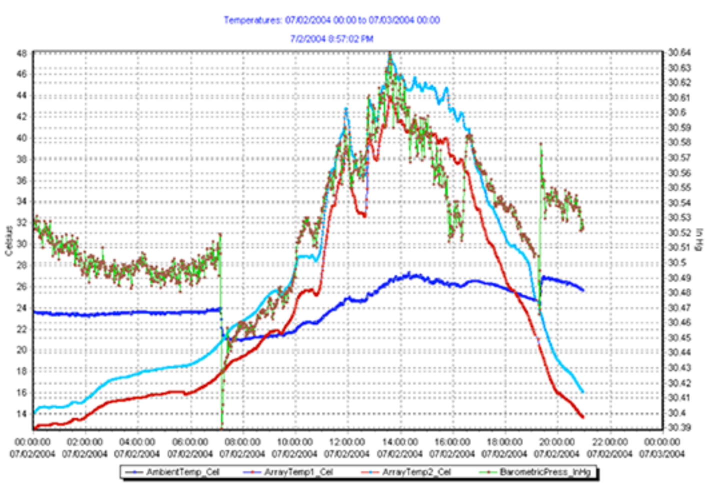
SOLAR - AND TURNING WASTES INTO NEEDED CLEAN INPUTS

WE ARE SOLAR POWERED




Instead of lawn: Edibles.

Many solutions in WilderHill Indexes are ideas we not only address in theoretical sense but also utilize everyday. We believe practical knowledge-gained can assist in discussing eco-solutions and sustainability ahead. For example we are intimately familiar with how solar, electric cars, and efficiency can be sensible today. This is more than theoretical; at our 1-acre San Diego and second site we utilize several systems to:

1. generate electricity;
2. harness solar power to run electric vehicles;
3. change wastes to needed inputs; and
4. grow foods, and prevent pollution.

2011 SolarSense Report - still a vision for tomorrows!

Completed in 2009, this SolarSense system makes great sense. Arguably solar-cars - with 100% renewable green transport is a compelling idea that ought to be scaled up rapidly. Not only because of climate change, sea-level rise and ocean acidification that's underway, not only because it's both smarter and cheaper than reliance on fossil fuels, consider this is now a solution that makes sense in its right. One way to do so soon will be with small, lightweight and most importantly very inexpensive EVs - including radically innovative simple 2-wheel, 3-wheel, and 4-wheel designs given that upfront costs of solar have been falling dramatically.

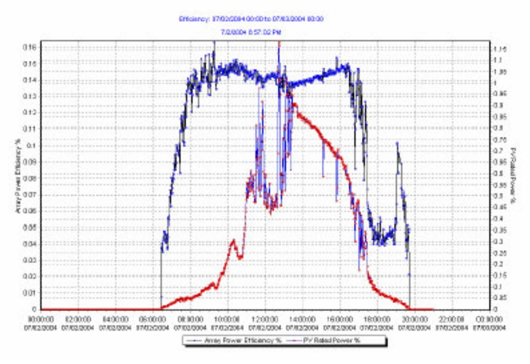
To visualize combining solar panels with electric cars, arguably a better solution for powering both transport and buildings, start with the solar. For generating our power we are harvesting considerable electricity from the sun using PV (PhotoVoltaic = electricity generating) panels. Totaling 6.65 kilowatts (kW) these are 'grid-tied' meaning this building is connected to the grid; during daylight we generally make much more power than we consume automatically 'selling' power to the grid.

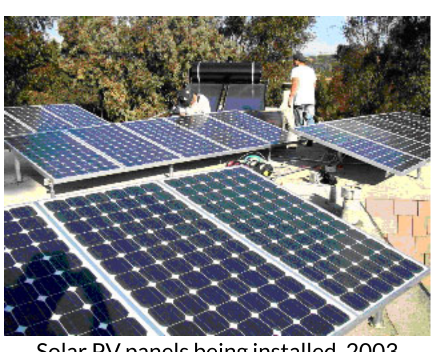
At night it's reversed; we 'buy' power from the grid - our meter runs the opposite way. Grid-interconnection simply means we're able to avoid cost of batteries while it allows for rebates from the State of California. Also using the grid leverages and increases value of PV. Overall in terms of costs, solar PV has performed well in cost/benefits, its return on investment, and in actual practice.

First phase was 3.85 kW of PV calculated to achieve payback in approximately 10 years and was installed in 2003 (solar PV system costs). A quick payback was mainly due to *California State solar subsidies, and *Time of Use (TOU) metering by our utility. Certainly upfront costs for the system were significant. However we estimate after generating solar power for 10 years, we've recouped full return on investment. Thereafter most electricity here including 'fuel' for our electric vehicles (EVs) is at no charge. That stability contrasts well with highly dynamic utility rates that usually go up over time; instead this smartly will go on making power for years to come. Solar panels are the main cost and carry a manufacturer's Limited Warranty of 25 years - notably a longer panel life is expected, given the performance of old panels in service for decades. (The two Inverters carry a shorter life and will need to be replaced). We expect to see years of profitable PV operation and feel without any undue sentiment, that this can be a sensible return on investment.


Solar Carport Powers our Vehicles


Solar Carport also provides Shade




Solar PV panels being installed, 2003


Prototype of Tesla Powerwall, 2013

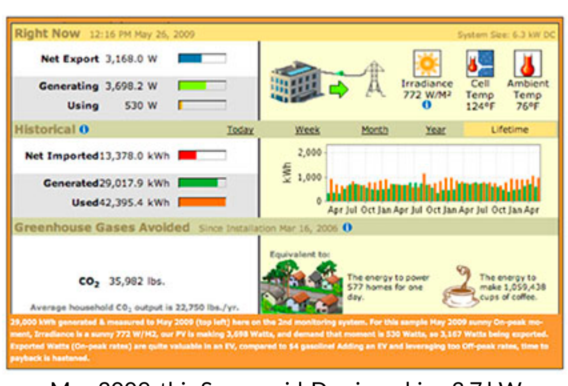

Converted to Hybrid/Solar Electric Power

We first installed 21 new 185-watt PV panels (see spec sheet) with then high 14.2% module efficiency to get most use of flat rooftop space. Those panels made in the USA were at that time among the most efficient consumer PV, with a power dense monocrystalline design. Monocrystalline panels were matched in 3 strings to a 3,500 watt inverter (along with two web-based real-time monitoring systems) in one of the first such applications then in California. We later added 24 surplus multi-crystalline PV panels built in 1999 rated at 120 watts each, choosing a passive inverter design. Latter panels + that 2nd inverter were rated 2.8 kW; total production for both Phase 1 & Phase 2 systems delivering 6.65 kW overall.

As illustrated by monitoring data in detailed graphs, we readily obtained module efficiencies ~5% to 10% over manufacturer rating.

Importantly since 2003 inception of this solar PV, it has provided us about 24 kWh (kilowatt/hours) per day of electricity. This 24 kWh per day is an amount we think of as "One Sun" and is relevant with addition of our electric cars below. It's also an average. We will see for instance more on longer, typically sunny, non-foggy days of late Summers & Fall. Conversely on shorter Winter days, or on any cloudy or foggy days, solar production will be very substantially less.


Ground mounted poly PV.



May 2009, this Sunny mid-Day is making 3.7 kW while using just 0.5 kW; sending 3.1 kW to the grid.

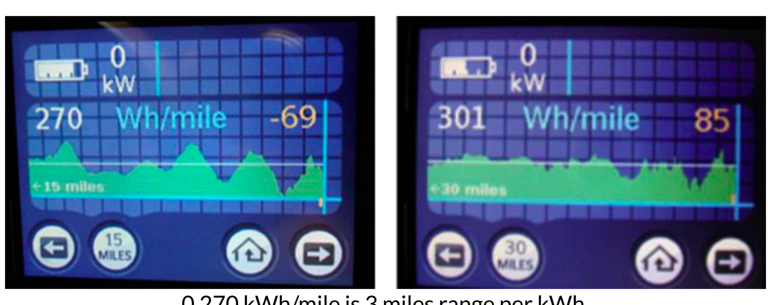
Similarly fuel costs actually go down towards zero over time when combining PV with virtual 'solar-powered' electric cars in transport, contrasting highly favorably with gasoline. Moreover this 'solar EV' needn't be slow like a gasoline-car (a "gasser"); not only does the EV avoid all oil changes and maintenance of a gasser, it can be considerably better and more fun to drive as well.

As noted we make about 24 kWh over an average day and call this 24 kWh/day, 1 Sun. Break that one Sun down over 24 hours, and roughly 1 kWh is being made each hour; we call that 1 kWh per hour one "sol". Two hours is thus 2 kWh, or 2 sol, etc. With a very fast electric vehicle (EV Phase 1) we get about 3 miles of range from each kWh of sun in our typical driving mix (we get 0.330 kWh/mile). Thus 1 sol = 3 miles range.

Simply, 24 kWh/Day means we can drive this car roughly 72 Miles Per day from Sunlight alone. Thus it has a range of 72 Miles Per day of Sun. Translating how far you can go from off sun power alone, and seeing it's 72 Miles Per Sun (MPS) or 3 miles per sol (3 m/sol), may feel more intuitive and simply more elegant than oily old MPG.

Some days however it's very cloudy with peak-measured irradiance under 100 W/M2 or under 5 kWh all day. Solar making under 5 kWh on a cloudy, or Winter day means the MPS figures for our cars then go very low the other direction indeed. Also without any subsidies, it's clear that both costly solar PV, and EVs have in the past been uneconomic. But as they grow in use, improve in performance and real costs come down fast, their calculus changes dramatically.


2008 Solar-powered Car: fast and fun!



0.270 kWh/mile is 3 miles range per kWh.
Thus only one sunny day can give this car 72 miles of range by the power of the sun.

Besides the solar PV that we use for electric power and transportation, avoiding much utility electricity and gasoline, we are using two different solar water heating systems. Both are thermal and rely on collecting and focusing the sun's warmth to heat water. First there's a small primary system that's completely passive. A larger secondary system uses an efficient multi-speed AC motor pumping motor (powered by PV arrays+inverters).


2003 smaller, passive thermal water heating.


2011: monitoring free Power made & Distance Traveled per sun in 2nd Solar car.

As important as is energy made by renewables, attention to demand is just as vital. Clever reduction in use delivers results from the very start; it's here that inexpensive, effective and readily worthwhile steps can first be taken. We thus monitor our demand in real time - since it's as useful to reduce need in the first place - as it is to make all energy renewably.

Solutions can be brilliantly simple. Passive building designs can for instance better heat and cool at very little cost. Or substituting in LEDs, in place of hot incandescent bulbs helps mitigate the need for cooling brought on by inefficient bulbs in a first place. One large lighting structure is rated by its manufacturer at 720 watts: by installing efficient bulbs we consume ~80% less power for similar light - and avoid unwanted heat.

Demand-side reduction can take many paths: think of hybrid solar/electric bikes; a digital thermostat adjusting heating to precise time of day; retractable awnings letting sun in cool hours or shading when hot; energy efficient appliances; multi-speed pumps etc. Each is a small step, but together they can add up to a larger difference.

For efficiencies yet farther afield, we seek smarter solutions in green waste & water-use. For instance we compost green waste, and have tasty vegetable gardens in an area once covered by water-thirsty, nonproductive lawn. Instead of just grass, there's now abundance. Efficiency once started is rewarded, and often doesn't end at shores of energy alone. Even small efficiency steps may yield a big difference as gains snowball. You can easily even find yourself looking back & thinking, why didn't we do that before?!

WILDERSHARES
info@WilderShares.com
760.634.1358
2240 Encinitas Blvd., Ste D-30
Encinitas, CA 92024

Gas Expensive? Here's a better Solution: Cars Powered by Sunlight
Dr. Rob Wilder. August 2011. Please feel free to distribute.

Your comments and suggestions are welcomed: **rwilder@wildershares.com**
http://www.wildershares.com/pdf/Solar_Power_for_a_Better_Solution.4.2011.pdf

Electric cars powered by free sunlight may sound totally unrealistic - or decades away. It's perhaps remarkable then to note they're here today: we drive a suncar daily. Given a high price for gas, practical new cars that could be powered by the sun might be attractive. What seemed far off could become ordinary, sooner than expected.

Solar not only for buildings, but realistically 'fueling' cars too would be profound change. This report looks at tying photovoltaics (PV) to electric vehicles (EVs). Costs/benefits have worked out for us as early adopters, and as costs drop, this concept might be embraced. That will mean U.S. jobs, patriotic self-reliance and greater independence.

Our experiences with 2 cars are detailed here: a 2008 fast roadster using sunlight for its fuel, and 2011 4-seat sedan running on ordinary power for an easy alternative. We've found that in both cases they're more economical to drive, than *any* car on gasoline!

It's not pie in the sky. Our newest sedan was $20,000 with credits and driving is a bargain. For 5 pennies per mile on power from the wall, it's even better value to drive than fuel-efficient 40 MPG gasoline cars (or 'gassers'). This sedan is enjoyable, its affordable and an every-day driver. For an example for looking at EVs alone — without the solar — we've kept costs and benefits of solar entirely out of the sedan's discussion.

Better yet our 1st EV solar roadster (below) uses zero-cost sun in essence for its fuel. Simply being driven thanks to *not* buying $4 gas, it paid us back $15,500 worth of solar. The sun has nicely made our roof 'fueling station' now *free*. We'll go on enjoying free fuel for this car, plus have much free electricity for this building the rest of our lives.

Please excuse a rather personal nature of this story. We just feel compelled to relay with some pride that solar *can* work for cars & buildings. Yes, issues must be overcome before broader adoption including high upfront costs, need for government subsidies, & range limits. But this idea works. Looking ahead it could grow American self-reliance, save on peoples' bills, plus become great fun to boot. We invite you to read on!

Solar on our roof quickly paid for itself on $4 gas, & with today's high Utility rates. Solar plus 2 electric cars means we don't stop at gas stations, we save money, and needn't worry about imported oil – and if adopted in numbers they would mean a stronger America.

To start with our own driving pattern is pretty typical. We drive some 30-40 miles per day on average. Our 2008 roadster (orange car, above) has a range of 200+ miles per charge and so can go much farther than needed, plus we recharge nightly. But the most fun is in its performance that's roughly comparable to a Porsche Turbo or fast Corvette ZR1.

As we detail the sun has paid us back all costs of our 6.5 kilowatt (kW) rooftop solar; it makes on average about 72 miles worth of electric 'fuel' per day. That's more than enough juice for this car, plus for some of the building too — in summers & fall it's enough juice for this roadster plus it can at times power this building entirely.

Our sedan too highlights value of EVs over gassers. Ignore the (free) solar here a moment. Charging it straight from a wall even on high electric rates here in San Diego costs about 5 cents per mile of driving, half the cost of a 40 MPG 'gasser'. And with the better electric rates in much of the U.S., it might be 1/4 the cost of driving a gasser.

Thinking of typical U.S. electric rates and driving 35 miles a day: this sedan would cost some $1.50 per day for all its 'fuel', or $15 every ten days. Compare that **$15** for fuel, to roughly **$70** one may spend filling at a pump every 10 days or so in a 20 MPG gasser. Or observe we pay the equivalent of about $1 per gallon *or less* in the sedan, and zero dollars per gallon(!) now in the roadster. It's easy to move off gasoline, and up to EVs!

