SARE Technical Report

Solar Electric Investment Analysis Series

By Eric Romich and F. John Hay

Available at: www.sare.org/research

August 2019

Peer-reviewed evidence based findings and practical strategies for photovoltaic solar systems in agriculture

Solar Electric Investment Analysis

By: Eric Romich and F. John Hay

Solar Electtric Investment Analysis is a peer-reviewed publication.

Original available at: www.wyoextension.org/publications/pubs/b1291.1.pdf

Suggested acknowledgment: Geiger, Milton; Eric Romich, Benjamin S. Rashford. Solar Electric Investment Analysis. Part 1: Estimating System Production. B-1291.1. 2016.

Editor: Steven L. Miller, senior editor, College of Agriculture and Natural Resources, Office of Communications and Technology.

Graphic Designer: Tana Stith, College of Agriculture and Natural Resources, Office of Communications and Technology.

Extension is a Division of the Institute of Agriculture and Natural Resources at the University of Nebraska–Lincoln cooperating with the Counties and the United States Department of Agriculture.

Acknowledgment

This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number ENC18-172 through the North Central Region SARE program under project number XNC16-XXX. USDA is an equal opportunity employer and service provider. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

Table of Contents

Introduction

Photovoltaic (PV) panels are an increasingly common sight on urban rooftops and rural properties across the U.S. The declining cost of equipment and installation makes installing a behind-the-electric-meter solar electric system enticing for agricultural producers. Any farm investment should include consideration of financial criteria prior to investment. These calculations may include calculating tax implications, payback period, or net present value. Solar PV investment analysis can be complex and the results are not always easy to interpret or compare between project quotes. This bulletin will step through the process of a quality economic analysis of a behind the meter grid connected solar array for a farm, ranch, or rural business. While this bulletin focuses on quality economic analysis it is clear there are other goals and motivations for solar such as marketing value, independence, and green energy. The values of these are beyond the scope of this bulletin yet should be seriously considered as part of the overall project.

Other Small Scale Renewable Systems

Solar electric is now the dominant type of distributed renewable energy system, but other renewable energy technologies, such as small wind, solar thermal, micro-hydropower, ground source heat pumps, and efficiency upgrades, require similar scrutiny. Systems that provide thermal energy, as opposed to electricity, have less regulatory and policy considerations, but the analysis framework is the same.

Possible Goals and Motivations

- Produce clean energy
- Gain some level of energy independence
- Reduced electric bills
- Provide return on investment
- Provide some marketing for the farm (May want solar to be seen by potential customers)

This publication will detail how to conduct a financial analysis for solar photovoltaic systems. The decision as to whether a farm installs solar will include not only the financial elements but also include the value of accomplishing non financial goals such as marketing or environmental. Evaluating the financial prudence of an investment in solar requires careful consideration of installation costs, the value of production, and operation and maintenance costs. Unfortunately, some installers are not forthcoming with information necessary to make fully informed investment decisions. Third-party ownership structures, such as leases, further increase the challenge of understanding the viability of an investment. This six-part bulletin distills the information collection and decision process throughout. We highlight in each part critical questions to ask yourself and your installer. You will be empowered in the ultimate goal of making an informed decision about whether PV is right for you.

1. Estimating System Production

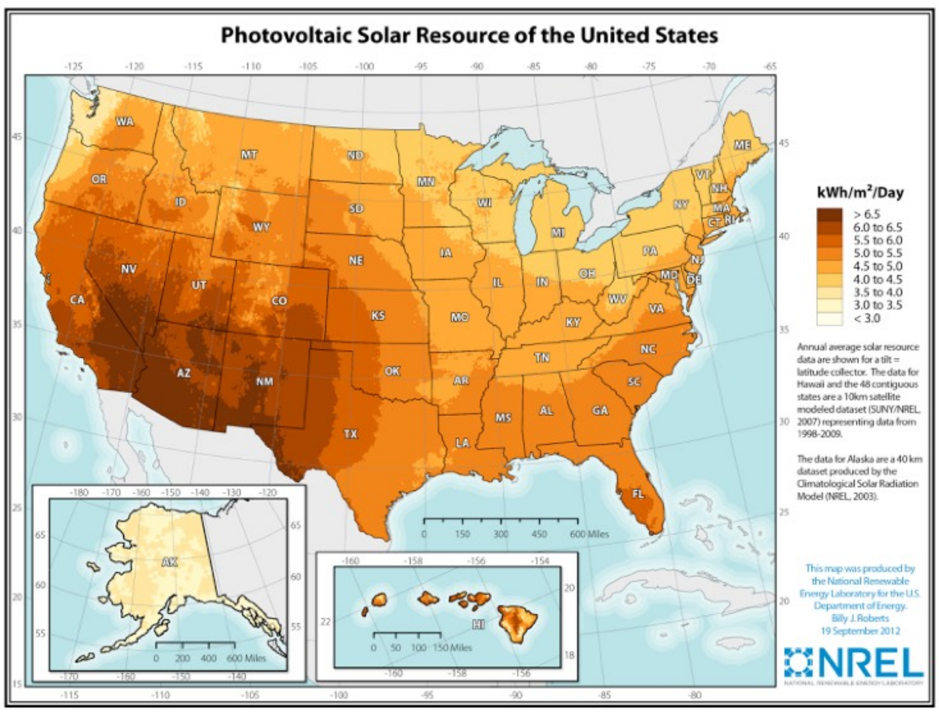
Producing renewable energy is much like gardening or farming – the quantity produced and the net value of the product determine profitability. If you grow more tomatoes, more tomatoes can be sold at the farmers market. Similarly, if you have tomatoes for sale when others do not, then the tomatoes can be sold at a higher price. The profit earned on tomatoes must consider the capital put into growing them (e.g., a high tunnel) and the ongoing inputs (e.g., labor and fertilizer) during the growing season.

Two similar components drive the return from a PV system – total amount of electricity produced and net value of that production. Since electricity is measured in kilowatt-hours (kWh), the value of a solar installation is dictated by the number of kWh produced and how much they are worth after expenses. The more kWh generated from an installation and the higher the net value, the better the rate of return.

Your site-specific solar resource

The sun shines everywhere on the surface of the earth yet the sunlight available to a solar PV panel is determined by the location on earth, the climate, weather, and the orientation of the solar panel. Generally, the solar resource decreases from the equator to the poles, but local factors can significantly influence production. For example, Lincoln, Nebraska, is at approximately the same latitude as Columbus, Ohio, but Lincoln has more sunny days, the same PV array produces 15 percent more electricity in Lincoln than in Columbus. Lincoln's solar resource is 5.0 to 5.5 kWh/m2/day while Columbus's is 4.0-4.5 kWh/m2/day (Figure 1).

Figure 1. Photovoltaic Solar Resource of the United States



Site-specific factors are most critical to determine production, and influence the value of a solar investment. Shading has the most visible negative impact on production. Shading effects will vary by season, often increasing as the sun angle becomes lower in winter months. Generally solar panels in the northern hemisphere should face south and be tilted at an angle based on their latitude (higher latitudes require larger tilt angles). Departure from true south also affects production, as panels facing east or west will generally produce less than the same installation facing due south. The tilt angle of the panels also influences production, as flatter angles will increase production in summer but decrease production in winter (tilt angles plus or minus 15 degrees from the latitude typically work well). Temperature can also affect production as increased temperatures increase electrical resistance and reduces PV efficiency. Figure 2 shows a solar array on a south facing barn roof in Ohio with a tilt angle of approximately 26 degrees.

The National Renewable Energy Lab's tools and resources can quickly verify an installer's estimates.

Most PV panel production slowly degrades over time. A typical warranty guarantees that production declines will be less than 0.5 percent a year. A 25-year old panel will produce at least 87.5 percent of original rated capacity of the system – a 10 kW system would be 8.75 kW in year 25. These calculations are considered in the National Renewable Energy Lab's PVWatts and System Advisory Model (SAM), a financial analysis should account for these losses. The National Renewable Energy Lab's tools and resources can quickly verify an installer's estimates. Figure 3 shows the result of a PV Watts model for a 10 kW array in Lincoln, NE.

