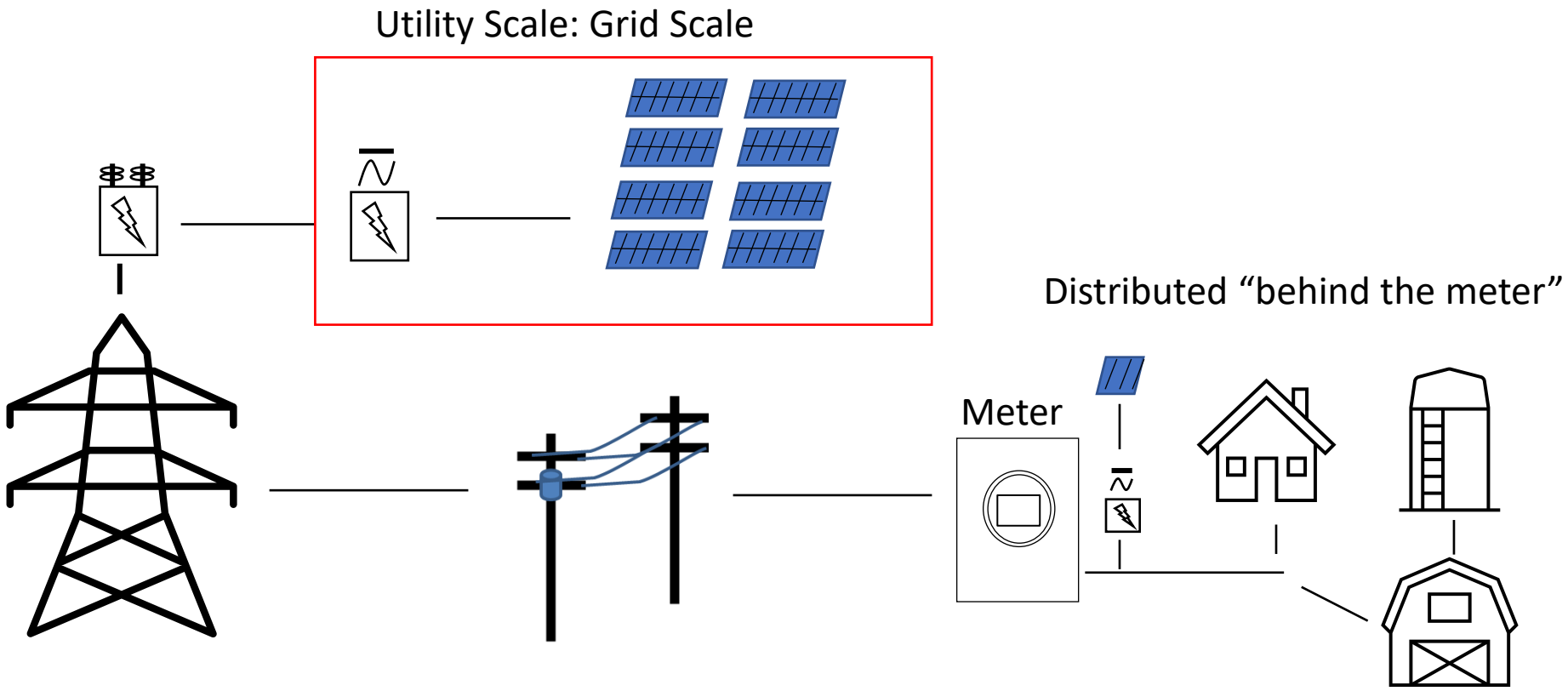
Economics of Behind the Meter On-Farm Solar Electric Systems (May 2023)

- F. John Hay (Extension Educator – Energy)

