Powering a Home, Farm, or Business with Solar Electric:

Tips and Tools for Project Evaluation

Noble County Ag Breakfast

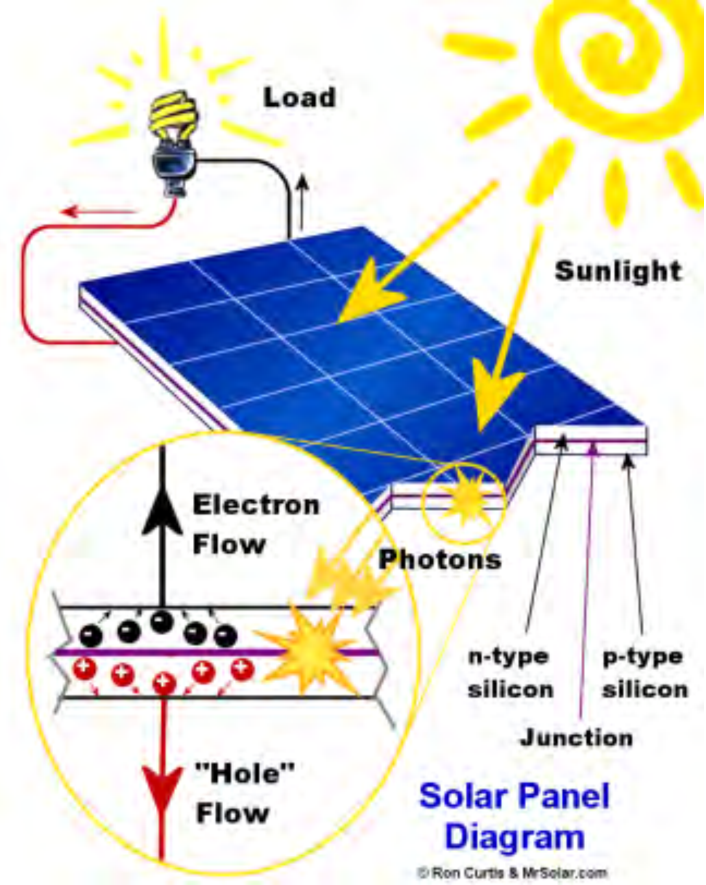
June 19, 2020

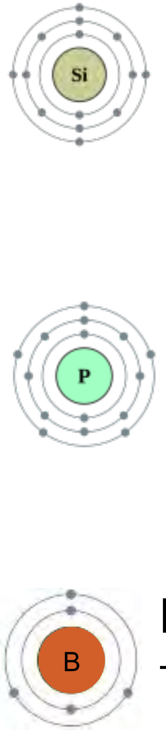
The Ohio State University
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

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.

Source: E3A Solar Electricity for Home, Farm & Ranch

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Solar Energy Trends in Ohio

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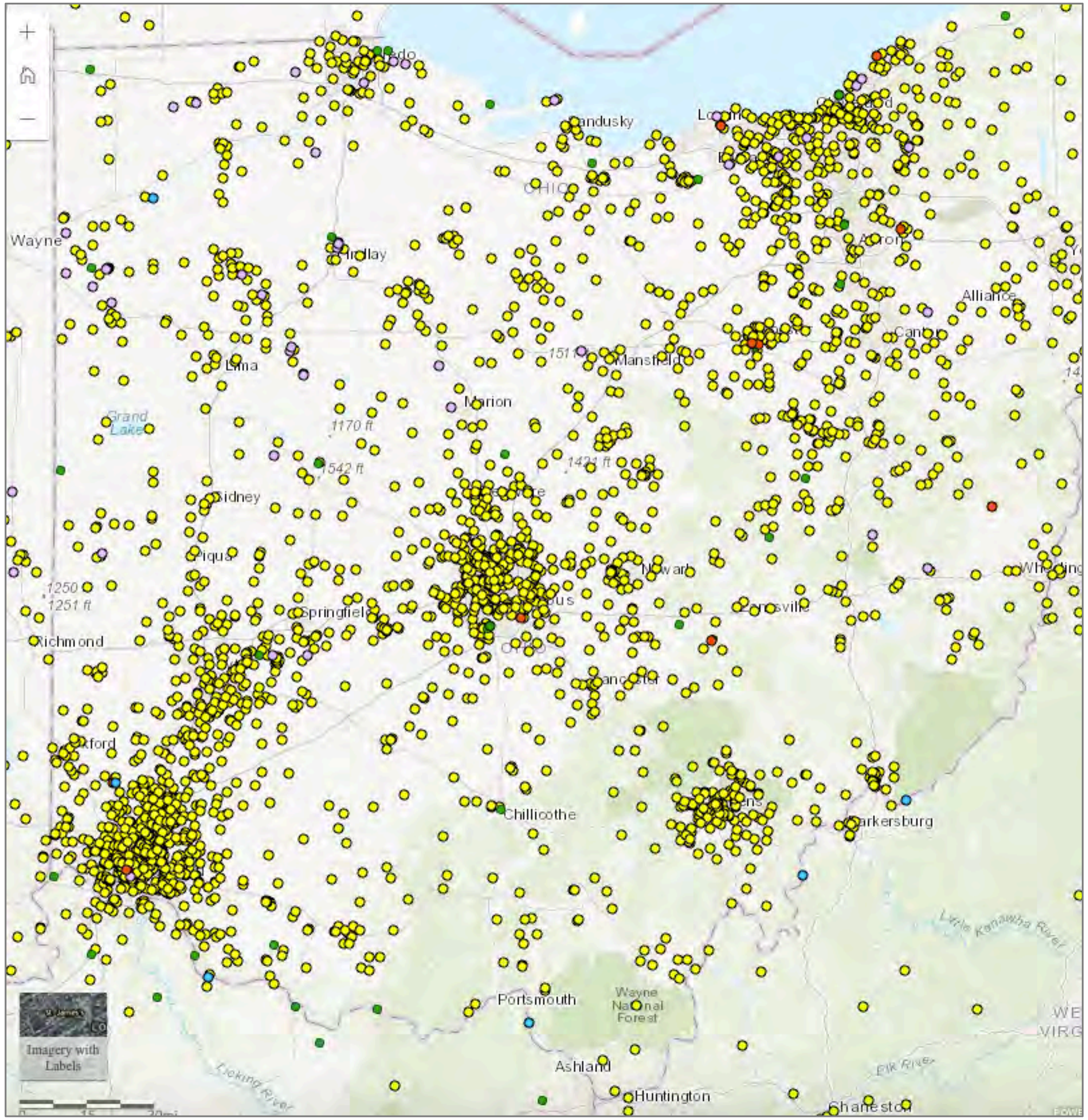
Renewable Energy Facilities Registered With PUCO



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**

https://www.puco.ohio.gov/utility-maps/electric-maps/ohio-certified-renewable-facilities/

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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.

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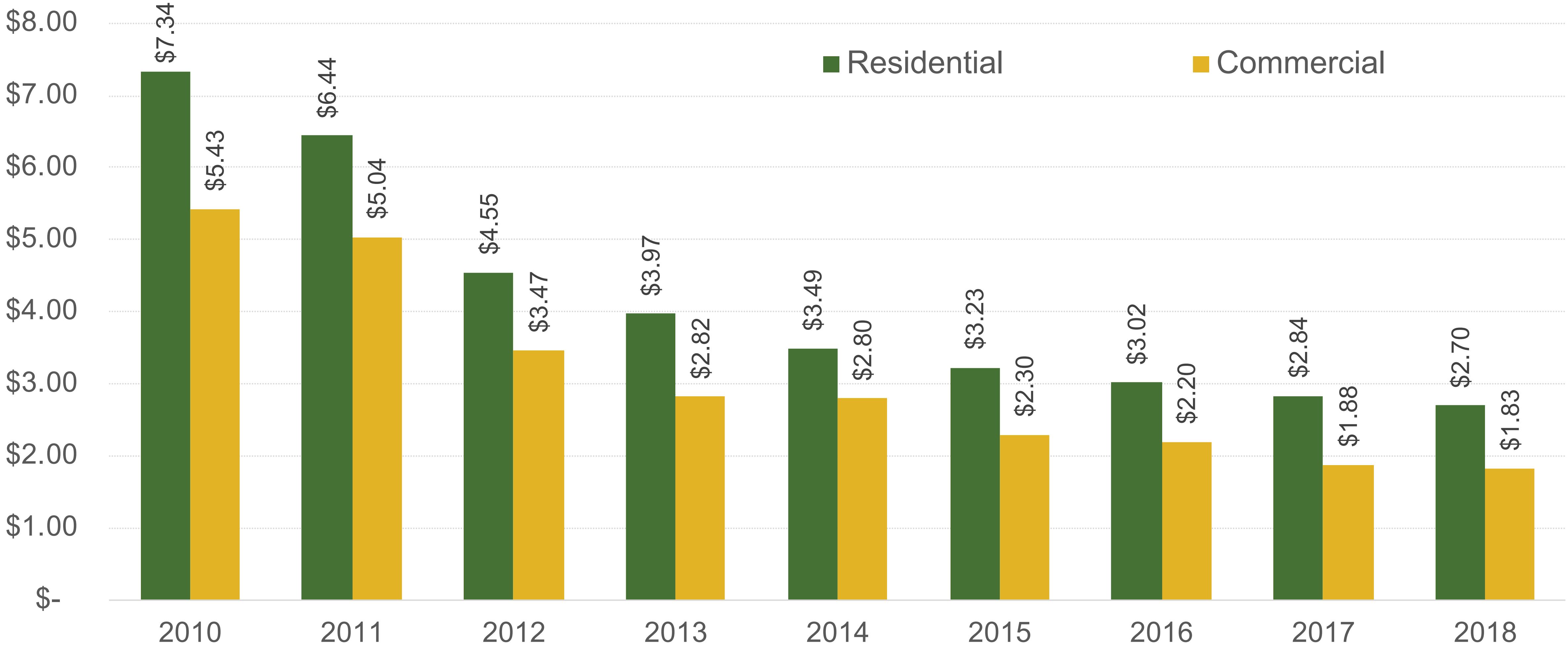
NREL Solar System Installation Cost $ Per Dc/Watt