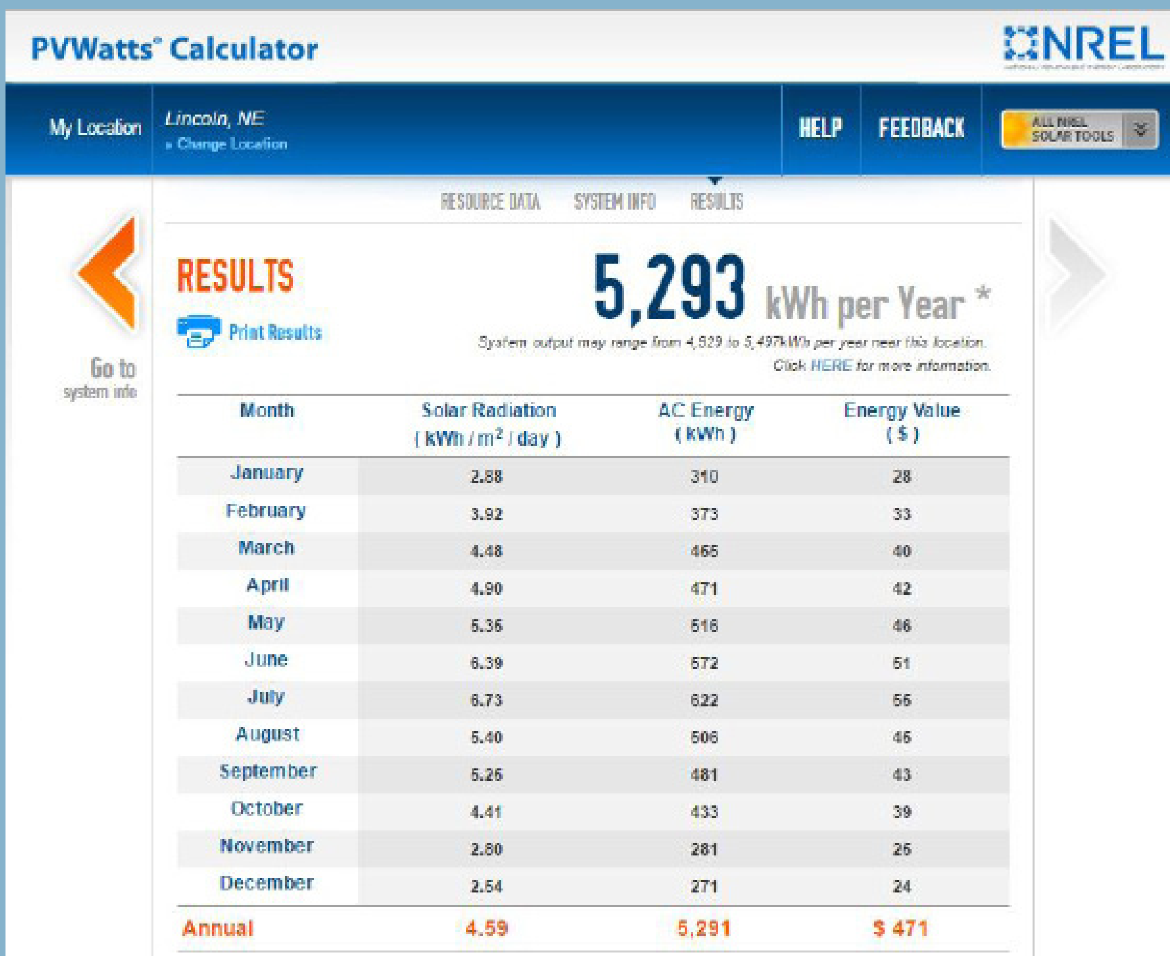
Figure 2: Photo by John F. Hay

PVWatts is a commonly used tool for evaluating solar resource. Novices and experts can use the easy-to-use platform. PVWatts even allows customized sizing of a solar array and variations based upon slope and orientation. The tool also offers rudimentary financial analysis. http://pvwatts.nrel.gov.

Key Questions

- Is shading, orientation, angle, and temperature included in production estimates?
- Does the lifetime production include annual declines from degradation?

Figure 3. National Renewable Energy Lab's PVWatts



Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)	Energy Value ($)
January	2.88	310	28
February	3.92	373	33
March	4.48	465	40
April	4.90	471	42
May	5.36	516	46
June	6.39	572	51
July	6.73	622	56
August	5.40	506	46
September	5.26	481	43
October	4.41	433	39
November	2.80	281	26
December	2.54	271	24
Annual	4.59	5,291	$ 471

PVWatts is a commonly used tool for evaluating solar resource. Novices and experts can use the easy-to-use platform. PVWatts even allows customized sizing of a solar array and variations based upon slope and orientation. The tool also offers rudimentary financial analysis. http://pvwatts.nrel.gov

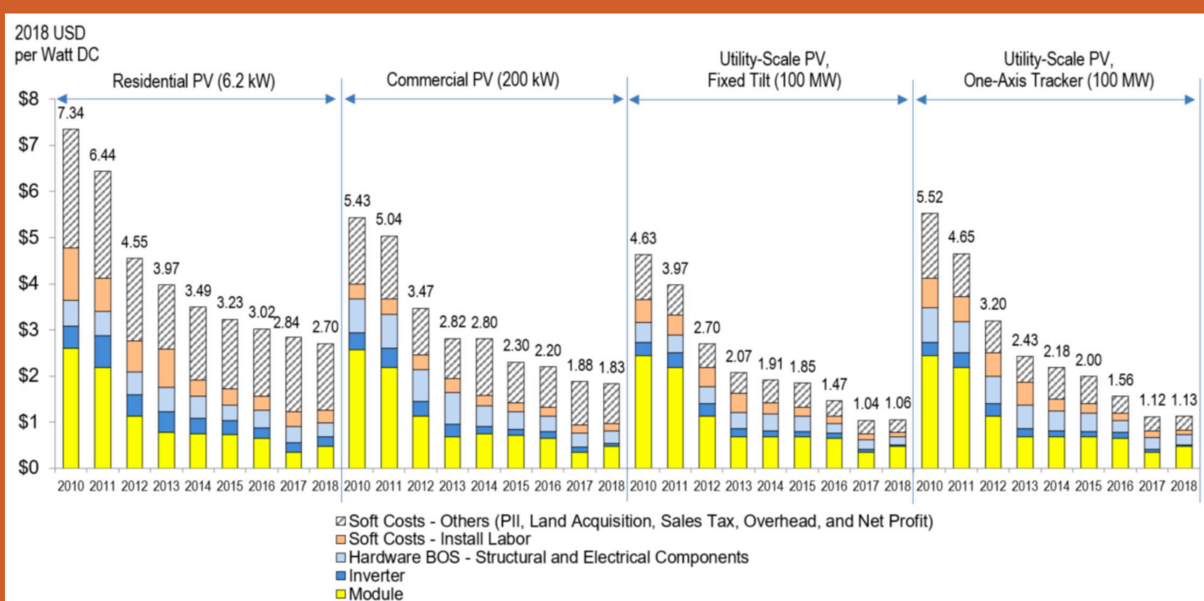
2. Assessing System Cost

Investing in a photovoltaic solar energy system is a major investment that will influence the future profitability of a farm or ranch. In many ways, investing in a solar system is similar to purchasing new farm machinery. When investing in a new tractor, investors start by reassessing their needs for the tractor before researching various models, options, and costs to determine the best option. Whether considering a new tractor or PV solar system, the goal is to get the most return on the investment by maximizing the ratio between performance and cost.

Investors should carefully evaluate multiple quotes or project proposals when considering a PV solar system. Due to different variables and assumptions used to develop a PV solar proposal, evaluating proposals may seem like trying to compare apples to oranges. Combining the total system cost with various savings, rebates, tax credits, grants, and subsidies will further distort the actual investment. If necessary, do not hesitate to ask the installer to put the information in an easier-to-understand format.

This section will help readers understand the core components of the cost of a PV solar system, including direct capital costs, indirect capital costs, and operations and maintenance. A better understanding of system costs and standard assumptions allows a more accurate financial analysis, fostering informed investment decisions.

Figure 4. NREL PV system cost benchmark summary (inflation adjusted), 2010–2018



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.

Direct Capital Costs

Direct capital costs are those directly associated with the PV solar system and can be clearly assigned to a specific piece of equipment or components related to the project. Direct capital costs are included in the total system cost, which is an upfront cost incurred in year zero of the cash flow analysis. Common examples of direct capital costs for a PV solar system include the solar panels, inverters, and the balance of system components that typically includes racking, wiring, fuses, breakers, and monitoring equipment. As illustrated in Figure 4, in 2018 the inflation-adjusted system cost for residential PV solar installations reached $2.70 per/DC-watt, while commercial projects were $1.83 per/DC-watt and utility-scale PV solar projects posted at $1.06 per/DC-watt. Specifically, comparing the declining system costs of inflation-adjusted commercial solar projects between Q1 2010 and Q1 2018 shows a 66 percent decrease from $5.43 per/DC-watt to $1.83 per/DC-watt.

Indirect Capital Costs

Indirect capital cost represents the soft costs associated with a project. Indirect capital costs are also included in the total system cost, which is an upfront cost incurred in year zero of the cash flow analysis. Common examples of indirect capital costs for a PV solar system include the installation costs (labor), grid interconnection, engineering, permitting, environmental studies, and sales tax. As illustrated in Figure 4, the indirect capital cost accounted for 56 percent of the total installation cost of commercial solar project in 2018. In most instances, the installation costs represent the largest indirect costs for small and midsized systems.

Operation and Maintenance

Unlike direct and indirect capital costs that occur upfront, operation and maintenance cost represent the ongoing annual expenses required to maintain, service, and/or replace critical components of a PV solar system. Common examples of operations and maintenance costs for a PV solar system include re-torqueing electrical connections, replacing fuses, repairing broken/crushed wiring conduit and fittings, locating ground faults, resealing leaking junction boxes, and repairing or replacing inverters and modules. Proposals use various assumptions and can report operation and maintenance costs in many ways, including as a simple fixed annual cost, fixed annual cost proportionate to the system size (nameplate capacity), fixed cost as a percentage of the overall capital investment, and a variable annual cost proportionate to the projected annual electrical production of the system. The National Renewable Energy Laboratory suggests a fixed operations and maintenance costs of $15 per kW/year for midsized (10 – 100 kW) PV solar systems. As an example, a 10 kW PV solar system would allocate $150 per year ($15 x 10kW = $150) for operations and maintenance costs. Some proposals will apply an annual inflation rate and annual escalation rate to the operation and maintenance costs. An escalation

Table 1: Example of Comparing Multiple System Proposals

	Proposal 1	Proposal 2	Proposal 3
System Size (kW)	9.848	11.777	7.927
kilowatts to watts	9,848	11,777	7,927
Direct Capital Cost	$16,600	$18,300	$14,600
Indirect Capital Cost	$11,500	$10,900	$13,000
Total Installed Cost	$28,100	$29,200	$27,600
Installed Cost Per Watt (Pre-Incentive)	**$2.85**	**$2.48**	**$3.49**

rate represents the estimated increase in operations and maintenance costs above the annual inflation rate due to the aging of system components. Because there are no moving parts, low operation and maintenance costs are a benefit of PV solar compared to other renewable energy technologies; however, a comprehensive PV solar proposal will account for the operation and maintenance costs because they represent a real cost and are essential to maximizing a system's production throughout its useful life.

http://bit.ly/2bBpged – Photo by: Matt Montagne – Figure 5.

