Thank you
Ecology Center
&
Sierra Club
Bay Chapter!

Solar Simplified

Part 1 of 2 - Getting Started

6/10/2017

Doug McKenzie
doug@sunwork.org

SunWork
Renewable Energy Projects

Solar Simplifed – Getting Started

Who's Doug?

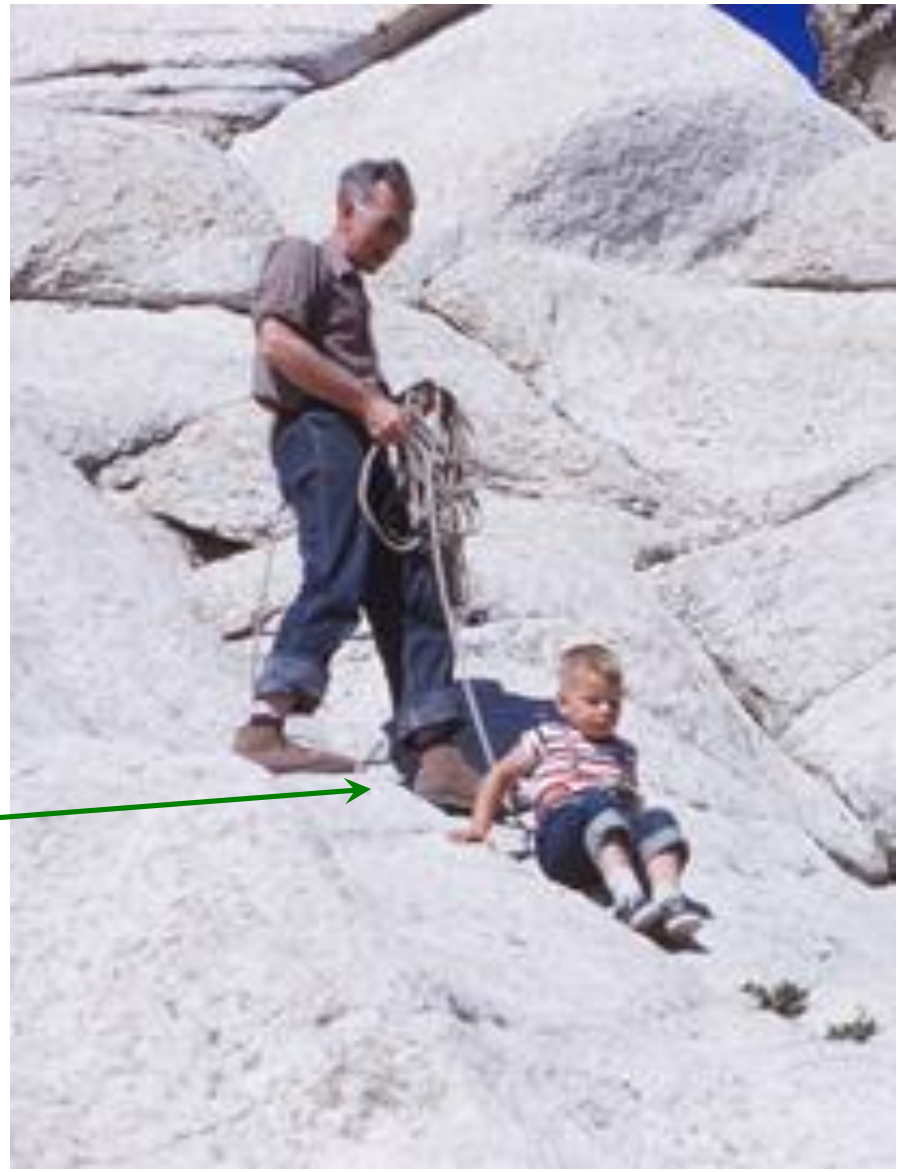
SunWork.org

NorCalSolar.org

LinkedIn.com/in/renewabledoug

***Long* Time Sierra Club Member**

EV enthusiast



Solar Simplified – Getting Started

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

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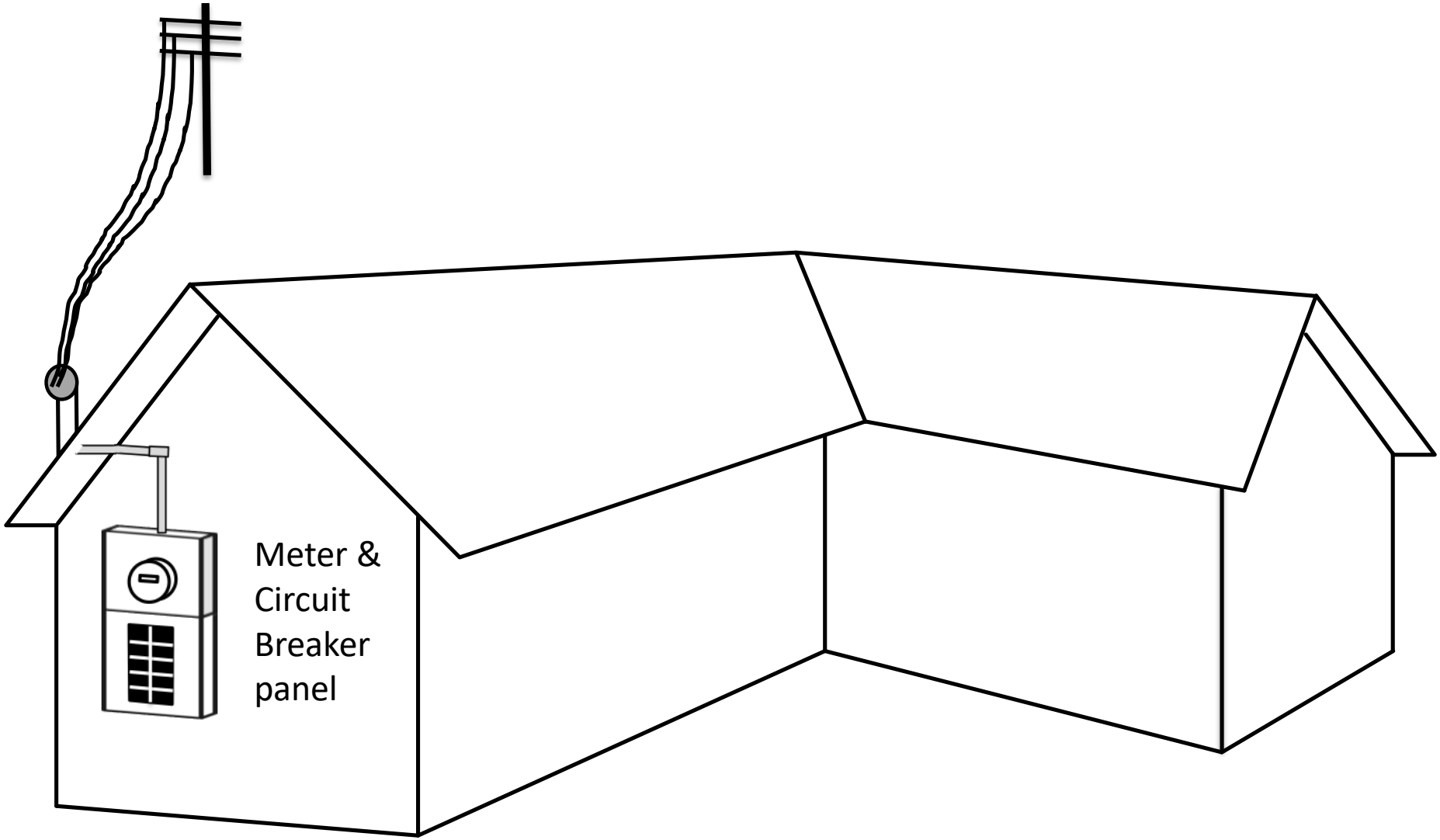
Solar Simplified – The Deeper Dive