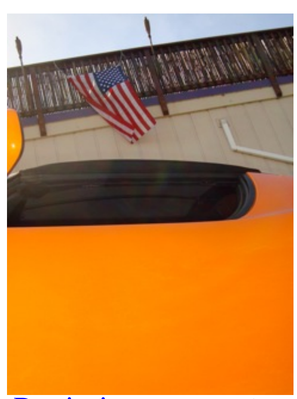
Charging from a wall, or running on sun, EVs can chip away at longtime energy fragility. To simply add solar fuel can be so sane, it challenges years of inertia and assumptions in the U.S. about how we should best fuel our cars, and power our buildings.

That said we mustn't ignore the fact there's terrible obstacles to this today. Our fast roadster had cost too much for a typical car; our affordable sedan has far too-little range to be a 1st & only-car. Plus the upfront $ costs for PV largely remain prohibitive today, while sub-zero temperatures are ill-suited still for today's EVs and batteries.

So it's by no means certain PV+EV would grow ahead. They may even whither.

That said there's arguably real promise to this pair. We look at the practical aspects of harnessing the sun for buildings & cars. As we'll show, this first sun roadster is great fun. A 2nd oil-free sedan using the grid is still a smart choice even without solar. Either way this pairing could be an idea whose has come, and tomorrow be a solution at hand.

Our PV 2 added 2.8 kW more power to total 6.5 kW solar overall.



Patriotic ***fuel: sunlight for this car - not oil!***

Interior of the roadster: speed & fun in a 2 seater.

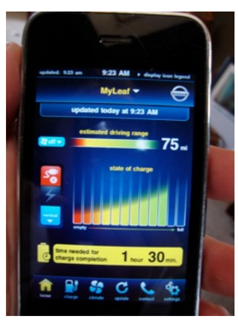
4 door sedan charging; roadster charging left.

Wall mount charger in rear.

Sedan's dash has advanced readouts.

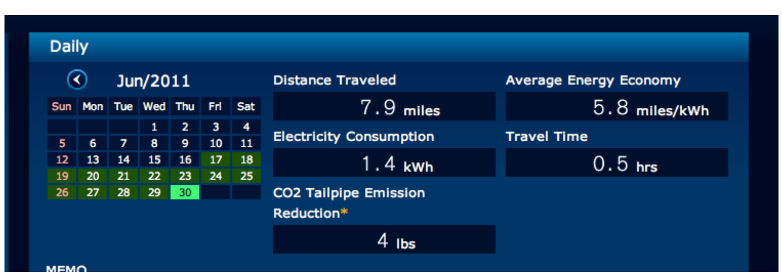
Cross between a Game, IPhone, and a Car!

Before sedan charge on IPhone app.



After sedan charge at 80% SOC.

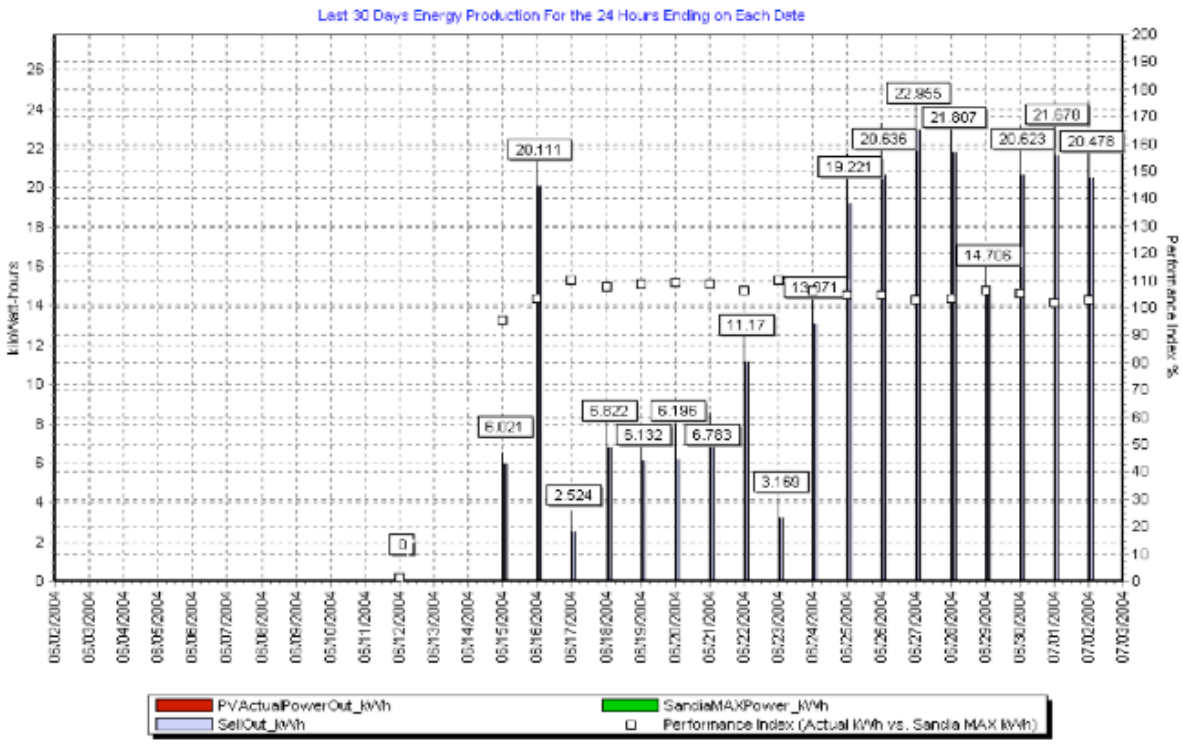
Dash: real-time energy use.



The sedan has a web portal for energy use by car, daily etc. But readouts for miles/kWh appear inflated, even if data are battery to motor only.

Phase 1 PV. The Photovoltaics: in 2003 we installed 21 new 185-watt panels with 14.2% module efficiency to get most from our limited rooftop space. Instead of more-affordable ***multi***crystalline PV, we chose USA-made ***mono***crystalline PV ("mono") panels with then-high efficiencies. It was paired to a 3,500 watt inverter, and a 1st then 2nd real-time web-based monitoring system. All nothing special today given recent PV systems, but it was rather unique then and among the first such applications in California.

As illustrated in detailed graphs those panels delivered efficiencies roughly 5% to 10% over manufacturer rating. Inverter efficiencies have also been measurably high. During the long, sunny days of summer and fall, we will make around 14 kilowatt/hours (kWh) per day from the Phase 1 PV alone. In the winter, spring and cloudy days, or anytime there is less irradiance (Watts/Meter^2), we will make much less per day:



Above: Daily energy output for 3.8 kW PV 1 in June/July 2004. Note daily production varies considerably depending on weather, as seen mid-June (cloudy overcast) compared to sunny early July. Average is near 14 kWh/day over June/July for PV 1. These data were gathered just after a 1st monitoring system was turned on, starting at mid chart, mid-June 2004.

Phase 2 Solar: Pleased with Phase 1 results, we next installed competing PV design by adding 24 **multi**crystalline ('multi') panels rated 120 watts each. We chose a differing passive inverter design. Phase 2 PV was rated 2.8 kW and so total ongoing PV capacity for both systems together is some 6.65 kW overall (we'll call it 6.5 kW).

Roof space gone, our Phase 2 multicrystalline panels were ground-mounted in 2 rows seen below, at greater inclination angle than roof PV. Ample space allowed us to optimize direction of (donated) ground panels for year round, an advantage over roof PV (but this ground area can be hindered at times by partial shading from our trees).

Phase 1 being installed on rooftop, 2003.
These make about 60% of our solar.

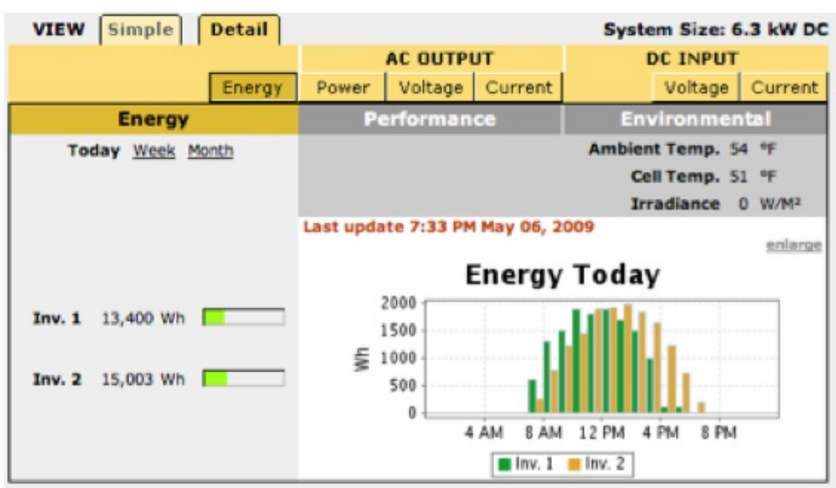
Phase 2 ground-mount poly, came next.
Here in 2011, all panels are going strong!

Phase 1 solar had cost $15,500 net for 3.8 kW – while Phase 2 panels were surplus donated by a University researcher so we couldn't figure costs here. We'll thus use only 3.8 kW from Phase 1 in the costs calculations below, though we produce 6.5 in total.

That roughly 6.5 kW combined solar PV was clearly enough power for the building needs alone. There'd been some daily water pumping early on, since eliminated — and it proved easily enough for our needs here, or for a small commercial office.

We were surprisingly pleased with these *multi*crystalline (or 'poly') panels of Phase 2. Back around 2000 we'd had a slight bias towards mono given higher efficiencies. But in a few short years poly panels narrowed that gap. They were achieving efficiencies greater than just a few years ago, and for much less $. PV technologies are fast evolving.

Relative performance is seen in a chart below for a typical day in May. Looking at ground-mounted poly going to Inverter 1 (**green**) – vs. rooftop mono to Inverter 2 (orange) — the output isn't much different. In mornings ground-mounted leads, rooftop peaks a bit later. While the roof made 15 kWh, the ground area was close at 13 kWh. Tree shading at times halts output (**green**) seen here at 4 pm (a photo is at the end of Report).



Output from ground PV, in green -- vs. from rooftop, orange: day in May.

Since installing systems 1 & 2 they're together making on average about 24 kWh (kilowatt/hours) per day of electricity from all 6.5 kW. That's roughly enough to meet the needs of many a small business, or a sizeable household. 24 kWh per day is an amount that we have come to think of as "One Sun"

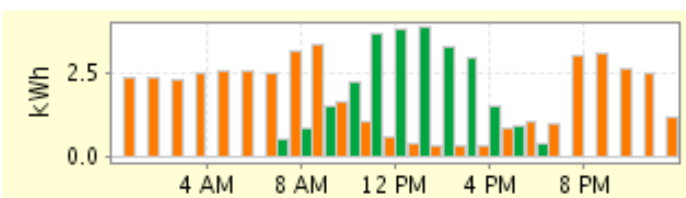
Regrettably our roof panels are encumbered by unnecessary disadvantages. Mounted at a flat angle due to local height restrictions, they favor summer, not ideal but necessary given our limited roof space. Other confounding variables conspire to fog any comparison, but a point is we're very pleased with both systems totaling 6.5 kW:

Consider next our billing period. We are on TOU (Time of Use) metering here and 1-year annual basis — not monthly. With grid essentially a battery, and 1-year billing cycle, we use greater power in summer/fall to offset winter/spring shortfalls. As PV in day covers night over 24 hours, surplus summer & fall carries winter & spring year in & year out.

Practical Knowledge Gained Adding an 1st Electric Vehicle

Since delivery of our 1st 100% electric car – a new 2008 roadster - It is much loved: exceptional, great to drive, quick & lovely. Notably too it is in essence 'powered by solar PV'. We plug in & it runs elegantly on surplus solar we make and feed to a 'grid battery', all creating something like 'sunfuel' for our 'suncar' (did we just coin a term?).

Consider first this chart from shortly after we first received this car. Here's solar energy-created (in **green**) vs. total energy-consumed here (**orange**) on a typical day in May :



Size & shape of *energy created* (**green**) is predictable — roughly a parabola from around 8 am to 6 pm matching (no surprise!) sunshine. Usefully, the same hours in green are prized (and priced) very highly by the electric utility. Of course PV *production* didn't change at all when the EV roadster was added to create this PV+EV equation.

Yet the shape of our energy *demand, in* **orange,** changed when the roadster was added. As seen above we suddenly had tall orange bars, high as green PV ones, something new. That reflects us consuming (much) more energy, due to a car, than we had before.

Though we strove to charge/keep new consumption 'Off-peak', it was a pretty-constant draw. Initially, as shown here, we didn't begin charging at Midnight (as we do now). Instead shown above we tried simply charging on a 120 volts outlet, called Level 1 (L1), from 8 pm to 8 am. We sought mainly to avoid on-peak charging, during the daytime.

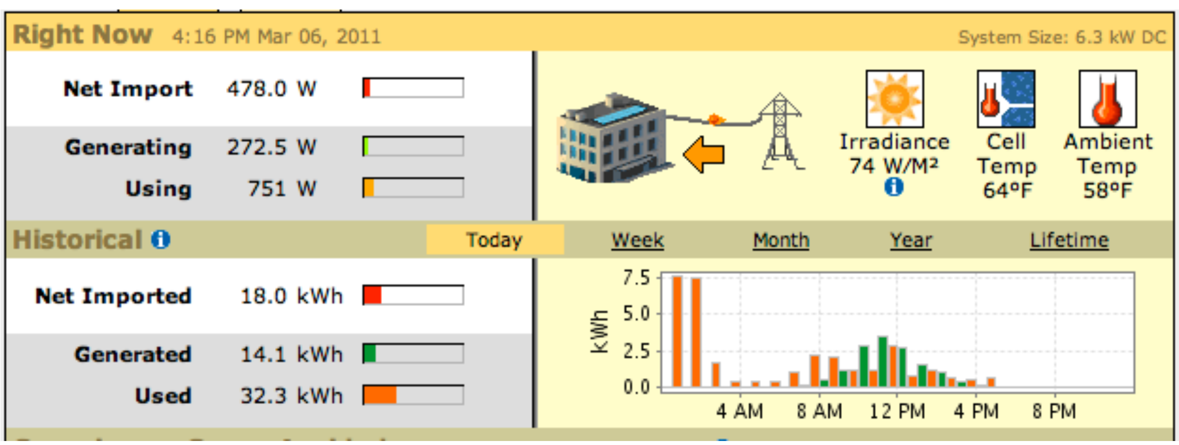
This profile **orange** shows us charging all night from 8 in the evening to next morning, in roughly 2.5 kWh tall bars at left / right. We quickly determined however this charging at 120 volts 13 amps was absolutely unworkable as L1 was such a slow-rate we regained car range at a ridiculously sluggish 3 to 5 miles per each hour of charging.

That said we did quickly see how a car changed consumption. It suddenly enlarged & shifted energy-use, something to be mindful of with solar cars. In June 2009 we moved up to now regular faster 240 volts at some 30 amps Level 2 (L2) charging— so **orange** bars below are today far taller! (And with a 2nd car added in 2011 the orange bars can show 10 kWh just after midnight)! See live data: http://wildershares.com/solar.php

Since going to L2, our Chart typically now shows just a few tall orange bars gulping down power starting left at Midnight, left. It's only a few tall bars since it takes far less time to refill for typically 30-40 miles of driving we did the day before. The scale of these bars gulping some 7.5+ kW each hour now also dwarfs the green PV production at less than half that, so the graph's appearance in that 2nd row at right has changed.

