

Thank you Ecology Center & Sierra Club Bay Chapter!

S lar Simplified Part 2 of 2 – Deeper Dive

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Solar Simplifed – Deeper Dive

Who's Doug?

SunWork.org



NorCalSolar.org



LinkedIn.com/in/renewabledoug

Long Time Sierra Club Member

EV enthusiast



Solar Simplified – Getting Started June 10, 2017

Topics

- Components of a PV system
- Solar Financing
- Solar Economics
- Environmental Benefits of Solar
- How to Find a Great Installer
- Solar in California and the World

Solar Simplified – Deeper Dive

Topics

- Solar Panel and Inverter Choices
- Electric Vehicles
- Batteries
- Home Appliance Electrification
- Community Choice Energy
- Net Metering
- Policies (that promote or stymie solar)
- The Future of Solar



Mono-crystalline silicon ______ Most expensive per watt, most efficient, great when unshaded roof space is limited



• Poly-crystalline silicon Less expensive, less efficient, typical choice (~65%) of residential solar market

Thin Film

Least expensive, least efficient, needs the most space, uncommon for residential solar



Panel Warranties*

- Usually 25 year "production" warranty
 - Will produce at least the specified watts over the period of the warranty
 - Usually ~90% of the original wattage in year 25
- Usually 10 year "product" warranty
 - Covers manufacturing defects
 - Cosmetic problems

* California installers provide at least a 10 year warranty on the whole system

String Inverter

Usually one per residential solar system Least expensive for larger systems



DC Optimizers

One optimizer attached to each solar panel Excellent for partial shade Still need the string inverter

Microinverter

Usually one attached to each solar panel Excellent for partial shade





Inverter Warranties*

- Usually 25 years for on-the-roof products
 - Microinverters and DC optimizers
- Usually 10-12 years for off-the-roof products
 - String inverters
 - Most manufacturers of string inverters offer extended warranties

* California installers provide at least a 10 year warranty on the whole system

Monitoring

SMA string inverter



Monitoring

Enphase

microinverters



Monitoring

SolarEdge DC Optimizers



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Solar Simplified – EVs



IN Winter, as in Summer, to use a Baker Brougham or Coupe is to enjoy the maximum of automobile luxury, utility and dependable service.

The Brougham and Coupe are cars of much power and unusual flexibility of control —quite unlike the average large electric.

These new Bakers present unique features of conveniepe and appointment among them being RE-VOLVING FRONT SEATS, which permit the occupants to face for ward or turn about. With this increased roominess, longer wheel

base and strikingly beautiful low-hung body lines, they are the latest development of stylish yet conservative Electrics.

THE BAKER MOTOR VEHICLE CO. Cleveland, O. Builders also of Baker Electric Trucks Branches or Dealers in Principal Cities

When answering advertisements it is of advantage to mention McClure's.

Solar Simplified – Electric Vehicles

Type into Google: electric vehicles

Cars > Electricity

2017 Nissan LEAF	2017 Ford Focus Elect	2016 smart fortwo ele
MSRP from \$30,680	MSRP from \$29,120	MSRP from \$25,000
2017 Tesla Model S	2017 BMW i3	2017 Kia Soul EV
MSRP from \$68,000	MSRP from \$42,400	MSRP from \$32,250
2017 Chevrolet Bolt EV	2017 Mitsubishi i-MiEV	2017 Tesla Model X
MSRP from \$36,620	MSRP from \$22,995	MSRP from \$82,500
2017 FIAT 500e	2017 Toyota Mirai	2016 Volkswagen e-G
MSRP from \$32,995	MSRP from \$57,500	MSRP from \$28,995
2016 Chevrolet Spark MSRP from \$25,120	2016 Cadillac ELR MSRP from \$65,000	
2017 Mercedes-Benz MSRP from \$39,900	2017 Hyundai Ioniq EV MSRP from \$29,500	

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EVs

Type into Google: electric vehicles First link: <u>plugincars.com/cars</u>

Compare Electric Cars and Plug-in Hybrids By Features, Price, Range

Check out the growing list of cars powered by electricity! A few years ago, you could count the number of available plug-in cars on one hand, with a couple fingers left over. Today, there are more than 20 models offered from more than a dozen different brands—in a range of sizes, styles, price points and powertrains to suit a wide range of consumers.



plugincars.com/cars

Sort by RANGE (high-to-low)



EVs

Tesla Model S

Electric Vehicle Sedan

315 miles (pure electric) \$71.000

The Tesla Model S is a bright vision of a practical and desirable all-electric sedan Tesla set a big goal for itself: to deliver not just a great EV, but one of the world's best luxury sedans. Mission accomplished.