June 24, 1:30-3:30pm, Ecology Center

Topics

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

PV Components - Before



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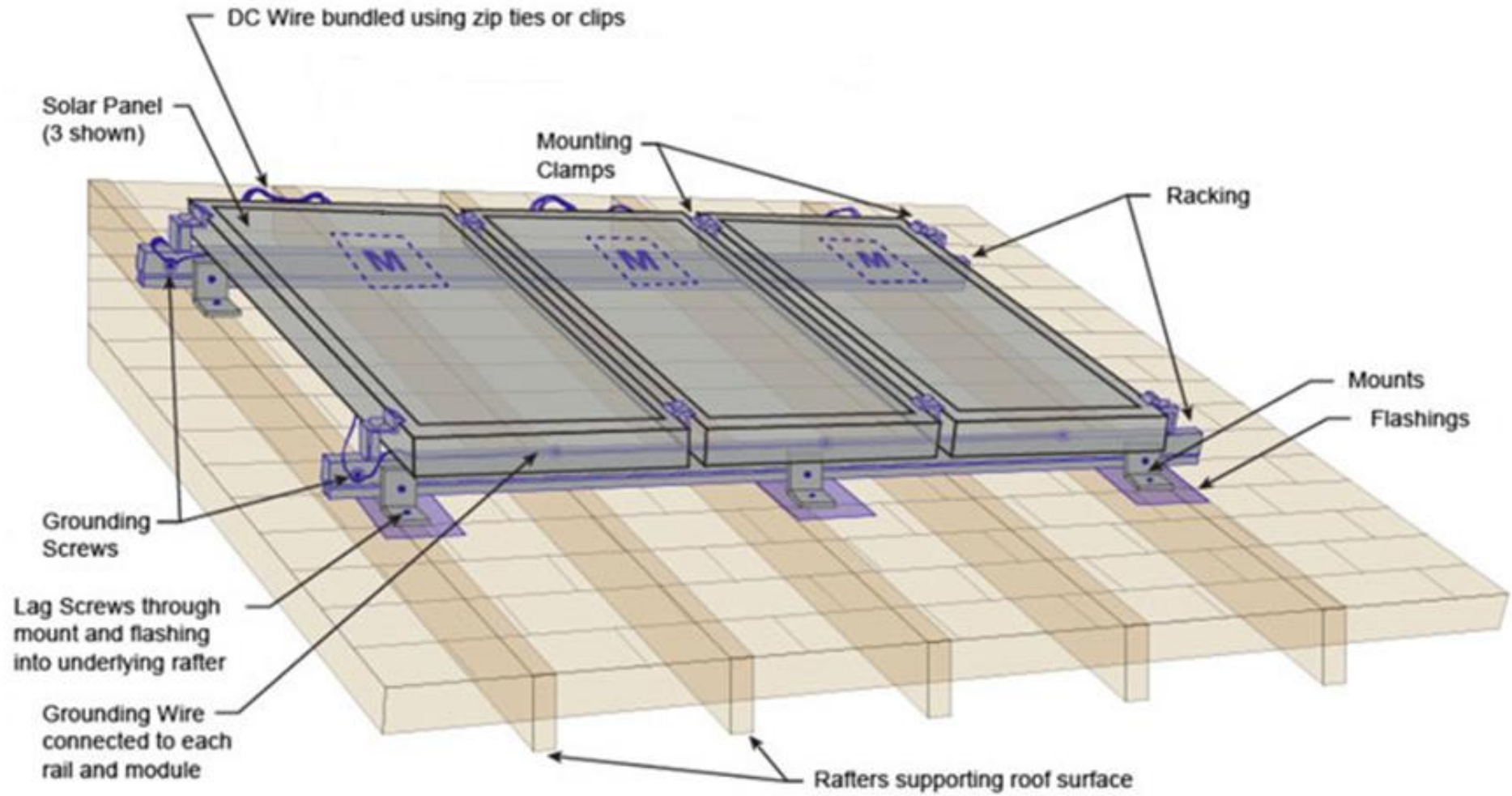
PV Components

Roof attachments - Racking and Mounting



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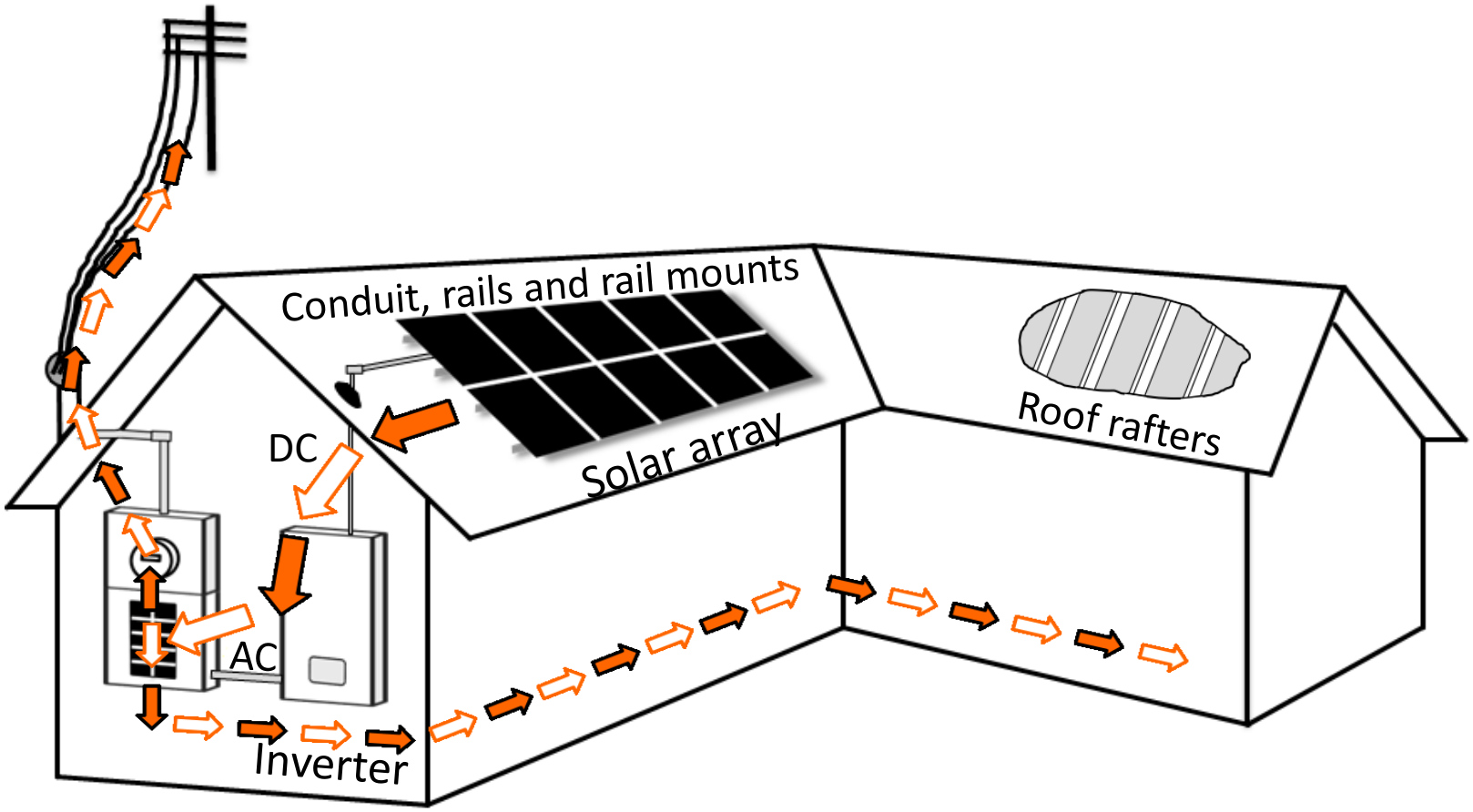
PV Components - After



