WELCOME to the Solar Simplified Workshop

Albany Carbon Reduction Action Team

ACRAT

St. Alban's Episcopal Church

ALBANY COMMUNITY FOUNDATION

Albany Carbon Reduction Action Team

Future Events

- Plug-in Electric Vehicle Workshop
- Open House - Energy Efficient House

Other Initiatives

Citizen's climate portal for Albany

Your ideas …

Contact madmaxwei@yahoo.com if interested in helping with these or other activities

Albany Carbon Reduction Action Team
Albany Community Foundation
St. Alban's Episcopal Church
Thank you!

Solar Simplified Workshop

2/22/2017

Doug McKenzie
doug@sunwork.org

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 introduction*
- *Solar products*
- *Solar for your house?*
- *Solar finance*
- *How to select a great contractor*

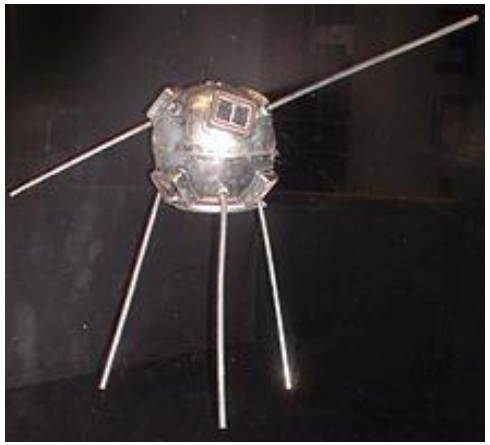
- *Q&A – During and after*

Doug McKenzie – doug@sunwork.org

Solar Simplified - Intro

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 (the "Solar Coaster") off & on subsidies, shortages and oversupplies, industry volatility & uncertainty until 30% tax credit in 2009
- Present federal subsidy:

  Through 2019: 30% tax credit for 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 - Intro

Short history of Presidential PV

- On (Carter), Off (Reagan), On (GW Bush; White House grounds)
- Pres Obama installed PV on the White House in 2014

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Solar Simplified - Intro

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, clothesline, …

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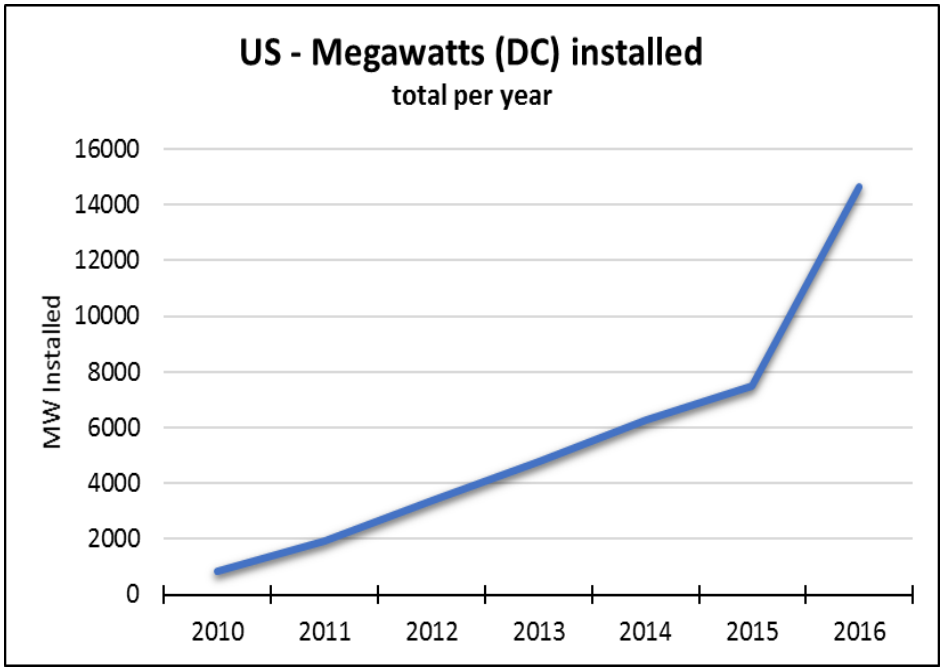
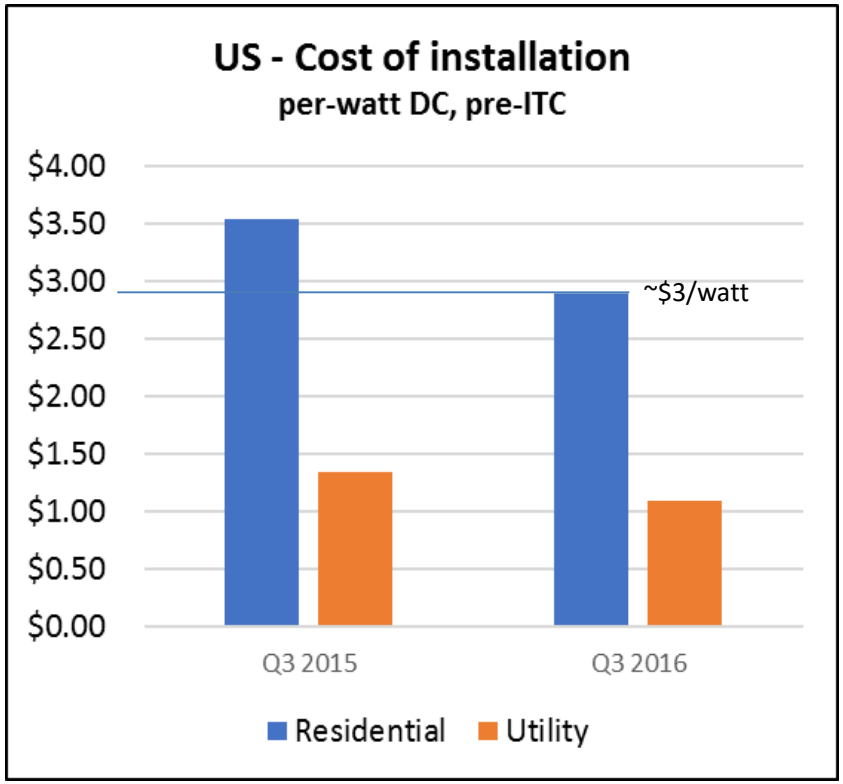
Solar Simplified - Intro

