El Cerrito Environmental Quality Committee

Solar Simplified Workshop

10/20/2016

Doug McKenzie
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Solar Simplified

Who's Doug?

SunWork.org

NorCalSolar.org

LightsOnSolar.com and AspirationalCoaching.com

LinkedIn.com/in/renewabledoug

EV enthusiast

Solar Simplified

Workshop Goals (and Agenda) – to understand:

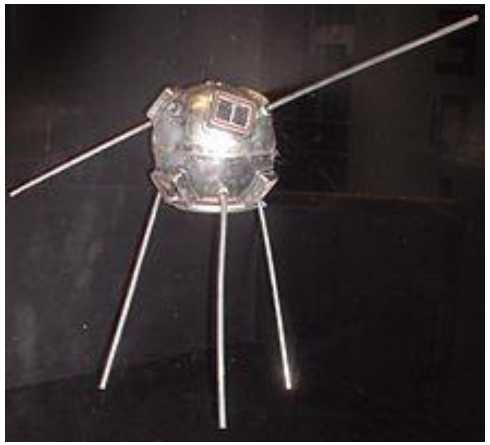
- *Solar power basics*
- *Solar Products*
- *Solar for your house?*
- *Ownership and finance*
- *How to (roughly) size a solar system for your home*
- *How to select a great contractor*

Doug McKenzie – doug@sunwork.org

Solar Simplified - Basics

Short history of solar electric power (photovoltaic or PV)

- Edmond Becquerel discovered the photo-voltaic effect in 1839
- First practical solar cell: Bell Labs in 1954
- Space Race (1950s/60s) and the 1970's oil crisis propelled PV. Vanguard I was partly solar powered (1958). Exxon lowered PV costs using solar to help power offshore oil rigs



- Solar's booms and busts (70's and 80's) "Solar Coaster" - on & off & on subsidies, shortages and oversupplies, industry volatility & uncertainty
- Present federal subsidy:

  Through 2019: 30% tax credit of the full cost of the system

  2020: 26%

  2021: 22%

  2023: permanent: 0% for residential, 10% for commercial & utility

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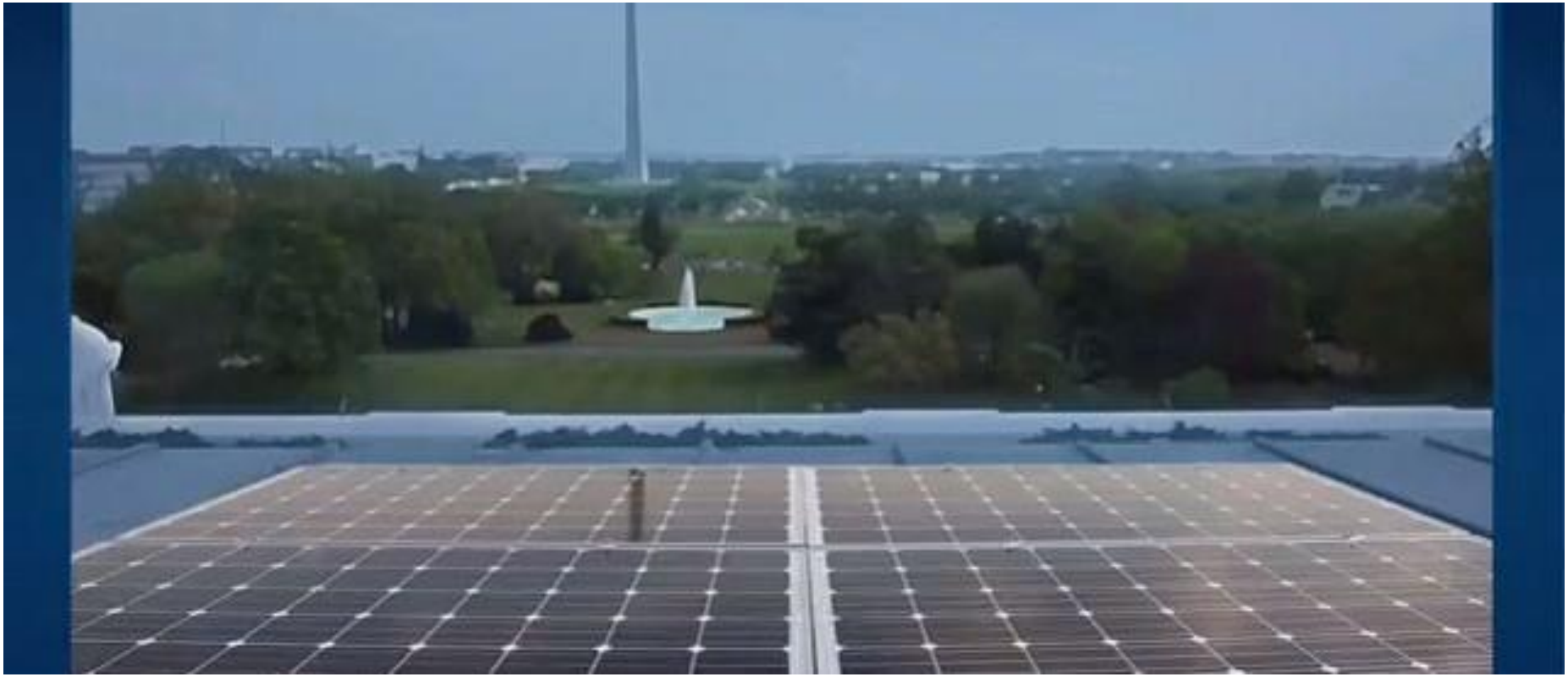
Solar Simplified - Basics

Short history of PV

- Pres Obama installed solar PV on the White House in 2014



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Solar Simplified - Basics

Types of solar power

- Solar Photovoltaic/PV
  - Sunlight produces electricity
- Solar Thermal
  - Heat water for home or business use
    OR, concentrate heat to generate electricity
    Ivanpah project in CA near Las Vegas:
    4,000 acres of mirrors
- Many other forms
  - Desalinization, Photosynthesis, Passive solar (green-houses), Pre-heating of ventilating air for large buildings, …

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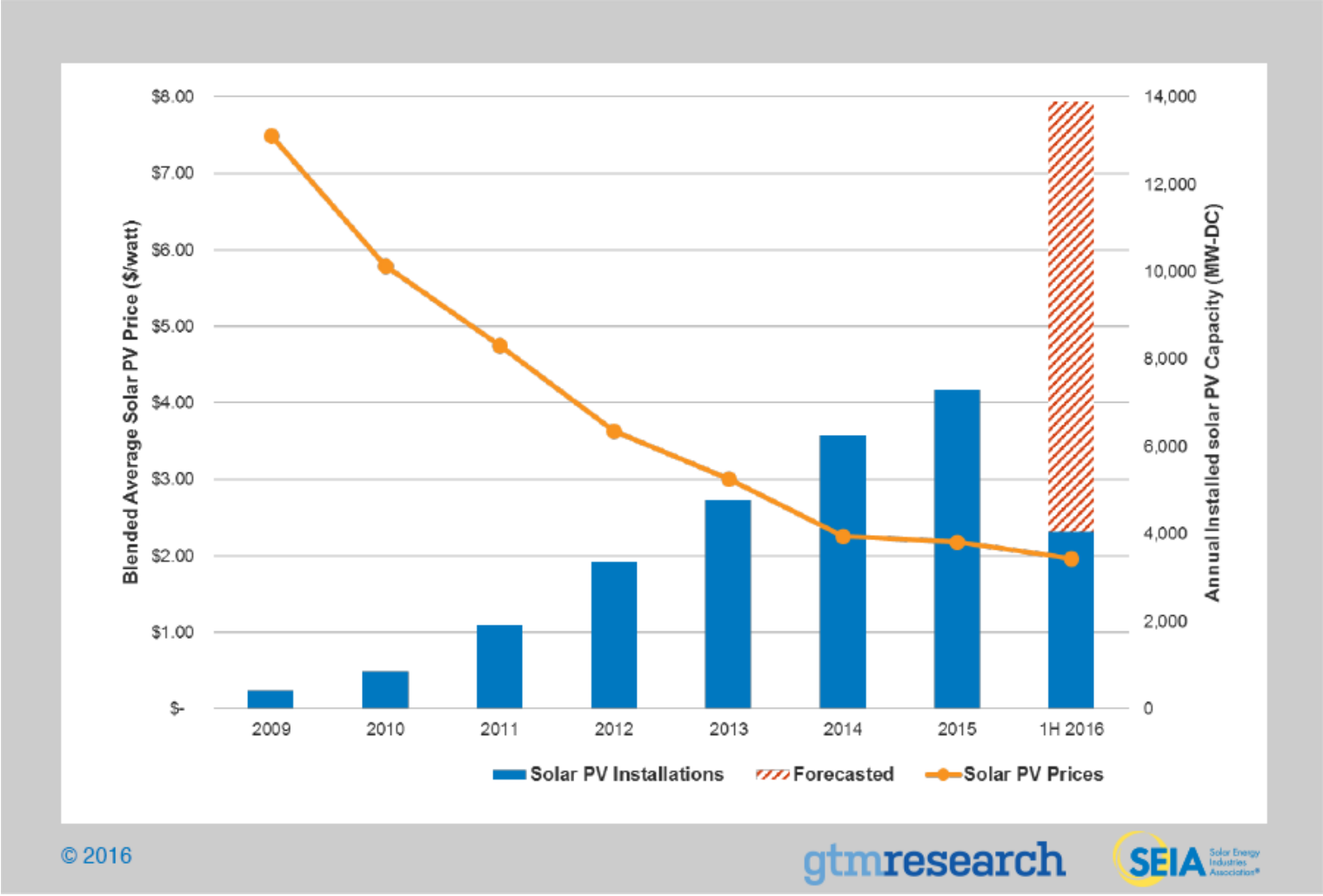
Solar Simplified - Basics

Solar Growth (USA)



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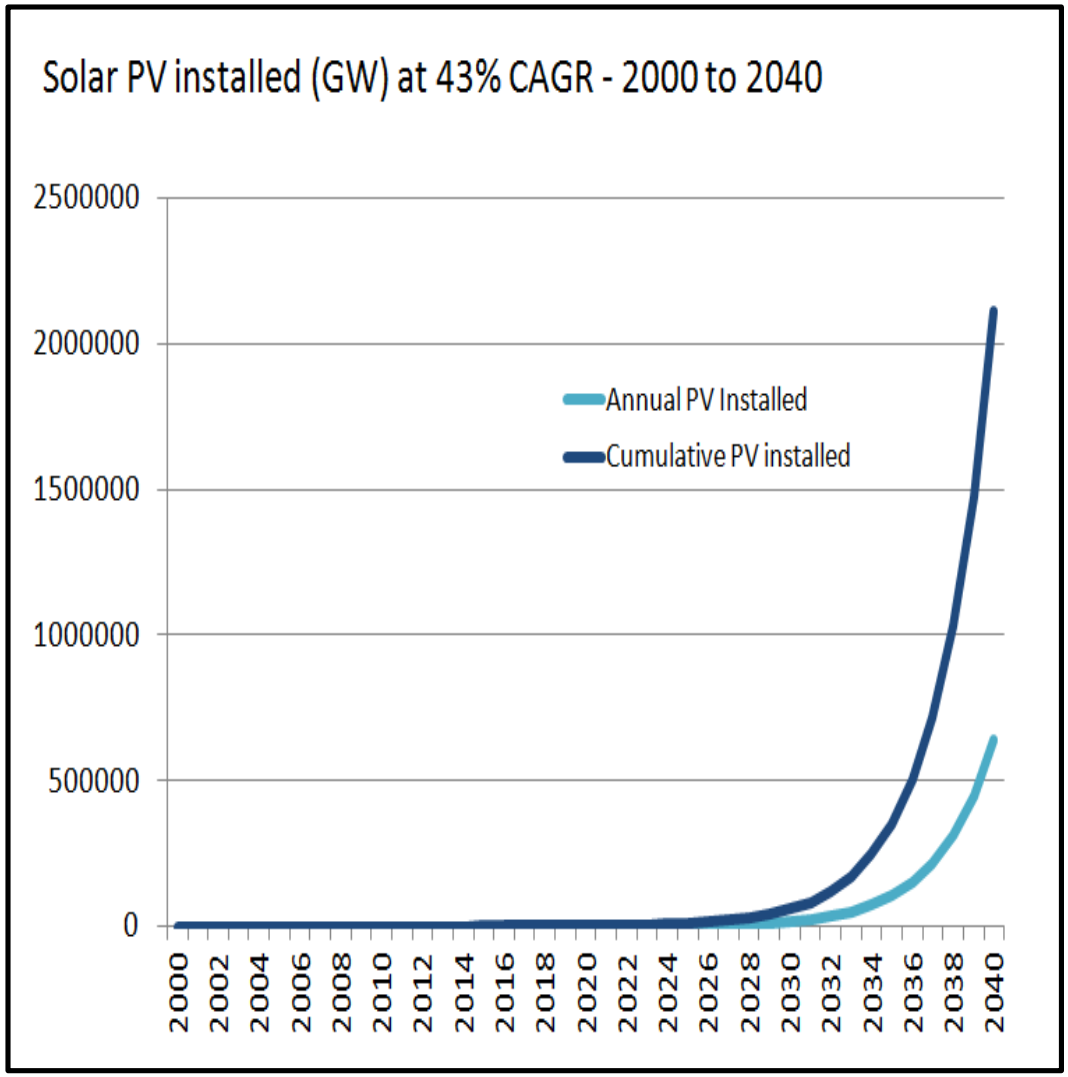
Solar Simplified - Basics