Solar electricity goes to the nearest load

1. Home loads
2. Out the meter to the grid and neighbors' loads
3. Grid to substation and beyond

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PV Components - Mounts

PV Components – Flashing

PV Components – Ready for Rails

PV Components – Rails and conduit

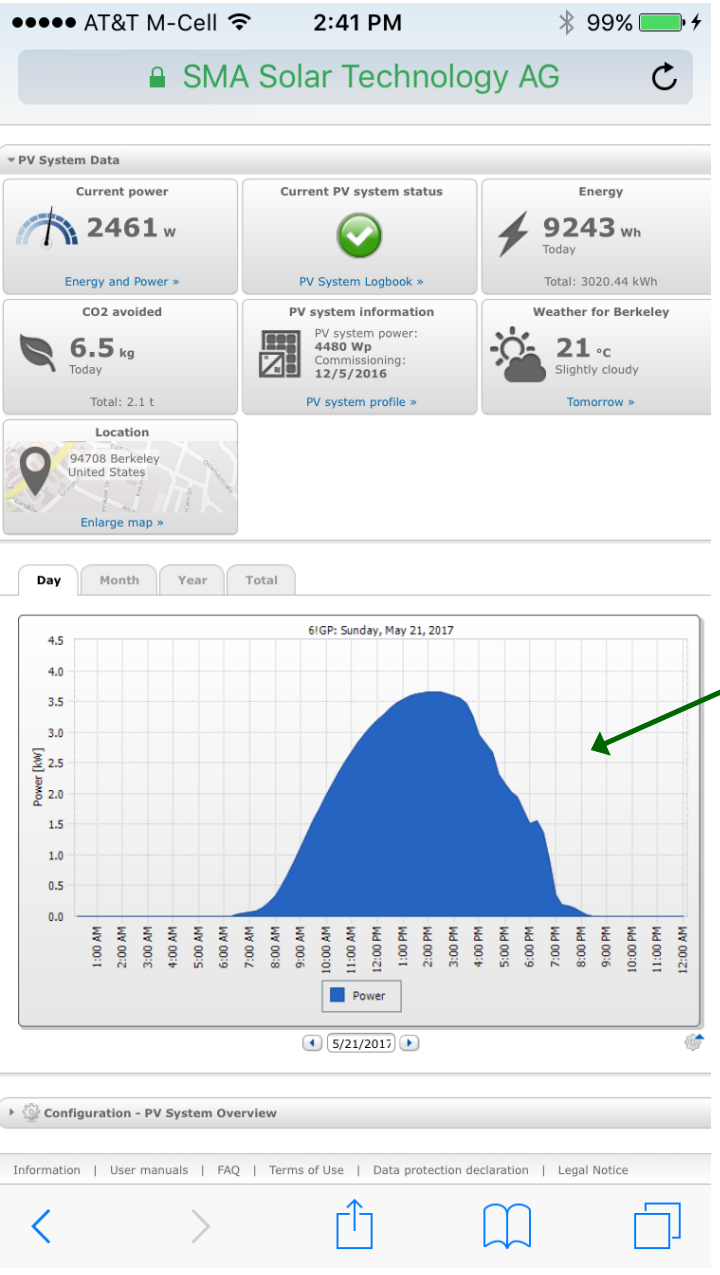
PV Components – Installers' View!

PV Components – “Fishing” the Wire

PV Components - Inverter

PV Components - Panel Layout

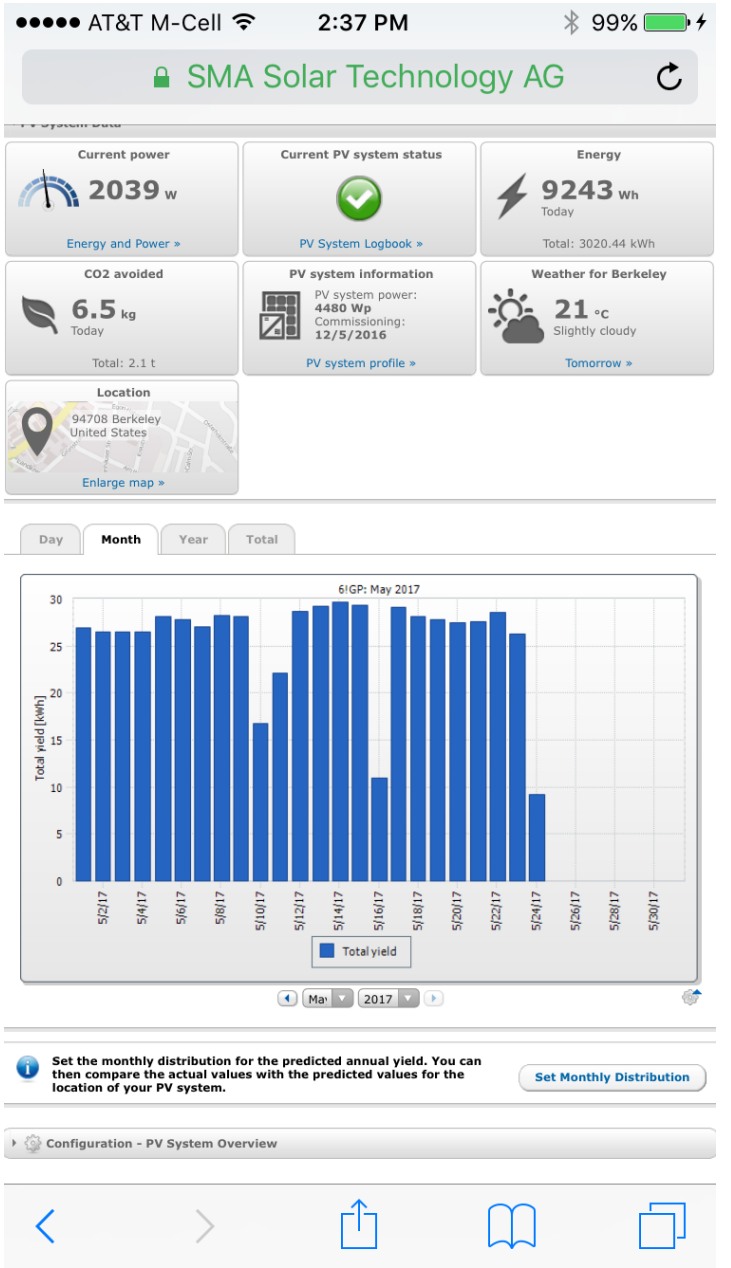
PV Components – Monitoring



Smartphone Monitoring

Intraday

Daily



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Solar Financing

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

Pros: Eligible for the 30% federal tax credit on the total system cost. Known, fixed cost for electricity 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+%) = 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)

- Low 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

** Interest may be tax deductible

*** 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 Financing

*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 may become 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

* Known as “Third Party Ownership” or TPO

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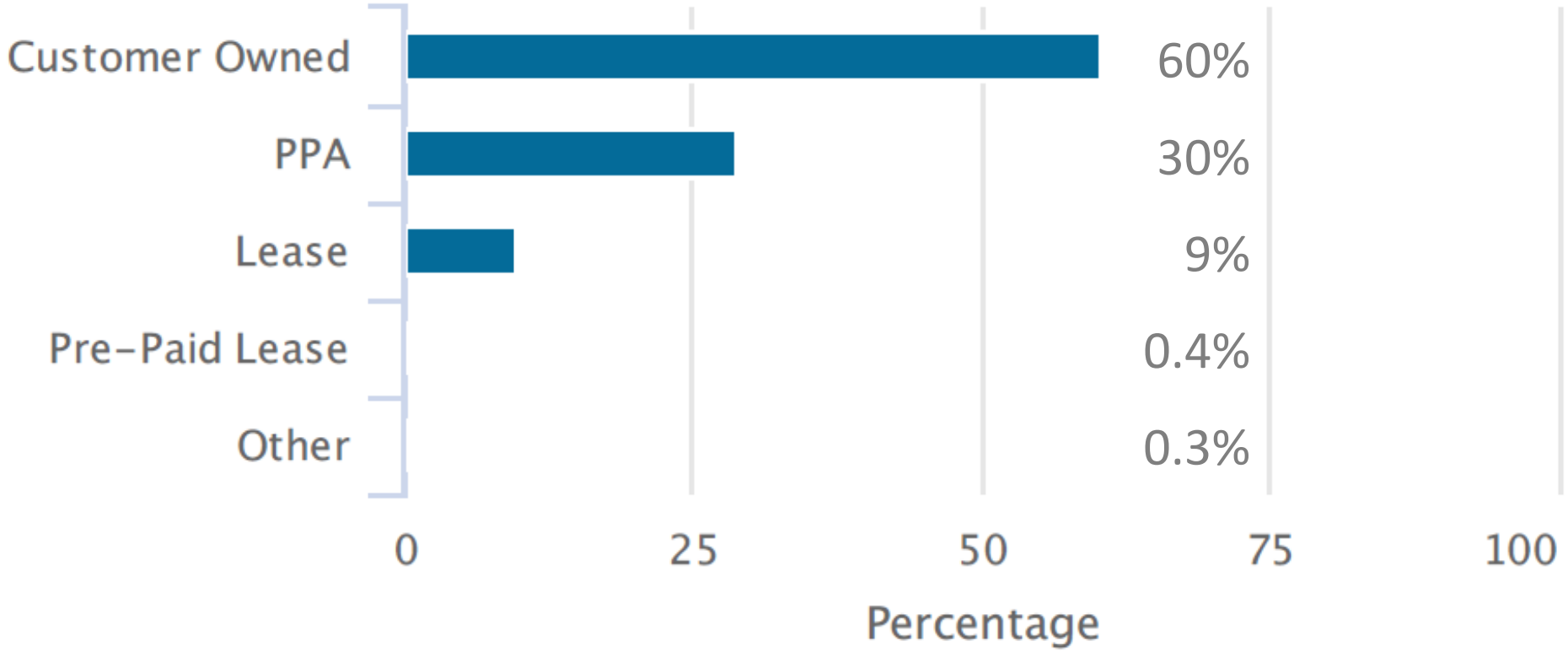
Solar Financing