Summary - Comparing Multiple Proposals

Separating the actual system cost from financial incentives, such as tax credits and grants, is important when evaluating multiple proposals. Typically, renewable energy incentives provided through state and federal government programs and utility providers are not unique to any one installer. The first question when comparing proposals is an important yet simple one: What is the total system cost?

While the question is simple, careful consideration of multiple PV proposals is challenging due to various configurations, assumptions, and system sizes. Establishing consistent metrics is critical to fairly compare system cost from multiple installers. An easy way to conduct an apples to apples comparison of multiple system costs is to calculate the installed cost per watt (Table 1). Divide the total installed system cost by the systems nameplate capacity in watts (tip: 1 kilowatt = 1,000 watts). Calculating the installed cost per watt is a valuable metric to compare system cost from multiple installers whose proposals may vary slightly in size and configuration.

Figure 5 shows a meter configuration with two meters. Utilities will require a meter configuration which ensures a proper metering and billing for the system.

Key Questions

- What is the total system cost before tax credits, rebates and grants?
- Can I easily identify the direct and indirect cost of the system?
- What is the installed cost per watt?
- Are the operations and maintenance costs included and clearly defined in the proposal?

3. Forecasting the Value of Electricity

Forecasting the Value of Electricity

The average retail price of electricity (all sectors) in the North Central Region (North Dakota, South Dakota, Nebraska, Kansas, Missouri, Iowa, Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio) ranged from a low in North Dakota at 9.04 cents/kWh to a high of 11.17 cents/kWh in Michigan. The price of electricity in the US increased from 7.29 cents/kWh in 2001 to 10.31 cents/kWh in 2019. Investing in a PV solar system is essentially hedging against future energy prices. Electricity production from a system will displace electricity that would otherwise be purchased from a utility. Although seemingly simple to calculate the energy savings for a project, many important variables should be considered, including the details of your individual rate structure and the assumed energy escalation rate that influence the value of electricity in future years. This section will help readers identify their utility rate structure, understand how the rate structure affects the value of electricity, evaluate energy escalation rates, 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, fostering informed investment decisions.

Understanding Your Rate Structure

There are more than 3,300 electric utilities in the U.S. and no standardized rate structure. Most electric consumers never consider the factors that influence the calculation of their electric bills; before assuming energy savings from a PV solar system, take time to review and understand the rate structure of your home, farm, or business. Common charges often

HOW ARE YOU CHARGED FOR ELECTRICITY?

Although the components of a bill vary by utility, the following charges are generally included:

- **Fixed monthly (Basic) charge –** This fee is a fixed dollar amount typically associated with infrastructure costs. A PV system will not reduce this charge.
- **Energy charge –** This charge covers the cost of producing energy (kWh). A PV install will reduce this expense.
- **Demand charge –** Covering peak demand (both daily and seasonal) requires power plants be available to provide energy for relatively short durations. A PV system may reduce this fee, but often PV does not align with peak demand charges.

included in farm or business rate structures may include a fixed (basic) charge, energy charge, demand charge, and other taxes and fees. Fixed charge is paid each billing period regardless of electrical use. Energy charges are paid per kWh of electrical use, sometimes these charges are split into energy, transmission and distribution charges. Energy charges can change throughout the year and even within a month or day to reflect the changes in generation and transmission costs at different times. Demand charges are paid based on measurement or estimate of peak power use usually in $/kW. Demand charges can be a significant cost and at times may be a majority of the electric bill. Farms with demand charges may benefit from careful study of the demand rate schedule and how it relates to electricity use in their operation. Significant savings are possible if demand can be reduced.

Farms with demand charges may benefit from careful study of the demand rate schedule and how it relates to electricity use in their operation.

Start with a simple study of your electric bill and progress to searching for the rate schedule on your utility provider's website. For information about rates across the country, the OpenEI Utility Rate Database (www.en.openei.org/wiki/Utility_Rate_Database) provides a comprehensive list of utility companies in the United States that can be filtered by ZIP code and utility name to research details of your rate structure.

Value of Electricity

The value of all electricity (kWh) produced from a solar array are not the same. The value will vary based on when production occurs (time of day and season) and how a utility charges for electricity (fixed, demand, and energy fees). Both factors can drastically alter the viability of a PV solar project. Wholesale electricity prices (the price your utility pays for electricity before reselling it to you) vary throughout the day based on demand. For example, wholesale power produced at 10 a.m. is generally less valuable than electricity generated at 6 p.m., when people return home and residential loads surge. Similarly, prices are different in the winter versus summer. In the summer, when air conditioning loads are greatest, the cost of electricity is higher than in autumn, winter or spring,

Figure 6. Rate with consumption tiers and time of use charges

	12 am	1 am	2 am	3 am	4 am	5 am	6 am	7 am	8 am	9 am	10 am	11 am	12 pm	1 pm	2 pm	3 pm	4 pm	5 pm	6 pm	7 pm	8 pm	9 pm	10 pm	11 pm
Jan	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Feb	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mar	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Apr	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
May	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Jun	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Jul	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Aug	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Sep	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Oct	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Nov	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Dec	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

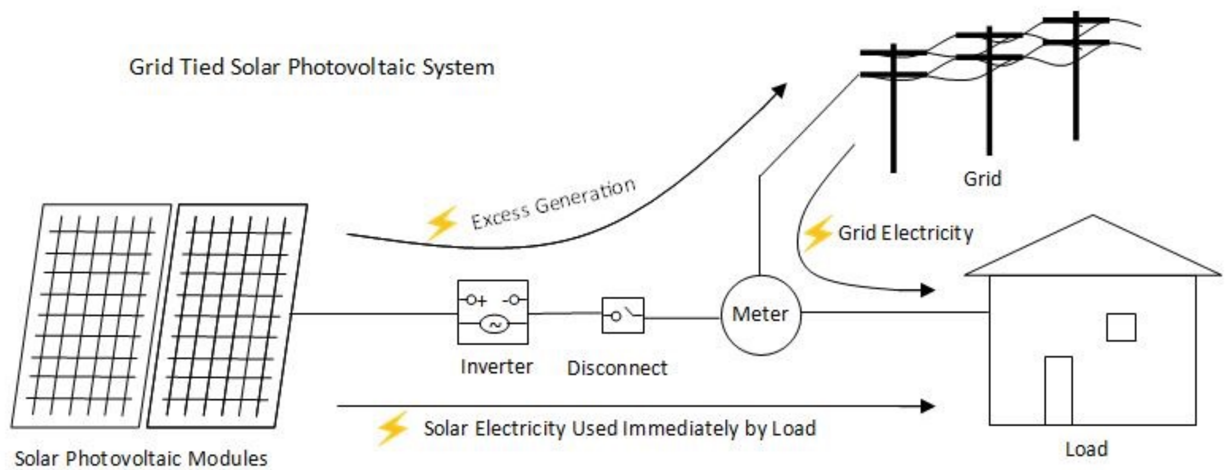
Period	Tier	Max Usage	Units	Rate $/kWh
1	1	1e38	kWh	0.0885
2	1	1000	kWh	0.1158
2	2	1e38	kWh	0.0858

subsequently solar PV production during the summer has higher value. Generally, the higher a utility's energy charge, the greater the value of PV-produced electricity. Figure 6 is an example of an electrical rate schedule with two time periods (winter and summer) and two tiers (below 1000 kWh and above).

Figure 6. (www.en.openei.org/wiki/Utility_Rate_Database) provides a comprehensive list of utility companies in the United States that can be filtered by ZIP code and utility name to research details of your rate structure. You can further assess how different charges influence the value of your energy after determining the rate structure.

An example helps illuminate the importance of understanding the value of PV-produced electricity. Consider a farm with average annual electric usage of 32,745 kWh. If a 10 kW solar system with an estimated annual output of 14,407 kWh is installed, the amount of electricity (kWh) purchased from the utility will be reduced by roughly 43 percent. However, the value of that electricity will vary depending on the utility's rate structure. Solar production will begin in the morning and peak around midday and decline through the evening hours. This curve does not always match the use of electricity, for grid connected systems electricity can flow from the solar to the load, from the grid to the load or from the solar to the grid. Figure 7 represents these three electricity flows. Electricity from the grid has a clear cost based on the electrical rate schedule. Electricity produced by the solar and used immediately by the load is displacing electricity use from the grid and thus has a similar value. The electricity flowing to the grid and thus being used by others has a value dependent on the state law and utility policy. The electricity flowing to the grid is called excess generation and its value will be explained in more detail in part four of this bulletin. Grid connected solar electricity simulation models such as the System Advisor Model (SAM) help illustrate how different rate structures affect the value of electricity produced by a PV solar system. The SAM model is a computer model developed at the National Renewable Energy Laboratory to estimate system performance and financial impacts of

