Building Electrification Committee
Solar 101 - The Basics
How to become your own power plant
All the details and more

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Best advise – hire a reliable solar professional

My goal is:
To help you be armed with good information

So if you decide to go solar - you can get the most cost effective system you can install –
I cannot design your system for you

Disclaimer: all calculations are estimates for examples

Can you electrify your home to
light, heat, and cool your home and charge your EV's
powered by your own fuel by 2030 ? By 2035 ?
What would it take ?
We can no longer think about this strategies in silos – but integrated holistic approaches

5 best solar estimators & calculators

coperniq.io

- Max Kazakov
  - Jan 31, 2021
  - 3 min read

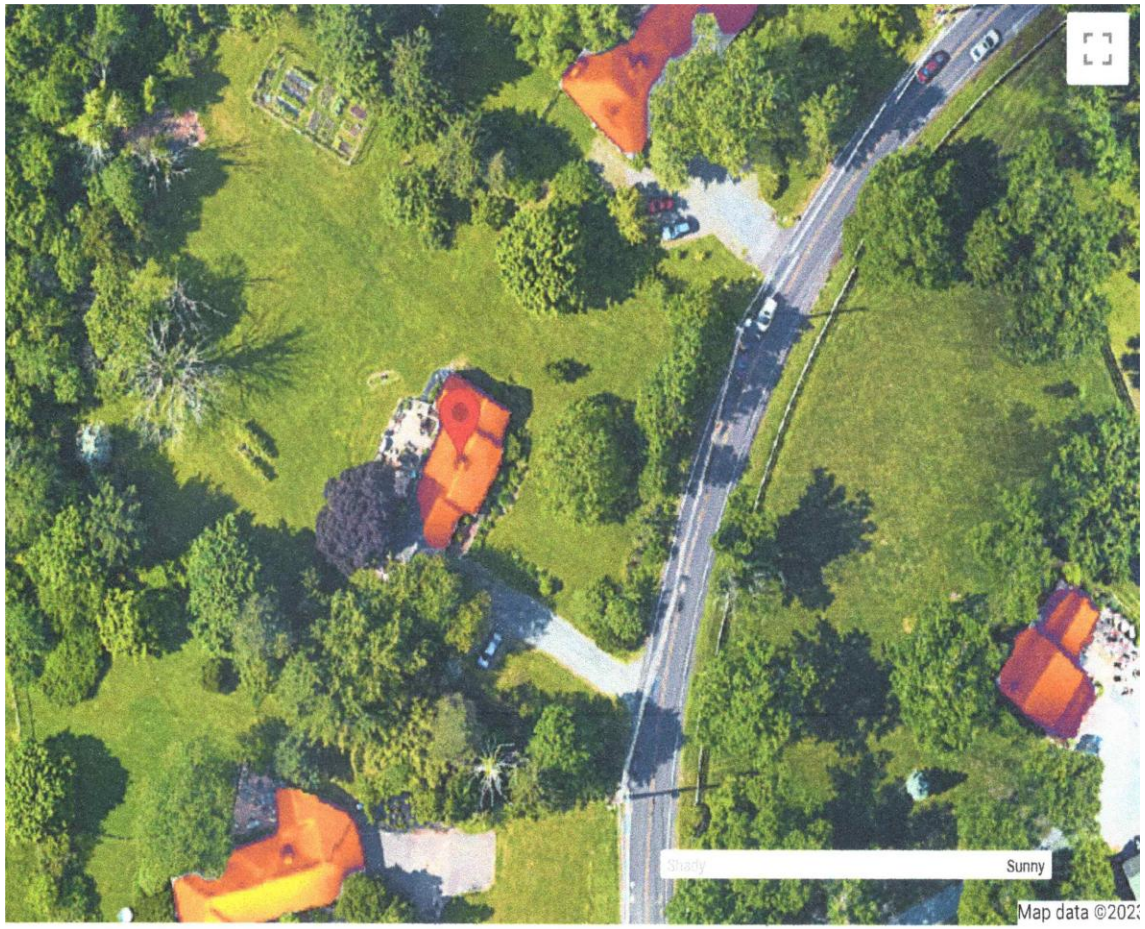
1. Google Project Sunroof (<1 min to estimate)

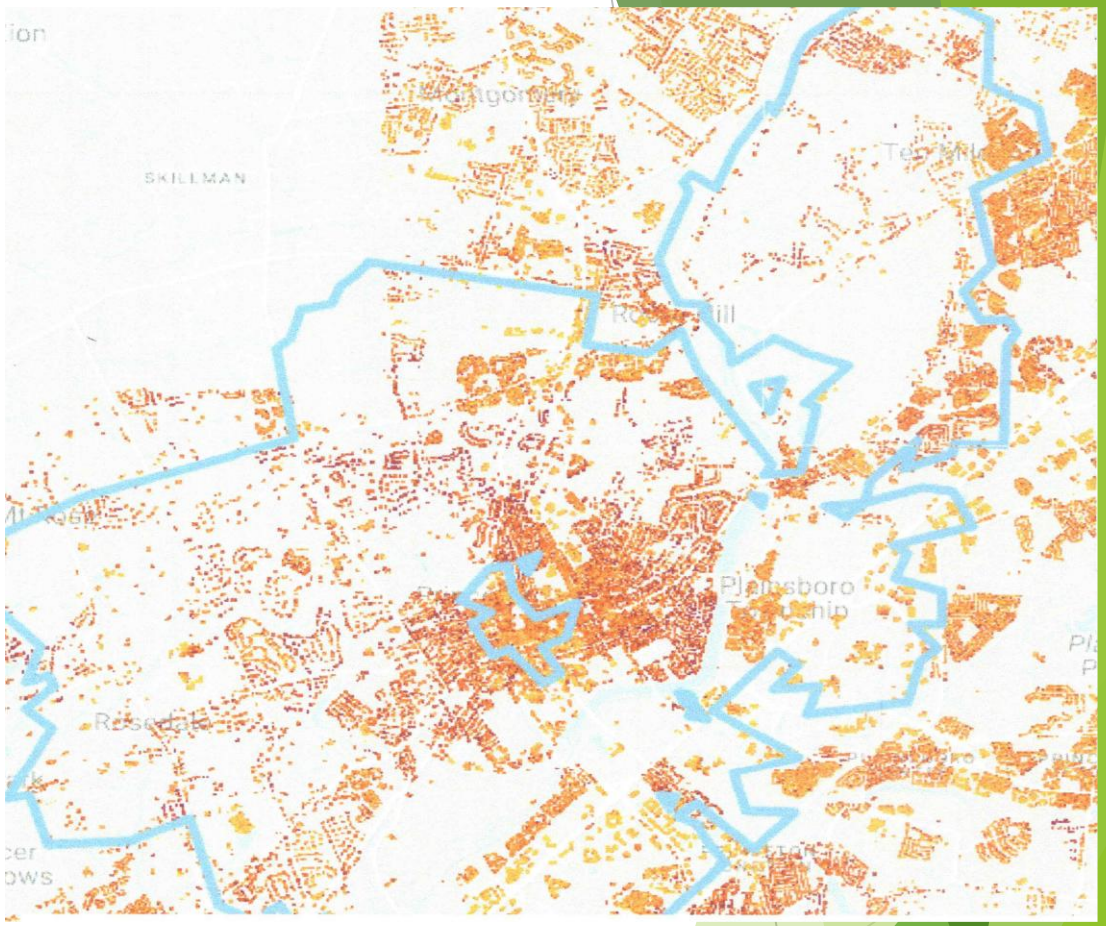
2. PV Watts (<1 min to estimate)

3. EnergySage (<1 min to estimate)

4. Solar.com (3 min to estimate, must sign in with email)

5. Sunpower (3 min to estimate, must give personal info)





1,427 sq ft of available roof space
1,351 hours of solar resources per year
8.5 kW solar system to produce 98% of electricity needs
$27,000 net savings over 20 years

71% of rooftop available for solar @ 75% annual needs
993 kWh/kW installed
10,100 roof 15.7 M sq ft 223MW
257,000 MWh per year
80% of Princeton total annual electricity needs

NREL's solar installation model – PV WATTS http://pvwatts.nrel.gov/

http://www.njcleanenergy.com/files/file/Renewable_Programs/NJCEPPVWattsCalculatorTraining21815.pdf

NREL

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at https://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

Disclaimer: The PVWatts® Model ("Model") is provided by the National Renewable Energy Laboratory ("NREL"), which is operated by the Alliance for Sustainable Energy, LLC ("Alliance") for the U.S. Department Of Energy ("DOE") and may be used for any purpose whatsoever.

The names DOE/NREL/ALLIANCE shall not be used in any representation, advertising, publicity or other manner whatsoever to endorse or promote any entity that adopts or uses the Model. DOE/NREL/ALLIANCE shall not provide any support, consulting, training or assistance of any kind with regard to the use of the Model or any updates, revisions or new versions of the Model.

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The energy output range is based on analysis of 30 years of historical weather data, and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

SOLAR RESOURCE DATA

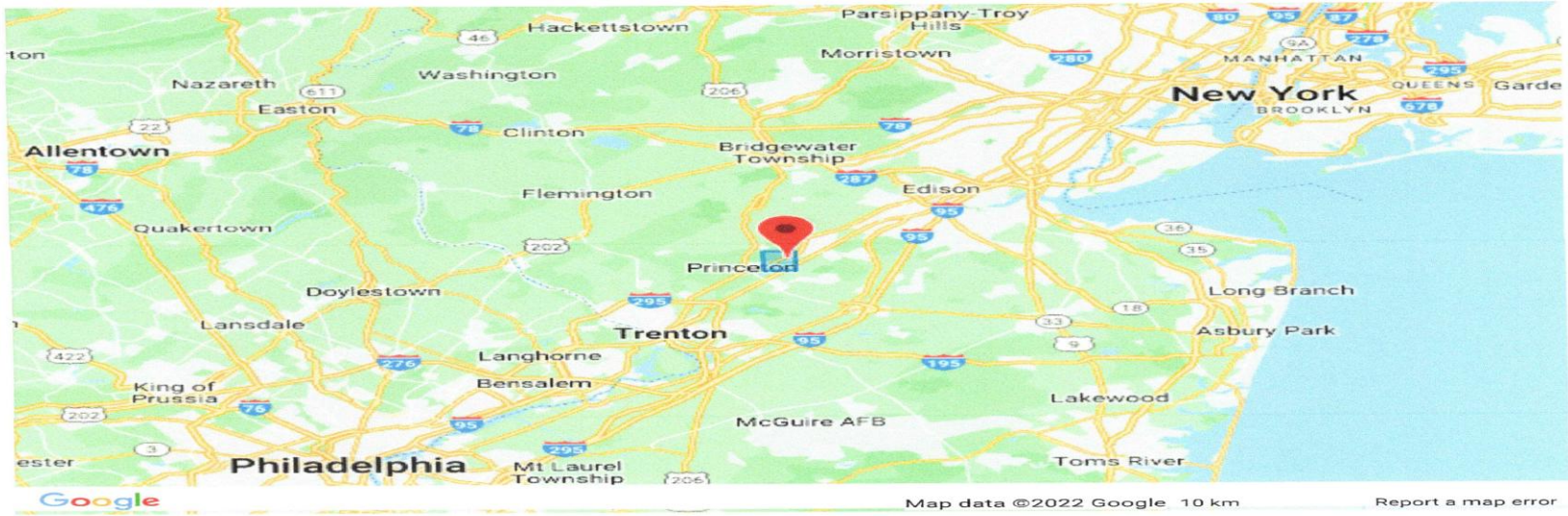
The latitude and longitude of the solar resource data site is shown below, along with the distance between your location and the center of the site grid cell. Use this data unless you have a reason to change it.

Solar resource data site

Lat, Lng: 40.37, -74.62 0.7 mi

Resource Data Map

The blue rectangle on the map indicates the NREL National Solar Radiation Database (NSRDB) grid cell for your location. If you want to use data for a different NSRDB grid cell, double-click the map to move the rectangle.
Dragging the rectangle will not move it.
If your location is outside the NSRDB area, the map shows pins for the nearest alternate data sites instead of a rectangle: Click a pin to choose the site you want to use.
See Help for details.



SYSTEM INFO

RESTORE DEFAULTS

Modify the inputs below to run the simulation.

DC System Size (kW):	7
Module Type:	Standard
Array Type:	Fixed (open rack)
System Losses (%):	14.08
Tilt (deg):	20
Azimuth (deg):	180

Loss Calculator

Draw Your System

Click below to customize your system on a map. (optional)

Advanced Parameters

SYSTEM INFO

RESTORE DEFAULTS

Modify the inputs below to run the simulation.

DC System Size (kW):

Module Type:

Array Type:

System Losses (%):

Tilt (deg):

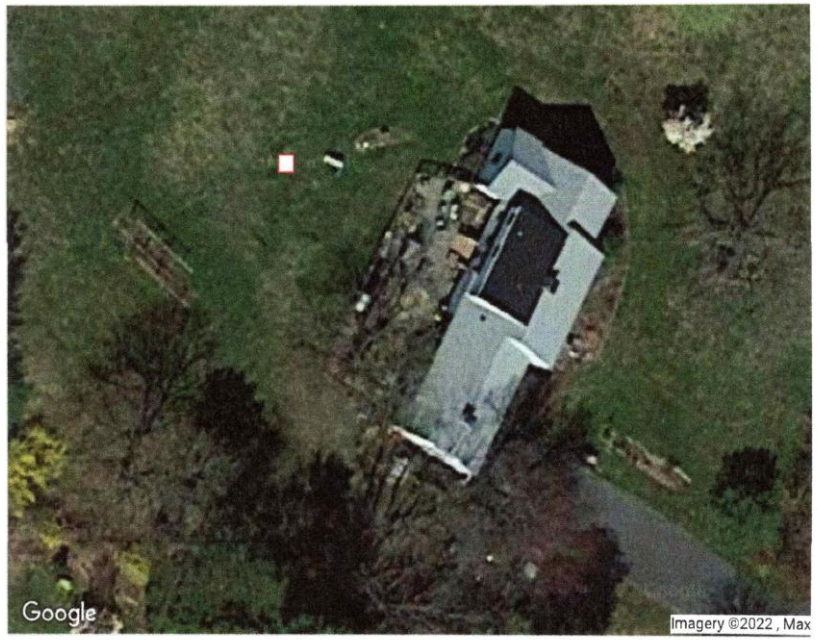
Azimuth (deg):

Advanced Paramete

Customize Your System To Your Roof

On the map below, click the corners of the desired system. Note that the roof tilt and azimuth cannot be automati
imagery, and consequently the estimated system capacity may not reflect what is actually possible.

System Capacity:



RESET

NREL's solar installation model - PV WATTS

http://pvwatts.nrel.gov/

NJCEP

http://www.njcleanenergy.com/files/file/Renewable_Programs/NJCEPPVWattsCalculatorTraining21815.pdf

DC System Size (kW): 7
Module Type: Standard
Array Type: Fixed (open rack)
System Losses (%): 14
Tilt (deg): 20
Azimuth (deg): 180
Draw Your System - customize your system on a map. (optional)
Average Cost of Electricity Purchased from Utility ($/kWh): 0.165/ kWh

Per PVWatts a 7 kW solar system facing south with a 20º slope

Month	Solar Radiation (kWh / m2 / day)	AC Energy(kWh)	Value($)
January	3.01	540	89
February	3.97	624	103
March	4.86	805	133
April	5.56	869	143
May	5.68	898	148
June	6.19	930	154
July	6.35	975	161
August	5.94	902	149
September	5.12	780	129
October	4.01	660	109
November	3.39	554	91
December	2.69	472	78
Annual	4.73	9,009	$ 1,487

This presentation is for a single family home that has
a rooftop that is not fully shaded by trees or another building
You may be able to install a ground mounted system
Not a historical designated home

If you live in a condo development –
Check with the condo board

If you live in a multifamily home or do not have access to the Roof space – explore **community solar** or buy electricity that is generated with solar via Class I RECs.

https://njcleanenergy.com/renewable-energy/programs/community-solar

This presentation is for a single family home
Why not commercial buildings

Residential electric customers pay one fix energy rate set as cents per kWh ($/kWh)

Commercial customers pay two rates

1. The energy charge $ per kWh
2. The demand charge $ per kW which is based on the customers highest electricity usage

Solar net metering tariff only applies to the energy rate $/kWh not the demand charge $/kW

Some basic terms

Kilowatt-hour (kW-h) - Amount of electric energy

Kilowatt (kW) – Amount of power (energy/time – kW-h/h)

Capacity or installed capacity

Capacity Factor – how long you have sun

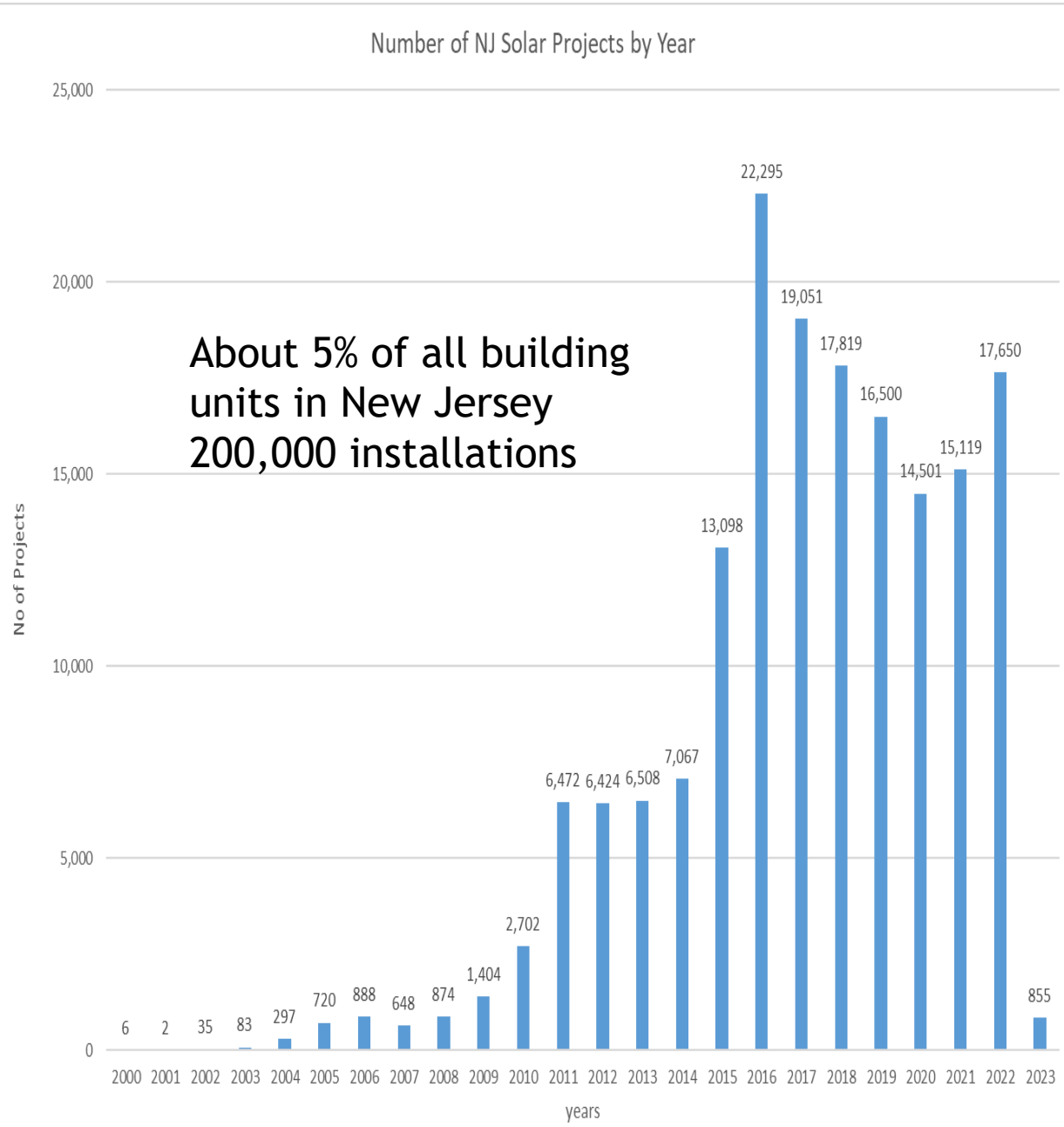
1000 watts (w) = 1 kilowatt (kW)

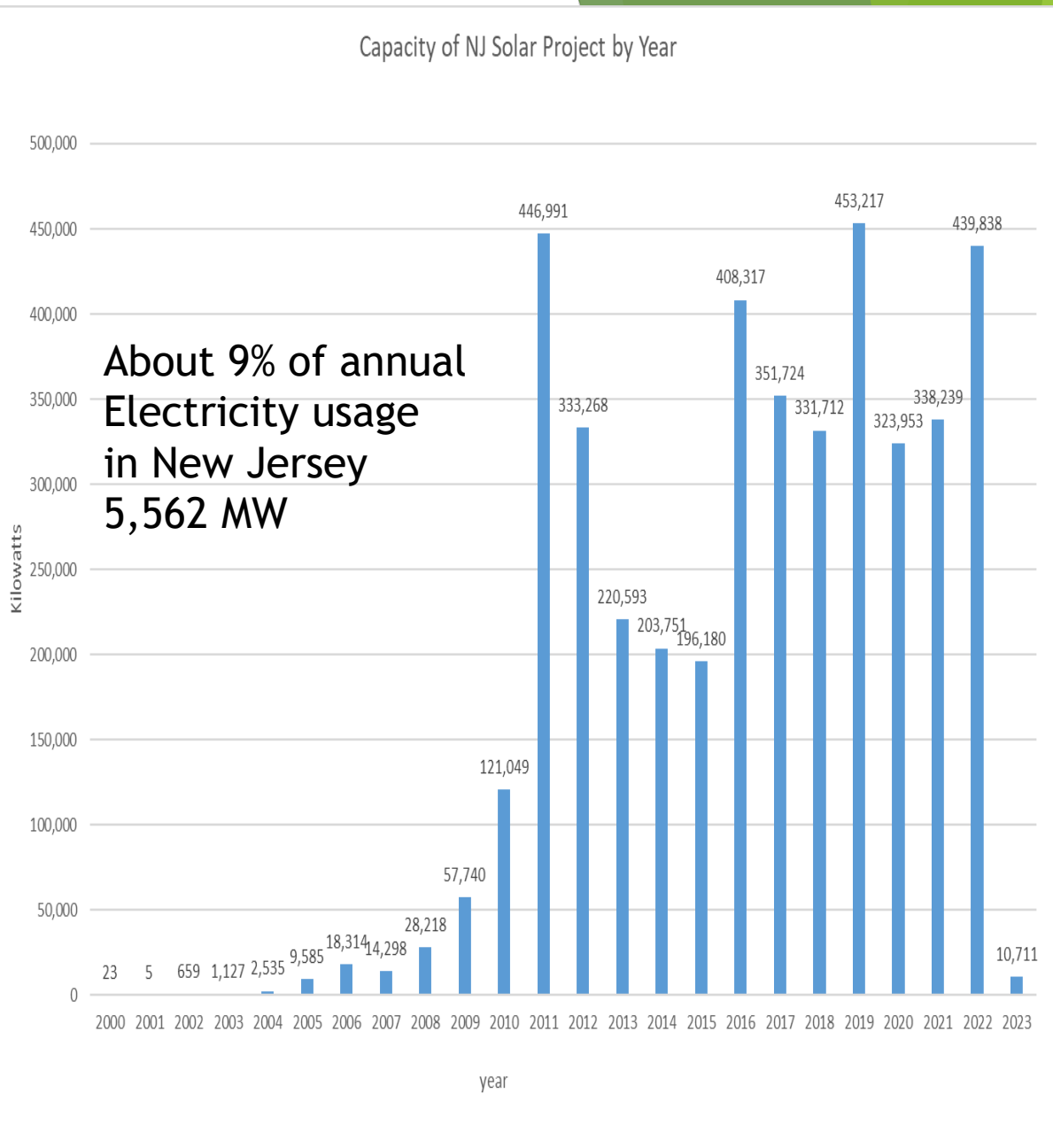
1000 kW = 1 megawatt (MW)

If someone used 10 – 100 w lightbulbs for one hour

They would use 1 kWh of electric energy at $0.19/kWh

A 14 W LED used for 7.5 hours = 1 kWh or 71 14 w - 1 hr


Number of NJ Solar Projects by Year
About 5% of all building units in New Jersey 200,000 installations
No of Projects
years
25,000
20,000
15,000
10,000
5,000
0
6 2 35 83 297 720 888 648 874 1,404 2,702 6,472 6,424 6,508 7,067 13,098 22,295 19,051 17,819 16,500 14,501 15,119 17,650 855
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023


Capacity of NJ Solar Project by Year
About 9% of annual Electricity usage in New Jersey 5,562 MW
Kilowatts
year
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
23 5 659 1,127 2,535 9,585 18,314 14,298 28,218 57,740 121,049 446,991 333,268 220,593 203,751 196,180 408,317 351,724 331,712 453,217 323,953 338,239 439,838 10,711
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023

First things First –
You may need zoning approval
You will need
Building construction approval
Potentially historic site approval
Utility interconnection approval
BPU approval for SREC II

Reach out to the zoning/code office

Reach out to PSE&G Interconnection (IX)

https://nj.pseg.com/saveenergyandmoney/solarandrenewableenergy/applicationprocess

Reach out to BPU to register for SuSi credits

https://njcleanenergy.com/renewable-energy/programs/susi-program

First things First

Energy efficiency –
Can lower your installed cost and payback time

Your solar capacity/energy for interconnection (IX) is limited to your historical electric usage per net metered tariff (NM)

Your NM usage gets set to 0 annually –
For excess or surplus electricity you get paid at the wholesale rate ($0.02 per kWh)
For any underage you pay at the retail rate
You get to set this date

First things First

The age of your roof ? Does it need replacement?
Can it support the solar panels
(2-4 #/ft2) panel weight – 30 to 50# per panel
Maybe insulate the roof ? Reduce heat gain and loss
Warranty for the roof ? –Call the Roofing contractor

Do you need Insurance? - Call your insurance company
Are there tax issues? – Call your tax accountant

Solar PV on your roof is exempt from property tax increase
Solar PV in New Jersey is exempt from NJ sales tax

First things First
Warranties

To get The NJBPU solar incentive
SREC II NJBPU requires

Systems must be covered by a full (not “limited”) five-year warranty and any manufacturers' warranties on specific components. Coverage must include all parts and labor, plus the cost of removing, shipping and reinstalling or replacing a defective component.