Ownership vs. Third-Party Ownership



californiadgstats.ca.gov/charts – through 3/31/2017

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Solar Financing – For Renters

PG&E allows "Virtual Net Metering"

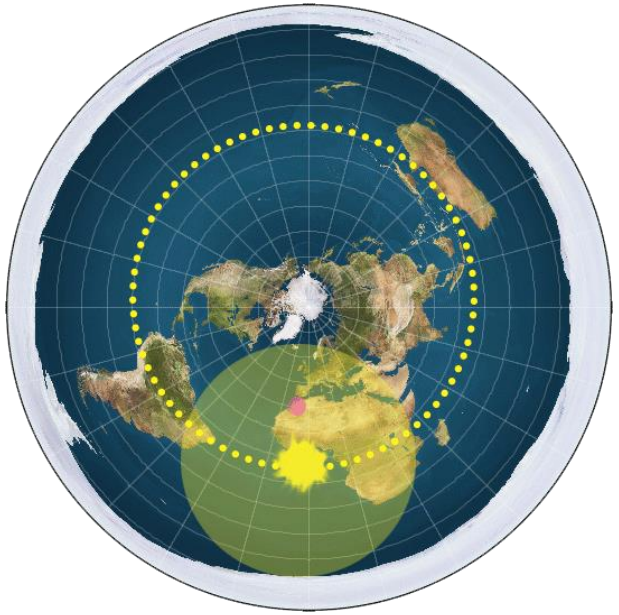
- The solar feeds a dedicated meter
- Individual units are credited with a portion of the solar electricity
- Building owner must pay for potential upgrades to PG&E transformer, etc.
- See PG&E NEMV

PG&E allows "Net Metering Aggregation"

- PG&E customers with multiple meters on one property, all in one name
- See PG&E NEMA

Community Choice Energy!

…Come back June 24



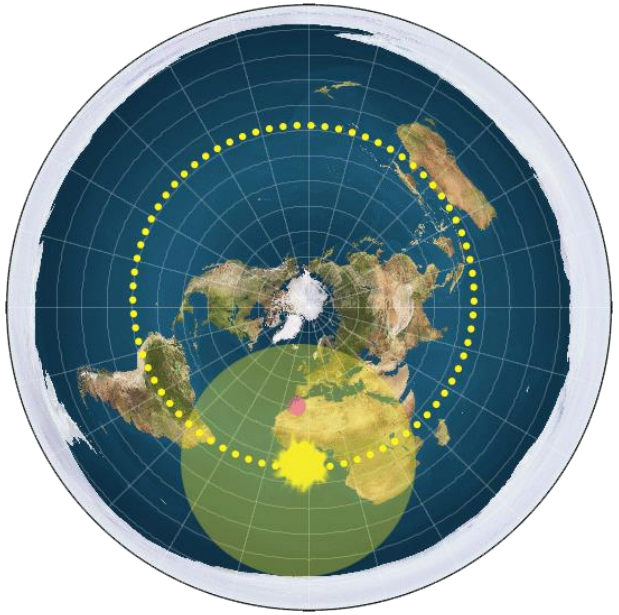
Solar Financing – Low-Income

Grid Alternatives

- Low to no-cost PV for low-income families
- CA administrator for Single-Family Affordable Solar Homes (SASH) program
- Turnkey design and installation services for multifamily affordable housing developers
- Participate in community solar programs

Community Choice Energy!

…Come back June 24



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Solar Economics

GreenTech Media article, 6/1/2017

Should I Sell My Mutual Fund to Go Solar?

by Tom Konrad

"I told her solar was one of the best investments I know of for a financial crisis, because it will still be generating the same amount of electricity and savings, no matter what the markets do. And I asked her what sort of payback she thought she was getting from her mutual funds."

Doug McKenzie – doug@sunwork.org

Solar Economics - Terms

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

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

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

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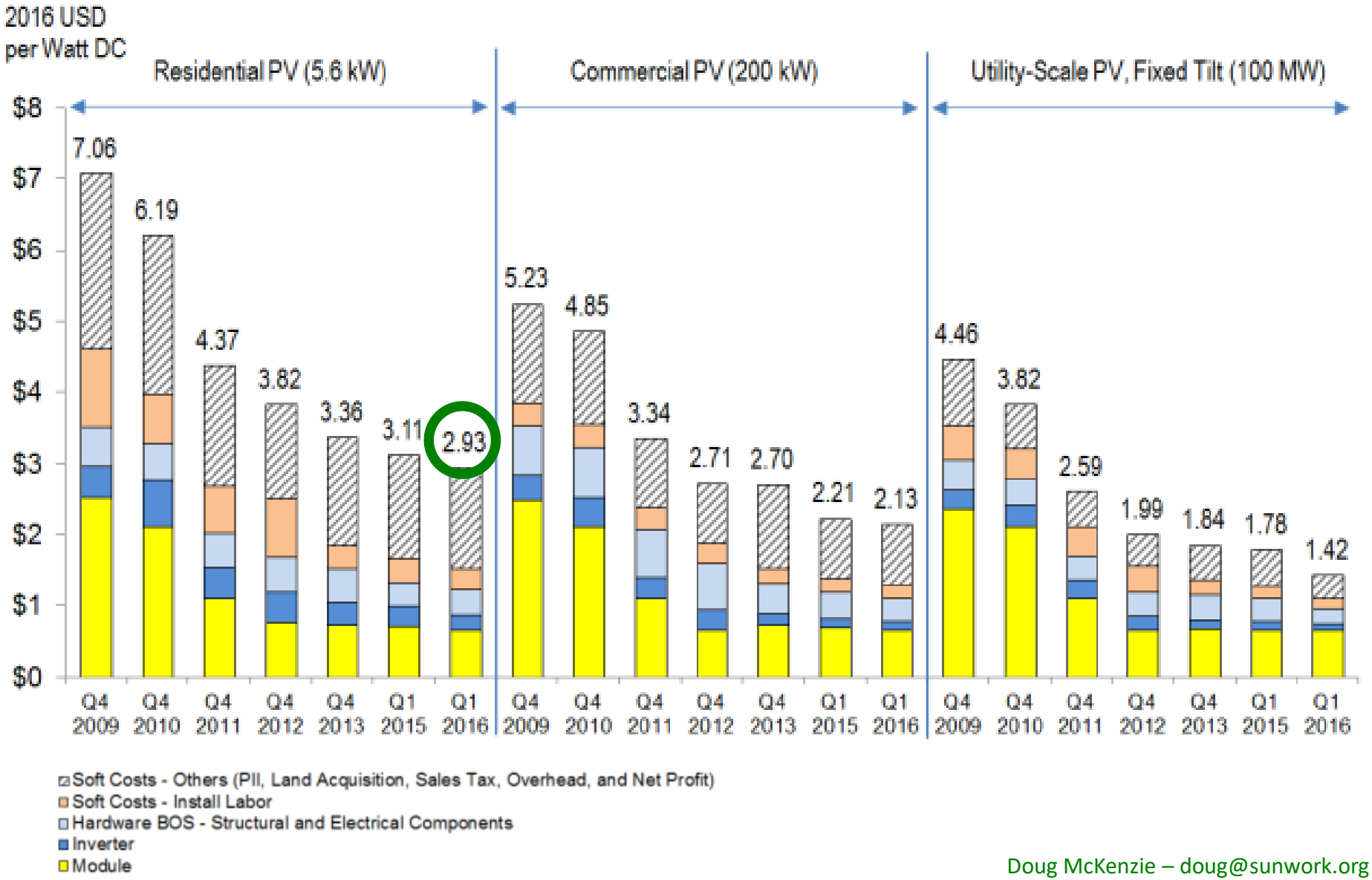
Solar Economics



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Solar Economics - Example

Assumptions

- Usage: 6000 kilowatt-hours (kWh) per year
- Bay Area cost of electricity: 24¢ per kWh
- Electricity bill

  *6000 * $.24 ≈ $1440/year ($120/mo)*
- Bay Area cost of solar

  *$2.50 to $4 per watt DC, before receiving the **30% federal tax credit***

Doug McKenzie – doug@sunwork.org

Solar Economics - Example

Cash purchase example (1 of 6)

- 4 kW (DC) system
  - Offsets ~90% of usage and bill
- $10,000 to $16,000 (before 30% tax credit)
  - $7000 to $11,200 after the credit
- Add $1000 for inverter replacement
- **Total (lifetime) cost: $8000 to $12,200**

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Solar Economics - Example

Cash purchase example (2 of 6)

Electricity bill: $1440/yr

4 kW system, total cost: $8000 to $12,200

Solar system energy output

- ~1400 kWh per kW per year
- 4 * 1400 ≈ 5600 kWh (year 1)
- 0.5% panel degradation per year
- **126,000 kWh lifetime energy output**

Solar Economics - Example

Cash purchase example (3 of 6)

Electricity bill: $1440/yr

4 kW system, total cost: $8000 to $12,200

126,000 kWh lifetime output

Simple Lifetime Cost per kWh

- $8000 / 126,000 ≈ **6.3¢/kWh** ($2.50/watt)
- $12,200 / 126,000 ≈ **9.7¢/kWh** ($4/watt)

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Solar ~~Economics~~ Motivation!