Solar Power Today





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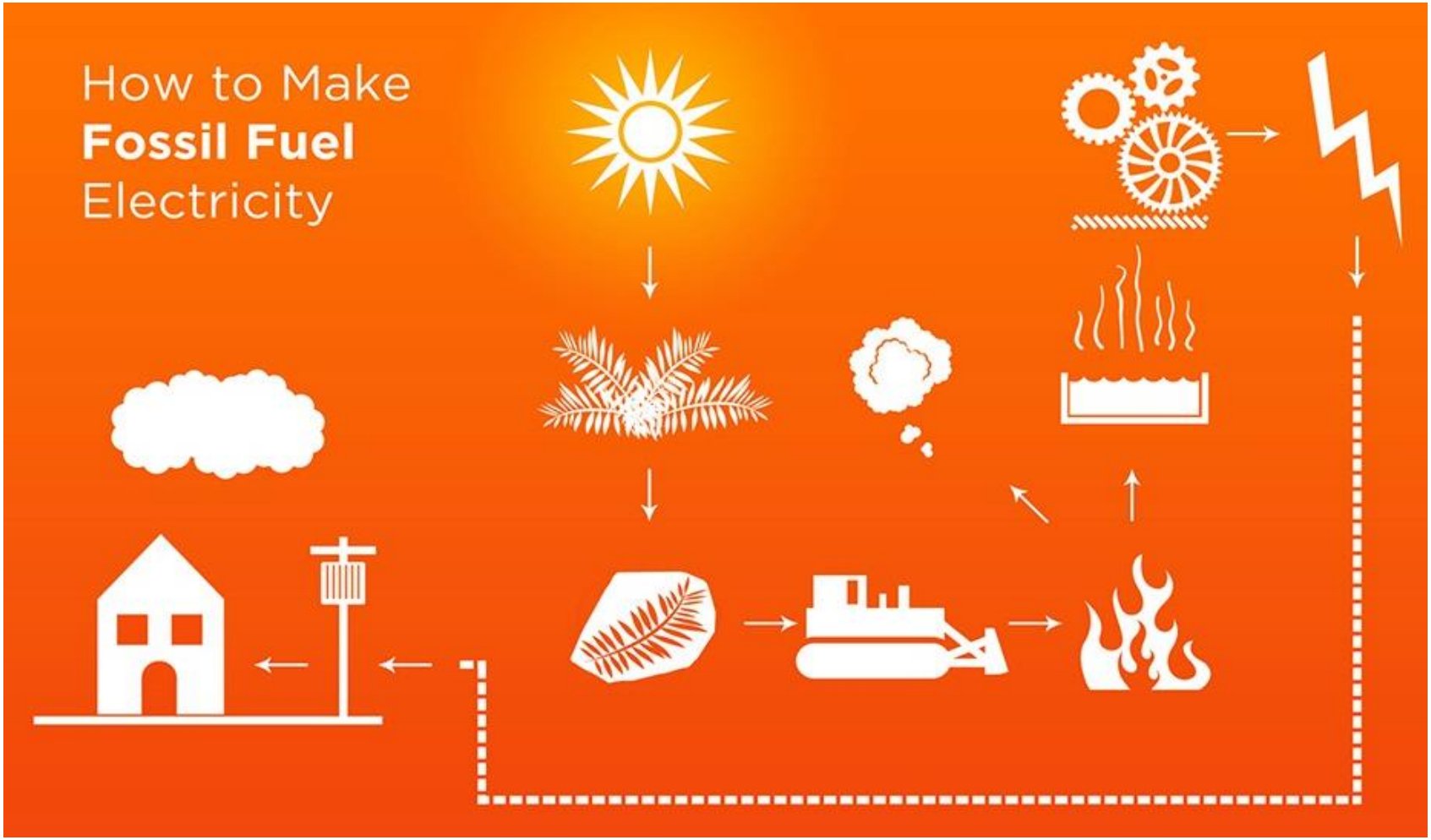
Solar Simplified - Intro

Let's go from this



From *Rooftop Revolution* by Danny Kennedy, used with permission

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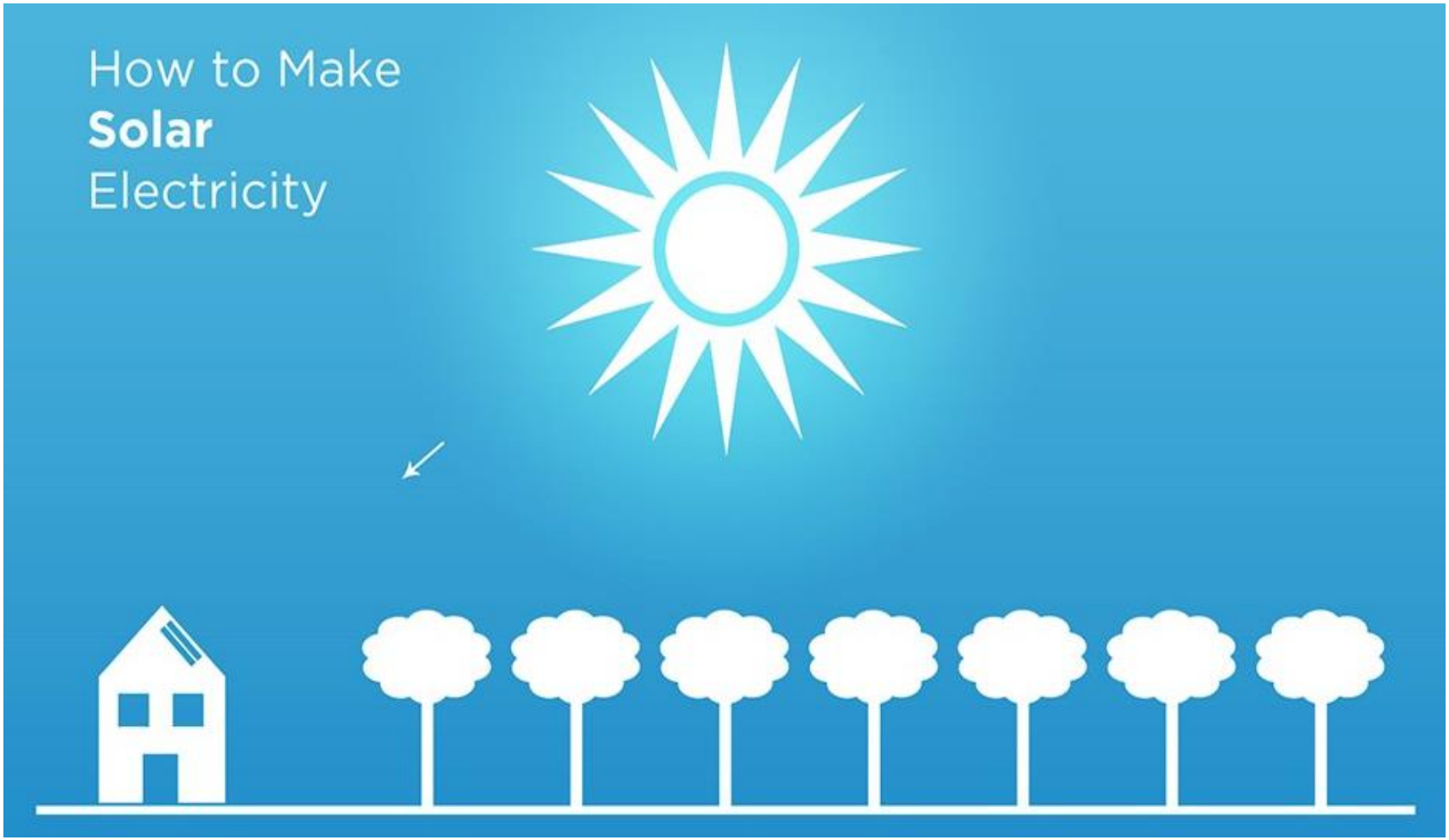
Solar Simplified - Intro