First things First

The system must be installed by a licensed electrician

https://www.njconsumeraffairs.gov/elec/Pages/default.aspx

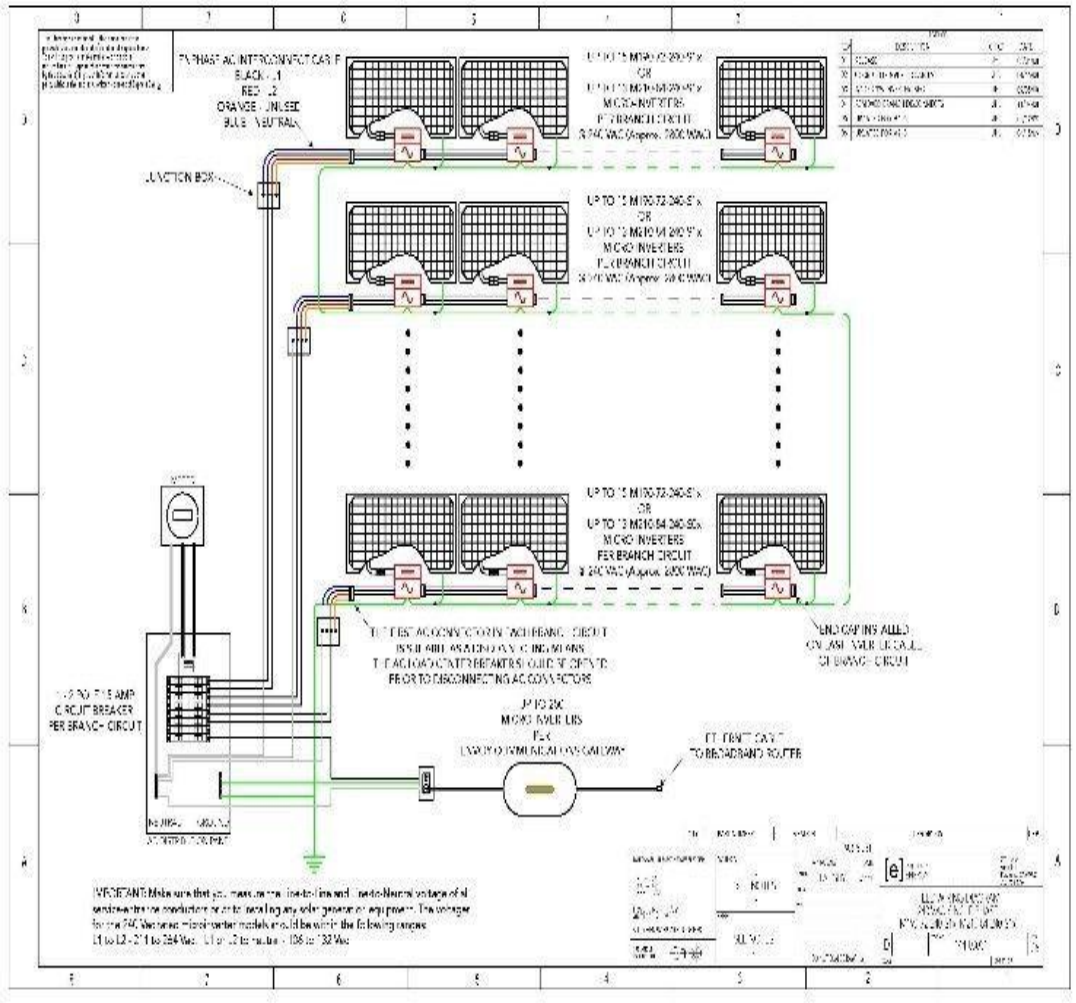
The system must be installed by a licensed Home Improvement Contractor (HIC)

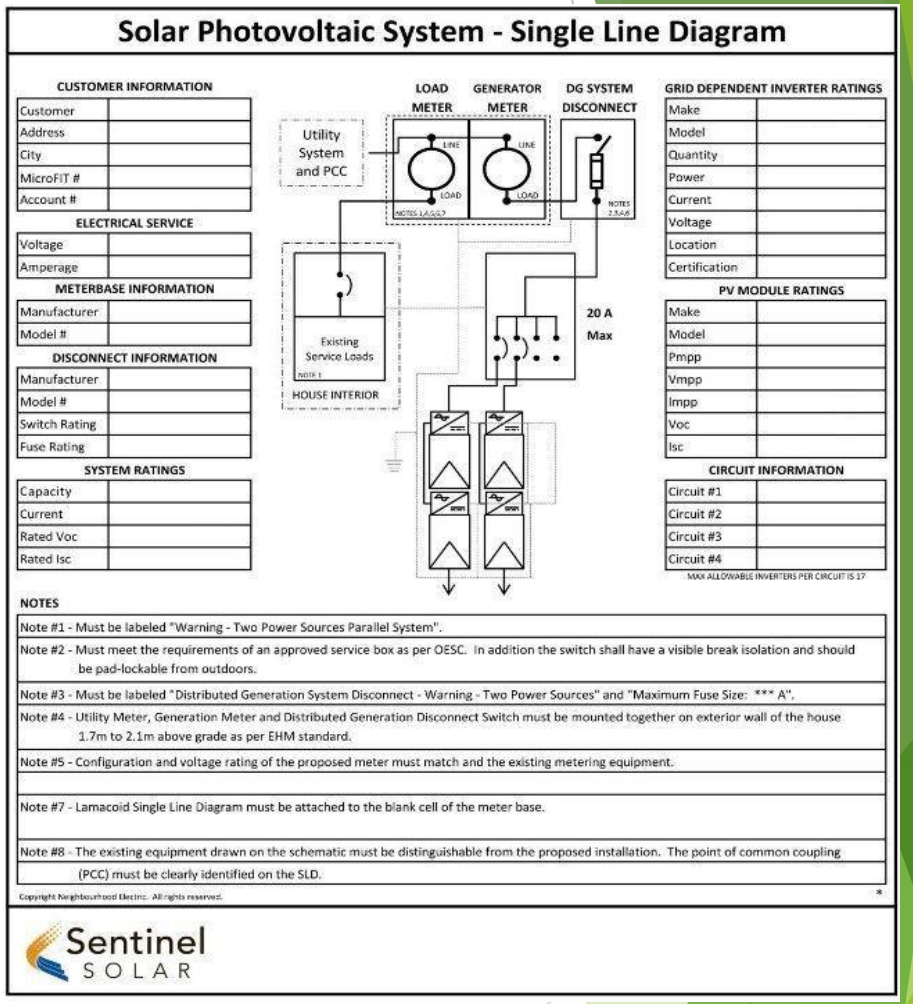
https://www.njconsumeraffairs.gov/hic/Pages/applications.aspx

The North American Board of Certified Energy Practitioners (NABCEP) is a nationally-recognized, independent, voluntary certification program for photovoltaic (PV) and solar-heating system installers,

https://www.nabcep.org/resource/certification-handbook/

Single one line drawing – Building permit





https://www.123zeroenergy.com/free-solar-line-drawings.html

First things First
You may need to upgrade your electric panel

100 Amps

200 or 400 Amps

Costs range from $1,500 to $3,000 + depending on site conditions
If you have an underground service it could cost upwards of $109,000
There is a 30% federal tax credit 1/1/23 to 12/31/32
Electric Utility – make ready incentives

PSE&G Interconnection (IX) Process for Solar Net Metering (NM)

To connect your PV solar system to the PSE&G electric grid is a 2 step process.

Step 1: Preliminary Solar Project Approval Phase

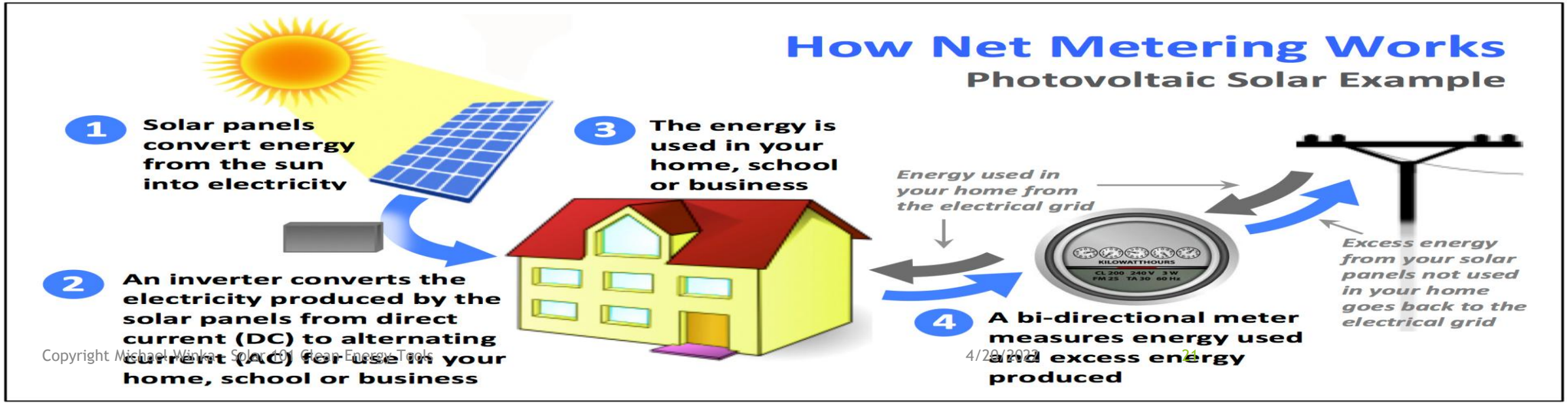
Step 2: Construction and Final Approval Phase – Approval to Energize

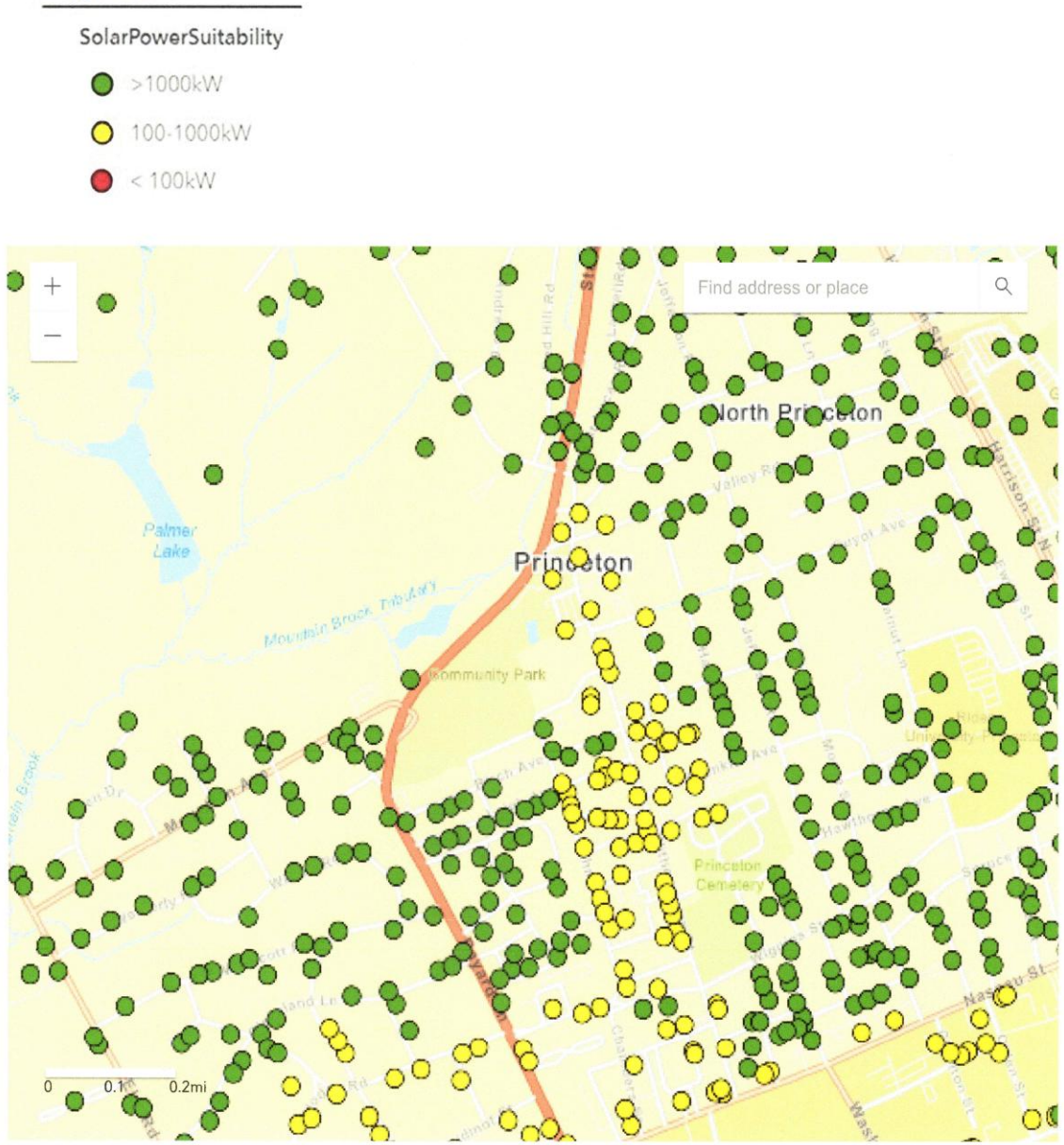
Level 1 invertor based 10 kW or less

Level 2 and 3 invertor based greater than 10 kW

Solar Power Suitability Map - hosting capacity

[Solar Power Suitability Map - PSE&G (pseg.com)]





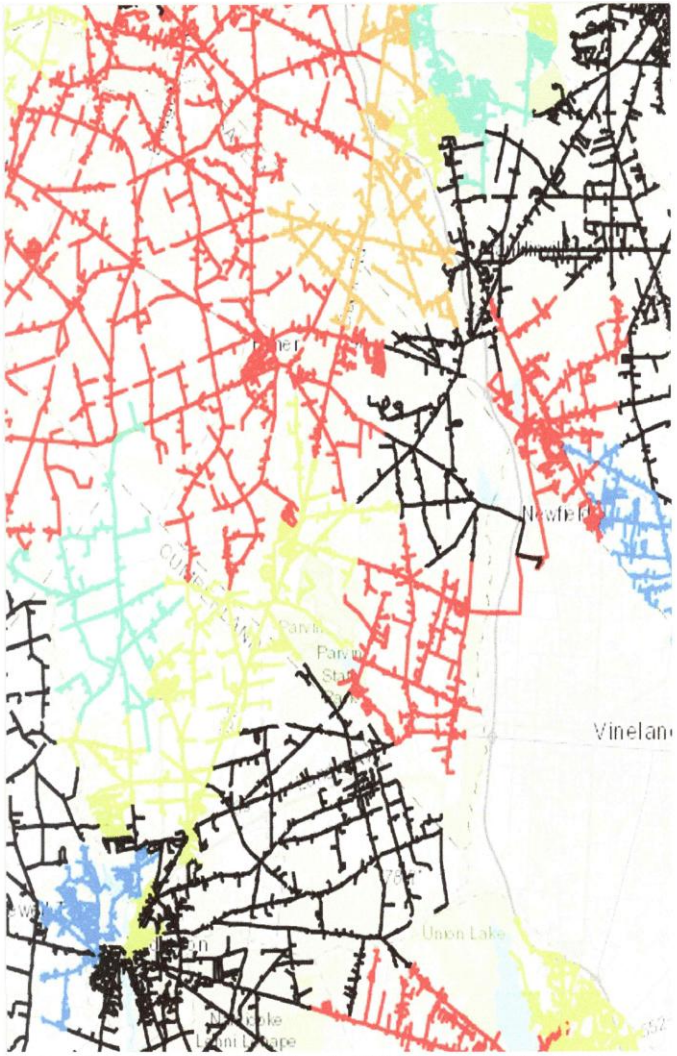
Pepco Holdings
An Exelon Company

Distribution Feeder Hosting Capacity

PHI defines large DER systems by feeder primary voltage class;

- 4-13.8kV: 250kW and greater
- 23-25kV: 500kW and greater
- 33-34.5kV: 1MW and greater

Feeder restrictions can be confirmed via the Restriction Map.



The technological, legal, and regulatory considerations that apply t constantly evolving. The map(s) are for illustrative purposes only. A

Addition information on NJBPU interconnection and net metering requirement and Utility contacts

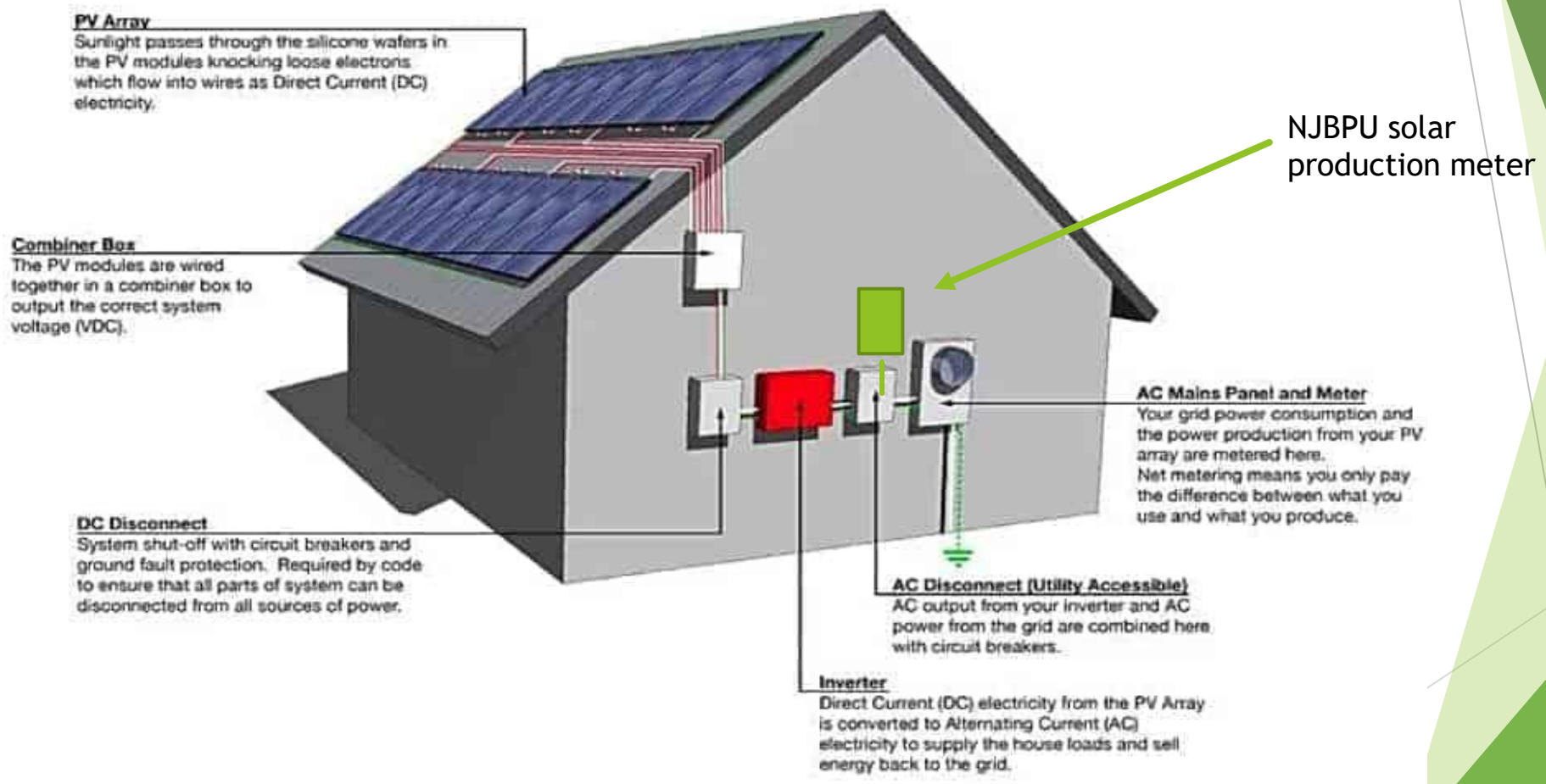
NJ BPU Solar Metering Requirement
https://www.njcleanenergy.com/renewable-energy/programs/metering-requirements

NJBPU Production Meter Requirements for Solar Projects (SRECs)
https://www.njcleanenergy.com/renewable-energy/programs/metering-requirements/production-meter-requirements-solar-projects-srecs

NJBPU Net Metering and Interconnection
https://www.njcleanenergy.com/renewable-energy/programs/net-metering-and-interconnection

Utility Interconnection and hosting capacity maps contacts
https://www.njcleanenergy.com/renewable-energy/programs/net-metering-and-interconnection/interconnection-forms

Basics of a solar system - panels, racking, inverter and meter Interconnection IX is how you communicate to the grid and Net Metering is the actual words – the energy feed to the grid



Grid tied inverters – outage

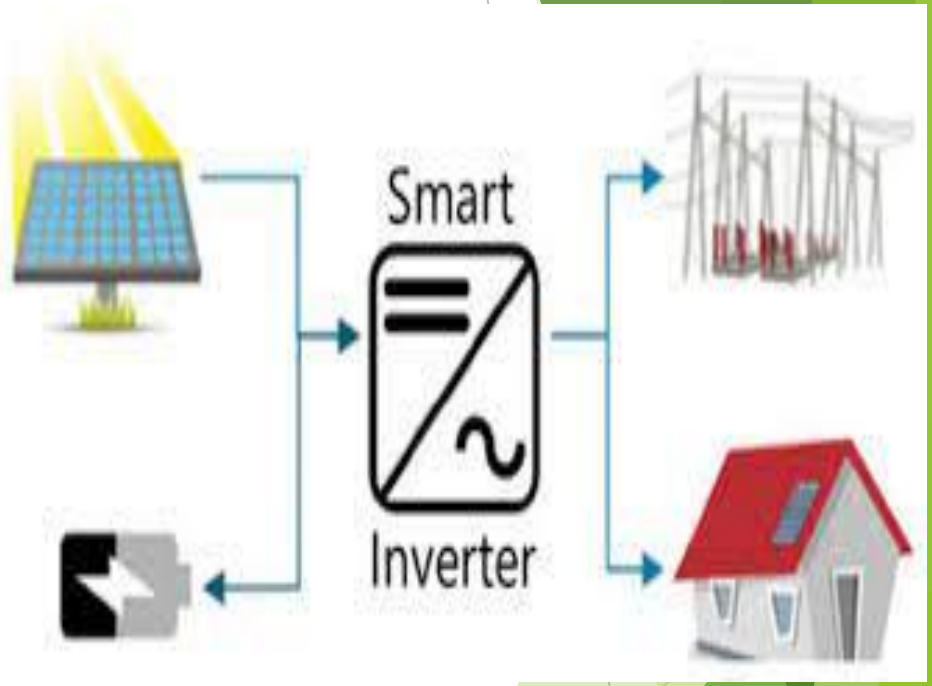
If there is an outage on the line your grid tied inverter will Shut down as a safety issue

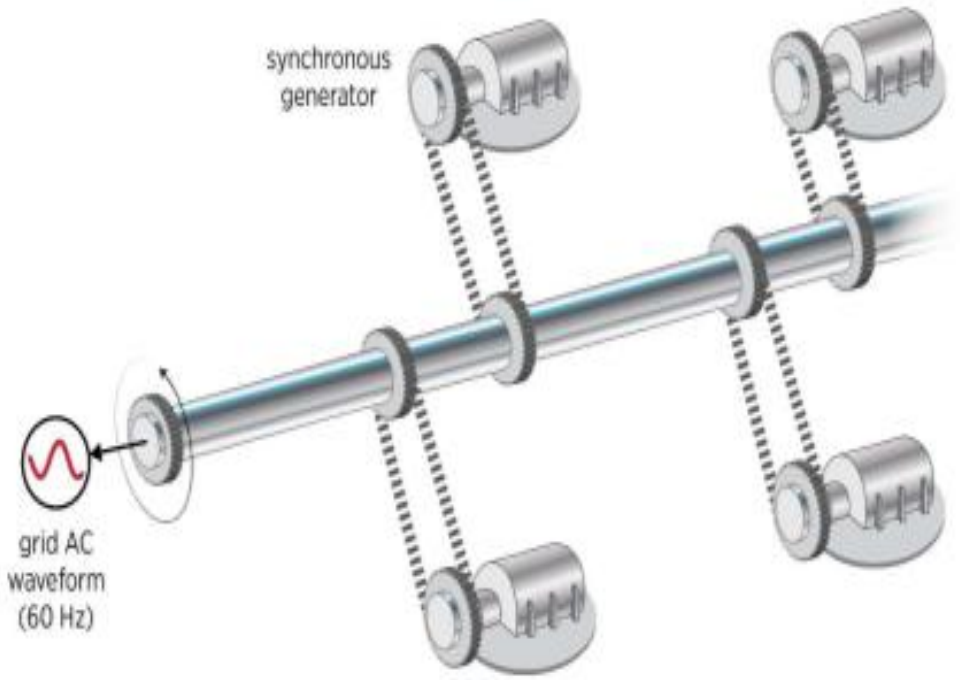
New smart inverters can “ride – through” any minor Transient issues on the grid

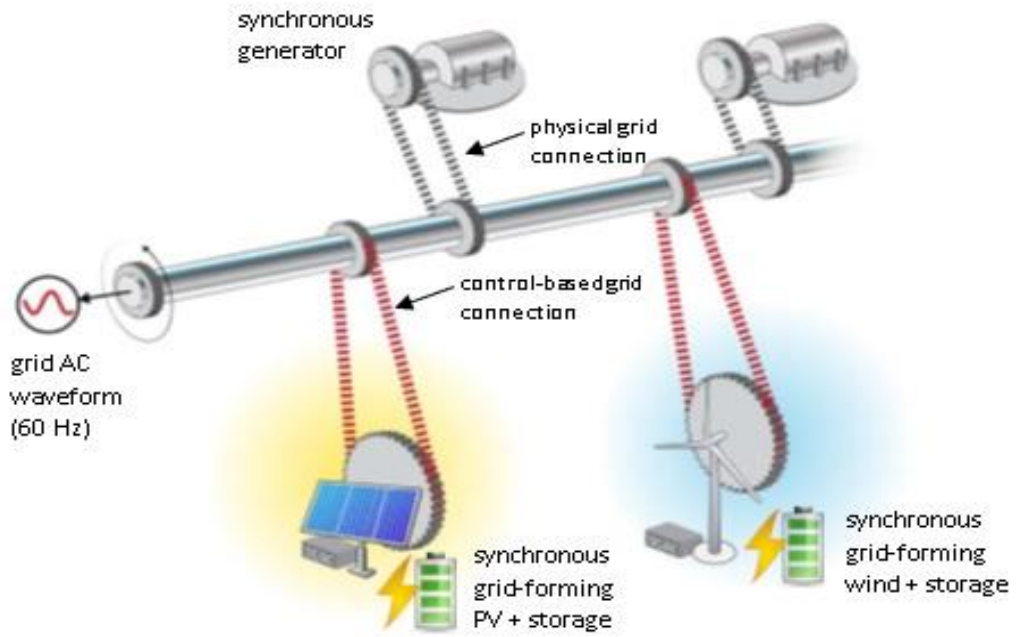
Current – load following or grid following Inverter It just follows what the grid is doing

To get to 100% clean electricity by 2035 Inverters have to be Load leading or grid forming inverters that add grid performance Voltage regulation and frequency regulation

So essential the whole grid needs to be upgraded

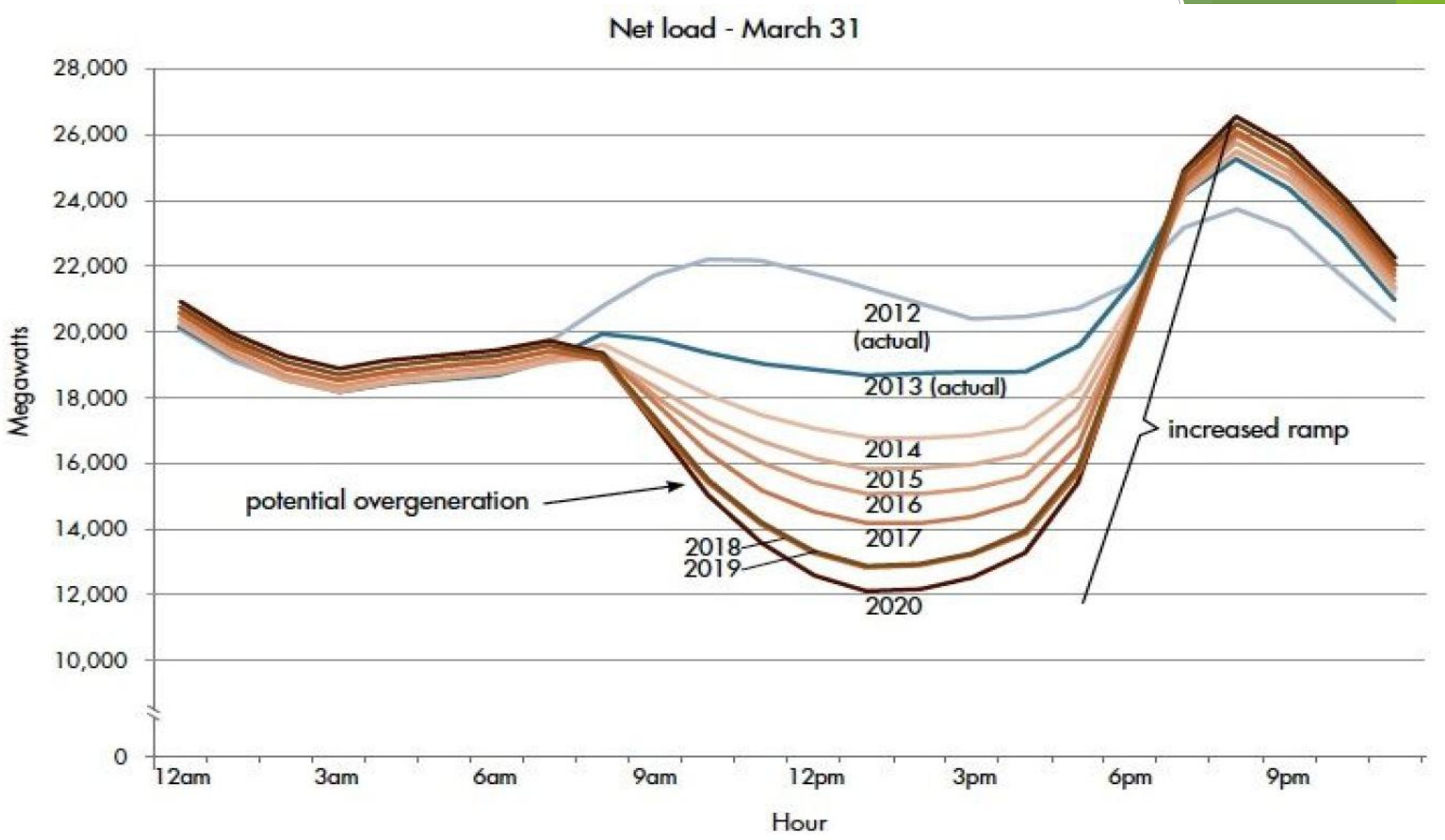






The concept of synchronous generators working together in an electrical grid. Image: National Renewable Energy Laboratory (NREL).