(Inflation Adjusted), Q4 2010–Q1 2018



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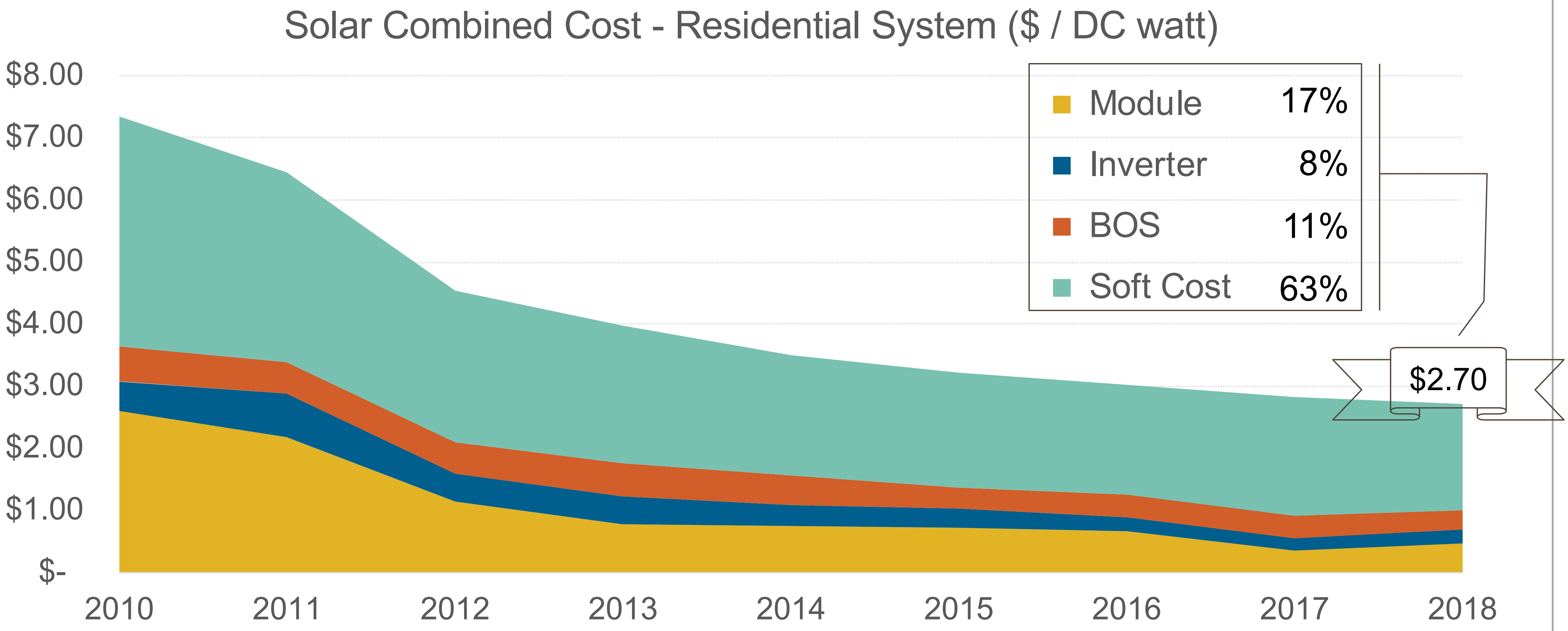
Source: NREL utility-scale PV system cost benchmark summary (inflation adjusted), 2010–2018

NREL Residential PV Benchmark Summary

(Inflation Adjusted), 2010–2018



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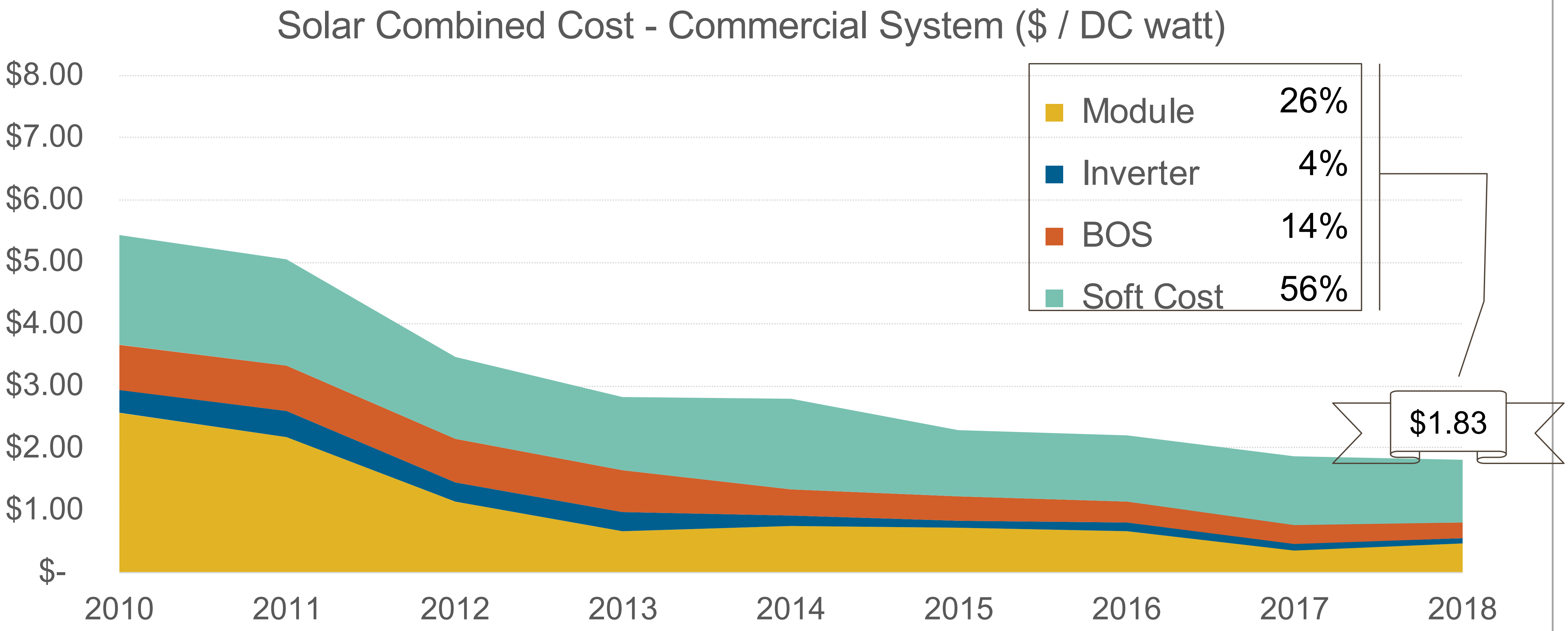
Source: U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017. Available at: https://www.nrel.gov/docs/fy17osti/68925.pdf

NREL Commercial PV Benchmark Summary

(Inflation Adjusted), 2010–2018



Source: U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017. Available at: https://www.nrel.gov/docs/fy17osti/68925.pdf