To this



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Solar Simplified - Intro

Just 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 for expensive peaker-power plants
- Tremendous job generation – twice the employment of coal in the US
- Rooftop solar increases voter awareness of energy use
- Saves money and protects against rising electricity rates
- Scales well (homes to businesses to schools to utility power plants)
- Enables clean transportation (solar powered electric vehicles)
- Enables clean home appliances (oven, cooktop, A/C, space and water heat)
- Starts conversations and enables clean power bragging rights

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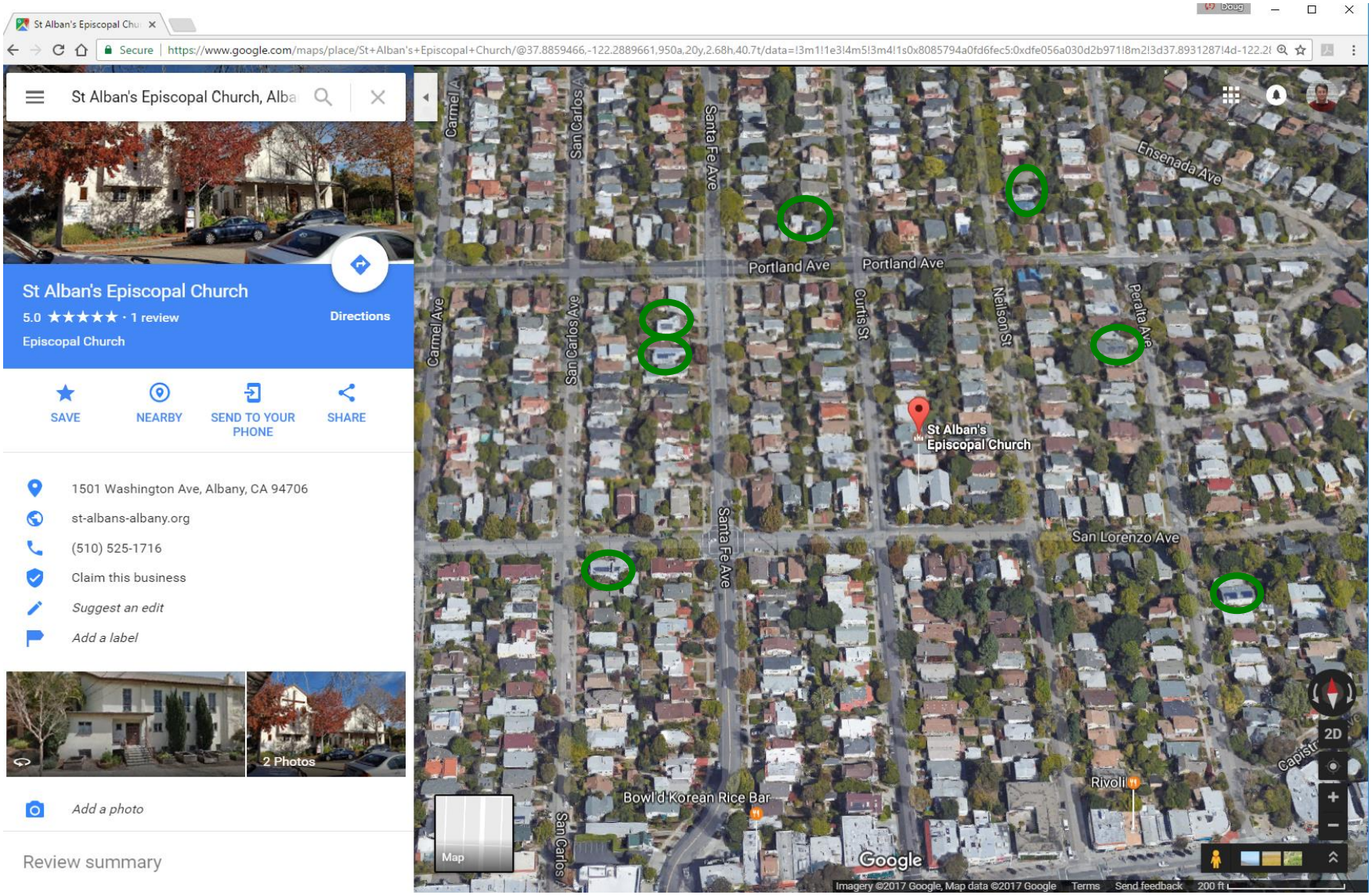
Solar Simplified - Intro



Why have so few people gone solar?