IN OUR GRIT, OUR GLORY™

Utility Scale Solar: Physics and Function

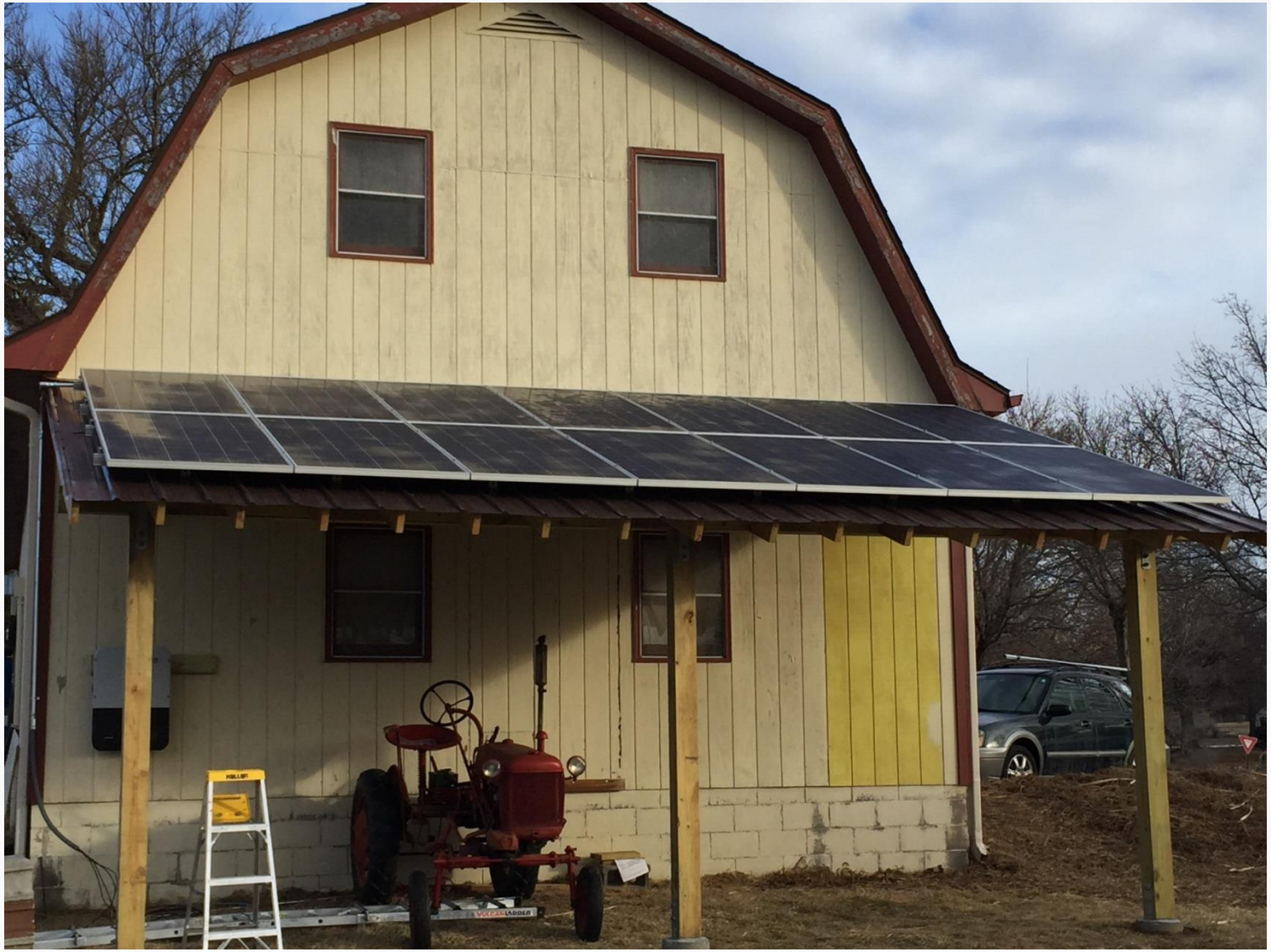


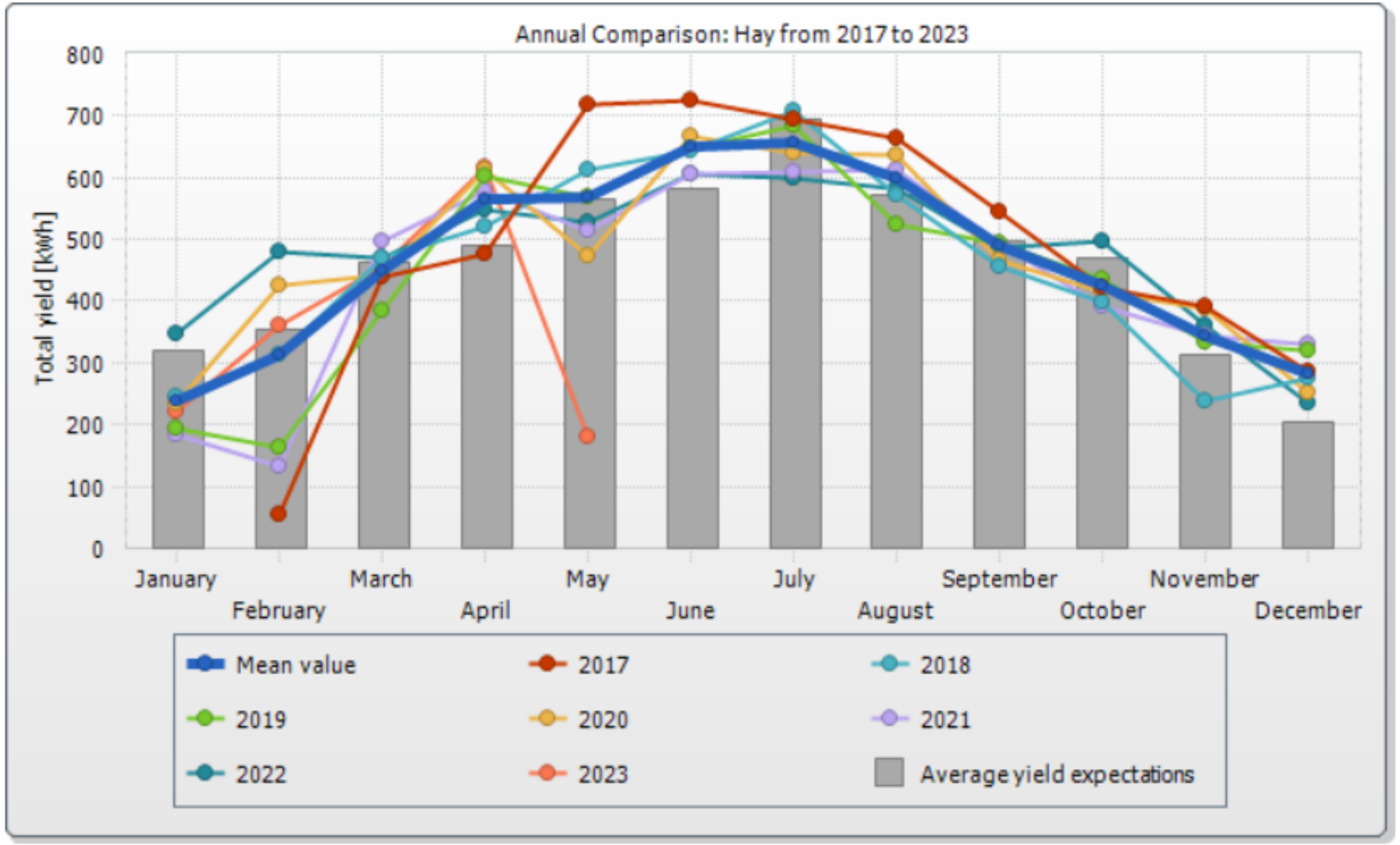
Residential or Business System	Community Solar Purchase
Pros: Green energy Tax credit Depreciation (businesses) Marketing Ongoing savings	**Pros:** Green energy Can participate even without place to install Sell it back if you move No O&M Little to no risk
Cons: Initial cost of system O&M May not regain investment if you move	**Cons:** No tax credit (maybe) Not at your location for marketing purposes

Renewable Energy Emissions

Table 1. Emissions by Type of Electrical Generation	
Carbon Dioxide Emissions of Electrical Generation Systems	
Generation Type	Emission Rate (g CO_2/kWh)
Coal, Steam generator	940[a] - 960.6[b]
Natural Gas, Combustion Turbine	604.2[b]
Natural Gas, Combined Cycle	406.6[b]
Nebraska's Generation Mix 2017	628[c]
Solar PV – utility scale	6- 14[dg]
Utility Scale Wind	4 - 9.11[efg]
Nuclear	4[g]
Hydro	97[g]

Note: Emission rates from electricity generation. Rates noted with "a" from Hong and Slatick, "b" from US DOE Environmental Baseline Report, "c" from EIA.gov State electricity profiles, "d" from Louwen et al. "e" from Gamaa et al. 2019, and Guezuraga et al., 2012. "g" from Pehl et al., 2017




Annual Comparison: Hay from 2017 to 2023
Total yield [kWh]
800
700
600
500
400
300
200
100
0
January
February
March
April
May
June
July
August
September
October
November
December
Mean value
2017
2018
2019
2020
2021
2022
2023
Average yield expectations

Steps in Solar PV Process

System Owner
Installer and Electrician
Utility is involved.

1. Study electric bills, efficiency
2. Solar homework, goals,
3. Get quotes, talk to multiple installers and apply for grants
4. Contact utility (before signing installation contract)
5. Design
6. Order solar modules, inverter, mounting
7. Building permit
8. Structure
9. Solar rail mounting
10. Solar module (panel) installation
11. Electrical permit
12. DC wiring and grounding
13. Inverter installation
14. AC wiring
15. Electrical inspection
16. Install safety labeling
17. Utility agreement
18. New meter (Utility site inspection)
19. Turn it on! (owner and installer)
20. Online Monitoring (owner and installer)

Solar Cash Flow

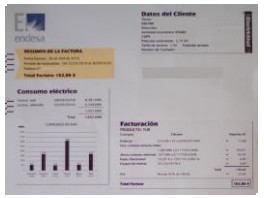
Gross System Cost:
$/Watt x Watt Capacity

Federal Tax Credit:
Received at tax time

Net System Cost

Solar Production

X



Value of Electricity

5 kW Solar Array

- Gross System Cost: 5000 Watts X $3/Watt = $15,000
- Federal Tax Credit (30%) = $4,500
- Net System Cost: $10,500
- Production = 7,100 kWh/year X ($0.0525 to $0.1025/kWh) = $575 savings/year
- Payback 15.56 years