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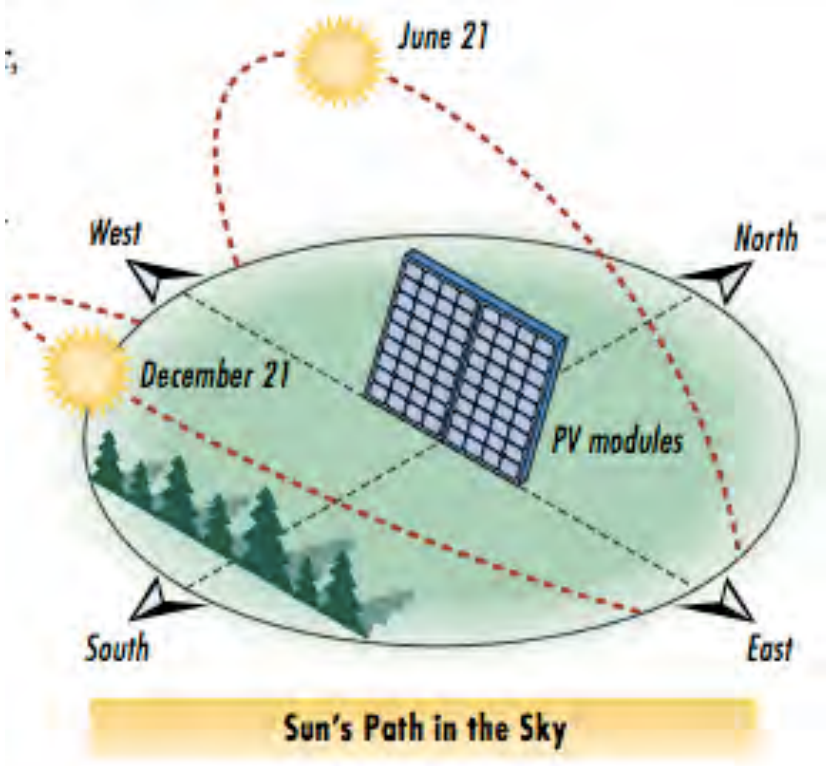
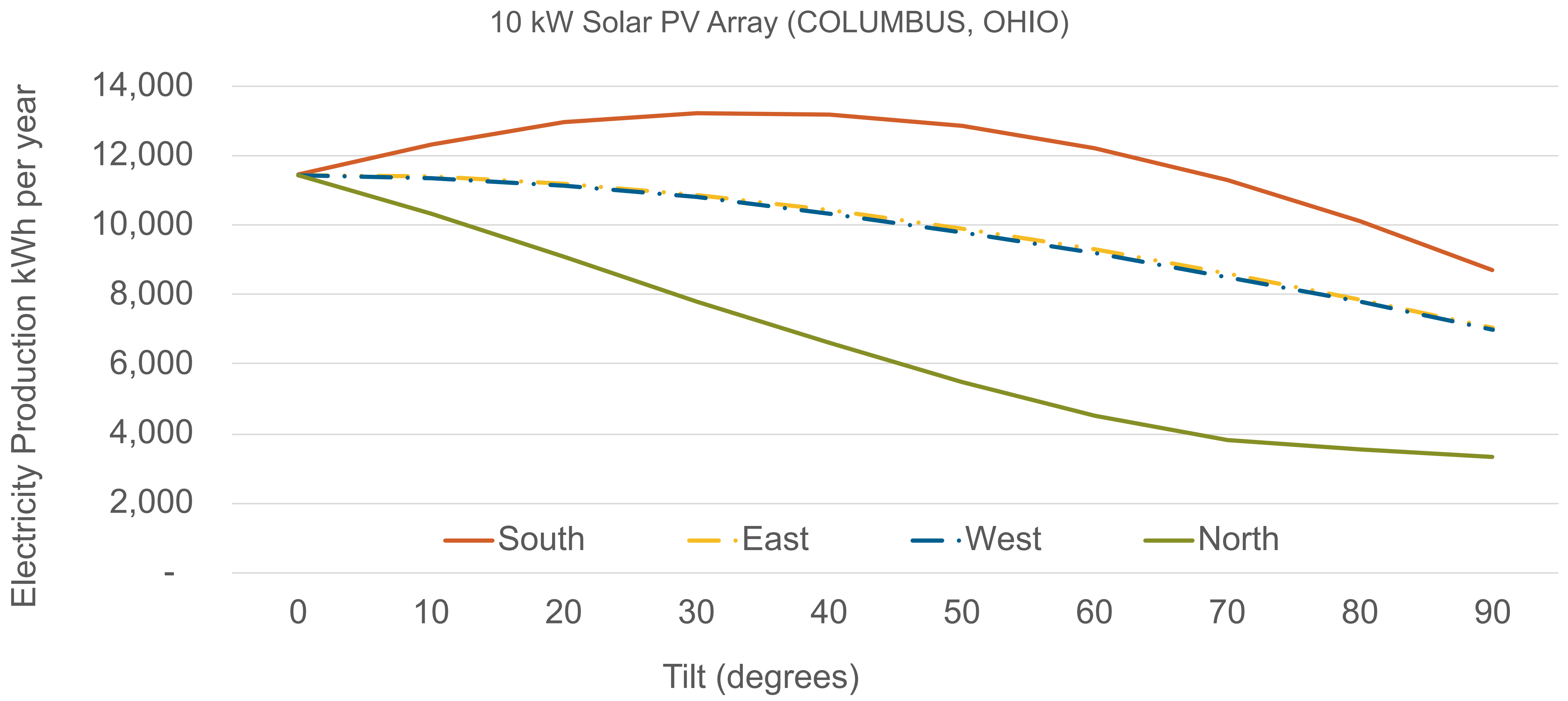
System Design Tips to Optimize Production

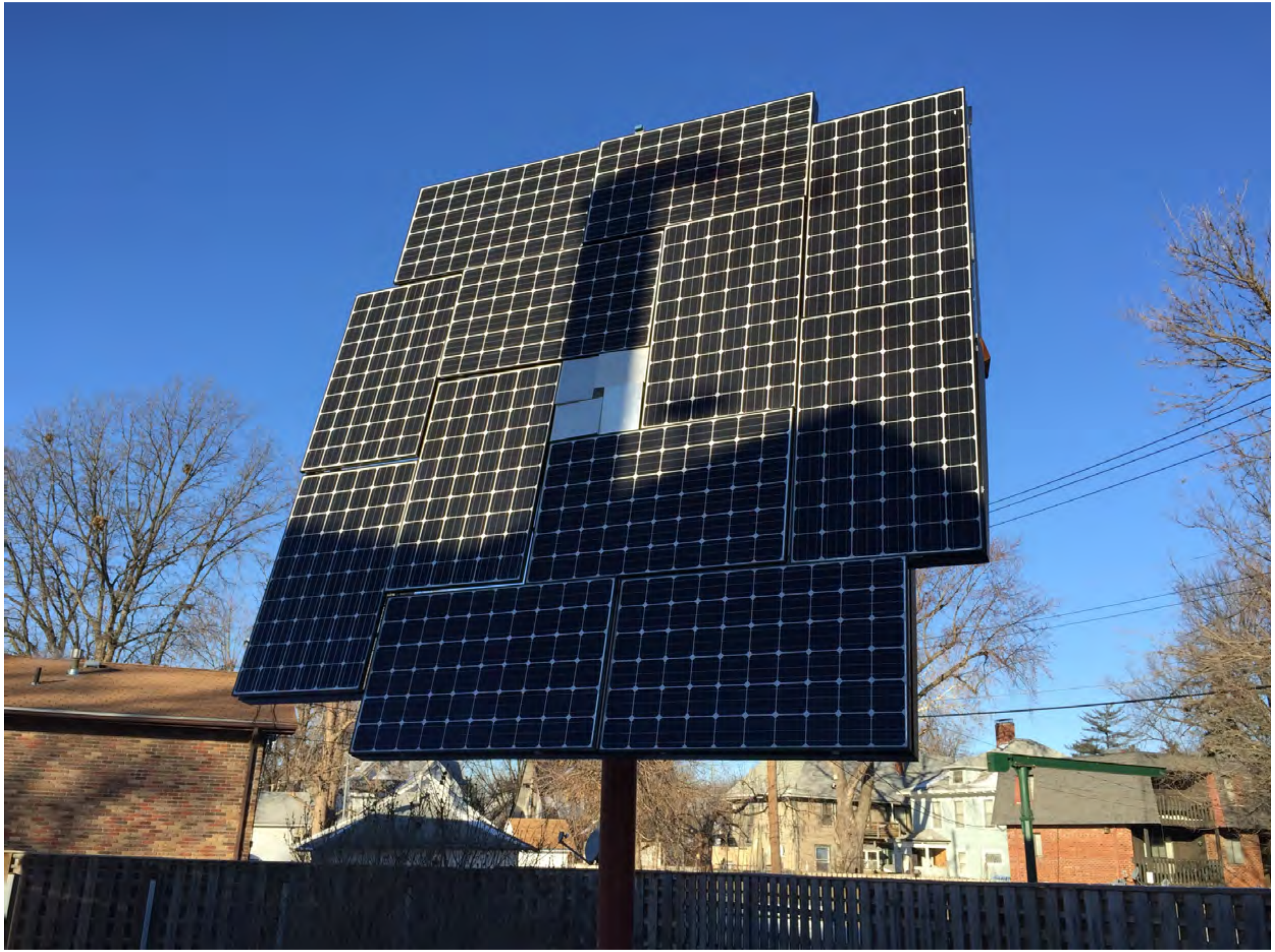
System Production – Module Orientation And Tilt

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



Influence of Tilt and Azimuth (Degrees)



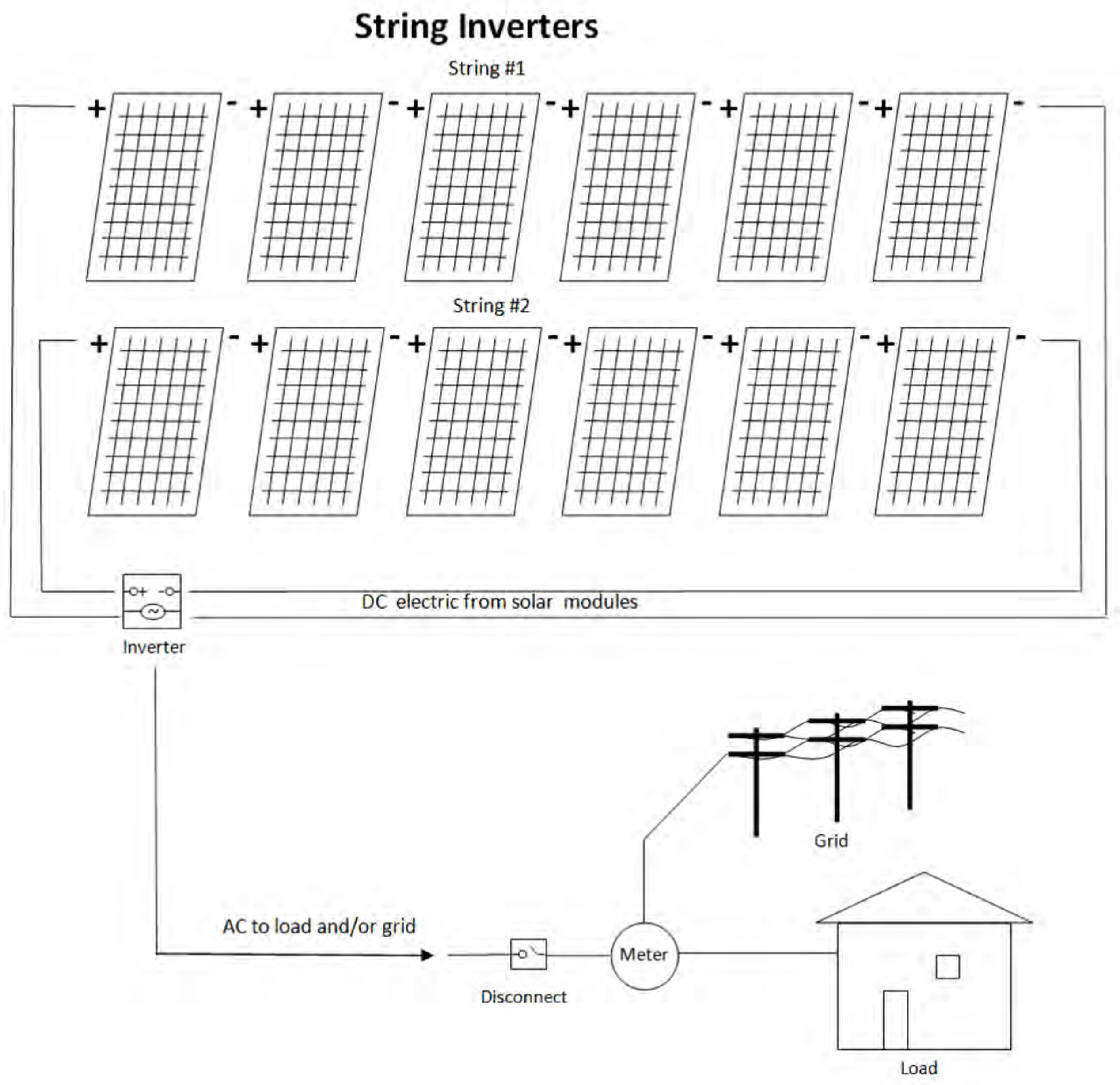


System Production – Shade

What is wrong with this picture?