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Solar Simplified

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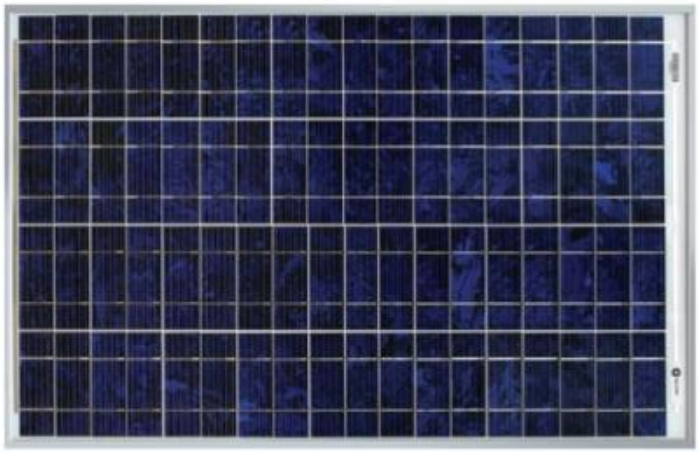
Solar Simplified - Products

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

Inverters

String Inverter

Usually one per residential solar system

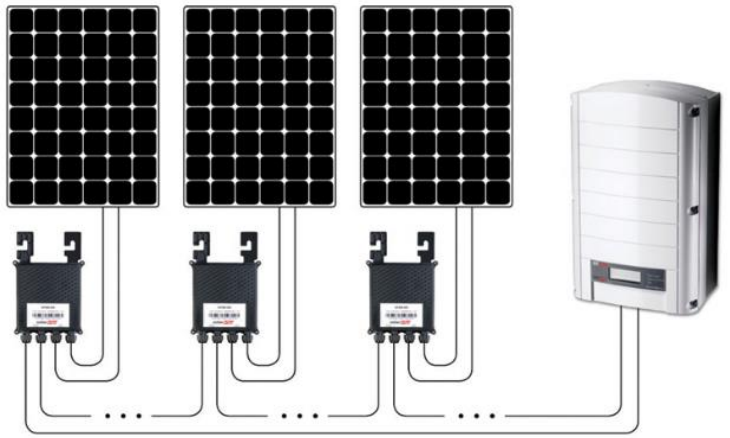
Micro-inverter

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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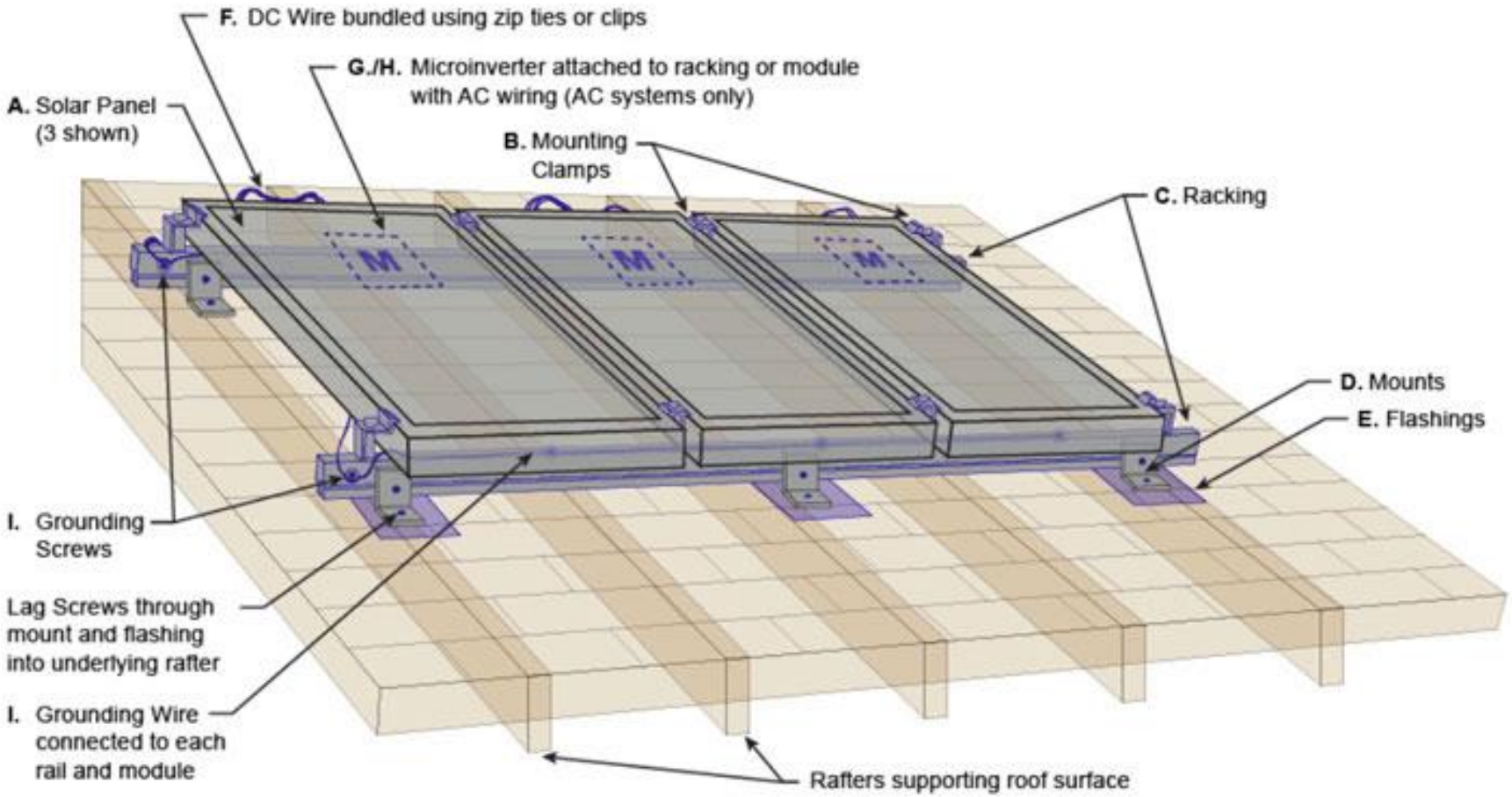
Solar Simplified - Products