Solar Cash Flow

Gross System Cost:

Federal Tax Credit:
Received at tax time

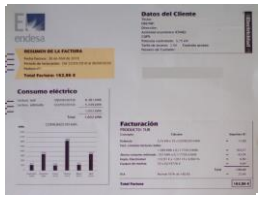
Depreciation for Businesses

Other Grants and Incentives:
USDA Rural Energy for America Program

Net System Cost

Solar Production

X



Value of Electricity

Operation and Maintenance
Insurance
Time value of money

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- Payback 15.56 years

O&M, Insurance, and Inflation = 16.2 years

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Gross System Cost:

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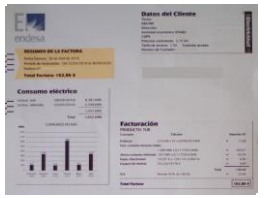
Net System Cost

Solar Production

X



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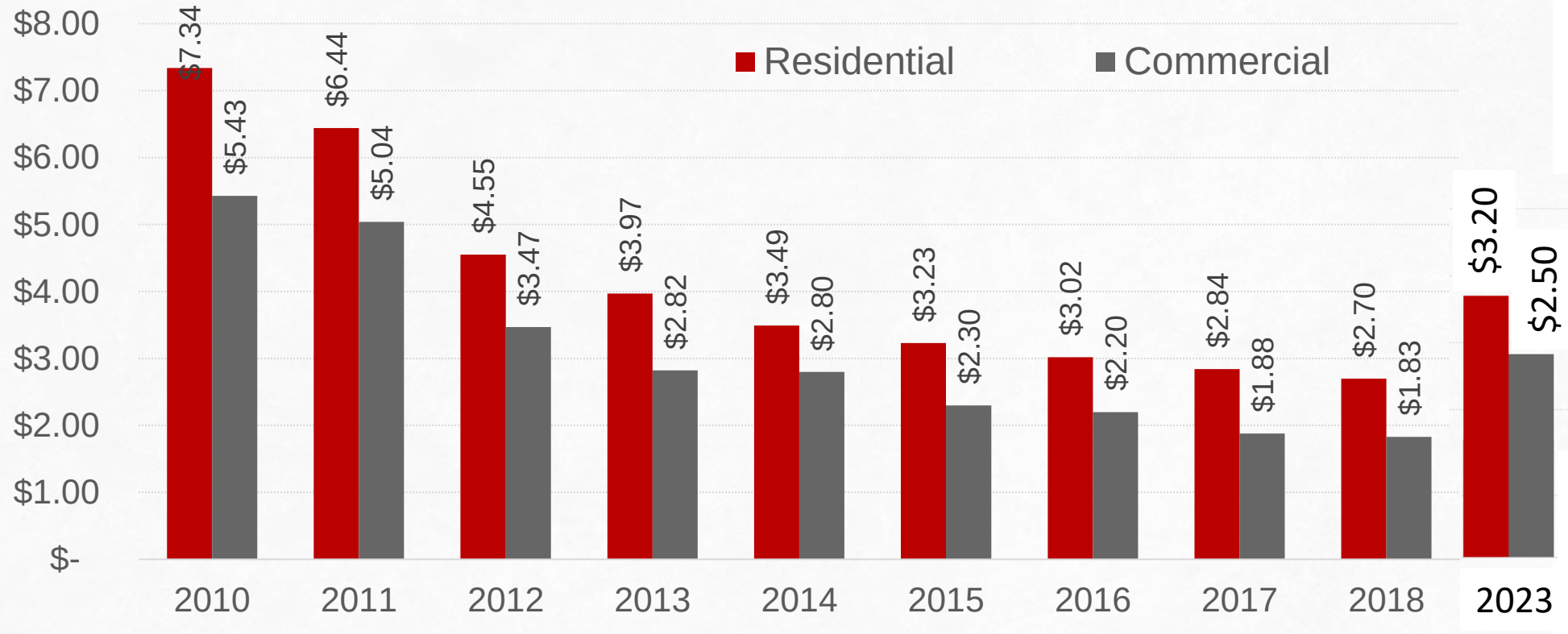
NREL Solar System Installation Cost $ Per DC/Watt (Inflation Adjusted), Q4 2010–Q1 2018



https://www.nrel.gov/docs/fy22osti/82854.pdf

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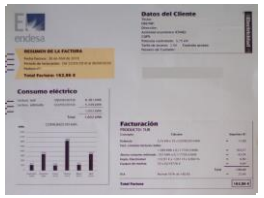

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Investment Tax Credits (ITC)

Residential:

- **30% ITC through 2032**

Commercial

- **ITC or Production Tax Credit (PTC) through 2025 – after 2025 switching to new tax credit rules**

Commercial Renewable Tax Credits

Investment tax credit

- Base of 6 percent of a project's cost
  - 30 percent for developers that pay a prevailing wage.
- Additional 10 percent bonuses are available
  - domestically made materials
  - in low-income or fossil fuel-reliant communities.
  - 10% for selling the electricity via community solar to low-income families – the tax credit could potentially reach 60%.

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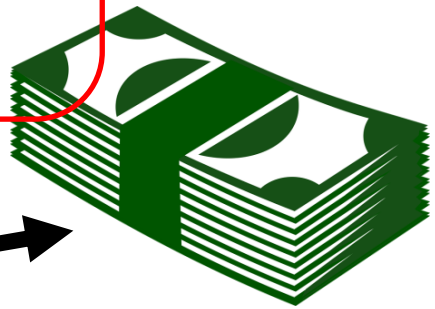
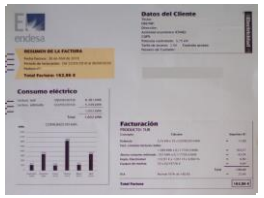


Solar Production

X



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Rural Energy for America Program: Inflation Reduction Act Changes