Solar Growth (needed)

- *One estimate: we need 13,500 Gigawatts of solar by 2040 to offset enough CO2 to hold warming to 2.4 C above pre-industrial times**
- *At 43% growth, we reach 13,500 Gigawatts in 2026*



* http://www.lightsonsolar.com/wp-content/uploads/2015/02/20150211_IEEE_SVPVS.pdf

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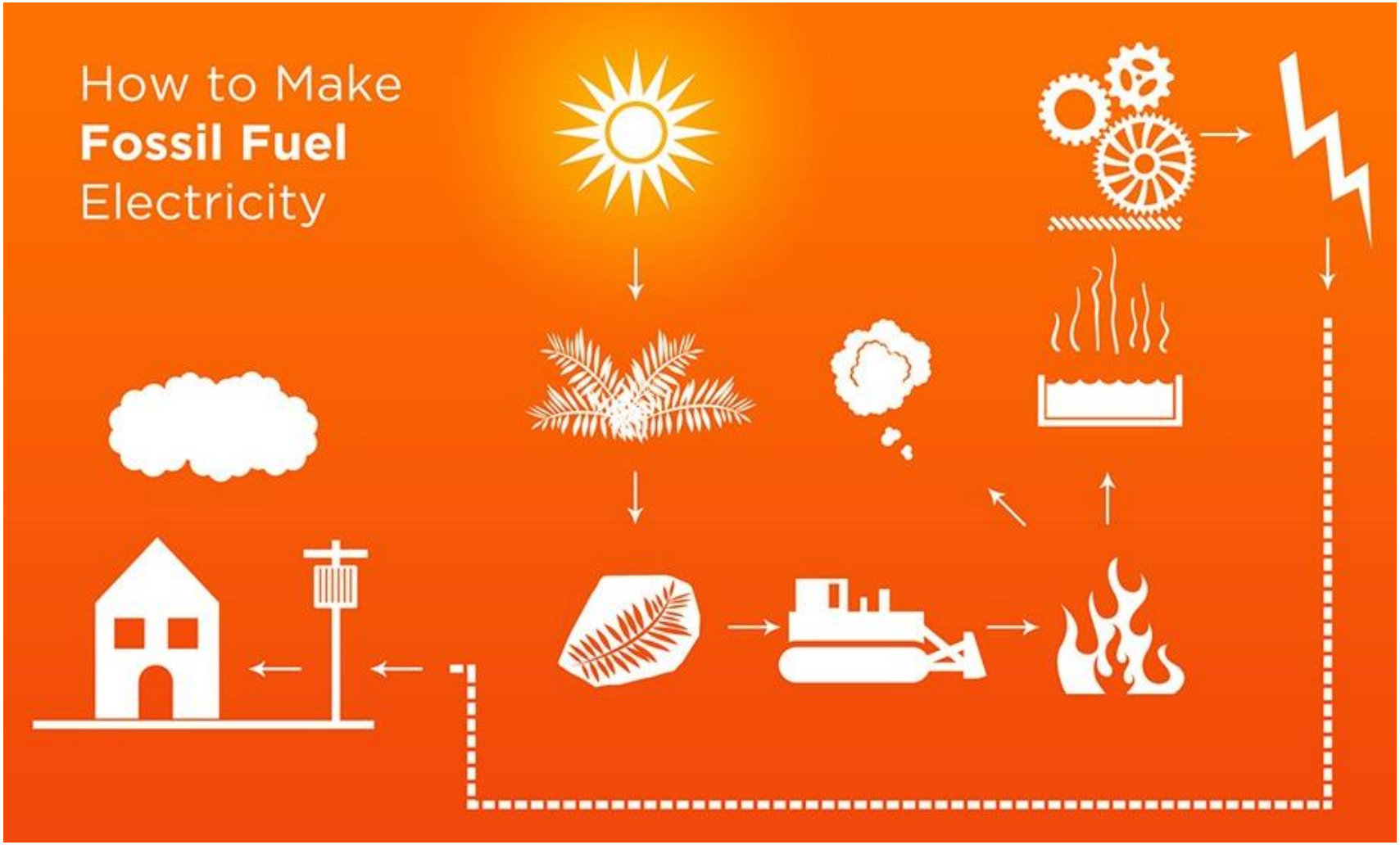
Solar Simplified - Basics

Let's go from this



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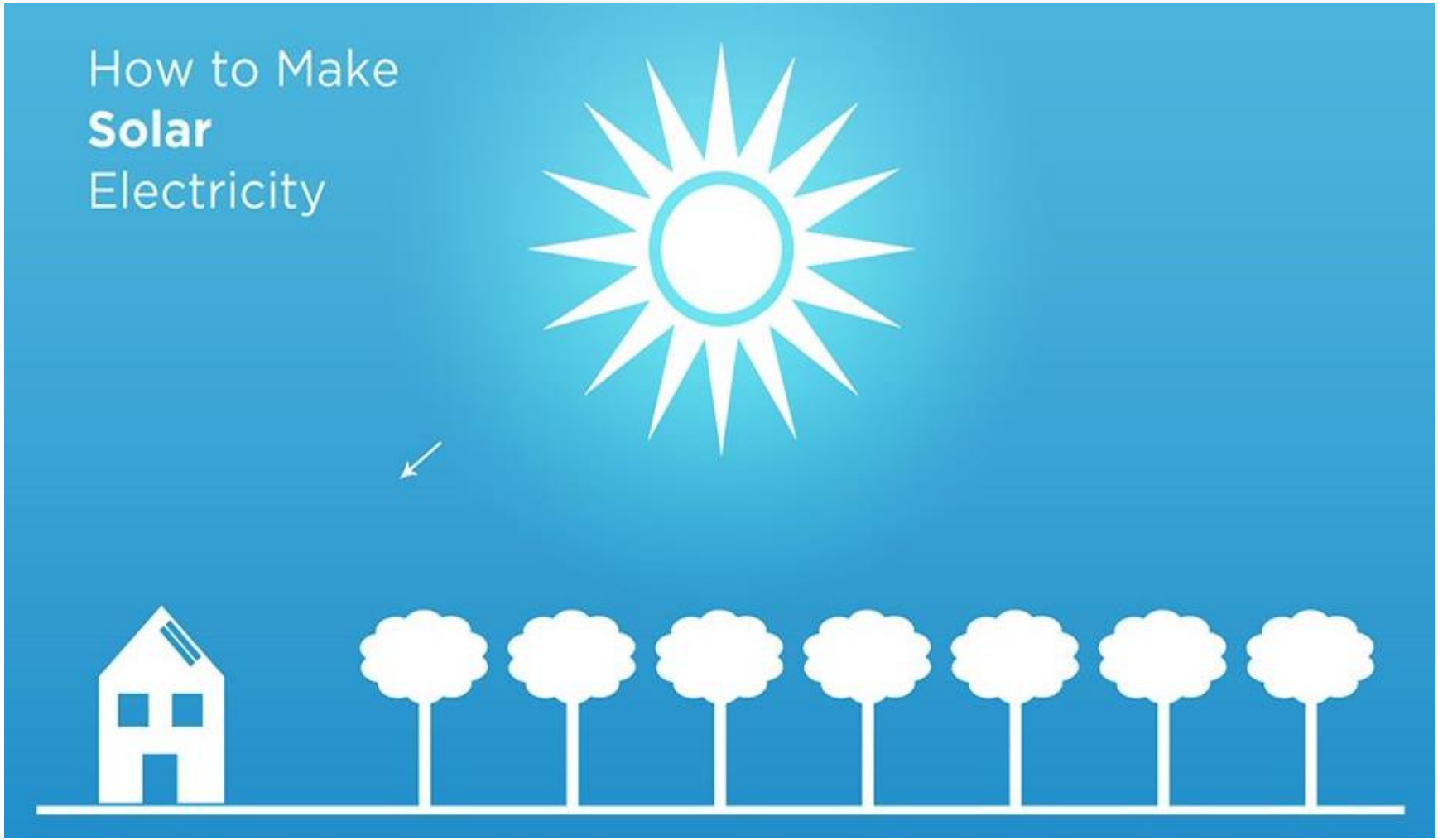
Solar Simplified - Basics

To this



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Solar Simplified - Basics

A few benefits of solar

- Replaces CO2-emitting fossil-fuel power plants
- Reduces dependence on foreign oil
- Minimal greenhouse gas emissions
- Minimal negative health impacts
- Minimal environmental damage from drilling/mining/spills/combustion
- Reliable and safe
- Reduces need for utility transmission lines
- Reduces need to build expensive peak-power plants
  - Produces power during peak demand
- Solar industry is labor intensive (creates jobs)
- Rooftop generation increases awareness of energy use
- Saves money and protects against rising electricity rates
- Scales well (homes to businesses to utility power plants)
- Enables totally clean transportation (solar powered electric vehicles)
- Enables totally clean home appliances (oven, cooktop, space and water heat)

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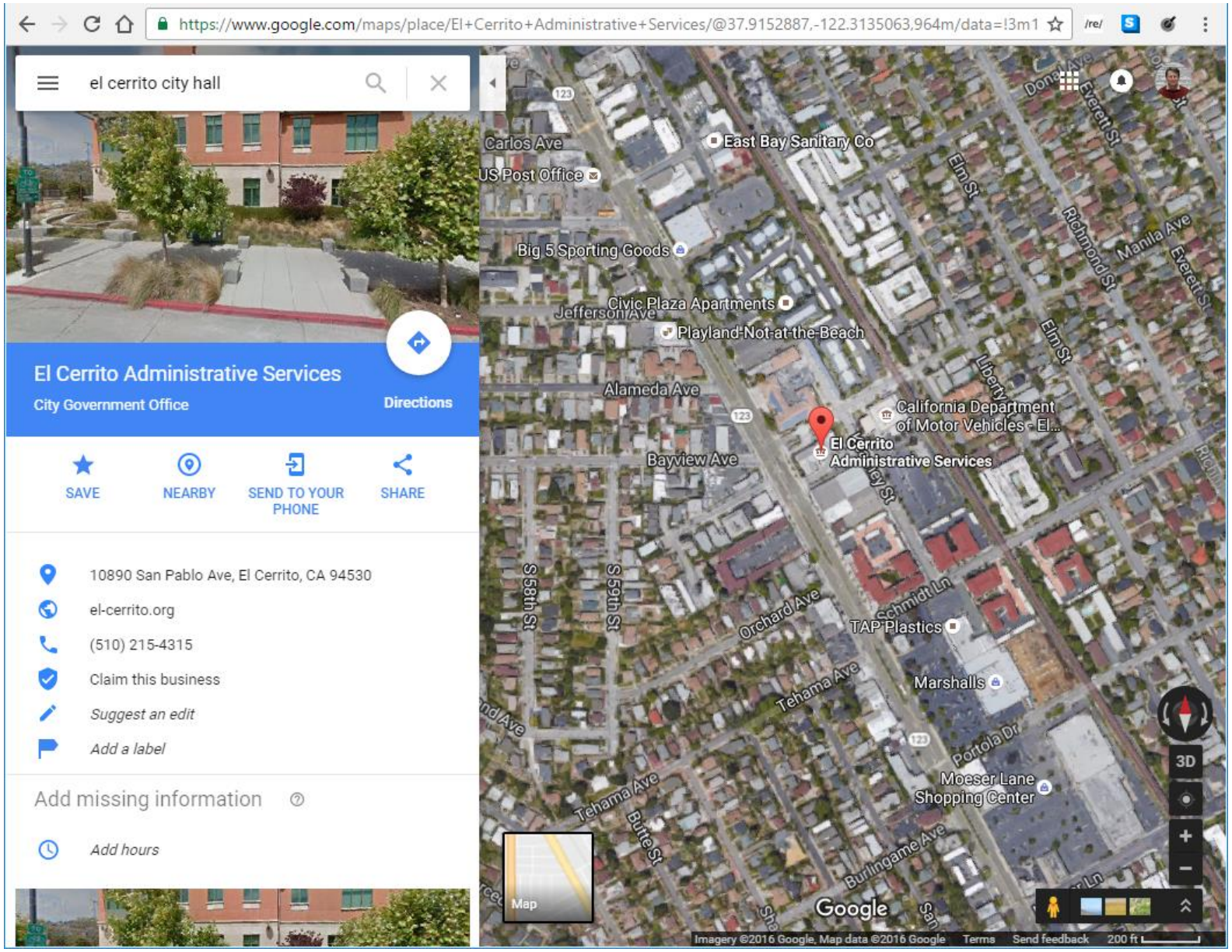
Solar Simplified - Basics



