Do-It-Yourself Solar Photovoltaic (PV) Workshop

Jack Barnett

Blair Buselli

Workshop Presenters

Jack Barnett - a retired computer engineer, business consultant, SEEDS board member, prior president of a chapter of the American Solar Energy Society, and current president of the local Clean Energy Co-op.

Blair Buselli - of Buselli Solutions, a family business in Beach Lake for over 30 years. In 2009 Blair took advantage of SEEDS' sponsored solar training and has since become a NABCEP Certified Solar PV and Solar Thermal Installer with over 50 system installations completed.

Agenda

Tonight:

- Solar Technologies
- Economics and Cost
- Intro to Photovoltaic (PV) Solar Systems
- Paperwork & Permitting
- Roofs and How to Mount
- Sizing and Layout
- Racking Installation
- Review of racking
- Inverter Installation
- Panel Installation
- Wiring & grounding
- Commissioning
- Maintenance

Homework Assignment:

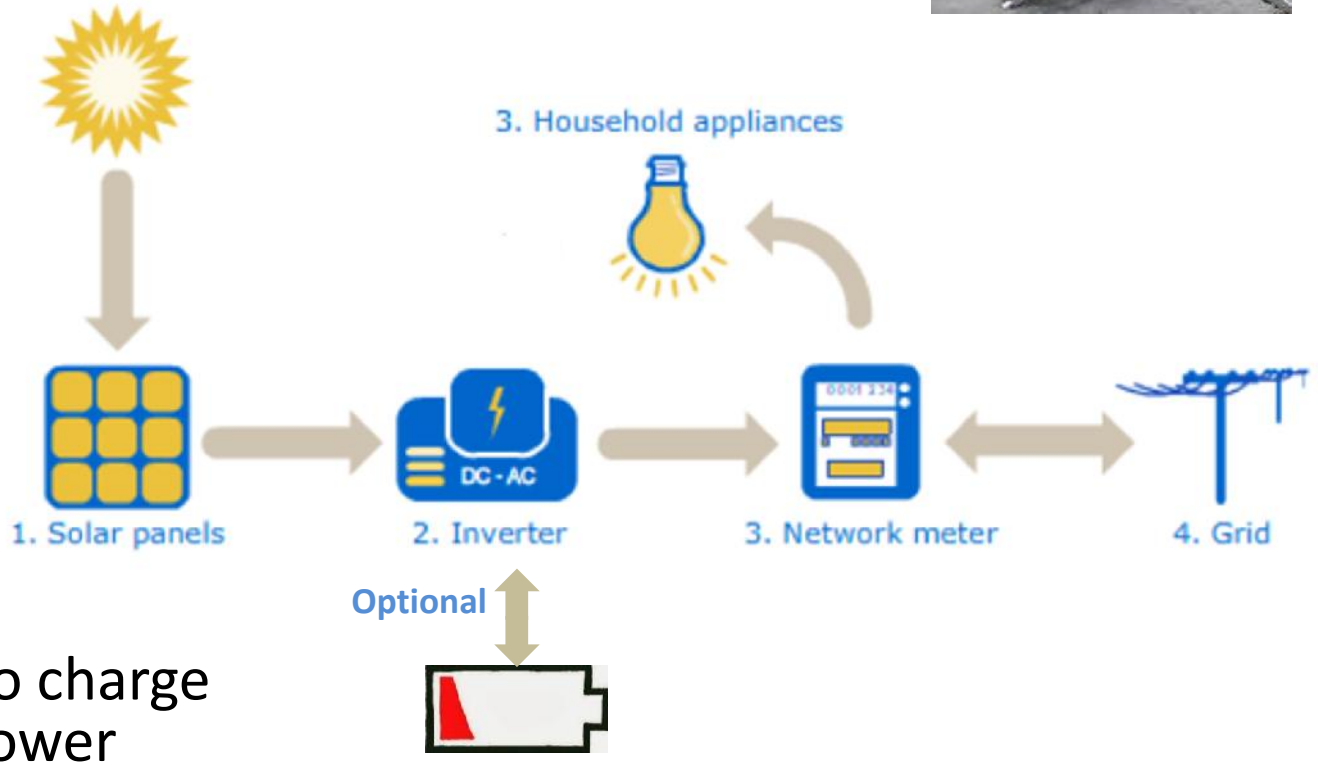
a) bring a sketch of your roof space, and b) an aerial picture (e.g. GoogleMaps)
include roof orientation and measurements (or estimation). Also make note of any obstructions and possible shading concerns.