A sample here shows first a cloudy March day, 4 in the afternoon. PV Cell temperature is a cool 64 degrees, not much above the Ambient air at 58 degrees indicating that little sun is warming panels, confirmed by Irradiance at just 74 W/M^2 or hardly any sun. The building alone is then consuming 751 watts, and the PV panels are making just 272 watts at this moment, so the grid is net pushing 478 Watts *into* the building (see arrow).

Green bars for PV production are dwarfed by 2 hours of charging Midnight to 2 am, tall orange bars at left. After the car briefly needed about 15 kWh (15 kWh in line with our driving 30-40 miles the day before), there's a total 32 kWh so far consumed total. About half then is building + half is car. As that day winds down, building consumption goes on so from being 1/2, it becomes about 2/3 of total demand over all 24 hours.



Consider next charging at nighttime (Utility off-peak) the roadster had cost 14.5 cents per kWh (rate to payback in 2011 — near what it would become on the 2011 sedan).

Of course our solar panels didn't start out free, so consider electricity costs without PV. Consuming a typical 15 kWh off-peak, the roadster 'cost' us only about $2.18 day (14.5 cents X 15), not bad for going 30-40 miles in a supercar! Even a boring gasser (20 MPG) would have cost about $7.00 per day. Put another way using just grid and without PV's free fuel, we saved some $5/day. We 'spent' just 5 cents/mile to drive a fast roadster, rather than 20 cents/mile for a ho-hum gasser, saving 15 cents each mile.

In fact it's really better. As we'll show every mile driven pushed down costs — unlike with gasoline where the money is 'thrown away'. And a truly comparable gasser to the roadster wouldn't get 20 MPG, it's more likely say [13 MPG](13 MPG) as in a Ferrari roadster.

Consider next this roadster's battery holds about 54 kWh. Like a big gas tank, that big battery gives a very good range though it needs a lot of (solar) juice to fully charge.

Due to battery cooling and other losses charging, filling the roadster from empty actually takes about 68 kWh, or some 26% more than the 54 kWh it holds new. This latter **68 kWh** is the seminal amount to consider, as it quantifies how much truly is needed. We'll use it to determine how far we can go from in essence the power of the sun.

As noted we charge at night (brown electrons) because on TOU that makes most sense – it leverages a dear value 'paid us' for our valuable green power made in day.

Our PV payback calculation in early 2000s was first made on 30 cents domestic on-peak rate for (solar) energy by the Utility, called DR-SES. Adding the roadster, we'd calculated then a nighttime charging at 18 cents/kWh Off-peak (later changed somewhat).

As expected a better 'Super-Off-peak' rate specifically for EVs was later rolled out called EV-TOU-2 - we switched to it in spring 2011. This rate now applies here to the main meter that's for the roadster, PLUS all building consumption. EV-TOU-2's night rate is better at 13.7 cents summer/fall (13.9 cents winter/spring) and we'll call 14 cents year-round.

When both producing + consuming power, you want lowest night lows (to buy at) PLUS highest highs (to sell at). Greater the spread between Off-peak car charging - and high summer/fall On-peak for strong surplus solar production, the better!

DR-SES summer/fall had been helpfully high 30 cents 11 am-6 pm (weekdays) as PV nicely sent out surplus power for a credit. But nightly charging at 18 cents was not-so-good.

Since payback in 2011, the EV-TOU-2 on-peak has improved matters and we're 'billed' less for this roadster at night (it could be FAR less in your part of the U.S., discussed below). Here are cost data for 2011 EV-TOU for our 1st car plus whole home.

Super off-peak is now only Midnight to 5 am. Yet setting the car onboard charger to begin at midnight hasn't been a hindrance at all; we'd probably do that anyway.

We're often asked, "How long does it take to charge?" Frankly *it feels like* 30 seconds! On L2's 240 volts 30 amps charging, either of these cars now normally takes 1 to 3 hours (and happens late at night). But here's why it feels like no time at all:

When we park in our garage, we open a port, plug in a cord – takes some 15 seconds. In mornings we remove the cord – all the work is done in 30 seconds total. So we pay no attention to how 'long' it takes: charging starting at midnight works great.

'Solar car 1'. Sedan (right) discussed below:

Sedan's L2 wall mount charger (left). ***Charging also controllable by cellphone (right):***

On the other hand we've learned many lessons about limits of PV+EV today. Early on we'd discovered Level 1 charging was ridiculously, impossibly slow. Even charging all hours outside on-Peak, the battery was only partly filled. Drawing 13 amps on a common 120V outlet proved way too slow. L1 filled at just 3-5 miles per each hour of charge, unlike the good 30 or so miles per hour rate we see on roadster (is far slower on sedan) at L2.

So switching to L2 fixed it. Our 2nd car, a sedan has its own separate L2 charger: it plus $1,200 towards installation (so we paid only $196), plus a 400v fast-charge car port were all free, as part of a huge EV Project deploying 14,000 free chargers in 18 large cities around the U.S. to jumpstart EV use. However the sedan charges at a verrryy slow 3.3 kW rate; we fully expect to see that onboard system to be upgraded soon.

L1 charging could be convenient as there are ubiquitous wall outlets everywhere, but 120v just can't cut it. A simple 120v extension cord warms up too, wasting electrons. Pushing a big EV charge through 120v 13 amps is like trying to force a large pool through a straw; using a much wider tube (240V and more amps) has been far quicker.

In future to upgrade wiring in homes & buildings therefore matters, since fast charges mean lots of amps going at once. It's worth it! Upgrading to robust 240V (40 amp on NEMA 14-50, 4 wire) dramatically shortens charging. The roadster battery now fills in normally <3 hours — rather than 24+. Because we never start from a battery at zero, to charge from midnight normally finishes between 1 am - 3 am. Moreover fast-charge batteries ahead could perhaps mean lots of amps if needed in retail & commercial settings.

Next a common unit to measure energy/time is the 'kilowatt/hour', kWh. Elegantly, it applies equally to energy *made* as by PV — or energy *used* in a building or car. 500 watts in 2 hours, or 1,000 watts in 1 hour, or 2,000 watts in 30 minutes all equal 1 kWh.

Consider now on an initial DR-SES rate of 30 cents On-peak for PV — and 18 cents Off-peak as used by roadster + building, each 1 kWh of surplus power *made* On-peak, was worth 1.6X each *used* Off-peak: a billing ratio of 30:18. Were *all* 24+ kWh made On-Peak 11 am-6 pm summer/fall and leveraged 30:18, it's akin to making 41 kWh. *But not all* is made On-peak (not all fall/winter) so we'll call it like supplying say 30 kWh/day Off-peak.

Next what is Range in this roadster that wants 68 kWh (some 2½ days of Summer sun)? Giving an exact range is slippery, regardless of PV. This fast car is impressively rated a 244-mile range, *or* can go 0-60 in 4.0 seconds. But it can't do both (go far, *and* fast).

To explain, sit inside turn the key and you see 3 driving modes; we choose from two. Main default is 'Standard': we almost always use it. A second 'Range' mode allows more battery charging overnight, slows the car slightly (but shortens battery life a bit).

We sometimes use that to go unusually far — but it makes this EV so much slower, like a gasser such as a BMW. (A 3rd Sports mode is for track performance: we never use it).

This car is grin inducing fast in Standard and goes *much* farther than 30-40 miles we typically drive in a day. There's little need then, for us to use other modes, but for occasional Range mode that slips in if going say 150+ miles or so on a single charge.

Turning the key in Standard to start, you'll first see a display of 'Ideal' range: it may start near 195 miles (on new-battery; capacity slowly decreases in time). This is not an EPA rated 244; you've 'lost range' by starting out in Standard. You're also seeing only 80% of theoretical total range partly for battery management. Charging to 90% in Standard prolongs pack life, while another 10% is still left in the reserve and not onscreen.

Yet likely range is even still less. Temporarily you can switch from 'Ideal' to 'Estimated' range, based on how you've driven recently. Estimated range gives a lower number.

In our experience on a 2008 roadster a few years old now and driving to where state of charge shows ½ 'tank' (½ charge), we've gone approximately 70-75 miles. Extrapolating we'd normally expect some 140-miles total range; that still leaves us able to dip into 10% Reserve, and while driving in the fast in standard which is ever-so enjoyable.

Sample of battery ½ depleted.

So at ½ charge above, there may be 70 estimated miles left, 95 miles ideally. Mindfully driving ahead you can easily get greater than 70 miles, nearer to 95 miles on remaining juice if you prefer to slow down — moving to Range mode would give even more.

<u>Forget oily MPG: We're getting 72 miles per day of sunshine, or 72 MDS!</u>

Now what's the real range per charge for this (fast, fun) suncar? We suggest rephrasing this as: How far can our 6.5 kW of combined sunfuel make this car go? As will be shown we get about 3 Miles Per KWh, or 3 MPK (meaning also 3 miles/sol in this roadster).

So on 24 kWh/day of PV, this car may be driven 72 Miles on a day of sun (charging losses addressed ahead). But it's so efficient the numbers used dramatically affect calculations.

For instance in Range you *could* get 300 miles on a charge being *extremely* careful. More normally its some 240 miles, from a newish battery, out of 68 kWh power going in. That means 240 miles on a charge of 2½ days worth of summer sun (TOU 30:18 boost, x 2 ½).

On the other hand, you may get only <15 miles on a cloudy day, as 15 MDS or less!

Some days it's cloudy here, peak-measured irradiance <100 W/M^2, under 5 kWh all day. Phase 1 PV at only 2.5 kWh on a June day yields <5 kWh total. So cloudy, 'May gray', June gloom' or Wintry days etc are less productive: figures go very low that direction.

Consider too energy demand by roadster is in addition to meeting building demand. Many days PV isn't even able to meet either building, or EV demand. For EV estimates alone we briefly assumed away building demand in calculating MDS (yet it exists!).

Indeed solar PV can DROP TO NEAR ZERO due to clouds, so for simplicity's sake we've kept 1 Sun constant as an average. Moving on, a 2nd variable here is Roadster *energy expended* while driving, which is keenly influenced by *how* & *where* we drive.

We estimate average consumption for the roadster is 330 Wh/mile after charging losses. We reckon as follows: local streets at 30-50 mph, the EV expends relatively little energy. We often see 250 Wh/mile or less, 1 sol (kWh) from battery before losses, giving 4 miles. But add in more 60 mph speeds and we'll expend roughly 270 Wh/mile (Ex. 1).

Add in faster freeway speeds, and consumption rises to say 300 Wh/mile (Ex. 2). We don't drive freeways much but when we do, or enjoy good acceleration, costs at battery swiftly rise above 0.300 sol/mi. Wind resistance especially jumps at higher speeds.

0.270 kWh/mile is typically spent in 30-50 mph stop & go traffic.

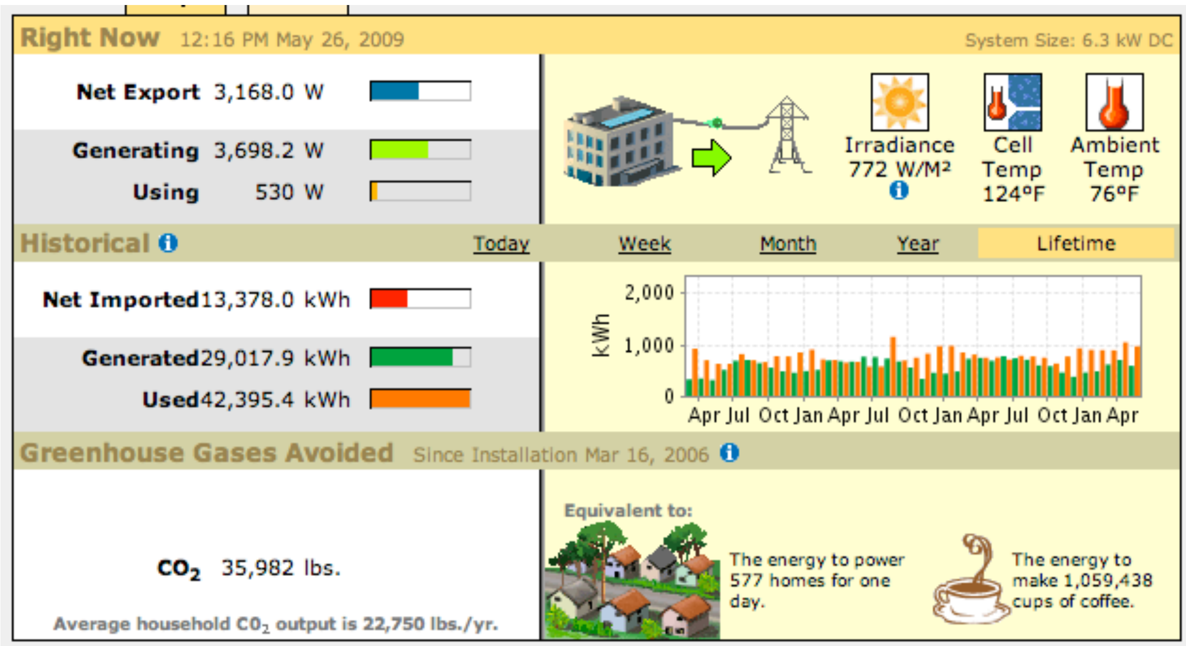
But add some highway miles and we can spend 0.301 kWh/mile or more.

Fast acceleration or 60+mph speeds push energy use to 350+Wh/m so speed is a huge variable. In sum our own driving mix is mostly local, probably <280 wh/mile overall. Subtract a bit for Range mode at times, we're likely near 270 wh/mile average. Adding a **26% charging loss** takes us to 0.330 kWh/mi, so we get roughly 3 MPK. Thus we spend 1/3 of a kW/h to go each mile. Data for car are found in the manufacturer's site. (Roadster battery is advanced, liquid cooled, needing more power when charging vs sedan).

Generating solar made us aware of building demand. Similarly awareness of EV demand on the road can yield noticeably more range. One could just forget a speed penalty, but it's fun to drive roadster (or sedan) for range at times too. For instance we hardly use brakes driving the roadster since regenerative braking slows this car down nicely charging the battery to boot. The roadster has strong 'regen', which is good (discussed ahead).

Since electrons used moving car are already bought & paid for, recapturing some with regenerative braking is just smart. Lifting off the accelerator this roadster slows itself, as inertia pushes up to 70 kW 'back in the tank'. This creates a smoother, much more satisfying ride and makes you more aware how archaic gassers are, heating friction brakes to arrest momentum while putting zero fuel in the tank for the effort!

Back to PV+EV we'd estimated time to payback and with years under our belt, we see the numbers were about right: we reached payback in 2011. Solar 1 cost $15,511 in 2003 and based on live data from a 2nd monitoring system since 2006, a back-of-envelope review showed adding the roadster hastened matters to cost-free solar panels & sunfuel in 2011. In other words ever-higher utility rates, plus later on $4+ gas prices, helped greatly!



29,000 kWh generated & measured to May 2009 (top left) here on the 2nd monitoring system. For this sample May 2009 sunny On-peak moment, Irradiance is a sunny 772 W/M², our PV is making 3,698 Watts, and demand that moment is 530 Watts, so 3,167 Watts being exported. Exported Watts (On-peak rates) are quite valuable in an EV, compared to $4 gasoline! Adding an EV and leveraging too Off-peak rates, time to payback is hastened.