Figure 7. Grid connected solar electricity flows

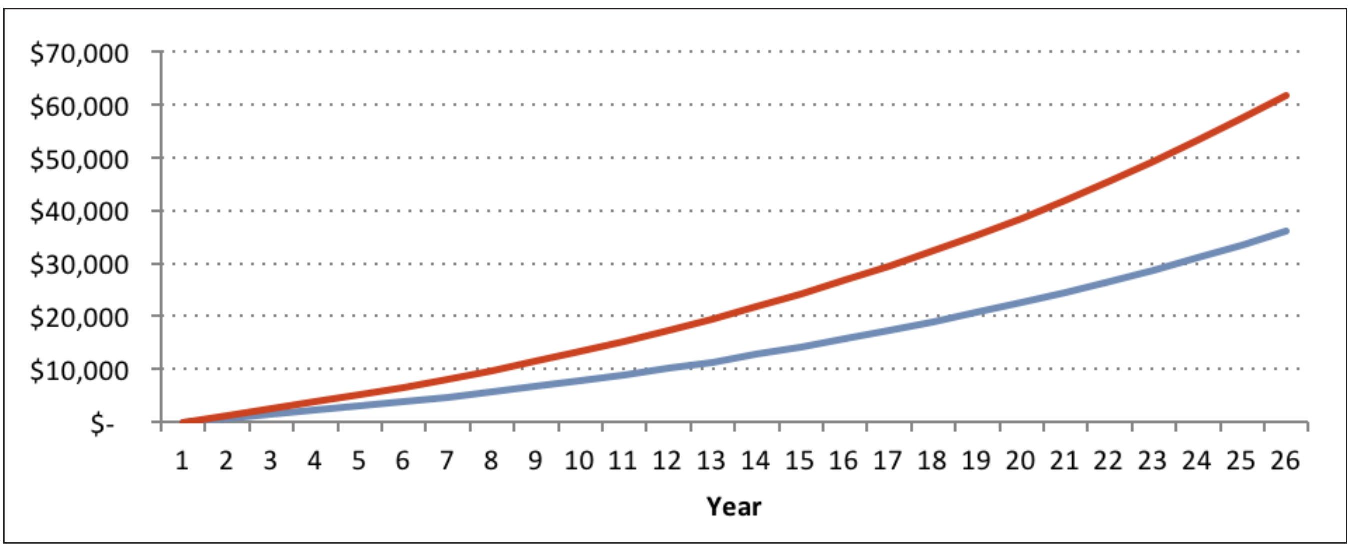


renewable energy projects. This financial model considers the value of electricity generated by the system, incentives, the cost of installation, operation and maintenance, taxes, and debt to simulate a detailed cash flow over the system's lifetime. Figure 8 shows the SAM summary results for the utility bill savings of installing a 10 kW solar system from two separate simulation models. As illustrated in Figure 8, the expected utility bill savings over the 25-year life of a system is $61,827 for a farm that is on a rate structure (25) with no demand meter charges. In comparison, the same PV solar system would only generate a utility bill savings of $36,138 if the farm had a rate structure (28) that includes demand charges and higher fixed charges. In summary, two PV solar systems that have the same electrical production (kWh) may experience very different energy bill savings based on the rate structure used to calculate their bills.

Energy Escalation

The final consideration for evaluating the value of PV-produced electricity is to identify the assumptions used to calculate the annual energy escalation rate. The nominal energy escalation rate estimates the annual rate energy prices will increase including overall inflation. The real energy escalation rate is the rate of change in energy prices with the overall inflation rate subtracted. For example, a nominal three percent energy escalation rate with two percent inflation results in a one percent real energy escalation rate. The distinction between nominal and

Figure 8. Value of Utility Bill Savings (Cumulative) 10 kW PV Solar System Calculated by the System Advisory Model (SAM)



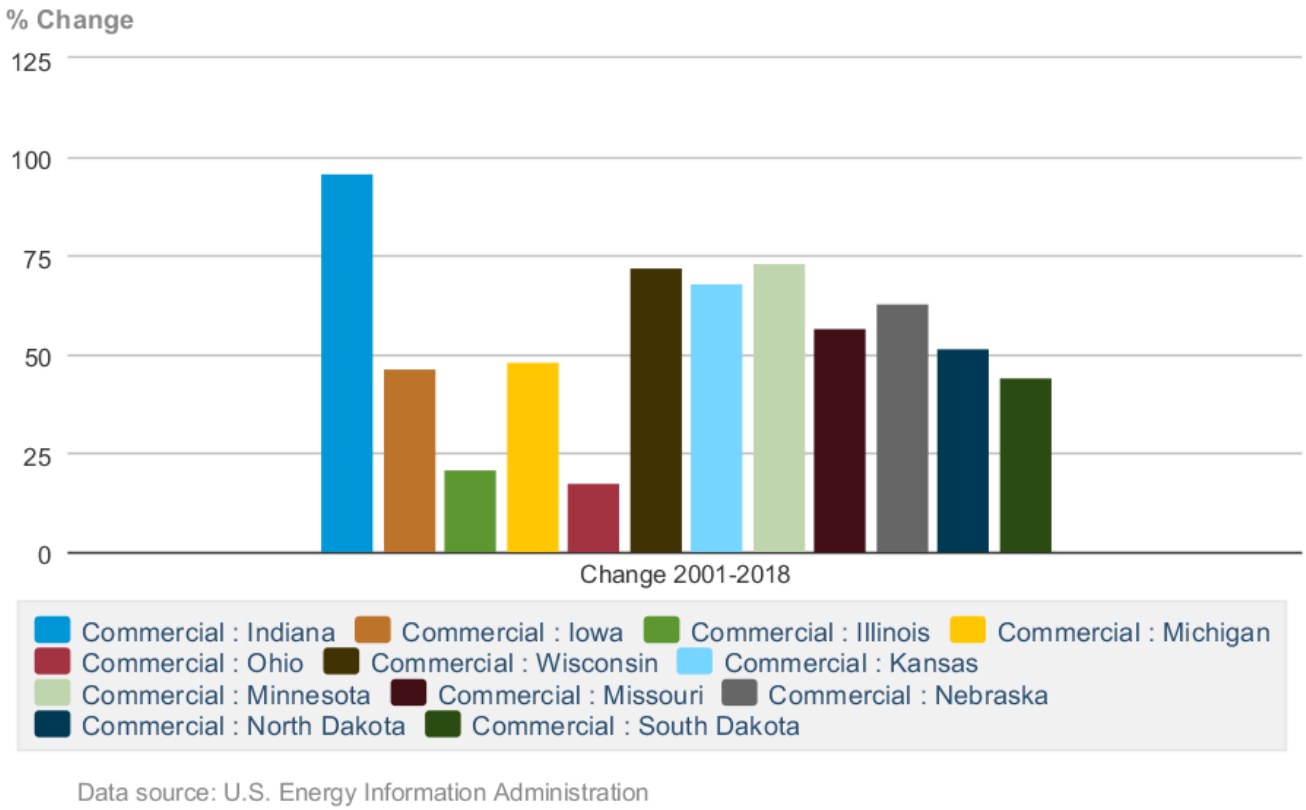
28 - General Service - Single Phase Primary
Demand Max: 20.5 kW
Energy Max: 5000 kWh

Fixed Charge: $39.00
Energy Charge (buy rate): $0.0352
Demand charge per kW: $16.20

25 - Small Gen Service - Single Phase Primary
Demand Max: 20.5 kW
Energy Max: 5000 kWh

Fixed Charge: $27.25
Energy Charge (buy rate): $0.0726
Demand charge per kW: N/A

Figure 9. Average retail price of electricity, Annual



real can significantly influence the expected value of PV-produced electricity in alternative proposals, and you must understand how each potential installer calculates energy savings to properly evaluate alternatives. Accurately forecasting the energy escalation rate is difficult. Figure 9 shows the percent change (nominal) in electrical prices from 2001 to 2018 for all North Central Region states. Real escalation rates between 0.5 percent and 2 percent are commonly assumed. You can express your beliefs by changing this value. If you believe policy or environmental concerns will drastically increase electricity prices, use a higher value. If you believe technology will lead to reductions, use a lower factor.

Key Questions

- When evaluating a solar installation quote, is the value of electricity based on an average utility rate or your utilities rate schedule?

- What is the escalation rate used to calculate energy savings? Is it real or nominal?

4. Understanding Incentives

Developing a PV solar project requires significant upfront capital investments. To help foster the development of PV solar projects, government agencies and utilities offer numerous incentives, such as tax credits, deductions, net metering, grants, and rebates to offset the initial investment. Incentive programs vary widely from one location to the next based upon state policy, local government, and utility programs. Similarly, incentive programs fluctuate based on sector type such as industrial, commercial, residential, non-profit/public buildings, and local government. This bulletin helps navigate the all-important incentive landscape as of 2019.

What are the important incentives?

Despite rapidly declining costs for PV solar, 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, from fostering the growth of energy independence and environmental responsibility (federal), to reducing individual energy costs and demand (state and utility), but all believe renewable energy and energy efficiency merit financial support. Incentives typically target specific sectors, so different incentives exist for residences, businesses, and agricultural producers. For example, a depreciation program serves as an incentive for businesses to invest in PV solar, allowing them to depreciate the value of the project assets over multiple years to reduce taxable income. However,

Key Residential Incentives

Although local or utility programs may exist, the key incentives for residential applications are:

- Residential Renewable Energy Tax Credit
- Net metering policies

While the 30 percent residential renewable energy tax credit program is similar to tax credits for businesses described below, the residential tax credit program expires in December, 2021.

Figure 10: Photo by Eric Romich

Table 2 - Incentives for Small-scale Photovoltaic Solar Energy Projects

Name	Description	Eligible Sectors	Additional Notes
Energy Investment Tax Credit	Dollar-for-dollar tax credit of the eligible construction and equipment costs towards federal income tax liability	Commercial, Industrial, Investor-Owned Utility, Cooperative Utilities, Agricultural, and Residential	Residential tax credit program expires in December, 2021
Modified Accelerated Cost-Recovery System (MACRS)	5-year depreciation schedule	Commercial, Industrial, and Agricultural	100% bonus depreciation available for qualified property placed in service before January 1, 2023.
Net Metering	Allows many RE systems to receive the full retail rate for production up to total consumption and credits system owners for excess generation	Commercial, Industrial, Government, Nonprofit, Residential, Schools, and Agricultural	Program details will vary based on state and utility policies
Renewable Energy Credits	Generated from a qualifying renewable energy system. One megawatt-hour of electricity is equal to one renewable energy credit.	Commercial, Industrial, Government, Nonprofit, Residential, Schools, and Agricultural	Program details will vary based on state renewable energy policy
USDA - Rural Energy for America Program (REAP) Grants	25% grant available only to rural small businesses (currently all areas except Cheyenne and Casper); loan guarantees also available	Agricultural and rural small businesses	Competitive grant program, funding is not guaranteed
Sales Tax Exemption	Partial or full exemption from state and/or sales tax	Commercial, Industrial, Residential	Program details will vary based on state renewable energy policy
Property Tax Exemption	Exempts renewable energy equipment from property taxes	Commercial, Industrial, Residential, and Agricultural	Eligible sectors and program details will vary based on state renewable energy policy

this program provides no benefit to a residential system owner. While the focus of this bulletin is on incentives for agricultural operations, many of the concepts also apply to residential systems. Table 2 details the most significant renewable energy incentives for agricultural operations. The table may seem daunting, but the benefit of harnessing available incentives makes understanding it worthwhile. Figure 10 (above) shows instillation of a residential solar array on a roof.

