

Powering a Home, Farm, or Business with Solar Electric: Tips and Tools for Project Evaluation

Noble County Ag Breakfast

June 19, 2020



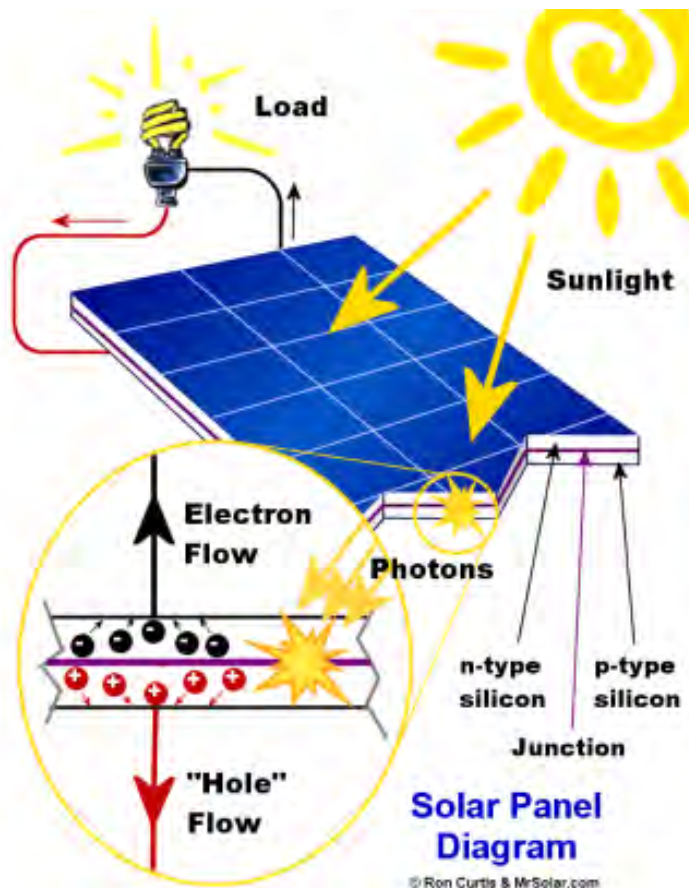
THE OHIO STATE UNIVERSITY

COLLEGE OF FOOD, AGRICULTURAL,
AND ENVIRONMENTAL SCIENCES

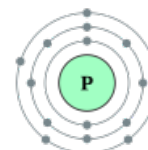
Program Learning Objectives

- Solar Energy Trends in Ohio
- Photovoltaic Solar System Cost
- System Design Tips to Optimize Production
- Photovoltaic Solar System Financial Analysis
- Strengths and Weaknesses of Financial Metrics
- Closing Thoughts

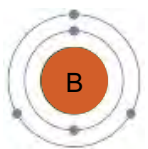
Photovoltaic Solar: How Does It Work?



Silicon
- 4 valence electrons



Phosphorus
- 5 valence electrons

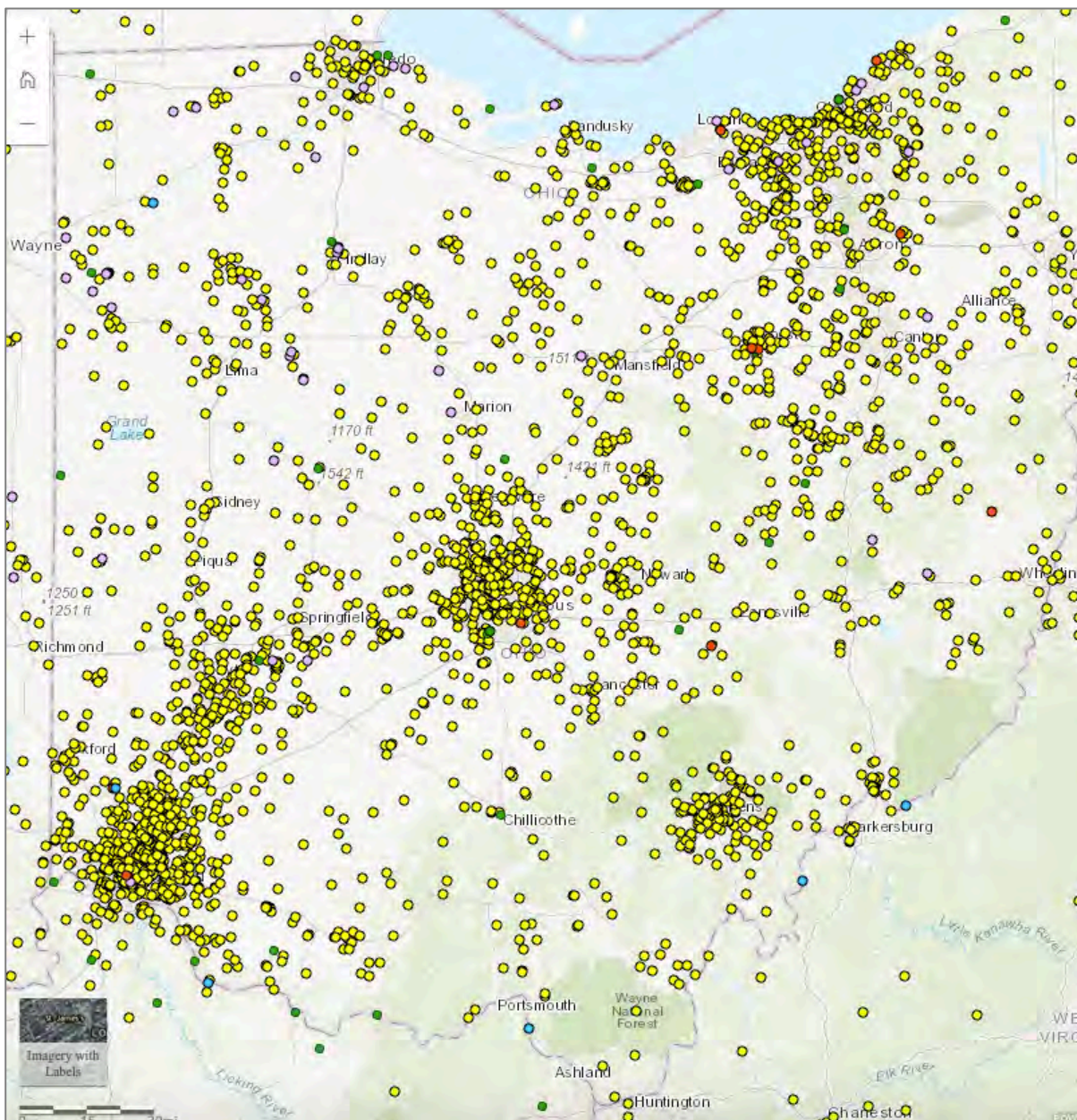


Boron
- 3 valence electrons

Photovoltaics (PV) is the process of **converting light into electricity**. When light hit a solar cell, photons dislodge electrons from their atoms. When conductors are attached to the positive and negative sides of a cell it forms an electrical circuit allowing electrons to flow, generating electricity.

Solar Energy Trends in Ohio

Renewable Energy Facilities Registered With PUCO



Size (Capacity)	# of Projects	Megawatts
> 50 MW	-	-
25 MW to 50 MW	1	29
10 MW to 25 MW	2	28
5 MW to 10 MW	3	23
1MW to 5 MW	39	82
< 1 MW	2,801	92
Total	2,846	253

**Distributed
Solar Projects -
What Type of
Farm Should
Consider PV
Solar?**



Veterinarian Clinic



Small Farm



Poultry Farm



Dairy Farm



Swine Finishing Barn



Grain Dryer

Photovoltaic Solar System Cost

U.S. Solar System Cost Benchmark Assumptions: Q1 2018

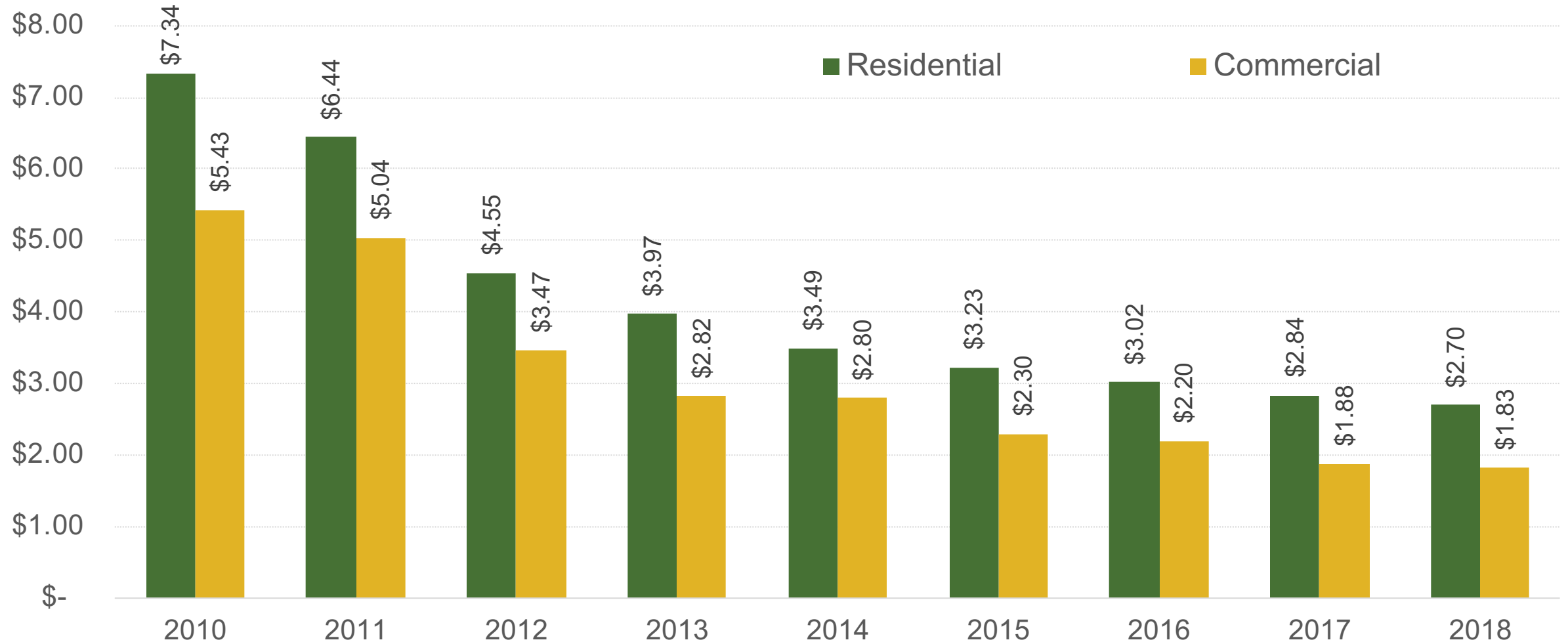
- The U.S. solar photovoltaic (PV) system benchmark reports uses a bottom-up method, accounting for all system and project- development costs incurred during the installation.
- Benchmark costs represent the sales price paid to the installer, including both profit in the cost of the hardware (purchased by the installer) and profit the installer/developer receives.
- Values are inflation adjusted using the Consumer Price Index (2018) and historical values are adjusted and presented as real USD.