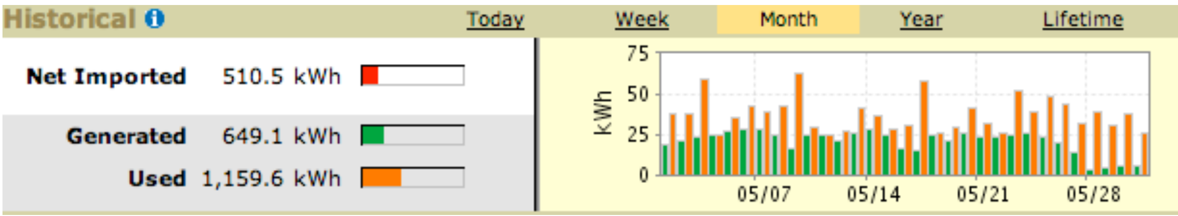
In all we're no longer talking about *if* PV+EV is feasible. The only issue now is: why didn't we do it sooner?! We don't miss gasoline stations a bit. As the saying goes, the stone age didn't end because we ran out of stones. Solar PV+EVs is a solution at hand, and it is dependence on imported oil that seems increasingly risky. Distributed renewables are compelling not only for cars, but homes & buildings too and a stronger America.

Combination PV+EV works, but there's Limits on both sides of the "+".

While pairing PV+EV is clearly viable we found practical limits on both sides of the "+". Most obvious are limited range of EVs today, and high upfront $ costs for PV. Time spent in an EV can reduce 'range anxiety' greatly, but range is an issue on today's batteries in the sedan. Thus it's here a 2nd car. Also, unsubsidized, PV+EV purchase prices are still far too pricey. This pairing holds great promise but cost clearly remains a huge hurdle.

Adding a 'thirsty' EV to an average home, or small business moreover increases power demand greatly. Before we added a 1st car our 6.5 total system met 100% of demand. That car hastened $$ payback, true, but it also created the case for more solar PV.

How well did 6.5 kW of our PV cope with building demand plus roadster on previous DR rates? Over a cloudy May month demand from building & EV was 1,160 sol (kWh) — yet in that overcast month PV made only 650 sol. Sounds a huge shortfall, but TOU leveraging at 30:18 almost covered it. But for 4 socked-in foggy days month-end (below), those DR Utility rates at 30:18 would have about covered combined demand:



650 kWh PV in May is closer to 1,000 sol due to TOU -- almost matching 1,160 used.

Clearly not enough watts were produced by solar alone to cover building PLUS car, over a year on original DR-SES. Yet a subsequent rate, EV-TOU-2 has had a better higher ratio of nearly 2 to 1 (in 2011). No doubt then, but that TOU has been critical. It meant 650 sol created in a month on-peak, was rather like 1,000 sol off-peak, just short of running building & roadster. (And future EV-TOU-2 rates possibly heighten the ratio).

It's actually more complicated given some building demand (but not car) is also on-peak, some PV credits are off-peak etc, yet this is the basic story. Of 1,160 sol used in a sample May, the building on a sample day used 810 sol or some 70% of total, and the roadster, our first EV used another 350 sol or 30% of total (after the charging losses).

Roadster used 279 kWh in May, 350 after losses. 57 kWh of regen. has added range.

In sum if building *demand* is say 25 sol/day on average, mostly off-peak, the PV making 24 nearly covers it straight — it does so easily on TOU boost as it's like making 30. More recently with our EV-TOU-2 rate and a 26:14 ratio, the same PV is making more still.

Yes a roadster has added demand for 12 kWh more/day (all off-peak at least). Needing roughly 37 (25+12) or 2/3 to building, 1/3 to car, we fell somewhat short of a virtual 30 kWh/day made on older TOU. In summer/fall though we make enough — other times not. *Yet none of this really matters, since the 6.5 kW can be surely increased! Indeed we hope to add Phase 3 of solar for more PV that will just take care of it all.*

Next we'll take a brief look at electric bikes emerging now too.

Electric Bikes

Bikes can readily make up an EV 'stable' too. We frequently ride the black one, at right below and replace some car miles with bike miles while providing fun exercise.

We'd first bought new in 2002 a 'primitive' lead-acid battery bike 1 (blue, at left). Our li-mn battery bike 2 (right) bought new in 2009 is far better technologically & in practice. After some commuting on obese older blue bike 2002-03, we can say the lighter battery 'real' 2nd bike is far more desirable. It rides like a regular bike (as pedal only) or a hybrid with infinitely variable throttle electric assist, or its 100% electric like a scooter. Costs were $1K for bike 1 (after $0.5K subsidy) — and $2K for bike 2 (no subsidy). Having used both, the old heavy 1st bike is forever now consigned to an obscure garage corner.

Bikes are no small matter. Globally they're immensely more common than in the U.S. For example in China, India, and Europe, or in other words most of the world bikes are ridden far more often. Some attention is warranted here to in essence, a 'solar hybrid bike.'

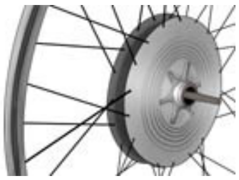
At left, heavy early Bike 1 (blue); right is better lighter bike 2 (black).

Riding the 'solar hybrid bike' you can continuously choose some/or all human-pedal power — variably with thumb throttle go anywhere from zero electric assist all the way to full electric power with no pedal effort, even uphill. That's utterly unlike our heavy lead-acid 1st model which was hardly a bike and tough to pedal (now only of historical interest).

On lithium batteries this bike 2 can go up to about 27 mph max by motor alone. Or it can also sense rider effort and assist by preset constant 75% assist, 150% assist etc. Charging on our surplus solar electricity, it is in some sense partly solar powered.

The console comes as kit fitting over an existing bike frame, and adds regenerative braking. The only kludge (work-around) fix we implemented, was mounting a sensor millimeters from a magnet affixed to the brake lever for automated regeneration.

Li-Mn Battery:
Battery is key to any EV: here it uses a Li-Mn (Lithium-Manganese) cell of good energy density (100-200 Wh/kg). This bike's pack, of minor note, uses different battery chemistry from our first and second electric cars and these results will be of some interest. Much lighter than dead-anchor-like lead acid cells in bike #1, lighter too than Ni-Mh cells, this lithium battery is costly. The battery communicates with motor & console.

350W Motor 

Power is rated 350 W nominal and 700 W peak.
Nominal torque:10 Nm; Maximum torque: 32 Nm
4 power-assist levels: Motor gauge measures rider effort and can boost assist from its electric motor by 35%, 75%, 150% or 300%, according to selected assist level.
Weight: 8.8 lb

Characteristics: External case Aluminum
4 regenerating levels: Battery can be recharged while riding downhill or on braking.

Command Console

Power-Assist controls 4 assistance levels. Analog display for power from battery.
Generation mode controls 4 regenerative settings. Displays energy to battery.
Console includes a multifunctional odometer that displays following information: Current speed, - Tripmeter, - Odometer, - Chronometer, - Average speed.
The control console includes battery charge indicator that helps manage battery charge to prevent running out of energy on return trip. However we are seeing less battery charge than expected and will watch the battery over years.
Throttle: Throttle allows you to ride like a small scooter, using thumb control. This is in addition to proportional power-assist. At full throttle range is severely limited.

For these electric bikes here, see
http://wildershares.com/pdf/hybridbikespecs.pdf

We'll leave bikes, and move to Costs and other consideration for PV+EV cars.

<u>EV Costs.</u> Starting with the EV cars let's look at their actual on-the-ground driving costs. So far we've enjoyed years living with our first electric car, the 2008 roadster. It was *very* pricey at $79.5K *after* credits. Yet it's also proven itself to be lovely & fun, an American-built roadster with range per charge typically far more than needed.

Our 2nd car was a 2011 4-door sedan for notably just under $20K after credits. Plain in appearance, this rather homely 'econobox' just blends in. Far more utilitarian than our spiff roadster this sedan looks & drives very much like a regular gasser (so ho-hum slow) with a *much* shorter range from its battery, roughly 50-90 miles per charge.

Together they were some $100K. Yes, considerable treasure but not more than what two comparable profile gassers might be. The roadster in fact, was less $$ than most similar-performing, oily supercars. So there was no premium paid for it being electric.

The sedan was a bit more than a similar gasser, think a low-price Versa. But its unique dashboard, smartphone apps, and its fancy 'telematics' etc are advanced.

Tax credits lowered costs greatly for both cars. Rather like Hummers sold in numbers due to tax benefits, tax policy matters: that said we're Not fans of subsidies — *we'd like to see ALL subsidies here **ended** including importantly those for fossil fuels & nuclear).*

Though costing no more than 2 comparable gassers, they convey important advantages making each superior to gassers. For example the roadster is more fun in our opinion than *any* gasser, even at twice the price. The oil-free sedan too means we needn't worry about gas prices and gets the job done hauling 4-5 people with ease shorter distances.

Infrequent times we go over 200 miles at a time, we have an old 125K+ miles gasser on hand. True in future, chargers will be common (1,400 coming to San Diego) yet short range is a real restraint — in our sedan. That said we far prefer our 1st car over any gasser, and eagerly embraced the sedan as a fine 2nd car that's 100% gasoline-free.

In sum costs were <u>$79.5K</u> for roadster ($92K minus a $7.5K federal tax credit, minus $5K state rebate check); and just under <u>$20K</u> for a much-lower-cost sedan ($32,780 MSRP – minus $7.5K federal tax credit –minus $5,000 state rebate, -minus too $1K off by dealer). The two electric bikes were roughly $1K and then $2K.

Note then that in theory one could buy 6 kW of PV for say about $16K and an EV at say $25K, for a total of 'just' $41K. After some years $16K in solar is paid back. It's then both car + sunfuel for $25K Net! Only major expenses after would be new car battery and new PV inverter - after some 10 years. This is beginning to make compelling sense!



Local Hwy 101 (left); sedan dash (middle); solar/building/EV 1, & EV2 meters (right).

Solar PV 1 Costs: Onto solar it was purchased in phases. We've found a good way to bite off daunting costly items like the electric cars ($79.5K & $20K), solar systems (our 2nd PV was donated surplus panels from a university researcher) and even bikes is to do it over years, one item at a time. Saving money to cover each item takes time; technology can also improve while prices come down giving more bang for the buck.

In 2003 we installed PV Phase 1, 3.85 kilowatts of rooftop solar at net cost of **$15,511**. (From $30,630 our cost was reduced by then-State rebate of about $4/watt; that rebate was subtracted by installer who got $$ directly: this enabled we the consumer to avoid large out of pocket costs so we wrote a check for $18.5K; later we got $3K credit off State taxes to net at $15.5K, or $3.90/watt. There was no Federal credit back then. Early State rebates that once halved PV costs have ended. We'd prefer to see ALL subsidies ended including far, far larger subsidies given to oil, coal, & nuclear — yet until there's that level playing field for all energy, these credits did bring down total PV costs).

Solar cost breakdown in 2003 was as follows:

Description	**Quantity**	**Price, Each**	**Price**
185 Watt Sharp Solar panels, NTS5E1U	21	850	$ 17,850
Sharp Sunvista Inverter, 3.5 Kilowatt	1	3,500	$ 3,500
Solarmount Rail Sets	7	157	$ 1,099
Top Mount Clips	7	20	$ 140
Terminal Block 175 Amp, 3 pole	1	36	$ 36
J Box, 10X8X4	1	46	$ 46
2 pole safety Disconnect, 30 Amp	1	66	$ 66
30A RK5 fuse	2	5	$ 10
Safety disconnect, 30 Amp, 600 V	1	165	$ 165
Delta Lightning Arrestor, 440-650 V	2	40	$ 80
Sharp PV Output cable, 50 ft.	4	28	$ 112
	Total of Goods:		$ 23,104
	Sales Tax:		$ 1,675
	Shipping:		$ 151
	Materials Total:		$ 24,930
	Labor:		$ 5,700
	Total Before Rebate:		$ 30,630
	(Minus, California State Solar Rebate)		***$ (12,119)***
	Our Total cash $ Paid at installation		$ 18,511
	(Minus, CA $3,000 State Tax Credit)		***$ (3,000)***
	Final Cost after Rebates etc		**$ 15,511**

The solar panels have a manufacturer warranty of 25 years but we expect to see *much* longer life given good performance of PV panels 50+ years old. We won't be surprised to see these producing decades ahead, basically the rest of our lives! Only the inverter has a 'shorter life'. A 1st Inverter was expected to last just 7 years which was exactly the case. We expect a newer one put in 2010 ($2.4K cost amortized ahead) to see roughly 15 years' life -- and any coming (microinverters) should last for many decades ahead.

In sum we look forward to <u>free electricity</u> from solar the rest of our lives & believe it is a sensible return on investment. 1, now 2 cars have sweetened by being cost-effective plus better rides. Next we look at powering a car from the sun — or from the wall.

<u>A 'Solar Car'</u>: Long ago at then-current electric rates, we estimated powering our building on $15.5K of solar would bring payback in roughly 10 years. At the time we felt that it was a pretty good return made possible by 1) Credits to buy solar PV; and 2) Time of Use (TOU) metering by our utility that credits us richly for our daytime surplus.

We later shortened payback to just 8-9 years. Why? Our payback was shortened due to costly gas and so the added $$$ we'd save too running our car on sunfuel. We typically drive about 35 miles per day. Some days much more, other days hardly at all, but our daily average is 35 miles. Driving elegantly & quickly in this 2008 electric roadster rather than in an old gasser has made a big dollar difference. Here's why:

Start with 35 miles. On gas at $4 per gallon in California we'd have spent 20 cents per mile, or $7 day in our old typical gasser. Gas can cost less, or more here (was over $4.50 a few summers back and was well over $4 in spring of 2011) but we'll use $4 for gas -- with a barrel of oil assumed to be around $100 (WTI crude, Spring 2011).

Yet an EV makes sense even without solar. At $7/day for gas in 2 years we'd have spent in theory some $200/month, $2,500/year or $5,000 in a gasser. By contrast (ignoring PV that makes power less costly, then free) consider charging the roadster from the regular wall socket at Off-peak hours would have been around 14 cents/kWh in 2009-2011.

Car able to go 3 Miles Per KWH, or 3 MPK, we'd have spent just under 5 cents each mile in the roadster, vs. spending 20 cents in a gasser. The smart choice is easy: this roadster saves 15 cents/mile even without the PV! If gas falls back to $2 per gallon so 'only' $2,500 over 2 years, payback holds: gassers can't compete per mile with EVs.

It's time to take cars that go on sunlight seriously. While the world isn't running out of oil, end to *cheap* oil would have consequences. In parts of Europe, gas is already $8 gallon and higher in 2011. There's no doubt it could go (much) higher there in future.

There are huge industries at stake that may arise ahead. America ought to be the world's clear leader in both EVs & PV. It is not. Instead we see Germany, China, Japan too often chipping away and out-competing, and they are pulling farther ahead. To be the leader can mean good jobs at home, especially as many technologies originated here!

In sum given natural benefits of EVs and solar fuel, we hope to add more PV to completely cover all demand here for our cars & building. A same calculus can make sense ahead too, for millions of people.