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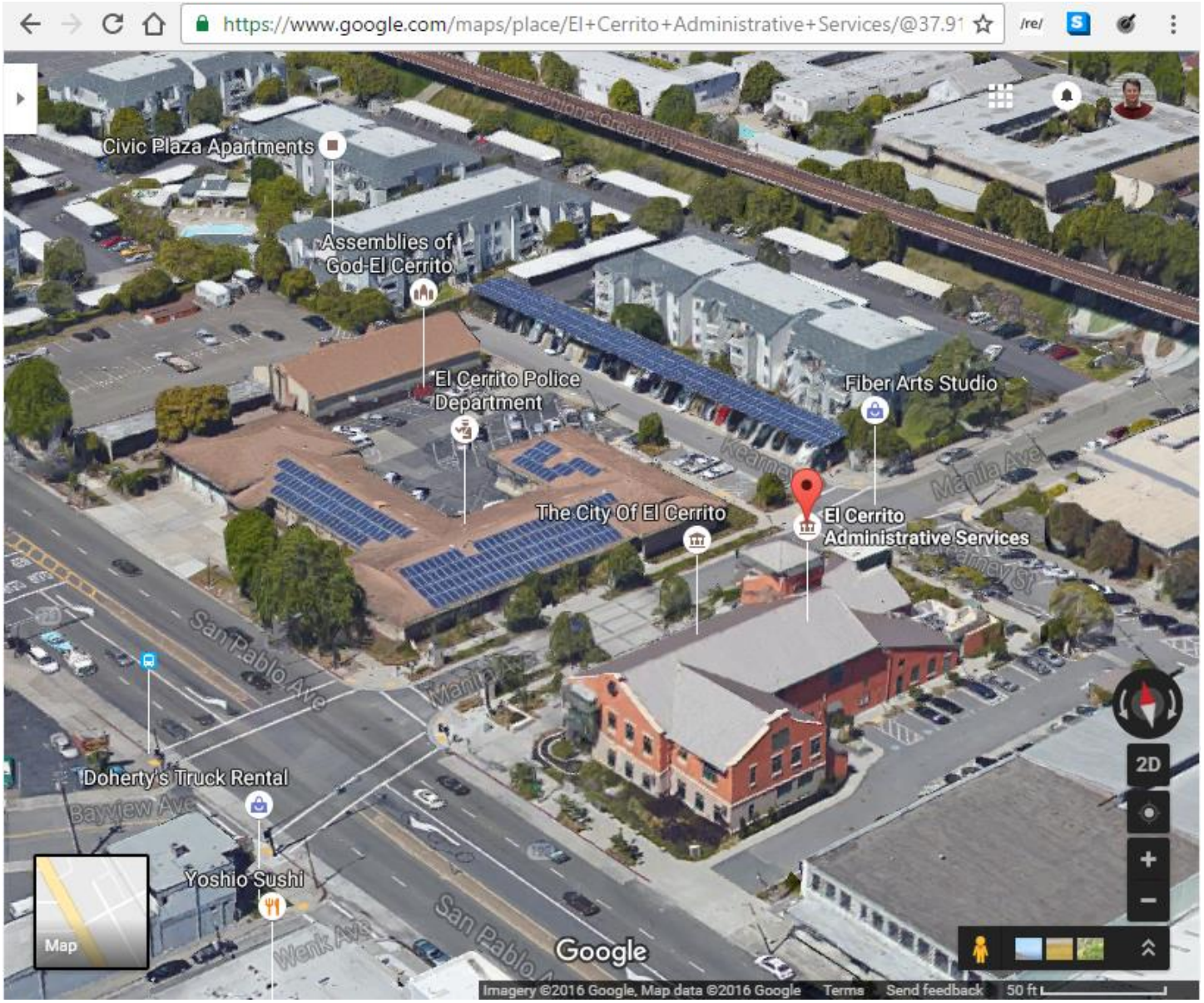
Solar Simplified - Basics



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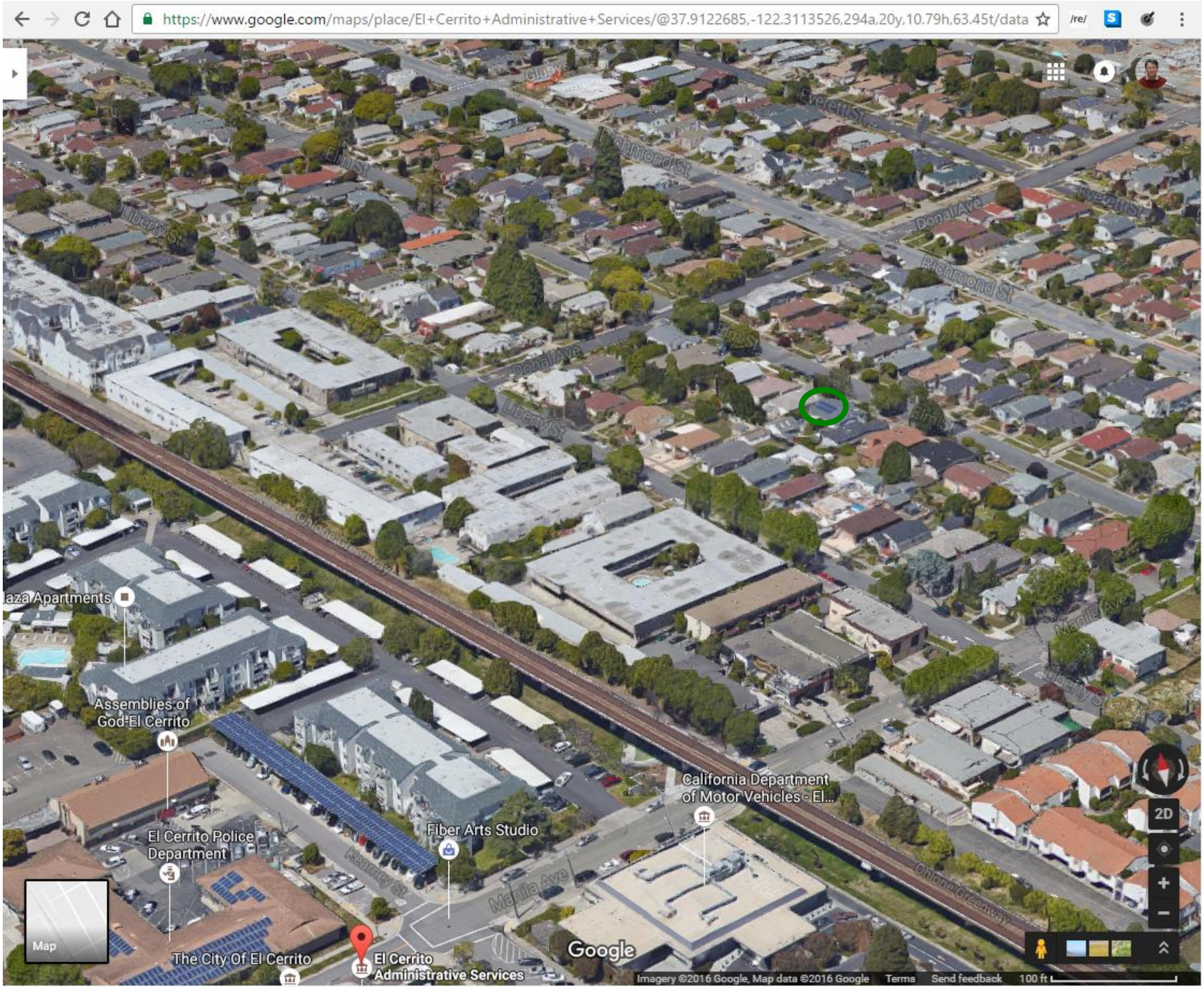
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Glad
Everett St
Elm St
Richmond St
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Elm St
Ohlone Greenway
Manila Ave
Liberty St
laza Apartments
Assemblies of God El Cerrito
El Cerrito Police Department
Fiber Arts Studio
California Department of Motor Vehicles - El...
Kearney St
Manila Ave
Ohlone Greenway
Map
The City Of El Cerrito
El Cerrito Administrative Services
Google
2D
Imagery ©2016 Google, Map data ©2016 Google
Terms
Send feedback
100 ft

Solar Simplified

Workshop Goals (and Agenda) – to understand:

- *Solar power basics*
- *Solar Products*
- *Solar for Your House?*
- *Ownership and finance*
- *How to (roughly) size a solar system for your home*
- *How to select a great contractor*

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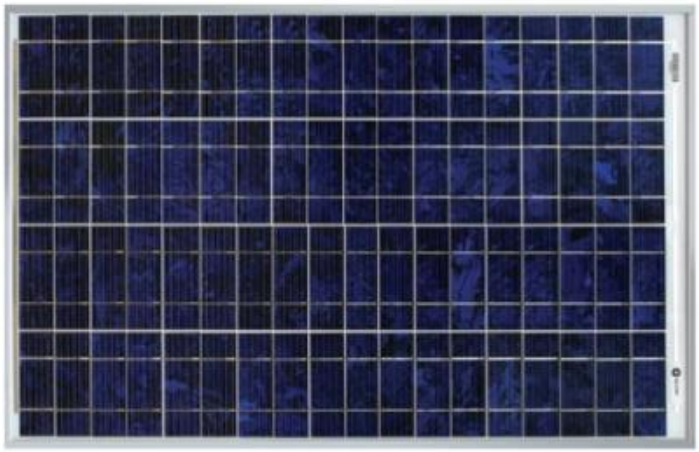
Solar Simplified - Products

Solar PV panels

Mono-crystalline silicon

Most expensive, most efficient,
great when 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