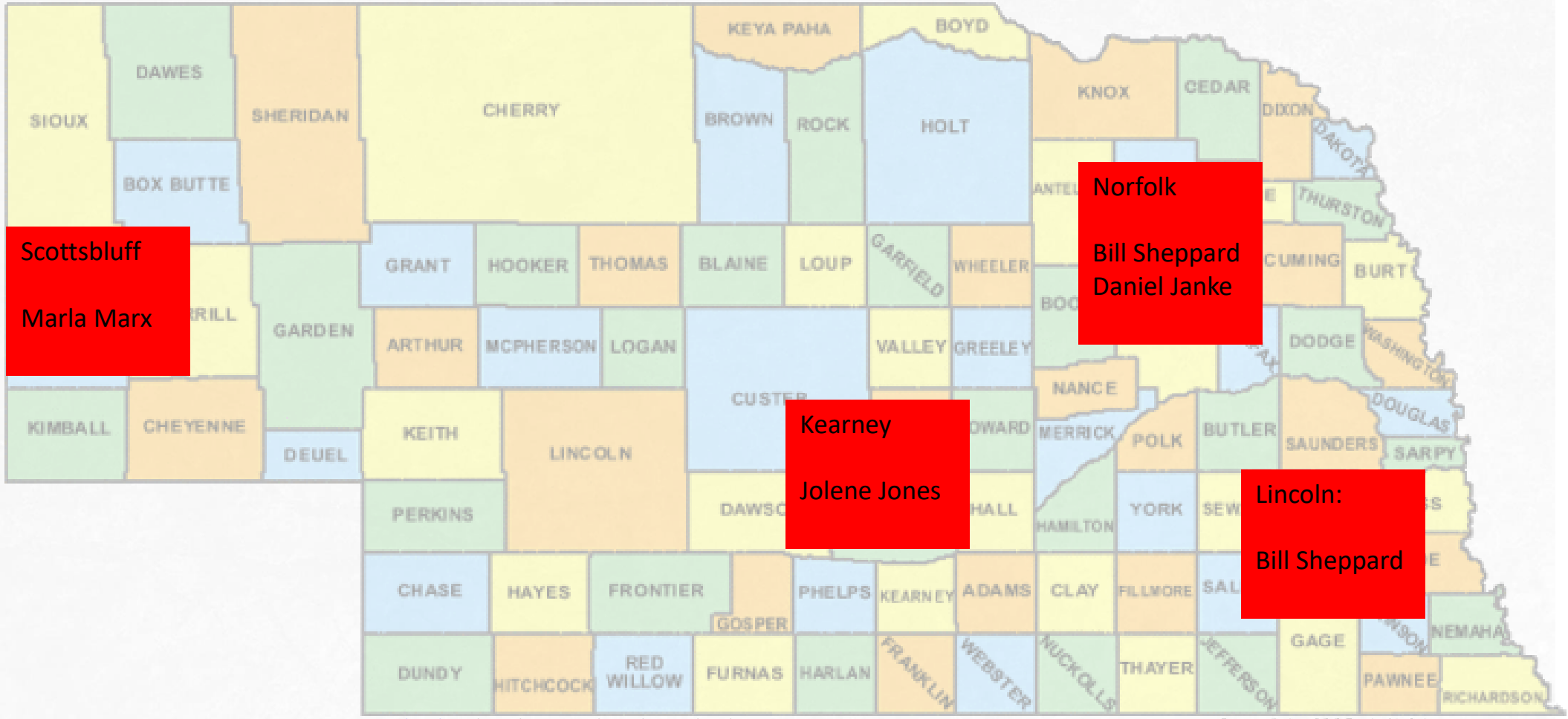
Applicable to REAP RES/EEI grant applications received on or after April 1, 2023

Description of Change	Brief Description
NEW Funding Source: Inflation Reduction Act of 2022	
	$1.055 Billion in Inflation Reduction Act Funding Underutilized Technology Set-aside

Subject	Current Language	Regulation Location	Brief Description of Change
REAP Energy Efficiency Improvements and Renewable Energy Systems			
Underutilized Technology		3/31/23 REAP Notice	Applicable to IRA funding only Renewable Energy technologies which do not produce greenhouse gas emissions at project level and that make up less than 20% of total grant dollars obligated at the end of the fiscal year (FY) two years previous to current year. *(Example, for FY23, FY21 award data is used)*
Number of Employees Calculation	Uses preceding 12 months	4280.103 Small Business 3/31/23 REAP Notice	Conforming REAP to SBA calculation of number of employees which has been updated to use preceding 24 months
Application Limits	Applicants may compete one RES and one EEI grant application per fiscal year. Legally formed entities based on tax identification number were viewed as independent applicants	4280.110 (c) 3/31//23 REAP Notice	Maximum grant award applies to all affiliated entities as if they applied as one applicant. Maximum grant assistance to an applicant in a fiscal year is $1,500,000
Grant Minimums	Minimum RES grant request of $2,500 Minimum EEI grant request of $1,500	4280.115 (a) 3/31/23 REAP Notice	Minimum grant request has been changed to a minimum total project cost. Regardless of federal grant share eligible projects must meet the minimum total project costs: RES of $10,000 and EEI of $6,000

Subject	Current Language	Regulatory Citation	Brief Description of Change
REAP Energy Efficiency Improvements and Renewable Energy Systems (Cont'd)			
Federal Grant Share	25 % of Total Eligible Project Costs	4280.115 3/31/23 REAP Notice	Federal grant share of up to 50% using IRA funding for projects that meet one of the following: -Renewable energy systems or retrofits that produce zero greenhouse gas emissions at the project level; -Projects located in an Energy Community defined in 26 U.S.C. 45 (b)(11)(B); -Energy efficiency improvement projects; -Projects proposed by eligible Tribal entities All other projects remain limited to 25% or less federal grant share
Scoring	Criteria — Points Energy generated/saved/replaced — 25 Previous recipient — 15 Length of payback period — 15 Commitment of matching funds — **15** Environmental benefits — **5** **Size of request** — **10** **Existing business** — **5** **State Director/Administrator Points** — 10 TOTAL POINTS — 100	4280.121 3/31/23 REAP Notice	Criteria — Points Energy generated/saved/replaced — 25 Previous recipient — 15 Length of payback period — 15 Commitment of matching funds — **10** Environmental benefits — **10** **Disadvantaged or distressed community** — **15** **State Director/Administrator Points*** — 10 TOTAL POINTS — 100 *Key priorities now embedded in scoring. See notice.
Application Windows	October 31 March 31	4280.122 3/31/23 REAP Notice	Announces 6 quarterly application windows. Complete applications *compete* in the following quarter: Q1 April 1, 2023 - June 30, 2023 Q2 July 1, 2023 - September 30, 2023 Q3 October 1, 2023 - December 31, 2023 Q4 January 2, 2024 - March 31, 2024 Q5 April 1, 2024 - June 30, 2024 Q6 July 1, 2024 - September 30, 2024

USDA Rural Development Contacts



Solar Cash Flow

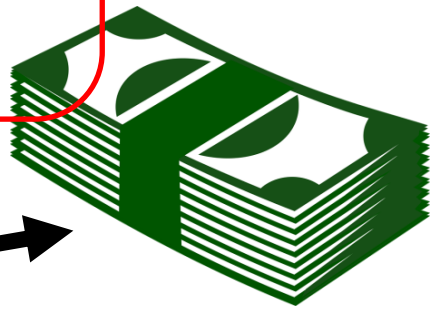
Gross System Cost:

Federal Tax Credit:
Received at tax time

Depreciation for Businesses

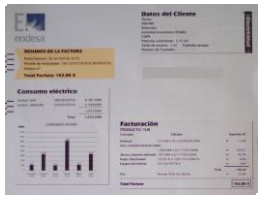
Other Grants and Incentives:
USDA Rural Energy for America Program

Net System Cost



Solar Production

X



Value of Electricity

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Solar Production

X

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Solar Array Tilt vs Azimuth (Lincoln, NE) Percentages compared to Max Annual Production

Azimuth (Direction Solar Array is Facing 0 = North 90 = East 180 = South 270 = West