Sedan Costs Much Less per Mile than Gasser, even Without Solar

After ample credits at $20K this sedan was still more than a comparable gasser (think $16K Versa) but credits meant we paid far less than a dear $33K MSRP. Yet no gasser once driving is close to its economy per mile, even on-grid and without solar. Indeed it is typically under $3 to fill up its (50 - 90 mile) 'tank'. Yes costs to fill this EV could go down to zero with solar but we're ignoring all PV aspects for this sedan for simplicity.

Let's explain costs since it's on its own separate schedule + 2nd meter - not the EV-TOU-2 for roadster and building. Because our utility (like many) wants to learn how customers react to differing On vs Off-peak rates, they have an Experimental EV (EPEV) rate with 3 scenarios. Two rates are pretty great, just 7 cents, or 8 cents – a 3rd is nothing special at a costly 14 cents to charge per kWh. To participate in EPEV rates one must be in the big EV Project (as we are) but it's extraordinarily simple to do and the large Project is now deploying 14,000 chargers in 18 major cities over 6 States.

1 of 3 ratios is next randomly assigned each driver for EPEV. Given 3 possibilities, most, or 2/3 of enrollees got good rates so we post a middle ratio Rate M for illustration (using it for discussion here as only a minority gets a high 14 cents):

RATES

Description – EPEV-M	UDC Total (See Chart Below)		EECC Rate		DWR-BC Rate		Total Rate	
Minimum Bill ($/day)	0.170							
Energy Charges ($/kWh)								
On-Peak – Summer	0.14092	I	0.14687	R	0.00505	R	0.29284	R
Off-Peak – Summer	0.12162	I	0.05751	R	0.00505	R	0.18418	R
Super Off-Peak – Summer	0.03596	I	0.03545	R	0.00505	R	0.07646	R
On-Peak – Winter	0.17831	I	0.06571	R	0.00505	R	0.24907	I
Off-Peak – Winter	0.10134	I	0.05965	R	0.00505	R	0.16604	I
Super Off-Peak - Winter	0.03983	I	0.03732	R	0.00505	R	0.08220	I

Before one gets excited seeing EPEV-M on-peak 3X higher than off-peak (or better EPEV-H 'selling' solar at 5(!) times low off-peak of around 7 cents), it's important to note EPEV is isolated from PV. You can't sell PV power back to utility at EPEV rates. Instead they help the utility understand if customers will charge EVs at very high On-peak daytime hours (we won't) vs. the far better Off-peak night hours (we will).

Look at Super Off-Peak, we'll call it 8 cents. This sedan on grid without solar at 3 miles/kWh would cost only 2.7 cents per mile … *95 cents (about a buck) for each typical day of 35 miles driving!* As noted we use a mid 8 cents cost here for illustration; rates will vary greatly nationwide and your own region may be nearest to that.

Gas by contrast at $4 even in a high mile 40 MPG gasser is near 3X that price, $2.80/day. Just for a laugh consider a Hummer or an SUV getting its typical 12 MPG: that is around 10X the cost of driving this 4-door sedan on rate M, each mile after mile!

Even without solar then this $20K sedan is lower cost on grid than any gasser.

Now in our case we drew a randomly high (bad) 14 cents EPEV rate. Yet it is about what a customer normally pays here in San Diego so no special benefit to being in the Project. And with rates here higher than most of the nation we have 'one hand tied behind our back.' Yet this sedan *still* is (much) less costly to drive than a gasser.

Consider 14 cents Off-peak in pricey San Diego as a kind of 'bad-case' scenario of utility rates. Your utility may well have a better Off peak, or a Super Off peak rate. An example would be the Pacific Northwest with its hydropower, at near 7 cents.

With sedan costs nearly-twice than if we'd been assigned a middle rate of 8 cents, we pay about 5 cents per mile to drive. Our utility's rate is no bargain by any means, but translated to driving per mile it easily beats the costs of buying gasoline.

We're probably about 1/2 (or less) the driving cost of a typical gasser on the road today. Had we been assigned a low electric rate, we'd be around just 1/4 of that cost. A recent national average rate near 11 cents delivers good results right between these two.

14 cents for sedan at midnight is also about the same as our EV-TOU-2 for whole house + roadster (in 2011). The latter TOU though has a key benefit: we 'get paid' at 26 cents kWh (18 cents semi-peak winter/spring) for surplus from our solar PV in day. (Coincidentally perhaps the 26 cents we do get is near the 27 listed in theory for EPEV On-peak).

Of course we can move to solar for this 2nd car as well. How much more PV is then needed for sunfuel? Very roughly 6.5 kW can cover an entire household or small business. Add 1 car, and around 4 kW more is needed. 10 kW could cover both a home + 1 EV.

Add a 2nd car without much more total driving, and its maybe 3 kW more -- or 13 kW for the building with two solar cars. Remember too this PV pays itself back over time.

Given we make 6.5 kW if we double it, we might power everything year-round. This means powering the building and two cars, and getting to payback on that new PV too!

On now to a totally different matter, slightly vexing is that like buying a cellphone (when sales tax is based on list price instead of the actual far lower price paid), the EVs sales tax is based on pre-credits MSRP, rather than actual cost after credits. Making the federal $7,500 EV credits come off the top instead, as with our PV, would fix that.

Also worth noting is the $5K State EV subsidy has ended, after our purchases. California may in future re-start that at a lesser amount, but our $10K received no longer applies. Credits did stimulate our 2 purchases but we feel subsidies are *always* a bad idea.

On a plus side in crash testing, the sedan won highest IHS rating for car safety.

In sum, EV drivers we know here are excited by their rides & independence the cars give: EVs are grin-inducing. In California too our electrons to charge at night are growing now greener (red, white & blue) because the state by law is moving to 33% renewable power in the grid by 2020 and greater levels beyond that. (Plus: Zero coal in San Diego by 2013!).

So dirty-cheap coal is largely removed from the grid's energy equation across California, with many places already zero coal here. And it is getting better every day.

These facts are still barely understood by a larger public. That needs to change.

EVs Under $30K Change Everything – But Misconceptions Must be Overcome

Critics to this still abound. The Wall Street Journal for instance (e.g. on 4/28/2011) tried to belittle a set-up like ours, claiming solar & wind is "irrelevant" to cars and "we trust anyone not recharging his federally subsidized $109,000 electric sportscar at his personal windmill is blinking in amazement." Sarcasm aside, they fail to convince.

At $25K after federal credit alone, this sedan was affordable: it was not $109,000! And at 1/4 the cost (on lower Utility rates) to 1/2 (at costly San Diego electric rates) to drive as compared to a typical gasser, we think sound economics just makes sense.

Better yet our 1st car runs on free sunlight - yes, it was $92K before credits or $79.5K after credits, but this capability holds true for a $20K EV. True, solar PV was $15.5K, but on $4 gas that brought us payback in just 8 years. Now past, we happily drive free. (How much do you get back on the money paid for gas? Does it ever achieve payback?).

In theory it's entirely real to spend $41K for BOTH car+solar fuel. You then MAKE BACK that $16K in PV -- unlike buying gas at $4/gallon! You'll have spent $26K for a car and get free fuel in time, plus then some free electricity for your home the rest of your life.

Tell us again, what part of capitalism does the Journal find so objectionable?

We believe in capitalism, competition, and best solutions winning. While WSJ's editorial may in essence embrace ongoing Soviet-era-like subsidies to oil, coal, & nuclear, and is antagonistic to clean energy, the key thing to remember is *subsidies for clean energy can end*. That's dramatically unlike fossil fuels oil & coal, or nuclear.

Yes some circumstances made EV+PV sensible here and they don't apply to all situations. They pushed us towards this more readily than had we lived in other regions. One notable item is **$4+ gas** in California. Gas is pricier here than in most states and $3,500+/year in costs for gas quickly helped make EVs more plausible.

Were gas back under $1 gallon here, like decades ago, there'd be no EVs today. An EV ride & experience is better, yes, but why put up with range limits if gas is just a buck? If an obese gasser gets only 15 MPG, on $1 gas why worry; just slap in a huge 30-gallon tank. The big carmakers would still merrily supply endless SUVs. It's what they know.

And yet $2, or $3+ or more for gas *nationally* may be a new normal. Indeed U.S. DOE expected gas *across the U.S.* to hit $3,235 in 2011, up 28% over 2010. That later grew to $350 per month, a thorny 14% of income for example in Mississippi. We don't expect U.S. gas much under $2 or $3 long term and if that's right, then with $1 gas gone, affordable EVs (and solar for them) *could* begin to make new sense in the U.S. and globally.

We have some help in sunfuel + EVs, given our **good** sun **in California for PV**. That said even cloudy Germany is way ahead of the U.S. in PV so climate isn't determining.

Harsh climates hit EVs hard when heating or cooling an EV, and they kill battery range especially. Thankfully that isn't an issue in San Diego due to a very clement **climate**.

Next consider high **electricity costs here.** Were our region still on cheap dirty coal for a few cents kWh, PV would be too costly. Dirty coal (with all its pollution) *can* power EVs cheaply, but destroys benefits — and drags EVs nearer pollution of gassers. The San Diego grid is still 3% coal but in 2013 that single source sunsets, and then drops to zero. We'd note coal in a grid powering an EV means in essence a 'longer tailpipe' to mining, combustion, and the harms from Mercury, SOX, NOX, particulates etc. Plus at that cost of $300+ billion per year for coal's subsidies with its bad externalities too, coal is a non-starter.

Instead our cleaner surroundings do reflect dearer greener power — **on-peak** rates higher than much of the US – that make PV viable. Though costly at $3.90/watt, the $15.5K we'd paid for solar proved very sensible vs. rising retail local grid electric bills. Note that no subsidies at all were involved in this point, about dearer on-peak $ costs.

It is true PV+EV subsidies go to diverse retail buyers and are vital at purchase. By contrast, (vital) taxpayer subsidies for oil, coal, & nuclear go quietly to a few firms in large sums, hundreds of millions at a time, billions to industries. They will always be facing their inherent supply risks, unending waste storage problems, etc.

Too little discussed are immense government subsidies for oil, nuclear, & coal. Subsidies distort, vast indirect subsidies for fossil fuels & nuclear distort the more so. Imagine if oil firms had to foot huge bills now paid by U.S. taxpayers to protect strategic oil chokepoints like Straits of Hormuz from an ongoing threat. 'Cheap' oil, and 'affordable' coal & nuclear long have depended on hidden diversions from the public purse.

Nuclear for instance can't function without enormous subsidies paid it. After 50 years of commercial operation the nuclear industry remains propped like a false Hollywood set. Imagine a proposed nuclear plant trying to line up needed capital, without guarantees of government like a Price-Anderson Nuclear Industries Indemnity Act that has U.S. Federal agencies (we taxpayers) covering all liabilities for accidents over $12 billion.

Yes, those huge subsidies go to a few recipients, not to retail-buyers, yet are terrifically distorting nonetheless. Corporate welfare aiding big oil, coal & nuclear are just different kinds of subsidies — and much of that $$$ (unlike for PV and EV) can't *ever* go away.

By contrast, PV+EV *can be weaned from subsidies*. Particularly after 2011 disasters in Japan clean energy appears wiser. Thinking about Japan's nuclear tragedy it was likely correct in a 2005 ECO Report to point out "radioactive fuel security/terrorism concerns, waste dilemma, and the fact one catastrophe might render billions of dollars of capacity into costly liabilities", and just "how far removed costly nuclear plants are from distributed wind or solar generation that's easily made renewably".

PV & EVs don't face undying risks: they needn't be propped up long term.

Importantly PV+EV subsidies may end far sooner than oil, coal & nuclear. That said we do observe credits had mattered greatly when we got our solar PV & EVs.

Recall numbers. We make roughly 24 kWh/day, 60% from 3.8 kW PV 1, so 14.5 kW/day is from a system costing $15.5K, or $3.90/watt after credits. If we fed our building only (no roadster), most 14.5 kWh/day on DR-SES meant PV 1 made us roughly $4.35 per day.

Over a month it paid us $130.00. Each year it in essence paid us back $1,500 for building power that did not need to be bought from the Utility.

Making roughly $1,500/year from PV 1 we'd approximately hit payback after 10 years (less with a car). But as we stress, PV 1 cost 'only' $15.5K because of a State subsidy that cut costs in half. Had we paid an original $30K for a same PV 1, it unsubsidized would instead have taken us far, far longer, very undesirable 20+ years to reach payback!

20 years is uneconomic so subsidies matter mightily in going solar.

We don't consider 2000 DR-SES rates here of 30 cents a subsidy however, as on-peak San Diego power actually has higher market value; that's capitalism. Pricing more for (scarce) daytime power, less for surplus (cheap) power at Midnight is a reflection of free markets although much skewed by utilities that are quasi-public entities.

In sum we love our sedan too that like our roadster gives freedom from gas, new independence, plus for much lower costs than *any* rock-oil gasser. We hope these rough back of envelope figures are broadly informative about the costs, benefits, limits, joys and potential payback in general of PV-EV.

What's it like to drive this latest $25K sedan (after just a federal credit) in everyday life? Sold initially in scarce numbers as production had ramped carefully, not many cars were available early on for sale. (Critics pointed to sparse initial sales as proof of no demand, rather than realize the sizeable wait lists meant many buyers were still waiting).

In a nutshell the sedan has precious little range, is rather homely, and drives like a gasser – very unlike our 1st car. Behind the wheel you have few cues (other than quiet drive) that you are even in an electric car. That has both bad & good consequences.

Think of our 1st car, the 2008 roadster: there's aggressive regenerative braking when the driver lets off the accelerator there even a bit. It's great!! You can slow down easily in traffic, keeping your foot on one pedal only and rarely use the brakes. Just let off the 'pedal on the right' and it slows quickly, making driving we think even more fun.

The sedan on the other hand appears set up in a far more cautious fashion, perhaps to not 'scare' drivers new to EV characteristics. For instance pop the hood and you'll see what looks like a valve cover and cylinder head(!); power electronics are covered a way looking identical to an old-school gasser's engine — perhaps to not startle!

So braking in this EV is almost devoid of regenerative feel and effect. A big downside is that you must use the brake pedal pretty constantly to slow, just like a gasser.

So a natural asset of EVs was lost in this 2nd car. It is possible to move its shifter into 'ECO' mode while on the fly engaging some modest regeneration, but that slows acceleration considerably. As a result there is no good mode for regular driving.

This car needs a standard mode with both strong regenerative braking, and its full power. At present its 2 modes are not very fulfilling.

For many people however the complaint will likely be its very limited range. This car simply can't be an only car given this limitation. As a 2nd car sure we use it that way and roughly 50-90 mile range suffices. But only as a 2nd car, for around town.

Starting in the morning, we won't even normally get a maximum 90 mile range. That's because as with the roadster, we don't charge its battery fully overnight since a 100% charge done regularly shortens EV battery life. So we normally charge to 80%.

Start it up then and you only see a range of about 75 miles as showing on a newish car. For us that's enough. We normally drive a typical 35 miles, just around town. But we do experience 'range anxiety' if on a longer trip, say for 30 miles each direction.

For instance it's about 27 miles to San Diego, the first few miles the dash display for range moves pretty wildly. It may drop from 70 miles remaining — down to say 52 miles — based on early miles on the freeway. If speed is lowered from 70-75 to 55-65, that helps a lot. A small 'tree' displayed on the dash grows limbs, as consumption goes down.