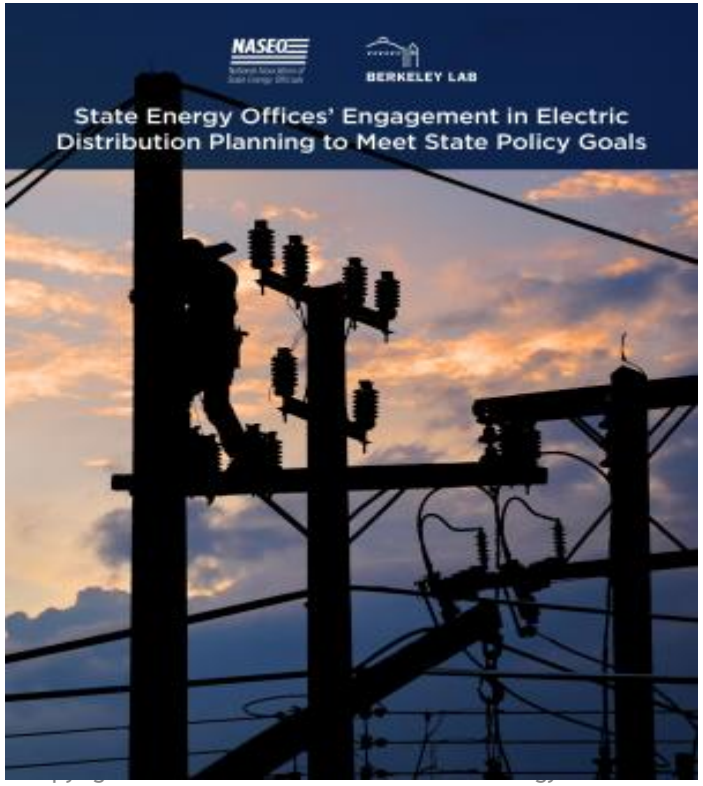
So essential the whole grid needs to be upgraded
Do you want to pay for Load or grid forming inverters or SMR/clean firm or both ?

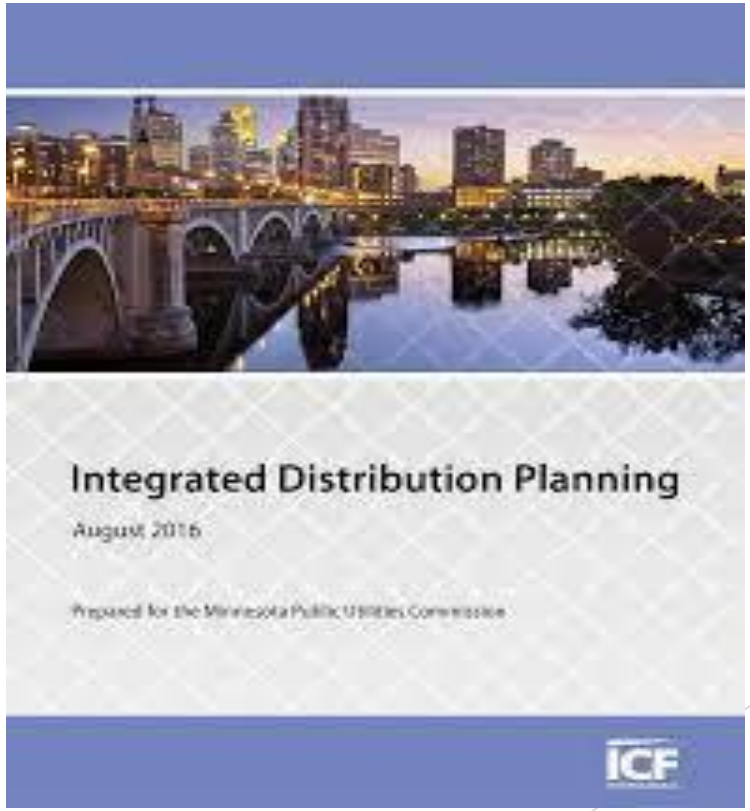

Net load - March 31
28,000
26,000
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
0
Megawatts
12am
3am
6am
9am
12pm
3pm
6pm
9pm
Hour
2012
(actual)
2013 (actual)
2014
2015
2016
2017
2018
2019
2020
potential overgeneration
increased ramp

C

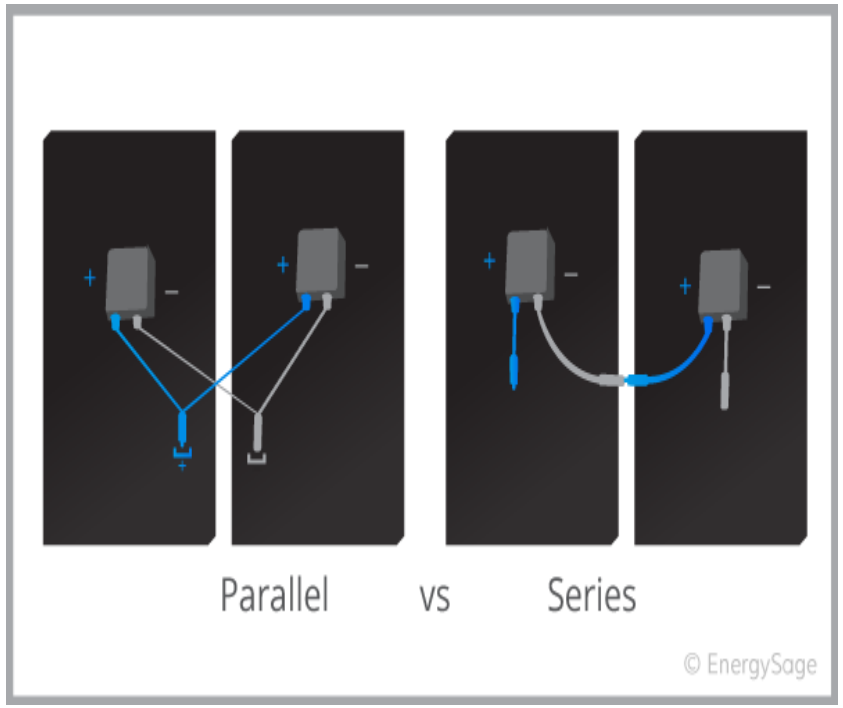
To address these changes in the grid
More variable inverter-based generation
Increased electrification – increasing load and shifting to a winter peak
If we electrify Buildings and Transportation sector we will double electricity but zero out gasoline and fossil heating fuels

The solution is Integrated Distribution Planning
The 2019 EMP required the utilities to do IDP 5 years later - They have not done so – yet –

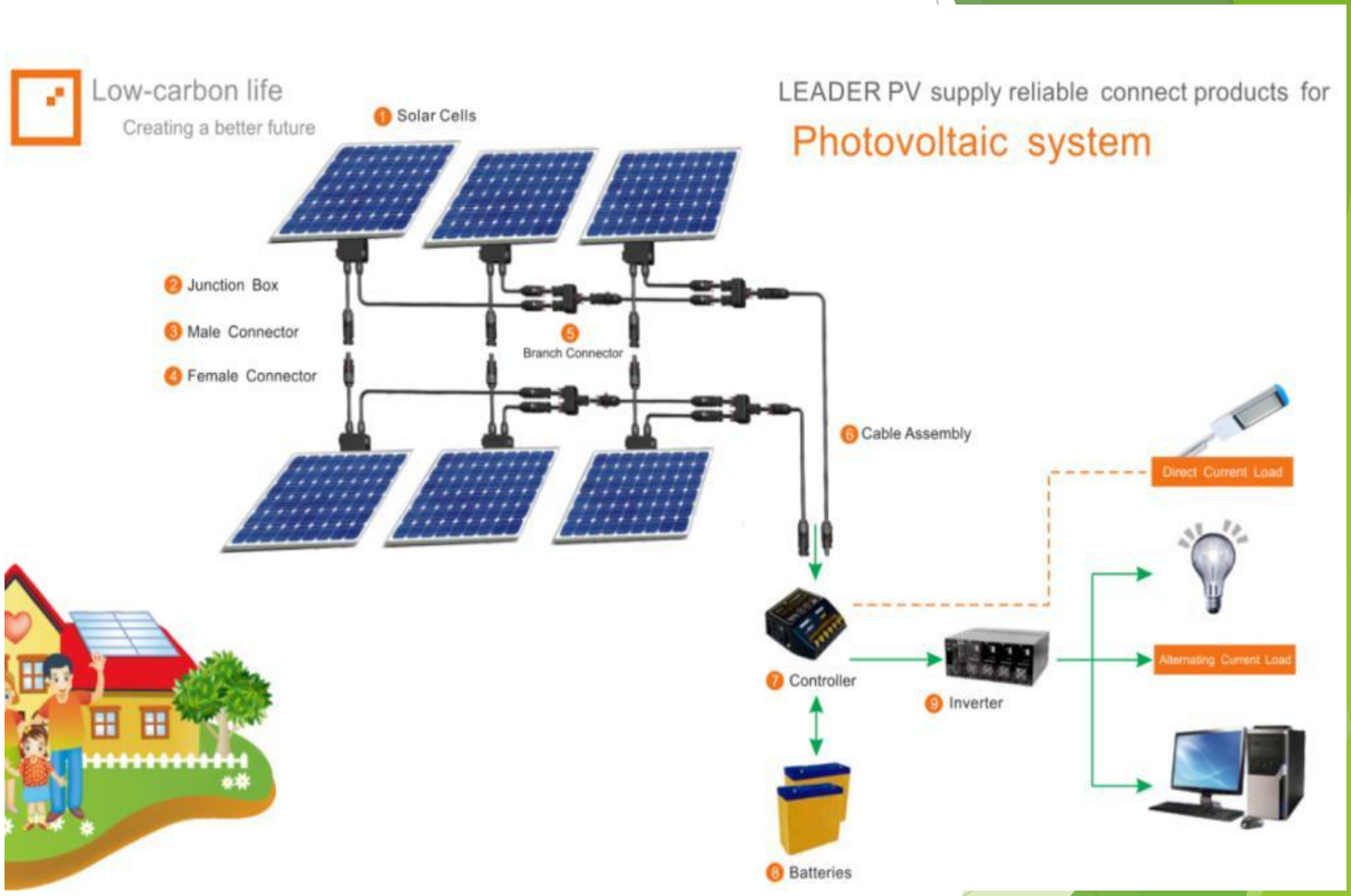




MC-4 connectors



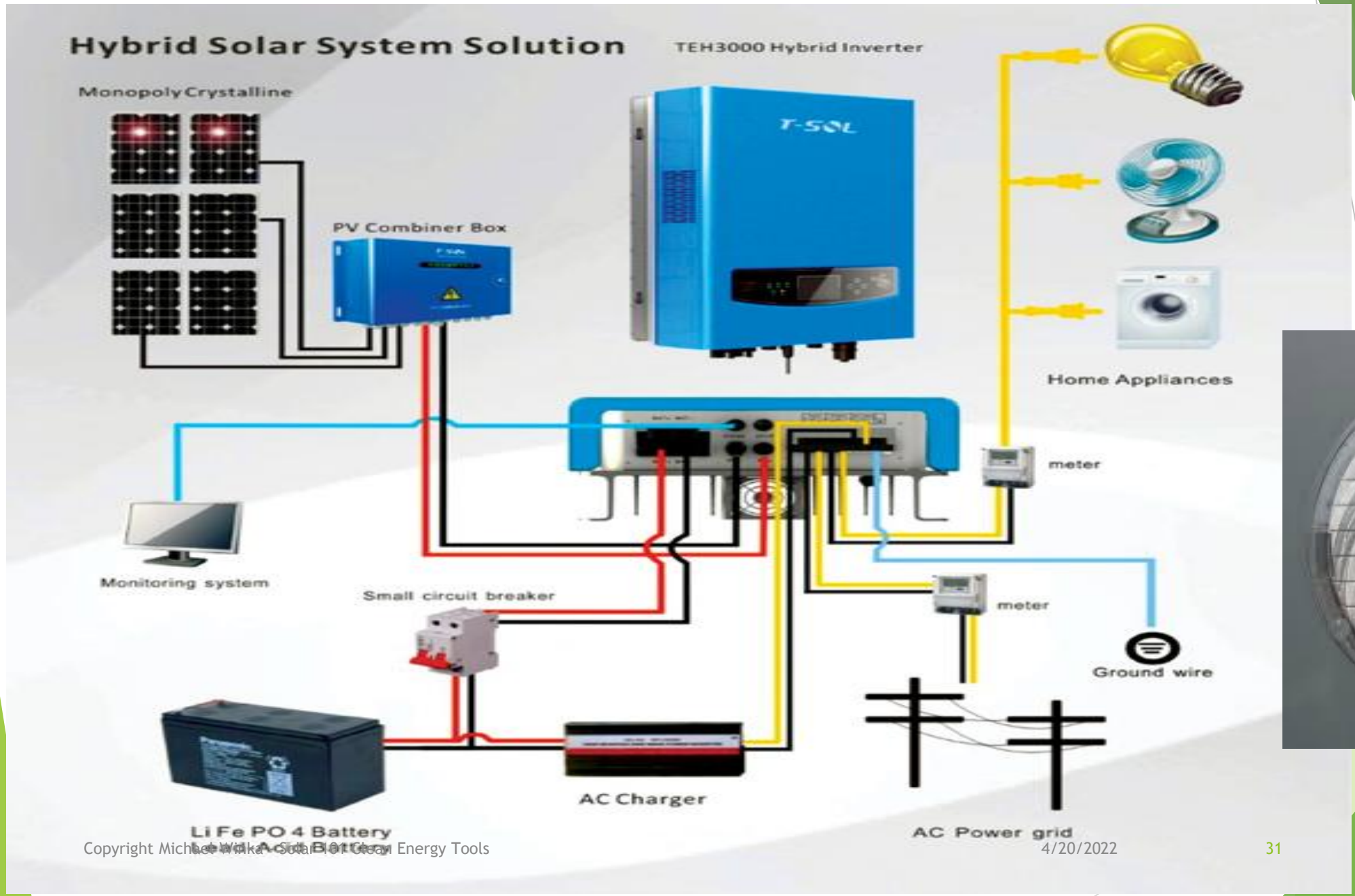
https://news.energysage.com/solar-panels-series-vs-parallel/



https://www.leadergroup-cn.com/solar-connectors-and-solar-extension-cables.html

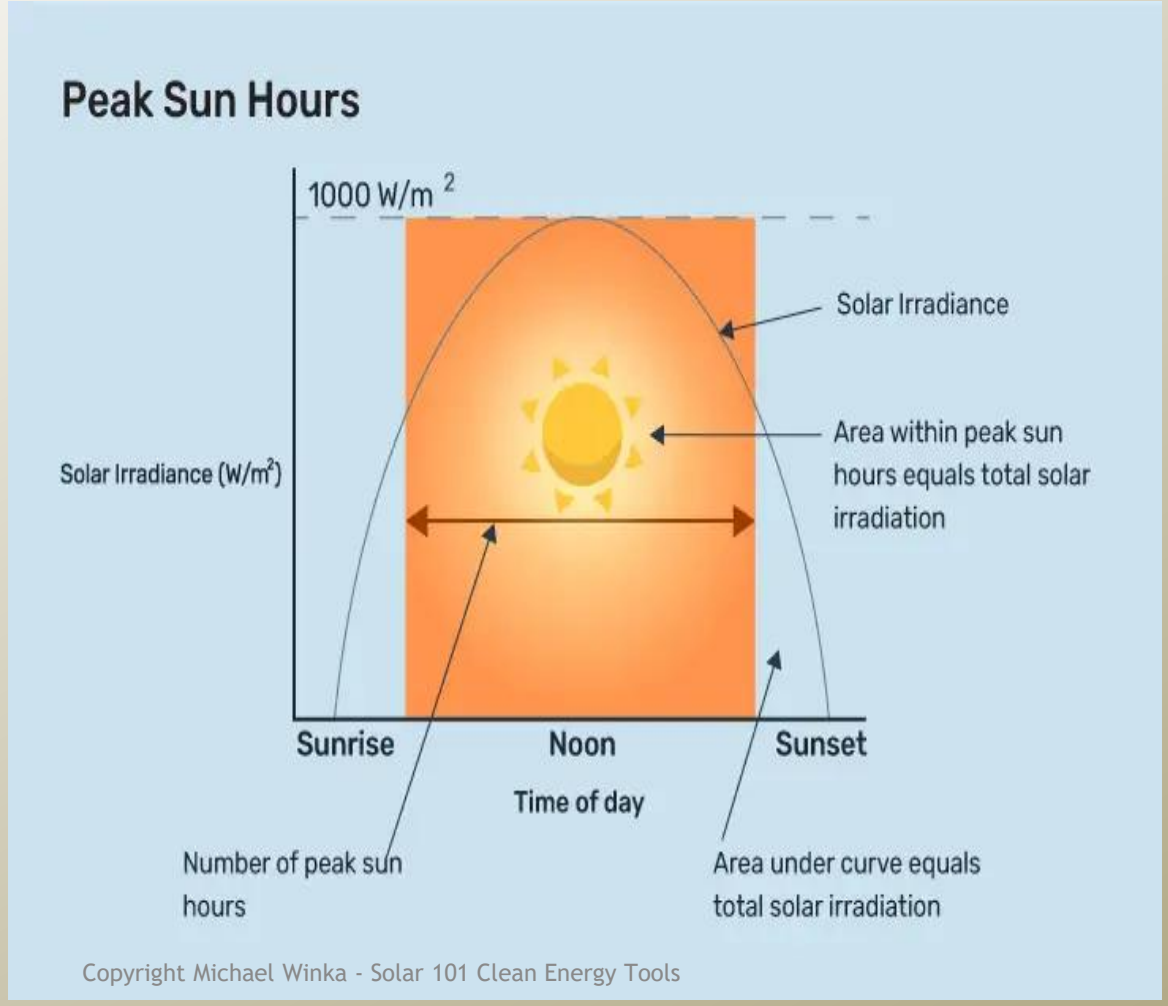
Surge protection
Fuses
Circuit Breakers
Over Current Protection
Back Flow Protection
Ground

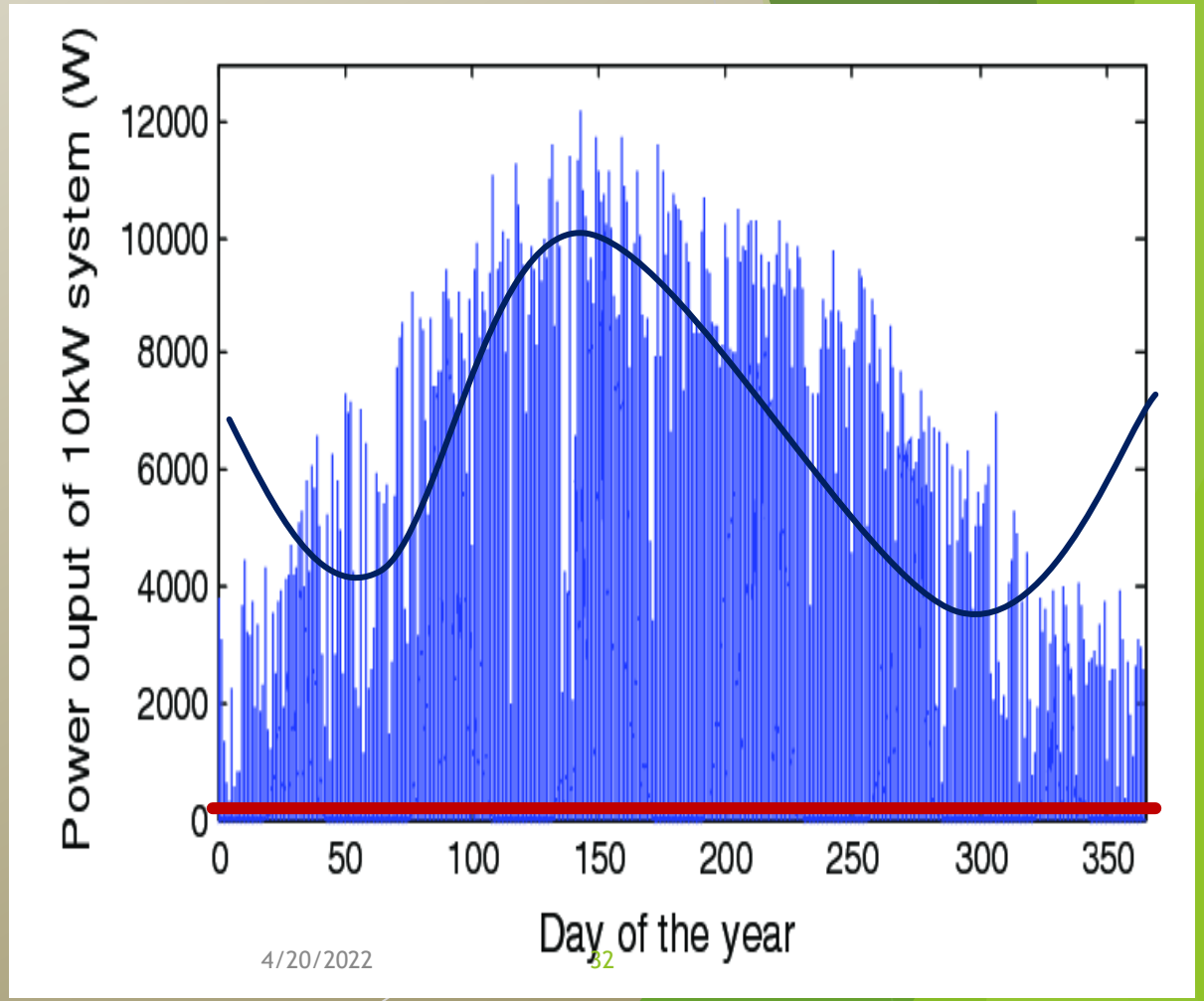
A solar panel combiner box is used to combine several solar panels or strings of panels into a common bus. It is basically a junction box for the types of wiring used in PV systems.