Warranties

- Solar PV panels
  - Most come with 10 year product warranties and 25 year production warranties
  - Panel production degrades ~0.5%/year (~88% after 25 years)
- 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 installers offer 10 year workmanship warranties (that is, call your installer first for any problems)

Solar Simplified - Products

Roof attachments - Racking and Mounting



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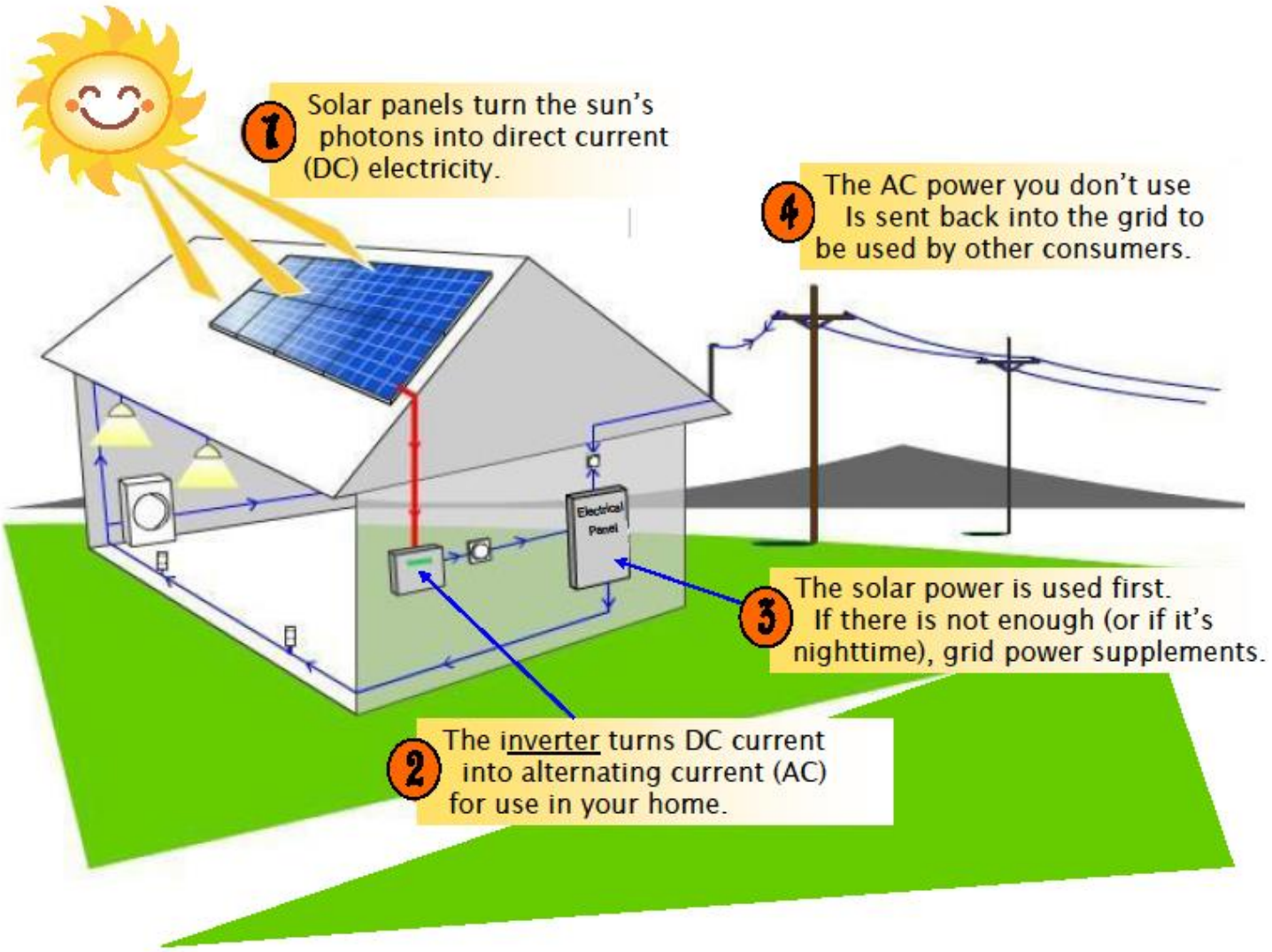
Solar Simplified - Products



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Solar Simplified

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Solar Simplified – for YOUR House

How is your roof?

- Shading issues?

- Roof age? (solar lasts a looooooong time)

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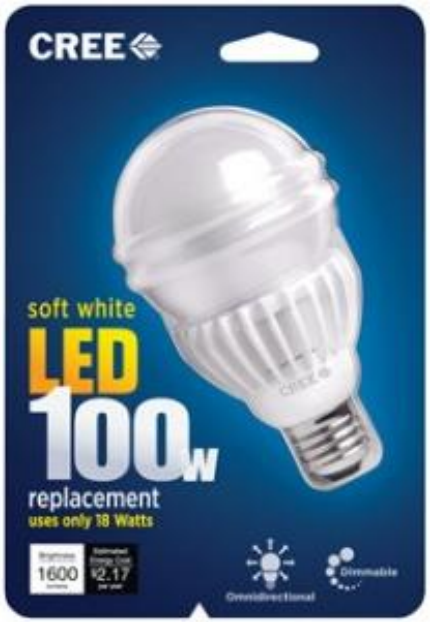
Solar Simplified – for YOUR House

Matching your solar to your needs



- Will you be reducing your electricity use?
  - Attic/crawlspace insulation
  - LED lights
  - Leaky furnace ducts and inefficient furnace
  - Double-pane windows
  - People moving out
- Will you be increasing your electricity use?
  - Electric car
  - Switch to electric appliances
  - People moving in

Consider these before going solar

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Solar Simplified – for 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 4 kW solar system
- *Kilowatt-hour (kWh)*
  - Physics unit of **energy**: In electrical energy, the flow of electrons
  - PG&E charges you per kWh
  - EV batteries are rated in kWh (Leaf: 24 kWh or 30 kWh, Tesla: up to 100 kWh)
  - A 100-watt bulb, on for 10 hours, consumes 1 kWh of energy
- 1 Terawatt-hour (TWh) = 1000 Gigawatt-hours (GWh)
  - California consumes almost 300 GWh per year
- 1 GWh = 1000 Megawatt-hours (MWh)
  - Average natural gas plant generates about 1000 MWh per hour
- 1 MWh = 1,000 Kilowatt-hours
  - Average US household consumes almost 1000 kWh per month

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Solar Simplified – for YOUR House

PG&E Bill Basics

- Electricity usage and cost?