So a major consideration is range at highway speeds. Over 65 MPH there's a very sizeable penalty. The dash shows more accurately the available miles remaining after some time, easing anxiety quite a bit, but initial swings in range are a bit eye-catching.

Going up hills, the range is hit especially hard. If you know total distance to be driven and that is no worries, then the car can go up hills quite swiftly. But the car's heavy weight is felt, and expect even shorter range for that day of driving.

Driving around town in standard mode, the car is peppy. It's even quick, like a mid-level sporty car from standing start (best performance is right off the mark) to around 40 MPH. After that, the car fades quite a bit, and torque drops to feel more an econo-box.

If the roaster is wonderfully Spartan, simple to drive, with a dash that needs little study, the sedan is the opposite. Learning all features of that dash could take literally hours, were one so inclined. And too much of that involves redundant or ambitiously over-automated features, perhaps as the limited range of EVs prompted its designers to go a bit overboard. Stylistically, we' prefer simplicity and more intuitive controls.

The car has some minor failings, though they rank about a noxious level of automatic seat belt tighteners of the 1980s. One is that on starting out in this car, all doors lock automatically above some 10 mph. How annoying to need to manually unlock them when the car pulls over and yet is not formally turned off. Another is a need to touch 'Accept' on the screen each & every time, to first engage dash systems like GPS.

But all in all, the ride is unremarkable, has some peppiness and is easy to drive. As a first mass-produced 4 seat EV out for an 'affordable' price (after $7,500 Federal credit; the $5,000 state credit might restart lower in future) this was the right aim for a 2nd car.

Finally EV chargers starting to be mass-produced provide a wealth of network information. An onboard info system called 'Carwings', and an Iphone app for car and charger provide more info than we need. Our roadster had none of those 'telematics', so in that way alone, the sedan & charger is more 'advanced.'

A Look Ahead:

Solar + EVs being just in their infancy; leaps forward might be reasonably expected. Our 1st two cars out-the-gate are exciting oil-free rides, better than 'modern' rock-oil gassers even with a century of technology behind them. But this is only the beginning.

Notably in the next few years many plug-in cars are slated to arrive. Add in Europe, Asia and coming microcars, there may be *dozens* of new plug in cars later this decade!

Remarkably more than a few will be in the sub-$30,000s range after credits. Various EVs of all stripes are possibly coming out ahead, some at affordable prices including soon:

Audi = e-tron version of R8
BMW = i3 City car
Chrysler/ Fiat = electric 500
Fisker = Karma
Ford = Focus EV, Transit Connect Van, C-Max minivan
GM = Volt here now, several new variants using Volt tech including a Cadillac SRX
Honda = Fit
Mercedes Benz = SLS AMG, A-Class EV, S-Class PHEV
Mitsubishi = iMiEV
Nissan/ Infiniti = Leaf here now, and new 8 car line-up
Tesla = Roadster here now, and Model S
Toyota = Prius Plug-in, RAV4 EV, Scion iQ EV, maybe Lexux RX SUV EV
Volkswagen = Jetta EV, Golf EV, the Up EV

Look a bit farther and change is more pronounced. Perhaps 160 electrics, and hybrids may come in a latter part of the decade. Compare that to a few years ago when all hybrids + EVs could be counted on fingers of one hand. Future Prius plug-in models may be not much more costly than standard ones. We recall how U.S. carmakers told us decades ago a hybrid car idea was impossible, and that *any* electric car idea was folly.

Most crucial of all, batteries have just begun. An EV is like a big battery surrounded by wheels, so this technology is key. Today's batteries are still basic yet after being ignored, a key EV from 2008 proved conventional wisdom wrong which had held that EVs must be slow as golf carts, have only 40-mile range and look like a science fair project.

Myths shattered, a car battery race is on.

We love high performance cars. Here too EVs do not take a back seat. Consider our 2008 roadster which right out of the starting gate, was already comparable to some famous super-cars -- and cost less any of them too: Aston Martin DBS; Corvette ZR1; Ferrari California; Ford GT; Lamborghini Gallardo; Mercedes SL63 AMG; Porsche 911 Carrera GTS, etc. Though less costly (even without credits), we'd still take our roadster!

Plus uniquely, our car can grow (much) faster ahead as batteries improve, a 1,000 lb roadster battery replaced by a lighter one, say in 2016. Good luck to any gasser getting faster, or any lighter over time, or to be sure in ever running on sunlight!

Clearly an EV is more economical to drive and its fuel more secure, than traditional vehicles and fuel. Gas or diesel is impossible to drill for and refine on your own. Moreover one has no control over how 'spendy' gas gets at a pump. Basing our national transport on these imported liquids is too risky for American security, and our economy.

Yes EVs have limits, too, just different ones. Batteries especially should be better understood so there are no surprises. Take an EPA rated 244-mile roadster range: if you're willing to drive this superb car slow as a gasser (Range mode), note speed (most efficient around 30-50 mph) and are OK reducing battery life on 100% fills — you can get some 244 miles on today's battery from the roadster. That just needs to be understood.

Moreover, EV battery performance declines with age. State of art 2008 commodity cells in the roadster decline by cycling & calendar-age, so performance degrades without mercy. This applies too to its 54 kWh capacity figure, that declines each year.

But not to paint an overly pessimistic picture the roadster's battery is up to snuff and has a long-term warranty. Like the sedan, it's giving us 100,000 miles peace of mind.

We expect original batteries to deliver good performance in both EVs for at least 8 years, or some 80,000 miles guessing we may see at least 70% left after 5 years of use. Importantly though battery and capacitor technologies improve over time, so it should get much better as improved batteries and possibly capacitor/batteries appear ahead.

Interesting studies here seem to come almost every month. For instance one report shows experimental lithium sulphur with possible high energy density (Nature Materials, 2460). An EV balances power density (kW) 'to go fast' with energy (kW/hr) to go 'far', so new chemistries may improve those densities, including in cold and hot weather.

Or imagine a capacitor/battery hybrid; Nature reported on "off-stoichiometry" (reactants / products in unbalanced reaction) using LiFePO4, lithium iron phosphate.

Replacing the battery is a significant cost in the roadster, but its known. At some 8 years we'll replace its battery having pre-paid $12,000 for a new one. A lot of money to be sure, but ponder a moment what we're NOT paying for over those eight years.

This battery is about the only maintenance item on this roadster. Its friction brakes are hardly used, since with one-foot driving in this EV, to just let off the accelerator in the roadster slows it rapidly down. Other than that and tires, there's few moving parts!

Tires are replaced about every 12,000 miles, comparable to a gas super-car. Otherwise few items need any attention over years. We take this car in once a year for an annual look-over, when it receives computer-like attention and some firmware upgrades.

For repairs the difference is even greater. Our roadster has needed almost zero repairs; we expect that robustness and lack of problems to persist. Gassers however need repairs over years on engines, transmission, clutch, cooling etc. And $$ spent to maintain and fix say a Corvette ZR-1, Turbo Porsche or a Ferrari, may be more than battery replacement cost in an EV! Checking with a friendly mechanic we're told that comparable performance cars can easily cost more than $12K the first 8 years to maintain and repair!

So $12K is a lot to pre-pay for its new battery after 8 years. Yet compared to costs in maintaining and repairing a comparable performing gasser, maybe not so bad.

Stepping back, there's very little maintenance on either side of the EV + PV equation. On the solar side looking ahead there's an Inverter that will die at some 15 years, knowable & predictably so. Yes that does add to the costs of running this suncar -- a great car running on sunlight, but that is a rooftop fueling systems' only weak link.

Nonetheless bringing this suncar dream about *will not be easy*. Big carmakers for instance remain half-hearted on EVs; they have too much capital & psyche invested in oily fuel and internal combustion engines. It's no great surprise that our roadster was made by an EV start up which builds only electric cars: they can embrace the dream robustly.

Or think of a BMW executive who in an unguarded moment, stated EVs "won't work for most people. For at least 90% and maybe more of the population [an EV] won't work [on current battery range]." We believe the opposite is true. *EVs work well for many*. Plus we imagine for most people EVs even on current range can relegate 2nd car gassers to rarely driven status. We'd expect to see an EV grin repeated over and over.

Don't let all this obscure a key point: the 2008 roadster is already capable at any speed. Without needing battery *unobtainium* (something great if it existed today but doesn't), this roadster is catalyzing growth in EVs. Expect to see electric & hybrid cars emerge over this remaining decade ahead. ***Now it's all about bringing down costs!***

If interested, it's not hard to rough out what an EV might cost you to drive, in cents per the mile in your locale simply without solar. First go to your Utility's website and there should be information there on (super) Off peak electric rates at night.

Consider for example, Baltimore Gas & Electric on the East Coast. Their Time of Use cost shows a night (Off peak) rate of 9.8 cents summers (9.0 cents in winters; March 2011), which we'll call 10 cents overall. 10 cents is pretty typical for much of the U.S.

Because electric cars today seem to get about 3 miles per kWh from wall after losses, driven normally yours may go 3 miles, or 3 MPK. So dividing your Utility's night rate by 3, gives cost per mile. Look at say Baltimore's 10 cents: an EV may cost you around just 3.3 cents per mile on grid (10 cents kWh/3). That's much better than a gasser's costs, so the numbers already appear to pencil out surprisingly well.

Folks at 7 cents, who drive with much care for 4.5 MPK: they pay just 1½ cents per mile! No need to worry about gas and a fine 4 door for just $25K, so what's not to like?!!

Forget oily old gassers and MPG. Fast fun cars including those that charge from the grid and greater still sun-guzzlers that use in essence clean sunshine for their fuel, may finally break the bonds of oil and become a better solution to boot.

So much for facts & data. What does it *feel like*, in the *heart* to drive the roadster? The following test drive is from 2008, while eagerly awaiting delivery of our first EV!

First Test Drive of our EV
http://www.teslamotors.com/blog/handing-over-keys-vi-dr-rob-wilder

What Does this Electric Car Initially Feel Like to Drive?? First thoughts:

With pieces already by others on 1st impressions test driving the coming 2008 Roadster, I'll instead focus on some of my own feelings & concerns going into a first — and it turns out rather surprising — test drive. Please excuse the fairly personal nature of this post.

Since sending in a check long ago, I reckon I've 'sort of' owned an early 2008 Roadster sight unseen. But it still was a tremendous leap of faith for the whole family and me to have spent so much on a car that I knew so little about. So when the company asked if I wanted to actually test-drive a near-production car, I jumped at the chance.

First it meant this car itself was probably for real: at least I needn't endure years of ribbing from my wife for buying a non-existent car! Secondly with keys at last in hand, I was curious: what would I feel in my heart and head behind the wheel driving this unique, entirely new electric vehicle (EV)? Can EVs even begin to fulfill the promises?

I'd long been captured by the idea of wrapping a beautiful lightweight car body around thousands of Li-ion cells, with a strong AC motor and regenerative braking. But still it was all merely a thought: could it really come together as a great driving car?? Nobody had pulled it off in production so this Roadster was trying something pretty special. Certainly the world's major automobile manufacturers had ALL given up on EVs long ago as a mass production proposition and their comments about EVs since were derisive.

So, there is a rather a lot riding on this coming car. Because I'm passionate about fast cars, emotional feedback was no small matter to me. But before going into the test drive, I'll share the thorny hurdle from when I first came across this car in concept long ago.

I'll admit straight off that the hurdle wasn't that it was electric. Rather it was the price: a quick calculation showed this would be not only the most expensive car I'd ever bought but roughly what I'd spent on all cars before in my life … all put together.

Yet in my gut, I felt an EV if put together in properly disruptive way absolutely *could* yield a car unlike any before. More than anything, that caused me to swallow and send a check … it was how much *better an EV could be,* by integrating right parts and thinking.

But whether this car could deliver when so many failed — still made this a leap of faith.

Mindful this car *might* deliver superior ride, more thrills at speed and be better all-round to boot profoundly changing perceptions — or instead could be the most expensive failure I'd ever known, I was going into this first actual test drive with a lot on my mind.

Walking up to this car, its mid-size and curvy proportions of a supercar stand out yet do not appear extravagant to my eye outside, nor once I first sit at the wheel. Happily it is appealing (it is pretty flashy yes, but) not too showy for my tastes inside or out.

I wanted it to be simply lovely; not over-the-top expensive-looking, nor plain, nor like some awkward science fair project as some EVs have been. I think its styling hits the nail on the head, elegant while singularly different, maintaining a nice sense of balance.

Whew(!) a first key hurdle is cleared. It's beautiful which is essential. It bears semblance to a lithesome Lotus Elise, or Exige though a bit longer wheelbase. However the Elise is evolving in appearance and this a bit larger Roadster seems more timeless to my eye.

Opening the door this doorsill is very high, much too high so it makes getting in a not happy experience for non-limber me. To their credit they lowered even higher(!) doorsills of an Elise and met added side-crash tests, but this doorsill is my biggest complaint on getting in. This clearly is going to be a long time complaint of mine about this car for years to come (but not related to its electric drivetrain, which is what's special)

Turning the key creates a buzzing and whirring but that's not too disconcerting and soon stops. The seats (near-production versions I think) hold one in tightly and I quickly adjust to the feel. Next on putting the car into gear 'D", I see there's creep programmed in so it feels like a gasoline-car (a 'gasser'). I thus lightly brake to prevent inching on ahead.

Next, allowing the car to gently move from the curb, I find steering is pretty stiff at very slow speed: this could take a bit of getting used to compared to power-assisted steering.

OK, deep breath… will this car meet my hopes when I tap the accelerator? I'm worried for example about a cogging feel, or this car may at last give sensation of just a an expensive golf cart. I'm hoping for something from this Roadster better than any EV I've driven. This is the first modern EV of consequence for sale and none heretofore shined.

Remarkably then a surprising feeling of abundance flows as I pull away from the curb even at slow speeds. An abundance of available pulling torque, and horsepower, of silence, of elegant engineering, and careful design is what this car 'is saying' to me.

Steering quickly lightens and my hopes for what an electric car *could be* begin to find basis in reality… so far so good, I begin to feel some feedback now behind the wheel. My apprehensions start to melt away. But I still need to push it, not treat this beast like something I'm glad can actually budge — but rather treat this as a real sports car.

At my first green light, I punch it: what really surprises me is how we pull away quickly with no flat spots in the motor's power, followed by my mouth feeling funny… I then notice I'm actually grinning. This is the 'EV grin' and it is indeed pretty wild.

So despite the conventional wisdom, EVs do not need to be slow like regular gassers.

I think about our solar-powered home. There's no Middle East unrest, ocean drilling spill, no terrorism, accident at rigs, pipelines or refineries, nor national oil name to hamper my drive. With 'my Roadster' (I'm beginning to *really* want this car), I should get 200+ MPG… heck, better than 1 million MPG since I *don't use* oil. I see little downside.

It's now I notice the speedometer says I'm going faster than I realize. I drive gassers at high RPMs using engine compression to slow and telegraph changes to the driver. Lacking any engine sounds and not always hunting for a gear, I now find driving is a bit like a 'game' or Disney ride (remember the Rocket Sled?!).

The turbine-like sound whirring behind my ears is relatively quiet. Having a motorcycle as a youth and owning very noisy older gassers today, I thought I might miss the instructive revving sounds of fossil fuels furiously converting into mainly waste heat in classic (read: old) British engines, but I find myself liking this EV silence quite a lot.