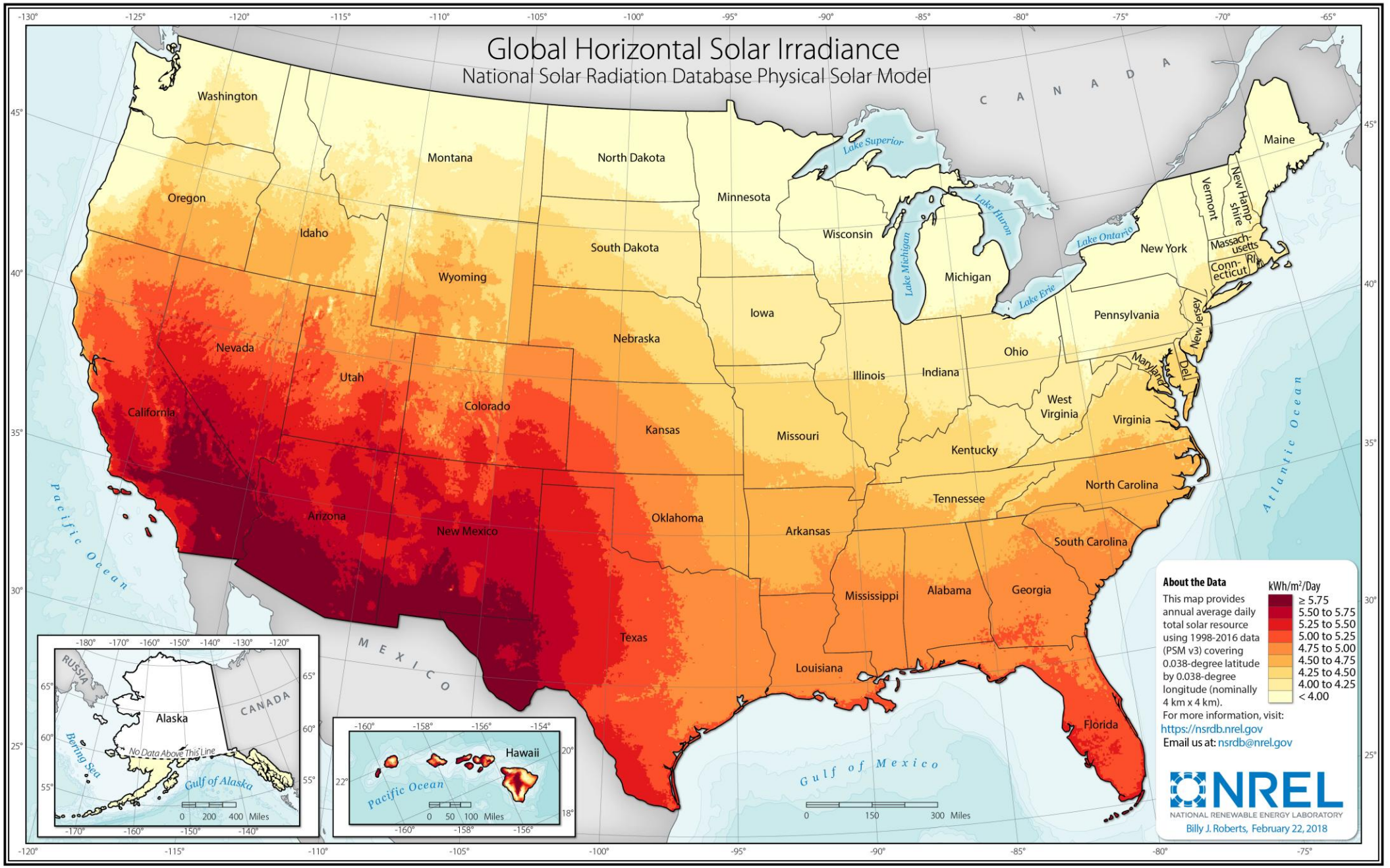

Hybrid Solar System Solution
TEH3000 Hybrid Inverter
Monopoly Crystalline
PV Combiner Box
T-SOL
Home Appliances
meter
Monitoring system
Small circuit breaker
meter
Ground wire
AC Charger
Li Fe PO 4 Battery
AC Power grid


FOCUS kWh
Net Meter

Solar energy changes over the day and year and depends on the weather - design the system for the average Battery storage can extend the solar day or fill in on cloudy days






Global Horizontal Solar Irradiance
National Solar Radiation Database Physical Solar Model
Washington
Oregon
California
Nevada
Idaho
Montana
Wyoming
Utah
Arizona
Colorado
New Mexico
North Dakota
South Dakota
Nebraska
Kansas
Oklahoma
Texas
Minnesota
Iowa
Missouri
Arkansas
Louisiana
Wisconsin
Illinois
Michigan
Indiana
Ohio
Kentucky
Tennessee
Mississippi
Alabama
Georgia
Florida
South Carolina
North Carolina
Virginia
West Virginia
Pennsylvania
New York
Maryland
Del
New Jersey
Conn-ecticut
RI
Massach-usetts
Vermont
New Hamp-shire
Maine
Lake Superior
Lake Michigan
Lake Huron
Lake Erie
Lake Ontario
CANADA
MEXICO
Pacific Ocean
Atlantic Ocean
Gulf of Mexico
Alaska
RUSSIA
CANADA
Bering Sea
No Data Above This Line
Gulf of Alaska
0 200 400 Miles
Hawaii
Pacific Ocean
0 50 100 Miles
0 150 300 Miles
About the Data
This map provides annual average daily total solar resource using 1998-2016 data (PSM v3) covering 0.038-degree latitude by 0.038-degree longitude (nominally 4 km x 4 km).
For more information, visit:
https://nsrdb.nrel.gov
Email us at: nsrdb@nrel.gov
kWh/m²/Day
≥ 5.75
5.50 to 5.75
5.25 to 5.50
5.00 to 5.25
4.75 to 5.00
4.50 to 4.75
4.25 to 4.50
4.00 to 4.25
< 4.00
NREL
NATIONAL RENEWABLE ENERGY LABORATORY
Billy J. Roberts, February 22, 2018

Questions ?

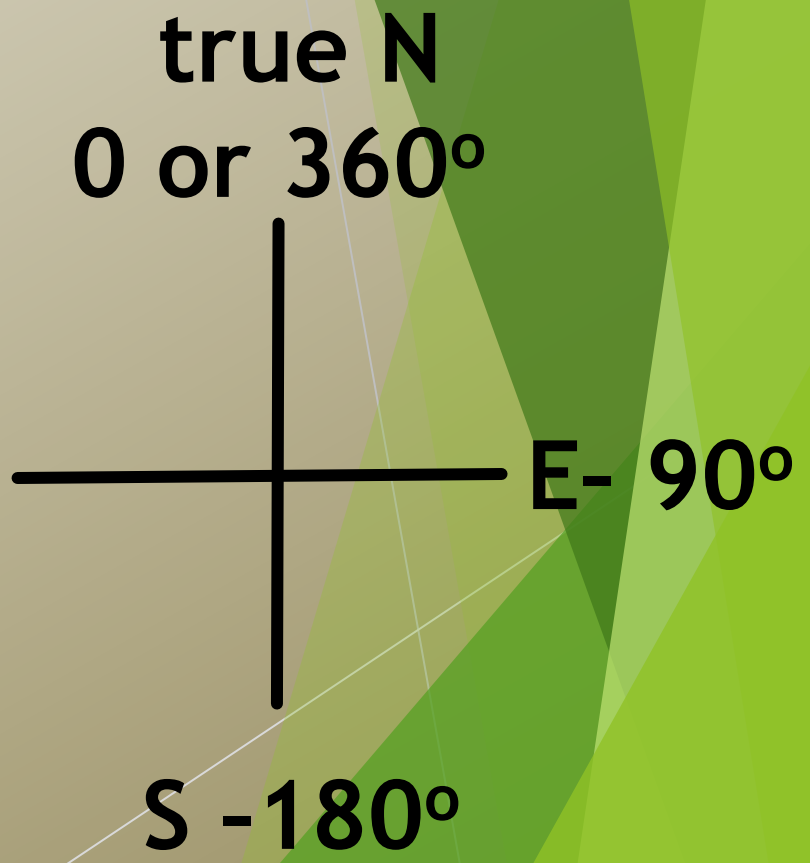
Estimating your PV solar size and cost
Two methods - both get to the same answer

Calculate the size in kW that can fit on your roof
Calculate the amount of energy that system can generate
Determine the amount of electricity you use monthly/yearly
Calculate the size in kW you need based on electricity use
Determine any EE measures to reduce electricity use
Calculate costs of your system
Calculate the total revenues of your system
Calculate simple payback of your system
Decide how to purchase/finance your system

All basically rough estimates

Calculating the size of your system on your roof - kilowatt (kW)

Go to Google Maps is your friend
Calculate the size of the roof
Your smartphone has a compass



Azimuth
with southern exposure 180°
with south west exposure 225°
with south eastern exposure 135°

Geometry and estimating – There's an app for that

Now you know why you learned geometry

Find the **area** of the roof

Area of a Rectangle or Square = L X W

Area of a Triangle = ½ B X H

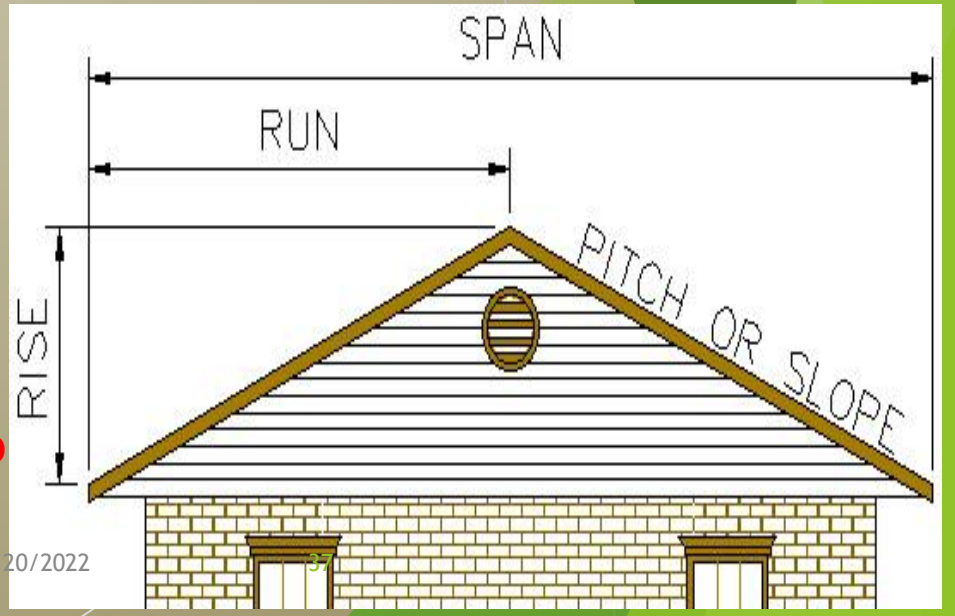
Find the **slope or tilt** of the roof

Typically 4/12 = 18.4° or 6/12 = 26.6°

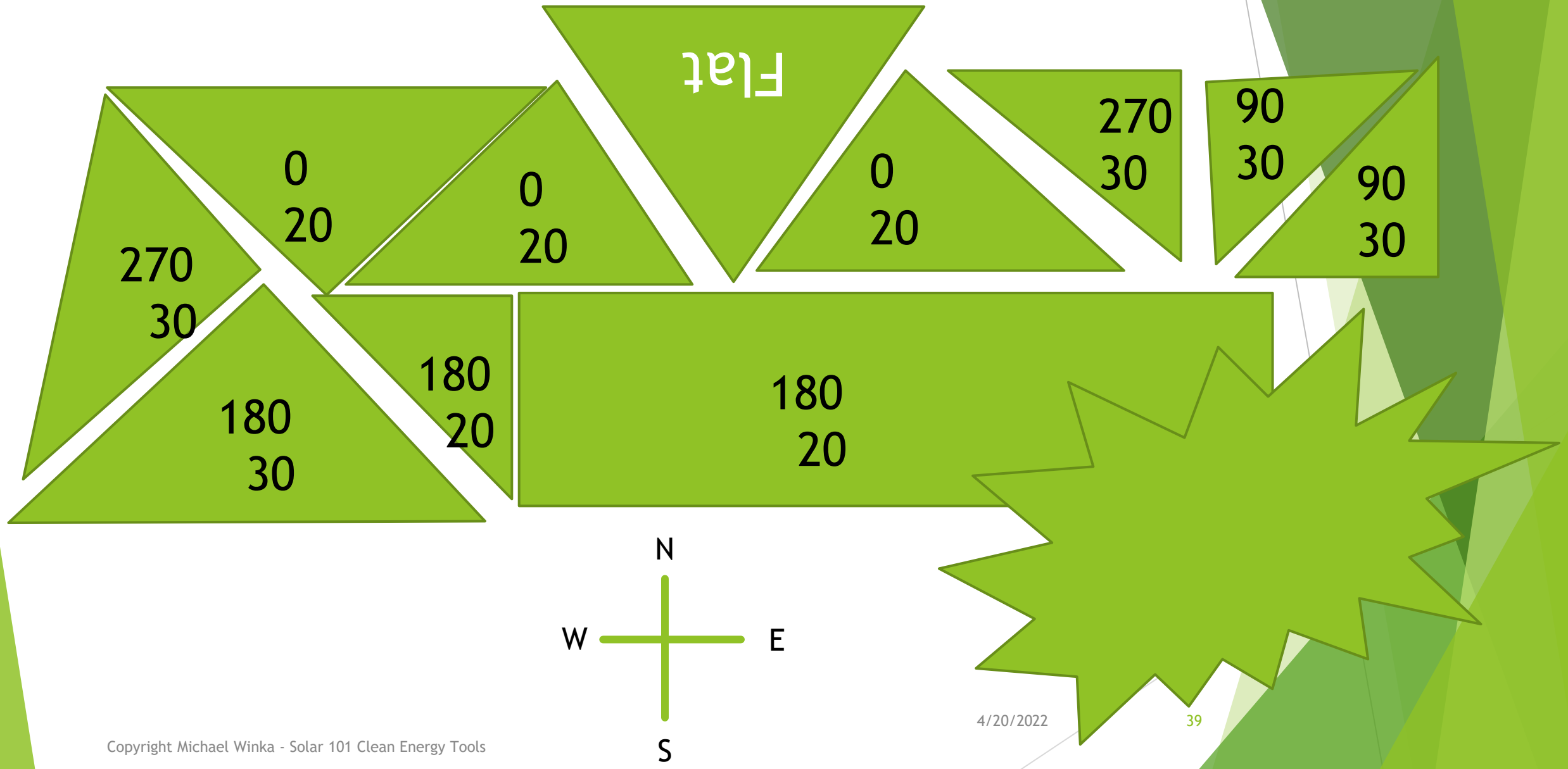
Tan $^{-1}$ (4/12) = Tan $^{-1}$ 0.33 = 18.4°

Best tilt is when roof slope = latitude = 41°

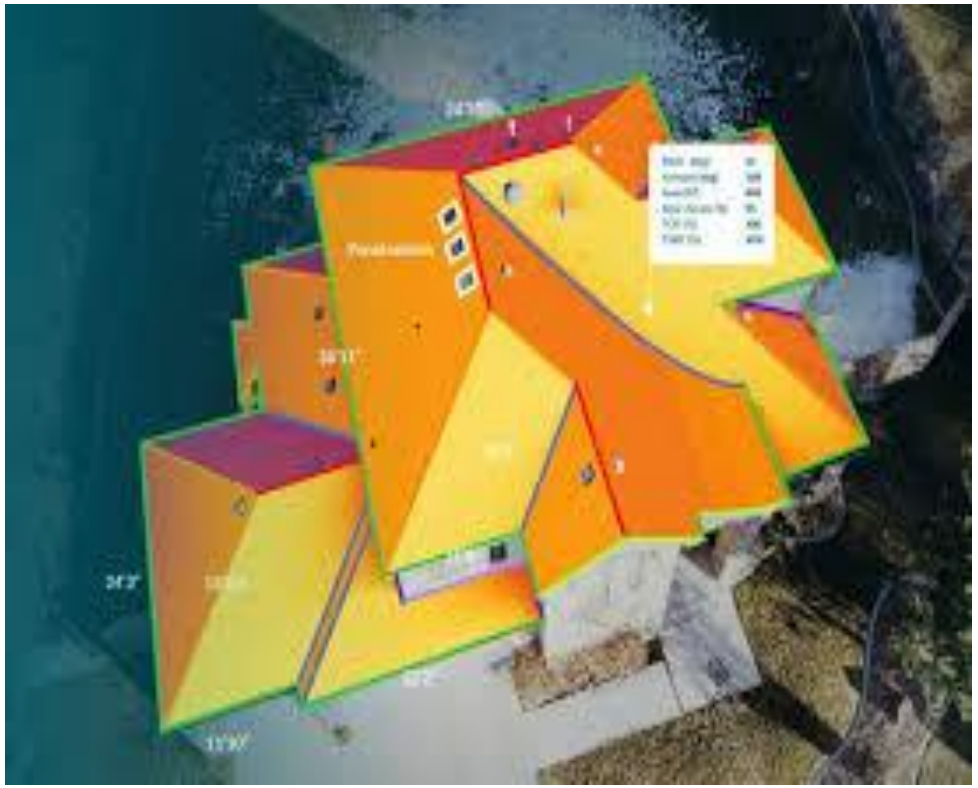
41° sloped roof is 10/12 (58° W & 26° S)

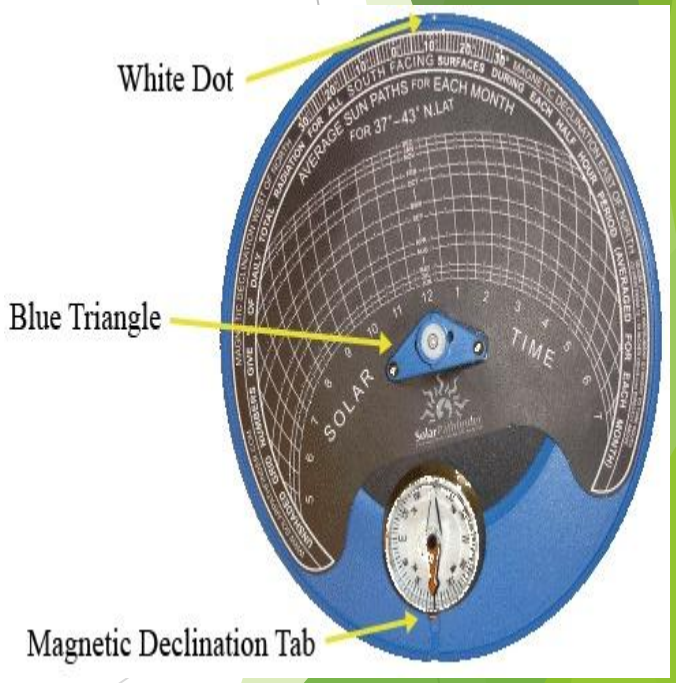



3D
Map
Google
Imagery ©2017 Google, Map data ©2017 Google
Terms
Send feedback
20 ft



Shading Analysis over the full year





Solmetric

https://solarbuildermag.com/tag/shade-analysis/

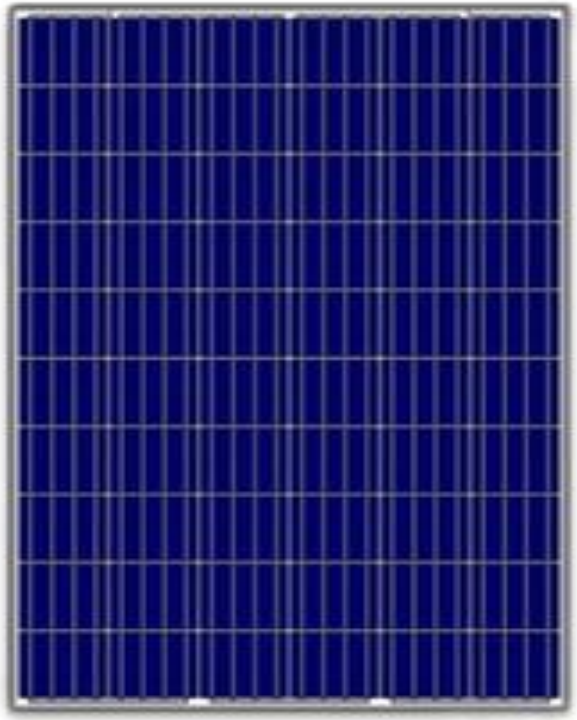
https://helioscope.aurorasolar.com/

Solar pathfinder

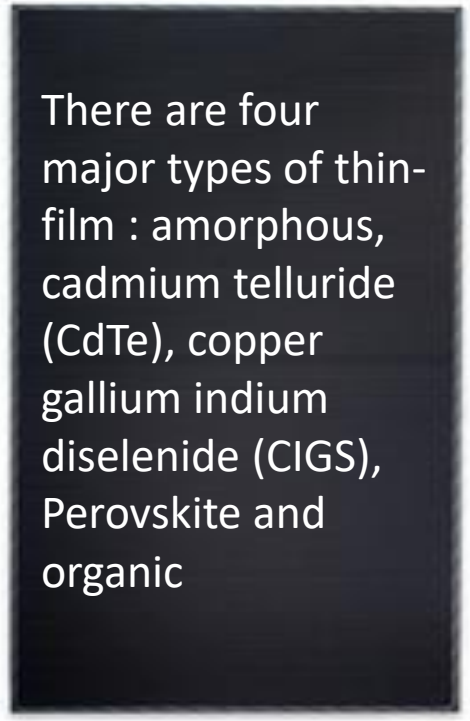
Types of solar panels

Monocrystalline

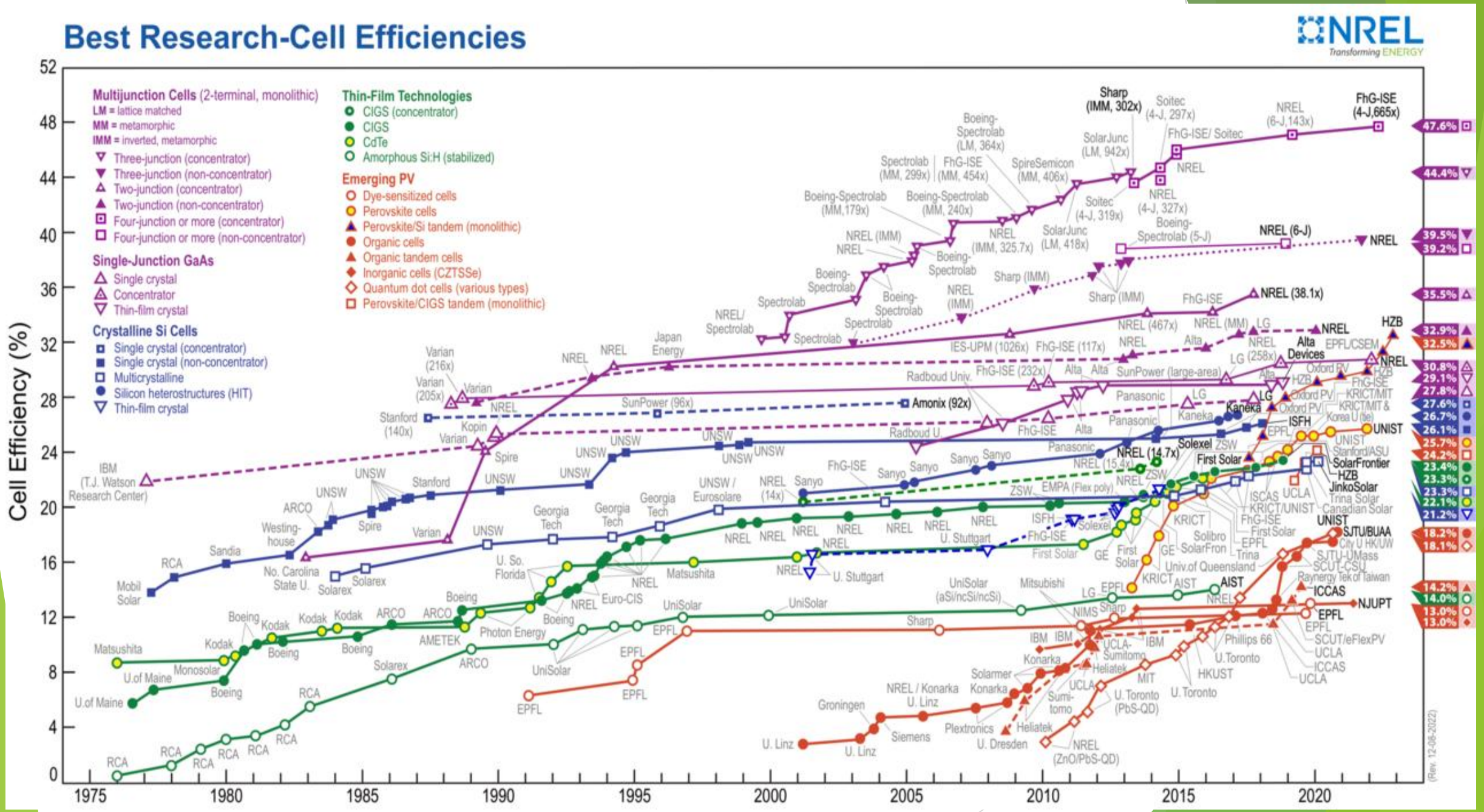
Polycrystalline



Thin film



Check out independent review of panel manufacturers https://www.solarreviews.com/solar-panel-reviews
https://news.energysage.com/best-solar-panels-complete-ranking/
https://www.cleanenergyreviews.info/blog/best-solar-panels-review

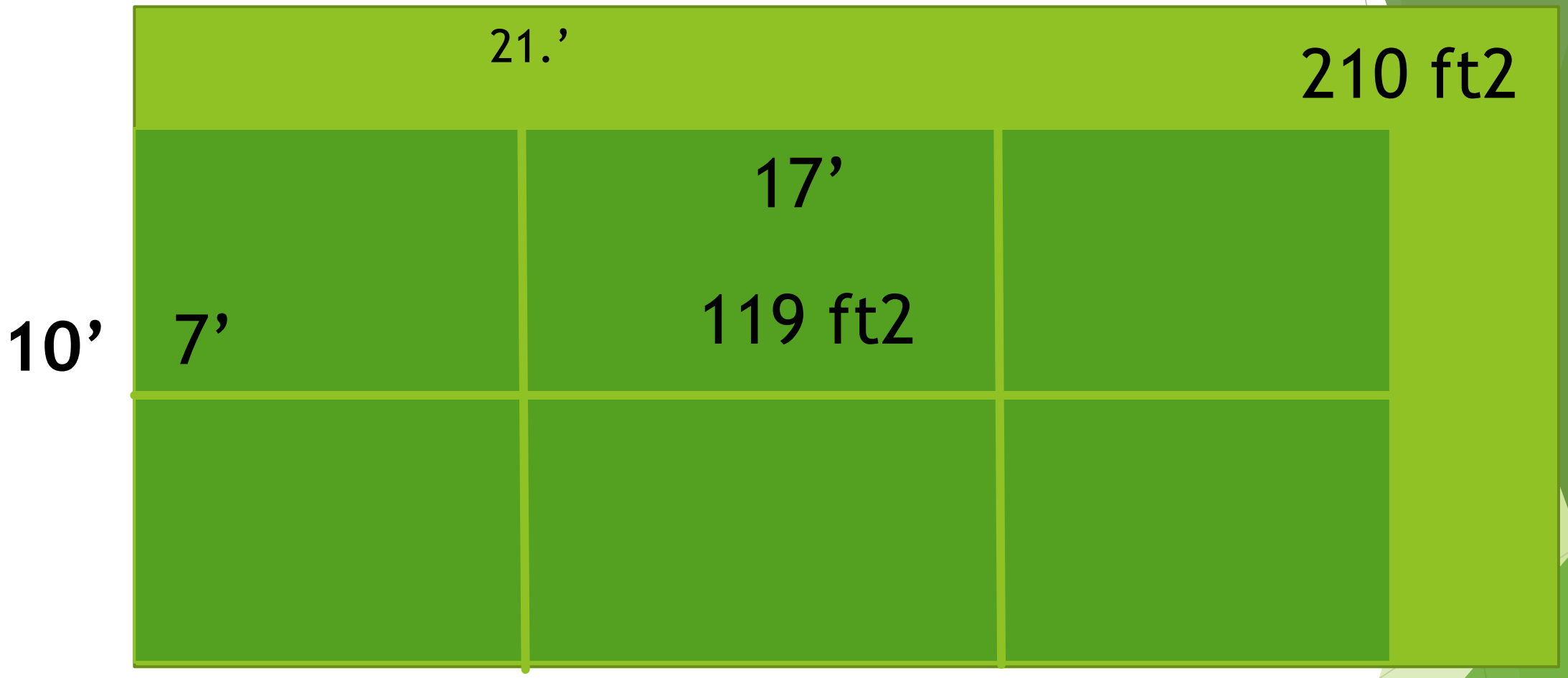

Best Research-Cell Efficiencies
NREL
Transforming ENERGY
Cell Efficiency (%)
Multijunction Cells (2-terminal, monolithic)
LM = lattice matched
MM = metamorphic
IMM = inverted, metamorphic
Three-junction (concentrator)
Three-junction (non-concentrator)
Two-junction (concentrator)
Two-junction (non-concentrator)
Four-junction or more (concentrator)
Four-junction or more (non-concentrator)
Single-Junction GaAs
Single crystal
Concentrator
Thin-film crystal
Crystalline Si Cells
Single crystal (concentrator)
Single crystal (non-concentrator)
Multicrystalline
Silicon heterostructures (HIT)
Thin-film crystal
Thin-Film Technologies
CIGS (concentrator)
CIGS
CdTe
Amorphous Si:H (stabilized)
Emerging PV
Dye-sensitized cells
Perovskite cells
Perovskite/Si tandem (monolithic)
Organic cells
Organic tandem cells
Inorganic cells (CZTSSe)
Quantum dot cells (various types)
Perovskite/CIGS tandem (monolithic)
47.6%
44.4%
39.5%
39.2%
35.5%
32.9%
32.5%
30.8%
29.1%
27.8%
27.6%
26.7%
26.1%
25.7%
24.2%
23.4%
23.3%
23.3%
22.1%
21.2%
18.2%
18.1%
14.2%
14.0%
13.0%
13.0%
(Rev. 12-08-2022)