System Production – Shade

Which Inverter is Right for You?

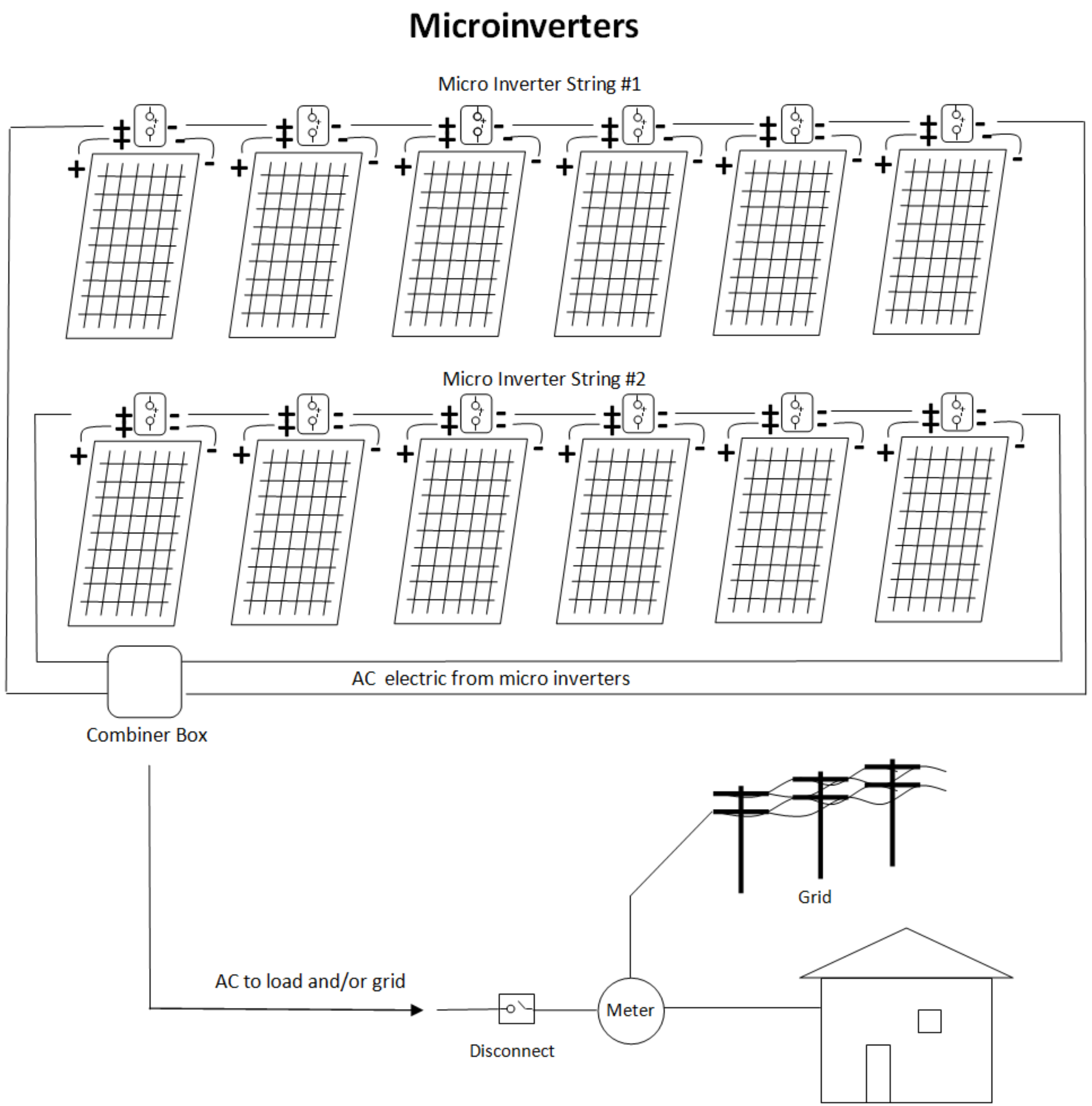


String Inverters

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

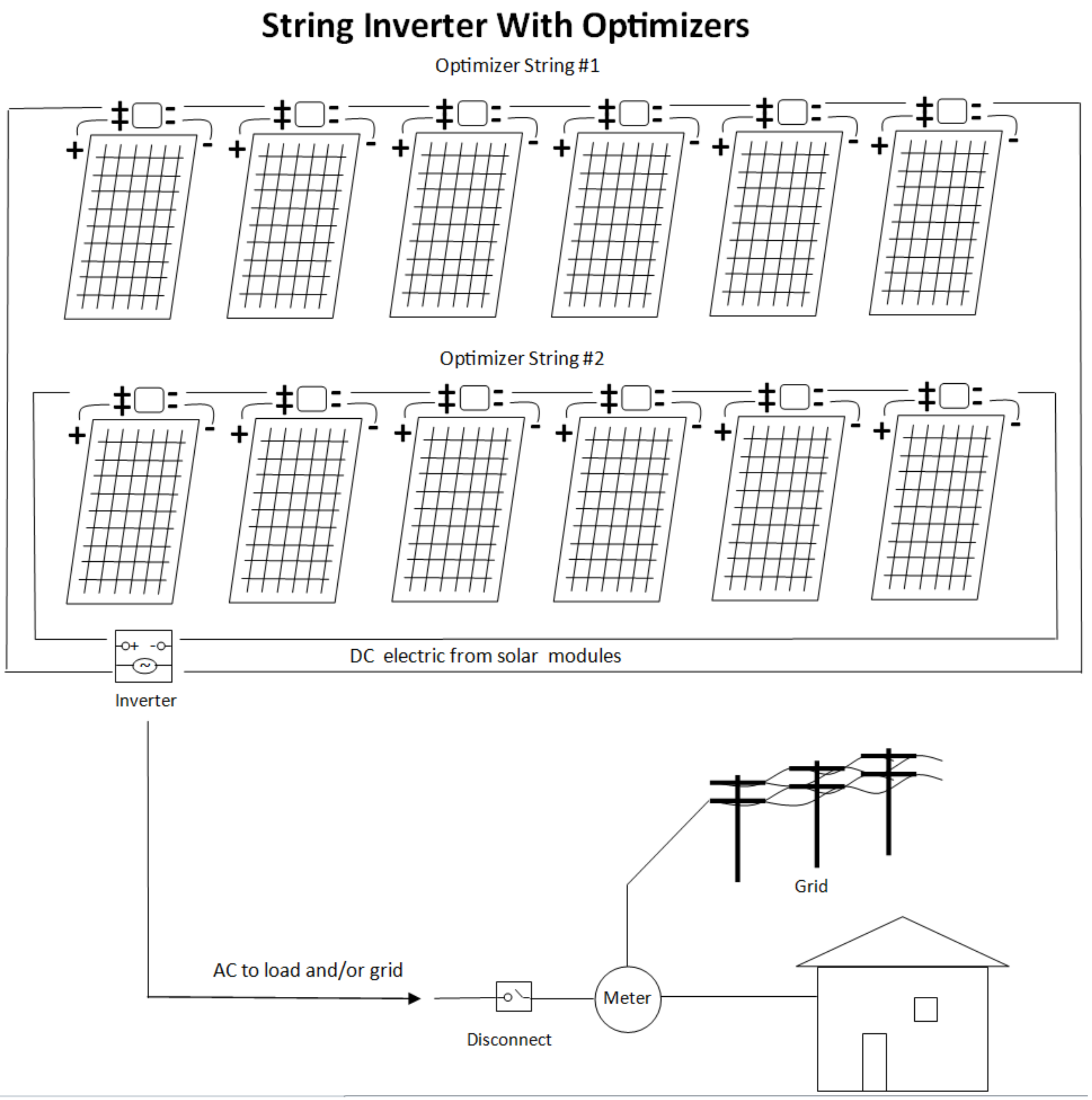
System Production – Shade

Which Inverter is Right for You?