Tilt angle (degrees) 12/12, 10/12, 8/12, 6/12, 4/12, 2/12 Roof Pitch	North			Northeast			East					Southeast					South				Southwest					West			Northwest				North		
	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350
2	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83	83
6	80	80	80	80	80	81	81	82	83	84	84	85	85	86	86	86	86	86	86	86	86	86	86	85	85	84	83	82	82	82	82	81	81	80	80	80
10	76	76	76	77	78	78	79	80	82	83	84	85	86	87	88	89	89	89	90	89	89	89	88	87	87	86	84	83	82	81	80	79	78	77	77	76
14	72	72	73	73	74	76	77	79	81	82	84	86	87	89	90	91	91	92	92	92	92	91	90	89	88	86	85	83	81	80	78	76	75	74	73	72
18	68	68	69	70	71	73	75	77	79	82	84	86	88	90	91	93	94	94	94	94	94	93	92	90	89	87	85	83	80	78	76	74	72	70	69	68
22	64	64	65	66	68	70	73	75	78	81	83	86	88	91	92	94	95	96	96	96	96	95	93	92	89	87	85	82	79	76	74	71	69	67	65	64
26	60	60	61	62	65	67	70	73	77	80	83	86	89	91	93	95	97	97	98	98	97	96	94	92	90	87	84	81	78	75	71	68	65	63	61	60
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44	44	44	45	48	51	55	60	65	70	74	79	83	87	90	93	96	98	99	100	100	99	97	95	92	89	85	81	76	71	66	61	56	52	48	46	44
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90	24	24	26	28	31	35	39	43	47	52	55	59	62	64	66	68	68	69	69	70	69	69	68	66	64	61	57	53	49	44	40	36	32	29	26	24

East

South

West

Sizing your Solar Array

1. Solar Array should produce = or less than you use annually (green energy goals)
2. Solar should produce < 75% of your annual use (economic return goals)
3. Size is based on available space (roof)
4. Size is based on budget (how much you have to spend or tax credit appetite)

Solar Cash Flow

Gross System Cost:

Federal Tax Credit:
Received at tax time

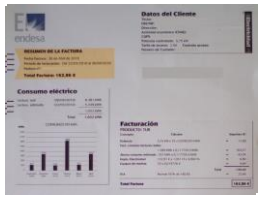
Depreciation for Businesses

Other Grants and Incentives:
USDA Rural Energy for America Program

Net System Cost

Solar Production

X



Value of Electricity

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Time value of money

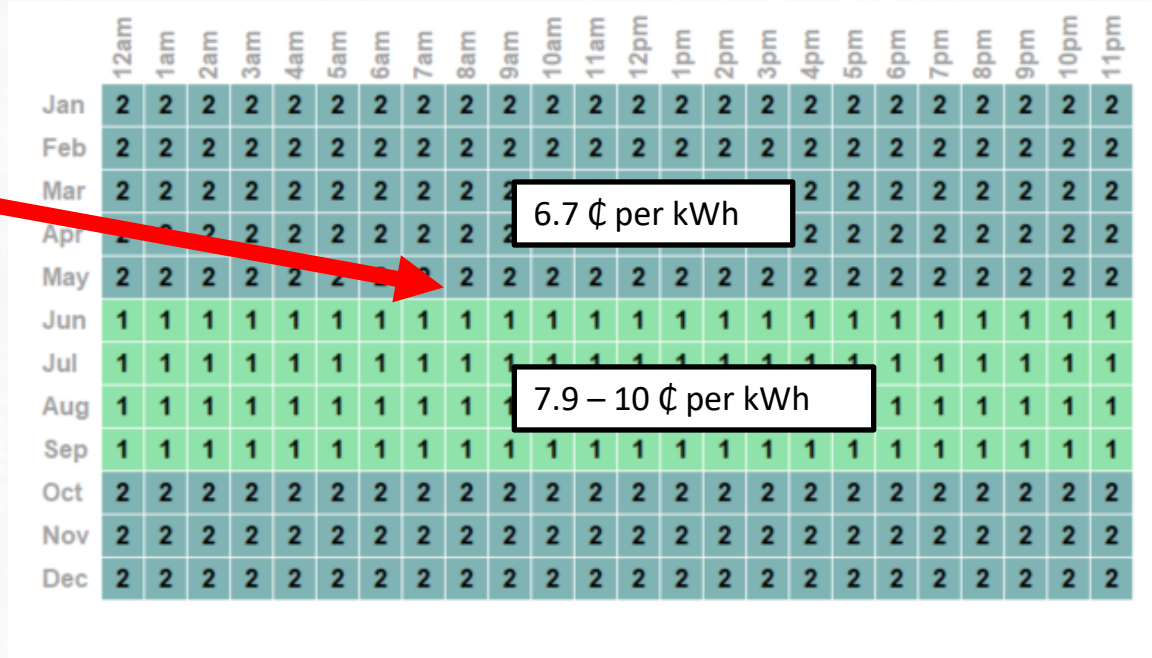
Rate schedule will determine the value of electricity