PV Sector	Description	Size Range
Residential	Residential rooftop systems	3–10 kW
Commercial	Commercial rooftop systems, ballasted racking	10 kW–2 MW
Utility-Scale	Ground-mounted systems, fixed-tilt and one-axis tracker	>2 MW

Source: Fu, Ran, David Feldman, and Robert Margolis. 2018. U.S. Solar Photovoltaic System Cost Benchmark: Q1 2018. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-72399. <https://www.nrel.gov/docs/fy19osti/72399.pdf>.

NREL Solar System Installation Cost \$ Per Dc/Watt

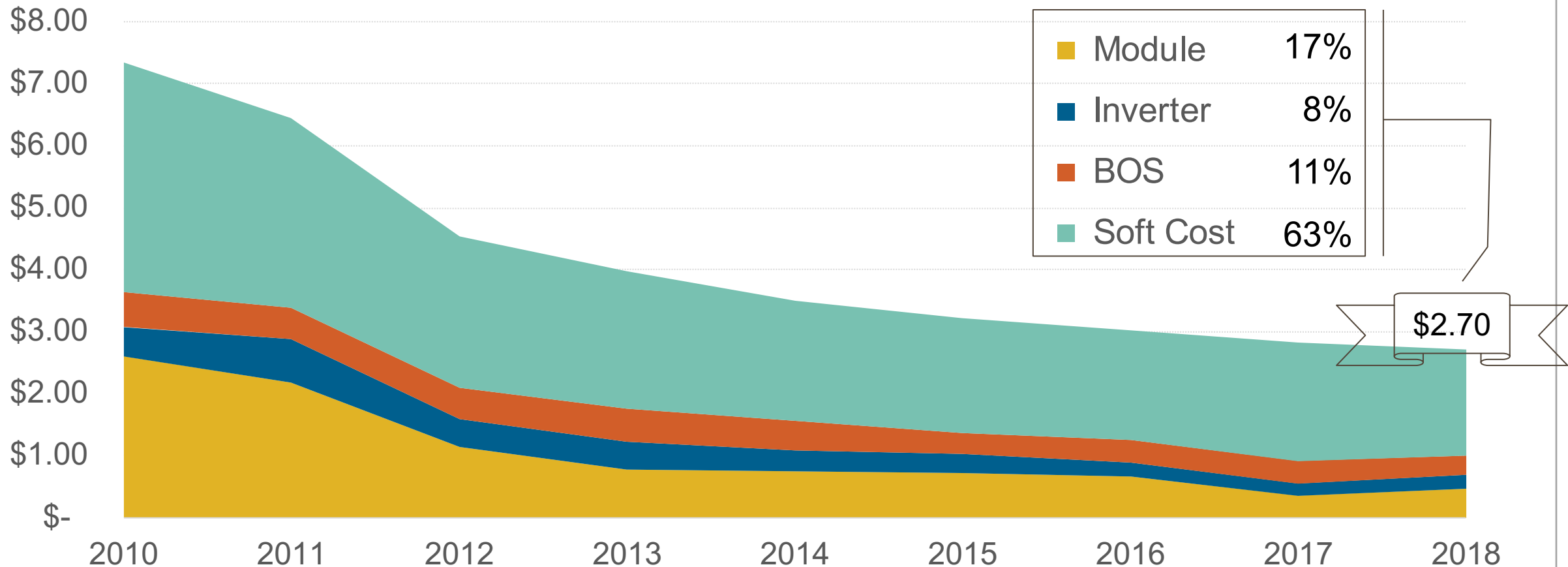
(Inflation Adjusted), Q4 2010–Q1 2018



NREL Residential PV Benchmark Summary

(Inflation Adjusted), 2010–2018

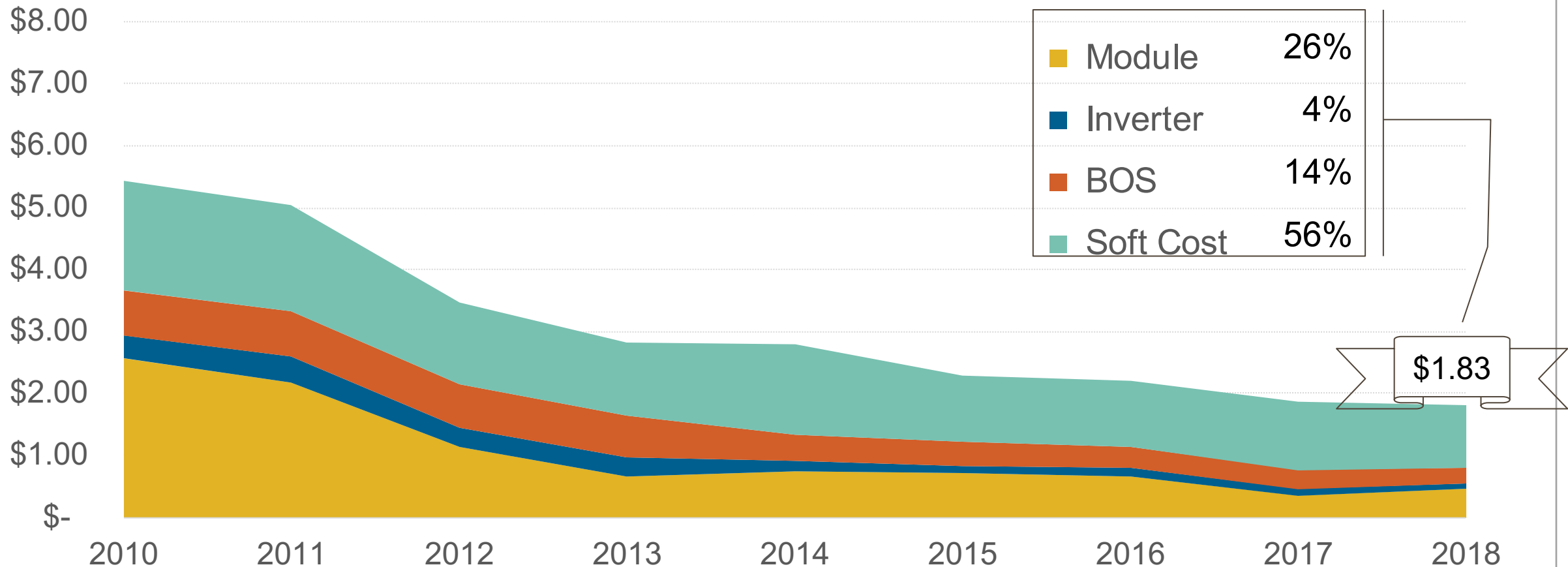
Solar Combined Cost - Residential System (\$ / DC watt)



NREL Commercial PV Benchmark Summary

(Inflation Adjusted), 2010–2018

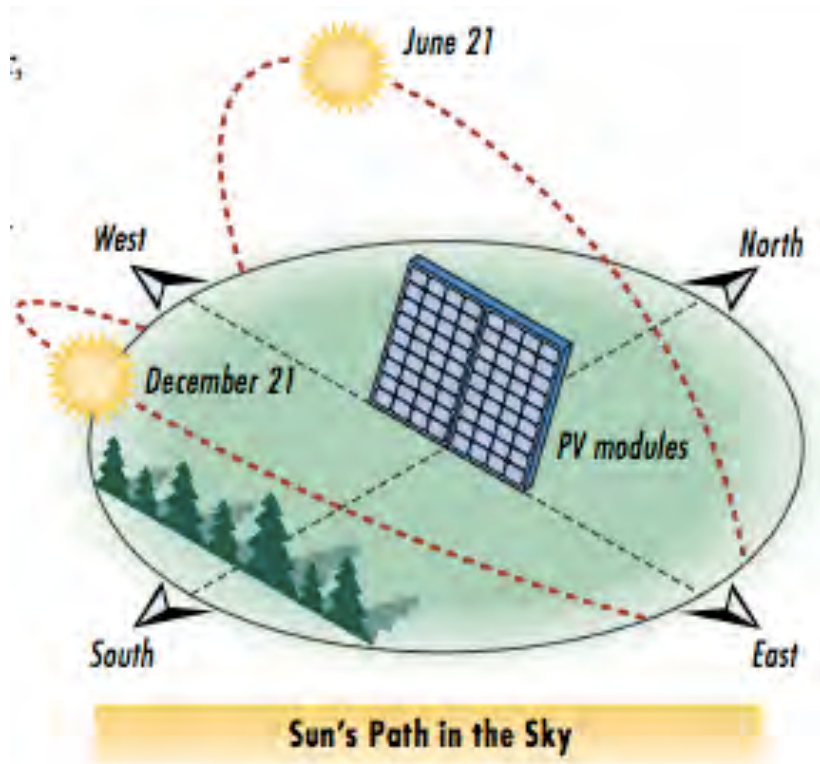
Solar Combined Cost - Commercial System (\$ / DC watt)