Federal Business Energy Investment Tax Credit (ITC)

Originally established in the Energy Policy Act of 2005, the Federal Business Energy Investment Tax Credit (ITC) is one of the most significant renewable energy incentives. Further defined by the Energy Improvement and Extension Act of 2008, the ITC program was scheduled for elimination or drastic reductions after December 31, 2016; however, passage of an omnibus budget bill (Consolidated Appropriations Act) extended these credits for certain renewable energy systems. This extension is exciting news for agricultural operations and businesses planning to install a renewable energy system. The federal ITC program offers system owners a dollar-for-dollar tax credit for eligible (construction and equipment) project costs toward their federal tax liability. For PV solar systems, the tax credit amount is currently set at 30 percent of the eligible project cost and will gradually decrease to 10 percent as shown in Table 3.

Table 3: The Federal Business Energy Investment Tax Credit (ITC) Schedule for Photovoltaic Solar

Date	ITC Amount
12/31/2016	30%
12/31/2017	30%
12/31/2018	30%
12/31/2019	30%
12/31/2020	26%
12/31/2021	22%
12/31/2022	10%
Future Years	10%

To accurately assess a project proposal, investors need to determine if cash incentives are subject to federal or state income tax. In most cases, grants are taxable income that must be reported on a income tax return. In general, if you pay taxes on the incentive, you are not required to reduce the basis for calculating the ITC; however, the incentive may not be taxable, in which case you should reduce the net system cost by the amount of the incentive before calculating the ITC.

For additional information, download the Department of the Treasury Internal Revenue Service (IRS) Form 3468 instructions at www.irs.gov/pub/irs-pdf/i3468.pdf.

Depreciation

Much like investments in other types of equipment, investments in a PV solar system can be depreciated to reduce taxable income. A qualifying PV solar system installed on a farm or business is eligible to depreciate the value of the project assets using the Modified Accelerated Cost Recovery System (MACRS) deduction method over a five-year recovery period.

Bonus depreciation is a tax incentive that allows a business to deduct an additional amount of an eligible asset's purchase price in the year that the asset was placed in service, rather than over the asset's useful life. The Tax Cuts and Jobs Act of 2017 established 100% bonus depreciation for qualified energy equipment put in service before January 1, 2023. In addition equipment placed in service before January 1, 2024 can qualify for 80 percent bonus depreciation, while equipment put in service before January 1, 2025 can qualify for 60 percent bonus depreciation, equipment put in service before January 1, 2026 can qualify for 40 percent bonus depreciation, and equipment put in service before January 1, 2027 can qualify for bonus depreciation of 20 percent.

For equipment that claims the energy investment tax credit, the owner must reduce the project's

Table 4: PV Solar Project Depreciation Example Using the Modified Accelerated Cost Recovery System (MACRS) Method

Year	Depreciation Rate[1]		Depreciable Basis for the System[2]		Depreciation Amount
1	20.00%	x	$26,350	=	$5,270
2	32.00%	x	$26,350	=	$8,432
3	19.20%	x	$26,350	=	$5,059
4	11.52%	x	$26,350	=	$3,036
5	11.52%	x	$26,350	=	$3,036
6	5.76%	x	$26,350	=	$1,518

[1] Using5-earrecoveryperiodfromMACRSPercentageTableGuide Table A1 from IRS Publication 946 (2014).

[2] If you claim the 30% ITC, you must reduce the depreciable portion of the system by 1/2 the tax credit (e.g. $31,000 * .85 = $26,350).

depreciable basis by one-half the value of the tax credit. For example, if a system owner claims the 30 percent investment tax credit on a PV solar project, the same project will reduce the depreciable portion of the project assets by 15 percent (half of the total tax credit), allowing the owner to depreciate 85 percent of the project. Table 4 provides an example of how to depreciate a PV solar project that costs $31,000 and claimed a 30% ITC, with zero bonus depreciation, using the MACRS method.

It is important to remember that a solar project is likely just one piece of your overall farm tax strategy and you should consider the long-term outlook for your farm or business. For example, while 100 percent bonus depreciation may be available, in some instances it may not be in your best interest to use 100 percent bonus depreciation in year one. Claiming a full deduction in the year of acquisition means you give up deductions against income in future years, which may work to your disadvantage. State depreciation schedules may vary, and tax laws are continually undergoing changes. Every tax situation is unique and you should discuss your project with a qualified tax professional who is familiar with your entire farm operation to identify the best depreciation options for your specific operation.

a solar project is likely just one piece of your overall farm tax strategy

Net Metering

Much like grants or tax credits, net metering policies promote the development of distributed (on-site) renewable energy systems. Net metering programs vary by state and utility, yet most follow a similar process. In general, electricity produced by a renewable energy system may be used by the farm or business load or flow to the utility's distribution system to service other loads. Each electric bill will indicate the net amount of electricity for that billing period (electricity used – electricity produced). If there is net excess generation the utility will apply a credit (kWh or dollar) to the electric bill to offset charges in future months. As shown in Figure 11, states and utilities may differ in how a net excess generation credit is applied. In states without net metering the same thing happens yet federal rules for distributed renewable generation are applied.

Most net metering agreements have a true-up period at the end of the year when credits are settled at a predetermined rate between the utility and the system owner. Regulations may restrict some net metering policies to a particular type of electric generation system. Common technologies included in net metering programs are solar, wind, geothermal, hydroelectric, anaerobic digesters, municipal solid waste, landfill gas, fuel cells, and tidal and wave energy. Many states have established capacity limits within their net metering rules to restrict the size of distributed energy system. Specific capacity limits often differ by states, utilities, customer type, and technology.

As described earlier, net metering provides system owners a credit for excess generation; however, there are different compensation rates for net excess generation. For example, the net metering program in Nebraska typically includes a billing arrangement that applies a dollar amount credit to a customer's next bill where net excess generation (kWh) is given a value of avoided cost (typically lower than retail rate) and resolves any balance annually. The avoided cost is the cost to an electric utility to procure (or generate) the same amount of energy acquired from

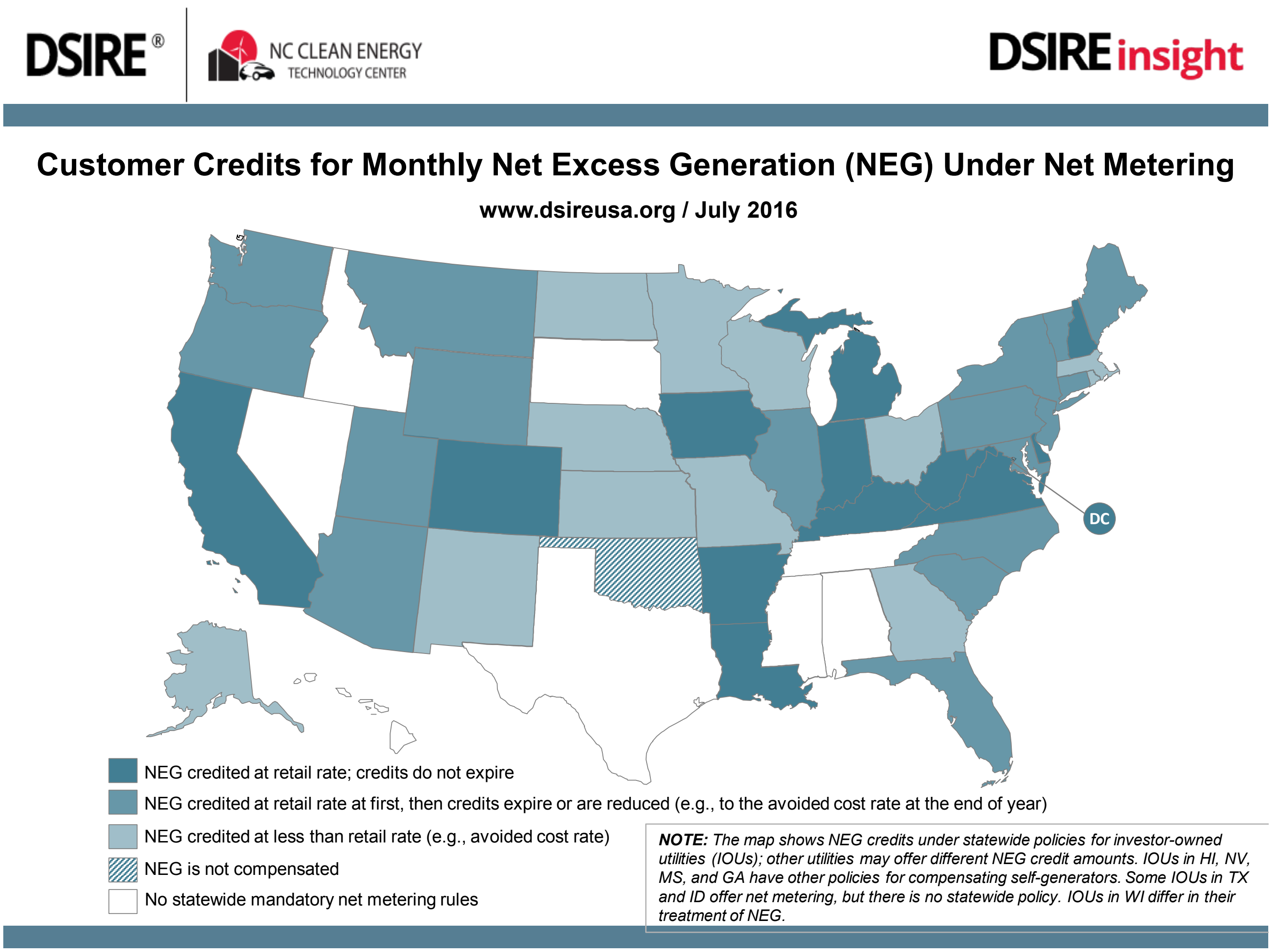


Figure 11: Net Metering Net Excess Generation Credits (Source: www.dsireusa.org)

another source. This approach allows renewable energy system owners who produce their own electricity to receive the full retail rate for production up to total consumption and pays avoided cost for excess production.