Types of Solar Systems

Solar Thermal – for hot water or space heating

Solar Photovoltaic (PV) – for making electricity

- **Grid-Tied**:



- **Grid-Tied** ***with battery backup***:
- **Off-Grid**: DC-design to charge a battery, power lights, fan or pump (AC inverter is optional)

Four Silicon-based PV Technologies:

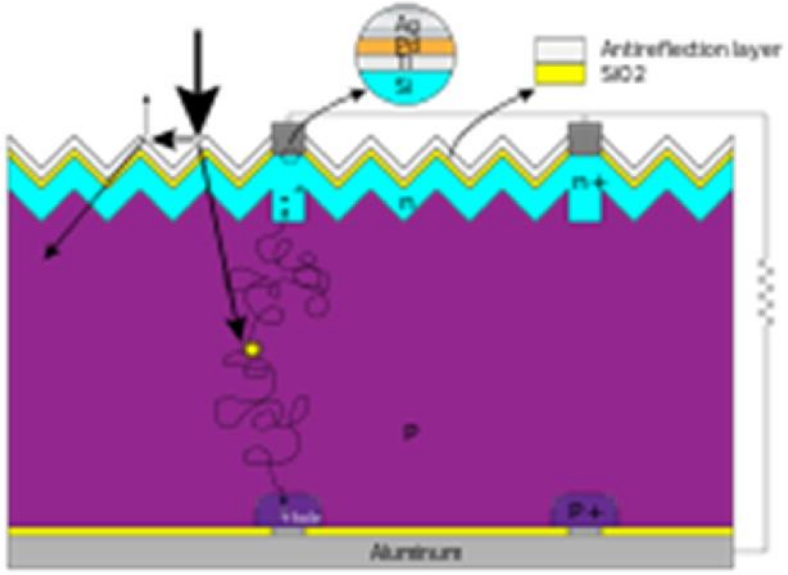
Thin Film:

Poly-Crystalline:

Mono-Crystalline:

Building Integrated:

All work from same basic physics:



Also more exotic PV:

GaAs Cells

Most Important Considerations

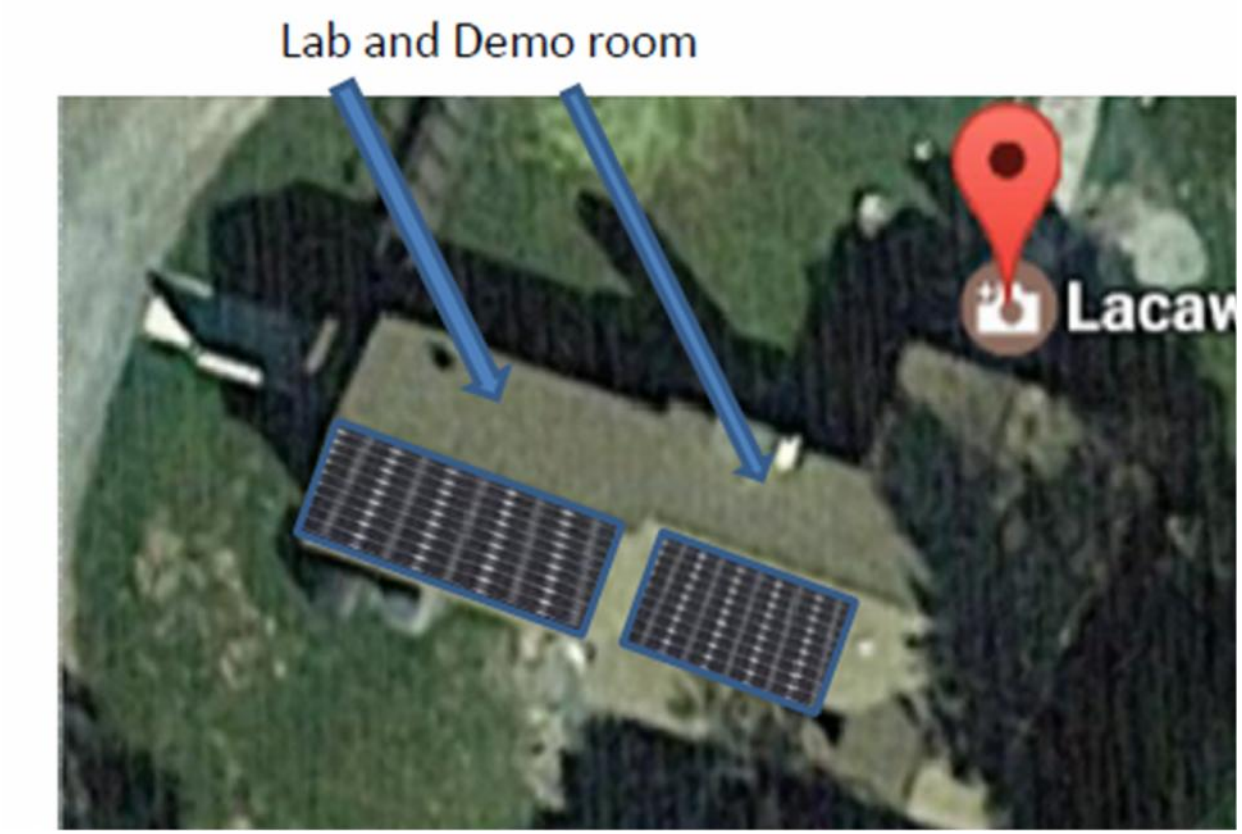
- Site Quality: Orientation and Shading
  - South(ish) facing roof or nearby area to install a ground-mount
  - No (or little) shading year around;

    Use a Solar Pathfinder to check =>

  Impacts: lower production = less ROI

- System Sizing: usually limited by one of
  - Physical site issues (e.g. roof size), or
  - Available budget (cash to invest)

Lacawac Visitors Center Roof



- Building faces SSW with a 200^{o} azimuth.
- The asphalt shingle roof was replaced just 4 years ago, is multi-segmented;
- but is partially shaded by a couple of trees to SE.
- The best available areas are the more western sections: over the demo room (12’ by 20’) and the new lab (11’ by 30’), both pitched at 27^{o}.

This means the Lab roof can fit 18 panels (~40” x 69”) in two rows of 9 (in portrait); and the Demo room roof can fit 10 panels in two rows of 5 for a total of 28 panels.
So if use 300watt panels, get a total system capacity of 8.4kW$_{dc}$

PVWatts Modeling

Putting the location and the site's characteristics into the NREL on-line PVWatts model determines the site's yield factors*.

However, this does not yet account for *site shading*. The Solar Pathfinder analysis (next slide) gives the % of each month's solar window that is shaded/blocked.

** The Yield Factor says that for every 1 kilowatt in capacity of PV panels installed (~3 panels), then the PV system can be expected to produce that many kWhrs of electricity, assuming it receives the same average sunshine in the future as from the weather over the past 20 years.*

RESULTS

Print Results

1,285 kWh

System output may range from 1,256 to 1,321kWh

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)
January	3.43	92
February	3.51	85
March	4.73	123
April	5.26	129
May	5.49	134
June	5.29	122
July	5.85	137
August	5.36	126
September	4.92	113
October	3.67	92
November	2.62	64
December	2.58	68
Annual	4.39	1,285

Shading Analysis

This Solar Pathfinder image was taken on the ridgeline near the mid-point above the demo room, so the panels below and east this will be more shaded, but the ones to west should do as well or better than this location.