Solar Economics - Example

Cash purchase example (4 of 6)

Electricity bill: $1440/yr

4 kW system, total cost: $8000 to $12,200

126,000 kWh lifetime output

Simple Lifetime Cost/kWh: 6.3 to 9.7¢/kWh

Yearly savings: kWh * per-kWh savings / 25

- 126,000 * (24¢-9.7¢) / 25 ≈ **$721** ($4/watt)
- 126,000 * (24¢-6.3¢) / 25 ≈ **$892** ($2.50/watt)

Doug McKenzie – doug@sunwork.org

Solar Economics - Example

Cash purchase example (5 of 6)

Simple Payback

$12,200 / $721 ≈ **17 years** ($4/watt)

$8000 / $892 ≈ **9 years** ($2.50/watt)

Simple Return on Investment

$721 / $12,200 ≈ **5.9%** ($4/watt)

$892 / $8000 ≈ **11.2%** ($2.50/watt)

Solar Economics - Example

Cash purchase example (6 of 6)

$4/watt ≈ 17 year payback => **5.9%** ROI

$2.50/watt ≈ 9 year payback => **11.2%** ROI

- Assumes NO rise in the price of grid energy
- Internal Rate of Return (IRR) is higher
- Solar ROI is *not taxable*
- 5-year CD: 2.25% taxable
- 10 year treasuries: ~2.2% taxable
- Stock Market: ~7% (look out below!) taxable

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Solar ~~Economics~~ – Auto-motivation

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Solar + PV Economics

Solar cash purchase example (7 of 6)

5.9% to 11.2% ROI

Cost to drive a gasoline **("ICE")** car

- **10¢/mile** (at 30 mpg and $3/gallon)

Cost to drive an electric car powered by solar

- **1.8¢/mile** (at 3.4 miles/kWh and 6.3¢/kWh)
- **2.8¢mile** (at 3.4miles/kWh and 9.7¢/kWh)

Savings (EV versus ICE): 7.2¢ to 8.3¢/mile

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Solar + PV Economics

Solar cash purchase example (8 of 6)

Yearly savings: $721 to $892

Savings (EV versus ICE): ~8¢/mile
At 10,000 miles per year: $800/year

Add solar savings to ~$800/yr solar+EV savings: $1521 to $1692/yr total savings

Solar + PV Economics

Solar + EV example (9 of 6 – DONE!)

$ 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)

Solar Economics - Spreadsheet

Free online solar economics calculator for cash or loans

PV Calc

pvcalc.org

Project Definition

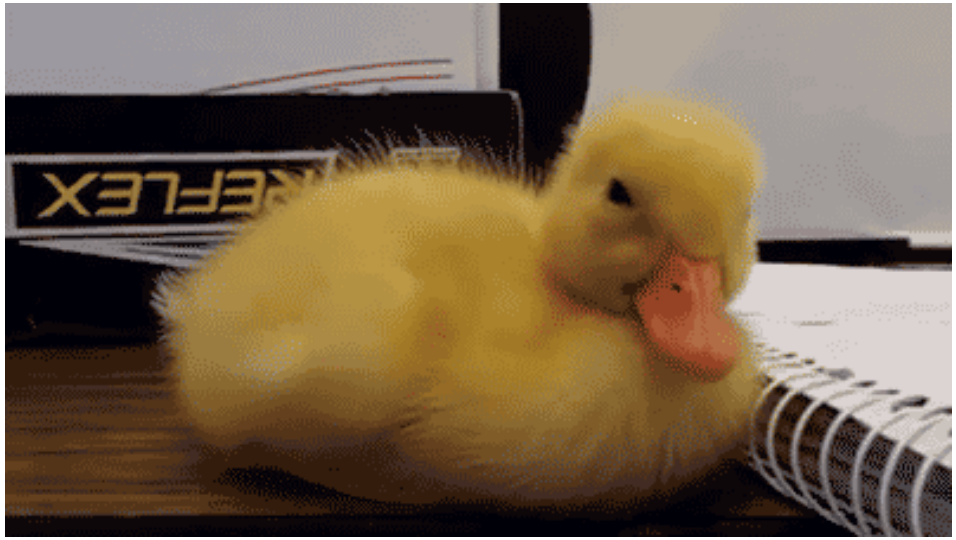
General Information	
Currency	USD
Divisor	1
Useful life (years)	25
Nominal power (kWp)	5
Annual Yield *per kWp* (kWh/kWp)	1400
Degradation (%/year)	0.5
Feed in tariffs	
Years	0
Price (per kWh)	0
Index linked	
Own consumption	
FIT subsidy (€/kWh)	0
Own consumption (kWh/year)	0
Electricity price projection	
Price now (per kWh)	0.24
Energy Price Inflation (%/year)	2

Setup cost (all in)	
Price (per kWp)	2800
Running cost	
Lease (€/year)	0
Insurance prem. (%)	0
Maintenance (%)	0
Inflation rate (%/year)	2
Financing	
Own funds (%)	100
Loan type	Redeemable
Redemption Sched.	Uniform
Years	0
Interest rate (%)	0
Disagio (%)	0
Investment Yield (%)	0
Tax	
Tax rate	0

help

Calculate Reset

Solar Sleeponomics?



How are we doing?

Questions?

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Solar Economics

Tony Seba: "Your next oil well makes my next oil well more expensive. Your next solar panel makes my next solar panel cheaper"

Solar Simplified – Getting Started

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Solar Environmental Benefits

- Reduces fossil fuel dependence
- Reliable, safe, clean energy
- Enables clean transportation (solar-powered EVs)
- Reduces need for utility equipment and maintenance
- Reduces need for remote power plants, substations and transmission lines
- Fast-growing labor-intensive industry creates many jobs
- Increases voter awareness about energy
- Enables clean home appliances (oven, cooktop, clothes dryer, A/C, space & water heat)
- Starts conversations, enables clean power bragging rights

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Find a Great Installer

Select a great installer

- Referrals from friends and neighbors (Nextdoor.com)
- Check online reviews to find or assess or select contractors
  - SolarReviews.com
  - Yelp.com
- 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

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Find a Great Installer

When you've found a great installer

- Ask about
  - Equipment choices, especially panels and inverters
    - Reputable equipment 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
  - Aesthetics
  - Warranties
- Few construction projects go perfectly.
  Great contractors know how to build, but also how to resolve all problems to your satisfaction

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Installed!

Watch your meter run backwards!