Micro Inverters

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



System Production – Shade

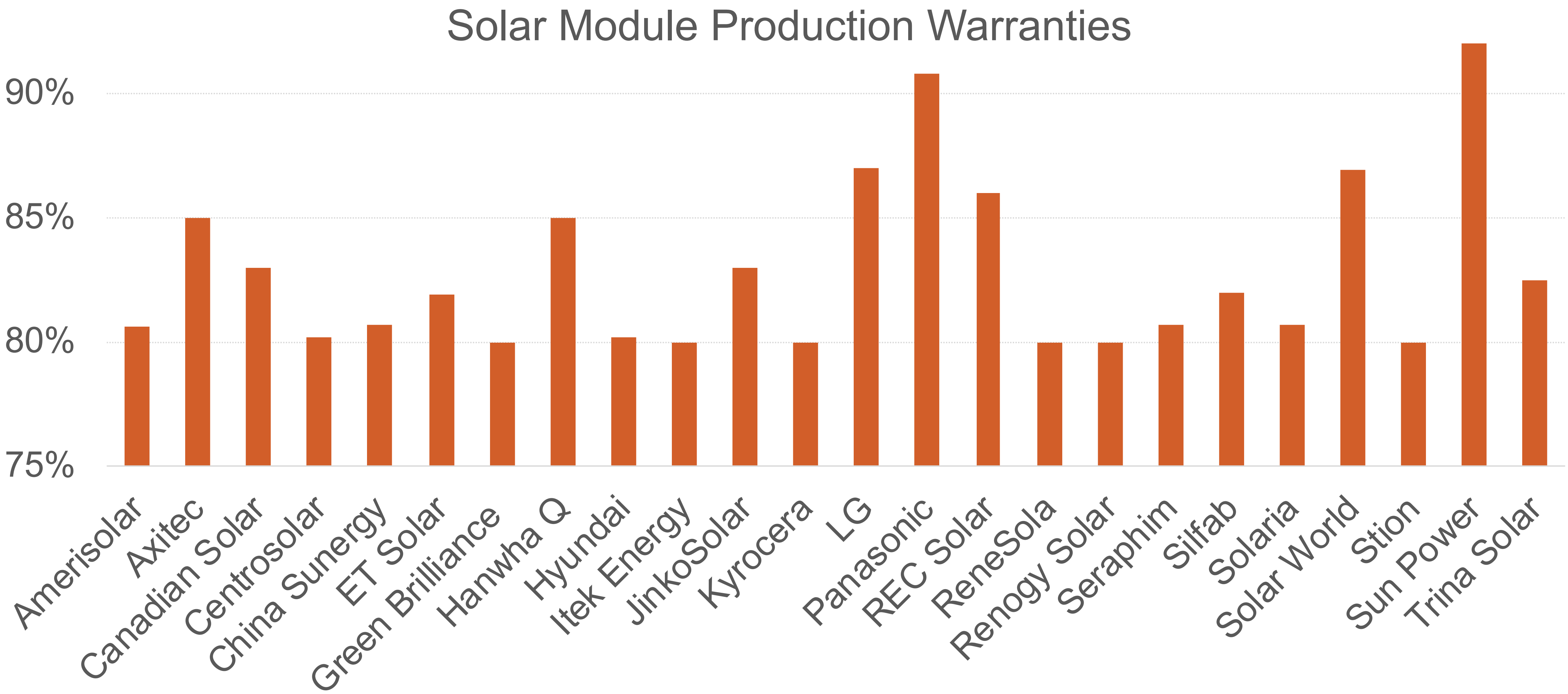
Which Inverter is Right for You?

DC Optimizers / Inverters

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

System Production – Temperature

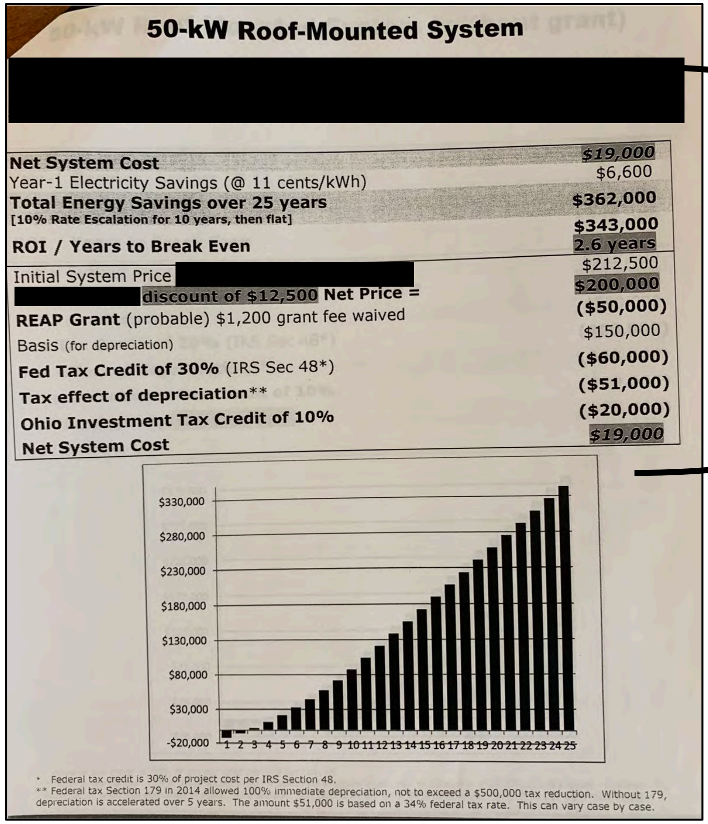
Panel Degradation (10kw Example System)



Source: https://www.energysage.com

Photovoltaic Solar System Financial Analysis

Really a No Brainer Decision?



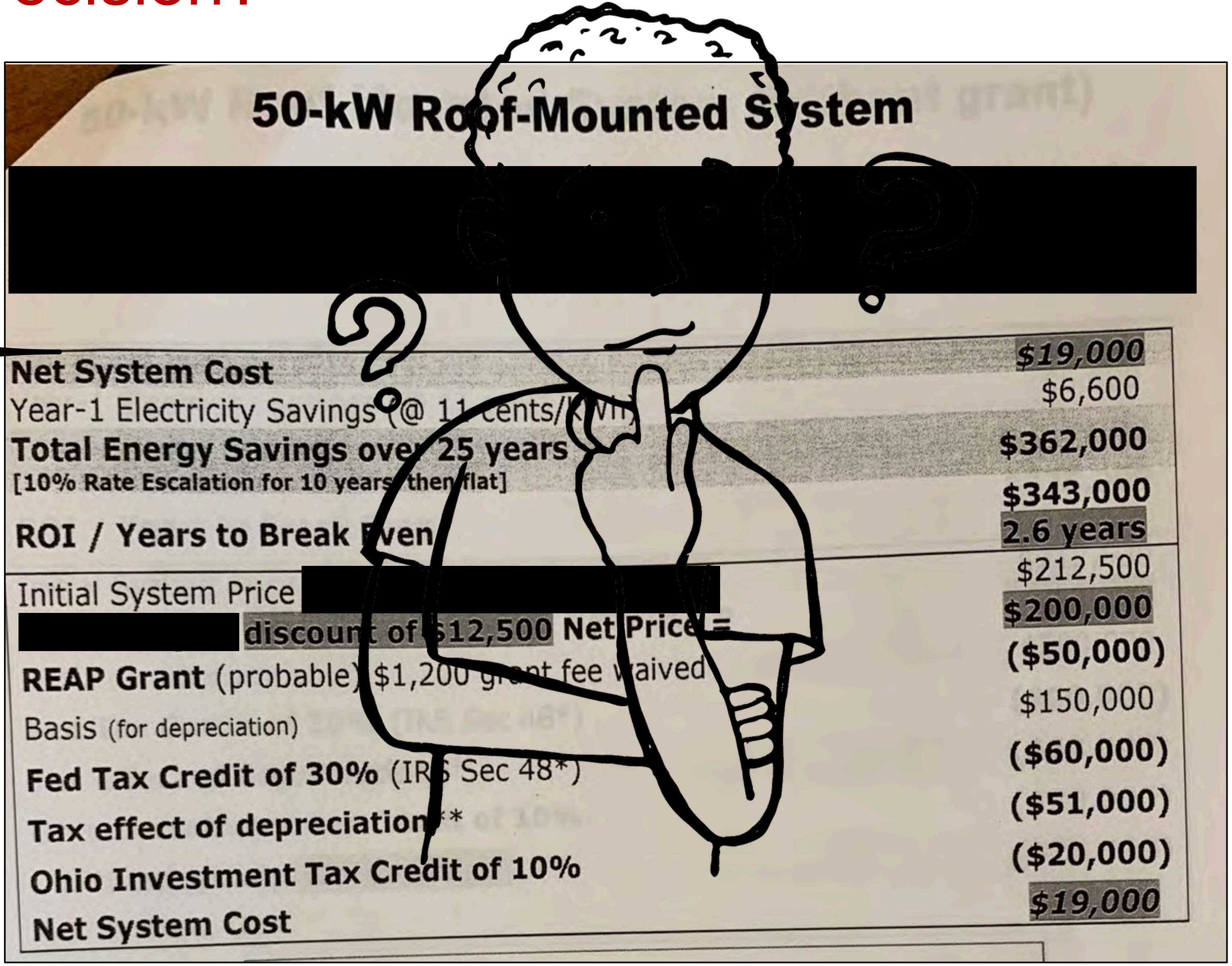
50-kW Roof-Mounted System

[redacted]

Net System Cost	***$19,000***
Year-1 Electricity Savings (@ 11 cents/kWh)	$6,600
Total Energy Savings over 25 years	**$362,000**
[10% Rate Escalation for 10 years, then flat]	**$343,000**
ROI / Years to Break Even	**2.6 years**
Initial System Price [redacted]	$212,500
[redacted] **discount of $12,500 Net Price =**	**$200,000**
REAP Grant (probable) $1,200 grant fee waived	**($50,000)**
Basis (for depreciation)	$150,000
Fed Tax Credit of 30% (IRS Sec 48*)	**($60,000)**
Tax effect of depreciation**	**($51,000)**
Ohio Investment Tax Credit of 10%	**($20,000)**
Net System Cost	***$19,000***

$330,000
$280,000
$230,000
$180,000
$130,000
$80,000
$30,000
-$20,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

* Federal tax credit is 30% of project cost per IRS Section 48.
** Federal tax Section 179 in 2014 allowed 100% immediate depreciation, not to exceed a $500,000 tax reduction. Without 179, depreciation is accelerated over 5 years. The amount $51,000 is based on a 34% federal tax rate. This can vary case by case.