  Example PG&E bill →

  Total Electric Charges $61.38

  Electric Usage This Period: 632 kWh

  Average cost per kWh is

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

- Doug's (pre-solar) PG&E bill

  Total Electric Charges $132.45

  Electric Usage This Period: 519.8286 kWh

  Average cost per kWh: $132.45/519.8286 =

25.5¢/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**

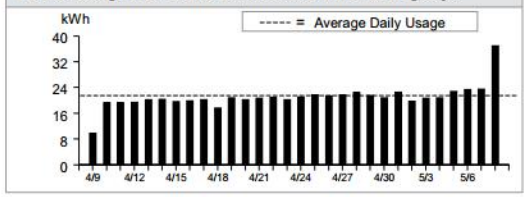
Service Information

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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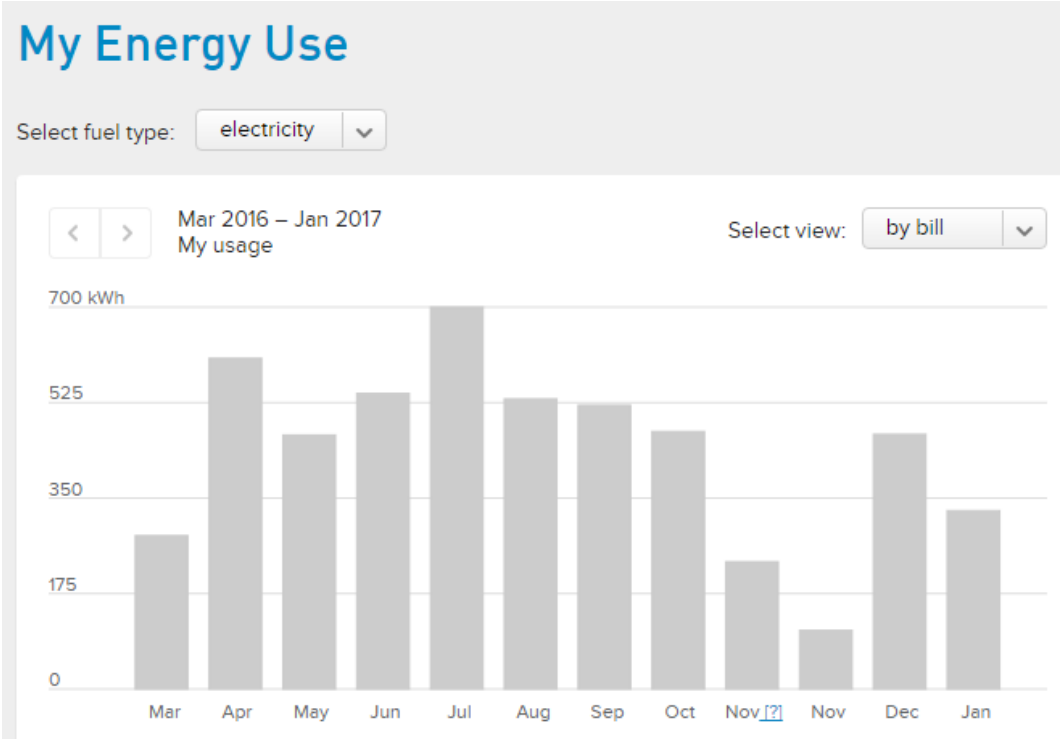
Solar Simplified – for YOUR House

PG&E Bill Basics

- Find your yearly numbers
  - Look through your last 12 bills, OR
  - Create/login to your PG&E account at pge.com and go to **ENERGY USAGE DETAILS**



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Solar Simplified – for YOUR House

Preliminary solar sizing calculations

Grid (PG&E) electricity cost and usage

- Example: $1200/year ($100/month average)
- 20¢/kWh (≈ PG&E Bay Area average)
- $1200/year at 20¢/kWh ≈ 6000 kWh annual usage

What size solar system?

- 1500 kWh per kW in the Bay Area*
- 6000 kWh/yr at 1500 kWh per kW => 4 kW solar system
- Panels are usually 280 to 360 watts each, so most 4 kW systems will be 11 to 15 panels
- Panels are ~3’ by ~5’ each. 12 panels ≈ 180 square feet.

*Under ideal conditions; kW usually means DC, kWh almost always means AC

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Solar Simplified – for YOUR House

Example PG&E Bill

- $1200/year ($100/month average)
- 6000 kWh/year consumption
- 4 kW (DC) solar system

- Your 4 kW system will generate about 6000 kWh/year and will offset about 100% of your PG&E electricity usage.

- … But not 100% of your PG&E charges

?????

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Solar Simplified – for YOUR House

Enter "Net Metering" (or Net Energy Metering or NEM)

- From the Solar Energy Industries Association (SEIA)

  Net metering is a billing mechanism that credits solar energy system owners for the electricity they add to the grid

- NEM is simple in concept
  - You're paid for solar at the same rate you would pay for grid electricity
- But NEM has some devils in the details
  - You're not paid *quite* as much for your solar
  - But *FIRST*… PG&E Rate Plans, and Tiers, and Baselines, and Territories, and Time of Use (TOU)

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Solar Simplified – for YOUR House

- Rate Plans
  - E-1, E-6, E-TOU-A, E-TOU-B EV-A, EV-B, …
  - How your per-kWh charges are determined
- Tiers
  - Tier 1 (Baseline), Tier 2, Tier 3
  - Use more energy, pay higher per-kWh charges
- Time of Use (TOU)
  - Peak, Partial-Peak, Off-Peak
  - Per-kWh charges depend on *when* you use energy
- Territories
  - Albany is in the “T” territory (coastal, mild)

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Solar Simplified – for YOUR House

- Most non-solar, non-EV people are on E-1
  - E-1's Tier 1 covers about 220 kWh/month*
    E-1's Tier 1 rate is ~18.3¢/kWh
  - After consuming ~220 kWh in the billing cycle, move to Tier 2
    Tier 2 is ~24.2¢/kWh for another ~220 kWh
  - After consuming ~440 kWh in the billing cycle, move to Tier 3
    Tier 3 is ~40.1¢/kWh. Tier 3 is the top.