Shading Reductions to Yield:

Jan	-20%	Jul	0%
Feb	-15%	Aug	- 1%
Mar	-12%	Sep	-12%
Apr	- 8%	Oct	-11%
May	- 1%	Nov	-22%
Jun	- 1%	Dec	-22%

Due to our snowcover, subtract another 11% for the winter months (Dec-Mar, or 3% annually) for moderate-pitched arrays.

For annual yield factor of 1138kWhr/kW_{dc}

Therefore the annual production should be 8.4 x 1138 = 9563 kWhrs in year 1, which is ~90% of building's annual use!

What Will a Solar PV System Cost?

- <u>Cost:</u> Approximations/Rules of Thumb:
  - PA 2017 costs for an "average" professionally installed 'basic' PV system: ~**$3.10/watt$_{dc}$**
  - Or, with DIY labor: **<$2.00/watt$_{dc}$** for 'basic' materials
  - Don't forget permitting and inspection costs
- To be certain, get one or more installation cost estimates from certified solar PV installers. Look for a *North American Board of Certified Energy Professionals (NABCEP)* certification.

How Do You Make Your Money Back?

Three basic ways:

1. Income tax credits
2. Savings from not paying a utility for electricity produced
3. Selling Solar Renewable Energy Certificates (SRECs)

Other grants, financial assistance,
or incentives may also be available
e.g. farms, small businesses loans, etc.

Visit: http://dsireusa.org for a summary of federal & state regulations and incentives across USA

Federal Income Tax Credits

Federal Individual Tax Credit of up to 30% of cost for new <u>residential</u> renewable energy systems

- Does not have to be your 'main' home
- Only for actual payments (not DIY labor)
- Available through 2019, then reduced 26% for 2020, and 22% in 2021, then gone!

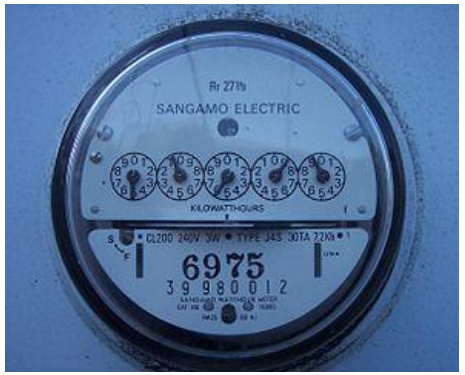
When: filing taxes for the year of the system's "in-service date"

- Use IRS Form 5695
- Must have taxable income to be offset; or can be carried forward, if needed

Paying the Utility for Less Electricity

PA law requires distribution utilities to provide **Net-metering**

- Meter runs backward! when producing more than you're using
- Utility acts as a 'virtual battery' – providing you with a kWhr of credit for each kWhr of excess production from your PV system
- Credits are then used when the household's electricity load is greater than production (i.e. when sun is not shining)

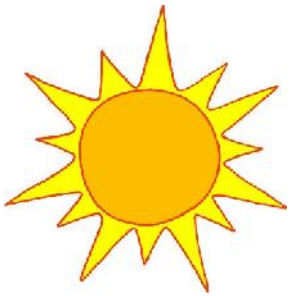


- You must still pay the distribution utility for
  - monthly connection fees,
  - demand charges (commercial tariffs), and
  - for kWhrs used when all credits are consumed
- In PA, if you have remaining kWhr credits on your May billing date, the utility will send you a check and zero the balance
  - BUT using the lower "rate-to-compare" price per kWhr

PV System Components

1. Panels to convert sunlight into DC electricity
2. Inverters to convert DC into AC
3. Racking to hold things in place
4. Wiring to connect everything
5. Grounding+bonding to keep it safe
6. Production meter and/or remote monitoring