System Design Tips to Optimize Production

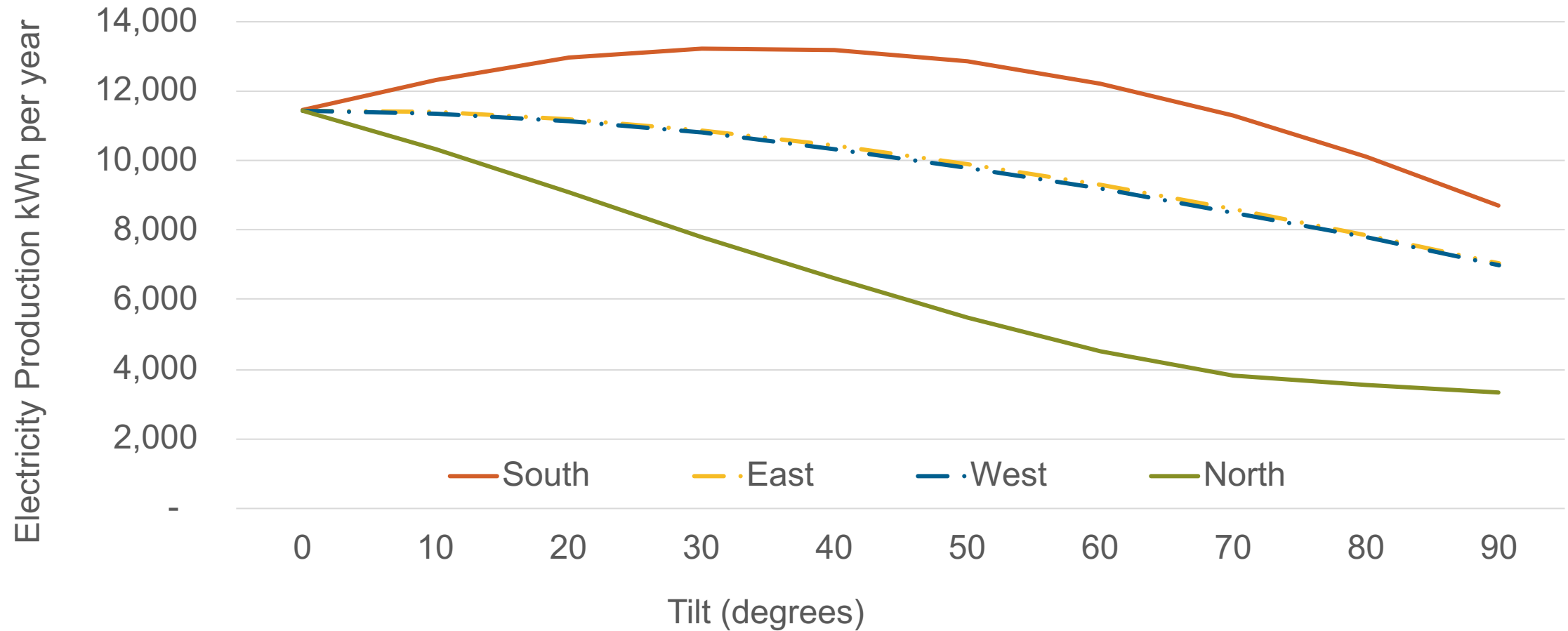
System Production – Module Orientation And Tilt

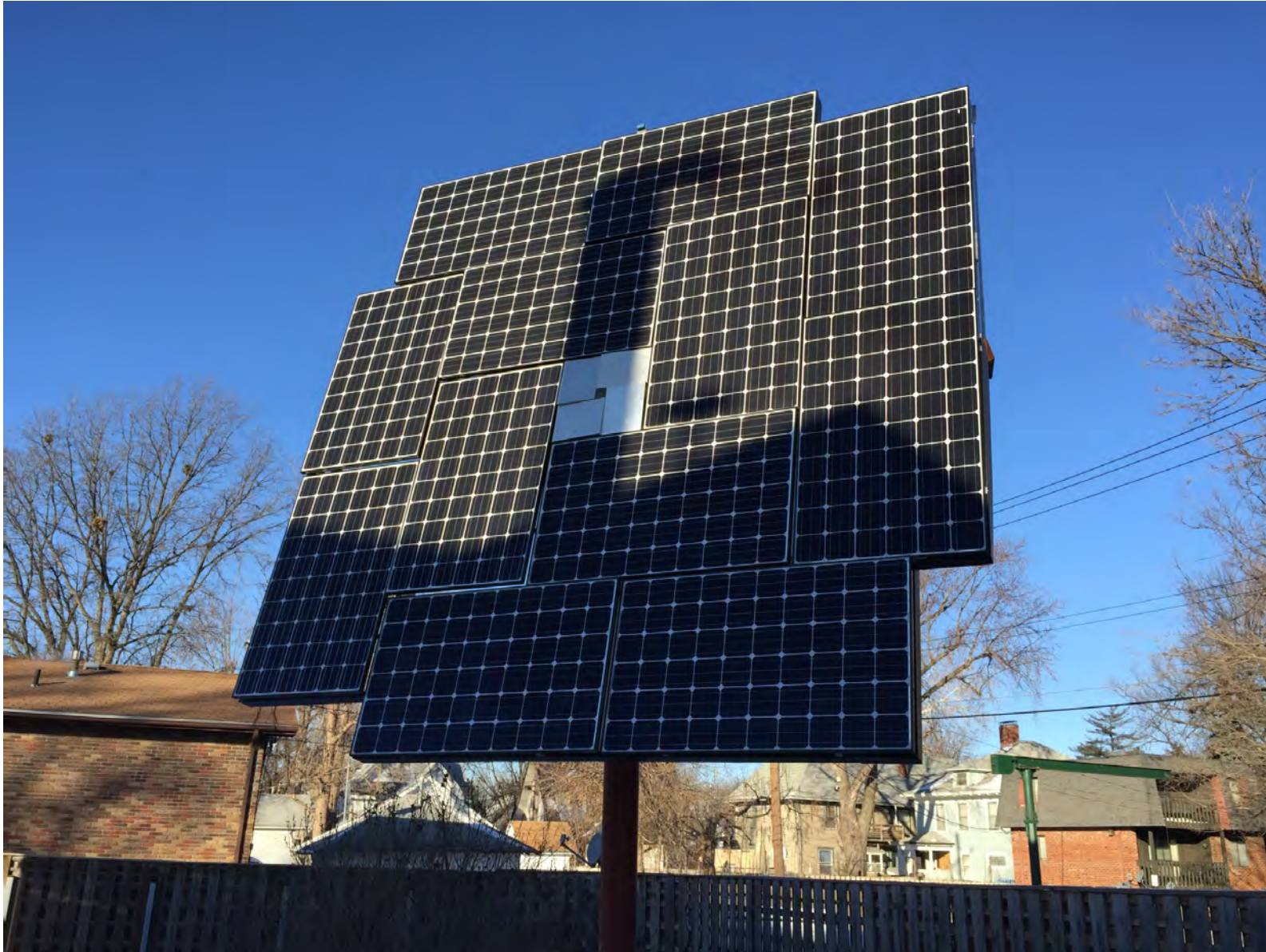
- Orientation and tilt of the panels will influence electricity production.



Influence of Tilt and Azimuth (Degrees)

10 kW Solar PV Array (COLUMBUS, OHIO)

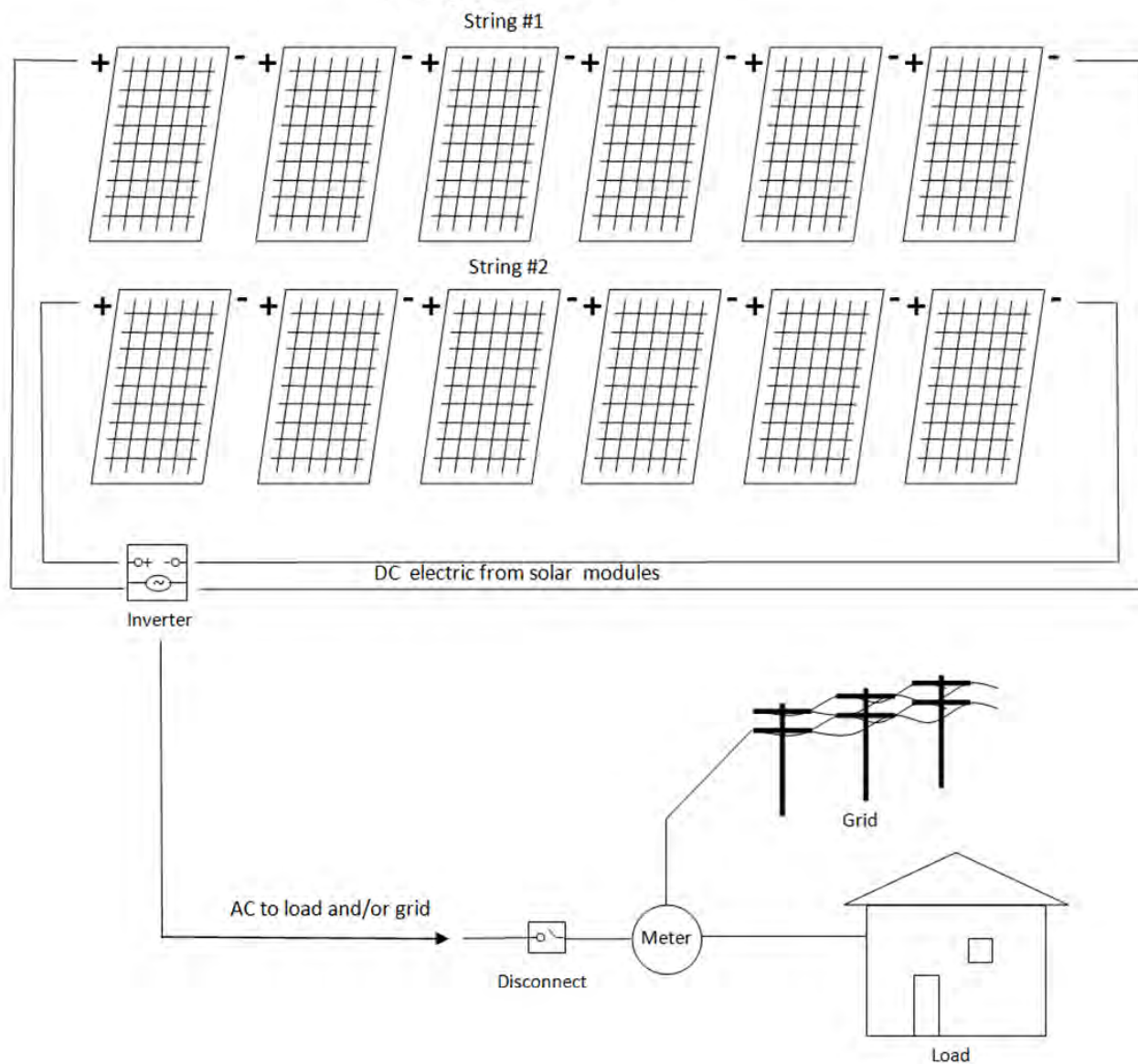




System Production – Shade

What is wrong
with this picture?

