

Solar People Power

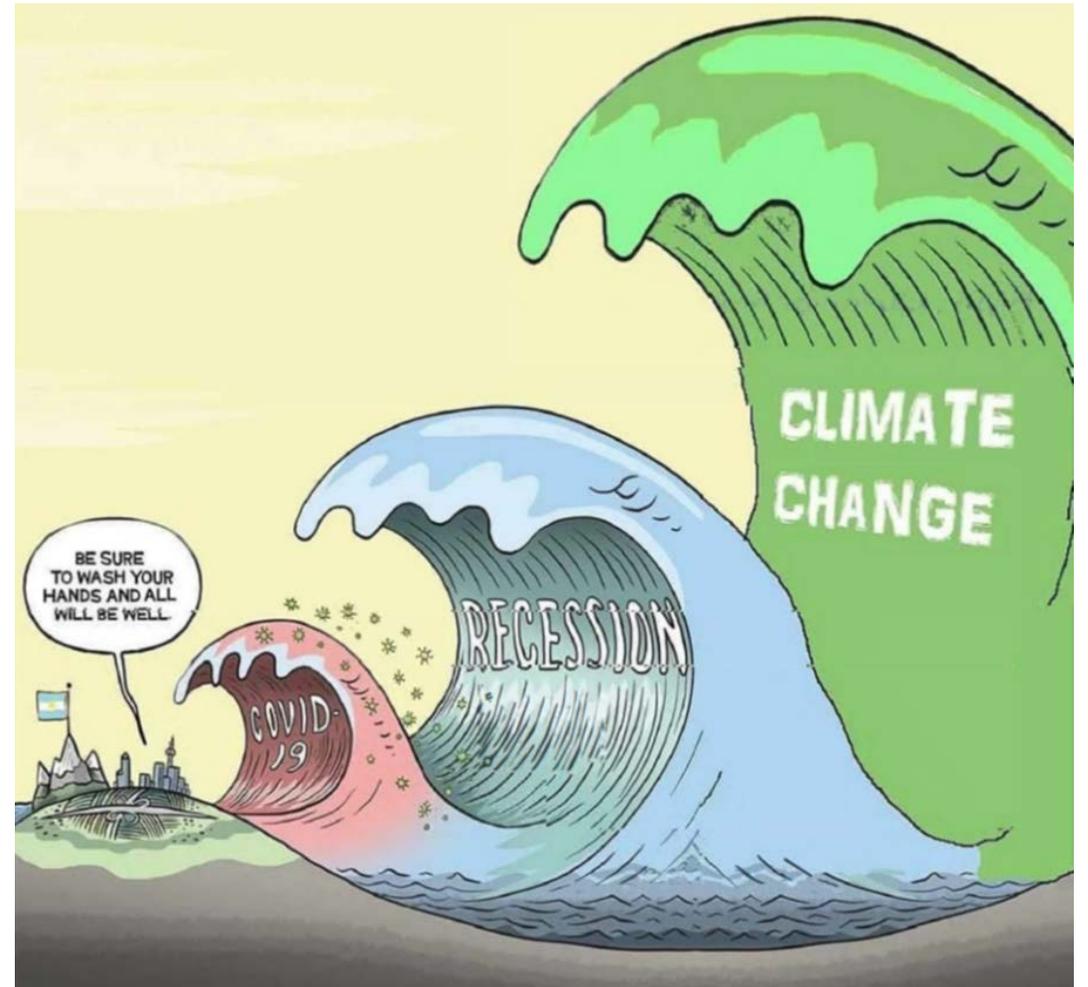
Solar Electricity and Building Electrification Retrofit Projects

Master Gardeners of Lake Tahoe
University of California Cooperative Extension, Central Sierra

Gerry Braun, November 5 2020

Outline

- Introduction – solar and energy storage
 - Terminology
 - Small, medium and large solar PV systems
- Net zero carbon buildings
- Solar and electrification retrofit projects – experience and lessons
 - Church campus
 - Home
 - Cabin
- Questions