In comparison, the compensation for net excess generation in Michigan is much different. In Michigan, net metering agreements (<20 kW) with investor-owned utilities will apply credits for net excess generation to the customer's next bill at retail rate, credits can carry over indefinitely. In other states there are also examples where net metering credits are limited to kWh charges only and will not reimburse system owners for distribution services, transmission services, demand meter fees, or other fixed monthly charges. In other words, even if a PV solar system generates all of the electricity for a farm, there could still be additional monthly charges remaining on the electric bill. To ensure the accuracy of a financial analysis, identify any costs that will remain and exclude them from the calculation of the electricity savings in a PV solar proposal.

Feed-in tariffs are not as common as net metering agreements, yet several states do have feed-in tariff programs. In general, for eligible PV solar systems, a feed-in tariff establishes a fixed price for the electricity a system generates. Simply put, a feed-in tariff compensates at a predetermined amount (normally above market rate) for all of the electricity from a PV solar system, and the PV system owner continues to purchase electricity from the utility based on its rate structure.

Renewable Energy Credits

State-driven policy programs designed to nurture the development of renewable energy projects include renewable portfolio standards, alternative energy portfolio standards, or renewable energy goals. While the details of various renewable energy policies differ, these policies generally require specified utilities or electric services companies to generate a percentage of electricity from renewable energy sources. Renewable Energy Certificates (RECs) help monitor the generation of electricity from qualifying renewable energy facilities and represent the environmental attributes of renewable energy. Based on production, every time a qualifying renewable energy system generates a megawatt-hour of electricity, the system also creates a REC. Some policies have a specific carve-out for solar, where a Solar Renewable Energy Credit (SREC) is electricity generated by a PV solar energy system. To comply with policy requirements, utilities or electric service companies can purchase RECs from other renewable energy systems.

Renewable Energy Certificates (RECs) represent the environmental attributes of renewable energy.

The sale of SRECs can generate significant income for PV solar system owners that can help offset the high upfront installation cost. There are different ways a system owner can sell their SRECs. For example, the owner may choose to directly manage the sale of their SRECs, enter into an SREC agreement with an aggregator or broker, or in some instances sell the SRECs directly to the system developer. Some PV solar proposals will try to oversimplify the transaction of SRECs by calling it a discount, rebate, payment, allowance, or refund. Regardless of names, the value of these agreements is significant, and the contract terms can extend for 20 years or more. There has also been ongoing debate related to the taxation of income from SREC sales. Consult a qualified tax professional to determine how to treat SREC proceeds for your project. Additional information on renewable energy credits is available at: www.epa.gov/greenpower/renewable-energy-certificates-recs.

Sales and Property Tax

Whereas in some cases agricultural buildings may be exempt from state taxation, often times building improvements on farm or business property will increase the assessed value of the property triggering an associated increase in annual property taxes. However, solar property tax exemptions allow farms, businesses, and/or homeowners to exclude the

Figure 12: Photo by Eric Romich

additional value of the solar system from the assessed value of the property. As a result, the annual property taxes will not increase as a result of the additional value associated with the installation of solar equipment.

Table 5: North Central SARE States with Property and Sales Tax Incentive Programs

State	Property Tax Exemption	Sales Tax Exemption
Illinois	✘	✘
Indiana	✔	✔
Iowa	✔	✔
Kansas	✔	✘
Michigan	✘	✘
Minnesota	✘	✔
Missouri	✔	✘
Nebraska	✔	✘
North Dakota	✔	✘
Ohio	✔**	✔
South Dakota	✘	✘
Wisconsin	✘	✔

** Not available for residential projects
Source: www.dsireusa.org

In addition, many state and local governments offer sales tax exemptions to incentivize solar development. A solar sales tax incentive program typically provides a full or partial exemption from the state and/or local sales tax for the purchase of qualifying solar energy equipment. As illustrated in Table 5, program details vary based on state and local policy. To get a full list of state specific property and sales tax exemption programs, visit: www.dsireusa.org

Grants

There are also some direct cash incentives available for renewable energy projects, such as federal, state, or utility grants. One important incentive program for renewable energy and energy efficiency projects is the USDA Rural Development Rural Energy for America Program (REAP), which helps agricultural producers and rural small for-profit businesses reduce energy costs and energy consumption. REAP provides grants for up to 25 percent of total eligible project costs not to exceed $500,000 and loan guarantees on loans up to 75 percent of total eligible project costs. If the grant and loan program are used together, the combined total may not exceed 75 percent of the project. The competitive application process does not guarantee funding. Future awards for the USDA REAP program are subject to annual appropriation levels.

Some installers or developers make assumptions and include competitive grants as a key component of their proposals. If a developer includes a grant in a proposal, investors should request details of the funding program and make sure they understand how the grant assumptions influence the proposal.

The Database of State Incentives for Renewables and Efficiency (www.dsireusa.org) website, created by the Department of Energy and North Carolina State University Solar Center, provides a comprehensive list of renewable energy incentives and policies that can be filtered by location, technology, and sector (e.g., you can filter incentive programs for a commercial PV solar project in your state).

As with any financial matter, consulting a qualified tax professional to ensure eligibility for tax incentives and grants is strongly encouraged. Please contact a local extension educator if you have additional questions.

5. Conducting a Financial Analysis

Conducting an accurate financial evaluation of your solar proposal requires a good understanding of numerous project variables and how they affect key financial evaluation tools such as simple payback period, net present value, and the levelized cost of energy. Three critical factors that influence successful project financial investment analysis include upfront project cost, annual operations costs, and project revenue. Additional considerations that will greatly influence the projects financial analysis include tax implications and the time value of money. This bulletin will further describe these key considerations and is designed to empowers you to make an informed decision to determine if the PV solar system on your farm is a sound investment.

The Importance of Pre-Tax and Post-Tax

A good first step in reviewing a solar proposal is to make sure the proposal conducts the analysis with all values analyzed on a pre-tax basis. Many proposals present the system cost as a "net system cost" which is the estimated cost balance once all of the grants, tax credits, and depreciation have been recovered. However, while the system cost is commonly viewed from a post-tax perspective, the systems electric savings is typically presented on a pre-tax basis. Energy savings on agricultural or commercial solar systems (not residential) may lower the value of tax-deductible operating expense or "write offs" of electricity purchases from a utility provider which will greatly influence a simple payback calculation. In summary, ensure proposals are consistent in how they apply tax affects.

Reoccurring (Annual) Project Costs

When evaluating a PV solar project, the first question you may ask is "what's the cost?" Not surprisingly, the installation cost is clearly most critical. After all, access to the sun light is free and there is no fuel cost for PV solar projects. However, there are ongoing annual project costs that you as a system owner will likely pay and therefore these costs should be given careful consideration in the projects financial evaluation.

Operation and maintenance (O&M) costs include annual cost associated with regularly scheduled preventative maintenance, as well as unplanned corrective maintenance to replace faulty equipment components. Most PV solar models allow you to allocate O&M cost in several ways including a fixed annual cost, fixed annual cost calculated by system size, or variable annual cost based on system generation. Because the probability of component failure increases over time, an O&M cost escalation rate may also be applied to incrementally increase the cost values above and beyond inflation over time. Depending on the project location, some state and local governments offer solar property tax exemption programs. However, often times the addition of solar projects are classified as building improvements on farm or business property will increase the assessed value of the property triggering an associated increase in annual property taxes. Any additional property tax cost associated to the solar project should be calculated and applied to the annual project cash flow table.

Another common annual cost associated with PV solar projects is interest expense on projects that borrow capital to install the project. Interest expense is the annual cost incurred by a project owner related to borrowing the funds. In general, interest expense is calculated as the interest rate times the outstanding principal amount of the debt. As a borrower of money, your total monthly payments to your lender will often remain constant over the duration of the loan period. However, the annual interest expense payments will decrease each year alongside the unpaid balance. For business applications, interest expense is tax-deductible.

Finally, one of the most critical annual costs is insurance. Yet often times insurance is overlooked and excluded from a proposal altogether. System owners who use the Federal Business Energy Investment Tax Credit (ITC) must retain ownership and operate the system for five full years after the original project commission date, and insurance can ensure you have the financial resource to replace a PV system in the event of a natural disaster. When reviewing proposals, PV system owners should contact their insurance providers and get a quote to add the PV solar system to their policy. While this will most likely lead to an increase in insurance rates, it is important to accurately consider insurance costs in the project cash flow analysis and perhaps more important to ensure the investment is fully protected. A common way to estimate the insurance cost is to multiply the total system cost by ½ percent ($5 per $1000 of coverage). Insurance costs also increase annually by the inflation rate selected for the project analysis. For farm and business applications, the insurance cost is a tax-deductible operating expense.

often times insurance is overlooked and excluded from a proposal altogether.

In addition, for residential applications contact your home insurance provider and add the PV system to your homeowner policy to include the cost of a replacement solar system in the event of a catastrophe.