It strikes me that my long-term fuel costs should be better too; one expects gasoline to head upwards in cost. Yet for this Roadster, 'fuel' costs on solar amazingly enough, drop down to zero. Solar panels sitting silently on our roof pay for themselves in 10 years or even less; we've already had them for many years and so reckon in 2011 or so they'll have paid for themselves — thereafter for decades we get green electron fuel, free.

Imagine that: free fuel from the sun + energy independence and a car faster than say a Porsche Cayman S … wow. It's been said the stone-age didn't end because we ran out of stones; combining elegant solar power with EVs just feels like a solution at hand.

Now a sports car needs competent brakes, a car is only as fast as its brakes. So I do a series of fast 0-50-0 stops/starts and detect no fade. Importantly, stopping distance is short, pedal feel excellent and degree of power assist right for me. Next up are ascending curves and chance for 20-50 mph bursts, to push handling closer to where I like to be.

I was convinced before this test drive I'd stay near speed limits, not push matters. Yet I kind of like to throw out rear wheels a bit in my Lotus 7. Mid-range acceleration and handling are my favorites. Tempted, I go into that first curve pushing matters a bit.

I'd note here probably the trait I seek most in any EV, or any gasser is lightness. Adding in lightness creates snowballing benefits like allowing for great handling, and it also makes for a better car. Heaviness has an opposite effect. So I am keenly aware of weight …

To briefly illustrate how far cars today drifted to obesity, if my three+ decades-old 1969 Lotus Super 7 TC weighing about 1,200 lbs was stacked on an identical one, *they both* would weigh *less than* a single Miata, considered among the lightest of modern cars.

Likewise two older classic Minis (Australia Moke) 4 seaters here each weigh about 1,500 lbs apiece. They're great for family & fun, yet if stacked (as were actually designed to be!) both those would still weigh much less than most single 4-seaters today. And I don't know how many 4 seater Minis it would take stacked, to equal a single morbidly obese Hummer in weight, but that's probably worth a laugh. Weight matters.

Thus I'd been encouraged early on to see a high priority put on lowest possible weight, when I first saw the 2008 Roadster's specs including use of carbon fiber and aluminum. Lightening is an area where mainstream manufacturers of even today's gassers should turn attention to ahead, given their obese gassers can benefit (although not as much as EVs which are more efficient and weight-sensitive).

With this Roadster starting out having an aluminum extrusion frame and adding in more lightness such as via Li-ion batteries and carbon fiber body, they clearly were being attentive to every pound and this was pretty impactful upon me. So I went into this very first curve attentive to how heavy this near-mass-production Roadster would feel, and how it might handle. With batteries alone adding around 1,000 pounds, I think, truly the pounds being put elsewhere upon this car would be felt and count.

Aiming into my first curve at speed, I first hear a very heavy 'thunk, thunk, thunk' sound at wheels as I drift a bit over 'Botts' dots', those small raised yellow reflective markers in centerline here in California. Maybe it's because the car otherwise is so quiet or the batteries make it (I am guessing several hundred pounds amidships?) heavier than a say roughly 2,000 lb. Exige, that heavy thunking is quite noticeable to me.

As the car continues to drop into this curve, I hit the accelerator at the apex and boy, does the rush of this car make those problems go away! Unlike a gasser one commands loads of torque without ever bogging the engine down or needing to downshift. It's so cool; even though I am heading uphill overall, it seems effortless to hug curves at high cornering limit. It appears so balanced I don't think my passenger sweats our speed.

A fear I'd had driving very early EVs was this one might feel like it needed to be pushed uphill — I now see that's totally unfounded here. And importantly this car I'm driving isn't 'vaporware' like an EV great in concept, but that never comes to fruition. Likewise this battery solution here doesn't require *unobtanium* at all (a substance that's great, if only it existed at a viable cost, but doesn't yet today): it's 100% real.

On this early test drive (of a non-final car), I don't greatly notice the regenerative braking; I imagine it is not far from the feeling of strong engine compression slowing some high-revving gasser. The difference is that instead of heating the brakes and venting waste heat, the energy captured in slowing this EV extends its range. How stupid a gasser now seems, to expend energy uphill but recapture none on the way back down!

[A brief note from 2011 is regenerative braking on the Roadster feels very comfortable. We use it to slow the car in everyday driving by lifting off the accelerator, rather than stepping on a brake… a slightly different way of driving that's more enjoyable and easier. The newer 2011 sedan has far less regenerative braking: we'd increase it. That said the oil-free sedan is still to us preferable, over any $20K oily gasser in the world!]

We take curve after curve and it's a whole lot of fun. As my test drive ends on this nearly-here-2008-production car, I'm surprised to find I now have much less of a 'Zen' attitude about actually getting my Roadster, compared to when I got in at the start of this drive. As others report, my feeling too is one of 'hey, I want this car as soon as I can get it!'

On first getting in for this test drive, a bicyclist had come over and asked what this car was … on reply he said he'd heard these were the most expensive cars ever made! I chuckled (can't afford something like that!) but also groan inside since this 2008 Roadster costs less $ than a German, British or Italian supercar of like performance.

But this is a crux of the matter: this Roadster may pretty radically alter perceptions of electric cars, importantly helping to start an interesting EV (with PV) future.

The Roadster's mystique should dissipate as they come out and I look forward to that. But most of all I like the idea we could all one day be driving a raft of great EV cars, many running on clean energy, and it's 'gassers' that give us all a chuckle.

Reprising some prior Thoughts on a Coming 2008 Phase 1 EV
http://www.teslamotors.com/blog/powering-tesla-Roadster-green-electrons

….
Having an EV plug in at home raises intriguing future possibilities. Potentially, home-owners could arbitrage the difference between very low cost power say 8 cents per kWh at night, when most plant capacity is just sitting idle — and much dearer electricity costs during daytime peak at maybe 25+ cents or more per kWh.

It might work like this: an electric car is based around a very big mobile battery. If that car has Vehicle to Grid (V2G) capability, it could also feed power back to the grid.

By charging up at night when juice is cheapest, and able to regularly sell back io the grid by V2G if a signal is sent from Utility calling for it, an EV simply sitting there plugged in to the garage can be a money spinner for the home or for building owner.

This has benefits for all, since one problem with renewable energy like solar, wind, micro-hydro and the like is they are each *intermittent* and so ***not firm*** *sources* — more desirable energy storage created by future EVs might do a lot to advance practical growth of renewable energy globally once batteries improve. However batteries of today are still quite limited by their duty cycles, and age, so this is now just a concept.

As batteries improve to thousands of cycles life, or are superseded by capacitors, this idea of V2G also can help Utilities also avoid building costly peaker plants and better use their idle capacity at night. They'd be able to sell more power overall than otherwise, to EVs -- shaving peaks and leveling a total load they're required to supply. If distributed solar generation grows, Utilities may capture new revenue (despite solar making power).

While EVs won't have V2G capability for at least several years, it may not be too far off. Today's Li-ion batteries have rather limited cycle life so it wouldn't make sense to hasten demise of costly batteries for small nightly profit gains (now a hardware issue). And communications protocols don't yet exist in grid (software issue), but as we've seen with for instance personal computers and the web, change can happen, and fast.

This new Roadster elegantly demonstrates how a whole can be greater than the parts. EVs with solar may well prove the most viable, enduring combinations of disparate emerging technologies we've seen in some time. They simply make sense!

Lastly we close with some images of varied steps taken here to improve our efficiency — and quality of life. They can take many forms, most all fun and we do love it!

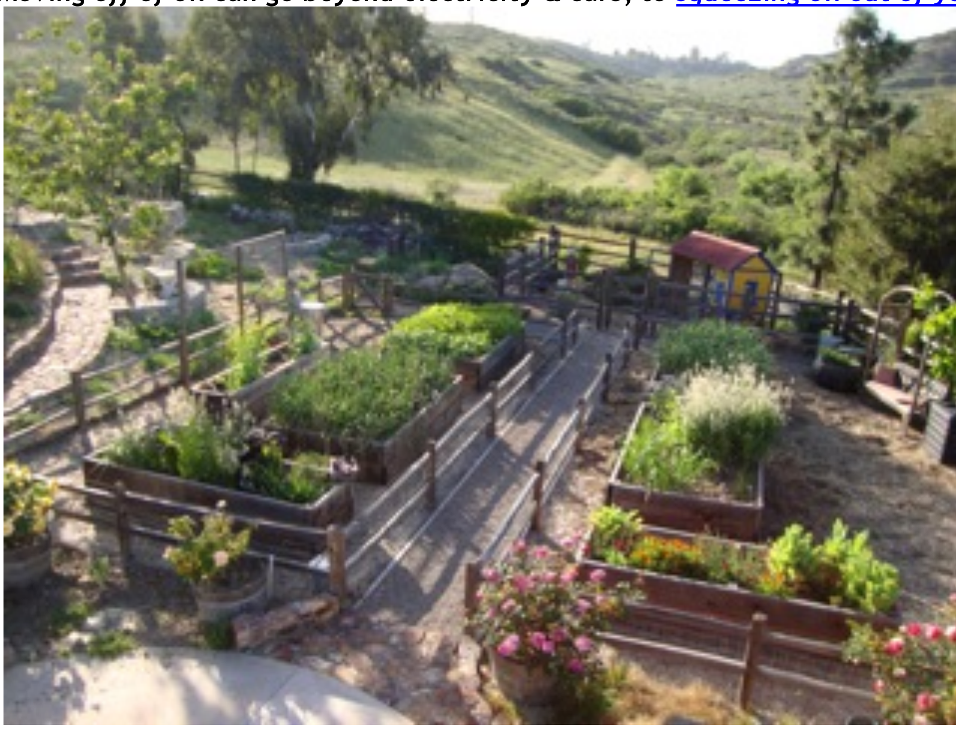
After the [rooftop PV](#) & solar hot water in 2003, we applied a waterproof foam layer atop our flat roof. The white foam reflects the sun helping cool our building, and it insulates in winter, holding in the warmth and reducing our energy use year-round. Moreover, it keeps the rain from seeping in through the flat roof, a major side benefit.

Solar hot water tank, right (round tank) and flat collector panels at bottom.

Additional solar water panels in foreground.

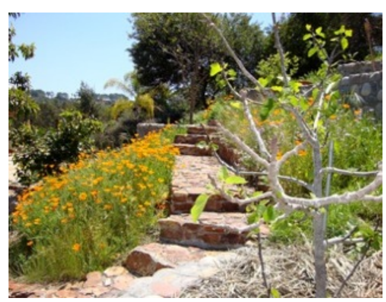
This lightweight production Mini weighs only 1,500 lbs, and so uses a tiny 1 liter engine; yet it seats 4 and we can use for short (fun) trips. Cars need to re-discover lightweighting!

Moving off of oil can go beyond electricity & cars, to squeezing oil out of your food!



Instead of a lawn — edibles! We've found our backyard-grown greens & fruits taste better than store-bought. To grow your own food however small the plot, reduces the amount of fossil fuels used to grow it far away (often non-organically) then trucking, shipping or flying it many miles to a grocer. Not only is it quite fun, it's tasty to be a Locavore!

Our 2 compost areas (center back, and at right) also provide good soil from waste scraps. Food waste is also recycled at our 'egg production facility' (red roof, in back).



We installed local-sourced stone.

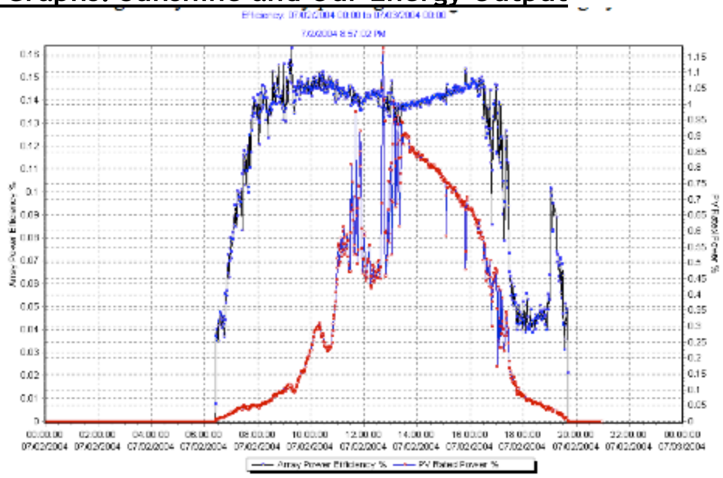
'Squeezing the oil out of your plate'. Our food gardens for example shown here in early May: growing organic vegetables & fruits here is efficient, tasty, and fun!



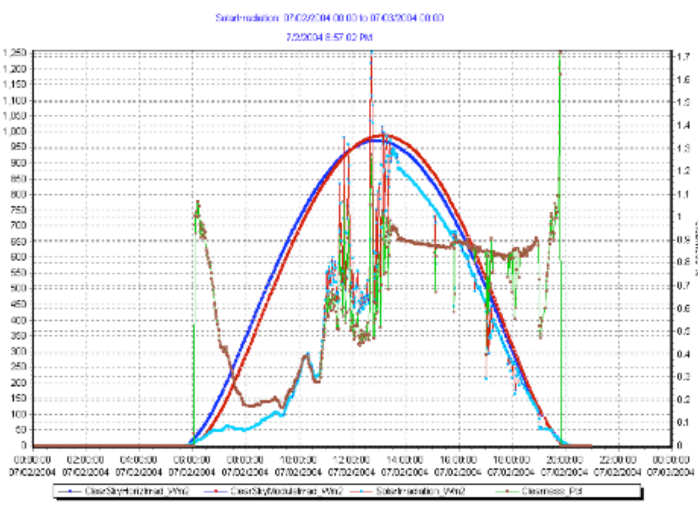

May: the food gardens. Also Sapote, Mulberry, Fig, Jujube trees starting to leaf!

From food waste: Egg Production!


PV Graphs: Sunshine and Our Energy Output



Above: Sun, array efficiency & power over a sample day, we see here roof mono PV at 14% module efficiency can outperform: it is doing well 8 am — to 5 pm. While the overall efficiency (blue) maintains a desirably flattened broad parabola, the power output (red) was more negatively influenced by passing cloud cover roughly 11 am — to 1 pm. Cloudy weather can have very sizable impact on PV output. More data are in graphs series, below.

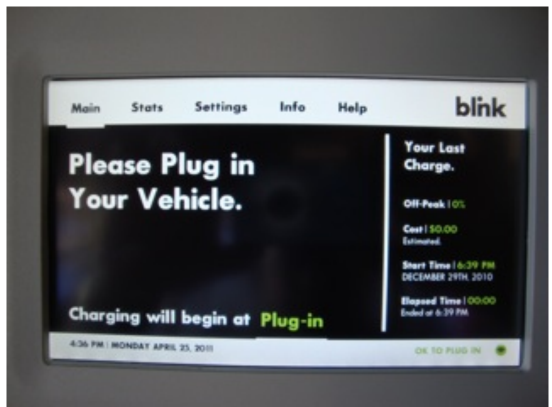


Above: Clearness % (green) on same day: corroborating cloud impacts 11 am — 1 pm, the power of sunshine drops well under a theoretical maximum of 1,000 watts/m^2 in same period. For more on monocrystalline PV see our rooftop performance graph series.

Above: 2 trees shading storage shed but also a bit of PV 2 ground mount area; we may switch to microinverters at replacement time, so whole array isn't impacted.