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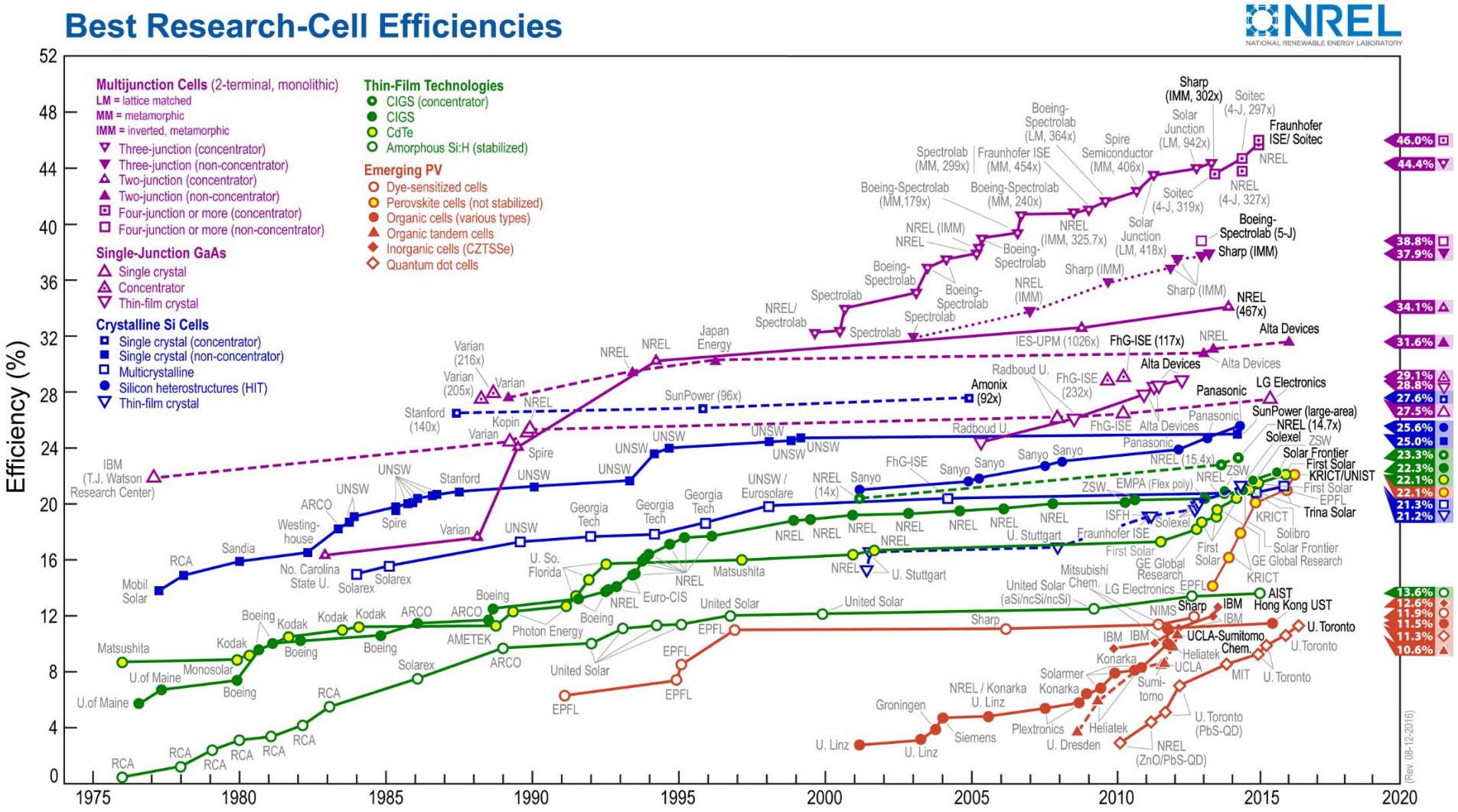
Solar Simplified - Products

Solar PV panels (for the nerds!)



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Solar Simplified - Products

Inverters

String Inverter

Usually one per residential solar system

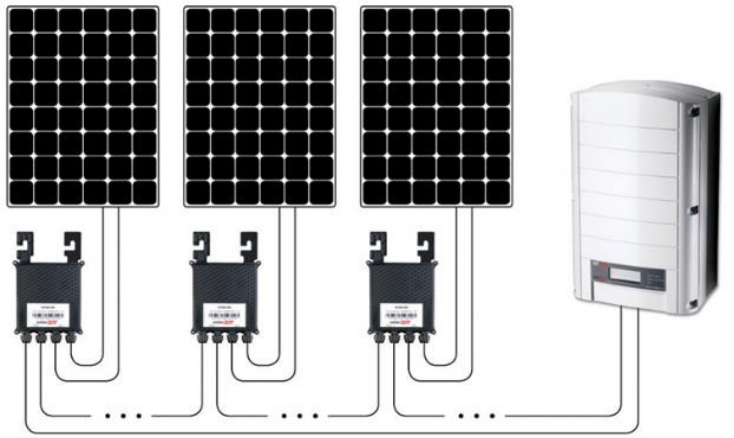
Micro-inverter

Usually one per solar panel, on the roof

DC Optimizer

One optimizer per solar panel on the roof

Still need a string inverter



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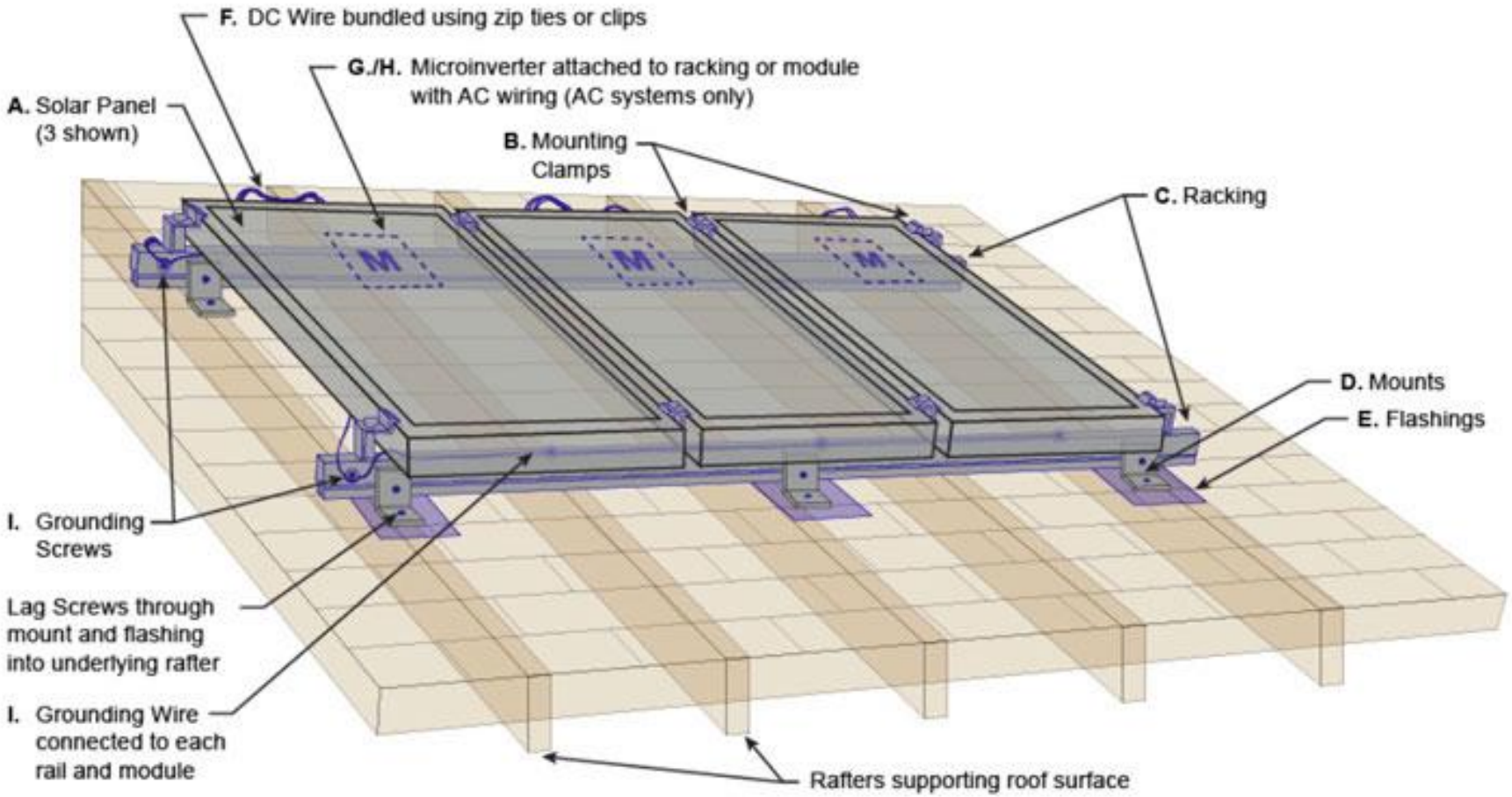
Solar Simplified - Products

Warranties

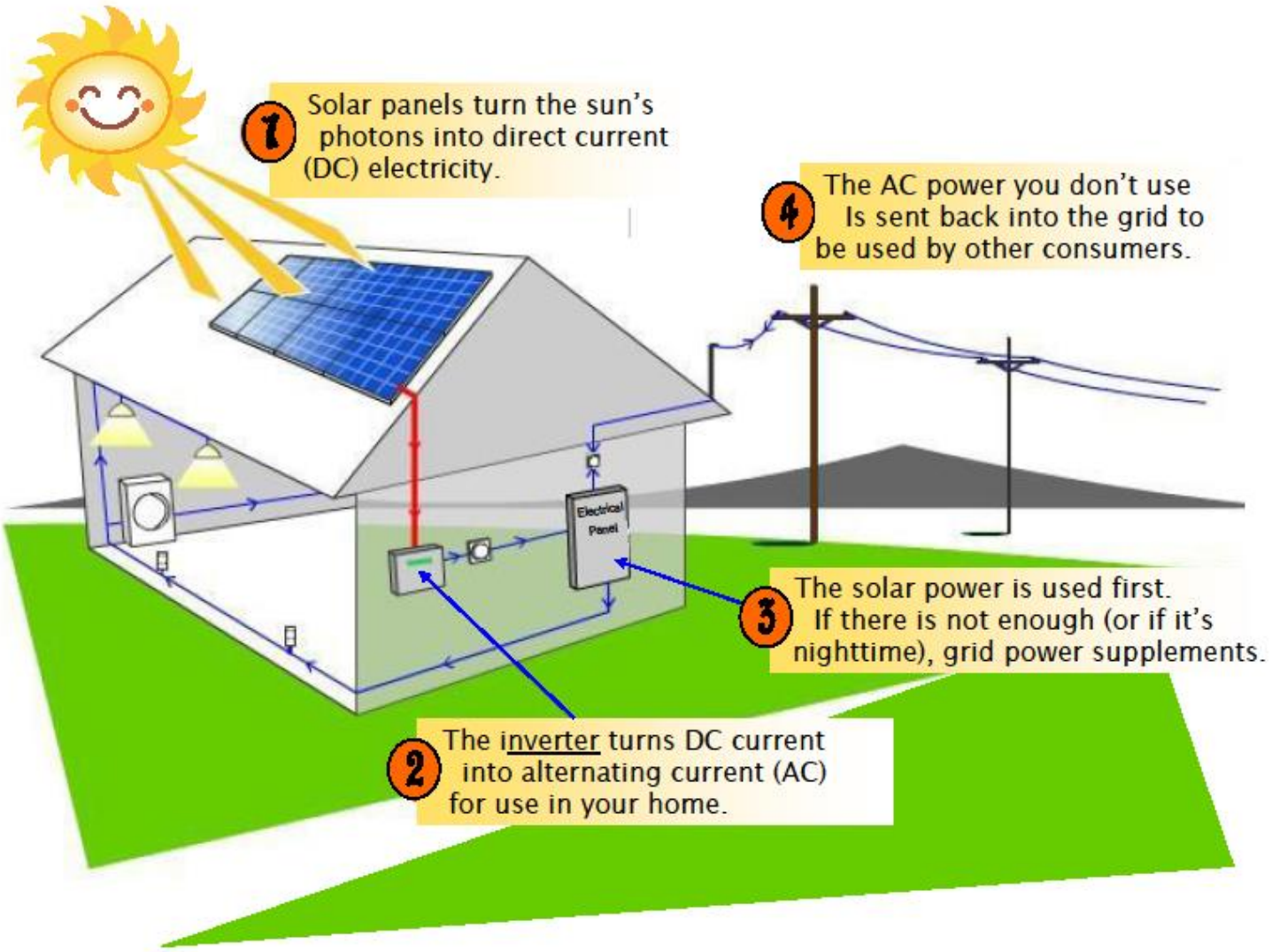
- Solar PV panels
  - Most come with 25 year production warranties
  - Panels degrade ~0.5%/year. So does the warranty
- Inverters
  - Most string inverters come with 10 year warranties (extended warranties are often available)
  - Most microinverters and DC optimizers come with 25 year warranties
- Workmanship
  - Most contractors offer 10 year workmanship warranties (call your contractor first for any problems)

Solar Simplified - Products

Racking and Mounting



Solar Simplified - Products



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Solar Simplified – Your House?