Time Value of Money

An important concept in investment analysis is the time value of money. The time value of money is usually positive – a dollar today is worth more than the same dollar in the future. Positive time value occurs for three reasons:

- Inflation – rises in the overall price of goods and services implies that every dollar in the future will purchase less than it can today – $1 may buy a candy bar today but because of inflation it will not 20 years from now;

- Opportunity cost – every time you wait to receive a dollar, you give up the chance to use that dollar right away, such as investing that dollar and earning interest. For example, if you invest $10,000 in a PV solar system, you forgo the chance to earn interest from keeping your money in a bond, stock, or savings account;

- Risk – there is always a chance you won't receive the money in the future. As the risk of a project increases, so will its cost of capital. As an investment poses greater risk, it must offer a greater return to make the risk worth it to the investor. As a general guide, a longer analysis period usually requires a higher return, due to increased risk and uncertainty related to external factors such as policy, economic market conditions, technology, and environmental factors.

Discount Rate

Ignoring the time value of money exaggerates the financial performance of a project. Just as interest rates are used between lenders and borrowers to capture money's positive time value, thereby compensating the lender for foregoing alternative investment opportunities and risk, a discount rate is used to equate a future dollar amount to its present value. Solar projects are long term investments, and it is critical the cash flows (revenue and costs) that occur in future years are discounted to accurately represent the economic value of the investment in present dollars terms.

The greatest challenge in determining the present value of cash flows is selecting the proper discount rate. The calculations used to estimate the present-day value of an investment are extremely sensitive to small changes (increase or decrease) to the discount rate used in the analysis. Determining the proper risk-adjusted discount rate for a project is an inexact science, but instead it is more of a personal decision based on how risky an individual deems a project and the willingness to accept that risk. There is no single discount rate makes sense for everyone. For example, the discount rate may represent the cost of borrowing capital, the rate of return needed to attract outside investment for a project, or the rate of return you could receive from an alternative investment. As a general guide, the longer the analysis period, the higher the discount rate. This is due to the additional uncertainty and risk associated with external variables in future years.

The greatest challenge in determining the present value of cash flows is selecting the proper discount rate.

As an example, a low discount rate (0-4 percent) would indicate a tolerance of risk and a high willingness to accept benefits in the future. A high discount rate (4-12 percent) would suggest the opposite. So, what does this mean for energy investments? Energy savings 10 years from now are worth less than the same savings today because of inflation, the lost opportunity to earn interest, and risk. In simple payback, the energy savings in the future are valued the same as energy savings in the present. For low discount rates (e.g., 4 percent), the error in the financial evaluation may be small because energy savings today are valued similarly to savings in the future; however, for higher discount rates (e.g., 10 percent) financial evaluation can severely underestimate the true payback.

Evaluating the Financial Return

While the decision to purchase a PV solar system is seldom based on costs alone – social and environmental criteria matter, too (how much do you value energy independence? how much do you value clean electricity?) – purchasing a PV solar system is a significant financial investment. Sound investment decisions require more than just understanding the production of a PV solar system and interpretation of a system proposal. Sound investment decisions require thorough economic analysis of expected costs and benefits.

Fortunately, there are various financial analysis tools that you can use to evaluate your PV solar project. Each evaluation tool comes with its own level of complexity, strengths and weaknesses, and the corresponding metrics measuring project performance. For example, simple payback is an easy calculation that is straightforward and easy to understand. However, it ignores the time value of money. Fortunately, additional tools which require more effort to calculate such as net present value and levelized cost of energy, consider important factors like the time value of money and escalation.

Simple Payback

Simple payback is one of the most requested measures of a PV system's economic feasibility. Simple payback determines the number of years for the energy savings from the PV system to offset the initial cost of the investment.

Simple payback is an attractive calculation because the calculation is straightforward and easy to understand. Investors can assess how quickly an investment might pay back (the smaller the simple payback, the better the investment) and whether the investment might payback within the expected lifetime of the project. However, because of the simplicity of the simple payback calculation, there are limitations when assessing the economic feasibility of PV projects. The simple payback calculation ignores several critical investment characteristics, including the time value of money, alternative investment options, and what happens after payback.

$$\text{Payback (years)} = \frac{\text{Initial Costs (\$)}}{\text{Annual Production (kWh/year)} \times \text{Value (\$/kWh)} - \text{O\&M (\$/year)}}$$

Simple payback also does not account for electricity price escalation (an increase in the real – inflation adjusted – price of electricity). This is an important economic consideration as expected electricity price increases are one of the most common reasons people consider renewable energy. If energy prices increase over the life of a PV investment, then the true payback period will be shorter than predicted by the common simple payback formula.

In addition, simple payback cannot easily accommodate variable rate electricity prices. The value of electricity generated, used in the denominator of simple payback, is typically calculated by assuming the same price for each unit of electricity produced. Many utilities, in contrast, have variable rates (tiered or block pricing). The cost per kWh depends on the number of kWh consumed – in some cases, the price per kWh may increase or decrease with greater consumption. A grid-connected PV system could offset the highest-priced electricity by bringing a household down to a lower pricing tier. This added benefit of renewable energy systems is not easily captured in the simple payback calculation. Ignoring variable pricing will tend to miscalculate the actual payback period.

Discounted Payback Period

Despite simple payback's several drawbacks, it can be used to effectively screen clearly undesirable investments that have extremely long payback periods compared to the life of the PV system. For instance, a system with an expected life of 25 years but a simple payback of 40 years is unlikely to be a sound investment decision regardless of whether or not you account for the drawbacks to simple payback.

Similar to the payback period, the discounted payback period measures the number of years an investment takes to pay back its initial cash outflow. However, the discounted payback period also accounts for the time value of money by applying a discount rate to the projects after tax cash flows table. By discounting the value of future cash flows, the discounted payback period is typically more accurate than the simple payback period.

Regardless if using simple payback or discounted payback, payback method is not well-suited to compare alternative investments. For instance, simple payback cannot meaningfully compare alternative investments that have different expected useful lives – payback treats a wind turbine with an expected life of 15 years and solar PV system with a life of 25 years as equal. The economic worth of an investment, however, is actually determined by the net benefits after payback. You invest in stocks hoping to make a return above and beyond your initial investment, right? Simple payback does not factor in the energy savings (benefits) and costs that occur after the payback period. As a result, two investments that have identical payback periods but vastly different useful lives (one will continue to produce benefits much longer than the other) will be incorrectly judged as the same by the simple payback criterion.

Net Present Value

Net Present Value (NPV) is a formula used to determine the present value of an investment by discounting the sum of the after-tax cash flows, which includes both the savings and cost from the project. NPV measures how much money the system will generate over the entire project period, compared to the initial project costs - Positive is good, Negative is bad.

Selecting the proper discount rate is critically important for an accurate NPV analysis.

In general, a positive net present value reveals an economically feasible project, but there are nuances to this assessment. Selecting the proper discount rate is critically important for an accurate NPV analysis. The greater the NPV, the better, but a positive NPV does not necessarily mean the investment should be made. The opportunity cost of the capital is also important. Are there better ways (higher NPV) to invest? On the other hand, a negative NPV indicates a poor financial investment, yet the value of other projects goals (resiliency or environmental) may motivate you to proceed with a project regardless.

$$\text{Net Present Value} = \frac{\text{After Tax Cash Flow}}{(1 + \text{Nominal Discount Rate})^{\text{Year}}}$$

The lifespan of the investment matters, too, making comparison of investments that have different timeframes difficult.

Leveled Cost of Electricity

The Levelized cost of energy (LCOE) considers the cost of building and operating a power plant over an assumed financial life cycle and is expressed as the per-kWh cost of the energy produced from the system. To be economically viable, the project's levelized cost of energy must be equal to or less than the current average retail kWh rate of electricity. The measure includes construction and operation costs, and if shown as real LCOE, is closely related to the net present value. One key advantage to the LCOE calculation is the variable electricity prices from complex retail electric rate sheets do not affect the levelized cost calculation. Additional benefits of LCOE calculations is that it allows for comparisons between different electricity sources, such as utility-

Table 6: Project Evaluation Tools

Evaluation Tool	Easy to Calculate and Understand	Accounts for Time Value of Money	Used to Compare Alternative Investments
Payback Period	✓	✗	✗
Discounted Payback Period	✗	✓	✗
Levialized Cost of Energy	✓	✗	✗
Net Present Value	✗	✓	✓

provided electricity and roof-mounted PV. You can also make comparisons across different system lifespans. However, be cautious when using LCOE to compare different types of renewable energy generation to that of a dispatchable energy source such as a natural gas or coal generator. While LCOE can help inform the decision, it should be noted that because PV solar electricity is a variable resource, other energy sources are required for the PV solar to take advantage of a low LCOE. Although seemingly the best option for comparing alternatives, LCOE is not immune to the effects of poorly considered discount and energy escalation rates. Be careful with your choices!

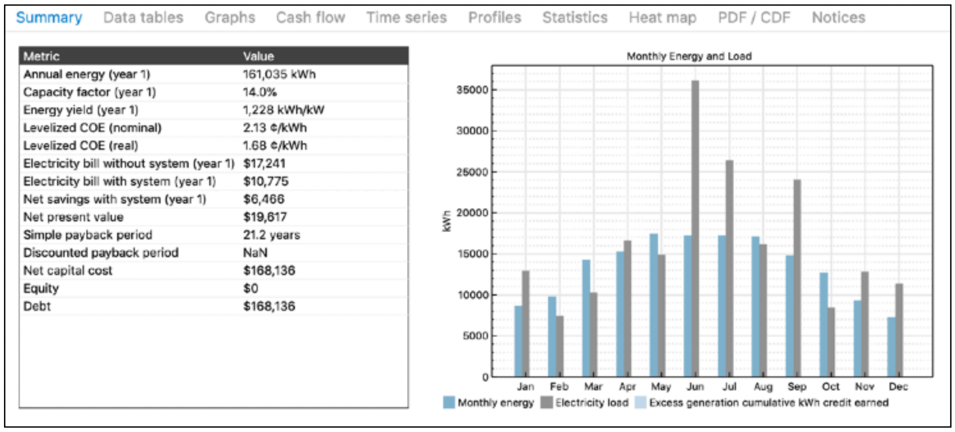
Take Home Message

The take-home message is that simple payback can provide an initial indication of economic viability but does not provide enough information to make a sound decision on such a large investment. Purchasing a PV solar system based on the simple payback alone may result in very disappointing returns. Net present value and levelized cost of energy require a more complex calculation but provide a more complete measures of economic viability (Table 6). Part 6: PV Solar Example will provide examples of how to use the National Renewable Energy Lab's System Advisor Model (SAM) to calculate simple payback period, discounted payback period, net present value, and the levalized cost of electricity as part of project analysis.