Roadster being charged: the main meter is for whole house + EV 1.

Sedan's charger, in garage.

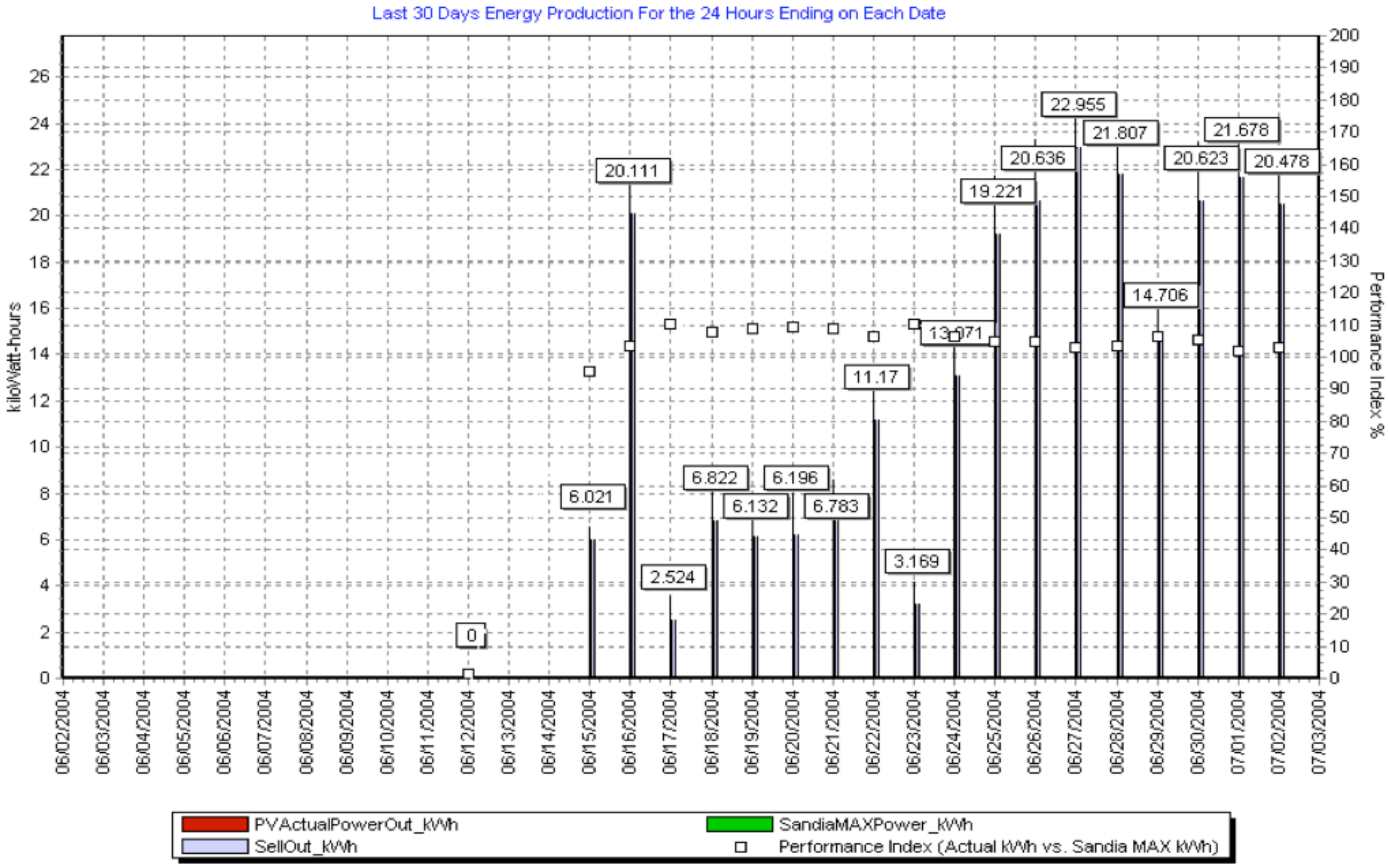


Sedan charges on this 2nd meter, EPEV rates.

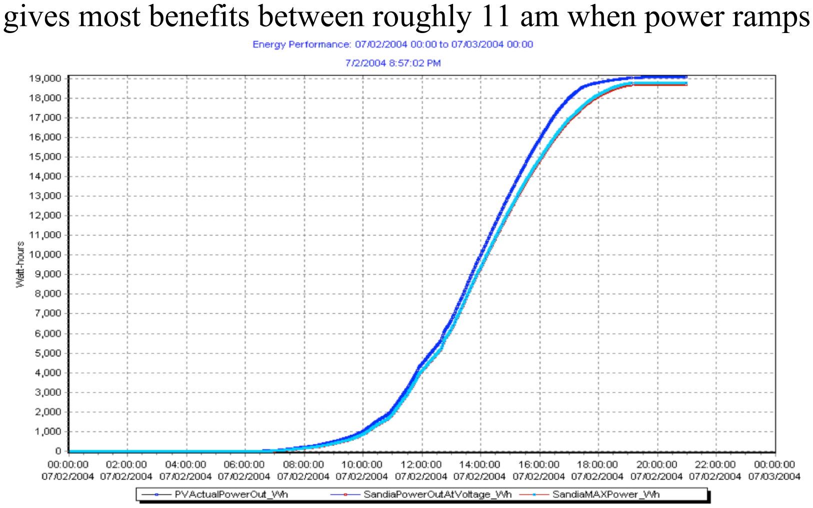
Much inside temperature & so comfort is adjustable by a simple retractable awning over a south-facing bay window (left). Hotter days we shade this window at top & sides like here; it makes a great difference. The natural clay on walls also helps to keep it comfortable inside, and of course a white foam reflective roof. It all adds up so we don't need A/C in summers.

Thanks to shade awnings, and air circulated as needed we don't need AC. Instead small fans like this (happens to be bladeless, large circle at right) are enough. Next to it is a small (Peltier effect) thermo electric unit providing minor heating or cooling (just 1.5 amps) in personal space. Often-simple things like retractable awnings over windows, growing food, and driving EVs and bikes make a tremendous difference reducing our energy demand.

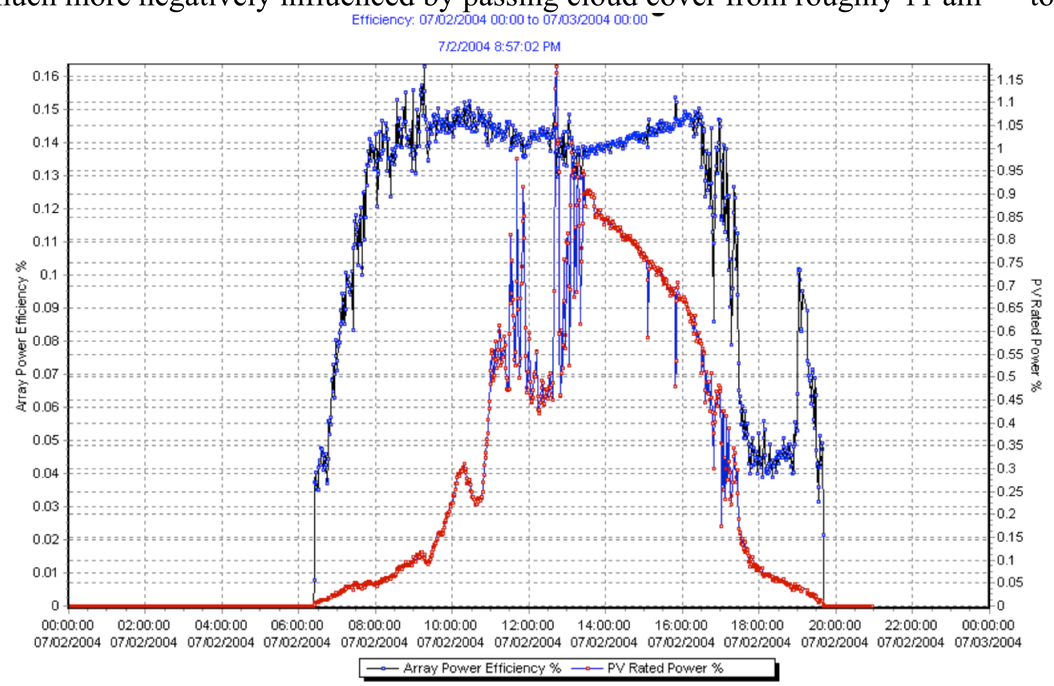
Daily Energy Output: as seen from 3.8 kW monocrystalline rooftop solar for June/July 2004. Note that daily production varies considerably depending on whether it's overcast, as seen the first week – or sunny as in the second week. An average, is say, 14 kWh/day in June/July. These data were gathered after a 1st monitoring system was installed in mid-June of 2004.



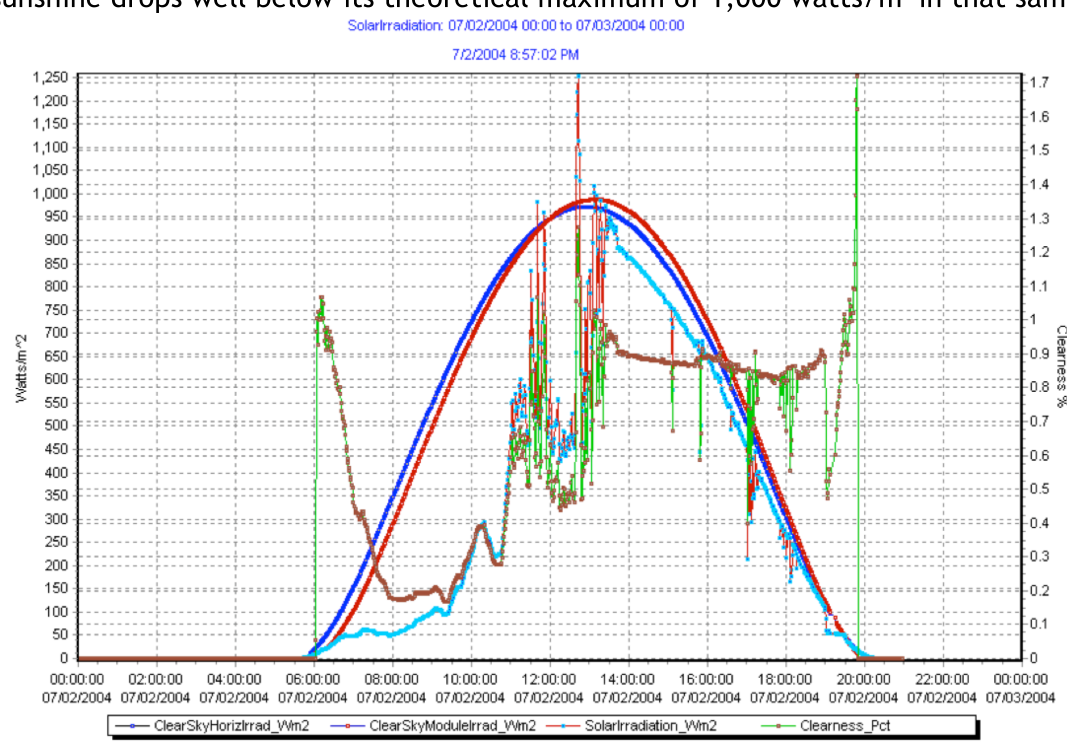
Total Energy Performance for July 3: here 19 kWh is made over a sample day (July 3rd 2004): the day's hourly generation curve matches very well with a Time of Use (TOU) metering that gives most benefits between roughly 11 am when power ramps — and 6 pm when it wanes.



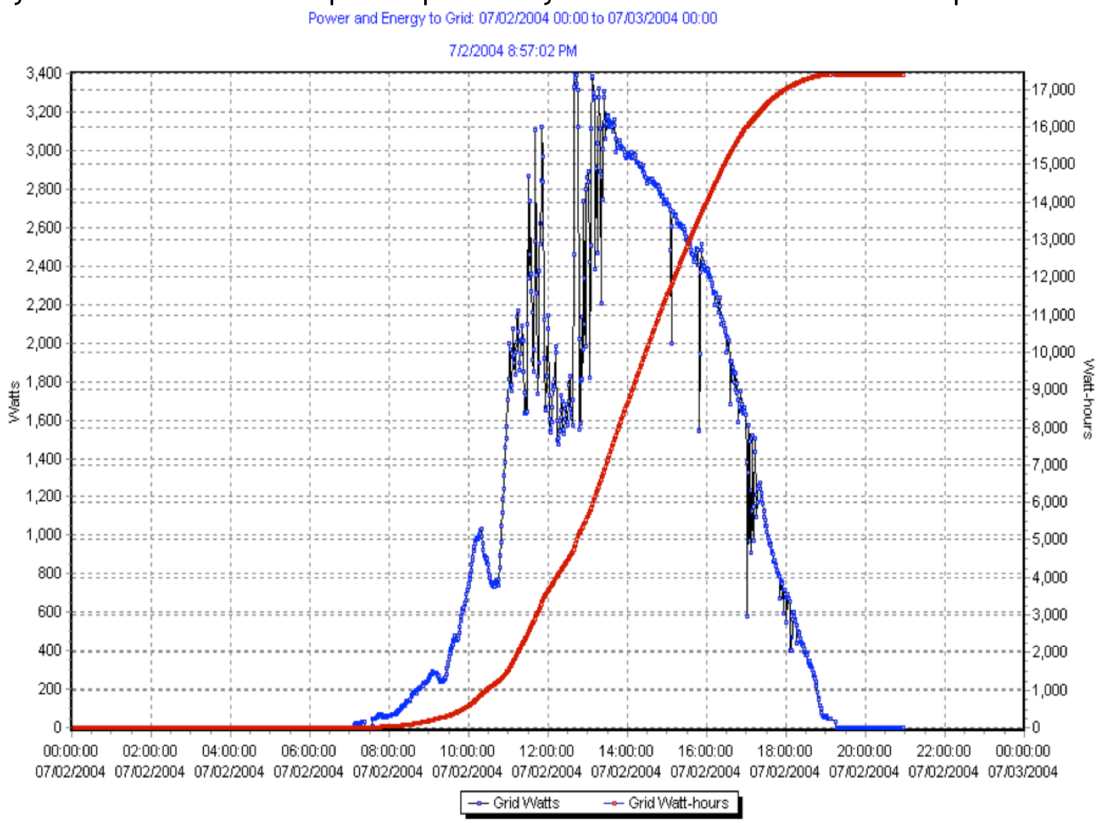
<u>Array Efficiency & Power Measured in a Day</u>: On a sample day the monocrystalline PV rated at 14,2% module Efficiency was seen to outperform and do very well from 8 am — to 5 pm. While Efficiency (**blue**) had its desirably-flattened-out broad parabola, Power output (**red**) was much more negatively influenced by passing cloud cover from roughly 11 am — to 1 pm.



<u>Solar Irradiance that Same Day</u>: Corroborating passing cloud impacts from 11 am — to 1 pm, sunshine drops well below its theoretical maximum of 1,000 watts/m^2 in that same period.



Power to Grid: Superimposing live output over the course of the Day in Watts, atop this same day's total cumulative output helps visually demonstrate the additive output of PV.



Temperature & Pressure at Rooftop PV Panels and Inverter housed in Garage: As expected a temperature parabola is seen this day for rooftop PV. Opening a garage door at 7 am where the first Inverter is housed causes an interesting brief change of temps and pressure inside.