Important Terms

- *Kilowatt (kW)*
  - Physics unit of **power**: the rate of doing work
  - A 100-watt bulb consumes 100 watts when it's on
  - Most solar PV equipment is rated in watts: a 4kW solar system

- *Kilowatt-hour (kWh)*
  - Physics unit of **energy**: the flow of electrons, in electrical energy
  - PG&E charges per kWh
  - EV batteries are rated in kWh
  - A 100-watt bulb, on for 10 hours, consumes 1 kWh of energy
  - Average US household: 11,000 kWh/year (1.1 MW/year)

- 1 Terawatt (TW) = 1000 Gigawatts (GW)
- 1 GW = 1000 Megawatts (MW)
- 1 MW = 1,000,000 Kilowatts (kW)

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Solar Simplified - Your House

PG&E Bill Basics

- Electricity usage and cost?

  Example PG&E bill →

  Total Electric Charges $61.38

  Electric Usage This Period:

  632.000000 kWh, 30 billing days

- Cost per kWh is

  $61.38/632 = **9.7¢/kWh** (CARE discount)

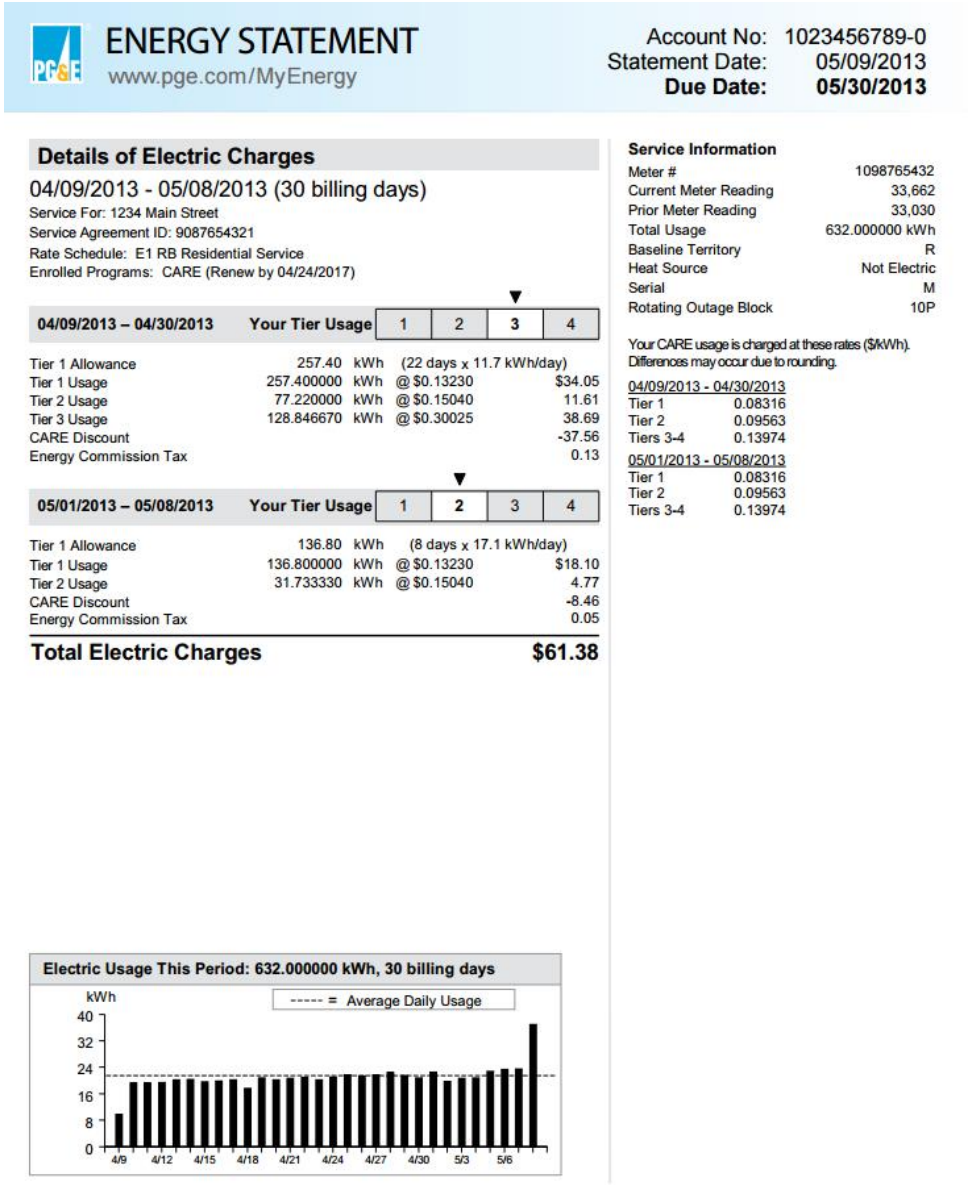
- Doug's PG&E bill

  Total Electric Charges $132.45

  Electric Usage This Period:

  519.828600 kWh, 32 billing days

  $132.45/519.8286 = **25.48¢**/kWh



ENERGY STATEMENT
www.pge.com/MyEnergy

Account No: 1023456789-0
Statement Date: 05/09/2013
Due Date: 05/30/2013

Details of Electric Charges

04/09/2013 - 05/08/2013 (30 billing days)
Service For: 1234 Main Street
Service Agreement ID: 9087654321
Rate Schedule: E1 RB Residential Service
Enrolled Programs: CARE (Renew by 04/24/2017)

04/09/2013 – 04/30/2013	Your Tier Usage	1	2	3	4

Tier 1 Allowance	257.40 kWh	(22 days x 11.7 kWh/day)		
Tier 1 Usage	257.400000 kWh	@ $0.13230		$34.05
Tier 2 Usage	77.220000 kWh	@ $0.15040		11.61
Tier 3 Usage	128.846670 kWh	@ $0.30025		38.69
CARE Discount				-37.56
Energy Commission Tax				0.13

05/01/2013 – 05/08/2013	Your Tier Usage	1	2	3	4

Tier 1 Allowance	136.80 kWh	(8 days x 17.1 kWh/day)	
Tier 1 Usage	136.800000 kWh	@ $0.13230	$18.10
Tier 2 Usage	31.733330 kWh	@ $0.15040	4.77
CARE Discount			-8.46
Energy Commission Tax			0.05

Total Electric Charges **$61.38**

Service Information

Meter #	1098765432
Current Meter Reading	33,662
Prior Meter Reading	33,030
Total Usage	632.000000 kWh
Baseline Territory	R
Heat Source	Not Electric
Serial	M
Rotating Outage Block	10P

Your CARE usage is charged at these rates ($/kWh). Differences may occur due to rounding.

04/09/2013 - 04/30/2013	
Tier 1	0.08316
Tier 2	0.09563
Tiers 3-4	0.13974
05/01/2013 - 05/08/2013	
Tier 1	0.08316
Tier 2	0.09563
Tiers 3-4	0.13974

Electric Usage This Period: 632.000000 kWh, 30 billing days

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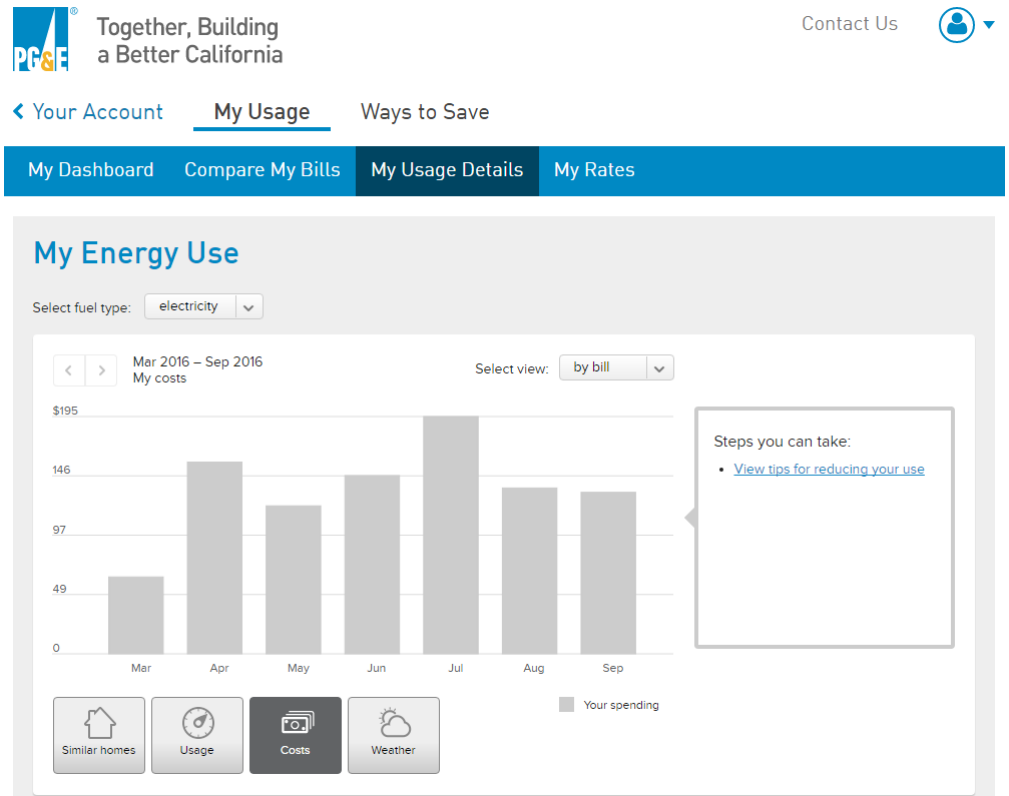
Solar Simplified - Your House

PG&E Bill Basics

- Find your yearly numbers
  - Look through your last 12 bills, OR
  - Online Usage: https://pge.opower.com/ei/app/myEnergyUse/usage/year
    Online Charges: https://pge.opower.com/ei/app/myEnergyUse/rates/year



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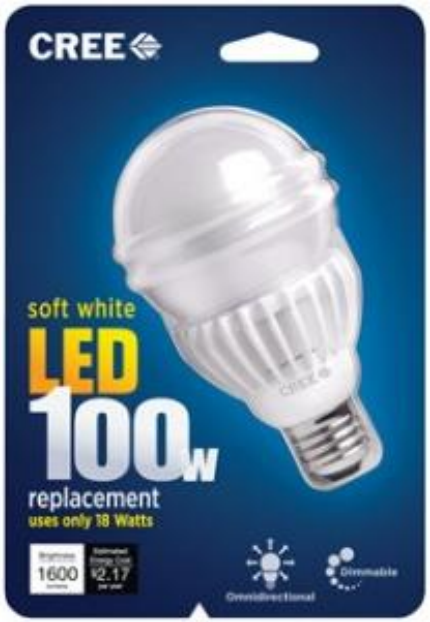
Solar Simplified - Your House

Before sizing your solar system…



- Will you be reducing your electricity use?
  - Attic insulation, LED lights, double-pane windows
    - 100 watt light bulb on for 2 hrs/day @ 20¢/kWh = $1.20/month
    - 10 watt LED bulb (same brightness): ~$.12/month

- Will you be increasing your electricity use?
  - EV, switch to electric appliances
    - Add ~1 kW of solar for each 5000 EV miles charged at home

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Solar Simplified - Your House

Before sizing your solar system…

- Is your roof good for solar?
  - Shading issues? ⟶
  - Roof age? (solar systems last a looooooong time)

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Solar Simplified - Your House

Example PG&E Bill – after energy planning

- $1200/year ($100/month average)
- 6000 kWh/year consumption
- $1200/6000 kWh = 20¢/kWh (approx. PG&E average)

- What size solar system?
  - Easy preliminary estimates: 4kW (DC) system
    - ~1500 kWh per kW in the Bay Area*
    - Panels are ~280 to ~335 watts each, so most 4 kW systems will be 12 to 15 panels