MAKE/ MODEL	WIDTH (IN.)	LENGTH (IN.)	WATTS	WATTS/ SQ. FT.
Kyocera Solar KU265-6ZPA	39	65.4	265	15
REC Solar REC260PE	39.02	65.55	260	14.6
SolarWorld SW280 Mono Black	39.4	65.95	280	15.5
Canadian Solar CS6P-265P	38.7	64.5	265	15.3
Yingli Energy YL260P-29b	39	65	260	14.8
AVERAGE:	39	65	265 (300)	15 (17)

SOLAR PANEL MANUFACTURER	MINI	MAXI	AVER	SOLAR PANEL MANUFACTURER	MINI	MAXI	AVER
Amerisolar	240	330	285	RECOM	265	370	308
Astronergy	350	370	360	Recom Solar	310	350	330
Axitec	250	385	302	ReneSola	245	320	277
BenQ Solar (AUO)	250	295	277	Renogy Solar	250	300	268
Boviet Solar	320	340	330	RGS Energy	55	60	58
Canadian Solar	225	410	320	Risen	270	390	329
CentroSolar	250	320	278	S-Energy	255	385	334
CertainTeed Solar	70	400	308	Seraphim	255	340	294
ET Solar	255	370	306	Silfab	300	390	335
First Solar	420	460	440	Solaria	350	430	375

https://news.energysage.com/what-is-the-power-output-of-a-solar-panel/

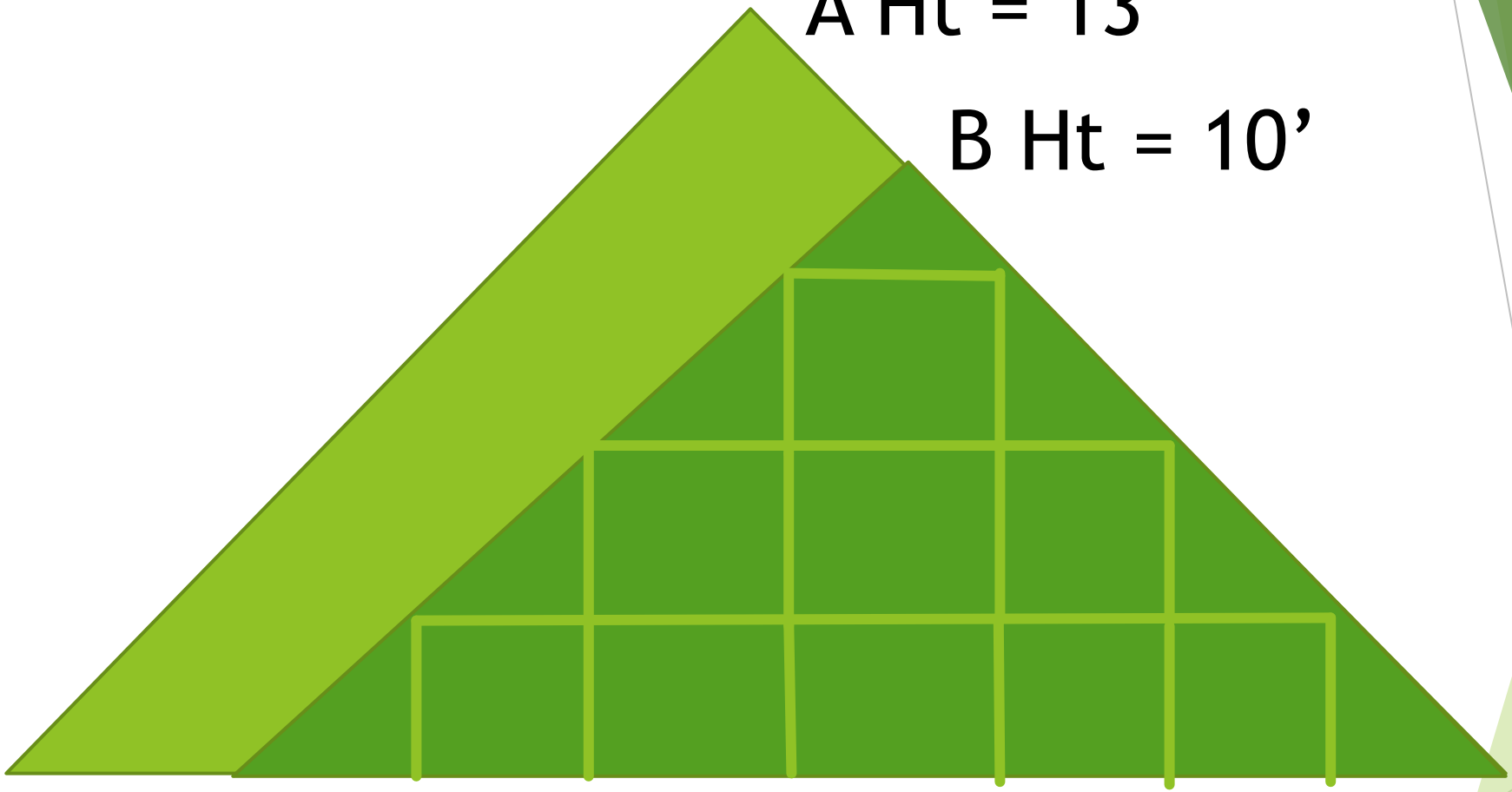
Average Solar Panel is 39” X 65” = 17.6 Ft^2 (39” = 3.25 Ft 65” = 5.4 ft2)



21’ X 10’ should fit 9 panels (265 w) = 2,385 watts or 2.39 kW
6 panels is 105.6 ft2 (265 w) = 1,590 watts or 1.59 kW

A Ht = 13’

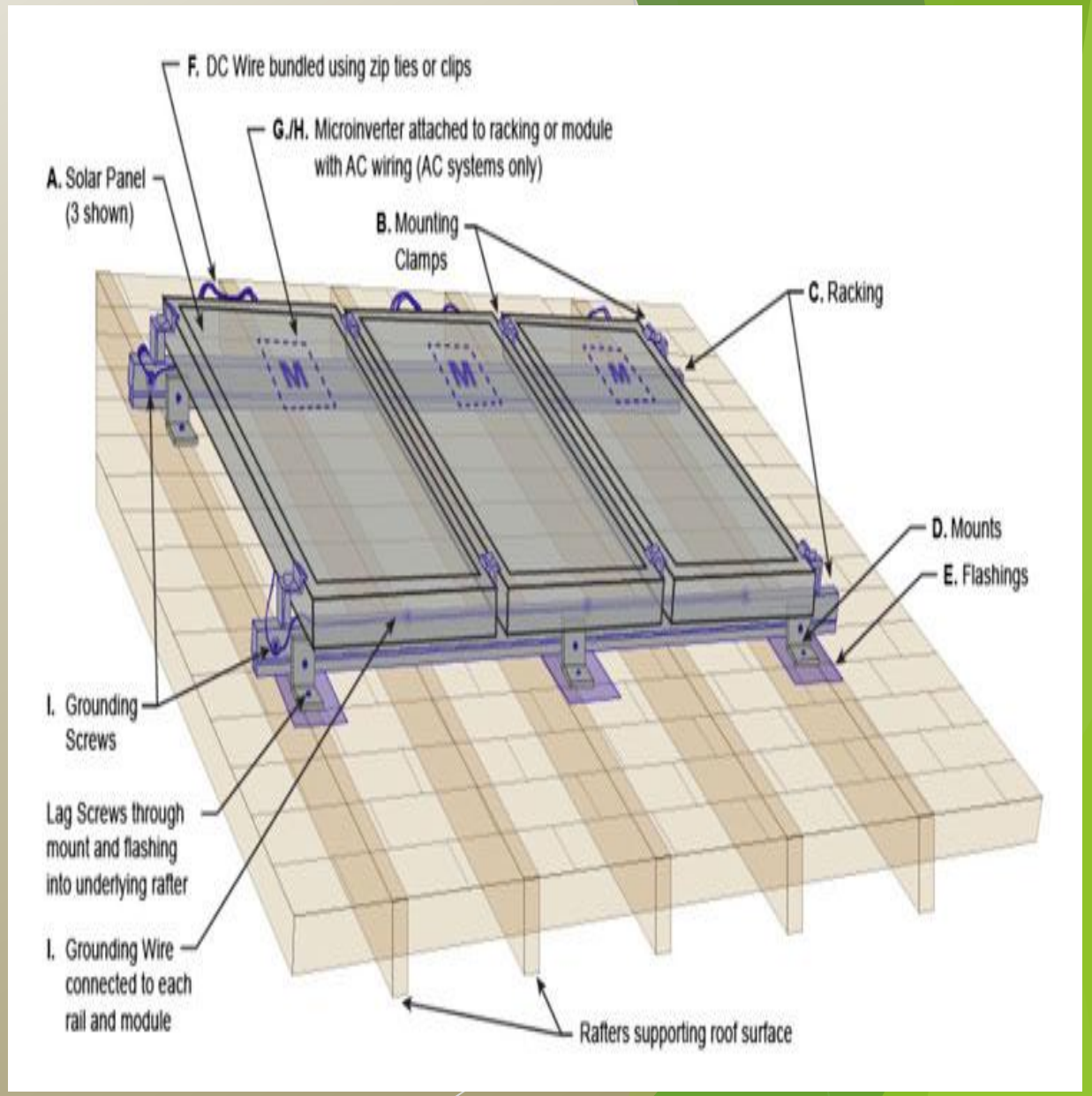
B Ht = 10’



A Base = 41’ A= 266 ft2

B Base = 38’ A = 190 ft2

9 panels is 158.4 ft2 and 2.29 kW


F. DC Wire bundled using zip ties or clips
G./H. Microinverter attached to racking or module with AC wiring (AC systems only)
A. Solar Panel (3 shown)
B. Mounting Clamps
C. Racking
D. Mounts
E. Flashings
I. Grounding Screws
Lag Screws through mount and flashing into underlying rafter
I. Grounding Wire connected to each rail and module
Rafters supporting roof surface

Example of panel type, cost and efficiencies - just for illustrative purposes

System size By efficiency and example of cost $/watt	Thin Film Economy eff 6- 15% (15%) $ 2/watt Tiles > $	Polycrystalline Standard eff 15- 18% $2.5/ watt	Monocrystalline Premium eff 18 - 22% $3/watt
5 kW	306 sq ft 17.5 x 17.5	254 sq ft	224 sq ft 15 x 15
10 kW	612 sq ft	508 sq ft	448 sq ft
15 kW	918 sq ft 30 x 30	763 sq ft	672 sq ft 26 x 26

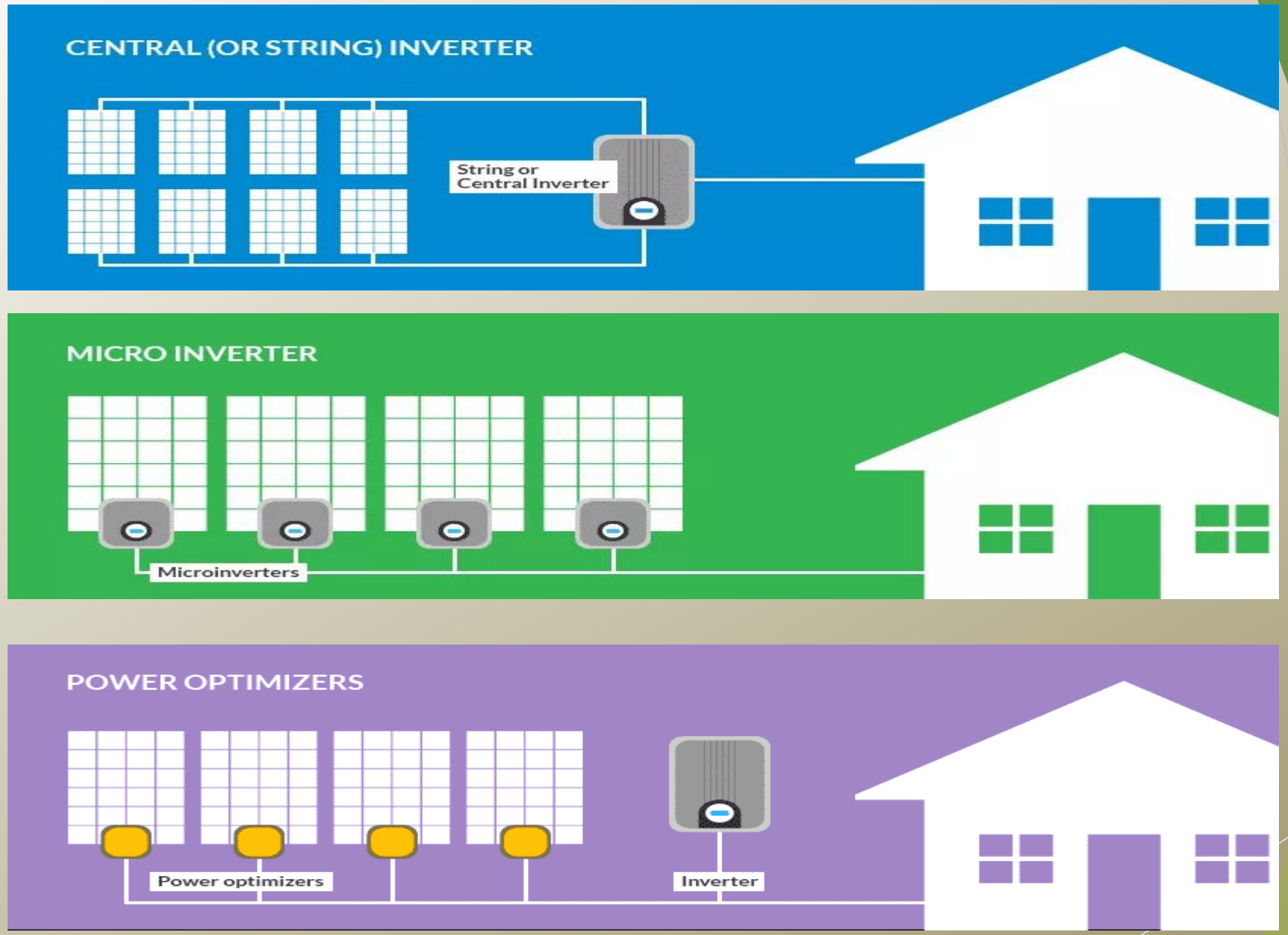
Different types of Inverters

String inverters (central inverters) connect a string of solar panels converting all DC to AC- typically centrally located near your electric panel least expensive also least efficient cannot monitor individual panels – if one panel in a string is shaded or bad it will reduce the output of the entire string- harder to expand the system

Micro-inverters connected to each solar panel – easier to expand the system. Each panel can maximize their output and not effected by shading in the string. Allows for individual panel monitoring but more difficult to replace – more efficient and most expansive

Power optimizers connected to each panel and to a string inverter. Each panel can maximize their output and not effected by shading in the string. Allows for individual panel monitoring. Allows for individual panel monitoring but more difficult to replace – more efficient and most expansive

https://www.cleanenergyreviews.info/blog/best-grid-connect-solar-inverters-sma-fronius-solaredge-abb



https://news.energysage.com/string-inverters-power-optimizers-microinverters-compared/

https://www.solarreviews.com/solar-inverter-reviews

String Inverter
(1 per solar *system*)

or

Micro-inverter
(1 per solar *panel*)

Solar residential installation costs by inverter type

In a 7 kW system add $1,000

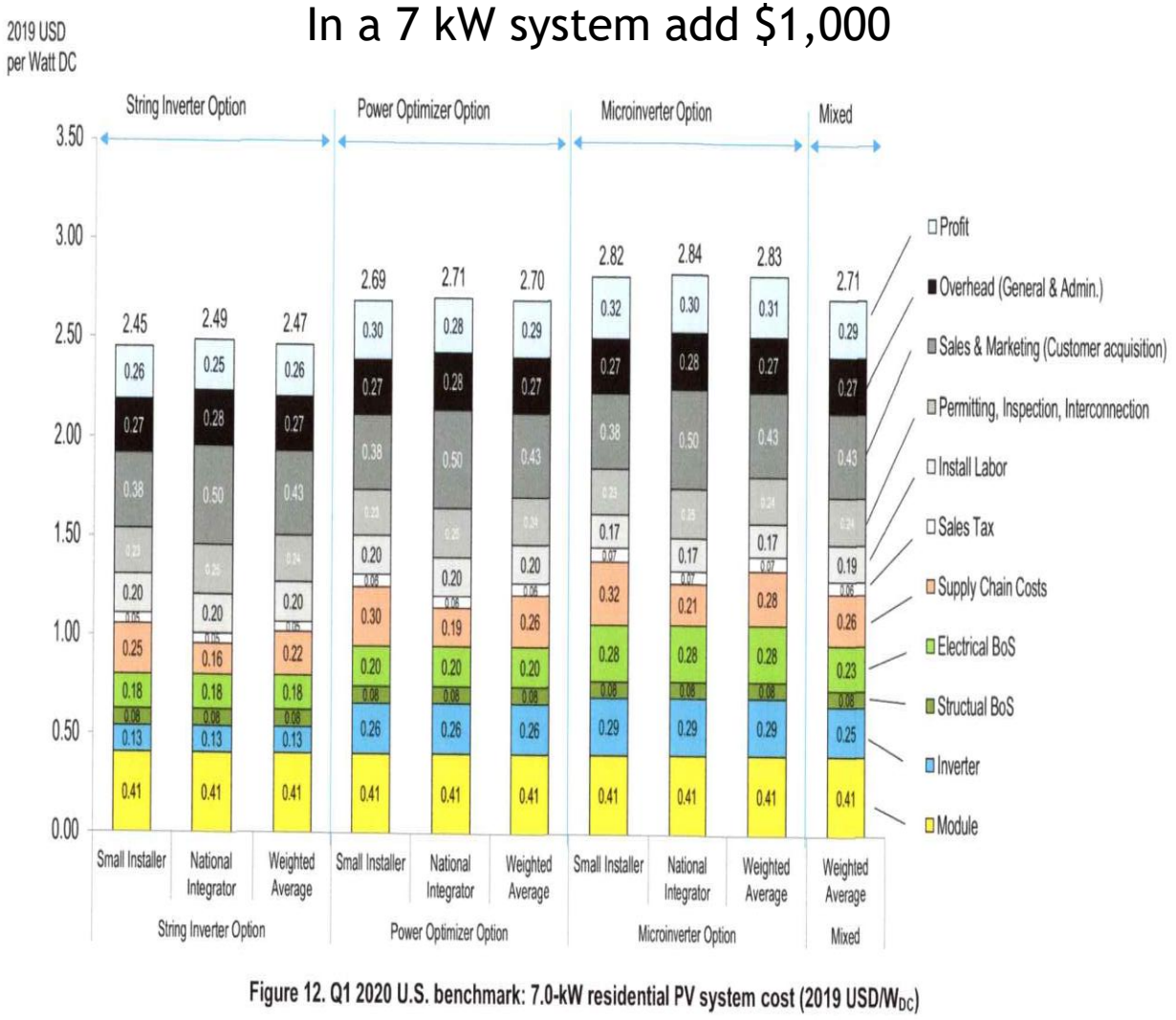
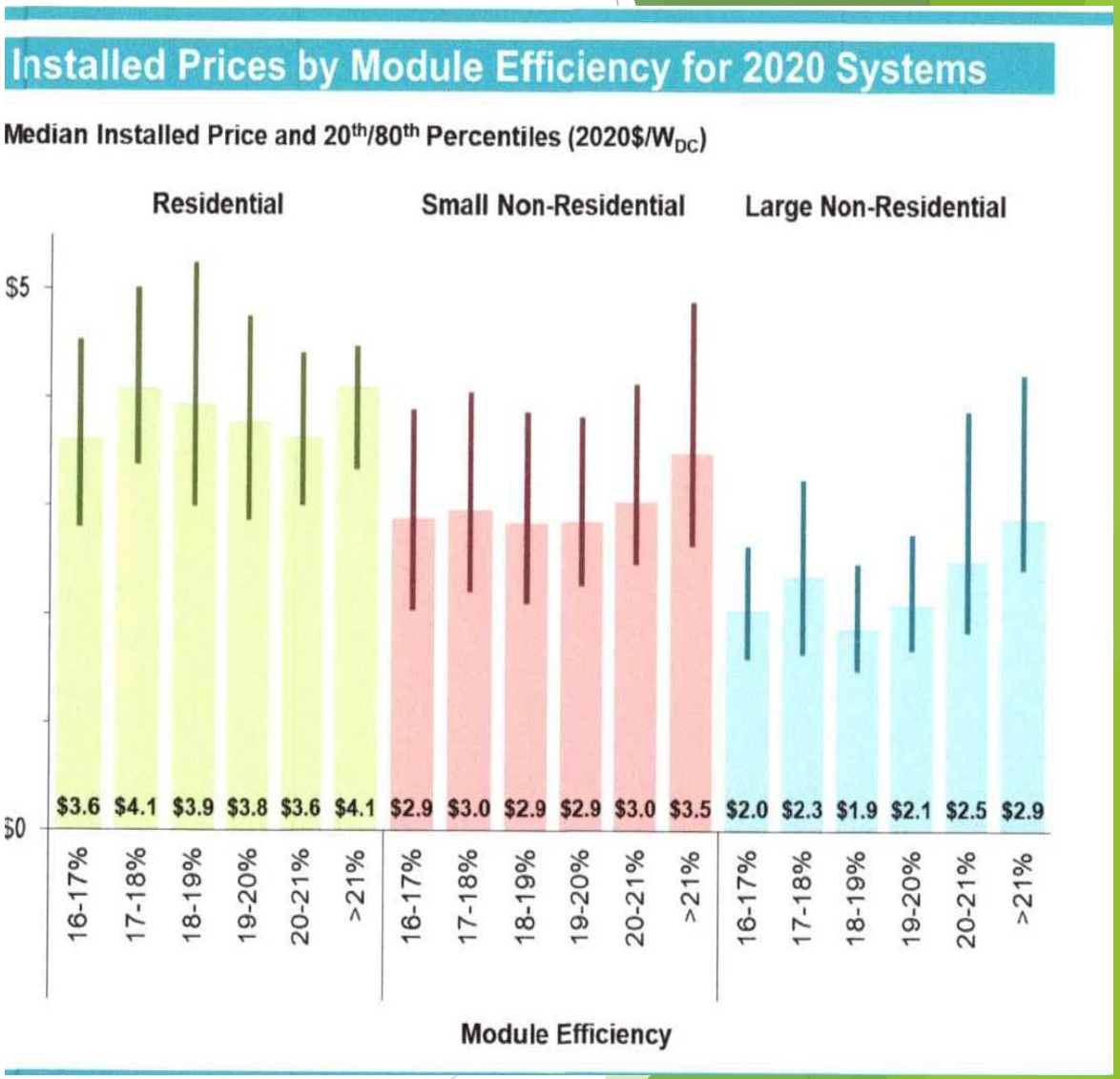


Figure 12. Q1 2020 U.S. benchmark: 7.0-kW residential PV system cost (2019 USD/W_{DC})



https://www.nrel.gov/docs/fy21osti/77324.pdf

Area of an average State to supply the annual average electricity needs

The Average US State is 75,000 sq miles and uses 75,000,000 MWh per year

At 640 ac per sq mile 75,000 sq miles is 48,000,000 Ac

A MW of solar requires 5 Ac – A MW of solar generates 1,000 MWh per year

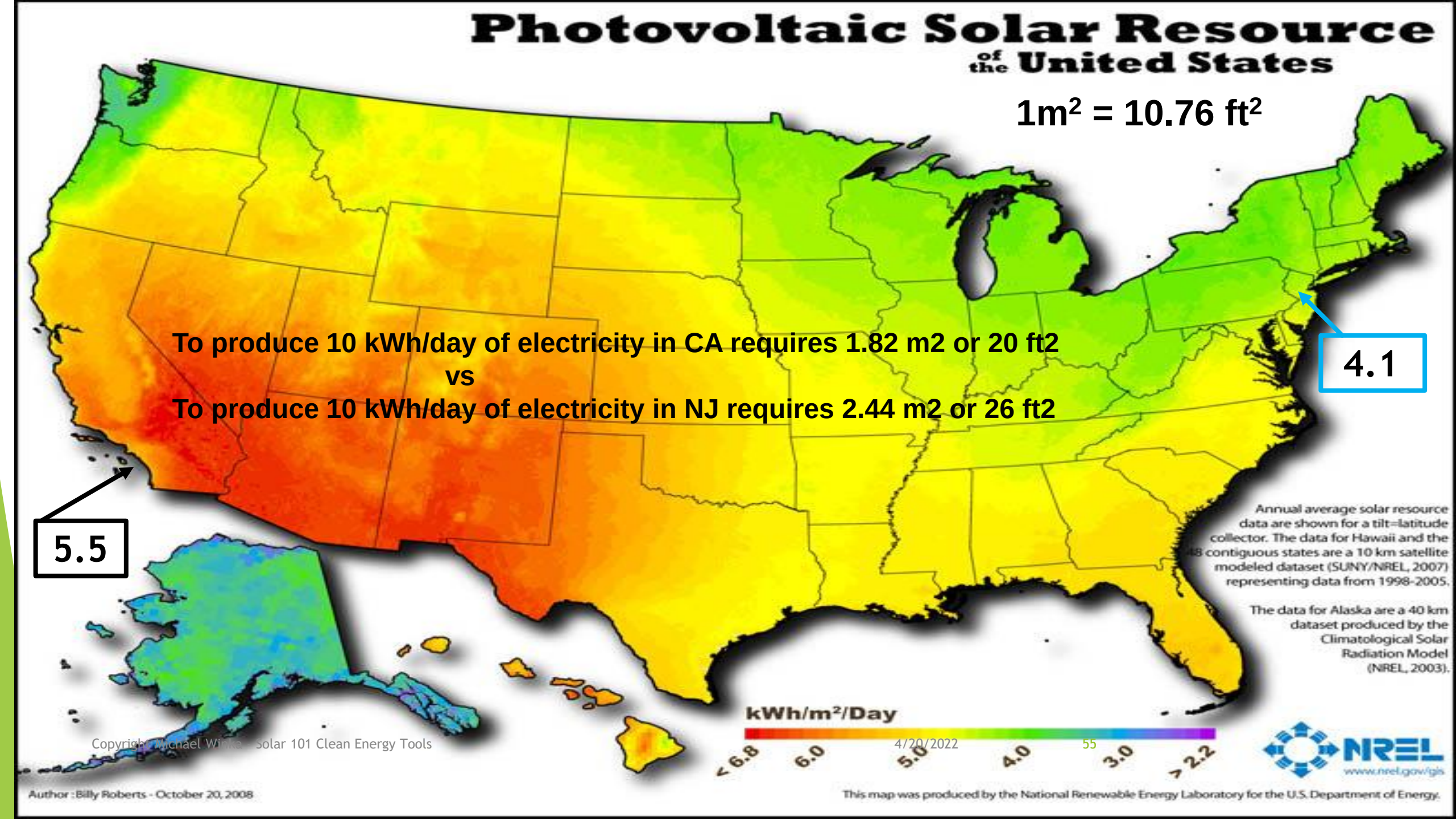
To produce 75,000,000 per year you need 75,000 MW of solar

At 5 Ac per MW that is 375,000 Ac

Which is 0.8% of the average state's land area

For NJ that 8% of NJ's land area which is less than the total rooftop space parking lots brownfield and fill areas in NJ without touch green open space or farmland

The average US state is 39% farmland – NJ is 16% farmland


Photovoltaic Solar Resource of the United States
1m² = 10.76 ft²
To produce 10 kWh/day of electricity in CA requires 1.82 m2 or 20 ft2
vs
To produce 10 kWh/day of electricity in NJ requires 2.44 m2 or 26 ft2
4.1
5.5
Annual average solar resource data are shown for a tilt=latitude collector. The data for Hawaii and the 48 contiguous states are a 10 km satellite modeled dataset (SUNY/NREL, 2007) representing data from 1998-2005.
The data for Alaska are a 40 km dataset produced by the Climatological Solar Radiation Model (NREL, 2003).
kWh/m²/Day
< 6.8
6.0
5.0
4.0
3.0
> 2.2
NREL
www.nrel.gov/gis
Author : Billy Roberts - October 20, 2008
This map was produced by the National Renewable Energy Laboratory for the U.S. Department of Energy.