Ford Focus Electric Electric Vehicle Sedan 115 miles (pure electric)

\$29 200

full review photos news

The five-door hatchback provides about 100 miles of range. It offers many features that make it an enticing EV package, including an attractive design and zippy drive. The Focus Electric employs a 107-kilowatt (143 horsepower) motor, compared to the LEAF's 110 horsepower motor.

BMW i3	full review
Electric Vehicle Sedan	photos
114 miles (pure electric)	inews 💮
\$43,400	

The stylish if slightly odd-looking BMW i3 is the lightest EV on the market. That makes it very efficient while providing a fast and fun 170-horsepower ride. The i3's battery pack delivers 114 miles of range. The electric Bimmer is also available with a small gas engine that boosts total driving distance to about 180 miles.



Tesla Model X

Electric Vehicle SUV

289 miles (pure electric) \$80,000

The Model X is Tesla's follow-up vehicle to the award-winning Model S sedan. The X shares about 60 percent of the content from the sedan-converting the sleek Maserati-looking five-passenger model into a stylish crossover utility vehicle.

With the Bolt, General Motors introduced the industry's first affordable long-range electric car, rated to provide 238 miles on a single charge. It's a milestone for the EV market. The Bolt is currently available only in California and Oregon but will roll out





\$29,000

	Iuli review
	photos
•	news

The Nissan LEAF is by far the most popular EV in the world. It is a well-equipped, all-electric hatchback that seats five adults and can travel up to 107 miles on a single charge. The LEAF is available to test-drive and purchase at Nissan dealerships throughout the United States.



Chevrolet Bolt

Electric Vehicle Sedan

238 miles (pure electric) \$37.500



full review

photos

news

full review

photos

news



Electric Vehicle Sedan

93 miles (pure electric)

full review photos news

lyundai-Kia arrived late to the EV party. But it appears that Kia made a careful study of the competition, and loaded its Soul EV with smart features for electric car drivers. For starters, it offers 93 miles of real-world range.



Mercedes B-Class Electric Drive		full review
Electric Vehicle Sedan	2	photos
85 miles (pure electric)		news
\$42,400		
This small Mercedes electric car directly competes wit	h the	BMW i3. Its

powertrain is provided by Tesla Motors, but engineers turned it into a comfortable and relaxed commuter car. If driven with care, the well-appointed B-Class could offer around 100 miles of range from a battery pack capable of holding 31.5 kilowatt-hours of juice.



Fiat 500e Electric Vehicle Coupe 84 miles (pure electric)

	full review
2	photos
۲	news

The Fiat 500e is every bit as cute as the gas-powered Fiat 500. It uses a 24 kilowatt-hour liquid-cooled lithium-ion battery pack, providing an official EPA range of 84 miles. The Fiat 500e is widely considered a "compliance" car produced only in small numbers to meet California regulations.



The Volkswagen E-Golf is the company's first all-electric car. It maintains the spirited driving experience of internal combustion versions of the Golf-one of the most popular small cars in the world. The VW E-Golf is arguably the best handling car among the emerging class of small affordable EVs.



Tesla Mo

Electric Vehicle Sedan

nationwide throughout 2017.

200 miles (pure electric)



Tesla would have to defy all expectations to achieve success on the Model 3, while avoiding all the potential pitfalls-not only for the 200-mile \$35,000 Model 3, but a massive new battery factory. Yet, based on the unveiling of the car in March 2016, the company appears ready to make another ground-breaking electric car.