*kW usually means DC but is often confused, kWh almost always means AC

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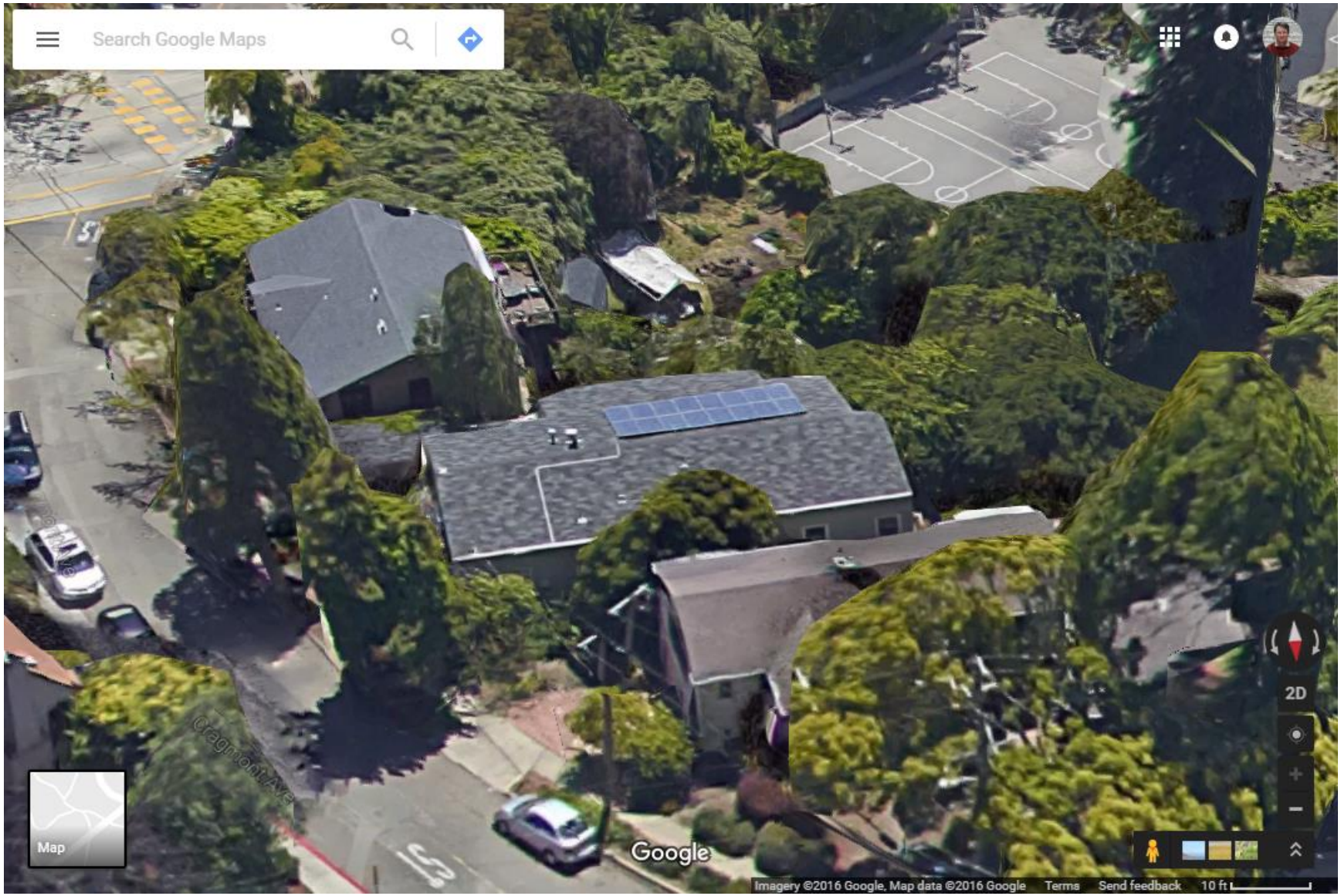
Solar Simplified - Your House



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Solar Simplified - Your House

Example PG&E Bill – after energy planning

- $1200/year ($100/month average)
- 6000 kWh/year consumption
- $1200/6000 kWh = 20¢/kWh (approx. PG&E average)

- Our 4 kW DC solar system will generate about 6000 kWh/year and so will offset about 100% of grid consumption.

- … but only about 90% of PG&E charges

?????

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Solar Simplified - Your House

Example PG&E Bill – after energy planning:

- $1200/year ($100/month average)
- 6000 kWh/year consumption
- $1200/6000 kWh = 20¢/kWh (approx. PG&E average)

- Minimum Bill
  $120/year which cannot be offset with solar

  For a $1200 bill, a maximum of $1080 ($1200-$120) or about 90% of $1200 can be offset with solar

- So, where did that $1200/year for 6000 kWh come from?

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Solar Simplified - Your House

PG&E Rate Plans

- Your rate plan is likely E-1 (typical residential)
  - E-1 is Tiered - the more energy you use the more you pay per kWh
  - Tier 1 (also called Baseline) is the lowest price, and covers about 220 kWh/month. E-1's Tier 1 rate is ~18.4¢/kWh
  - After consuming ~220 kWh in the billing cycle, move to Tier 2 at ~24.3/kWh for another ~220 kWh.
  - After consuming ~440 kWh in the billing cycle, move to Tier 3 at ~40.3¢/kWh. Tier 3 is the top.

  - So if you use 500 kWh in a month (6000/year)
    - 220 kWh at 18.4¢/kWh = $40.48
    - 220 kWh at 24.3¢/kWh = $53.46
    - 60 kWh at 40.3¢/kWh = $24.18
  - Total = $118.22 (23.6¢/kWh average)

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Solar Simplified - Your House

PG&E Rate Plans

Example E-1 Total = $118.22/month = $1418/year:
More than $1200 ???

Enter: “Time of Use” (TOU) rate plans E-TOU-A and E-TOU-B

New solar customers usually choose E-TOU-A or E-TOU-B

- TOU: pay less, or more, per kWh depending on *when* you use energy
- E-TOU-A is tiered, E-TOU-B is non-tiered
- Both have Peak and Off-Peak rates
- E-TOU-A Peak is 3-8pm M-F, E-TOU-B Peak is 4-9pm M-F

Time-of-Use calculations are more complex - you might use your electric dryer or charge your EV at 3am or at noon

➢ $1200 for 6000 kWh usage is an E-TOU-A based estimate

Solar Simplified - Your House

PG&E Rate Plans

- EV owners can choose EV-A or EV-B
  - EV-A and EV-B are TOU, non-tiered
    - Peak, Partial-Peak Off-Peak
    - EV-B for separate EV meter only

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Solar Simplified - Your House

Example Home

- $1200/year ($100/month average)
- 6000 kWh/year consumption
- $1200/6000 kWh = 20¢/kWh (approx. PG&E average)
- 4 kW Solar (DC) offsets 100% of use and 90% of charges

- *How* do you get paid for the solar electricity you generate?

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Solar Simplified - Your House

- Net Energy Metering (or Net Metering or NEM)
  - Records the difference between the amount of electricity generated by your solar system and the amount of electricity you use from the grid

- Nighttime – charging your EV – 100% from the grid*
  - Meter tracks that you're consuming 100% grid energy: you pay your utility for all your consumption
- Mid-day – minimal load – 100% powered by your solar
  - Meter tracks your total solar production minus your minimal load: your utility pays you for your net energy production
- Early morning, early evening – weak solar, heavy load
  - Meter tracks your solar production minus your load: you pay your utility for your net energy consumption

* Assumes no storage batteries attached to your solar system

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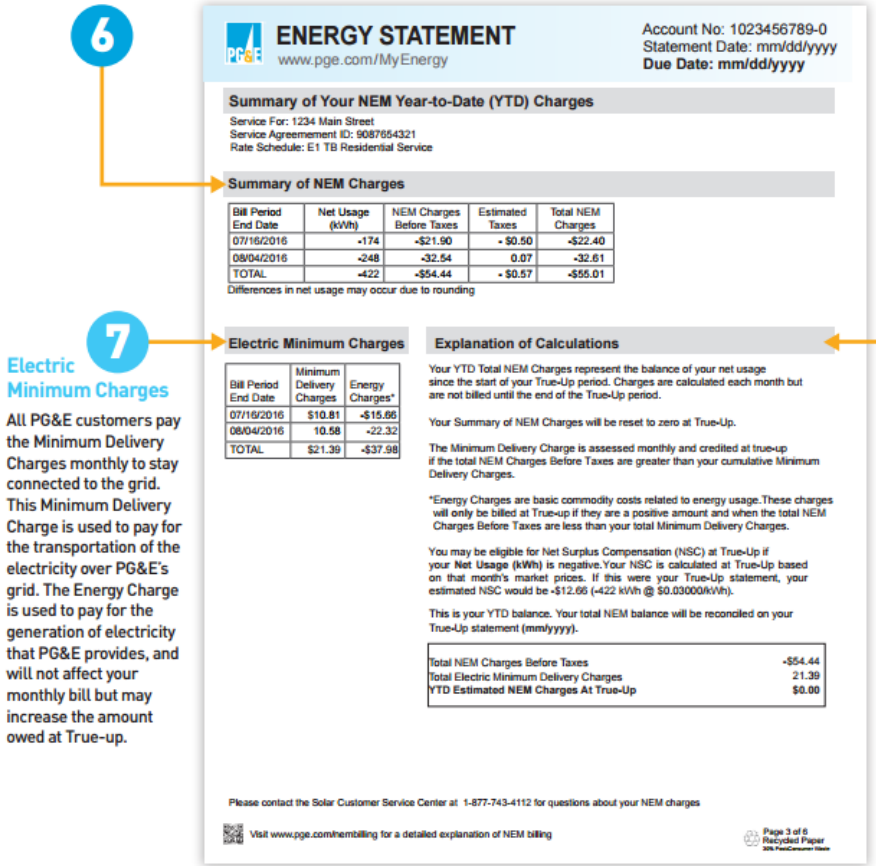
Solar Simplified - Your House

- How much are you paid for the electricity you generate?
  - Full retail, based on your rate plan (i.e., more during “Peak” hours)
  - Not including the minimum bill
  - And only up to the amount you consume from the grid
  - After 100% of consumption, you’re paid the wholesale rate (~4¢/kWh)
  - PG&E will not allow an 8 kW system on a house that uses 6000 kWh/year

Summary of NEM Charges

The chart below shows how much net energy you generated or consumed each month and the associated charge or credit. The chart provides a summary of the total NEM charges from the start of your annual True-up period and a monthly snapshot of your net energy use including time periods if you are on a Time-of-Use rate schedule.



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ENERGY STATEMENT
www.pge.com/MyEnergy

Account No: 1023456789-0
Statement Date: mm/dd/yyyy
Due Date: mm/dd/yyyy

Summary of Your NEM Year-to-Date (YTD) Charges

Service For: 1234 Main Street
Service Agreement ID: 9087654321
Rate Schedule: E1 TB Residential Service

Summary of NEM Charges

Bill Period End Date	Net Usage (kWh)	NEM Charges Before Taxes	Estimated Taxes	Total NEM Charges
07/16/2016	-174	-$21.90	- $0.50	-$22.40
08/04/2016	-248	-32.54	0.07	-32.61
TOTAL	-422	-$54.44	- $0.57	-$55.01

Differences in net usage may occur due to rounding

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Electric Minimum Charges

Bill Period End Date	Minimum Delivery Charges	Energy Charges*
07/16/2016	$10.81	-$15.66
08/04/2016	10.58	-22.32
TOTAL	$21.39	-$37.98

Explanation of Calculations

Your YTD Total NEM Charges represent the balance of your net usage since the start of your True-Up period. Charges are calculated each month but are not billed until the end of the True-Up period.

Your Summary of NEM Charges will be reset to zero at True-Up.

The Minimum Delivery Charge is assessed monthly and credited at true-up if the total NEM Charges Before Taxes are greater than your cumulative Minimum Delivery Charges.

*Energy Charges are basic commodity costs related to energy usage. These charges will only be billed at True-up if they are a positive amount and when the total NEM Charges Before Taxes are less than your total Minimum Delivery Charges.