Calculating the capacity (kW) that fits on you roof

Average Solar Panel is 39” X 65” = 17.6 ft^2

39” = 3.25 Ft 65” = 5.4 ft2

Example

Roof area = 27 x 27 = 730 sq ft

Solar area with set back = 460 ft2

(21 X 21) / 17.6 ft^2 = 26 panels

26 panels X 265 w/ panel = 6,960 watts or 7 kW DC

26 panels X 330 w/ panel = 8,580 watts or 8.5 kW DC

Calculating the capacity (kW) that fits on your roof and the energy it may generate (kWh)

26 panels X 265 w/ panel = 6,960 watts or 7 kW DC
Convert DC to AC – derated by efficiency of inverter

Rule of thumb of high efficiency panels

Every DC kW of solar installed = 1,200 kWh AC energy per year

---

Example
7 kW x 1,100 kWh per year per kW installed = 7,700 kWh/year AC
8.5 kW x 1,200 kWh per kW per year /kW installed = 10,200 kWh/yr
7 kW x 1,200 kWh per year per kW installed = 8,400 kWh/yr

Panels decrease about 1% per year – 80% after 25 years

RULE OF THUMB

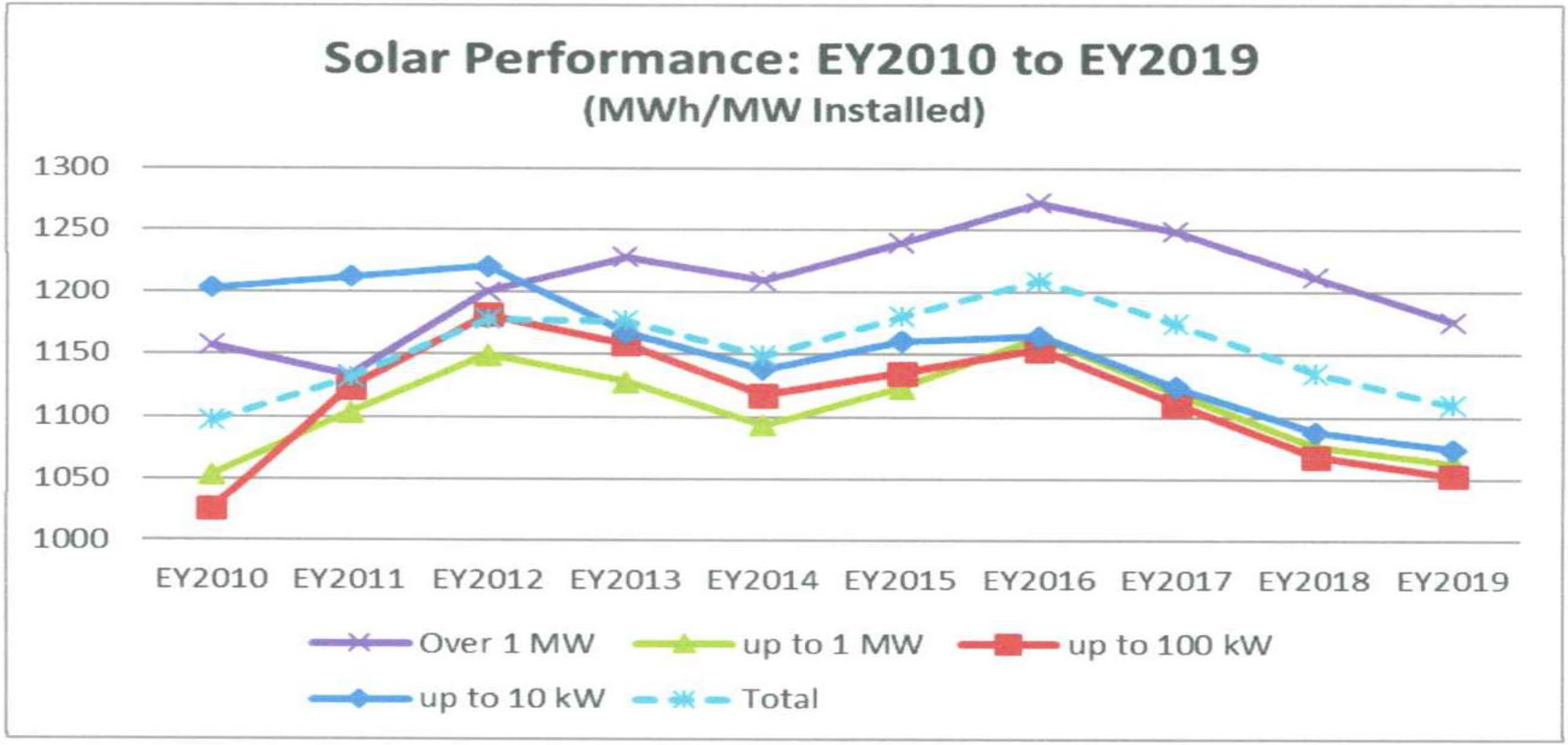
1,200 kilowatt-hours per year per KW installed
For higher efficiency panels
(1,000 to 1,100 kWh/ yr / kW installed to be conservation)

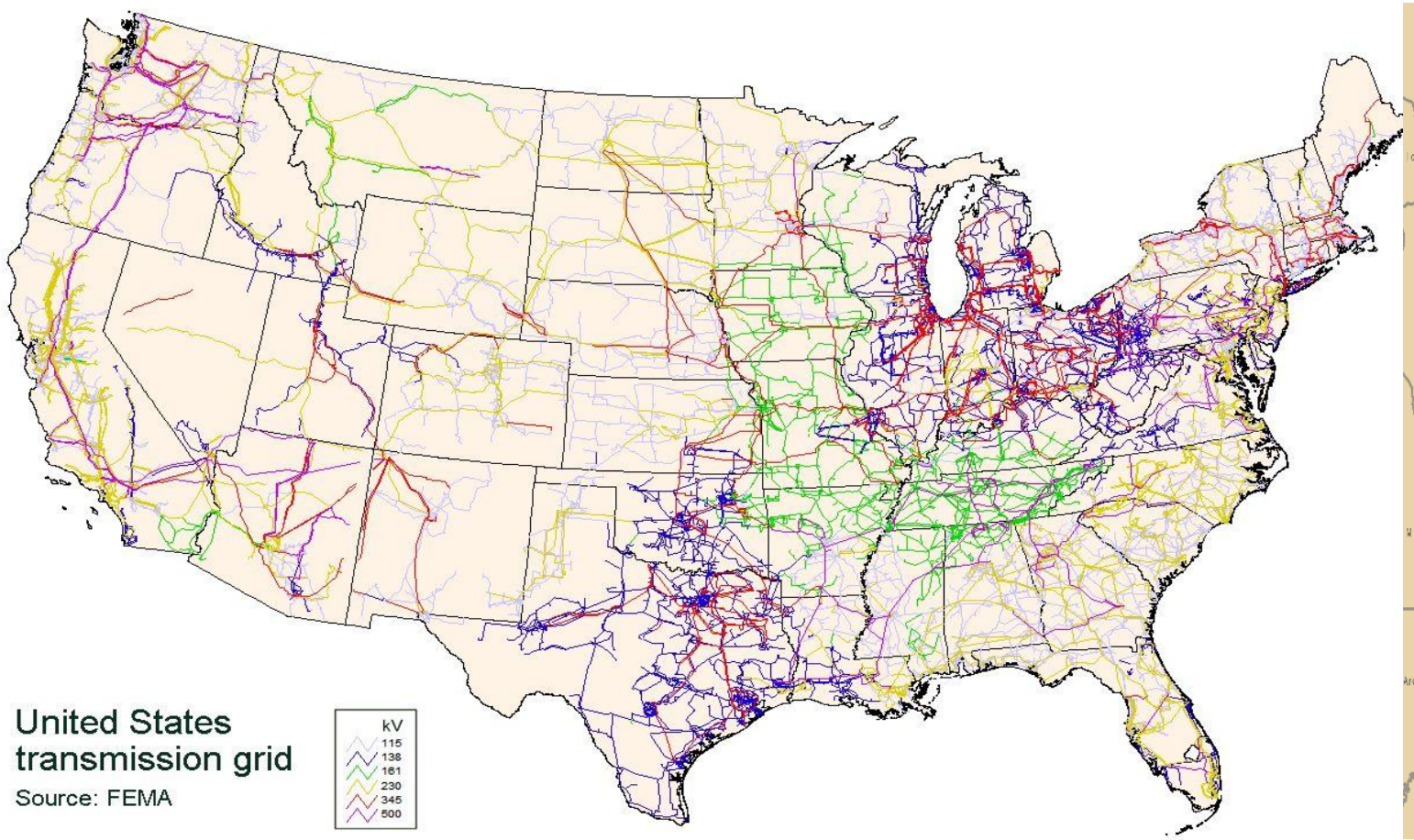
4.1 peak hours/day * 365 days/ year = 1,500 kWh/ year
1,500 kWh / year * 0.8 System eff = 1,200 kWh /kW/year

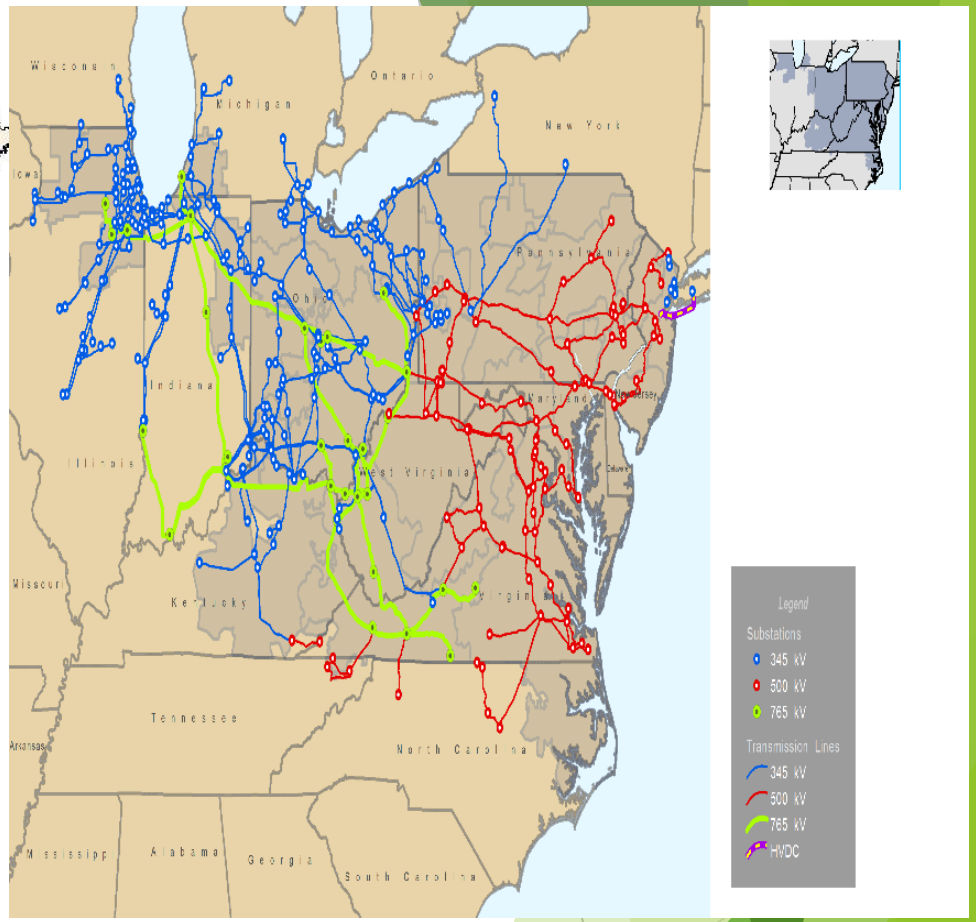
365 days per year 24 hours per days
Capacity factor = how long the sun shines – losses(efficiency)

1 kW X 365 days/year X 24hours/day X 0.14
= 1,200 kWh/ kW installed/year

RULE OF THUMB
PJM Generator Attributes Tracking System (GATS)







200,000 miles of transmission lines and 5.5 million miles of distribution wires

Questions ?

Determine you electricity usage kWh

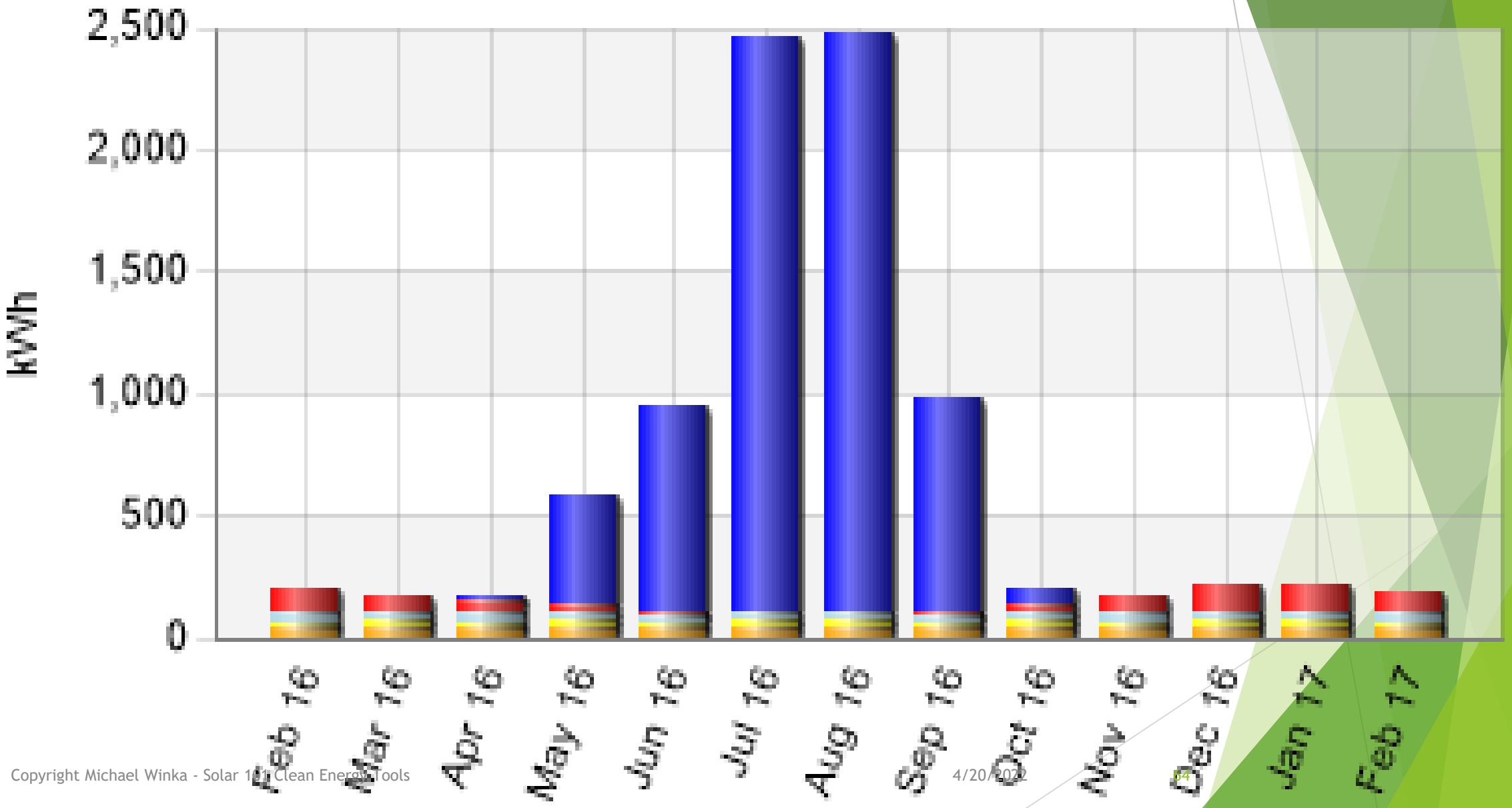
NJCEP Home Energy Analysis
https://njcleanenergy.com/residential/tools-and-resources/home-energy-analysis/home-energy-analysis

Home Energy Calculator
https://nj.pseg.com/saveenergyandmoney/energysavingpage/homeenergyassessment

Register a PSE&G account
https://nj.myaccount.pseg.com/user/login

	kWh	Electric Costs
Cooling	6,929	$1,142
Heating	498	$73
Refrigerators/Freezers	511	$78
Lighting	288	$44
Dishwasher	49	$7
Clothes Washer	28	$4
Clothes Dryer	469	$72
Elec. Base Charge	N/A	$29
Total Per Year	8,771	$1,450
Average Per Month	731	$121

8,771 kWh per year / 1,200 kWh /kW install = 7.31 kW


kWh
2,500
2,000
1,500
1,000
500
0
Feb 16
Mar 16
Apr 16
May 16
Jun 16
Jul 16
Aug 16
Sep 16
Oct 16
Nov 16
Dec 16
Jan 17
Feb 17

NREL's solar installation model – PV WATTS http://pvwatts.nrel.gov/

http://www.njcleanenergy.com/files/file/Renewable_Programs/NJCEPPVWattsCalculatorTraining21815.pdf

NREL

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at https://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

Disclaimer: The PVWatts® Model ("Model") is provided by the National Renewable Energy Laboratory ("NREL"), which is operated by the Alliance for Sustainable Energy, LLC ("Alliance") for the U.S. Department Of Energy ("DOE") and may be used for any purpose whatsoever.

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The energy output range is based on analysis of 30 years of historical weather data, and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

SOLAR RESOURCE DATA

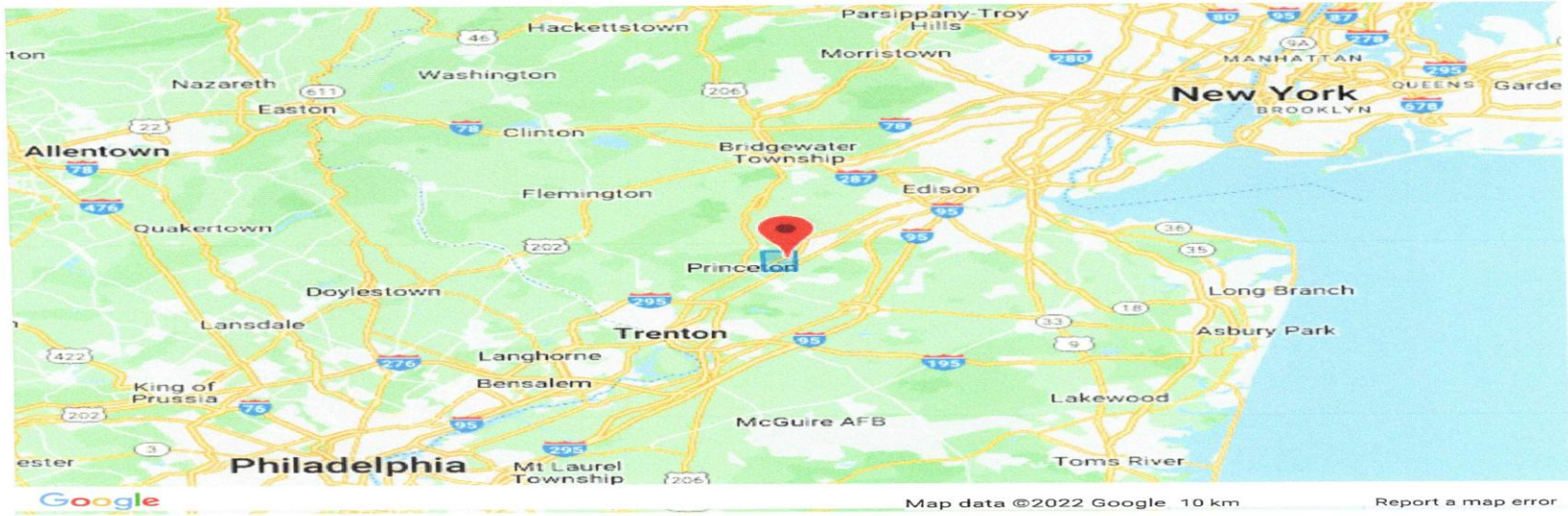
The latitude and longitude of the solar resource data site is shown below, along with the distance between your location and the center of the site grid cell. Use this data unless you have a reason to change it.

Solar resource data site

Lat, Lng: 40.37, -74.62 0.7 mi

Resource Data Map

The blue rectangle on the map indicates the NREL National Solar Radiation Database (NSRDB) grid cell for your location. If you want to use data for a different NSRDB grid cell, double-click the map to move the rectangle.
Dragging the rectangle will not move it.
If your location is outside the NSRDB area, the map shows pins for the nearest alternate data sites instead of a rectangle: Click a pin to choose the site you want to use.
See Help for details.



SYSTEM INFO

RESTORE DEFAULTS

Modify the inputs below to run the simulation.

DC System Size (kW):	7
Module Type:	Standard
Array Type:	Fixed (open rack)
System Losses (%):	14.08
Tilt (deg):	20
Azimuth (deg):	180

Loss Calculator

Draw Your System

Click below to customize your system on a map. (optional)

Advanced Parameters

SYSTEM INFO

RESTORE DEFAULTS

Modify the inputs below to run the simulation.

DC System Size (kW):

Module Type:

Array Type:

System Losses (%):

Tilt (deg):

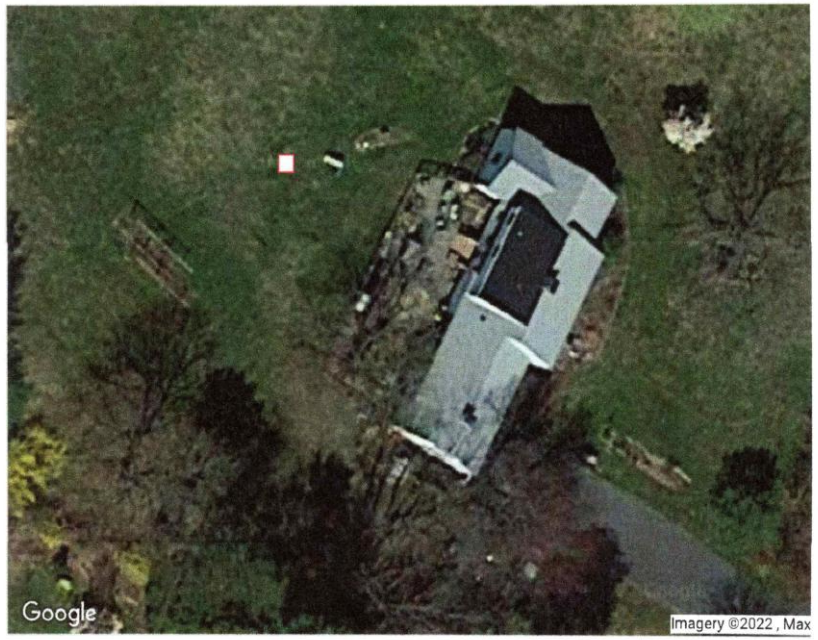
Azimuth (deg):

Advanced Paramete

Customize Your System To Your Roof

On the map below, click the corners of the desired system. Note that the roof tilt and azimuth cannot be automati
imagery, and consequently the estimated system capacity may not reflect what is actually possible.