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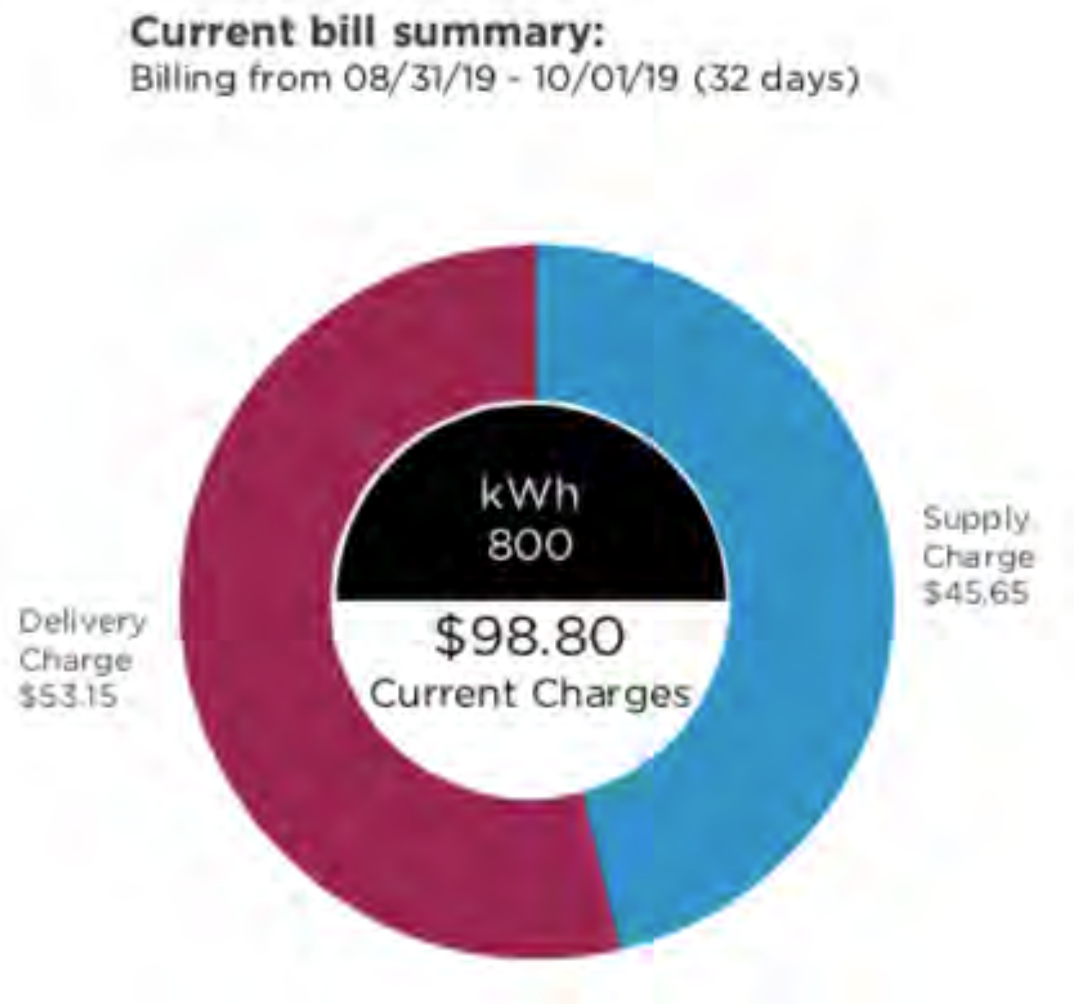
How Will Solar Generation Impact Your Electric Bill?



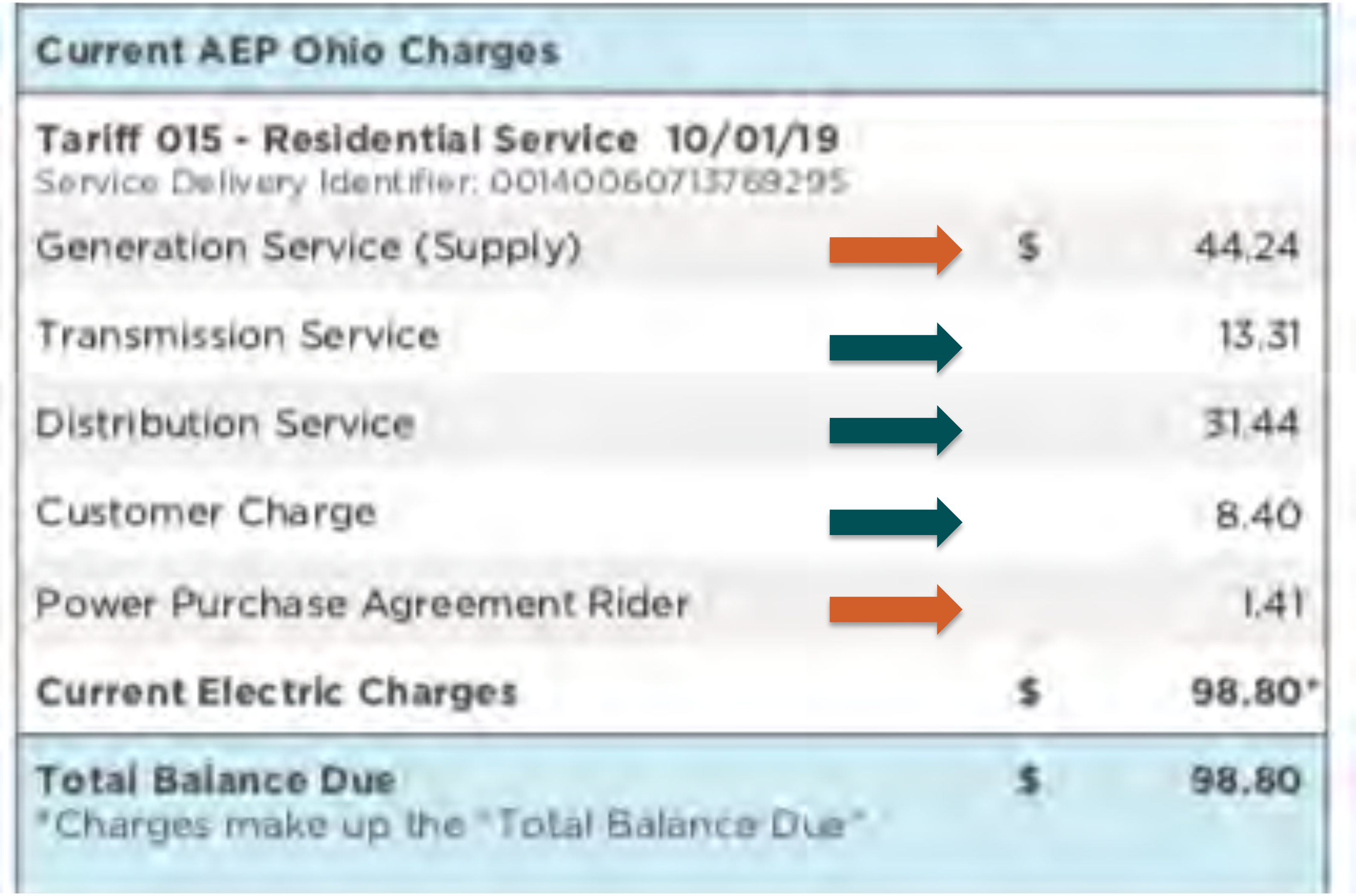
It is important to understand your electric bill to determine the value of electricity from solar generation.

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	**$**	**98.80***
Total Balance Due *Charges make up the "Total Balance Due"	**$**	**98.80**

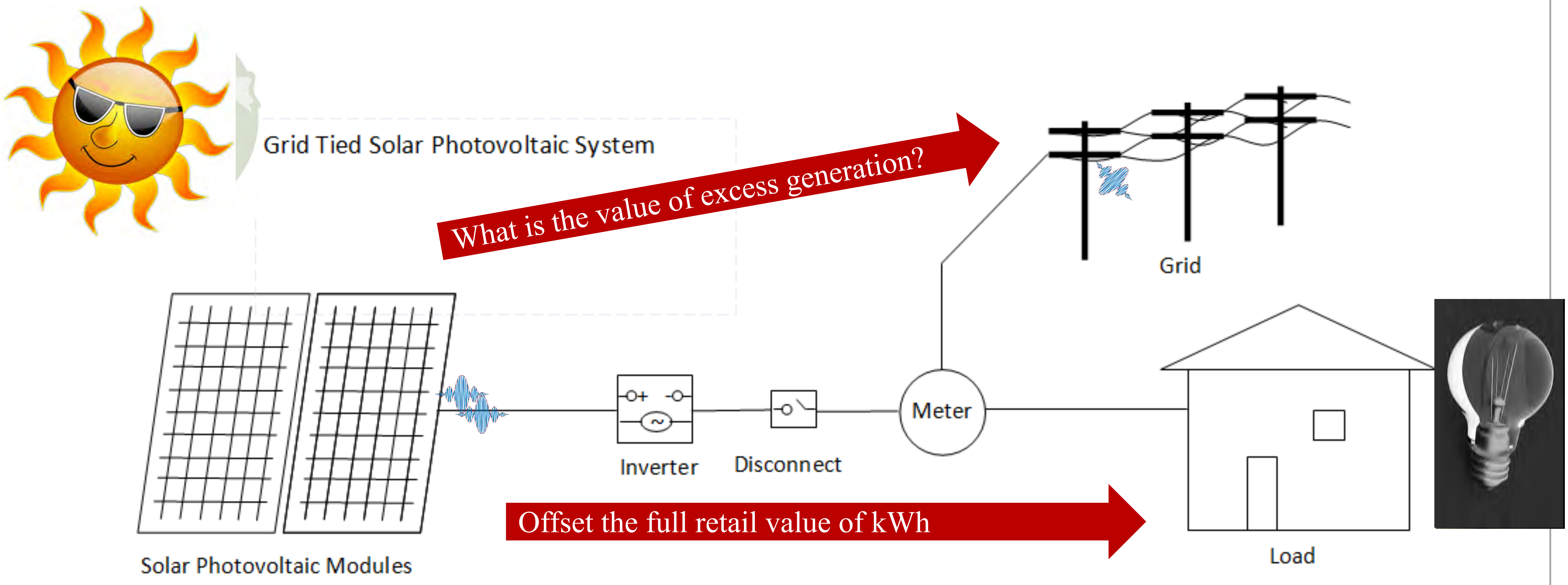
It is important to understand your electric bill to determine the value of electricity from solar generation.