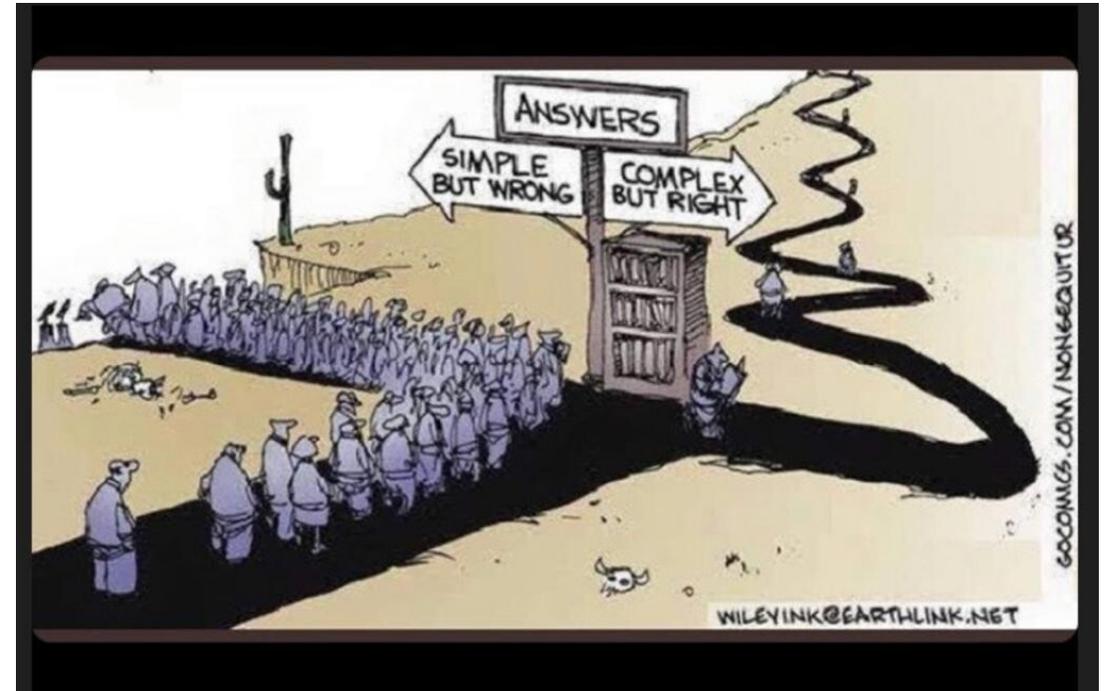
Solar PV Systems

- Trade-offs
 - Large
 - Least cost production, high-cost energy transport
 - Small
 - Low cost, low impact structure, risk of under and over production
 - Medium
 - Currently best and worst of both, but just and equitable.
- What would Goldilocks do?



Terminology

- Decarbonization = Greenhouse gas (GHG) emissions reductions
- Energy resilience = Ability to restore energy services quickly when cut off from regional energy supply networks.
- Renewable energy security = Clean, affordable, locally produced energy available 365/24/7.