String Inverters



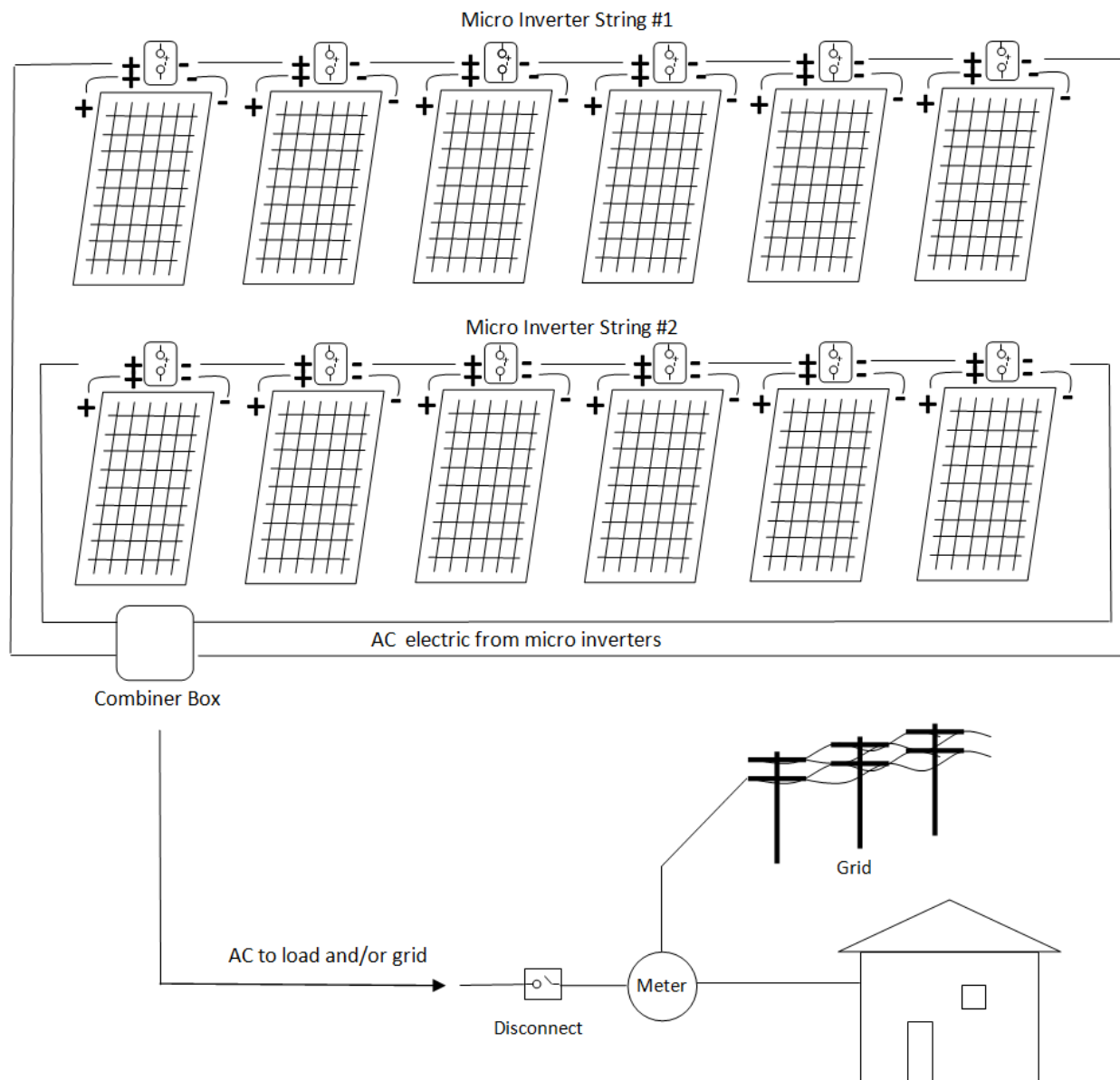
System Production – Shade Which Inverter is Right for You?

String Inverters



- Lowest Cost
- System Level Monitoring
- Poor Shade Performance
- Requires Additional Equipment for Rapid Shutdown

Microinverters



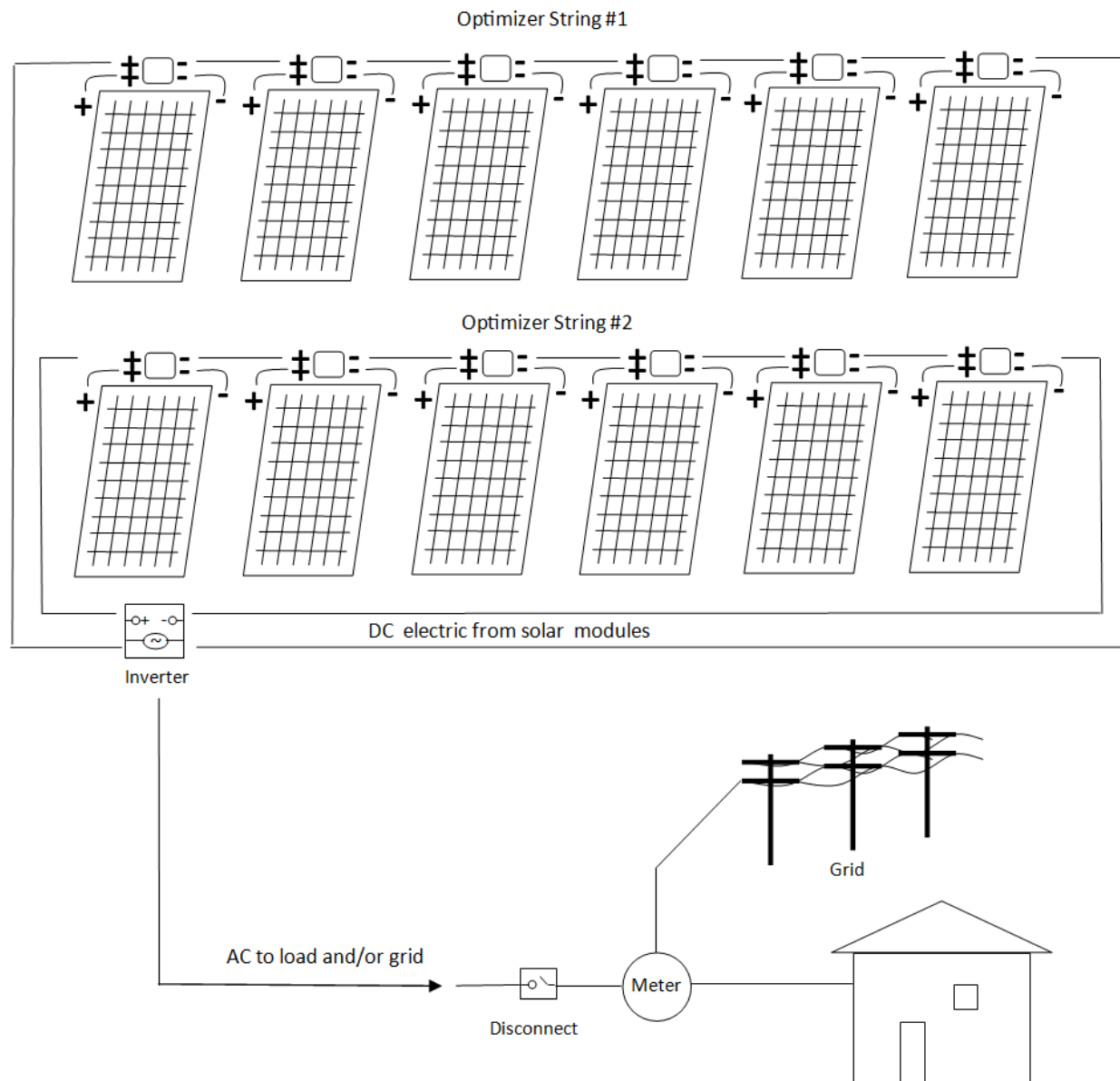
System Production – Shade Which Inverter is Right for You?

Micro Inverters



- Highest Cost
- Panel Level Monitoring
- Good Shade Performance
- Rapid Shutdown Ready
- Ease of Installation

String Inverter With Optimizers



System Production – Shade

Which Inverter is Right for You?

DC Optimizers / Inverters



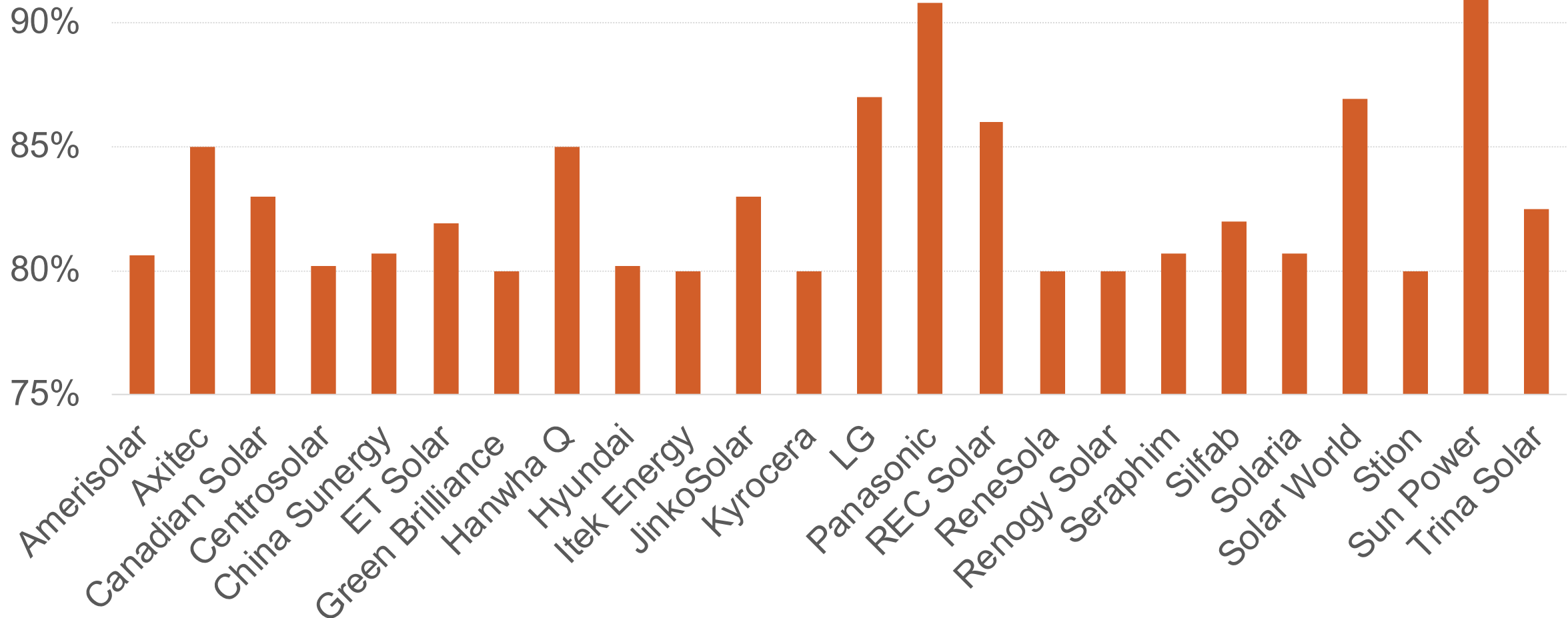
- Low Equipment / High Installation Cost
- Panel Level Monitoring
- Good Shade Performance
- Rapid Shutdown Ready