Total cost of electricity is $0.125 per kWh.

Generation = $0.055 per kWh

Delivery = $0.066 per kWh.

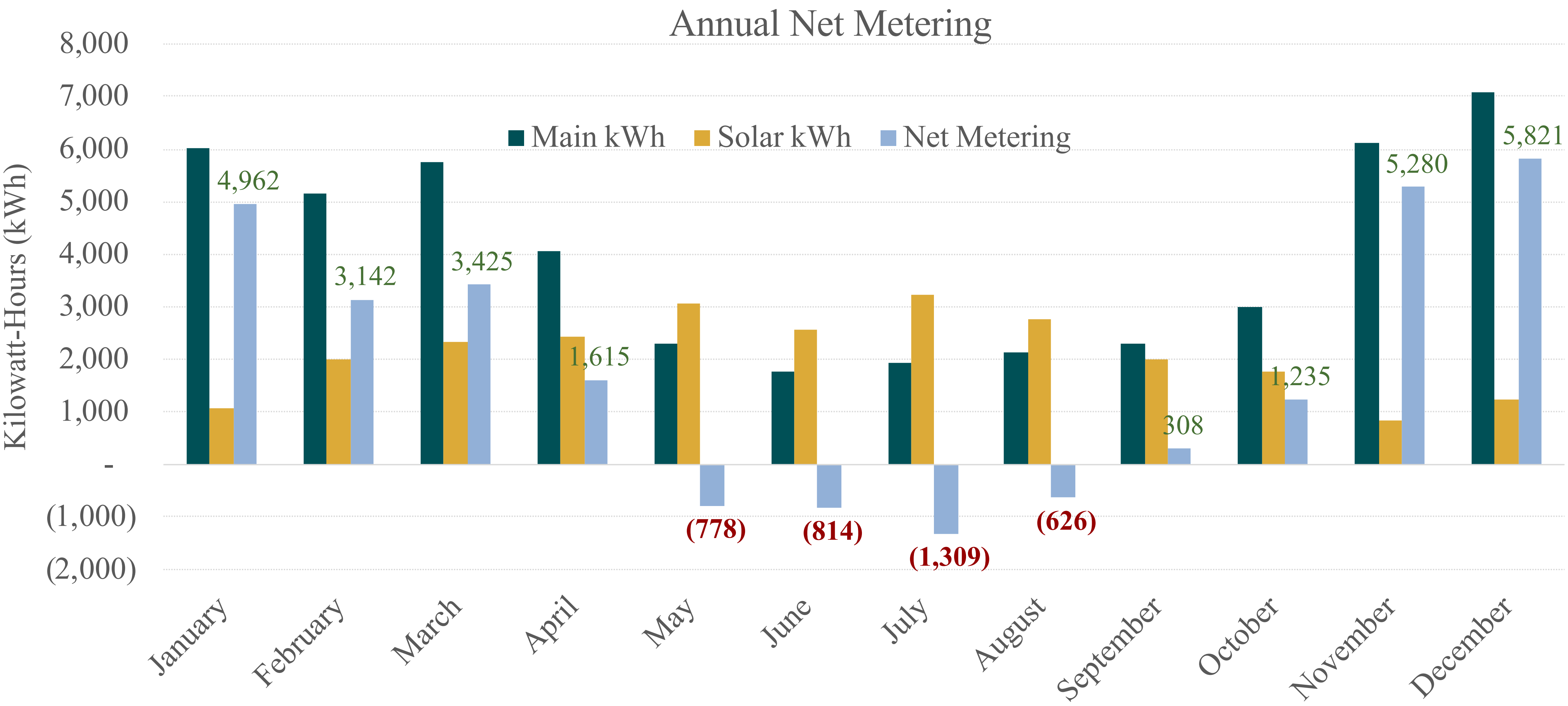
Example of Grid Tied Photovoltaic Solar System



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?



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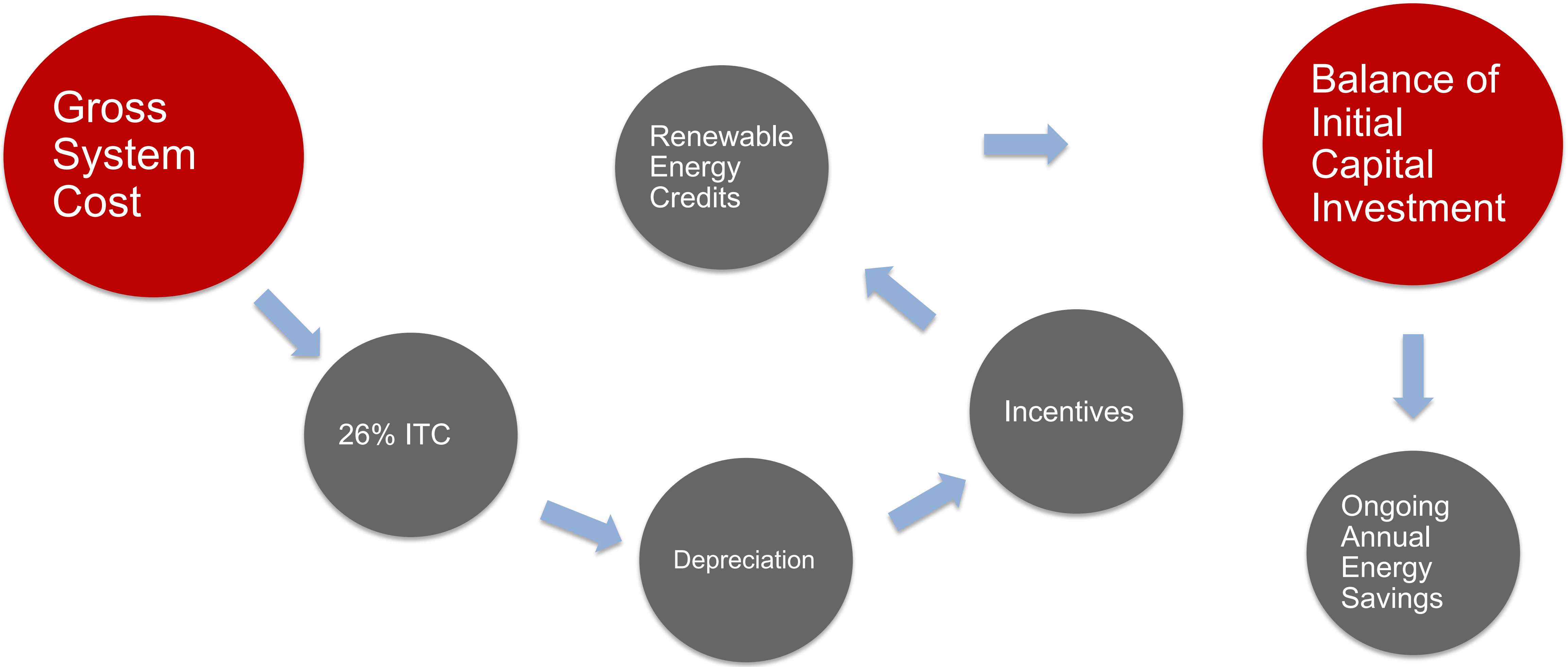
To maximize the value of a unit of energy (kWh) your solar system generates, you must use it!

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?

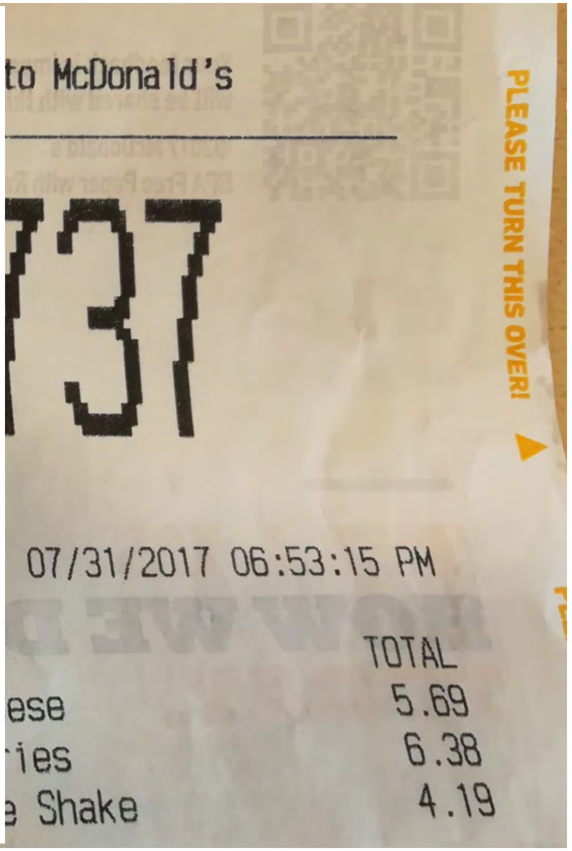
- Complex and ongoing cash flows!
  - – Solar production variables (degradation)
  - – O&M cost variables
  - – Inconsistent revenue (ITC, Grants, SRECs, Depreciation)
  - – Energy savings?
    - Energy price escalation
    - Variable rate structures and pricing models

Analysis Period

Time Value of Money!

