It's a gamble.

If you want a stand-alone system, you'll want some batteries. A battery holding 5-10kWh worth of energy will retail for around $2,000.

Labour is typically folded into the retail costs. There are other expenses to push things up. For example, if you have a tiled roof, the panels require extra supports, which adds $150-$400 to the cost.

In all, taking we could be looking at $15,900 for a grid-connected 1kW solar system without rebates, or $17,900 for the same with battery backup for security.

The rebates and retail cost

The federal government offers $8/W as a rebate, with a minimum of 450W and maximum of 1,000W. In practice, nobody bothers installing anything less than 1kW. Essentially it's $8,000 off your 1kW system.

There also exist renewable energy certificates. For each 1,000kWh of electricity expected to be generated over 15 years, a certificate is issued. This REC may be bought and sold, and companies buy them to fulfill their renewable energy targets. For example, Hazelwood power station can be considered 20% renewable if it buys enough RECs. When installing rooftop solar PV, typically the householder surrenders their RECs to the installer who then sells them. This drops another couple of thousand off the price of a system.

Thus the panels and inverter cost of around $14,500 drops to about $4,000; the cost of meter and any extras remain unchanged. The capping of the rebate at 1kW means a big jump in price from a 1kW to a 1.5kW or larger system. Thus 1kW systems appear to make up the bulk of the market.

Last year the rebate system was too successful, with the federal government having to pay out more rebates than it had budgeted for. In response they put a means test on it; if the household earned more than $100,000, they couldn't get a rebate. In practice this removed a good chunk of the rooftop solar market, as even with all the rebates and RECs, it was still several thousand, and households with an income of less than $100,000 aren't likely to have several thousand to blow in one go. After June 30 2009 the rebate will be abolished entirely, and a higher price put on the RECs instead. It's expected that this will cause the cost of a typical 1kW system to rise about $2,000-$3,000 (see the website of any rooftop solar installer for quotes before and after 30/06/09.)

"Buy now!"

This imminent price rise has caused a surge in demand as people who were humming and hawing over getting the system in a rush to do it before it gets too expensive. Companies have responded to this by buying solar photovoltaic systems in bulk from China and Germany. The bulk buying has let them get the things cheap.

A typical offer from a long-established power company is $4,000 for panels and inverter for a 1kW system. New companies have offered systems of $2,500, and there is even one offering it for *free*. Generally, you pay the listed price, with the $8,000 rebate and the RECs being paid directly to the company. In the case of the "free" offer, you pay $8,000 and then the federal government pays you back later; so even though it's "free" you still have to have $8,000 spare for a few months.

While researching this I was of course initially quite attracted to the cheaper companies. However, I noted that no history could be found for these companies; they appear to be quite new. What happens to them once the big rebate ends and their market shrinks? A consideration in any large purchase is the **warranty**. Most companies offer a 25 year warranty for rooftop solar. If my $20 toaster conks out after month, I simply swear a lot and buy another one. If my $4,000 rooftop solar fries out after a couple of years, it could cost in the thousands to get fixed, so I want them around to honour their warranty.

Thus, for the price today, the smaller and new companies look good, but it could end up costing us *more* in the long run with repairs after a dishonoured warranty. It could be worth the extra $2,000 or so to know that they'll still be around ten years from now.

Payback time

A 1kW system in the Melbourne latitude and climate we can expect to generate around 1,825kWh a year, or 5kWh/day on average. around 3kWh/day in winter and 8kWh/day in summer. The

average Melbourne household with its 6,265kWh of consumption, or 17kWh/day (generally about 14kWh/day for households with gas hot water and cooking, and 21kWh/day for all-electric households), will almost *never* generate more than it consumes; the net feed-in tariff of A$0.60/kWh can be forgotten.

However, it's possible for a household to reduce this consumption. We can use cool drinks and fans not airconditioning, jumpers and hot drinks not heating, hang washing out to dry, change to CFLs and pull plugs out on appliances not in use, and in this way get it down to about 5kWh/day (as my own household has done). But the net feed-in tariff is still a non-issue. With a standard 5kWh/day consumption, the 2kWh bought from the grid in winter (at conventional rates) would cost some $33, and the 3kWh/day exported in summer would earn $162, leaving $129 profit annually, which is not nothing, but not huge, and that level of export is easily wiped out by some airconditioning use. In usefulness, the net feed-in tariff is really for larger installations of 3kW and up.

In practice, we must simply calculate the dollar value of the electricity generated by a system.

1kW system, 1,825kWh/yr

Eq. conventional	$0.18469 $337
Eq. wind	$0.23969 $437

We can then divide its cost into the savings made to find the payback time. For the savings made I choose a middle figure of $400 annually; over the next decade we can expect the price of conventional electricity to rise by that sort of amount, and some people may prefer to compare rooftop renewables with retail renewables.

Below a table shows the initial cost of the 1kW system, and the resulting payback period. The minimum solar panel and inverter cost is *zero*, as I described above, but another $1,000 for reinforcing frames and meter changeover seems to be the minimum.

1kW system costs and payback

$1,000	2.5 years
$2,000	5 years
$3,000	7.5 years
$4,000	10 years
$5,000	12.5 years
$6,000	15 years
$7,000	17.5 years

I am told that in business a payback period of under 5 years is considered a certain thing, while more than 10 years it's dismissed without thought, since anything could happen in ten years, and that could change everything. Thus 5 to 10 years is where people become uncertain.

The $1,000 and $2,000 systems have payback periods of 5 years or under, *but* can only be got from companies we're not certain will be around in ten years. I don't know how much it costs to repair a typical solar panel fault, but when we had a blackout in February the bill was $275 just for the callout, so it seems safe to assume $1,000 or more is plausible.

About the cheapest you could hope for with a reputable and established company is $5,000 - $4,000 for the system, and another $1,000 for rooftop reinforcement, meter changeover and so on; as noted earlier, you usually won't know the meter changeover cost until the solar panels are already installed.

Thus, if you want a rooftop solar photovoltaic system, you can have a short payback period but with risk of further costs, or a decade-plus payback period but with certain costs.

CONCLUSION

Every householder must weight up the different considerations of vanity, society, systemic, security, environmental, and finance. Each plays into the other. For example, a standard grid-connected system offers no batteries, and thus no security of supply; adding batteries adds to the cost and the payback period.

For our household, our vanity was already satisfied by the other greenish things we did, and we felt they also made a social contribution. The systemic contribution would be small, and since we didn't plan on having batteries we'd have no security of supply. As for the environment, we already buy GreenPower, so it was not an issue for us. That left only the financial aspect - would we be financially better off?

The system may or may not repay itself in increased real estate value. Too few households in the country have solar panels for us to be able to tell; it seems reasonable to assume that every extra thousand on improving a house adds a thousand to its value; it could be more but we don't know. In any case we expect to be living in our house, not selling it, nor will we use our mortgage as a low-interest-credit-card, so whether it's worth more or less doesn't matter to us.

Taking the expected cost of $3,000-$5,000, a return of $400 annually on that is a decent rate of 8-13%. However, we are halfway through our mortgage, so we had to consider what $3,000-$5,000 now could do in avoided interest payments. The net gain is thus 2-5%, depending how interest rates go over the next decade. That's not much on inflation, and so we expected *effectively zero financial gain* from installing rooftop solar.

As the other considerations were for us not issues, and as we expected zero financial gain over the next decade from installing them, we decided not to. We'll continue buying GreenPower, and leave building renewable energy generation to big companies.