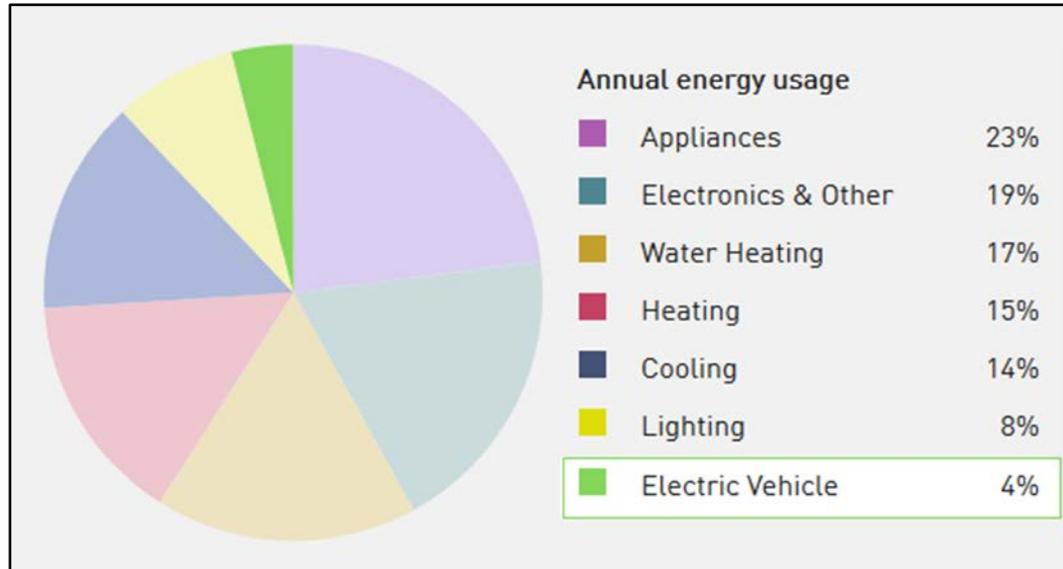


Net Zero Carbon Buildings

- General definition: Zero carbon building energy supply matches annual energy use (typical) or real time use (still relatively rare).
- Specifics:
 - Solar - virtual vs. real, i.e. purchasing green energy vs. producing green energy
 - Electrification
 - Space and water heating
 - Personal vehicles
- Existing and new buildings
 - Retrofit solar systems cost twice as much as systems installed during building construction but are now the main route to timely decarbonization.
 - New buildings allow more design flexibility, but builders are highly first-cost-conscious and tend to avoid including energy features that are not mandated by local building codes.



Retrofit Decarbonization May Take Years - Track Your Energy Usage and Carbon Footprint While You Decarbonize



Basic information needed to estimate annual footprints is readily available

GHG Source:	\$	\$/MT	Miles	MPG	\$/month
Building fuel (1)					
Space heating					
Water heating					
Cooking					
Building electricity (2)					
Heating					
Lighting					
EV charging					
Plug loads					
Transport (3)					
Vehicle 1 (4)					
Vehicle 2 (4)					
Vehicle 3 (4)					
Air					
GHG Unit Cost (5)					
GHG Off-set Cost (6)					

You can also calculate the cost of offsetting your net GHG emissions.