Inflation

Total in 1998: $



Total in 2017: $16.26

Image Source: https://www.reddit.com/r/mildlyinteresting/comments/6r6ihp/mcdonalds_receipt_from_1998_vs_2017/

Time Value of Money

Option # 1

Option # 2

$4,000 for
25 Years

Winner!
$100,000

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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

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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
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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

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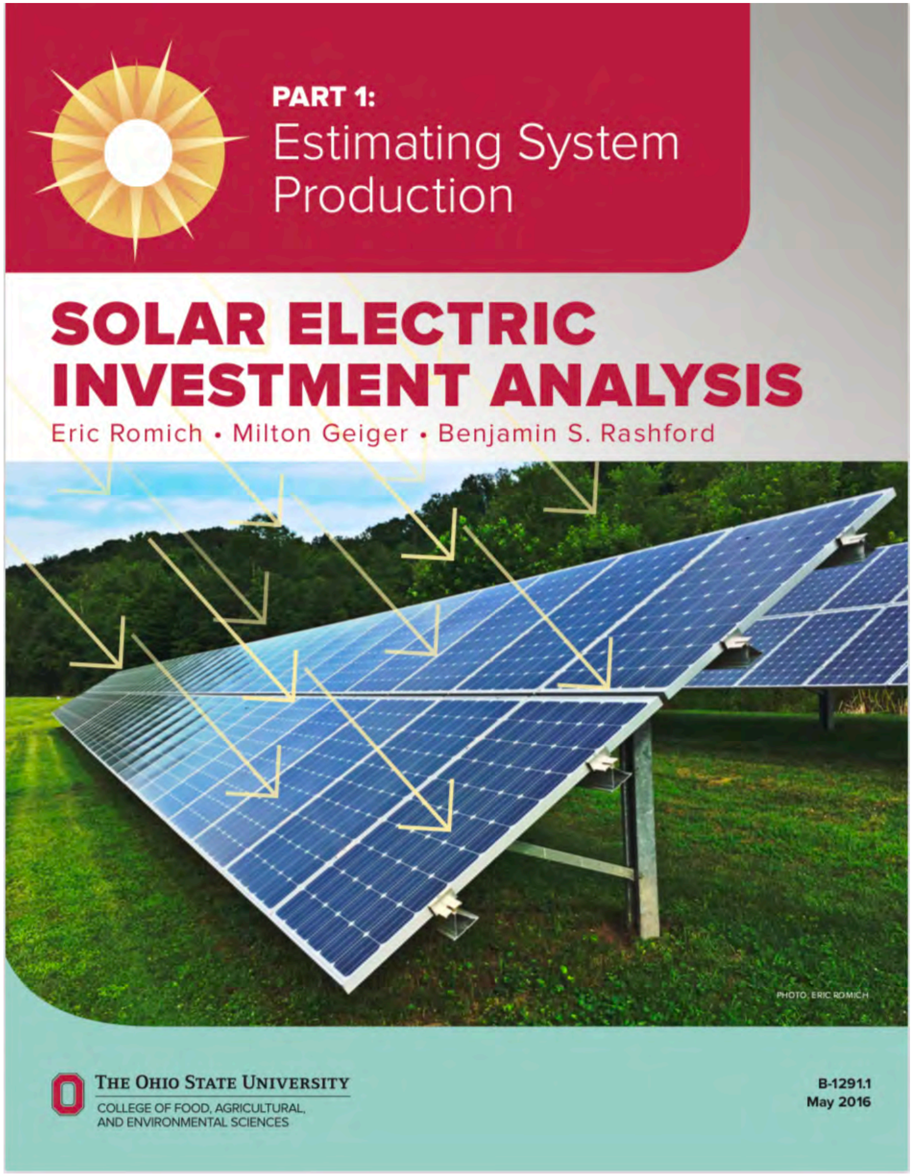
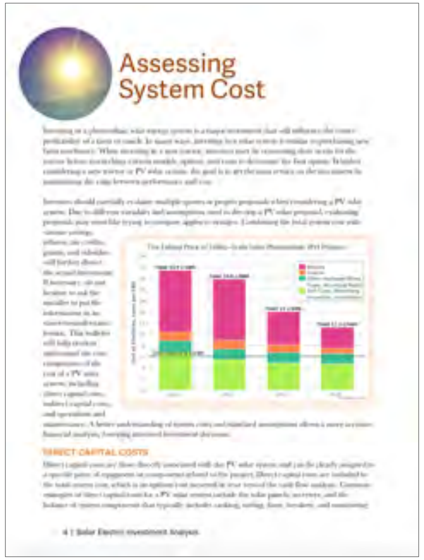
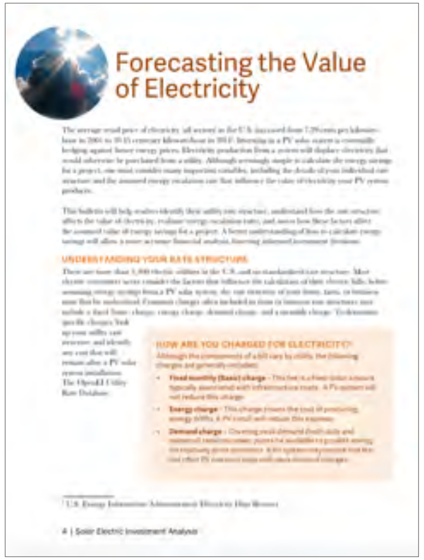
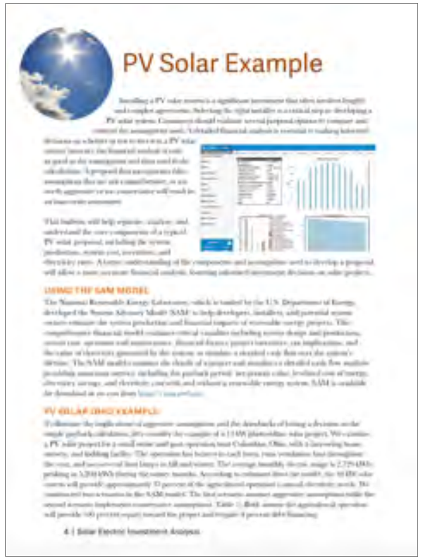


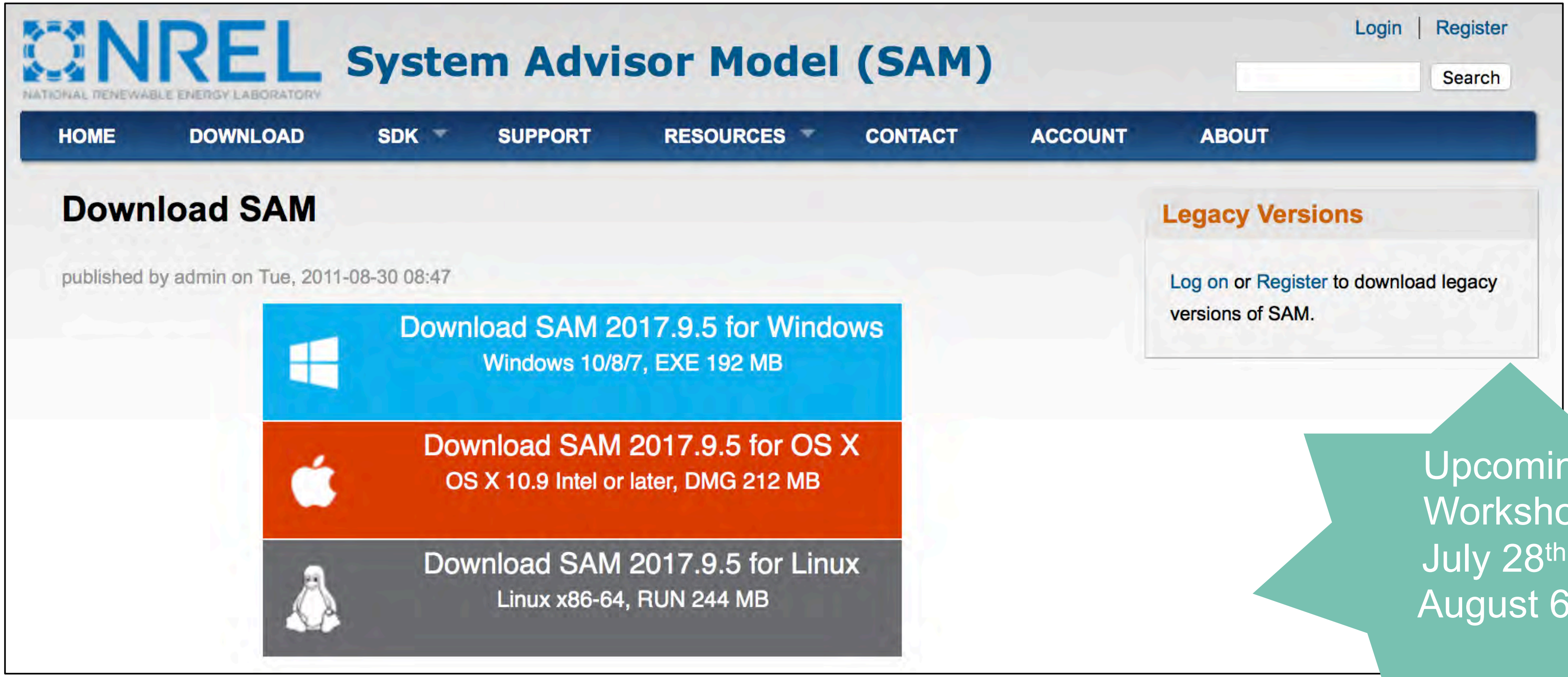






www.go.osu.edu/farmenergy

SYSTEM ADVISOR MODEL (SAM)



Upcoming Workshop July 28th – August 6th!

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

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Thank You!

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