Hyundai loniq

Electric Vehicle, Plug-in Hybrid Sedan

124 miles (pure electric) \$29,500

Hyundai's new aerodynamic compact hatch is offered as a pure electric car with a driving range of about 124 miles. It has more space, better efficiency and smarter electric features than the competition in its price range. The EV goes on sale in April 2017, followed by a plug-in hybrid before the end of the year.



del 3		

\$35,000



photos

news

EVs – Environmental Benefits

- No tailpipe emissions ______
- No toxic refueling stations needed No trucking of fuel needed; no spills
- Less wasted energy Internal Combustion Engine (ICE)
 ≈ 30% efficient
 EV ≈ 90% efficient







EVs – Economic Benefits

- Fuel Cost per Mile ICE
- Cents per-gallon / miles per gallon = cents per mile At \$3/gallon*:
 - 50 MPG Prius: 6¢/mile
 - 30 MPG Sedan: 10¢/mile
 - 25 MPG SUV: 12¢/mile
 - 20 MPG Pickup: 15¢/mile
 - 10 MPG Hummer: 30¢/mile

* Additional 12¢/gallon California tax will go into effect Nov. 2017

EVs – Economic Benefits

- Fuel Cost per Mile EV
- Cents per kWh / miles per kWh = cents per mile Industry average: 3.4 miles per kWh
- Using PG&E grid energy 22¢/kWh (approx. average PG&E for Bay Area)*:
 - 22¢/kWh / 3.4 miles-per-kWh = 6.5¢/mile (About the same as the Prius)

*2/7/2017 Headline: <u>Bay Area customers cry foul as PG&E enacts double-digit rate hikes</u>

EVs – Economic Benefits

Fuel Cost per Mile - EV Cents per kWh / miles per kWh = cents per mile Industry average: 3.4 miles per kWh

Using Solar

- 9.7¢/kWh (for a \$4/watt solar system)*
- 9.7¢/kWh / 3.4 miles-per-kWh = 2.8¢/mile
 6.3¢/kWh (for a \$2.50/watt solar system)*
 - 6.3¢ / 3.4 miles-per-kWh = **1.8¢/mile**

* From Solar Simplified Part 1 – June 10, 2017

Solar + PV Economics – Review*

Solar + EV example (4 kW solar system) \$ 1521/yr to \$1692 /yr total savings

Simple Payback \$12,200/\$1521≈ **8 years** (\$4/watt) \$8000/\$1692 ≈ **4.7 years** (\$2.50/watt)

Simple ROI (not taxable)
\$1521/\$12,200 ≈ 12.5%
(\$4/watt)
\$1692/\$8000 ≈ 21.1%
(\$2.50/watt)

* From Solar Simplified Part 1 – June 10, 2017



EVs – Lots More Benefits

- The "tank" is full every morning. Never go to the gas station
- Minimal maintenance needed
- EV engines are quiet at all speeds
- Smooth, immediate acceleration with no lag, no shifting
- Regenerative braking slows the car by recharging the battery
- No idling: No wasted fuel in traffic, stop signs or lights
- Use the heater or A/C with the engine off
- No starter motor noise
- No engine warm up needed
- Use HOV and express lanes for free
- Precise monitoring of real-time and cumulative energy use
- Low center of gravity (below-floor batteries) turning stability
- Conversation starter, clean conscience, bragging rights
- Cleaner wheels (much less grime from braking)

EVs – One More Benefit

Get your \$500 Rebate from PG&E

- EV or plug-in hybrid
- Own or lease
- Go to this link:

https://www.pge.com/en_US/residential/solar-andvehicles/options/clean-vehicles/electric/clean-fuel-rebatefor-electric-vehicles.page

Or just search for: pge ev rebate

Solar Simplified – Deeper Dive

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- Electric Vehicles

Batteries

- Home Appliance Electrification
- Community Choice Energy
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- The Future of Solar

Two solar-related uses

- **Backup** for when the grid goes down
- Load-Shifting for "Time-of-Use" (TOU)
 PG&E rate plans