Farm Rate Schedule Example

Customer Charge: $30 per month

Demand Charge: $0

Energy Charge: $0.067-$0.10/kWh

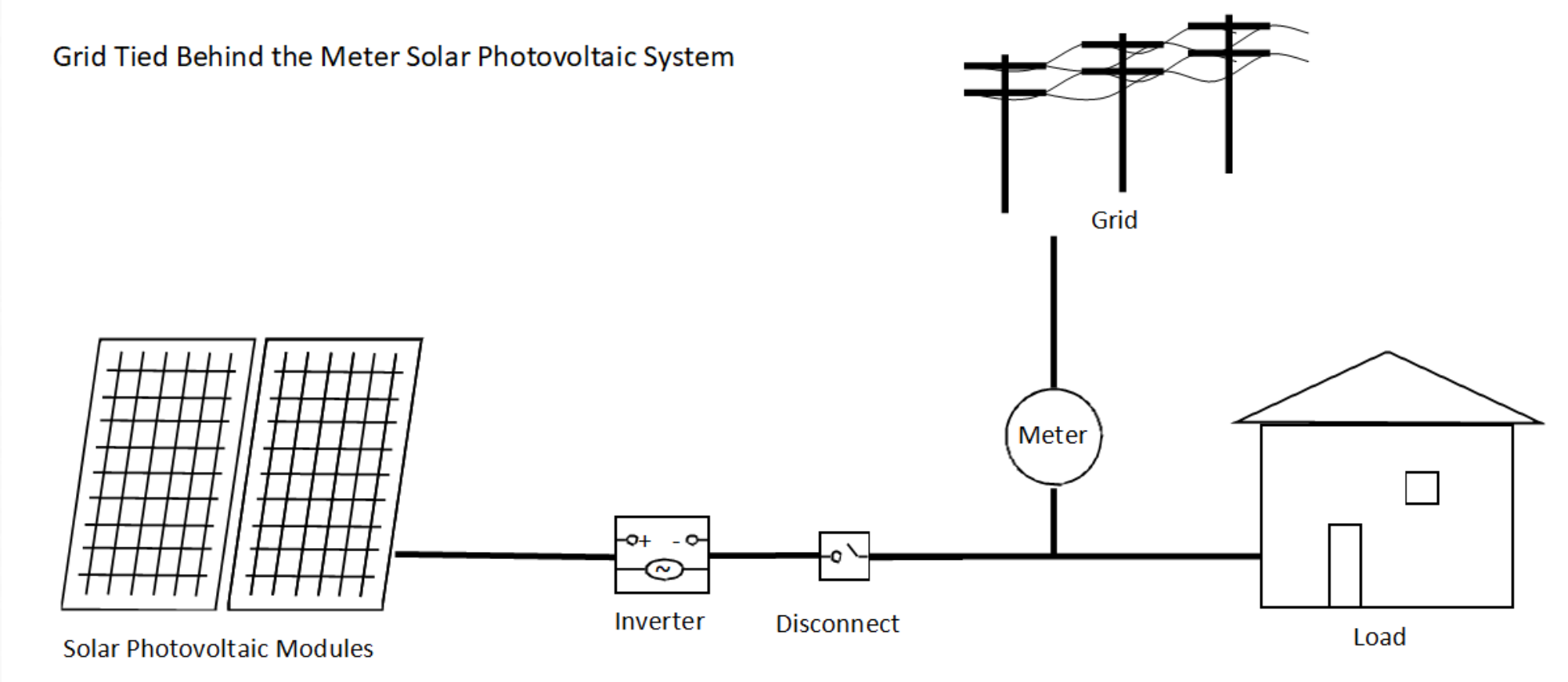


Solar Production Reduces Energy Charges (kWh) and Excess is credited back to the customer based on policy

- **Net Metering:** Get retail credit for most of instantaneous electricity that flows to the grid
- **Net Billing:** Get wholesale credit for all instantaneous electricity that flows to the grid
- **Buy All Sell All:** All solar generation is credited at wholesale, all energy use is purchased at retail

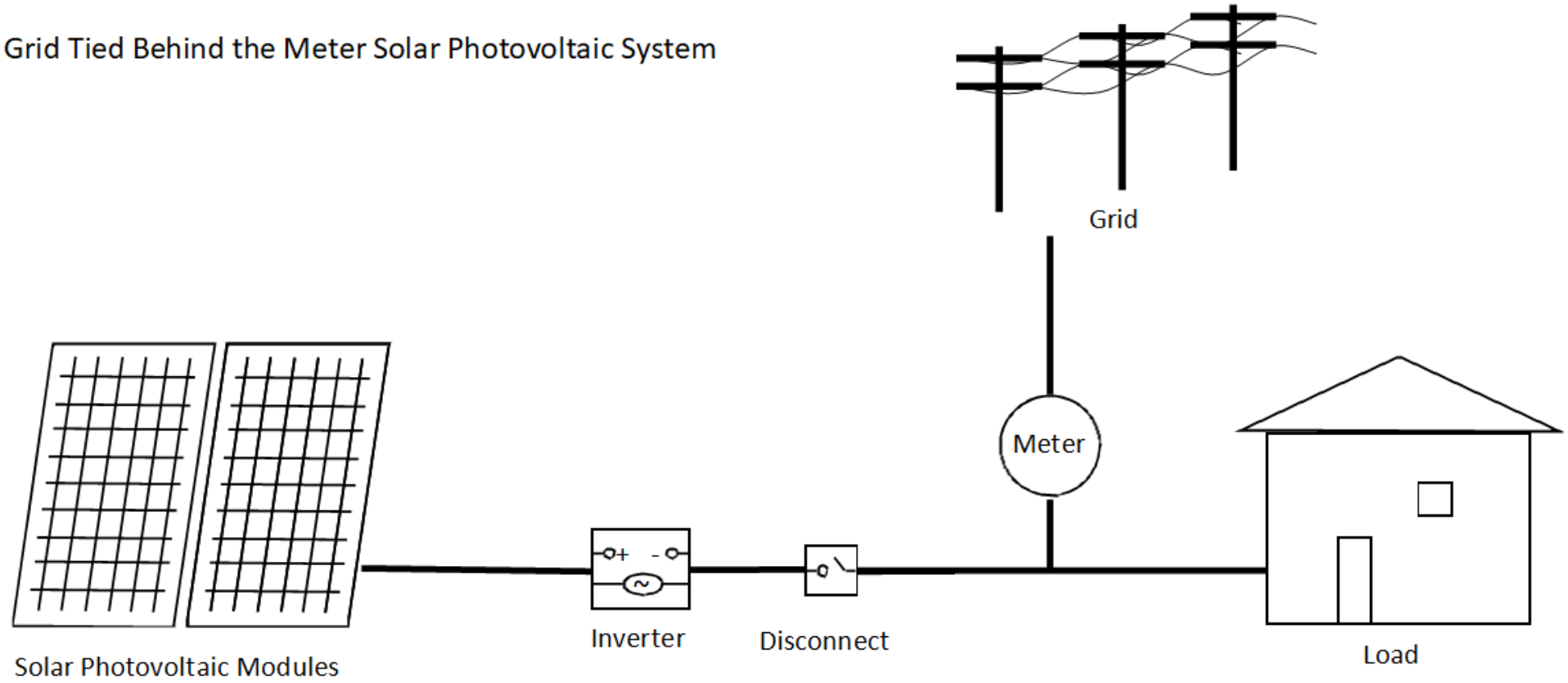
	Net Metering	Net Billing	Buy All Sell All
Payback (years)	16.2	19.6	>25 years