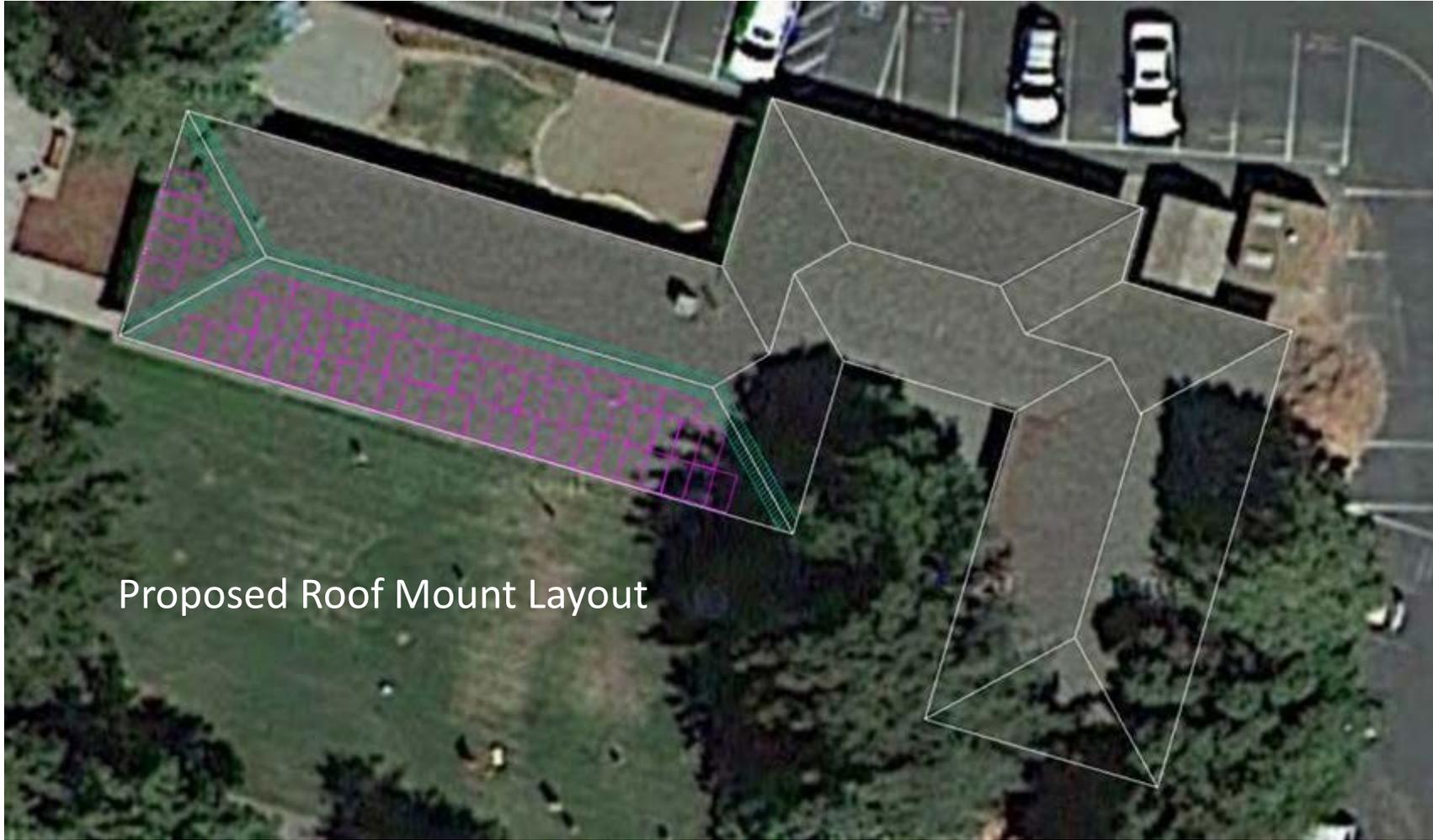
2002 – Rooftop PV on Church Office Roof



Project experience highlights:

During bidder inspections in 2014, discovered that one of two inverters for the solar array had failed. Arranged for inverter replacement.

Church Solar Output Upgrade Project – Initial Design



Church Solar Upgrade Project – Phase 1

2014 –

- Started with energy usage and GHG emissions analysis.
- Asked bidders to assist financing. Only one bidder offered power purchase and leasing options.
- Negotiated 25-year power purchase agreement (PPA) and included penalties for annual underperformance.



New solar carport installed in 2014

Project experience highlights:

- Bidder's finance model enabled choices. Economic benefits were highly sensitive to system performance.
- Timely reports of construction defects and equipment failures
- 2019 review production data revealed under-performance vs. PPA forecast
- Lessons and Notes:
 - Closely monitor performance and equipment status in early years and at later at least annually.
 - Contractor estimates of annual performance may be inaccurate if contractor lacks solar technology training and certifications.
 - Dry season array cleaning can boost annual production by 10% in dusty Central Valley. (Owner chose instead to continue paying an annual under-performance penalty.)

Church Electrification Project

Gas Appliance Replacements

- Since 2014, when existing furnace-based HVAC units failed, they were replaced with electric heat pump units.
- In 2020 we replaced:
 - Remaining, aging gas furnace units with electric heat pump units
 - Gas water heater with electric heat pump unit



Project experience highlights:

- Multi-year retrofit program total cost = \$65,000
- Always requested competitive bids. Small but highly competent Sacramento company won all the bids and became a trusted partner.

Lessons:

- Replacing gas furnaces with heat pumps did not increase annual electricity usage, probably because:
 - Efficiency of old units had degraded by as much as 30%
 - Most replacement projects used highly efficient mini-split units – see photo
 - Reduced electricity consumption for cooling off-set increased electricity use for heating.

Church Solar Upgrade Project - Phase 2

Second On-site Solar Production Upgrade

- Estimated system size to get to net zero, budgeted accordingly and requested bids.
- Selected low bidder (local area residential solar retailer.)



Project experience highlights:

- Needed 2019 installation for purchase price donor to fully capture tax credits
- Permitting delays due to high end of year business volume and contractor inexperience with commercial system permitting.
- Further delays due to mounting system design mistake.
- Further delays due to documentation errors.

Lessons:

- Permitting of commercial and residential solar projects differ.
- Site surveys require engineering attention.

Home Solar Project Phase 1

- 2014 - Solicited bids from local and national retailers.*
- Selected local company with long track record and paid cash.