You may be eligible for Net Surplus Compensation (NSC) at True-Up if your **Net Usage (kWh)** is negative. Your NSC is calculated at True-Up based on that month's market prices. If this were your True-Up statement, your estimated NSC would be -$12.66 (-422 kWh @ $0.03000/kWh).

This is your YTD balance. Your total NEM balance will be reconciled on your True-Up statement **(mm/yyyy)**.

Total NEM Charges Before Taxes	-$54.44
Total Electric Minimum Delivery Charges	21.39
YTD Estimated NEM Charges At True-Up	**$0.00**

Please contact the Solar Customer Service Center at 1-877-743-4112 for questions about your NEM charges

Visit www.pge.com/nembilling for a detailed explanation of NEM billing

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Recycled Paper

8

Electric Minimum Charges

All PG&E customers pay the Minimum Delivery Charges monthly to stay connected to the grid. This Minimum Delivery Charge is used to pay for the transportation of the electricity over PG&E’s grid. The Energy Charge is used to pay for the generation of electricity that PG&E provides, and will not affect your monthly bill but may increase the amount owed at True-up.

Explanation of Calculations

This section explains how your year to date (YTD) and month over month NEM charges are calculated. If you are eligible for Net Surplus Compensation those calculations will be applied at your annual True-Up.

http://www.pge.com/includes/docs/pdfs/myhome/saveenergymoney/solarenergy/billing%20callouts%20NEM%20monthly.pdf

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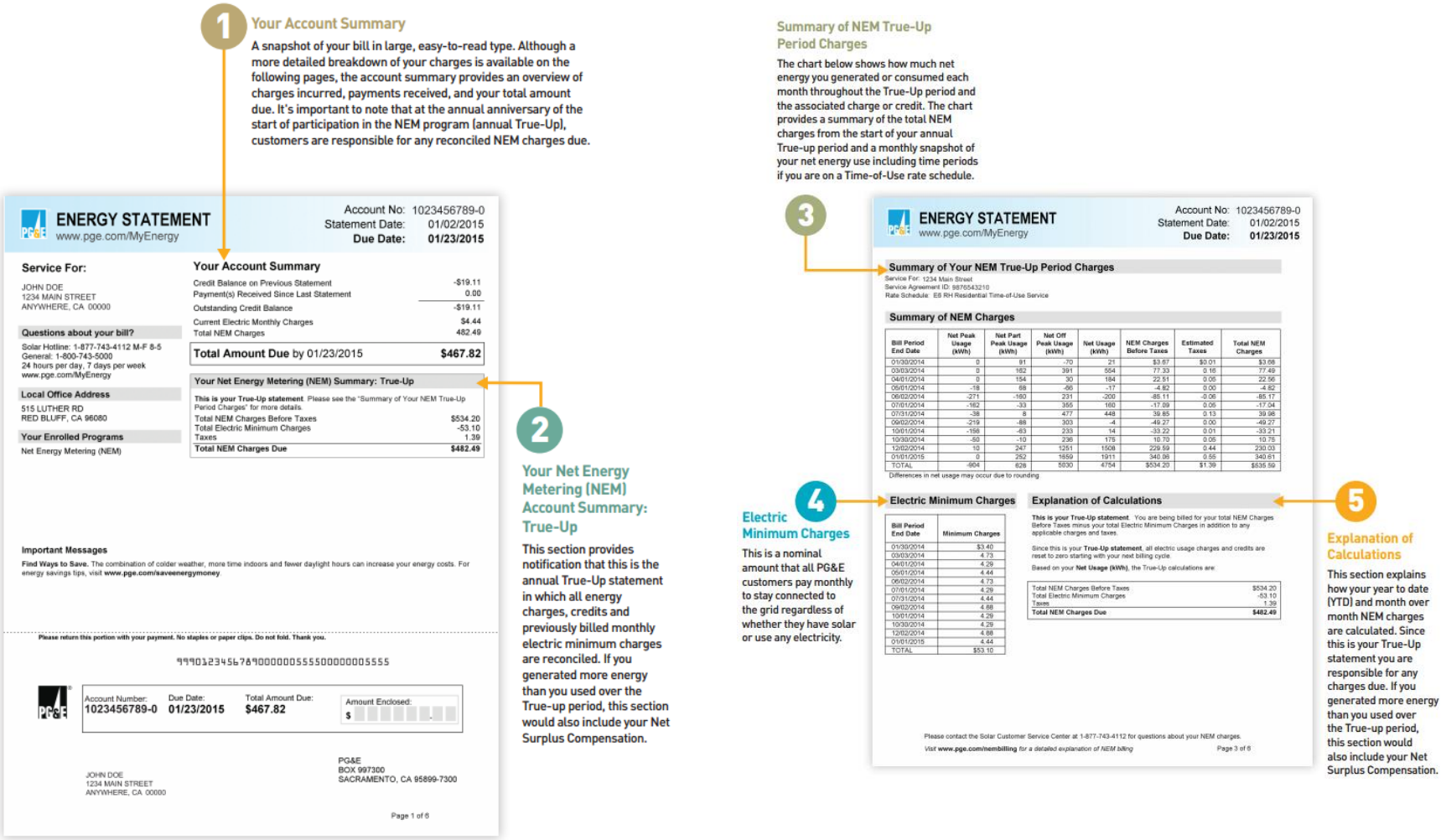
Solar Simplified - Your House

PG&E's "True Up" period is 12 months (pay once per year)



http://www.pge.com/includes/docs/pdfs/myhome/saveenergymoney/solarenergy/billing%20callouts-trueup.pdf

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Solar Simplified - Your House

And now…

MCE!

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Local Impacts

MCE Clean Energy
My community. My choice.

Solar "Cash Out"

City of Benicia: $100,000+
WCCUSD: $28,000+

Frequently Asked NEM Questions

Q: Can customers keep their old rate schedule?

Q: Do customers remain grandfathered into NEM 1.0?

Q: Does MCE offer virtual or aggregated NEM?

Q: Do MCE customers have tiered rates?

Q: Do MCE customers still receive CARE discounts?

Q: Are MCE customers subject to PG&E's NEM cap?

MCE Clean Energy
My community. My choice.

Yes

Frequently Asked NEM Questions

Q: Do MCE NEM customers need to fill out extra forms or apply?

Q: Can I use MCE's program to oversize a solar installation beyond what PG&E allows?

Q: If I enroll then opt-out later, will I lose my E6 rate and/or NEM 1.0 interconnection?

No

MCE Clean Energy
My community. My choice.

Solar Simplified

Workshop Goals (and Agenda) – to understand:

- *Solar power basics*
- *Solar Products*
- *Solar for Your House?*
- *Ownership and finance*
- *How to (roughly) size a solar system for your home*
- *How to select a great contractor*

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Solar Simplified - Ownership/Finance

Two types of Residential Solar Ownership

Homeowner owns the system

- Cash purchase
- Home Equity Loan
- Unsecured Solar Loan
- Property-Tax Loan (PACE – Property Assessed Clean Energy)
- Energy Upgrade Loan

Homeowner does not own the system
(Third Party Ownership or TPO)

- Power Purchase Agreement (PPA)
- Lease

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Solar Simplified - Ownership/Finance

*Homeowner **owns** the system – pros and cons*

Pros: Eligible for the 30% federal tax credit on the *total* system cost. You probably don't need to insure your system (check with your insurer)

Con: Homeowner is responsible for system production, maintenance & repairs*

Cash purchase

- Excellent return on investment
- High upfront cost ($10,000 to $25,000)

Home Equity Loan

- Good interest rate (3-8%) = good ROI. Minimal upfront cost
- Low interest rate depends on good credit score. Home is at risk on default

Unsecured Solar Loan

- Home is not at risk on default. Minimal upfront cost
- Need good credit. High interest rates (~7-14%)** = lower ROI

Property-Tax Loan (PACE - Property Assessed Clean Energy)

- Minimal upfront cost. Good credit is not needed. Repayment is transferable to new owners
- Higher interest rates (5 yr: ~6.75% … 20 year: ~8.4%)*** = lower ROI

* Most installers provide a 10 year workmanship warranty

** One source (Lightstream): https://www.lightstream.com/solar-financing

*** ABAG: http://abag.ca.gov/bayren/pace/pdfs/PACEcomparison_060315.pdf

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Solar Simplified - Ownership/Finance

*Homeowner **does not own** the system – pros and cons*

- Power Purchase Agreement (PPA): Pay per kWh for energy generated by the system (monthly payment is not fixed)
- Lease: Pay a set monthly fee for energy generated by the system
- PPAs and Leases may be $zero down, fully pre-paid, or partial-down

Pros (PPAs and Leases)

- Not responsible for any system maintenance
- Can be zero upfront cost to go solar
- Payback for lower cost of electricity is immediate (for $0 down systems)

Cons (PPAs and Leases)

- Not eligible for the 30% federal tax credit
- Home is encumbered with a lien (commonly 20 years)
- May complicate sale of home
- Many PPAs and leases have an “escalator” clause increasing your payments over time

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Solar Simplified - Ownership/Finance

- Is putting solar on your roof a good investment?
- How to choose an ownership model?

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Solar Simplified - Ownership/Finance

- Simple Payback (years)
  Total investment divided by annual savings

- Simple Return on Investment (ROI) (percent)
  Annual savings divided by total investment, times 100

- Simple Cost per kilowatt-hour (¢/kWh)
  Total investment divided by total lifetime energy generated

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Solar Simplified - Ownership/Finance

- Grid Parity

  Means many things and is often confused and abused. For tonight:

  - Grid Parity for solar on *your* home means it will be *economically* beneficial to you during the lifetime of your solar system
  - Calculation: Your cost per kWh *with* solar, compared with your cost *without* solar

  ➢ (average cost for PG&E electricity is ~20¢ per kWh)

OR?

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Solar Simplified - Ownership/Finance

Cash purchase example

Instead of

- $1200/year ($100/month average)
- 6000 kWh/year consumption
- $1200/6000 kWh = 20¢/kWh (approx. PG&E average)
- 4 kW Solar (DC) offsets 100% of use and 90% of charges

Use an example that offsets 90% of costs

(This is common for sizing solar systems)

- $1333/year pre-solar bill ($111/month average)
- 6667 kWh/year consumption
- $1333/6667 kWh = 20¢/kWh (PG&E average)
- 4 kW Solar (DC) system will generate 6000 kWh/yr and so will offset 90% of use and 90% of charges

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Solar Simplified - Ownership/Finance

Cash purchase example

- $1333/year bill, 6667 kWh/year consumption
- $1333/6667 kWh = 20¢/kWh (PG&E average)
- 4 kW Solar (DC) generates 6000 kWh/yr and offsets 90% of use and 90% of charges

- Simple Payback - *Total investment divided by annual savings*

  Example: $12,500 total system cost ($15,000 up front minus $4500 ITC
  plus $2000 inverter in 15 years – this is a common system)
  4kW system **($3.75/watt pre-ITC**, $2.62/watt post-ITC): $1200 annual savings ($1333 * 90%)
  Simple payback is $12,500 / $1200 = **10.4 years**

- Simple ROI - *Annual savings divided by total investment, times 100*

  Example: $1200 annual savings, $12,500 total investment
  Simple ROI is $1200 / $12,500 times 100 = **9.6%** (for 25 years)

- Simple Cost per kWh - *Total investment divided by total energy generated*

  Example: $12,500 total investment, ~150,000 kWh over its 25 year life
  (4 kW system: 6000 kWh/yr so about 150,000 kWh over 25 years)
  Simple Cost per kWh: $12,500 / 150,000 kWh = **8.3¢ per kWh**

Grid Parity? **YES** (8.3¢ is less than PG&E average 20¢)

And… free electricity after 25 years!