Net Metering

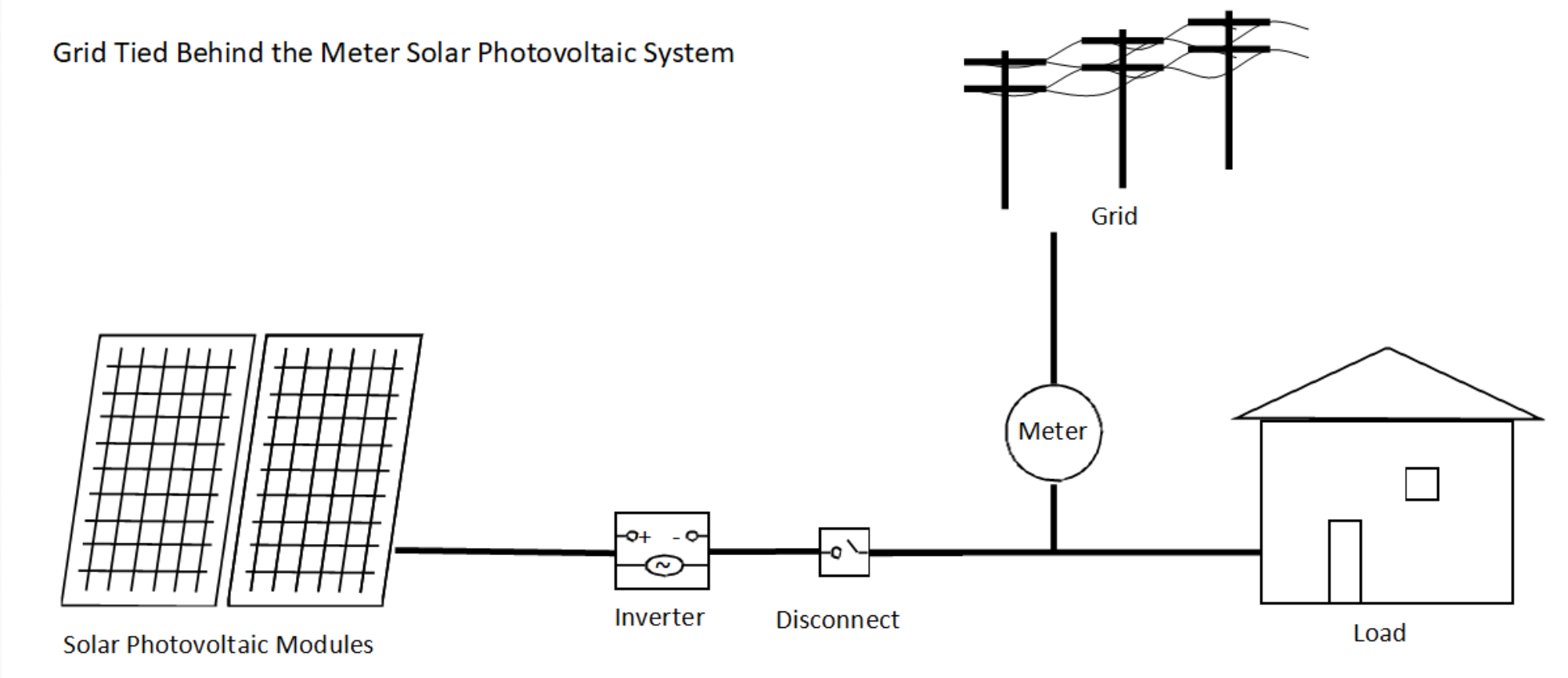


Net Billing

Grid Tied Behind the Meter Solar Photovoltaic System



Buy All Sell All



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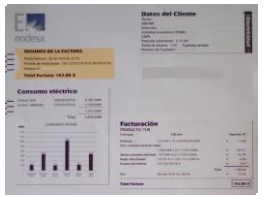

Value of Electricity

Operation and Maintenance
Insurance
Time value of money

Solar O&M is low but not Zero

- **Operation and Maintenance**
  - Monitoring
  - Replacement of equipment under warranty
  - Panels broken due to accidents, rocks, bullets, kids, stupidity
  - Replacement of equipment which fails after warranty (10 years for some inverters 25 years for panels and some inverters)
- **Insurance**
  - There may or may not be increase in insurance premiums due to solar installation
- **Time Value of Money**
  - Good analysis will consider that money now is worth more than money in the future
- **Cost of capitol (loans)**

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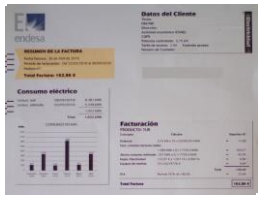

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Operation and Maintenance
Insurance
Time value of money

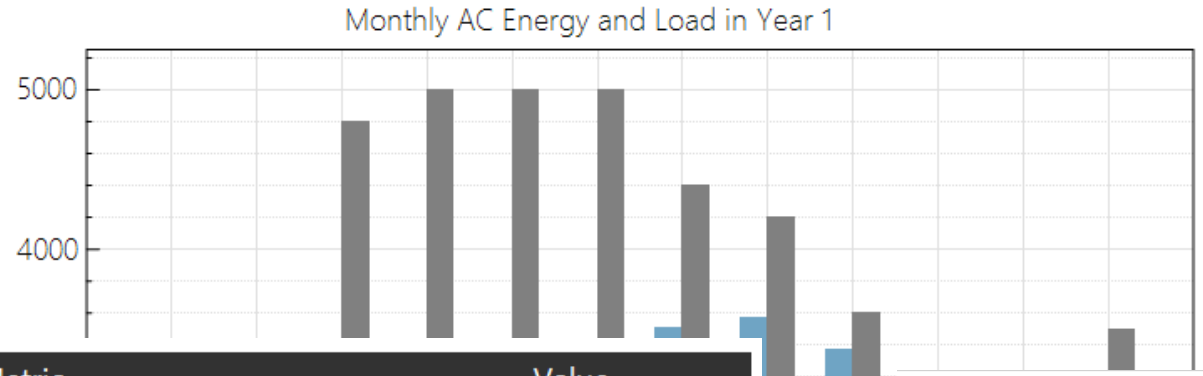
25 kW Solar Array

- Gross System Cost: 25,000 Watts X $2.8/Watt = $70,000
- Federal Tax Credit (30%) = -$21,000
- ~~USDA REAP = -$27,000 after taxes~~
- Net System Cost: $22,000
- Depreciation: -$14,000
- Production = 34,000 kWh/year X ($0.09 to $0.105/kWh) = $2,500 savings/year
- O&M, Insurance, Inflation
- Simple Payback 12.5 years