*National retailers offered leasing, power purchase arrangements and options for direct purchase

Project experience highlights:

- Installed cost: \$15,000 minus 30% tax credit = \$10,500
- 37,400 kWh produced over 6.5 years.
- Savings (production to date valued at estimated average of \$0.2/kWh) = ~\$7500*
- System performs reliably and maintenance free, except for simple, quick array cleaning, and will have paid for itself in less than 9 years.
- Contractor did not offer or agree to set up monitoring. Monitoring set up was way beyond the average homeowner's capability.

Lessons:

- Leased and third party owned systems take a lot longer to pay back.
- Insist that solar contractor provide monitoring set-up.

*Does not include property value increase, which is roughly the present value of future avoided utility bills, i.e. typically more than the present value of installed cost.

Home Solar Electrification Project

2014 - Electric Vehicle Purchase

- Leased a short range EV in early 2014 and purchased it at the end of the 3-year term at its market price. Gasoline savings to date equal 50% of purchase price.
- Charged EV at home with Level 1 charging cable.

2014 - Gas Furnace Replacement

- Solicited bids from local and national HVAC retailers; selected experienced local area HVAC contractor, paid cash and recommended contractor to church.

2018 - Gas Water Heater Replacement

- Purchased a heat pump water heater from a big box retailer along with installation services by a local area plumber



Project experience highlights:

- Original annual electricity usage = 5500 kWh
- Our estimated current annual electricity usage:
 - Lighting and plug loads = 3500 kWh
 - EV charging = 1400 kWh
 - Space heating = 2500 kWh
 - Water heating = 1200 kWh
 - Total = 8600 kWh

Lessons:

- Short range electric vehicles can be recharged overnight in garage at low cost.
- National retailers outsource home energy retrofits to local contractors (Factor of two range in HVAC retrofits bid prices.)
- Charge EV during off peak hours from midnight to noon.
- Plumbers are not electricians.

Home Solar Project Phase 2

- Additional array necessary to match additional ~3500 kWh net usage since first array was installed.
- Used PG&E on-line usage data to estimate grid electricity usage after installing heat pump water heater.
- Selected experienced local retailer to install second solar PV system and paid cash.



Project experience highlights:

- Installed cost: \$10,500 minus 30% tax credit = \$7300
- Small panel-mounted inverters enable exact match between added solar capacity and annual usage but at a price premium.

Lessons:

- Competitive residential solar bid prices typically differ less than technical diligence and competence of competing local retailers/installers.

Cabin Solar Project Phase 1

- 2019 –
 - No local solar retailers
 - No local solar homes
 - Tall trees



Project experience highlights:

- Considered contracting for roof extension and self-install – no contractor interest
- Contacted Central Valley retailer familiar with local area
- Installed cost: \$11,500 minus 30% tax credit = \$8,050

Lessons:

- Where a home or cabin is surrounded by tall trees, array layout is key to maximizing production and matching annual production and usage.
- GPS based shading analysis is accurate and essential.

Recommendations

- Consider investing in on-site solar because it can reduce monthly utility charges to near zero.
- Solar electrification is preferable to grid electrification because it quickly and fully decarbonizes building energy usage. (1)
- Consider EV or FCEV purchase because charging an EV with on-site solar decarbonizes transportation, saves money over time and may be an antidote to grid power shut-offs. (2) (3)
- Recognize that “time of use” utility charges can be reduced by scheduling usage and/or by integrated on-site solar and battery systems.
- Generally, buy local and take full advantage of relevant local experience.
- Monitor regulatory changes that may allow sizing on-site solar arrays to match future higher electricity usage (after gas appliances are replaced with heat pumps).

Notes:

1. Solar plus battery systems also mitigate problems caused by grid power shut-offs.
2. EVs recharged daily with on-site solar electricity have enough battery capacity to power critical building circuits indefinitely.
3. Smarter local grids will enable vehicle-based electricity supply to power buildings under emergency conditions.

By the Way...

- Total unshaded and code compliant roof area in most California cities suffices to produce more solar electricity than a city's existing buildings use.
- 100% city or county decarbonization is technically feasible and affordable, would cost local governments almost nothing, while strengthening local economies and shielding communities from grid power cut-offs.
- A sensible response to climate change is “all hands on deck”.



Thank You!

Questions?

Contact:

gbraun@iresn.org

For articles, blogs, reports, and slide decks on renewable integration and collaboration topics:

www.iresn.org