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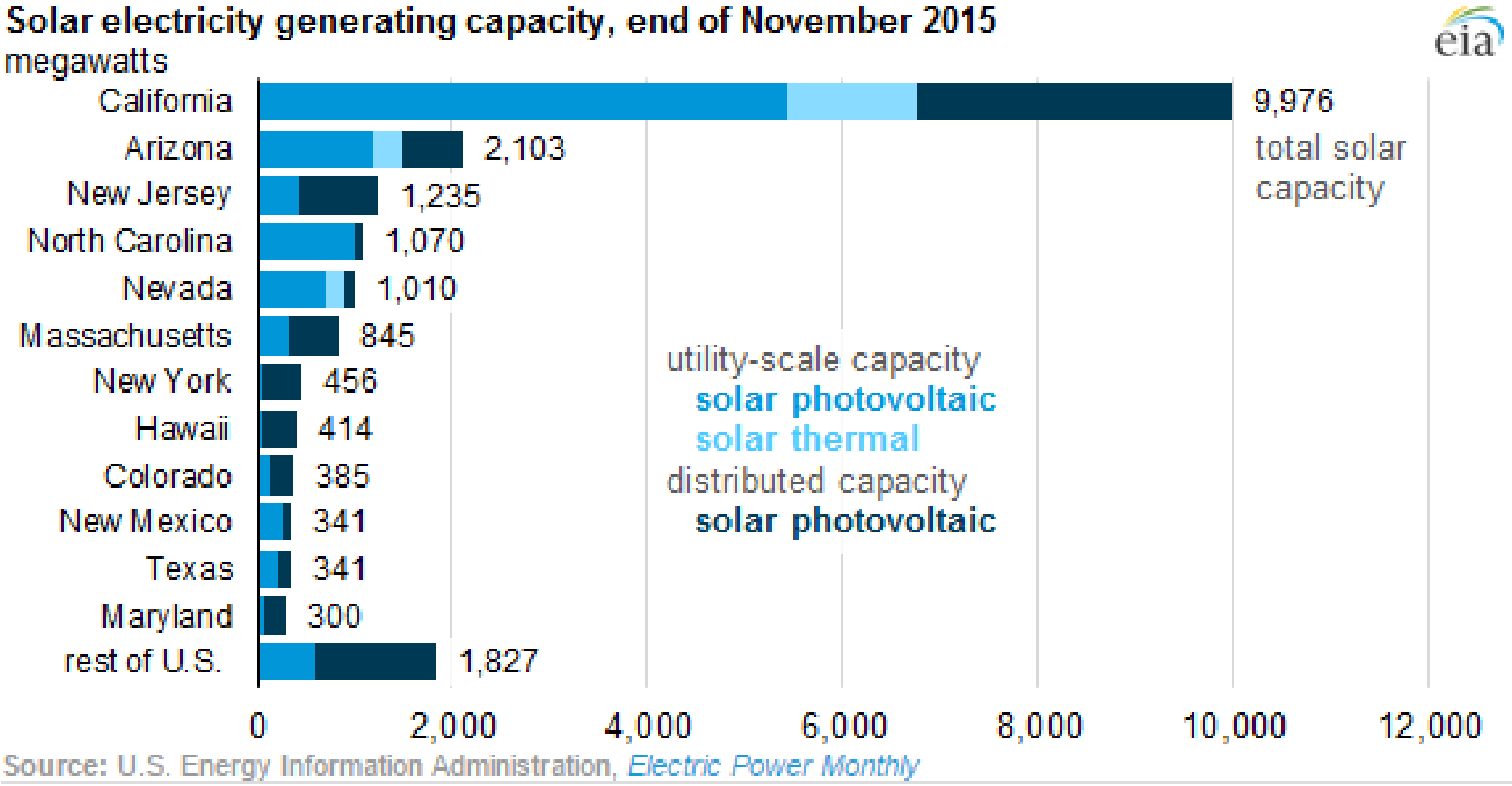
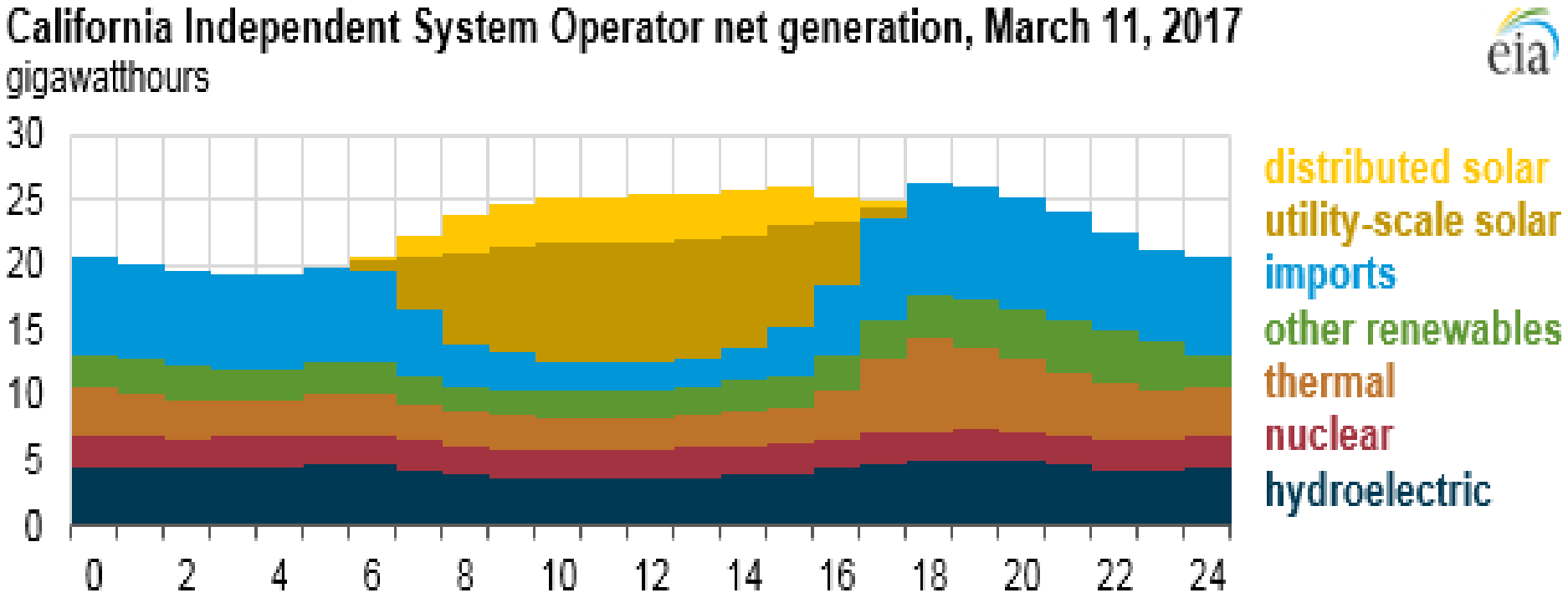
Solar in California

Half of all solar in the US is in California!



Solar in California

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



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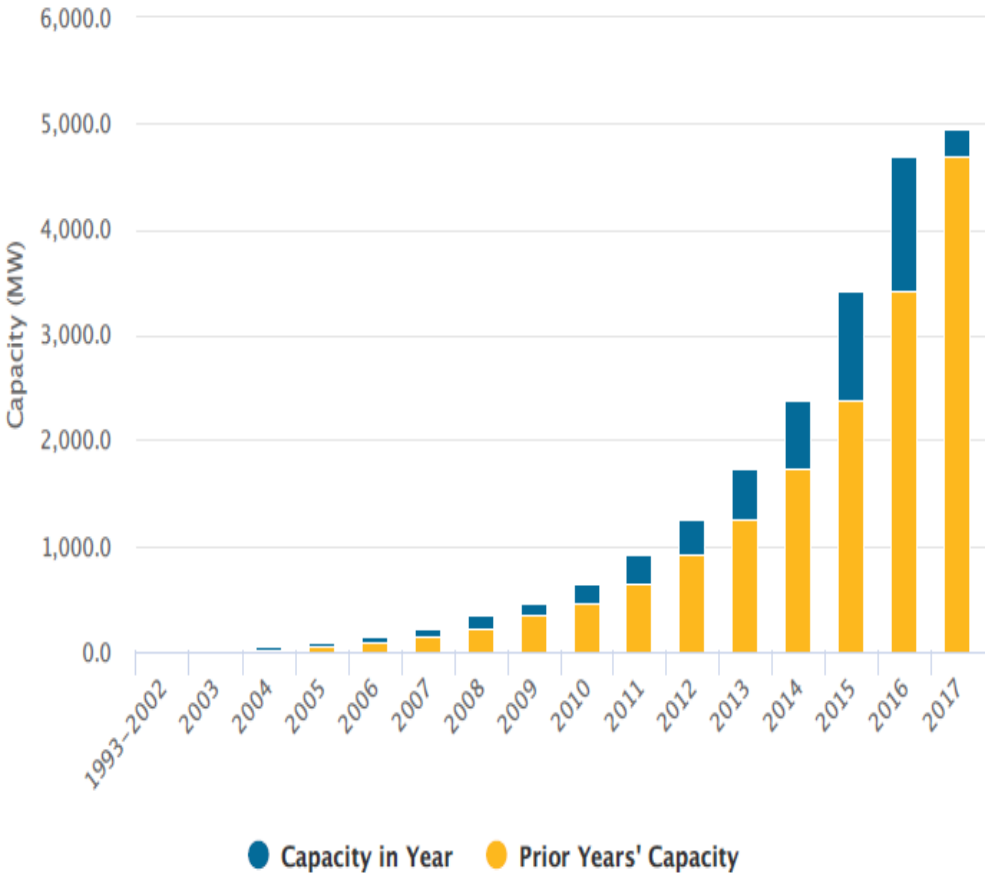
Solar in California