System Production – Temperature



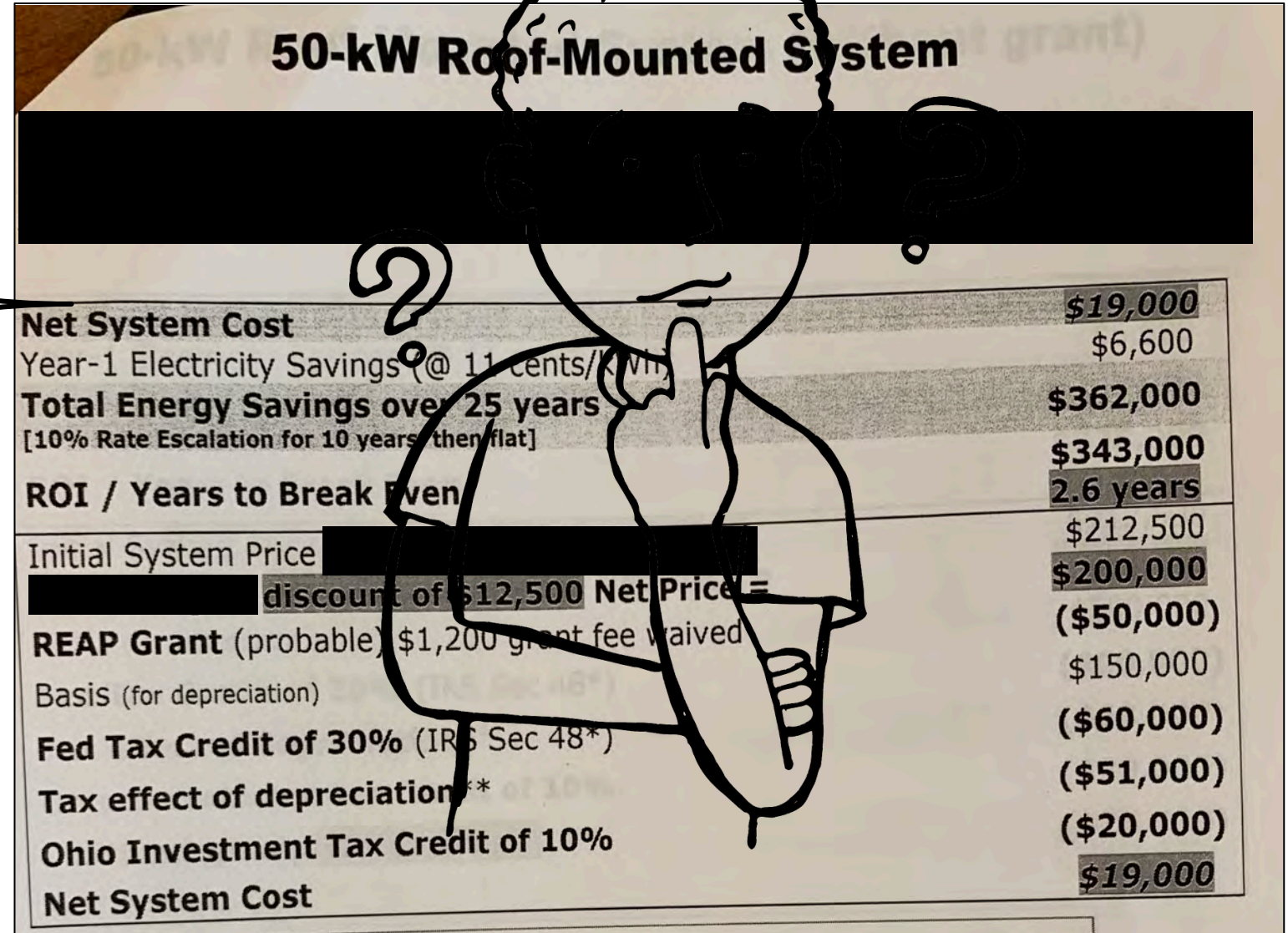
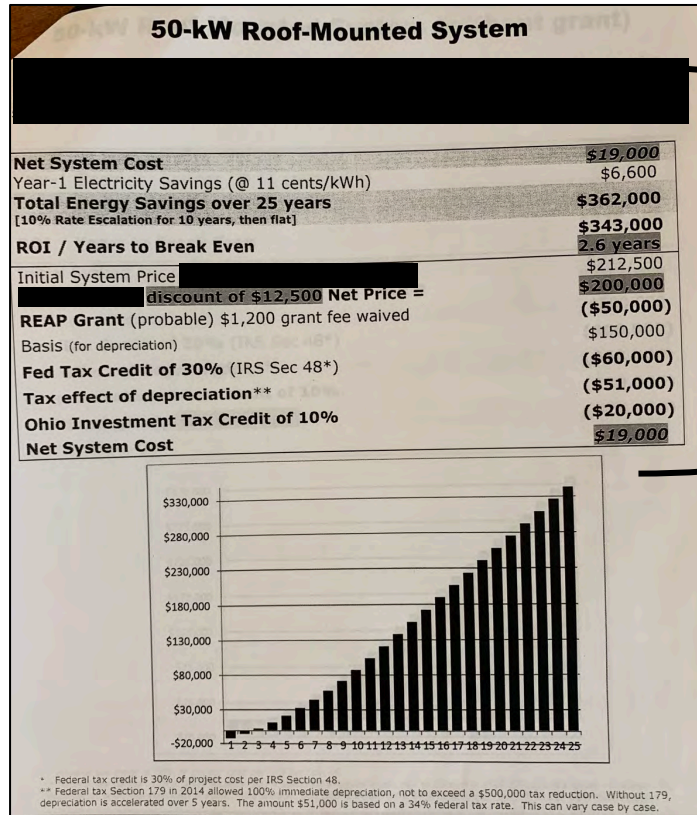
Panel Degradation (10kw Example System)

Solar Module Production Warranties



Photovoltaic Solar System Financial Analysis

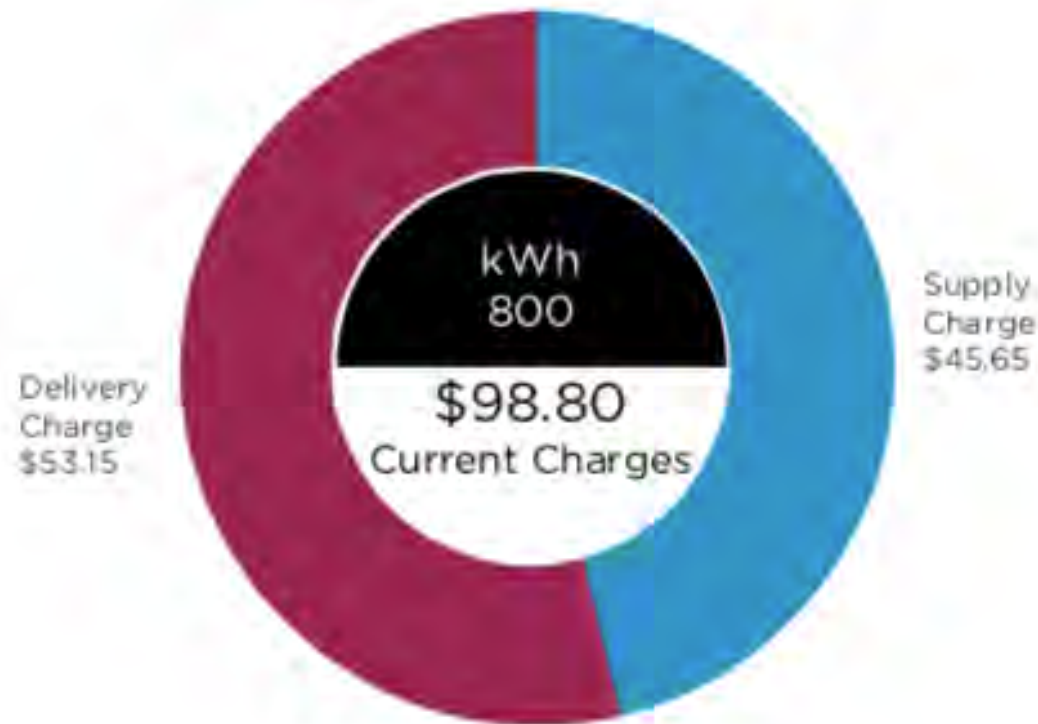
Really a No Brainer Decision?



How Will Solar Generation Impact Your Electric Bill?

Current bill summary:

Billing from 08/31/19 - 10/01/19 (32 days)





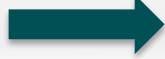


It is important to understand your electric bill to determine the value of electricity from solar generation.

Total cost of electricity is \$0.125 per kWh.

Generation = \$0.055 per kWh

Delivery = \$0.066 per kWh.

How Will Solar Generation Impact Your Electric Bill?