Backup – for when the grid goes down

- Energy Independence! (sort of)
- Expensive
 - Add enough storage for multiple sunless days
 - But... there is currently a big rebate in California, the Self Generation Incentive Program (SGIP)
- Complex
 - Switching to enable "critical loads" to be battery powered, but let no energy back through the meter
 - Need additional expertise, permit and inspection

Backup – for when the grid goes down



Load-Shifting – for TOU rate plans

- Control over per-kWh pricing (sort of)
 - Arbitrage is not allowed
 - Have to balance battery efficiency loss and daily cycling, with ¢/kWh saved on TOU rate differential
- Somewhat expensive
 - Less equipment needed than backup, but just the batteries are expensive
 - But... SGIP rebate
- Somewhat complex
 - No need to separate critical circuits
 - Need additional expertise, permit and inspection

Batteries (and everything solar) Home Power magazine!*

Lithium-Ion Battery Prices*



* Issue 179, May-June 2017, "Battery Chemistry"

Battery Chemistry Characteristics

	Lead-Acid			Lithium-Ion		Nickel-
Characteristic	Flooded	AGM	Gel	NMC	LFP	Iron
Recommended applications	Off-grid	Off-grid, backup	Off-grid, backup	Off-grid, backup, energy mgmt.	Off-grid, backup, energy mgmt.	Off-grid
Upfront cost	Low*	Low to moderate	Low to moderate	High	High	High
Maintenance-free	No	Yes	Yes	Yes	Yes	No
Efficiency	Moderate	High	High	High	High	Moderate
Acceptable DOD	Low to moderate	Low	Low to moderate	High	High	High
Cycle life	Low to moderate*	Low to moderate	Low to moderate	High	High	Highest
Power-to-weight ratio	Low	Low	Low	Highest	High	Moderate
Resistance to harm from overcharging	High	Low to moderate	Low to moderate	Low	Low	Highest
Freeze tolerance	Low	High	High	High	High	High
Self-discharge rate	Moderate	Low	Low	Low	Low	High
Stability	Moderate	Moderate	Moderate	Low to moderate	High	High
Venting required	High	Some	Some	None	None	High
Voltage sag with low SOC	Yes	Yes	Yes	Minor	Minor	Yes
Cold weather capacity	Low	Moderate	Low	High	High	Low
Ease of recycling	High	High	High	Low	Low	Moderate
Familiarity	High	High	High	Low	Low	Moderate
Cell BMS required	No	No	No	Yes	Yes	No

*Premium (industrial) FLAs can have moderate cost and high cycle life

Home Power magazine, Issue 179, May-June 2017, "Battery Chemistry"

Some things to think about...

- EVs contain very large batteries
- Today in the US, electricity goes only into EVs
- Tesla cars and solar-roofs and batteries are expensive now, but their (and competitors') products are getting cheaper and cheaper

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Natural gas (NG) is cheap!

- ~\$1.30 per therm (household use)
 - 1 therm ≈ 30 kWh => NG: ~4.4¢/kWh
- Versus PG&E electricity: ~22¢/kWh (5x NG)
- Even at \$2.50/watt, solar: 6.3¢/kWh (1.4-2.2 x NG)
- But... with leakage throughout the NG industry, NG may produce as much greenhouse gas per unit of energy as coal!



Many good organizations say: "Reduce energy use!"

They should instead say: Increase electricity use (a LOT), and reduce fossil fuel use

- Electric cars
- Clothes dryer
- Oven and cooktop
- Water heater
- Furnace

Clothes dryer considerations

- Possible cost of running a 220 volt circuit to the laundry area
- Similar appliance cost
- 5 times the energy cost, grid vs NG;
 ~2x with solar
- Clotheslines work sometimes, too

Oven and cooktop considerations

- Possible cost of running a 220 volt circuit to the kitchen area
- Resistance heat: similar appliance cost
- Induction cooktop: ~2x the cost
- Lots of cooks hate electric stoves
- But carbon monoxide should be fan-vented
- ~5 times the energy cost, grid vs NG;
 ~2x with solar
- Solar cookers work sometimes, too