California DG

Year	DG MW	Growth	Cumulative	CAGR
2004	30		61	
2005	34	14.9%	95	
2006	49	44.7%	145	
2007	83	68.1%	228	
2008	128	54.0%	356	
2009	117	-8.5%	473	
2010	175	49.8%	648	
2011	283	61.1%	931	
2012	335	18.7%	1266	
2013	473	41.0%	1739	
2014	641	35.5%	2380	
2015	1049	63.6%	3429	
2016	1267	20.8%	4696	36.7%
3/31/17	243		4938	



californiadgstats.ca.gov/charts – through 3/31/2017

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Solar in California

SolPad

solpad.com/product/solpad-mobile

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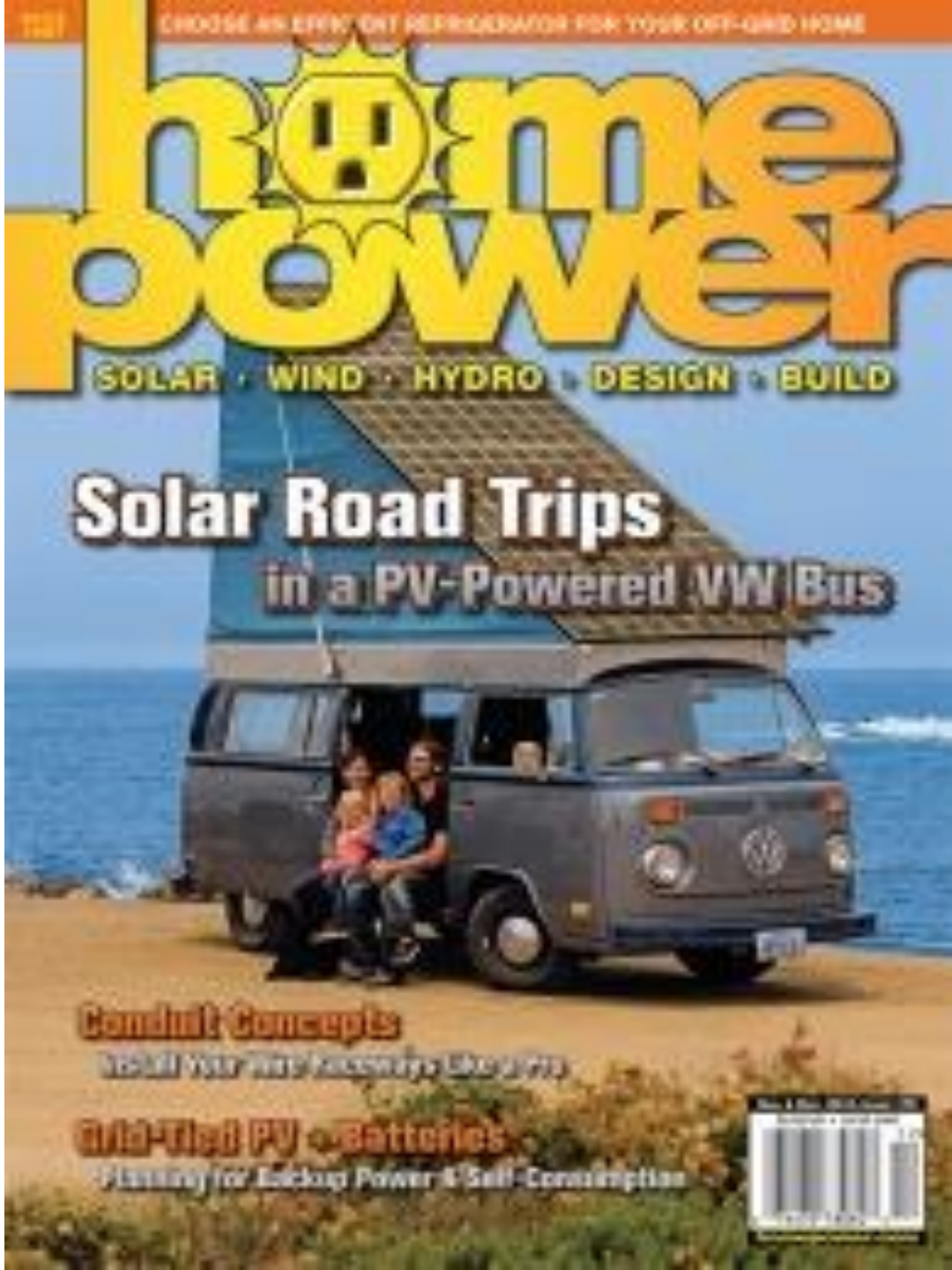
Solar in California

Solar Powered VW Bus



Solar in California

Solar Powered Home

Solar in California

Tesla Solar Roof

tesla.com/solarroof

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Solar in California

Church-top Solar

Solar in California

Power to the Creatures

Solar in California

Solar Parking - De Anza College

Solar in California

Alcatraz – Join the NorCal Solar tour! July 10, 2017

Solar in California

Ivanpah Solar Power Plant

Solar in the World

Off-grid Solar

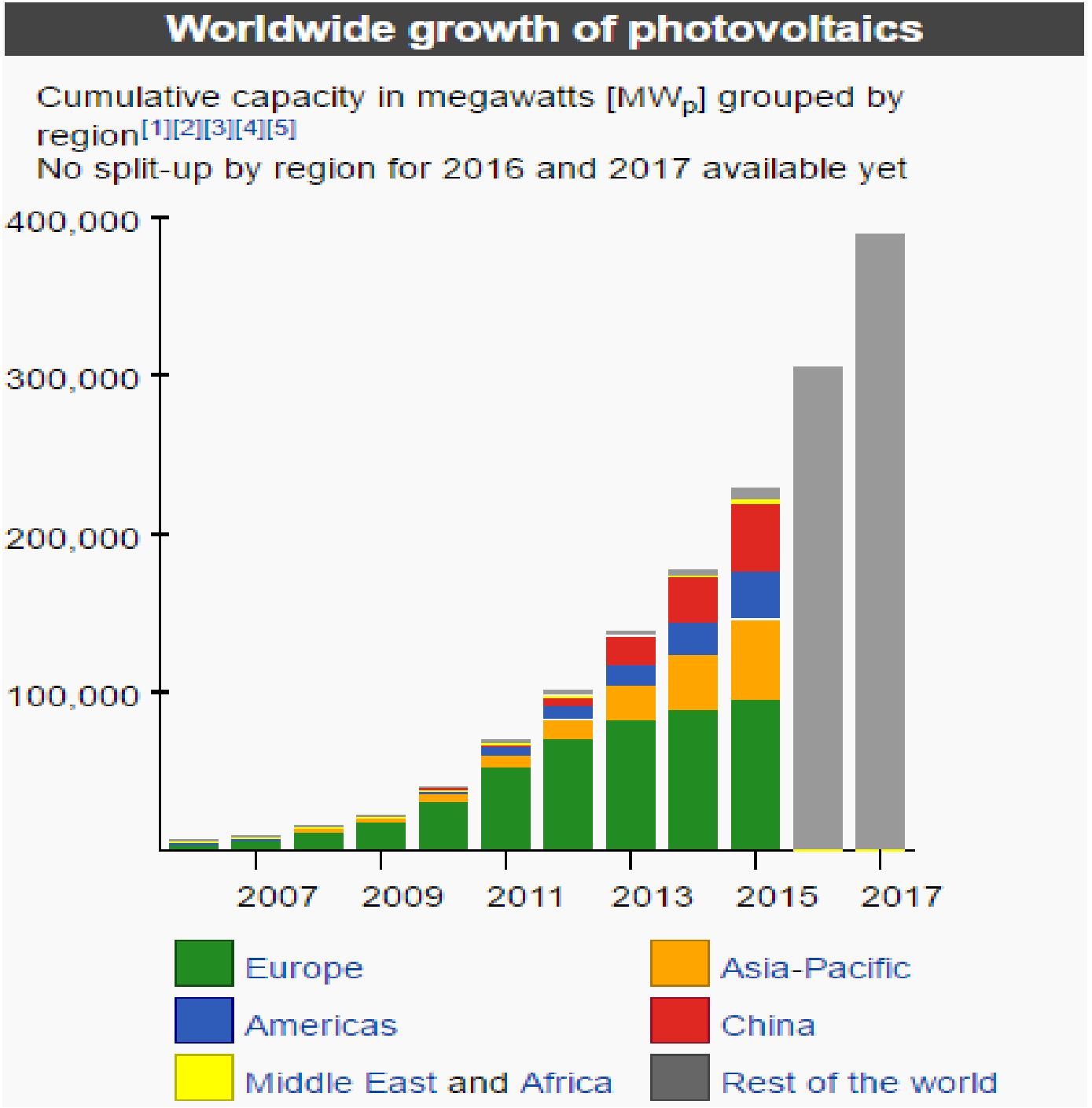
Rwanda ~10 watts

Nepal ~100 watts

Solar in the World

Solar Power Plant - Les Mées, France

Solar in the World



Solar in the World

Timeline of the largest PV power stations in the world

Year[a]	Name of PV power station	Country	Capacity MW
1982	Lugo	United States	1
1985	Carrisa Plain	United States	5.6
2005	Bavaria Solarpark (Mühlhausen)	Germany	6.3
2006	Erlasee Solar Park	Germany	11.4
2008	Olmedilla Photovoltaic Park	Spain	60
2010	Sarnia Photovoltaic Power Plant	Canada	97
2011	Huanghe Hydropower Golmud Solar Park	China	200
2012	Agua Caliente Solar Project	United States	290
2014	Topaz Solar Farm[b]	United States	550
2015	Solar Star[b]	United States	579
2015	Longyangxia Dam Solar Park	China	850
2017	Kurnool Ultra Mega Solar Park	India	900

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Solar in 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.