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Solar Simplified - Ownership/Finance

Purchase with loan example

- $1333/year bill, 6667 kWh/year consumption
- $1333/6667 kWh = 20¢/kWh (PG&E average)
- 4 kW Solar (DC) generates 6000 kWh/yr and offsets 90% of use and 90% of charges

- Simple Payback *Total investment divided by annual savings*

  Example: $5000 down payment plus $12,000 loan
  Cost of 5 year $12,000 loan at 5% interest: $226/month times 60 months = $13,600
  (interest may be tax deductible)
  Total system cost: $16,060 ($5000 down + $13,560 - $4500 tax credit + $2000 inverter)
  4kW system **($4.64/watt pre-ITC**, $3.24/watt after tax credit)
  Simple payback is $16,060 / $1200 = **13.9 years**

- Simple ROI *Annual savings divided by total investment, times 100*

  Example: $1200 annual savings, $16,060 total investment (same loan)
  Simple ROI is $1200 / $16,060 times 100 = **7.5%** (for 25 years)

- Simple Cost per kWh) *Total investment divided by total energy generated*

  Example: $16,060 total investment, ~150,000 kWh over its 25 year life
  (4 kW system: 6000 kWh/yr so about 150,000 kWh over 25 years)
  Simple Cost per kWh: $16,060 / 150,000 kWh = **10.7¢ per kWh**

Grid Parity? **YES** (10.7¢ is less than 20¢)
(and free electricity after 25 years)

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Solar Simplified - Ownership/Finance

Pre-paid lease or PPA (no monthly payments) example

- $1333/year ($111/month average), 6667 kWh/year consumption
- $1333/6667 kWh = 20¢/kWh (PG&E average)
- 4 kW Solar (DC) generates 6000 kWh/yr and offsets 90% of use and 90% of charges

- Simple Payback *Total investment divided by annual savings*

  Example: $11,000 total cost
  4kW system ($2.75/watt, not eligible for tax credit)
  $1200 annual savings
  Simple payback is $11,000 / $1200 = **9.2 years**

- Simple ROI *Annual savings divided by total investment, times 100*

  Example: $1200 annual savings, $11,000 total investment
  Simple ROI is $1200 / $11,000 times 100 = **10.9%** (for 20 years)

- Simple Cost per kWh) *Total investment divided by total energy generated*

  Example: $11,000 total investment, ~100,000 kWh over its 20 year life
  (4 kW system generates about 6000 kWh/yr but production will only be guaranteed for about 4000 kWh/yr, so about 100,000 kWh over 20 years)
  Simple Cost per kWh: $11,000 / 100,000 kWh = **11¢ per kWh**

Grid Parity? **YES** (11¢ is less than 20¢)

(System is removed, or lease/PPA is renewed at 20 years)

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Solar Simplified - Ownership/Finance

$0 down lease or PPA example

- Simple Payback *Total investment divided by annual savings*
  Simple payback is immediate, but meaningless… except you can go solar for $0!
- Simple ROI *Annual savings divided by total investment, times 100*
  Simple ROI is meaningless. There is no investment, so no return.
- Simple Cost per kWh) *Total investment divided by total energy generated*
  Simple Cost per kWh: No investment but typically 10% to 15% less, so
  18.5¢ to 19¢ per kWh in the first year. Payments typically rise at 3%/year using the assumption that grid prices will also rise.

Grid Parity? YES (85-90% of 20¢ is less than 20¢)
(System is removed, or lease/PPA is renewed at 20 years)

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Solar Simplified - Ownership/Finance

Limitation of Simple Payback/ROI/cost-per-kWh

- Difficult to capture the changing cost of electricity over the years, or inflation, the cost of a new inverter in year 15, or other costs and benefits
- Your solar contractor may include some other calculations

Solar Simplified - Ownership/Finance

- Time Value of Money (TMV) (in dollars)
  $100 today is worth more than $100 in the future. If you make $2 in interest in a year, you'll have $102 which is more than $100
- Future Value (FV) (in dollars)
- Present Value (PV) (in dollars)
- Discount Rate (in percent)
- Cash Flows (in dollars)
- Net Present Value (NPV) (in dollars)
- Levelized Cost of Energy (LCOE) (¢/kWh)
- Internal Rate of Return (IRR) (in percent)

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Solar Simplified - Ownership/Finance

- Future Value (FV)

  Future value of $100 is $102 in one year,
  given a 2% interest rate
  Messy calculation:
  FV = Principal * ((1+interest_rate) ^ number_of_years)
  In 5 years: FV of $100 with 2% interest, compounded annually =
  $100 * (1.02 ^ 5)) = $100 * 1.104 = $110.4

- Present Value (PV)

  Present value of $102 expected in one year, is $100, given 2% "discount" rate.
  The discount rate determines the PV of future cash (not the Fed's discount rate)
  Messy calculation:
  PV = Principal / ((1+interest_rate) ^ number_of_years)
  To reverse the FV example, in 5 years, the PV of $110.4 with 2% interest rate =
  $110.4 / (1.02 ^ 5)) = $100

- Cash Flows

  Extends the idea of a single value (PV or FV) to a series of incoming and/or outgoing money, between now and a future date

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Solar Simplified - Ownership/Finance

- Net Present Value (NPV)

  Determines the PV of a series of incoming and outgoing cash flows.

  Messy calculation:

  NPV = sum of (net_yearly_cash_flows / (1+discount_rate) ^ number_of_years) minus initial_investment

- Levelized Cost of Energy (LCOE)

  Determines your overall cost for energy over the lifetime of the system

  NPV of the total cost over the lifetime of the system, divided by the lifetime production of the system (in kWh for electrical generators)

  Calculation can get extremely messy

Internal Rate of Return (IRR) (percent)

ROI for a series of earnings or savings, and expenses

Similar to NPV except expressed as a percentage rather than a dollar amount

Messy calculation:

Set NPV to zero and solve for discount_rate in the NPV messy calculation

Calculation: use a spreadsheet…

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Solar Simplified - Ownership/Finance

IRR calculation for cash purchase

- Column A: Year number
- Column B: Cash income or outgo
- Column C: Savings
- Column D: Net income or outgo
- Column E: IRR

- Same $15,000 for the system
- $4500 back from the tax credit
- $2000 for the new inverter in year 15
- Same $1200 savings per year
- Assume the grid rate will rise by 3% per year

IRR = 14.1% (25 years)

(Simple ROI was 9.6%)

	A	B	C	D	E
1		**Cash in/out**	**Savings**	**Net**	**IRR**
2	Year	System, ITC, Inverter	Avoided utility charges, rising at 3%/year	Savings minus Expenses	IRR formula: =IRR(D3:D27)
3	1	-$15,000	$1,200	-$13,800	14.1%
4	2	$4,500	$1,236	$5,736	
5	3	$0	$1,273	$1,273	
6	4	$0	$1,311	$1,311	
7	5	$0	$1,351	$1,351	
8	6	$0	$1,391	$1,391	
9	7	$0	$1,433	$1,433	
10	8	$0	$1,476	$1,476	
11	9	$0	$1,520	$1,520	
12	10	$0	$1,566	$1,566	
13	11	$0	$1,613	$1,613	
14	12	$0	$1,661	$1,661	
15	13	$0	$1,711	$1,711	
16	14	$0	$1,762	$1,762	
17	15	-$2,000	$1,815	-$185	
18	16	$0	$1,870	$1,870	
19	17	$0	$1,926	$1,926	
20	18	$0	$1,983	$1,983	
21	19	$0	$2,043	$2,043	
22	20	$0	$2,104	$2,104	
23	21	$0	$2,167	$2,167	
24	22	$0	$2,232	$2,232	
25	23	$0	$2,299	$2,299	
26	24	$0	$2,368	$2,368	
27	25	$0	$2,439	$2,439	

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Solar Simplified - Ownership/Finance

IRR calculation for prepaid lease or PPA

- Column A: Year number
- Column B: Expenses
- Column C: Savings
- Column D: Net income or outgo
- Column E: IRR

- $11,000 for the system
- Same $1200 savings per year
- Assume the grid rate will rise by 3% per year

IRR = 13.7% (20 years)
(Simple ROI was 10.9%)

	A	B	C	D	E
1		**Cash in/out**	**Savings**	**Net**	**IRR**
2	Year	Prepaid Lease/PPA	Avoided utility charges, rising at 3%/year	Savings minus Expenses	IRR formula: =IRR(D3:D22)
3	1	-$11,000	$1,200	-$9,800	13.7%
4	2	$0	$1,236	$1,236	
5	3	$0	$1,273	$1,273	
6	4	$0	$1,311	$1,311	
7	5	$0	$1,351	$1,351	
8	6	$0	$1,391	$1,391	
9	7	$0	$1,433	$1,433	
10	8	$0	$1,476	$1,476	
11	9	$0	$1,520	$1,520	
12	10	$0	$1,566	$1,566	
13	11	$0	$1,613	$1,613	
14	12	$0	$1,661	$1,661	
15	13	$0	$1,711	$1,711	
16	14	$0	$1,762	$1,762	
17	15	$0	$1,815	$1,815	
18	16	$0	$1,870	$1,870	
19	17	$0	$1,926	$1,926	
20	18	$0	$1,983	$1,983	
21	19	$0	$2,043	$2,043	
22	20	$0	$2,104	$2,104	

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Solar Simplified - Ownership/Finance

Examples are conservative. Actual case study (Doug's house)

- $1812/year ($151/month average), 7200 kWh/year consumption
- $1812/7200 kWh = 25.1¢/kWh (PG&E charges)
- 4.48 kW Solar (DC) will generate 6480 kWh/yr and offset 90% of use and 90% of charges

- Simple Payback - *Total investment divided by annual savings*
  $8955 total system cost ($10,650 up front minus $3195 ITC, plus $1500 inverter in 15 years)
  4.48kW system ($2.37/watt pre-ITC, $1.66/watt post-ITC): $1630 annual savings
  Simple payback is $8955 / $1630 = **5.5 years**

- Simple ROI - *Annual savings divided by total investment, times 100*
  Example: $1630 annual savings, $8955 total investment
  Simple ROI is $1630 / $8955 times 100 = **18.2%** (for 25 years)

- Simple Cost per kWh - *Total investment divided by total energy generated*
  Example: $8955 total investment, ~150,000 kWh over its 25 year life
  (4.48 kW system: 6480 kWh/yr so about 162,000 kWh over 25 years)
  Simple Cost per kWh: $8955 / 162,000 kWh = **5.5¢ per kWh**

Grid Parity? **YES** (5.5¢ is less than *my* PG&E 25.1¢/kWh)

And… free electricity after 25 years!

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Solar Simplified - Ownership/Finance

Common investment interest rates today

- 10 year US treasuries: 1.75%
- Savings account interest: 0.06%
- 1 year CD: 0.31%; 5 year CD: 0.81%
- Stock Market: 7-10%/year over the long run BUT may get whacked in any given year or years
- Equity-indexed annuity: 2-3% minimum, higher if the index performs well
  - Lower return than the index, may have annual cap, may be surrender charges

All of these returns are taxable

Returns on solar (purchase/loan/lease/PPA) are NOT taxable

- "Returns" are savings you'd otherwise pay to your utility

Compare

- **Mediocre (1.75%) return for safe 10-year bond - taxable**
- **High to *amazing* (7.5% to 18.2%) return for safe solar - not taxable**

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Solar Simplified - Ownership/Finance

Ready to take solar action for your house?

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Solar Simplified

Workshop Goals (and Agenda) – to understand:

- *Solar power basics*
- *Solar Products*
- *Solar for your house?*
- *Ownership and finance*
- *How to (roughly) size a solar system for your home*
- *How to select a great contractor*

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Solar Simplified - Contractor

Select a great contractor

- Get referrals from friends and neighbors
  - Nextdoor.com is excellent
- Check online reviews to find or assess or select contractors
  - SolarReviews.com (solar only)
  - EnergySage.com (solar only)
  - Yelp.com
  - AngiesList.com (now free to join)
- Get bids from several licensed contractors
  Ask if they're familiar with *your* building dept.
- Ask for (and check) their references
- Check California's database of solar contractors
  - http://www.gosolarcalifornia.ca.gov/database/search-new.php
- Verify the contractor's license
  - www.cslb.ca.gov or 1-800-321-2752

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Solar Simplified - Contractor

When you've found a great contractor

- Ask them about
  - Equipment choices, especially panels and inverters
    - Reputable manufacturers?
    - Lower cost or higher efficiency panels?
    - String inverters or microinverters or DC optimizers
  - Panel layout on your roof and system size suggestions
  - Financing choices offered
  - Timelines
- Few construction projects of any kind go perfectly. Great contractors know how to build, but also how to resolve all problems to your satisfaction

- And now it's time to …

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Solar Simplified

Go Solar! And watch your meter run backwards!

Thank you!

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