  - If you use 500 kWh in a month
    - 220 kWh at 18.3¢/kWh = $40.26
    - 220 kWh at 24.2¢/kWh = $53.24
    - 60 kWh at 40.1¢/kWh = $24.06
  - E-1 Total = $117.56/mo (23.5¢/kWh average)

* ~220 kWh is the summer baseline. Winter is ~255 kWh

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Solar Simplified – for YOUR House

- PG&E requires solar customers to be on a TOU plan
  - E-TOU-A's Summer rates
    - Summer: Off-Peak is ~32.9¢/kWh, Peak is ~40.5¢/kWh
    - Winter: Off-Peak is ~27.2¢/kWh, Peak is ~28.7¢/kWh
    - Rates are ~12¢/kWh less up to Baseline (~220 kWh in summer, ~255 kWh in winter)

  - If you use 500 kWh in a month (no solar)
    - How much you're charged depends on WHEN you use electricity
    - For a winter month: between $100 and $114.26
      - at least: 246 kWh * 15.2¢/kWh + 256 kWh * 27.2¢/kWh
      - at most: 246 kWh * 16.7¢/kWh + 256 kWh * 28.7¢/kWh
    - For a summer month: between $114.68 and $184.20
      - at least: 220 kWh * 20.9¢/kWh + 300 kWh * 32.9¢/kWh
      - at most: 220 kWh * 28.5¢/kWh + 300 kWh * 40.5¢/kWh
  - E-TOU-A Total (no solar): $100/mo to $184.20/mo
    (20¢/kWh to 36.8¢/kWh)

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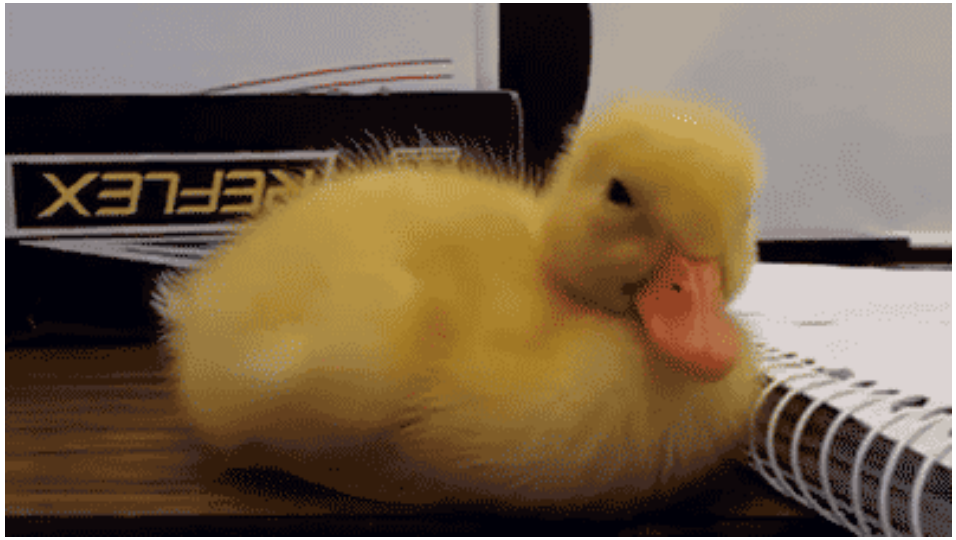
Solar Simplified – for YOUR Friends



How are we doing?

Any Questions?

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Solar Simplified – for YOUR House

Back to Net Metering

- Records the difference between the amount of electricity generated by your solar and the amount of electricity you use from the grid
- Nighttime – 100% from the grid*
  - Meter tracks that you're using 100% grid energy
- Mid-day – mostly or all powered by your solar
  - Meter tracks your solar production minus any load
- Early morning, early evening – weak solar, heavy load
  - Meter tracks your load minus your solar production
- Pay PG&E your net total once per year

* Assumes no storage batteries attached to your solar system

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Solar Simplified – for YOUR House

NEM – the details devils

- Enter the Minimum Bill
  - $10/month – cannot be offset with solar
  - Rationale: people with low bills should still pay for the costs of delivering electricity (infrastructure, labor, maintenance, overhead)
- Enter Non-Bypassable Charges (NBCs)
  - 2.3¢/kWh for each kWh drawn from the grid – cannot be offset with solar
  - Rationale: people with low bills should still pay for funding energy-efficiency programs, low-income assistance, nuclear power plant decommissioning, "competition transition charge," "DWR Bond charge," etc.

The Minimum bill and NBCs are why you can offset 100% of your kWh *usage* with solar, but not 100% of your *bill*