This is a Grid-tied and Battery-less system, so will not function during utility outages



Various Types of

Mounting Methods:

- Racks on shingles, tile, or steel roofs
- Weighted trays on flat roofs (no penetrations)
- Fixed ground-mount
- Tracking Systems
  - 1 axis
  - 2 axis

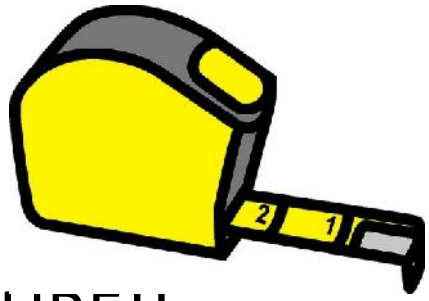
Inverters:

- Central or String Inverter
  - Panels are wired in series (strings) to a large inverter
  - Requires 600v DC wiring
- Micro-inverter
  - One inverter per PV panel, mounted behind each
  - Standard 240v AC wiring
- Optimizer (hybrid)
  - DC power-optimizer at each PV panel, but also with a centralized inventer

Order of Events

1. Site and Sizing
2. Apply for permit & interconnection
3. Order Equipment
4. Install
5. Electrical Inspection (required)
6. Final Paperwork submission
7. TURN ON SYSTEM!

1. Site and Sizing



Roof Space:

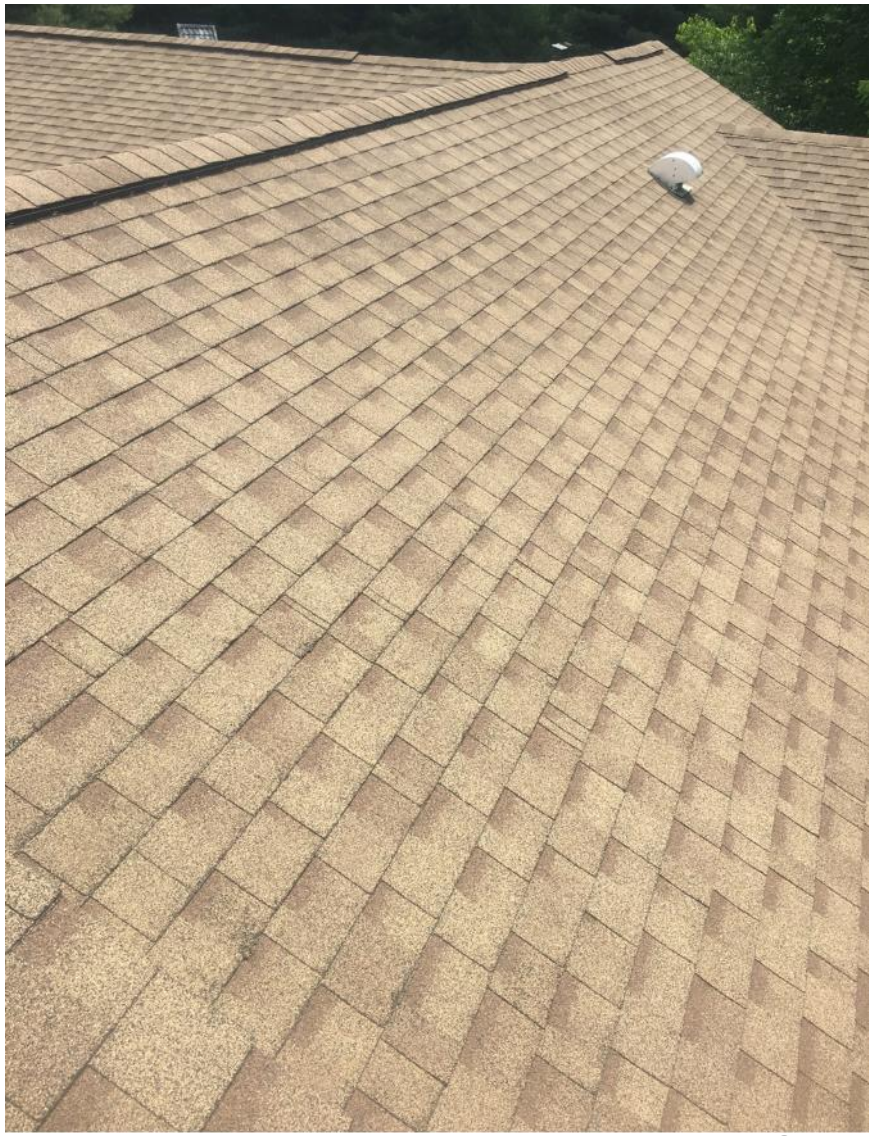
- Will It Fit? MEASURE MEASURE MEASURE!!
- Panels: ~40” Wide x ~65” Tall
- Roof Age, Roof Type: Metal or Shingled or Flat