- Electric water heater considerations
 - Two kinds: Resistive and heat-pump Two kinds of resistive: tank & tankless
 - Possible cost of running a 220 volt circuit to the water heater area
 - Resistive heat: similar appliance cost
 - Heat pump: significantly higher cost (also needs more space)
 - Energy costs
 - Resistive/Tank: ~5x, grid vs NG; ~2x with solar
 - Resistive/Tankless: ~3-4x, grid vs NG; ~1.75x with solar
 - Heat pump: ~2.5x, grid vs NG, ~equal with solar

Electric furnace considerations

- Two kinds: Heat pump or resistive
- But... it can be very difficult to go from NG heat to electric heat
 - Title 24 Time Dependent Valuation (TDV) must be determined
 - TDV is the \$/kWh wholesale cost of a particular load considering seasonal and hourly load characteristics and including fuel cost and carbon allowance cost and generator capital requirements
 - Depends on home size, building envelope, capacity and efficiency of space heating equipment
 - There *may* be some pilot programs to test prescriptive Title 24 compliance later this year.

- Plug-in electric heaters
 - Cheap to purchase
 - 5 times the energy cost, grid vs NG;
 ~2x with solar
 - Sweaters work sometimes, too

Some things to think about...

- California imposes a ~\$14 per ton fee on CO2 emitters. Almost all economists think it should be \$40 to \$100/ton by 2030
- Each \$1/ton adds about 1¢/gallon of gasoline
- Each \$1/ton adds about 1% to the wholesale price of NG-generated electricity

Anyone need a little electrification?

Questions?





Hanging in there?

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Solar Simplified

Community Choice Energy (CCE) also known as Community Choice Aggregation (CCA)

Enabled in California in 2002 First instance in 2010 Coming to Alameda County in Spring 2018!



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CCEs / CCAs – What

Continue to use PG&E infrastructure

• Wires, poles, transformers, substations, maintenance crews

Stop using PG&E electric generating plants



CCEs / CCAs - Who

Example CCEs

- MCE Clean Energy (was Marin Clean Energy)
 - First in California!
- Silicon Valley Clean Energy
- Clean Power SF
- Peninsula Clean Energy
- East Bay Community Energy (<u>EBCE.org</u>) Coming to Alameda county in 2018!
 CalCCA (<u>Cal-CCA.org</u>) is the
 California Community Choice Association

CCEs / CCAs – Why (EBCE)

- Community-governed nonprofit*
 - Will enable clean power for renters
 - Will enable clean power for low income people
- Emphasis on local power
 - Local jobs
 - Lower transmission & distribution costs and losses
- Higher percentage of renewables than PG&E
- Enables competition in the energy market
- Reduces everyone's carbon footprint
- Helps cities reach climate action goals

* Your participation will make a difference

CCEs / CCAs – When (EBCE)

The EBCE CEO was just chosen: Nicolas Chaset, Chief of Staff to **CPUC President Michael Picker**

STEPS AHEAD FOR EBCE

EBCE will provide electricity generated from clean, renewable sources that pollute less and produce fewer greenhouse gases. Using more renewable energy is an easy, economical way to reduce our carbon footprint and meet community climate action goals.

You can join the conversation in your community and sign up on the website to follow our progress during the coming year. Learn more at EBCE.org

Conduct community outreach

WINTER 2016

FALL

SPRING

2018

Form Joint Powers Authority (JPA) with County and participating cities

Submit Implementation Plan to the California Public Utilities Commission

Finalize energy 2017

2017

SUMMER

Ongoing

services contracts

Set electricity rates and send customer enrollment notices

WINTER 2017

Begin providing cleaner, greener electricity

CCEs / CCAs

CCEs are a big deal

- Disruptive of the 100+ year old utility monopoly business model
- 80% of California utility rate payers will be part of a CCE by ~2025

Consider participating in the Local Clean Energy Alliance (<u>LocalCleanEnergy.org</u>), the Bay Area's largest clean energy coalition

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Net Metering (or Net Energy Metering or NEM)

Net Metering is conceptually simple enough

- PG&E pays owners of solar systems for electricity sent to the grid
- The price per kWh is the same whether you're paying PG&E or they're paying you
- You pay PG&E for grid energy, PG&E pays you for solar energy. The "net" is what you either owe, or are owed
- Because of seasonal variations (credit in the summer, debit in the winter), just "true up" the bill once per year