System Capacity:



RESET

NREL's solar installation model - PV WATTS

http://pvwatts.nrel.gov/

NJCEP

http://www.njcleanenergy.com/files/file/Renewable_Programs/NJCEPPVWattsCalculatorTraining21815.pdf

DC System Size (kW): 7
Module Type: Standard
Array Type: Fixed (open rack)
System Losses (%): 14
Tilt (deg): 20
Azimuth (deg): 180
Draw Your System - customize your system on a map. (optional)
Average Cost of Electricity Purchased from Utility ($/kWh): 0.165/ kWh

Per PVWatts a 7 kW solar system facing south with a 20º slope

Month	Solar Radiation (kWh / m2 / day)	AC Energy(kWh)	Value($)
January	3.01	540	89
February	3.97	624	103
March	4.86	805	133
April	5.56	869	143
May	5.68	898	148
June	6.19	930	154
July	6.35	975	161
August	5.94	902	149
September	5.12	780	129
October	4.01	660	109
November	3.39	554	91
December	2.69	472	78
Annual	4.73	9,009	$ 1,487

NREL's solar installation model – PV WATTS

http://pvwatts.nrel.gov/

Month	Solar Radiation(kWh / m2 / day)	AC Energy(kWh)	Value($)
January	2.31	405	73
February	3.25	505	91
March	4.32	714	128
April	5.28	824	148
May	5.70	897	161
June	6.29	940	169
July	6.38	974	175
August	5.73	868	156
September	4.65	707	127
October	3.39	554	100
November	2.62	420	76
December	2.00	340	61
Annual	4.33	8,148	$ 1,465

7 KW south facing at 0° tilt – SPB – 9.6 years

Month	Solar Radiation(kWh / m2 / day)	AC Energy(kWh)	Value($)
January	3.68	649	117
February	4.58	709	128
March	5.16	841	151
April	5.48	846	152
May	5.24	821	148
June	5.61	837	151
July	5.83	887	160
August	5.74	862	155
September	5.32	798	144
October	4.49	726	131
November	4.11	661	119
December	3.37	582	105
Annual	4.88	9,219	$ 1,661

7 KW south facing at 40° tilt – 8.4 years

Month	Solar Radiation(kWh / m2 / day)	AC Energy(kWh)	Energy Value($)
January	1.03	172	31
February	1.75	272	49
March	2.79	493	89
April	3.92	668	120
May	5.03	866	156
June	5.45	888	160
July	5.20	863	155
August	4.51	742	134
September	3.37	539	97
October	2.09	340	61
November	1.15	184	33
December	0.85	143	26
Annual	3.10	6,170	$ 1,111

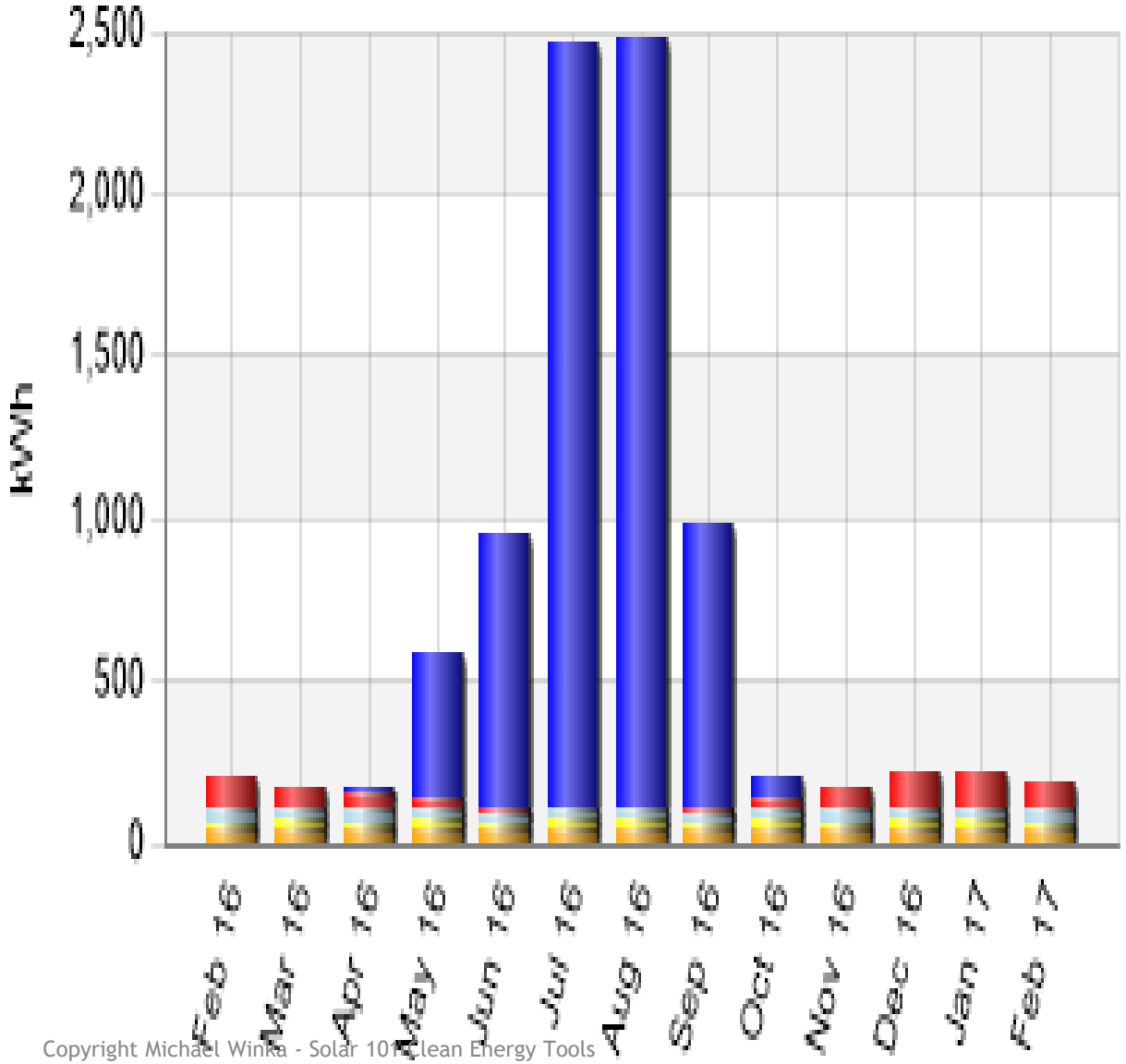
7 KW north facing at 20° tilt –
SPB = 12.6 years -

Month	Solar Radiation(kWh / m2 / day)	AC Energy(kWh)	Energy Value($)
January	1.87	346	62
February	2.68	450	81
March	3.62	662	119
April	4.48	768	138
May	5.40	928	167
June	5.73	929	167
July	5.45	901	162
August	5.03	827	149
September	4.19	684	123
October	3.10	537	97
November	2.01	347	62
December	1.61	291	52
Annual	3.76	7,670	$ 1,379

7 KW east facing at 20° tilt
SPB = 10.1 years

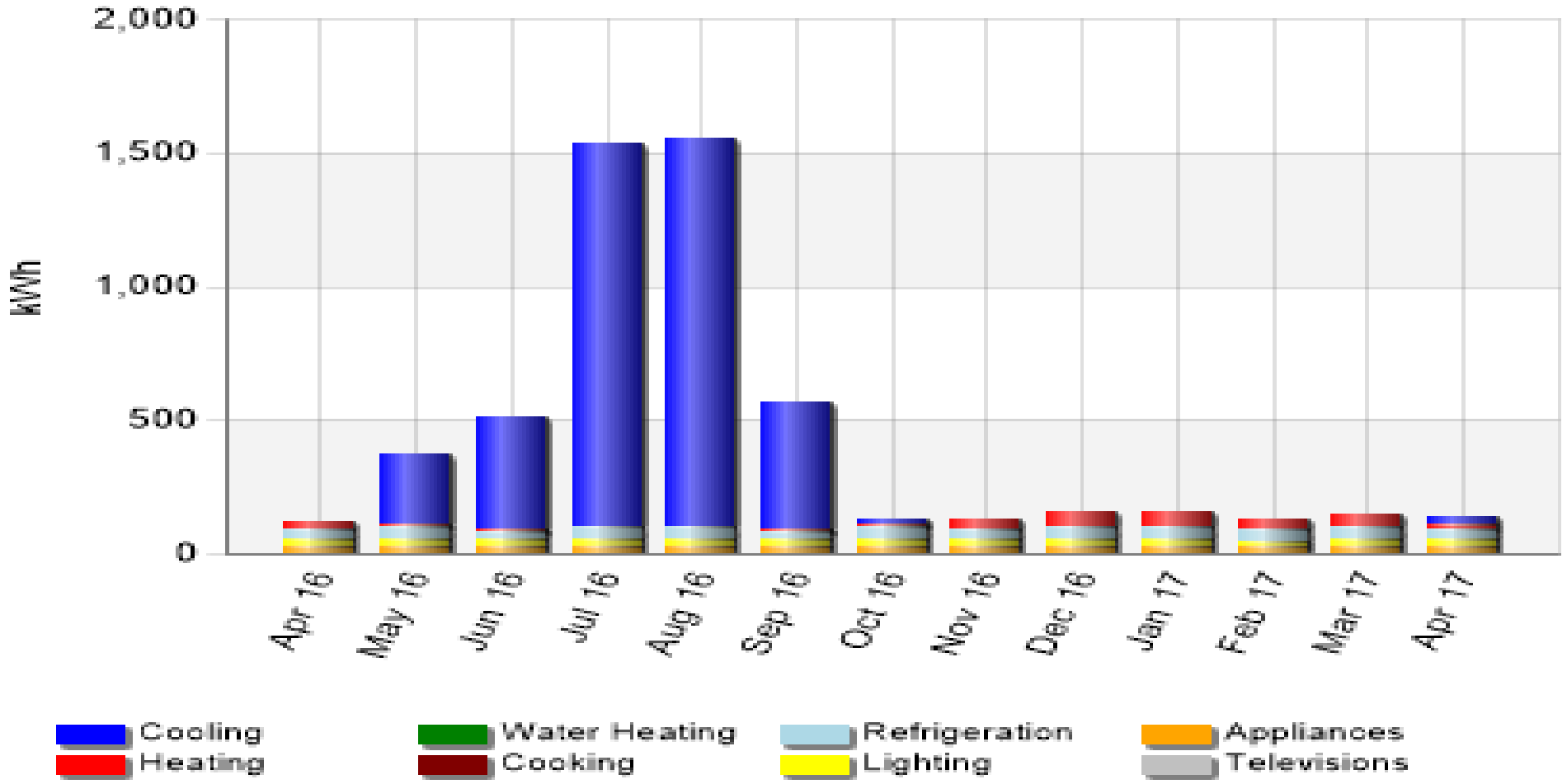
Month	Solar Radiation(kWh / m2 / day)	AC Energy(kWh)	Energy Value($)
January	1.97	363	65
February	2.66	443	80
March	3.59	653	118
April	4.45	762	137
May	5.38	923	166
June	5.63	910	164
July	5.52	913	164
August	5.00	822	148
September	4.17	678	122
October	3.06	526	95
November	1.86	318	57
December	1.60	288	52
Annual	3.74	7,599	$ 1,368

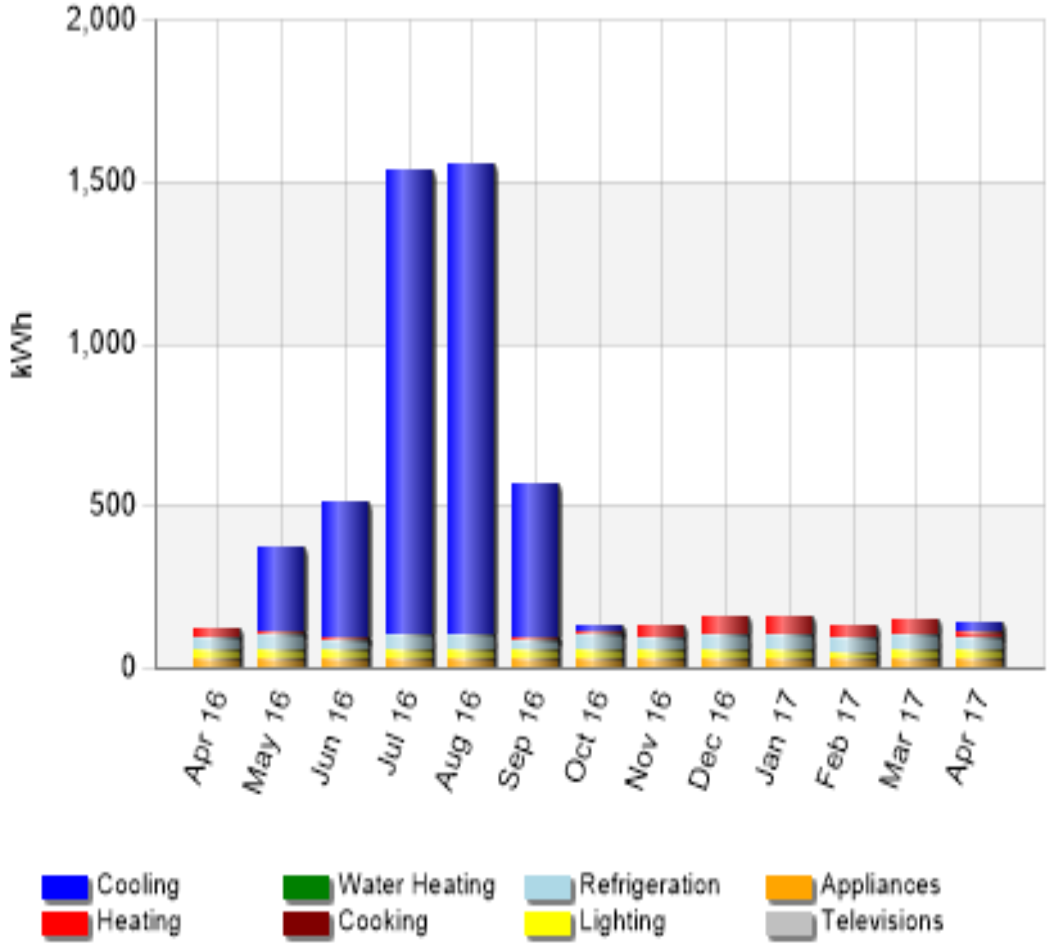
7 KW west facing at 20° tilt
SPB = 8 years10.2



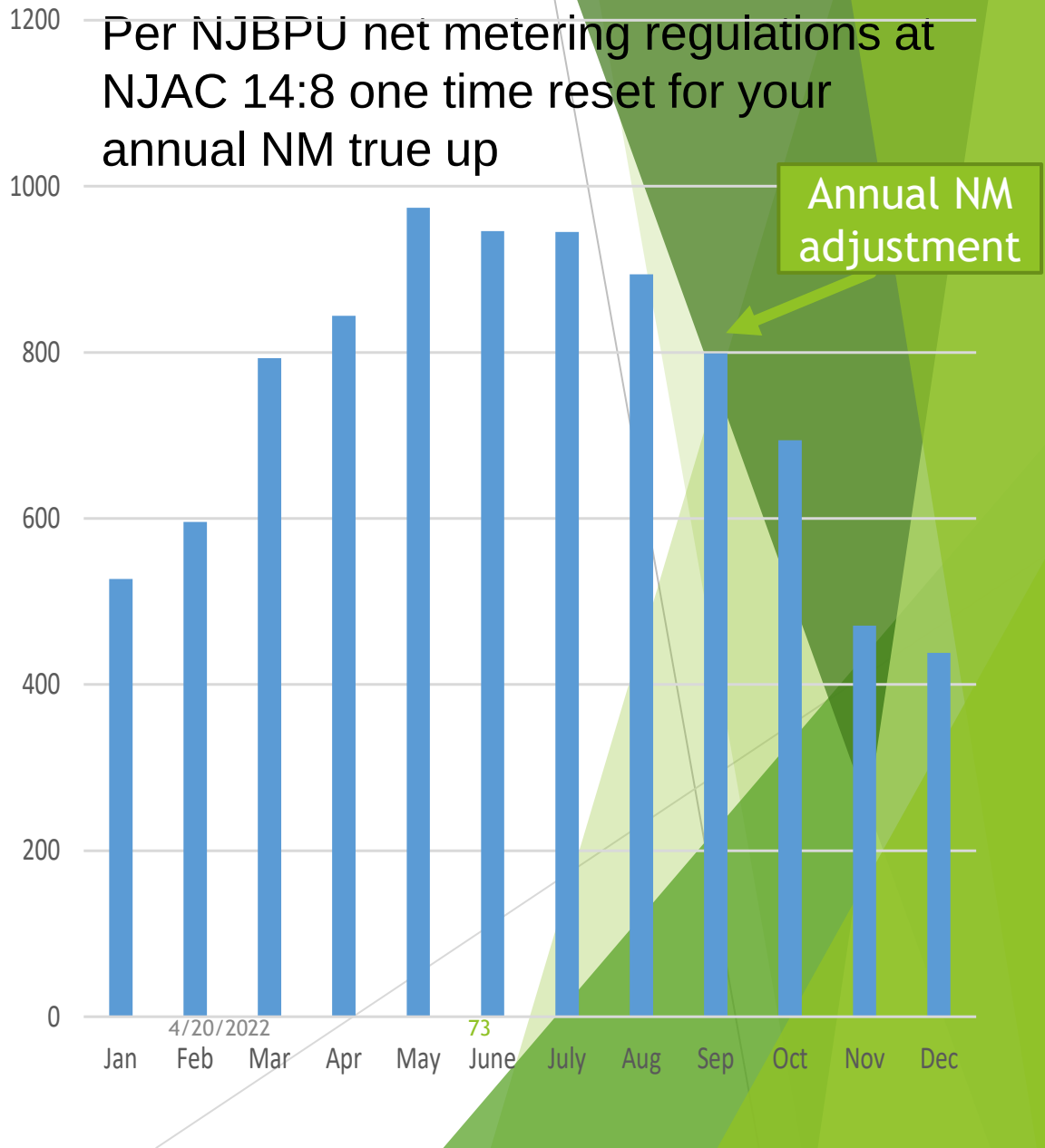
Month	Solar Radiation(kWh / m2 / day)	AC Energy(kWh)	Value($)
January	3.01	540	89
February	3.97	624	103
March	4.86	805	133
April	5.56	869	143
May	5.68	898	148
June	6.19	930	154
July	6.35	**975**	161
August	5.94	**902**	149
September	5.12	780	129
October	4.01	660	109
November	3.39	554	91
December	2.69	472	78
Annual	4.73	9,009	$ 1,487

July and August electricity usage = 1,500 KWh/month more than the PV system generates but net over the Year it is 0


2,000
1,500
1,000
500
0
kWh
Apr 16
May 16
Jun 16
Jul 16
Aug 16
Sep 16
Oct 16
Nov 16
Dec 16
Jan 17
Feb 17
Mar 17
Apr 17
Cooling
Heating
Water Heating
Cooking
Refrigeration
Lighting
Appliances
Televisions



Per NJBPU net metering regulations at NJAC 14:8 one time reset for your annual NM true up



5 best solar estimators & calculators

coperniq.io

- Max Kazakov
  - Jan 31, 2021
  - 3 min read

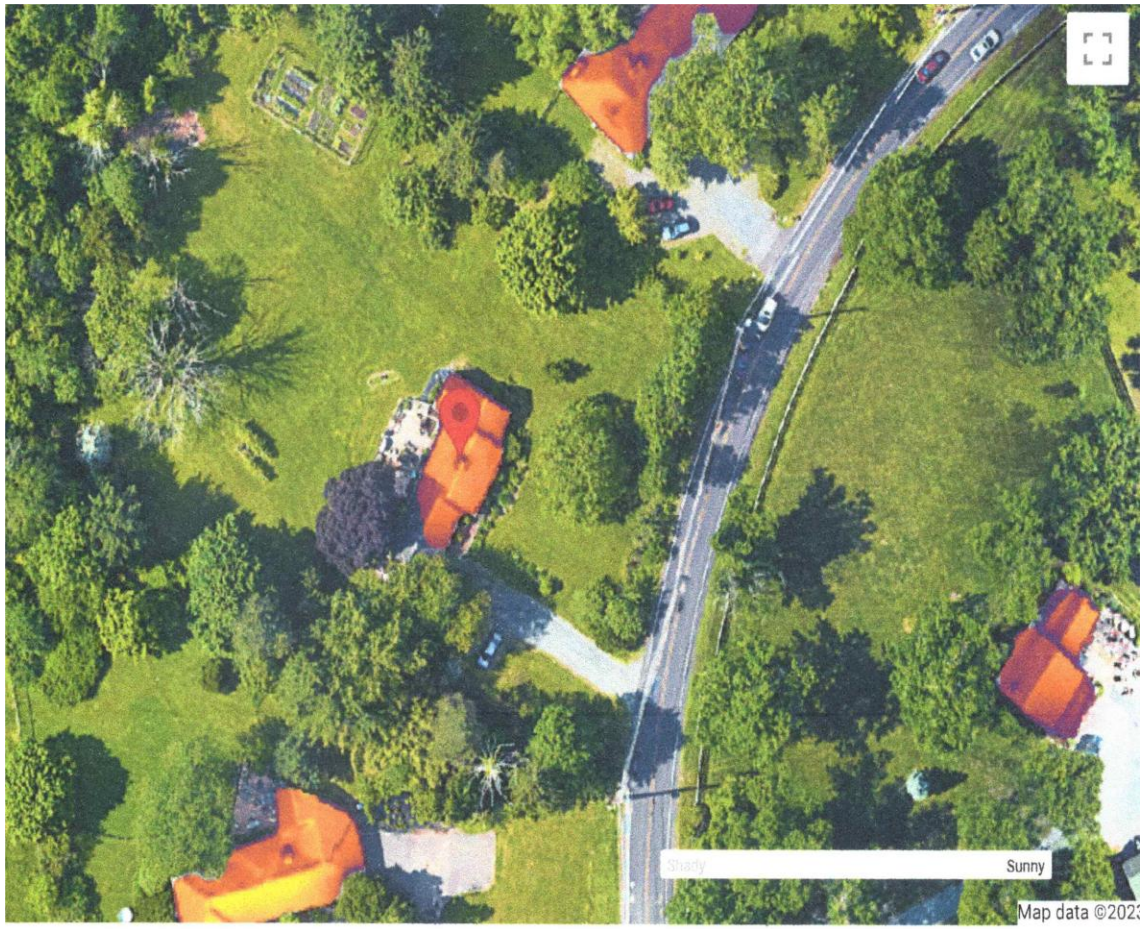
1. Google Project Sunroof (<1 min to estimate)

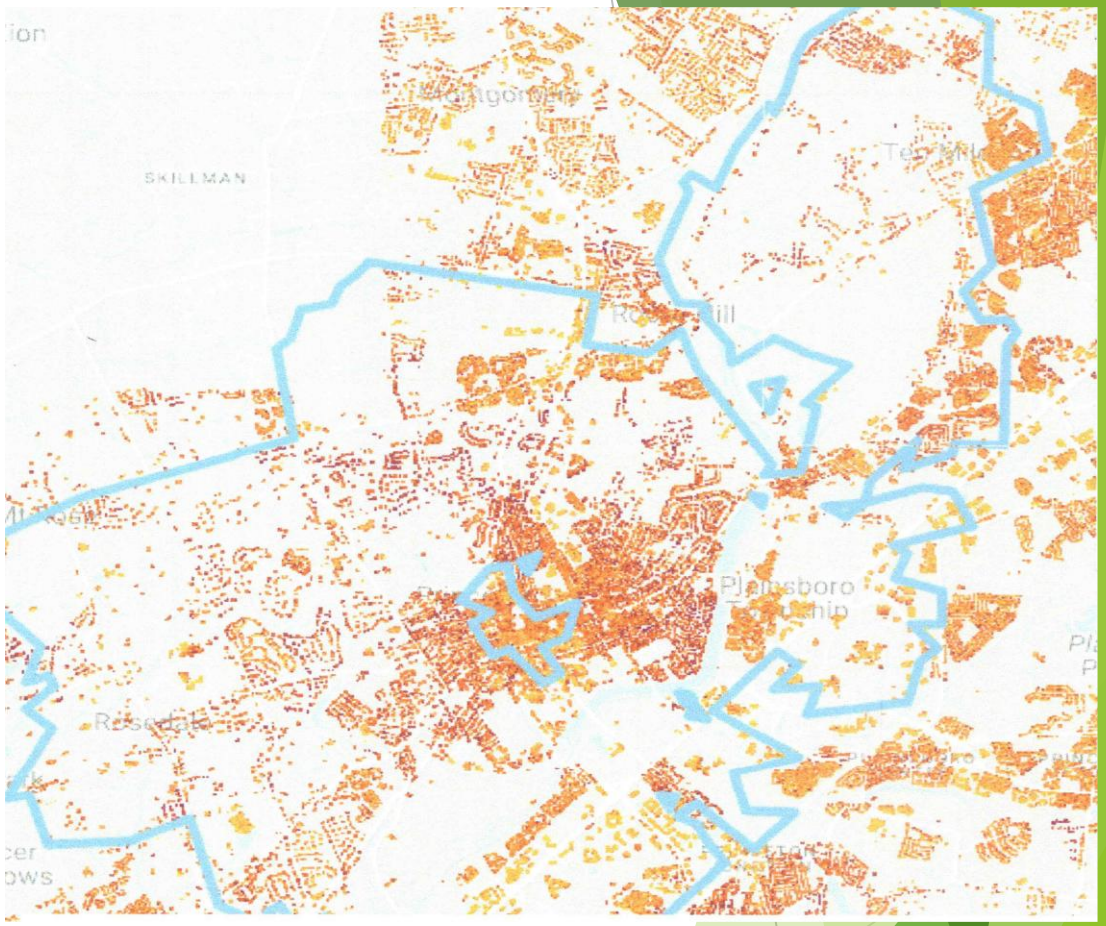
2. PV Watts (<1 min to estimate)

3. EnergySage (<1 min to estimate)

4. Solar.com (3 min to estimate, must sign in with email)

5. Sunpower (3 min to estimate, must give personal info)





1,427 sq ft of available roof space
1,351 hours of solar resources per year
8.5 kW solar system to produce 98% of electricity needs
$27,000 net savings over 20 years

71% of rooftop available for solar @ 75% annual needs
993 kWh/kW installed
10,100 roof 15.7 M sq ft 223MW
257,000 MWh per year
80% of Princeton total annual electricity needs

Calculate your simple payback period (SPP)

The payback period is the amount of time it will take to recoup the initial cost of an investment, or to reach its break-even point.

$$\text{SPP} = \frac{\text{Total cost}}{\text{Total annual revenues /year}} = \text{years}$$

1 / SPP = Return on Investment (ROI)

Calculate your simple payback

Calculate your cost (capital cost - incentives)
Example
7 kW X $3 per watt installed = $21,000
7 kW x $3,000/ kW
Sales tax exemption and Property tax exemption

30% federal Investment tax credit ITC = $6,300

$14,700 is the net cost of the 7 kW solar PV system after accounting for your ITC

***Tracking the Sun* – LBL- NREL USDOE energy labs**
https://emp.lbl.gov/tracking-the-sun

Calculate your simple payback
Calculate your annual revenues
Example

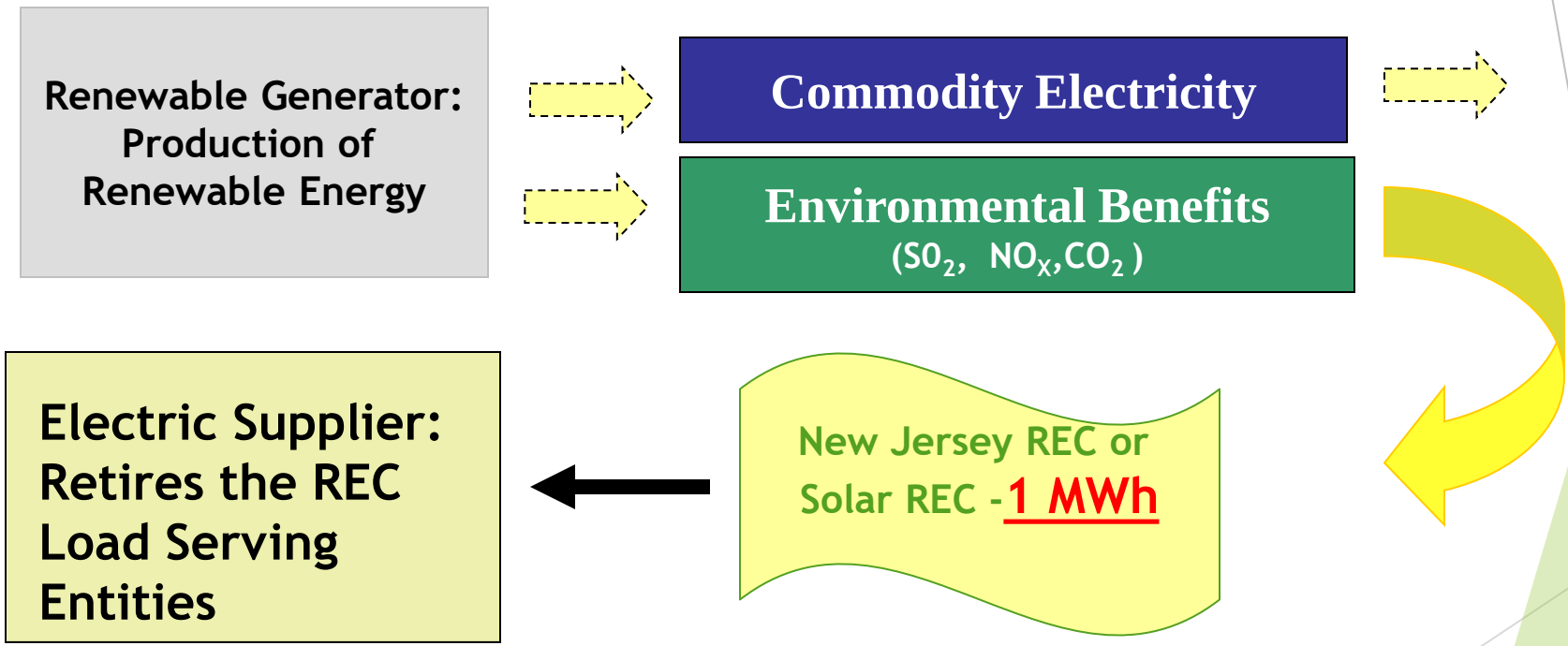
Avoided electricity generated
9,000 kWh per year
Annual value for NM/IX at $ 0.1988/kWh (per EIA)
= $1,789 per year

Solar Renewable Energy Credit (SREC) = 1 MWh or 1,000 kWh
SREC II generated = 9 per year
Successor Solar Incentive (SuSi) at $85 per MWh = $765

Total revenues = $1,789 + $756 = $2,545/year

New Jersey

Renewable Energy Certificates (RECs)



Certificates represent the environmental benefits and other attributes associated with electricity generated from a renewable energy generator . May be traded independently of underlying electricity.