No Obstacles: Chimney, Trees, Satellite dish, Vents

South(ish) Orientation without Shading:

- Want Sun All Day!! Best: 6+ hours/day, all year
- Use a Solar Pathfinder

Lab roof & Demo Rm roof



2. Apply

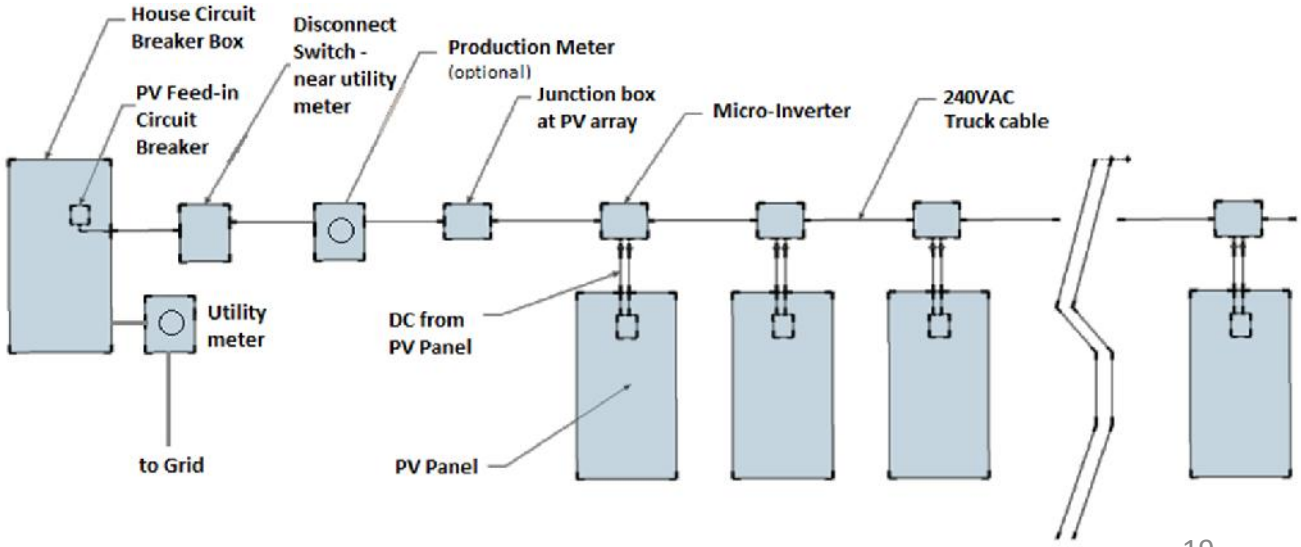
Lacawac PPL Interconnect

A. Utility Interconnection - Part 1

Google: *[utility name] interconnection agreement*