Current AEP Ohio Charges			
Tariff 015 - Residential Service 10/01/19			
Service Delivery Identifier: 00140060713769295			
Generation Service (Supply)		\$	44.24
Transmission Service			13.31
Distribution Service			31.44
Customer Charge			8.40
Power Purchase Agreement Rider			1.41
Current Electric Charges		\$	98.80*
Total Balance Due		\$	98.80
*Charges make up the "Total Balance Due"			

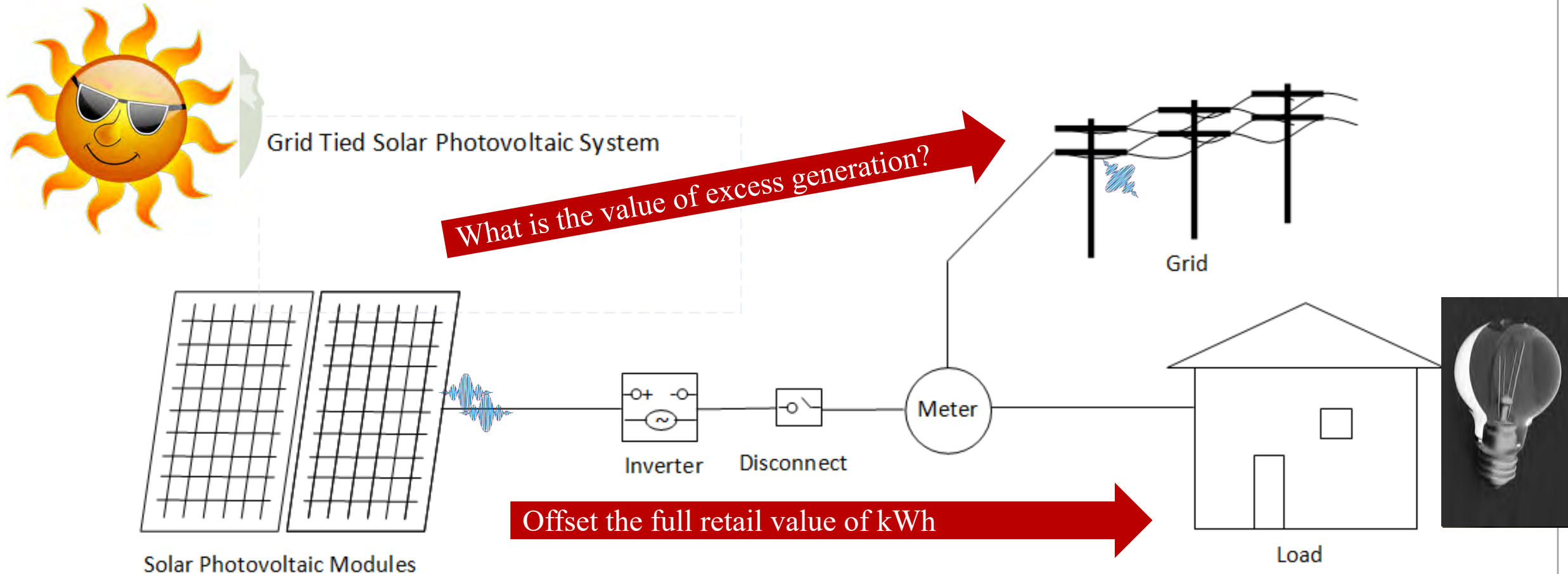
It is important to understand your electric bill to determine the value of electricity from solar generation.

Total cost of electricity is \$0.125 per kWh.

Generation = \$0.055 per kWh

Delivery = \$0.066 per kWh.

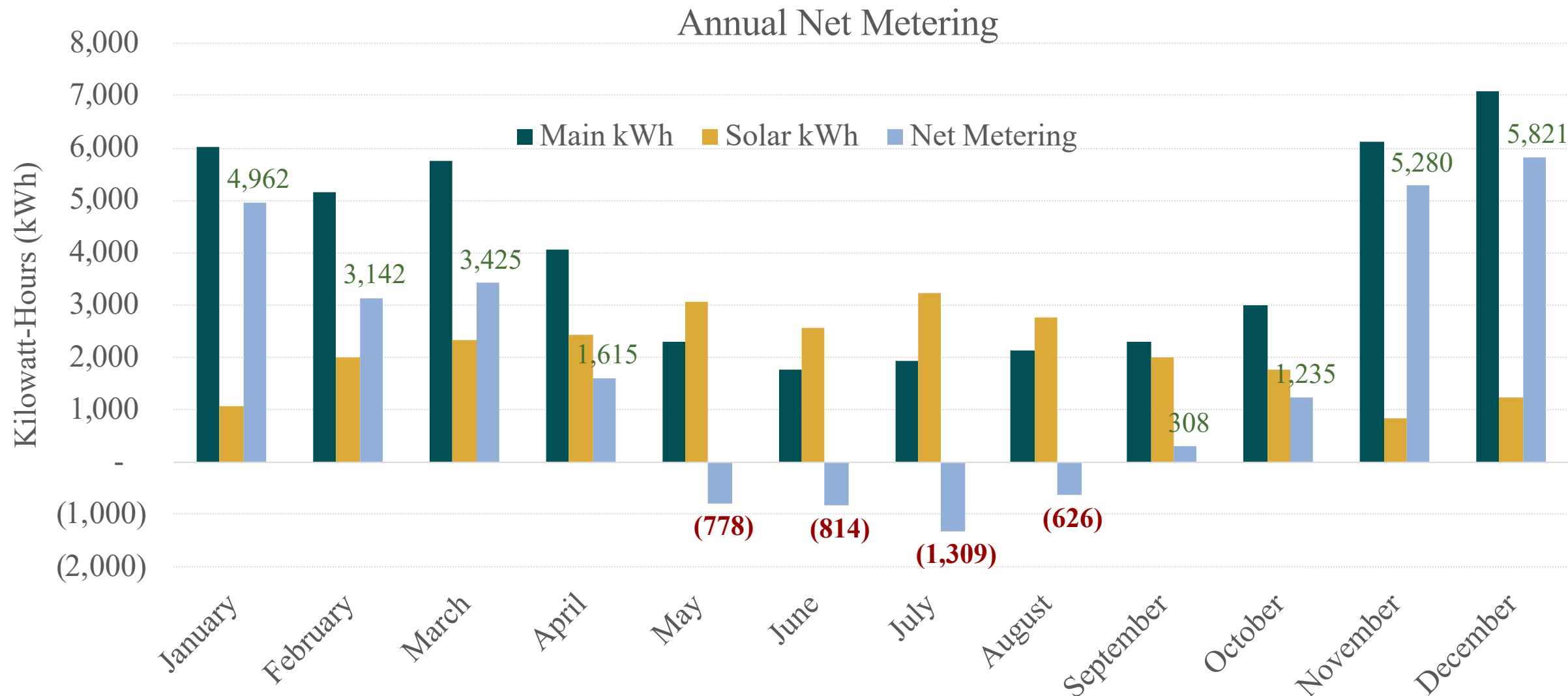
Example of Grid Tied Photovoltaic Solar System



Net Metering

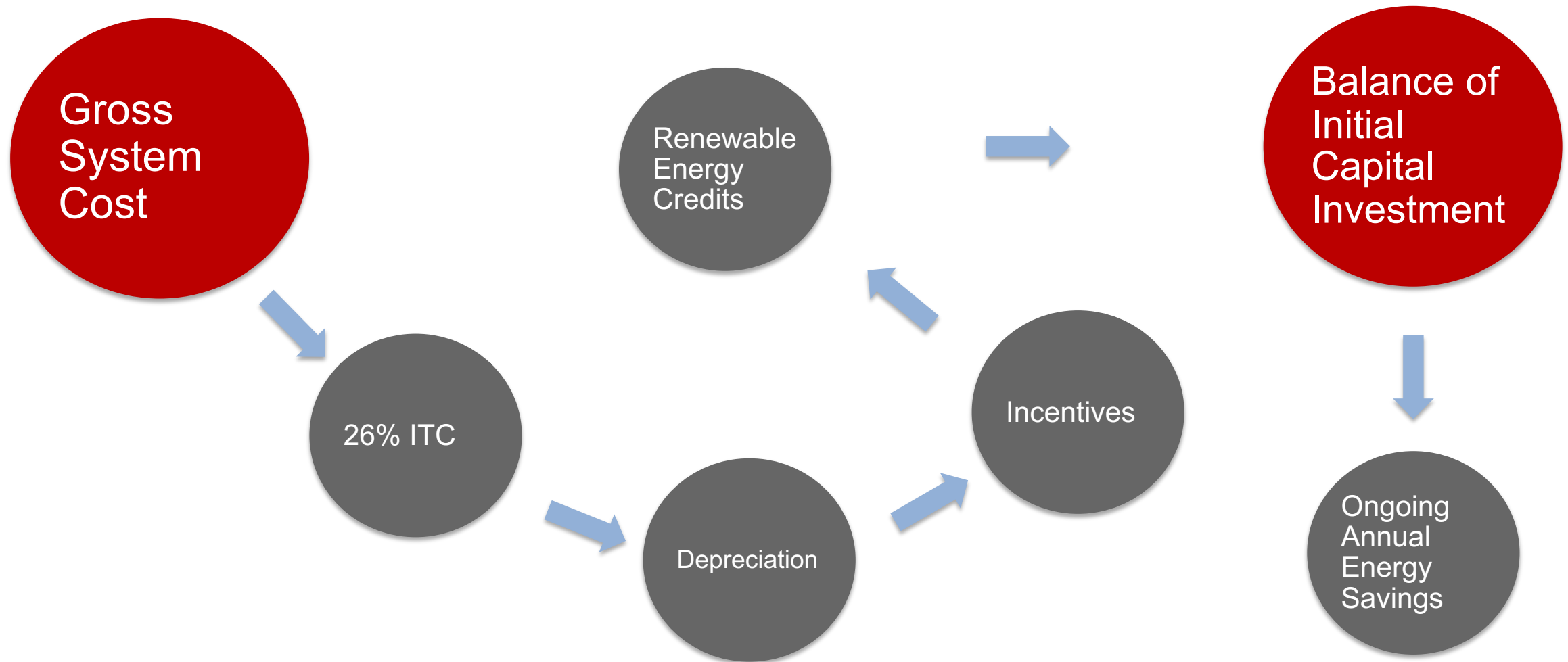
- A **Net Metering** policy is an agreement between a utility provider and electric consumer who own generates their own electricity with an onsite renewable energy facility.
- "Net", in this context, refers to what kWh's remain after deductions of any energy outflows from metered energy inflows during the billing period.
- Under net metering, a system owner receives retail credit **for at least a portion** of the electricity they generate.

How Does Net Metering Work?



To maximize the value of a unit of energy (kWh) your solar system generates, you must use it!