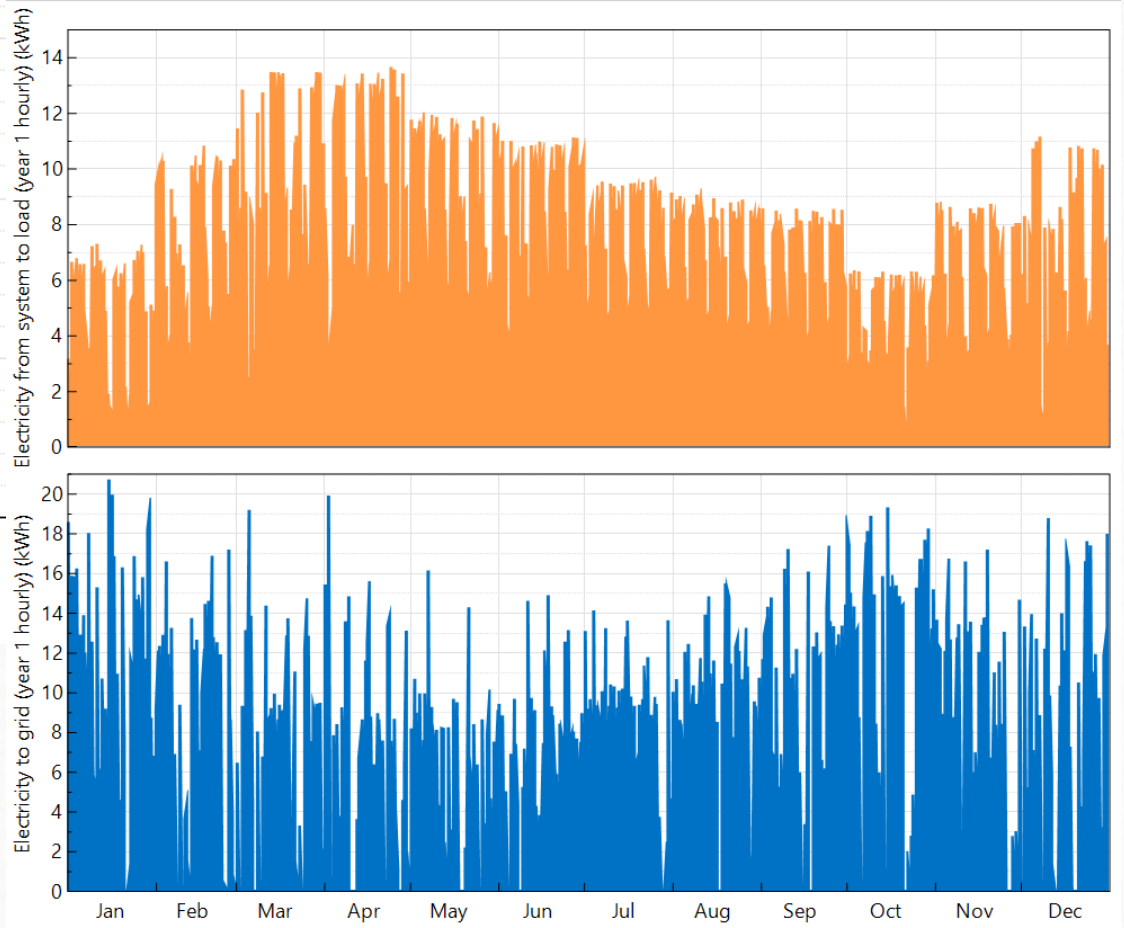
25 kW Solar Array

- Gross System Cost: 25,000 Watts X $2.8/Watt = $70,000
- Federal Tax Credit (30%) = -$21,000
- USDA REAP = -$27,000 after taxes
- Net System Cost: $22,000
- Depreciation: -$14,000
- Production = 34,000 kWh/year X ($0.09 to $0.105/kWh) = $2,500 savings/year
- O&M, Insurance, Inflation
- Simple Payback 4.3 years

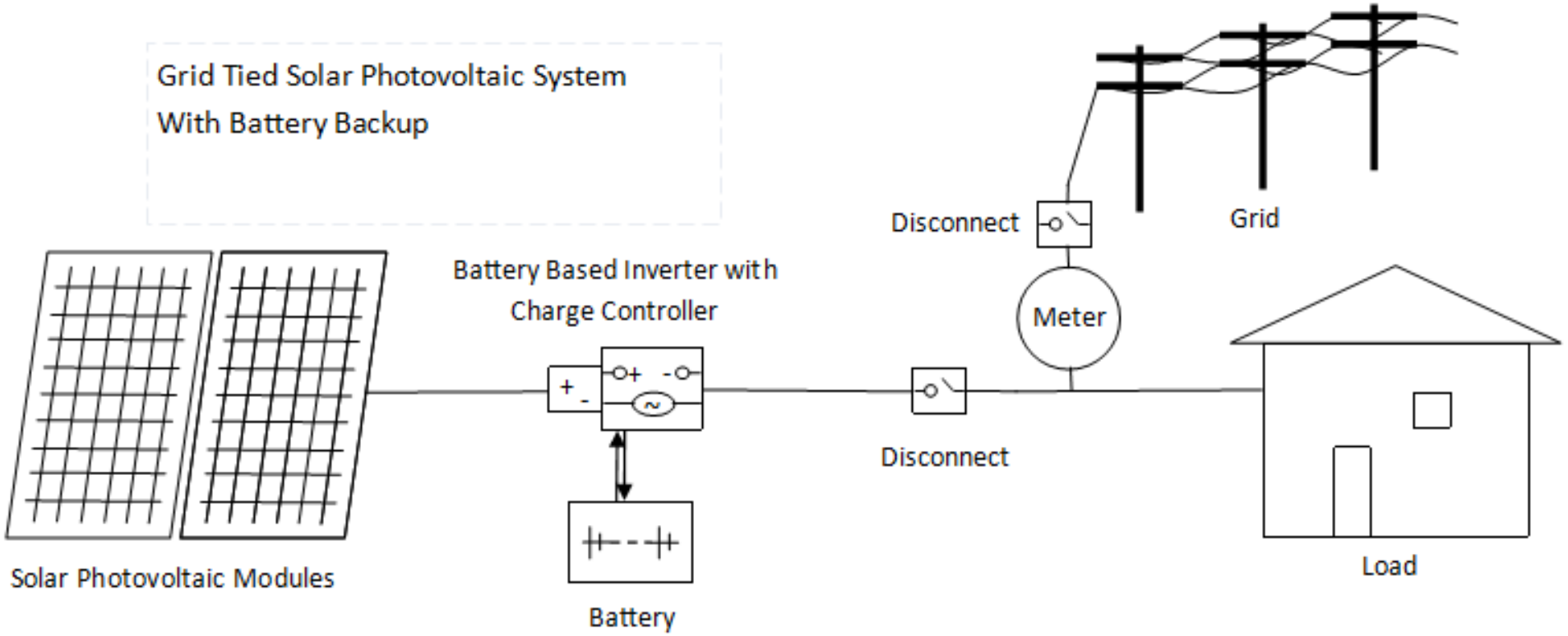
NREL System Advisor Model



Metric	Value
Annual AC energy in Year 1	37,023 kWh
DC capacity factor in Year 1	16.9%
Energy yield in Year 1	1,481 kWh/kW
LCOE Levelized cost of energy nominal	4.17 ¢/kWh
LCOE Levelized cost of energy real	3.28 ¢/kWh
Electricity bill without system (year 1)	$4,879
Electricity bill with system (year 1)	$1,290
Net savings with system (year 1)	$3,589
Net present value	$18,321
Simple payback period	4.3 years
Discounted payback period	6.2 years
Net capital cost	$35,000
Equity	$35,000
Debt	$0



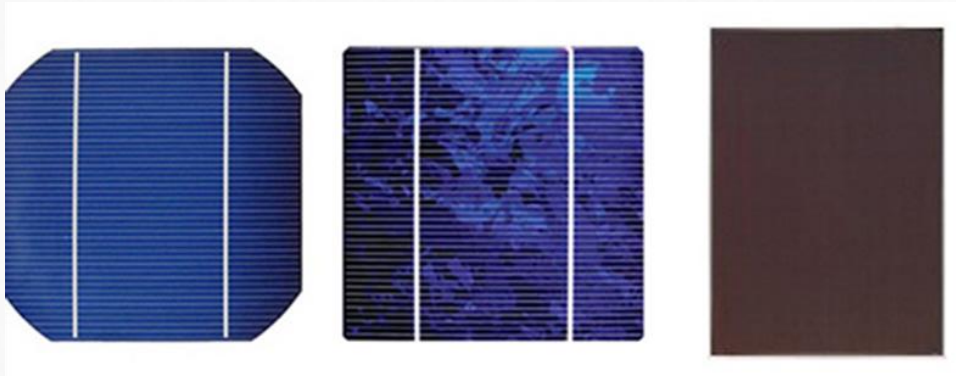
Distributed Solar with Battery Backup



Contact me for Questions

F. John Hay
Extension Educator - Energy
Department of Biological Systems Engineering
University of Nebraska–Lincoln
250 L. W. Chase Hall,
Lincoln, NE 68583-0726
402-472-0408
jhay2@unl.edu
http://bioenergy.unl.edu

Silicon Solar Cells



Other Chemistries

- Cadmium telluride (CdTe)
- Amorphous silicon (a-Si)
- Copper indium gallium selenide (CIGS)

	Mono	Poly	Thin Film
Efficiency	Up to 20+ %	~16%	Up to 12%
Life span (years to reach 80% capacity)	25-30 years	25-30 years	<20 years
Manufacturing costs	High	Moderately High	Low


Microinverters (one small inverter under each panel)


String Inverter (many panels in a string into one inverter)