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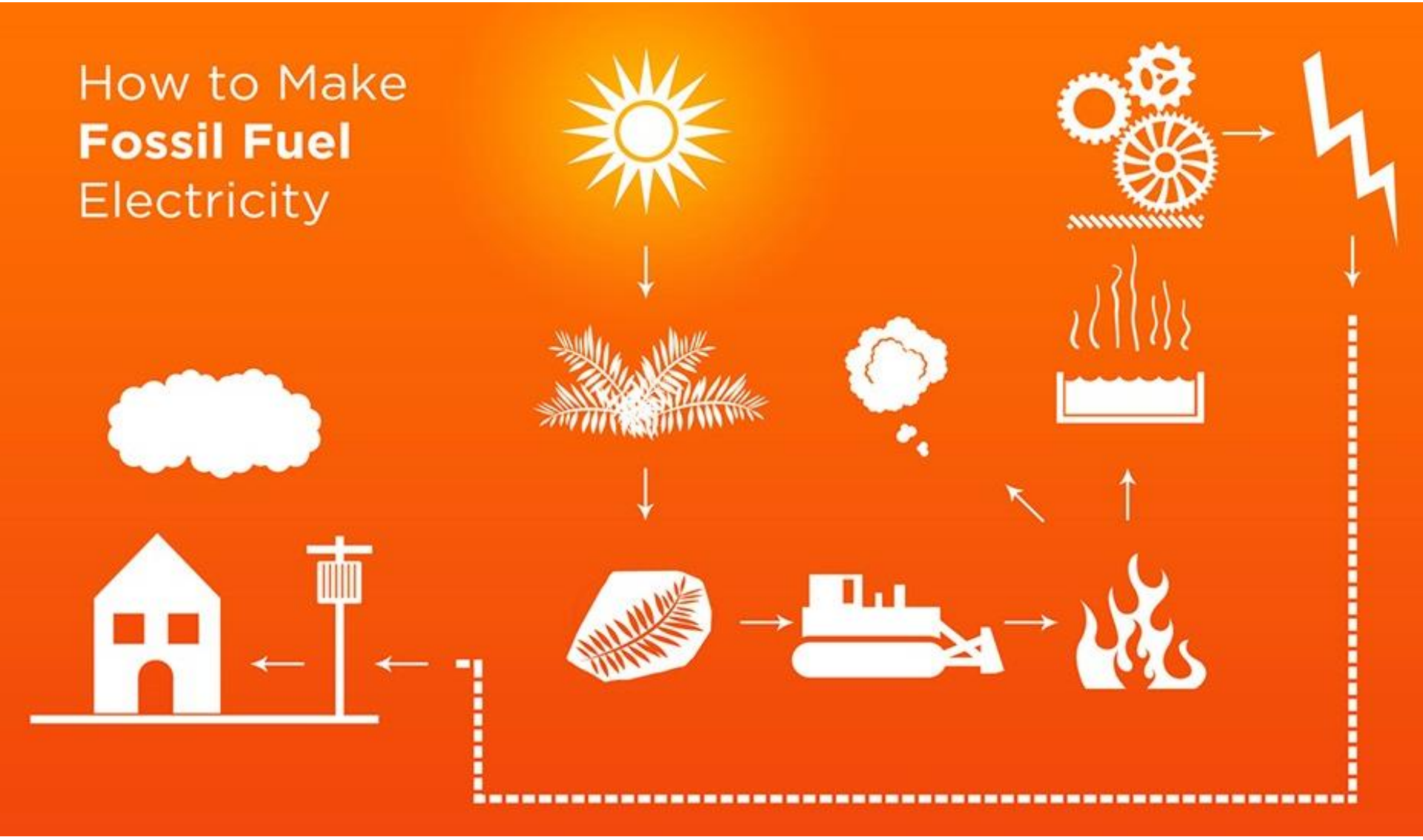
Solar in the World

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

Doug McKenzie – doug@sunwork.org

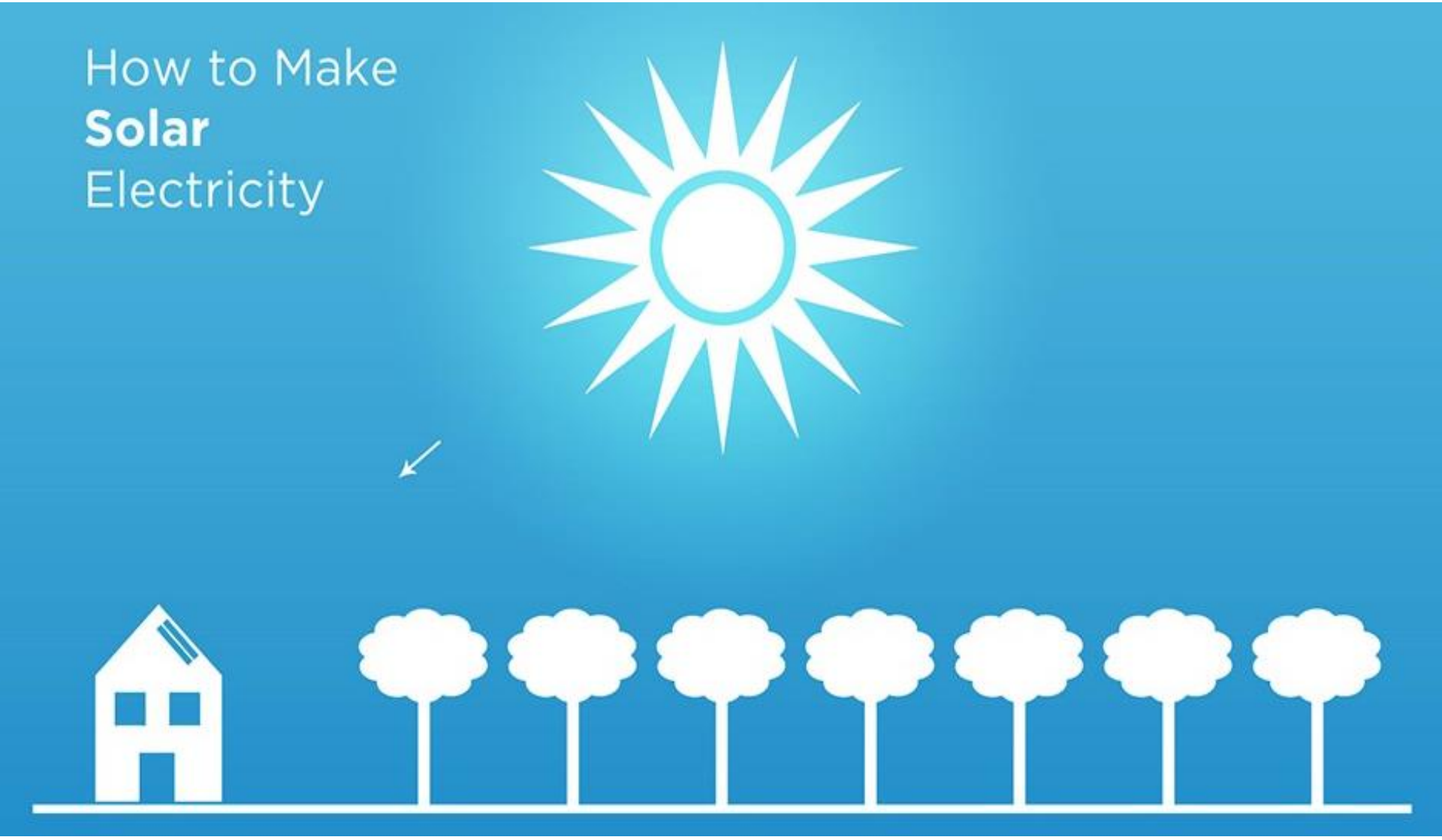
Not-Solar Not-Simplified

Help go from this…



Solar Simplified

To this!



Thanks!

Questions?

Now or anytime
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