Cash Flow Mechanics of Investing in PV Solar



On Farm Solar Energy - Lessons Learned

- Get multiple quotes
- Simple payback is not the correct tool to evaluate projects
- Don't mix pre-tax and post-tax numbers
- Focus on the system cost, excluding incentives and assumptions
- Every farm and solar proposal is unique
- Value of energy savings (net excess generation)
- Review project with utility representative, accountant, and attorney



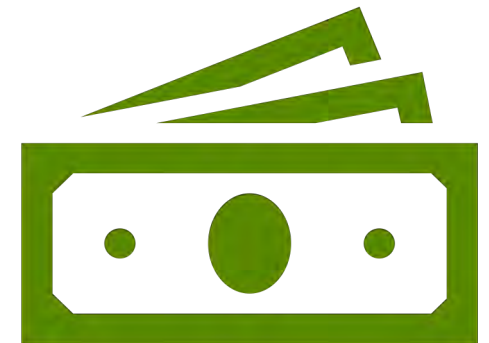
Strengths and Weaknesses of Financial Metrics

Why are Solar Projects Difficult to Evaluate?

- Complex and ongoing cash flows!
 - Solar production variables (degradation)
 - O&M cost variables
 - Inconsistent revenue (ITC, Grants, SRECs, Depreciation)
 - Energy savings?
 - Energy price escalation
 - Variable rate structures and pricing models



Analysis Period

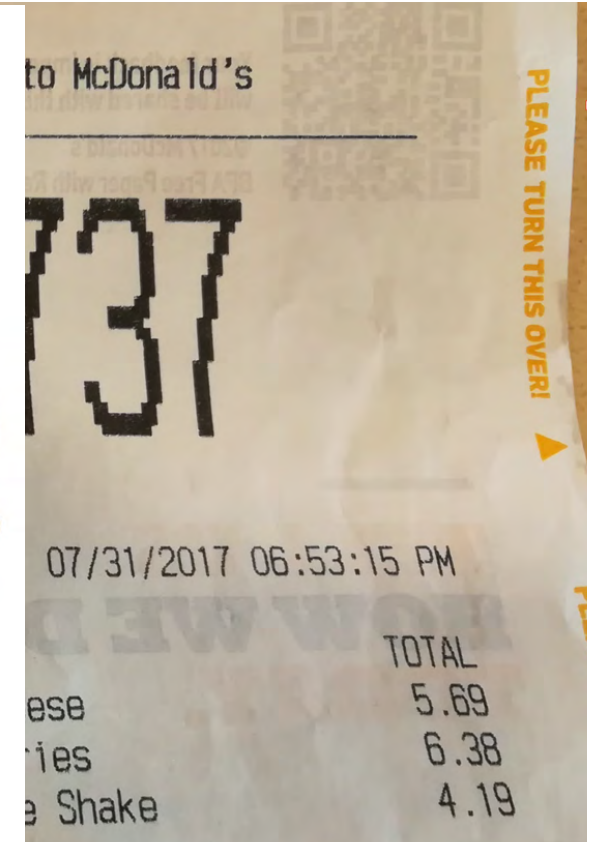


Time Value of Money!

Inflation



Total in 1998: \$3.77



Total in 2017: \$16.26

Option # 1



Option # 2

\$4,000 for
25 Years

Time Value of Money



Winner!
\$100,000

Time Value of Money

- The time value of money (TVM) is the concept that money available at the present time is worth more than the identical sum in the future due to its potential earning capacity.
- As we just discussed, we can multiply the present value of money by the potential annual rate of return of an investment to calculate the future value.....Conversely, we can apply a discount rate to convert value of future money to the corresponding value in present dollars.
- Consistency is **KEY!**

Example: Discussion of Financial Metrics for a 50 kW Solar Project

Simple Payback –

An energy investment's Simple Payback is the time it would take to recover the initial investment in energy savings.

$$\text{Simple Payback} = \frac{\text{Cost of Energy Project}}{\text{Energy Savings Per Year}}$$

Year	After-Tax Cash Flow (Non-Adjusted)
1	\$ 34,665
2	\$ 11,237
3	\$ 8,123
4	\$ 6,279
5	\$ 6,337
6	\$ 4,971
7	\$ 3,606
8	\$ 3,669
9	\$ 3,733
10	\$ 3,799
11	\$ 3,867
12	\$ 3,937
13	\$ 4,008
14	\$ 4,081
15	\$ 4,156
16	\$ 4,233
17	\$ 4,312
18	\$ 4,392
19	\$ 4,475
20	\$ 4,560
21	\$ 4,646
22	\$ 4,735
23	\$ 4,827
24	\$ 4,920
25	\$ 5,016

Example: Discussion of Financial Metrics for a 50 kW Solar Project - Payback Period

Total Investment	\$88,180
Analysis Period	25 years
Payback Period (Non-Adjusted)	10.5 years

Year	After-Tax Cash Flow (Non-Adjusted)	After-Tax Cash Flow (Discounted)
1	\$ 34,665	\$ 32,703
2	\$ 11,237	\$ 10,001
3	\$ 8,123	\$ 6,820
4	\$ 6,279	\$ 4,974
5	\$ 6,337	\$ 4,735
6	\$ 4,971	\$ 3,504
7	\$ 3,606	\$ 2,398
8	\$ 3,669	\$ 2,302
9	\$ 3,733	\$ 2,210
10	\$ 3,799	\$ 2,121
11	\$ 3,867	\$ 2,037
12	\$ 3,937	\$ 1,957
13	\$ 4,008	\$ 1,879
14	\$ 4,081	\$ 1,805
15	\$ 4,156	\$ 1,734
16	\$ 4,233	\$ 1,666
17	\$ 4,312	\$ 1,601
18	\$ 4,392	\$ 1,539
19	\$ 4,475	\$ 1,479
20	\$ 4,560	\$ 1,422
21	\$ 4,646	\$ 1,367
22	\$ 4,735	\$ 1,314
23	\$ 4,827	\$ 1,264
24	\$ 4,920	\$ 1,215
25	\$ 5,016	\$ 1,169

Example: Discussion of Financial Metrics for a 50 kW Solar Project - Discounted Payback

Total Investment	\$88,180
Nominal Discount Rate	6%
Analysis Period	25 years
Payback Period (Non-Adjusted)	10.5 years
Payback Period (Discounted)	19.6 years

Year	After-Tax Cash Flow (Non-Adjusted)	After-Tax Cash Flow (Discounted)
1	\$ 34,665	\$ 32,703
2	\$ 11,237	\$ 10,001
3	\$ 8,123	\$ 6,820
4	\$ 6,279	\$ 4,974
5	\$ 6,337	\$ 4,735
6	\$ 4,971	\$ 3,504
7	\$ 3,606	\$ 2,398
8	\$ 3,669	\$ 2,302
9	\$ 3,733	\$ 2,210
10	\$ 3,799	\$ 2,121
11	\$ 3,867	\$ 2,037
12	\$ 3,937	\$ 1,957
13	\$ 4,008	\$ 1,879
14	\$ 4,081	\$ 1,805
15	\$ 4,156	\$ 1,734
16	\$ 4,233	\$ 1,666
17	\$ 4,312	\$ 1,601
18	\$ 4,392	\$ 1,539
19	\$ 4,475	\$ 1,479
20	\$ 4,560	\$ 1,422
21	\$ 4,646	\$ 1,367
22	\$ 4,735	\$ 1,314
23	\$ 4,827	\$ 1,264
24	\$ 4,920	\$ 1,215
25	\$ 5,016	\$ 1,169

Example: Discussion of Financial Metrics for a 50 kW Solar Project - Net Present Value

Total Investment	\$88,180
Nominal Discount Rate	6%
Analysis Period	25 years
Payback Period (Non-Adjusted)	10.5 years
Payback Period (Discounted)	19.6 years
Net Present Value	\$7,036

Closing Thoughts

[illegible]

DIRECT CAPITAL COSTS

Direct capital costs are those directly associated with the PV solar system and include (but are not limited to) a specific type of equipment or component placed on the project. Direct capital costs are included in the total system cost, which is the sum total and is derived in our report of the total first analysis. Common examples of direct capital costs for a PV solar system include the solar panels, inverter, and the balance-of-system components that typically include racking, wiring, fuses, breakers, and monitoring.

▶ **4.1 Solar Energy Investment Index**

Developing a PV solar project requires significant capital investment. To help lower the development of PV solar projects, government agencies and utilities offer various incentives, such as tax credits, rebates, net metering, grants, and leases to offset the initial investment. Incentive programs vary widely based on region and utility, and project size/usage. For example, rebates and incentives are available for different incentives. Significantly, the federal solar tax credit for different incentives (such as those in Ohio) has been halved in the all-important recent legislation as of February 2015. Consolidating these incentives can maximize the financial return from PV investments.

WHAT ARE THE IMPORTANT INCENTIVES?

Despite rapidly declining costs for PV and other, incentives are still important to the cost-effectiveness of a project. Incentives come from four primary sources: federal, state and local government, and utility companies. Each has different reasons for providing incentives, thus forming the growth of energy independence and environmental responsibility. Below:

KEY RESIDENTIAL INCENTIVES

Although most of today's programs are pay-out, the top five states for residential applications are:

- Renewable Renewable Energy Tax Credit (RRETC)
- Loan guarantee facilities

The 2009 American Recovery and Reinvestment Act created the following tax incentives:



4 | Solar Electric Investment Analysis

The average retail price of electricity (all sectors) in the U.S. increased from 7.78¢/kWh in July 2006 to 10.11¢/kWh in January 2007. Interestingly, in a PV system, a significant amount of electricity is produced during the summer months, when electricity prices are generally higher. Electricity production from a system will displace electricity that would otherwise be purchased from a utility. Although seemingly simple to calculate, the energy output for a project, one must consider many important variables, including the details of your individual cost structure and the assumed energy production rate that influence the value of electricity your PV system produces.

This bulletin will help readers identify their utility rate structure, understand how the rate structure affects the value of their property, evaluate energy-saving options, and assess how these factors affect the assumed value of energy savings for a project. A better understanding of how to calculate energy savings will allow a more accurate financial analysis, lowering informed investment decisions.