Calculate your simple payback
The New Jersey Solar Incentive is now a feed-in-tariff

Successor Solar Incentive (SuSI) - SREC II
The incentive is administratively determined (ADI)

Value of SuSI is fixed based on blocks
Residential IX - $85 per MWh or per SREC II
Qualification life = 15 year
7kW = 9,000 kWh or 9 MWh = 9 SREC II @ $85/SREC = $765 / year

Total net cost for 7 kW is $14,700
15 years of SREC at $85/MWh is $11,475

REVISED Energy Year 2023 ADI Capacity Blocks by Market Segments

Market Segments	System Size	MW (dc) Capacity Blocks
Net-Metered Residential	**All Sizes**	**250**
Net Metered Non-Residential	All sizes at or below 5 MW (dc)	257.836
Community Solar including LMI and Non-LMI	All sizes at or below 5 MW (dc)	150
Interim Subsection (t) Grid	CLOSED	5.19

https://njcleanenergy.com/renewable-energy/programs/susi-program/adi-program

Market Segments	System Size MW (dc)	Incentive Values ($/SREC-II)	*Public Entities (($20 Adder)
Net-Metered Residential	**All Sizes**	**$85**	**N/A**
Small Net-Metered Non-Residential located on Rooftop, Carport, Canopy and Floating Solar	Projects smaller than 1 MW (dc)	$110	$120
Small Net Metered Non-Residential Ground Mount	Projects smaller than 1 MW (dc)	$90	$105
Large Net Metered Non- Residential located on Rooftop, Carport, Canopy and Floating Solar	Projects 1 MW to 5 MW (dc)	$100	$110
Large Net Metered Non-Residential Ground Mount	Projects 1 MW to 5 MW (dc)	$85	$100
Community Solar LMI	Up to 5 MW (dc)	$90	N/A
Community Solar Non-LMI	Up to 5 MW (dc)	$70	N/A
**Interim Subsection (t) Grid	All Sizes	$100	N/A

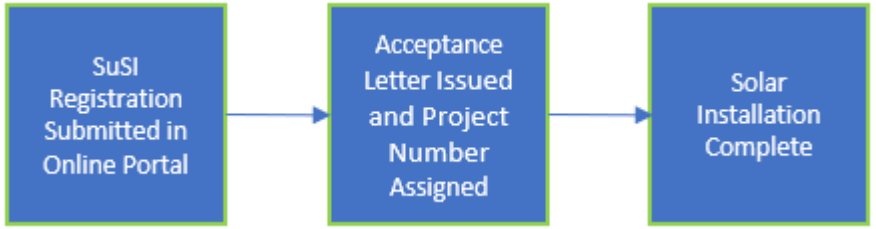
REVISED ADI Incentive (SREC-IIs) Values Per Market Segment

Effective March 13, 2023

Market Segments	System Size MW (dc)	Current SREC-II Value	*REVISED* SREC-II Value	Public Entities ($20 Adder)
Net-Metered Residential	All Sizes	$90	$85	N/A
Small Net-Metered Non-Residential located on Rooftop, Carport, Canopy and Floating Solar	Projects smaller than 1 MW (dc)	$100	$110	$130
Small Net Metered Non-Residential Ground Mount	Projects smaller than 1 MW (dc)	$85	$90	$110
Large Net Metered Non-Residential located on Rooftop, Carport, Canopy and Floating Solar	Projects 1 MW to 5 MW (dc)	$90	$100	$120
Large Net Metered Non-Residential Ground Mount	Projects 1 MW to 5 MW (dc)	$80	$85	$105
Community Solar Non-LMI	Up to 5 MW (dc)	$70	No Change	N/A
Community Solar LMI	Up to 5 MW (dc)	$90	No Change	N/A

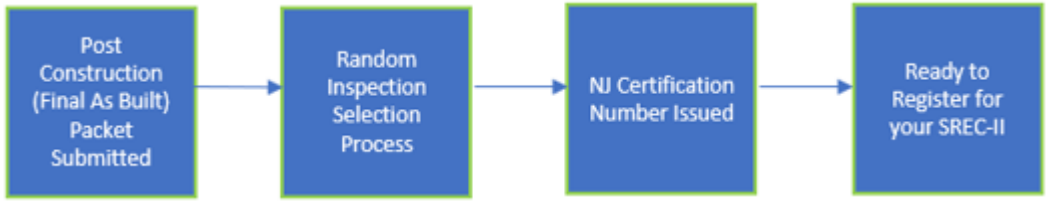
The SuSI Program has a Two-Step Registration Process to get Certified:

STEP ONE:



Before Construction/installation

STEP TWO:



Post Construction

STEP THREE:

OPEN A PJM-EIS GENERATION ATTRIBUTE TRACKING SYSTEM (GATS) ACCOUNT

STEP FOUR:

OPEN A PAYMENT ACCOUNT WITH THE SREC-II ADMINISTRATOR

For any questions regarding the status of your SuSi registration, please contact, NJREINFO@NJCleanEnergy.com.

ADI Program Key Eligibility Requirements:

•Net-metered residential, non-residential solar facilities 5 MW (dc) or less, and community solar projects.

•Projects located on property types that were previously eligible to seek conditional certification from NJBPU under Subsection (t), now be referred to as “interim Subsection (t) projects.”

•Solar facilities that have not yet reached commercial operation (defined as permission to operate) prior to the opening of the ADI Program.

•Solar facilities that reached commercial operation before August 28, 2021, must be granted special dispensation by NJBPU to participate in the ADI Program.

•All solar equipment must be new.

•Solar facilities connected to a distribution or transmission system owned or operated by a New Jersey public utility or local government unit.

•Solar facilities receiving incentives that are 1 MW (dc) or greater in size are subject to the Prevailing Wage Act N.J.S.A. 34:11-56.25, et seq.

Calculate your simple payback

Total Capital cost – Incentives
Total Revenues (avoided electricity and SREC)

$14,700 / $2,545/year = SPP
about 5.78 years or about 17% ROI

If you get a loan you need to calculate the time value of money – NPV & DCF
NREL solar installation, performance cost and financing model –
System Advisor Model SAM https://sam.nrel.gov/

Options to Purchase your solar

1. Pay Cash upfront
2. Finance through a loan 10/15 year loan
3. Solar Lease 15 -25 year lease
4. Power Purchase Agreement PPA 15 -25 year

Evaluate your costs and benefits within your risk profile

https://www.njcleanenergy.com/renewable-energy/tools-and-resources/ownership-financing-options
https://www.cesa.org/wp-content/uploads/Homeowners-Guide-to-Solar-Financing.pdf

Step 6. Options to Purchase your solar

Solar Loan

Advantages	Disadvantages
Homeowner eligible to receive applicable federal and/or state tax and/or other incentives*	Not all homeowners can obtain a loan
Homeowner eligible to receive Solar Renewable Energy Credits (SRECs),** which can be sold	Homeowner responsible for relatively minor costs associated with maintenance and repair of system and possible minor increases in insurance costs
Homeowner owns the solar system and therefore has significant ability to manage it independently	Poor performance or low SREC values may reduce homeowner's ability to repay
In most cases, lower overall cost	

Solar Lease Power Purchase Agreement (PPA)

Advantages	Disadvantages
Little or no upfront cost to homeowner, ownership at the end of the lease term may accrue to the site host	Most leases restrict some property owner activities, for example, new construction that may cast shade on the system, roof replacement, property sale, etc.
Leasing company usually responsible for maintenance and repair of system (most systems require little of either)	Tax incentives may not accrue to the site host

Difference between a lease and a PPA is in a lease you pay monthly to rent the solar equipment and in a PPA you buy the solar electricity at a fix rate or an with an annual escalator

Step 6. Options to Purchase your solar

Questions	Solar Lease	PPA	Solar Loan
Who buys the system?	Third-party developer	Third-party developer	Homeowner
Who owns the system?	Third-party developer	Third-party developer	Homeowner
** Who owns the SRECs?	Third-party developer	Third-party developer	Homeowner
*Who takes advantage of federal and State tax incentives?	Third-party developer	Third-party developer	Homeowner
Who is responsible for the operation and maintenance of the solar equipment?	Typically, third-party developer	Third-party developer	Homeowner-Solar equipment should have manufacturer warranty for at least five years from the date of installation
Who is responsible for damage or destruction to the solar system?	Third-party developer	Third-party developer	Homeowner
What happens if the homeowner sells the home where the solar system is located?	This should be defined in the contract agreement	This should be defined in the contract agreement	Homeowner owns the system and can leave the system in place or relocate the system to new home

https://www.njcleanenergy.com/renewable-energy/tools-and-resources/ownership-financing-options

PAS Its Electrifying - Solar 101

Best advise – hire a reliable solar professional

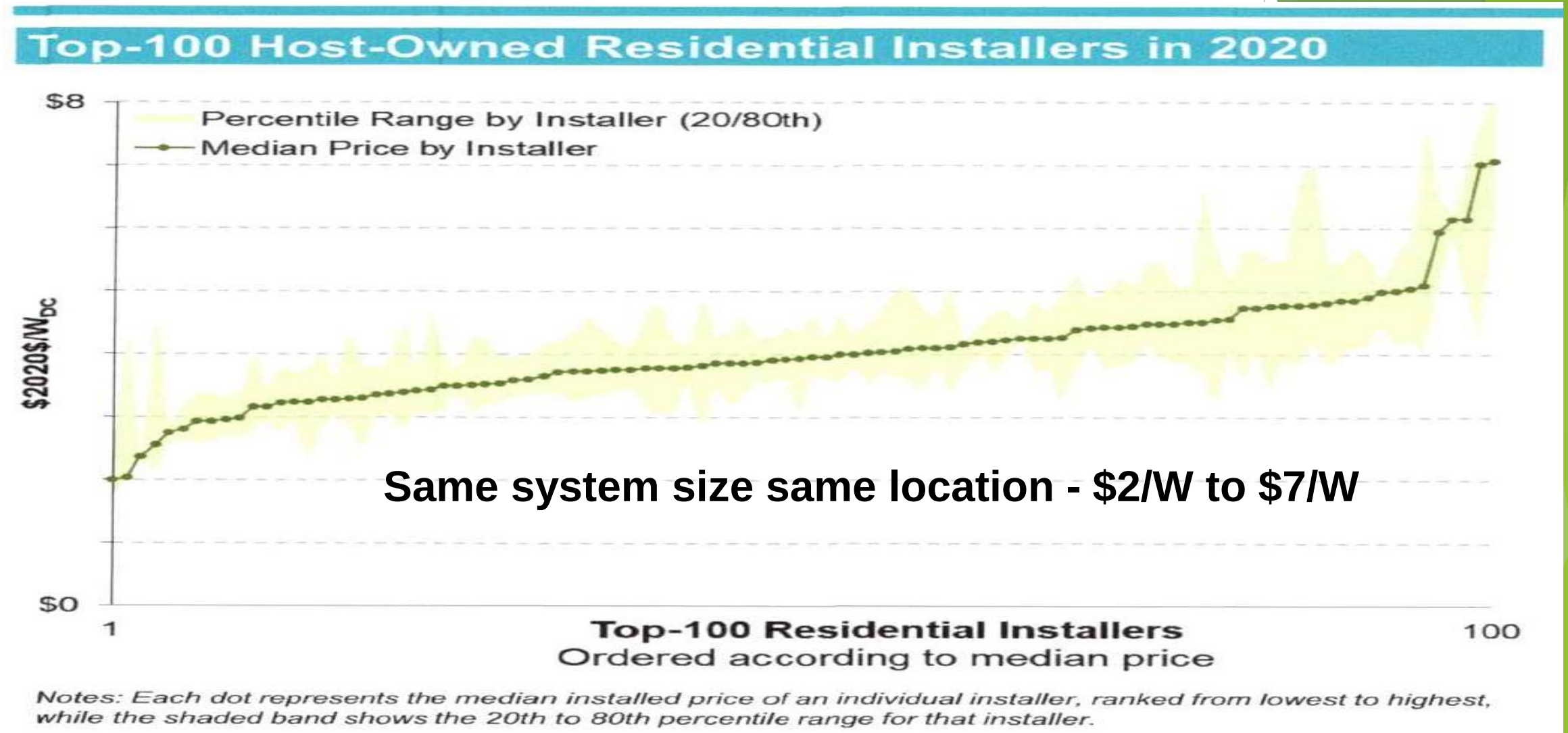
NJCEP website trade ally - https://njcleanenergy.com/findavendor

https://njcleanenergy.com/renewable-energy/project-activity-reports/project-activity-reports

Google- how to hire a solar installers
Grain of salt - relatively independent

Energy Sage - https://www.energysage.com/
Solar Review - https://www.solarreviews.com/
Solar Power World-https://www.solarenergyworld.com/

Why it is important to call multiple vendors and get multiple quotes



https://www.nrel.gov/docs/fy21osti/77324.pdf

https://emp.lbl.gov/sites/default/files/2_tracking_the_sun_2021_report.pdf

Estimating your PV solar size and cost
Two methods - both get to the same answer

Calculate the size in kW that can fit on your roof
Calculate the amount of energy that system can generate
Determine the amount of electricity you use monthly/yearly
Calculate the size in kW you need based on electricity use
Determine any EE measures to reduce electricity use
Calculate costs of your system
Calculate the total revenues of your system
Calculate simple payback of your system
Decide how to purchase/finance your system

All basically rough estimates

Questions ?

Adding Storage as part of a New or Existing Solar System

What is Storage – A way to capture energy for later use
Mainly electricity since oil and natural gas are already stored energy

Many ways to store energy
Pump Hydro
Thermal Storage
Capacitor
Flywheels
Batteries Li ion, Pb acid, Ni-Cd, M+ hydride, Zn air, Alkaline flow batteries
Li Ni Co and Li Fe PO4 wet vs dry cells vs solid state

Basically a metal + and a electrolyte -

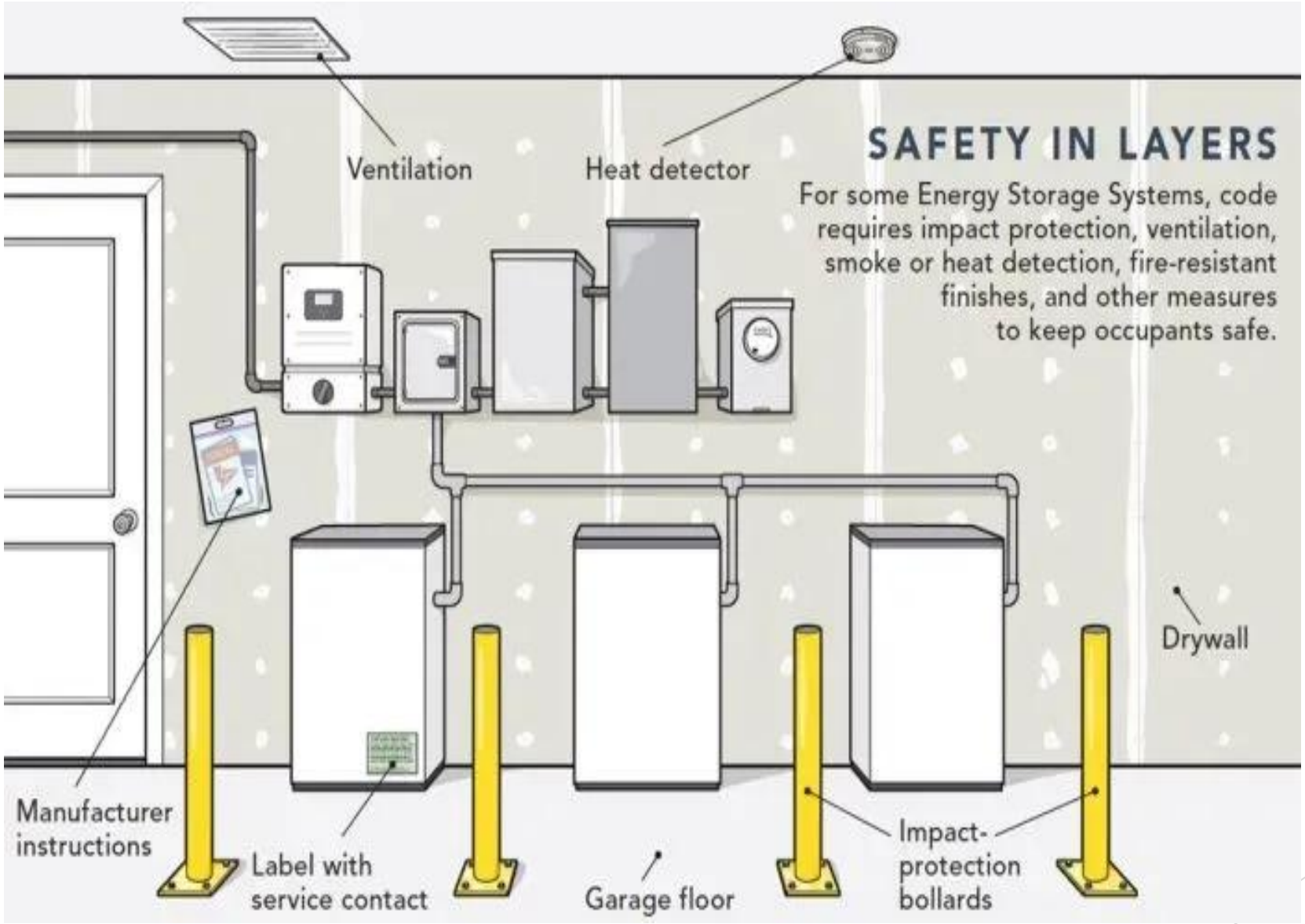
Storage is more complex than solar

Solar is essentially plug and play

Storage – especially battery storage requires routine monitoring and maintenance to operate properly

If you are good at routine maintenance battery may be OK for you

If not you need to think about how to get the system serviced


SAFETY IN LAYERS
For some Energy Storage Systems, code requires impact protection, ventilation, smoke or heat detection, fire-resistant finishes, and other measures to keep occupants safe.
Ventilation
Heat detector
Drywall
Manufacturer instructions
Label with service contact
Garage floor
Impact-protection bollards

Battery Terms

Energy – kWh

Power - kW

Depth of Discharge – 100% 80-90% > 40%

Round trip efficiency (charging – discharging) – losses > 80%

Duration – 1 hour, 4 hours, 8 hours

Battery Life 8 – 10 years 6,000 - 10,000 cycles > 70% (15+ years)

Watts, Volts and Amp and Amp-hours

AC or DC coupling

Do you want a integrated system or custom

https://www.cleanenergyreviews.info/battery-storage-comparison-chart

Battery Company	Price Per KWh*	Typical Battery Size**	Total Installed Cost After The Federal Tax Credit
Enphase	$1,344/kWh	10 kWh	$9,408
Tesla	$1,000/kWh	13.5 kWh	$9,450
FranklinWH	$1,103/kWh	13.6 kWh	$10,501
SolarEdge	$1,683/kWh	9.7 kWh	$11,428
Panasonic	$1,111/kWh	9 kWh	$6,999
EG4	$1,049/kWh	11.44 kWh	$8,400
SunPower	$1,304/kWh	13 kWh	$11,866
Growatt	$1,289/kWh	9 kWh	$8,121
Generac	$1,961/kWh	9 kWh	$12,354
HomeGrid	$1,332/kWh	9.6 kWh	$8,951

Cost of top 10 battery brands

**The median price per kWh of the 10 most quoted batteries on EnergySage in the first half of 2024.*

***The median usable capacity of the 10 most quoted batteries on EnergySage in the second half of 2024.*

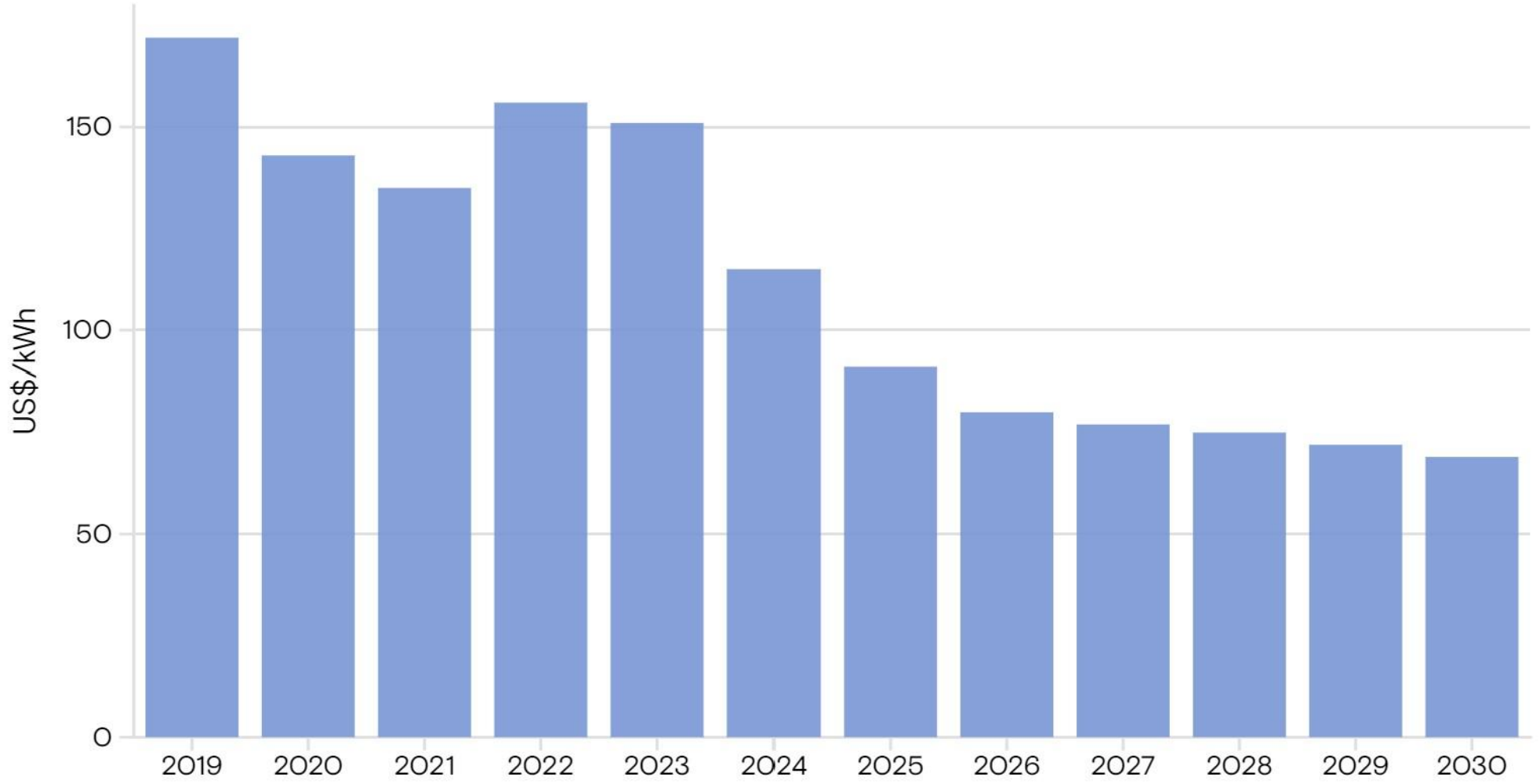
https://www.solarreviews.com/solar-battery-reviews

https://news.energysage.com/best-solar-batteries/

https://www.energysage.com/energy-storage/how-much-do-batteries-cost/

Battery prices are forecast to fall

Global average battery pack prices



Source: Company data, Wood Mackenzie, SNE Research, BNEF, Goldman Sachs Research
2023-2030 are estimates

Goldman Sachs

Battery - start small with a battery power pack

The EMP mitigation measures are not perfect
Need to know the issues to pull together a "real" plan

Solar – only generates electricity when the sun is shining – less in the winter, more in the summer
end of life issues – recycling/reuse

OSW – only generates electricity when the wind is blowing - more in the winter. less in the summer
end of life issues – recycling/reuse

Storage – expensive, impacts in mining, lower performance in cold weather,
end of life issues – recycling/reuse

EV – expensive, impacts in mining, impacts in disposal, lower performance in cold weather

Heat pumps – lower performance in cold weather, may need a backup in very cold weather

The Grid – needs to be expanded to manage double the load and inverter based

These mitigation technologies are good but not 100% and not for everyone today
The key is incremental – implement where it works and build up and out

Transportation Sector - Going Electric

How to Change the Demand Curve for Oil and Gasoline to Prevent Future Oil pipelines
Start slow and small and build into a movement

MM Btu is a million Btus

Used EV for under $20,000 (+ $2,000 - level 2 charger)
50 miles RT for 260 days (5 day work week)

An average ICE vehicle
520 gal/ yr - 60.3 MM Btus/yr -$1560/yr. ($3.00)

An average EV
3,900 kWh /yr - 13.3 MM Btu - $640/yr.($0.14)
4.5 times less energy - 2.4 times less cost
Savings $1,124/yr. avoiding 3.74 MT of CO2

3,900 kWh / year - 3.5 kilowatts (kW) of solar
@$3/watt SPP for EV and solar 15 yrs. (ROI 6.7%)
Avoiding 4.62 MT of CO2
Reducing both gasoline and natural gas demand and emissions and storage solar electricity

Building Sector - Going Electric

How to Change the Demand Curve for Natural Gas to Prevent Future Natural gas pipelines
Start slow and small and build into a movement

GWH = $1,200
230 therm - 23 million Btus $320/yr emitting 2.3T
HPWH = $2,500
2,000 kWh 6.8 million Btus $330 /yr emitting 0.5T
3 times less energy - Avoiding 1.8 T of CO2

2,000 kWh /year = 1.5 kilowatts (kW) of solar @ $3/W = $3,330
HPWH + solar = 10.5 years (ROI 9.5%)
Avoiding 2.3 T of CO2

Reducing natural gas demand in electric and heating sectors
A major advantage is you can store your solar electricity in the HPWH

30% federal tax credit plus $600 Utility EE incentive

Can you electrify your home to
light, heat, and cool your home and charge your EV's
powered by your own fuel by 2035 ?
What would it take?

Questions ?

Princeton Adult School - Solar 101

Thank You
Michael Winka
energy translator
mwinka@comcast.net