Net Metering Implementation Devils

- Monthly "Minimum Delivery Charge" of ~\$10
- Non-Bypassable Charges (NBCs) of 2.3¢/kWh for every kWh drawn from the grid
- Rate plans and territories and tiers and Time-Of-Use Peak/PartPeak/OffPeak and winter/summer rates
- The PG&E Net-metered bill is very complex and difficult to fully understand*

 PG&E recently formed a working group with CCE and solar-installer stakeholders to help align and improve solar-related messaging, including the bill

Net Metering Policy Devils

- This is not quite true: The price per kWh is the same whether you're paying PG&E or they're paying you
 - NBCs mean grid energy costs you more than you're paid for solar energy
 - The Minimum bill can't be offset with solar
 - If you generate more energy than you consume (12 months), PG&E pays you the wholesale rate (~4¢/kWh) for this energy

Net Metering Angels (sort of)

California Net Metering is excellent even under "Net Metering 2.0" (NEM2)

- NEM2 took effect in Dec 2016
- Included one-time \$145 interconnection fee and NBCs
- 5% to 10% less excellent return on investment compared with original NEM, but still excellent
- Prices on solar panels and inverters have dropped significantly since NEM2; lower prices should offset 5-10 years of lower NEM2 returns

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Solar Simplified – Policies

Pro-Solar

- 30% Federal Tax Credit
- SGIP rebate
- California Solar Initiative rebate is gone
 - "Volumetric" & extremely well crafted
- Renewable Portfolio Standard
 - Calif: 50% renewables by 2030; considering 100% by 2045
- California Cap-and-Trade (now about 14¢/ton of CO2)

Anti-Solar

- Utilities-versus-NEM battles across the USA
- Globally, fossil fuel subsidies are probably not too much more than a TRILLION DOLLARS PER YEAR*
- * priceofoil.org/2012/06/13/1-trillion-in-global-fossil-fuel-subsidies-the-urgent-need-for-transparency oug@sunwork.org

Solar Simplified – Policies

Something to watch:

Suniva's "Section 201 Petition"

- Would double the price of most solar panels imported into the US
- Aligns with "America First" theme
- 50-50(?) chance of being imposed
- 9/22/2017 US Int'l Trade Commission decides
- 11/13/2017 US ITC submits recommendations to US President
- 1/122018 President decides how to proceed

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Soft Costs - Others (PII, Land Acquisition, Sales Tax, Overhead, and Net Profit)

Soft Costs - Install Labor

Hardware BOS - Structural and Electrical Components

Inverter

Module

Half of all solar in the US is in California!



Source: U.S. Energy Information Administration, Electric Power Monthly

March 11, 2017 midday: solar generated half of California's total electricity demand

California Independent System Operator net generation, March 11, 2017 gigawatthours

> distributed solar utility-scale solar imports other renewables thermal nuclear hydroelectric

eia



Solar Powered Home



Solar Power Plant - Les Mées, France



Worldwide growth of photovoltaics Cumulative capacity in megawatts [MWp] grouped by The region^{[1][2][3][4][5]} No split-up by region for 2016 and 2017 available yet 400,000 T Future of Solar 300,000 200,000 100,000 20112013 2015 2017 2007 2009 Europe Asia-Pacific Americas China

Middle East and Africa

Rest of the world

Worldwide growth of photovoltaics

China's New 5 year plan

- \$360 billion into renewable power by 2020
- \$144 billion into solar
 = 150 GW of solar by 2020

India's New National Solar Mission

• Expand from 3 MW today to 20,000 MW (20 GW) by 2020, and 200 GW by 2050.

The Sun: Less than two hours of sunlight reaching the earth contains enough energy to provide all of humanity's energy needs for a full year

Not-Solar Not-Simplified

Help go from this...

How to Make **Fossil Fuel** Electricity

Solar Simplified

To this!

How to Make **Solar** Electricity



Thanks!



Questions?

Now or anytime doug@sunwork.org 650-279-6063