UNDERSTANDING YOUR RATE STRUCTURE

There are more than 1,000 electric utilities in the U.S. and no standardized rate of return. Most electric consumers would consider the factors that influence the calculation of their rates, listed below, as among their major inputs from a TV rate system. Do you estimate your home, town, or business rate that is calculated from these changes often is based on these 11 common rate questions: rate include a fixed base (charge, energy charge, demand charge, and a variable charge); Transmission specific charges; Fuel

USERS ARE NOT CHARGED FOR COLLECTIONS

Although the components of a bill vary by state, the following changes are generally included:

- **Fiscal monetary (fiscal) change** - This involves a change in the amount typically associated with international trade. A fiscal change will not reduce this change.
- **Energy change** - This change shows the total of generating energy within a PAV and will not change this response.
- **Demand change** - This change will demand flexibility and resources, given a PAV, to maintain a possible energy in response to the environment. In the system, the demand for a PAV is not the same as the demand for a PAV.

¹ U.S. Census Bureau, *Adolescents and Blacks in the Work*.

4.1. Some Electric Instrument Analysis

Understanding your risk reduction rate is more, PV, since it is a value of interest rate, not available because it is a value of interest rate. To make an investment decision, interest rate is not considered for PV comparison. If PV is present with low, it is a value of the interest rate, not a value of interest rate. This helps compare it to a value that is not a value of interest rate.

442 benefits while doing the electric wiring on a particular house. Energy savings may also result, as commercial solar systems are increasingly being leveraged for use in low-income housing projects. In "Net-bills" of electricity purchases from a utility provider,

For example, a program with a total execution time of 140,000 ms, saving the cost at \$2,000 after applying all the present and new benefits, but will generate the 100 ms, allowing for 91,250 per year. However, if the program is in the 90 percent benefit but has the same, the effective cost of the program, saving a total \$700. Although increased program and not accurate, the benefits/program may reach the effective cost of the program, \$2,000 for the full-time cost of the program, \$2,000 and the cost of the program is \$2,000. However, after evaluating everything on an effective cost and finding \$4,500 to \$700, the result is a significantly longer period period of 10,000 ms. In summary, current programs are currently in the way they apply, but after.

[illegible]

In addition, for presidential applications I suggest you have someone available and add the PW system to your community gallery to include the part of a replacement when you're in the process of a replacement.

[illegible]

Producing renewable energy is much like producing or harvesting—the quantity produced and the net value of the product determine profitability. If you grow more tomatoes, more tomatoes can be sold at the farmers' market. Similarly, if you flow more water into the lake when others do not, then the tomatoes want be sold at a higher price. The growth related to tomatoes means a steadily low capital cost since growing them, e.g., in high tunnels, and the ongoing inputs, e.g., labor and fertilizer, during the growing season.

Two similar comparisons follow. In series least a PV system, total amount of electricity produced (and not value of that production). Since a battery is measured in kilowatt-hours (kWh), the value of a unit conversion is defined by the number of kWh produced and how much they are worth (the unit response). The more kWh generated from an installation and the higher the response, the better the overall return.

YOUR NEW SPECIFICALLY DESIGNED

PE activities itself provide an estimate of production, typically expressed here as average monthly production. Data for landscape, tree, climatic, and vegetation characteristics determine the amount of energy produced by PE solar system. However, the amount of energy use varies from the response to the inputs but not all factors can significantly influence production. For example, Location. Reasoning, it is approximately the same response to Cleveland, Ohio, but Los Angeles is warmer, colder and higher, the same PE solar system response to various cities including in Los Angeles than in Cleveland.



Most PV panels come in two different varieties, but the same principle applies: the two will convert PV energy into heat. If you're interested, however, that would mean the heat will be lost due

4.1 Solar Electric Investment Analysis

Figure 1 *Panel A* shows the estimated marginal effects of the variables on the probability of using a computer to conduct the assessment tool. The variables are: Age, Gender, Education, Income, and Computer Use. The y-axis represents the probability of using a computer to conduct the assessment tool, ranging from 0 to 1. The x-axis represents the variables. The legend indicates that the solid line represents the estimated marginal effect, and the shaded area represents the 95% confidence interval.

Flat buttons will help explain, analyze, and understand the core components of a typical

TV series proposed, including the system, production, service, and maintenance, and service fees. A large understanding of the components and assembling used to develop a program.

USING THE SAM MODEL
The National Renewable Energy Laboratory, which is funded by the U.S. Department of Energy, developed the System Advisory Model (SAM) to help developers, installers, and potential owners estimate the system production and financial impacts of renewable energy projects. The

Copyright © 2004 by John Wiley & Sons, Inc.

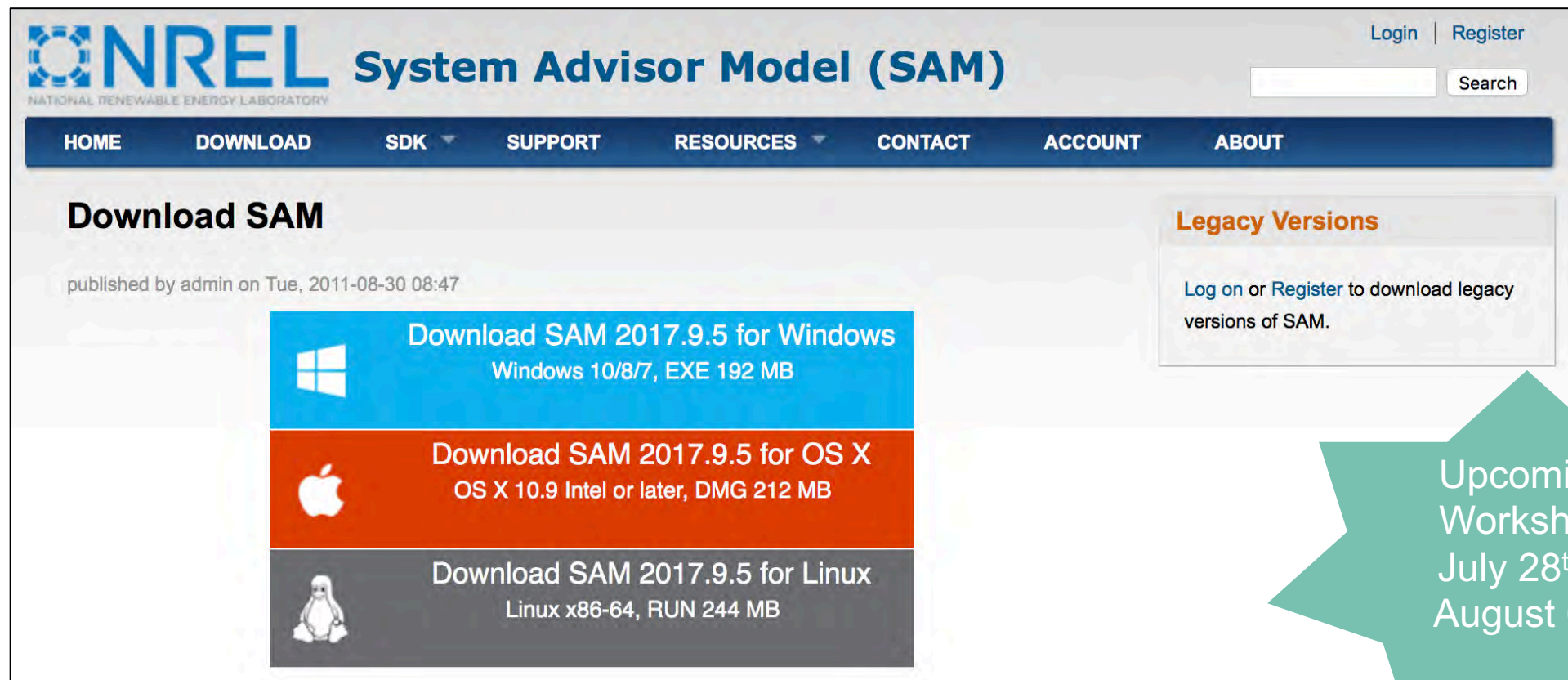
The value of electricity generated by the system is calculated as detailed work flow over the system's lifetime. The NAM model's outputs include the details of a power plant including a detailed work flow analysis including mass and energy flows, including the product period, the gross and net, levelized cost of energy, the energy storage, and the overall, on-site and without a renewable energy system. NAM is available for download on an open source basis from www.nam-project.org.

Abstract

To illustrate, the length of time of aggressive interactions and the likelihood of losing a victim's mother's milk perfectly correlated, 70% monthly for a sample of 11500 (100000) milkings. We estimate a 10% milk property (a good mother and good position) from California, Ohio, and a dairy farming business, and building facility. The operation has better in each farm, less variation than the operation the more, and a lower level of loss in all and victims. The average monthly milk loss range is 2.75% (0.001) during a 2000-0000 during the victim's lifetime. According to estimate this rate, the 10000 milkings in 2000-0000 approximately 10 percent of the aggressive interaction caused, therefore, about 20 percent of milk loss is caused by the 10000 milkings. The first estimate shows aggressive interactions with the victim's mother, but a victim's mother's aggression is approximately 20% of the aggressive interactions. The first estimate shows aggressive interactions with the victim's mother, but a victim's mother's aggression is approximately 20% of the aggressive interactions.

A-1. Sample Electric Instrumentation Diagram

SYSTEM ADVISOR MODEL (SAM)



The screenshot shows the NREL System Advisor Model (SAM) website. The header includes the NREL logo, the title "System Advisor Model (SAM)", and links for "Login" and "Register". A search bar is also present. The main navigation bar contains links for "HOME", "DOWNLOAD", "SDK", "SUPPORT", "RESOURCES", "CONTACT", "ACCOUNT", and "ABOUT". The "Download SAM" section is highlighted, showing a post published by admin on Tue, 2011-08-30 08:47. Below this, there are three download buttons: "Download SAM 2017.9.5 for Windows" (Windows 10/8/7, EXE 192 MB), "Download SAM 2017.9.5 for OS X" (OS X 10.9 Intel or later, DMG 212 MB), and "Download SAM 2017.9.5 for Linux" (Linux x86-64, RUN 244 MB). A "Legacy Versions" section on the right encourages users to "Log on or Register to download legacy versions of SAM."

Download SAM

published by admin on Tue, 2011-08-30 08:47

Download SAM 2017.9.5 for Windows
Windows 10/8/7, EXE 192 MB

Download SAM 2017.9.5 for OS X
OS X 10.9 Intel or later, DMG 212 MB

Download SAM 2017.9.5 for Linux
Linux x86-64, RUN 244 MB

Legacy Versions

Log on or Register to download legacy versions of SAM.

Upcoming
Workshop
July 28th –
August 6th!

Available to download at: <https://sam.nrel.gov/download>

Thank You!

Eric Romich

OSU Extension

Field Specialist, Energy Education

Office: 419-294-4931

Email: romich.2@osu.edu