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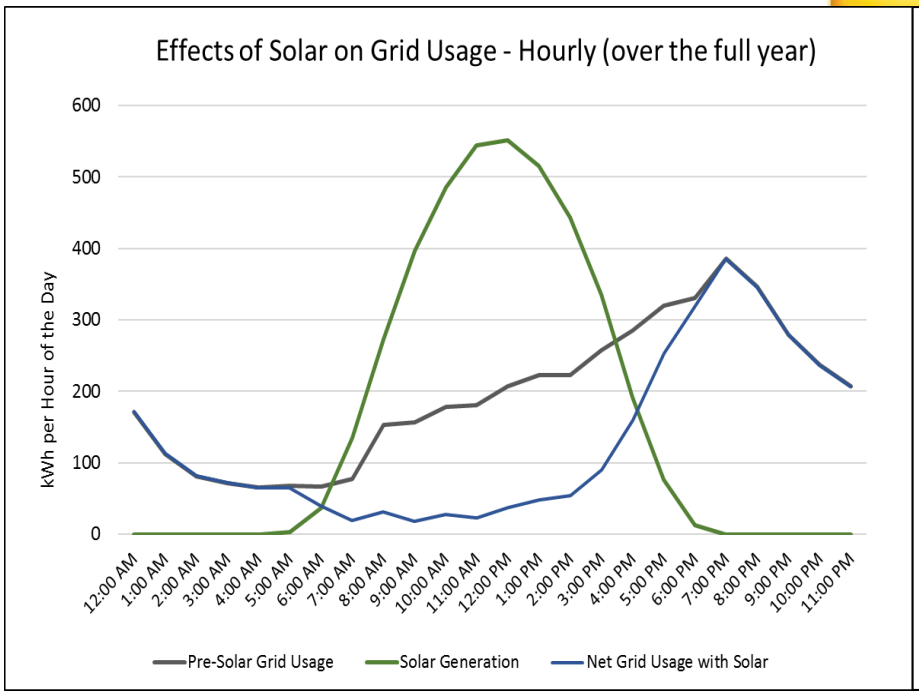
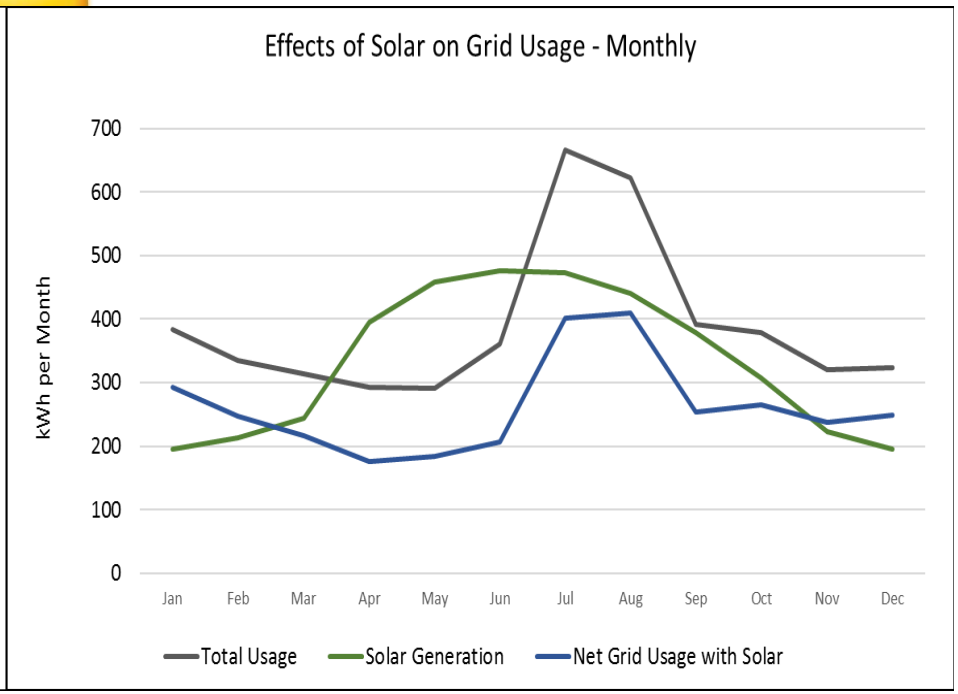
Solar Simplified – for YOUR House

Example impact of Non-Bypassable Charges





Totals Pre-Solar Grid Usage: 4684 kWh/yr

Solar Generation: 4000 kWh/yr (~85% of grid usage)

Net Grid Usage with Solar: 3142 kWh/yr (~67% of grid usage)

Percent of solar used by home ("self-consumption") ≈ 39%

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Solar Simplified – for YOUR House

- Net Metering Summary
  - You're paid the full retail price, based on your rate plan
    - Minus the minimum bill
    - Minus Non-Bypassable Charges
  - PG&E: After generating 100% of your usage, you're paid the wholesale rate (~4¢/kWh)
  - PG&E: You'll receive monthly statements with detailed charges but except for the monthly minimum, you pay just once per year. This is called the True Up.
  - PG&E will not permit a solar system that will generate significantly more energy than the household consumes*

* However, PG&E will OK an interconnection based on a future purchase of an EV, etc.

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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

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 know what your electricity will cost for 25+ years. 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 $16,000 for a 4 kW system)

Home Equity Loan

- Good interest rate (4-8%) = good ROI. Can be 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

* However, almost all installers provide at least 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
- PPAs and leases may have an “escalator” clause increasing your payments over time

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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

Cash purchase example

- $1500/year bill, 7500 kWh/year consumption. $1500/7500 kWh = 20¢/kWh (PG&E average)
- 4 kW Solar (DC) generates 6000 kWh/yr and offsets 80% of use and about 80% of charges

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

  Example: **$11,800** total system cost

  (4 kW * $3.50/watt = $14,000 - $4200 ITC + $2000 inverter in 15 years)

  6000 kWh at 20¢/kWh = $1200 savings per year

  Simple payback: $11,800 / $1200 = **9.8 years payback***

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

  Simple ROI is $1200 / $11,800 times 100 = **10.1% ROI*** (for 25 years)

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

  6000 kWh/yr * 25 years = 150,000 kWh. Include 0.5%/year degradation: 141,000 kWh.

  Simple Cost per kWh: $11,800 / 141,000 kWh = **8.3¢ per kWh**

- 8.3¢/kWh (fixed for 25 years) is less than half of the PG&E average rate today
- Internal Rate of Return is better (inverter replacement is made with future dollars)

* Payback will be shorter & return will be better if PG&E ***ever*** raises rates

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Solar Simplified - Ownership/Finance

Common investment interest rates today

- 10 year US treasuries: ~2.5%
- Savings account interest: under 1%
- 1 year CD, 5 year CD: both under 1%
- Stock Market: 7-10%/year over the long run but … watch out below!
- Equity-indexed annuity: 2-3% minimum, higher if the index performs well
  - Lower return than index, may have annual cap and surrender charges

All of these returns are taxable

Returns on municipal bonds are generally not taxable

- AAA rated: 1 year, 3 year 5 year: all under 1%

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

- Returns are just savings you'd otherwise pay to your utility
- Solar ROI on cash purchase is ~10% non-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 introduction*
- *Solar Products*
- *Solar for your house?*
- *Ownership and finance*
- *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 alternatives 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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