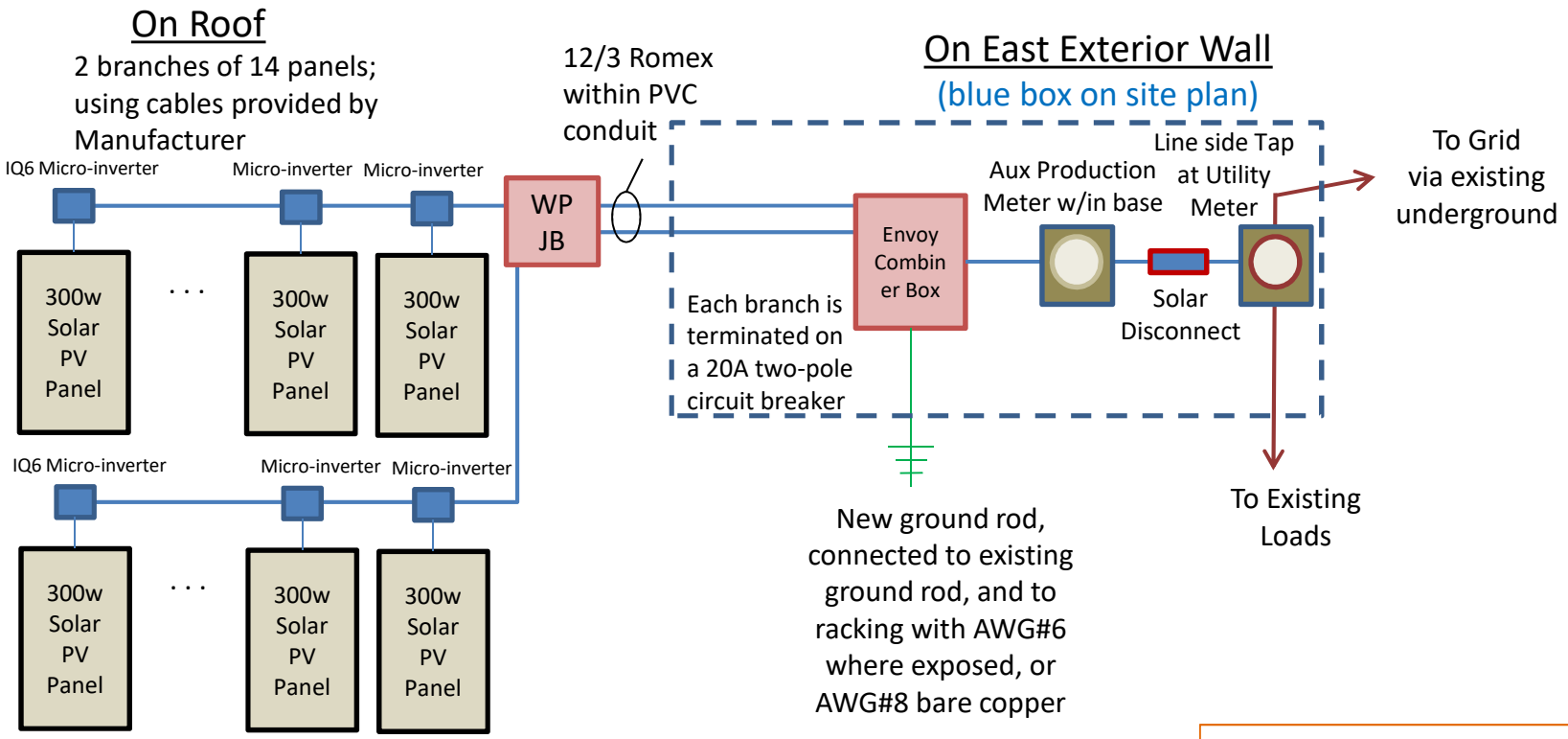
- Inverter Spec Sheet “DATA SHEET”
- Application
- Fee??
- Site Plan
- 1-Line Electrical Diagram:

EnPhase IQ6



1-line Electrical Diagram for 8.4kW Solar PV Install

at 94 Sanctuary Dr, Lake Ariel (Salem Township), PA



Drawn by Jack Barnett, rep for Lacawac Sanctuary Foundation On May 9, 2018