Figure 13: Photo by Dennis Schroeder / NREL

6. PV Solar Example

Figure 14: Output Summary of NREL System Advisor Model (SAM)



Installing a PV solar system is a significant investment that deserves careful consideration. Selecting the right installer is a critical step in developing a PV solar system. Consumers should evaluate several proposal options to compare and contrast the assumptions used. A detailed financial analysis is essential to making informed decisions on whether or not to invest in a PV solar system; however, the financial analysis is only as good as the assumptions and data used in the calculations. A proposal that incorporates poor assumptions or is not comprehensive will result in an inaccurate assessment. This section will help separate, analyze, and explain the core components of a typical PV solar proposal, including the system production, system cost, incentives, and electricity rates. A better understanding of the components and assumptions used to develop a proposal will allow a more accurate financial analysis, fostering informed investment decisions on solar projects.

Using the SAM Model

The National Renewable Energy Laboratory, which is funded by the U.S. Department of Energy, developed the System Advisor Model (SAM) to help developers, installers, and potential system owners estimate the system production and financial impacts of renewable energy projects, Figure 14. This comprehensive financial model evaluates critical variables including system design and production, system cost, operation and maintenance, financial factors, project incentives, tax implications, and the value of electricity generated by the system, to simulate a detailed cash flow over the system's lifetime. The SAM model examines the details of a project and simulates a detailed cash flow analysis providing numerous metrics, including the payback period, net present value, levelized cost of energy, electricity savings, and electricity cost with and without a renewable energy system. SAM is available for download at no cost from https://sam.nrel.gov.

PV Solar Example

To illustrate the implications of aggressive assumptions and the drawbacks of basing a decision on only a simple payback calculation, let's consider the example of a 10 kW PV solar project. We examine a PV solar project for a small swine and goat operation near Lincoln, NE with a farrowing house and nursery facility. The operation has heaters in each barn, runs ventilation fans throughout the year, and uses several heat lamps in fall and winter. The average monthly electric usage is 3166 kWh peaking at 5,200 kWh during the winter months. According to estimates from the model, the 10 kW solar system will provide approximately 38 percent of the agricultural operation's annual electricity needs. We constructed two scenarios in the SAM model. The first scenario assumes aggressive assumptions while the second scenario implements conservative assumptions (Table 7). Both assume the agricultural operation will provide 100 percent equity toward the project and require 0 percent debt financing. This section will use this PV solar example to evaluate how different assumptions influence project performance. Using information from this example, we will use SAM to simulate various scenarios for the system's electric production, system cost, electricity value, and incentives. A financial analysis will then compare the two scenarios to illustrate how changes in the inputs of a model significantly influence estimated payback period, net present value, and levelized cost of energy.

System Production

To develop a proposal, PV installers must provide an estimate of production, typically separated into average monthly production. Site-specific factors most critical to determining the system's production include the geographic location, tilt of the solar panels, orientation of the system, shading, and degradation. The SAM allows uploading a site's shading data from a sun eye or solar pathfinder.

Table 7 - PV Solar Example Details

Variables	Scenario 1: Agressive Proposal	Scenario 2: Conservative Proposal
System Cost	$25,000	$25,000
30% Investment Tax Credit	$7,500	$7,500
Grant	25% USDA REAP Grant (income tax not applied)	$0
System Performance: Degradation	None	0.50% annually
Operations and Maintenance Costs	$0/year	$15 per KW annually plus 1% escalation
Insurance Costs	$0/year	0.5% of system cost
Energy Rate	11¢ per kWh flat rate	Actual rate structure that includes a fixed monthly charge, time of use charges, and demand charges.
Energy Price Escalation Rate (real)	6% annually	1% annually
Inflation Rate	2.5% annually	2.5% annually
Discount Rate	6% annually	6% annually
Depreciation	5-year Modified Accelerated Cost Recovery System	5-year Modified Accelerated Cost Recovery System

System Orientation and Tilt Influence on Production

Some system owners prefer rooftop systems on the top of existing agricultural buildings. However, consider the difference in system production before making a decision. For example, a 10 kW system on a barn oriented to the east (90°) with a 4:12 pitch roof would produce an 18° panel tilt. This rooftop system would produce roughly 13% less than a ground mount system facing south (180°) with panels tilted at 40°.

Shading can also be modeled in the system with a 3-D shade modeling tool. In addition, you can apply production loss using snow coverage data from local weather stations. We used SAM to simulate the difference in production between scenario 1 and scenario 2 each with a 10kW grid connected solar PV system. Both scenarios assume a system orientation of 180° south with a 20° tilt, and no shading. Both scenarios had similar energy yield with an average production of 14,414 kWh annually and a 25 year life cycle (planned life of the system is 25 years).

System Cost

When evaluating multiple quotes or project proposals, identify the total upfront system costs and the ongoing system costs. In the example, scenario 1 did not include any cost for operation and maintenance or insurance. Conversely, scenario 2 includes $15 per kW annually for operation and maintenance and 0.5% of total cost annually for insurance which would include additional costs of $275 per year or $10,112 over the 25-year project lifespan. Considering operating expenses such as insurance and maintenance is essential to the financial analysis because they represent real ongoing costs. This example demonstrates how excluding small costs can still significantly influence the cash flow analysis of a system.

Value of Electricity

The value of electricity a solar system yields will depend on factual details, such as how the utility charges for electricity and assumptions such as the escalation rate, or the future cost of electricity. In the example, scenario 1 calculates the energy savings based on a flat rate energy value of 11¢ per kWh and applies 2.5 percent inflation and a 6 percent (real) energy escalation rate annually. In comparison, scenario 2 used SAM to select and import a real utility rate structure intended for a local NE utility with rural electric consumers. The rate structure used in scenario 2 includes a fixed monthly charge of $33 and different winter and summer rates. In the more conservative scenario 2 the real energy escalation went from 6% (scenario 1) to 1 percent annually. As shown in Figure 15, the aggressive assumptions used in scenario 1 exaggerate the value of energy from the project, estimating total energy savings of $120,000 over the 25-year project. In comparison, the simulation for scenario 2 is 66 percent less, estimating total energy savings of $41,000 over the 25-year project life.

Incentives

Despite rapidly declining costs for PV solar, incentives are still critical to the cost-effectiveness of a project. There are numerous types of incentives, such as tax credits, deductions, net metering, grants, and rebates available to offset the initial capital investment. When evaluating a project proposal, investors must identify and understand any incentives included in the calculations. In the example, scenario 1 applied the 30 percent federal Business Energy

Investment Tax Credit (ITC), and the USDA REAP grant, scenario 2 only considered the 30 percent ITC. Note that because the USDA REAP grant funding is not guaranteed, scenario 2 excluded the incentive program from the financial calculations.

Financial Analysis Summary

The straightforward and easy-to-understand simple payback formula is a preferred evaluation metric for solar installers; however, as discussed in Part 5, the simple payback calculation has limitations because it

Figure 15. Value of Electricity (Annual)

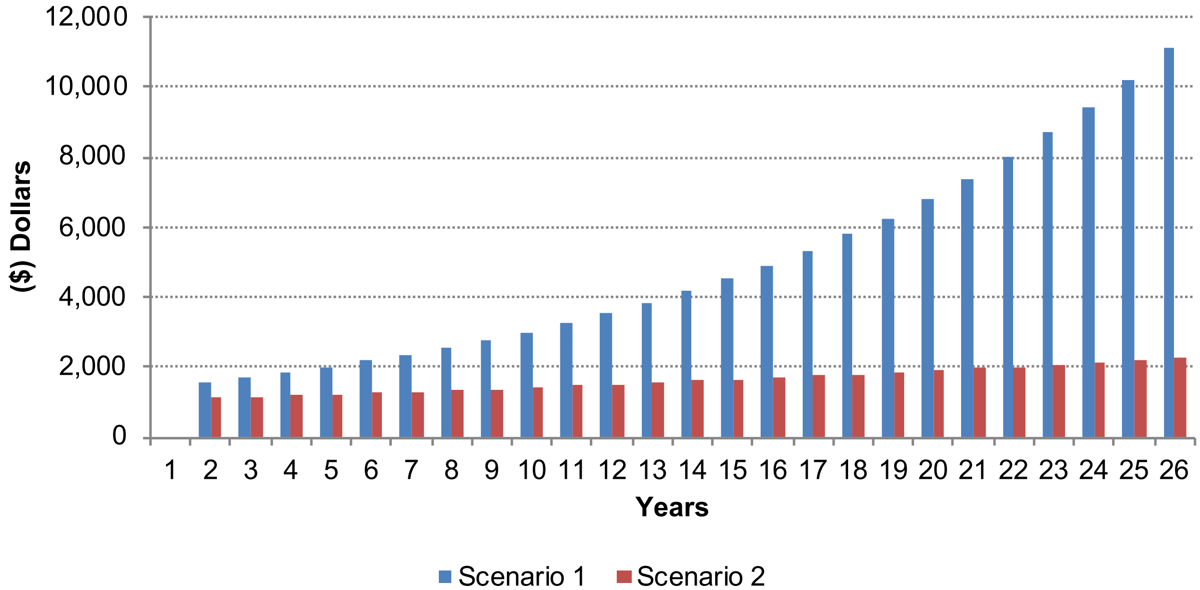
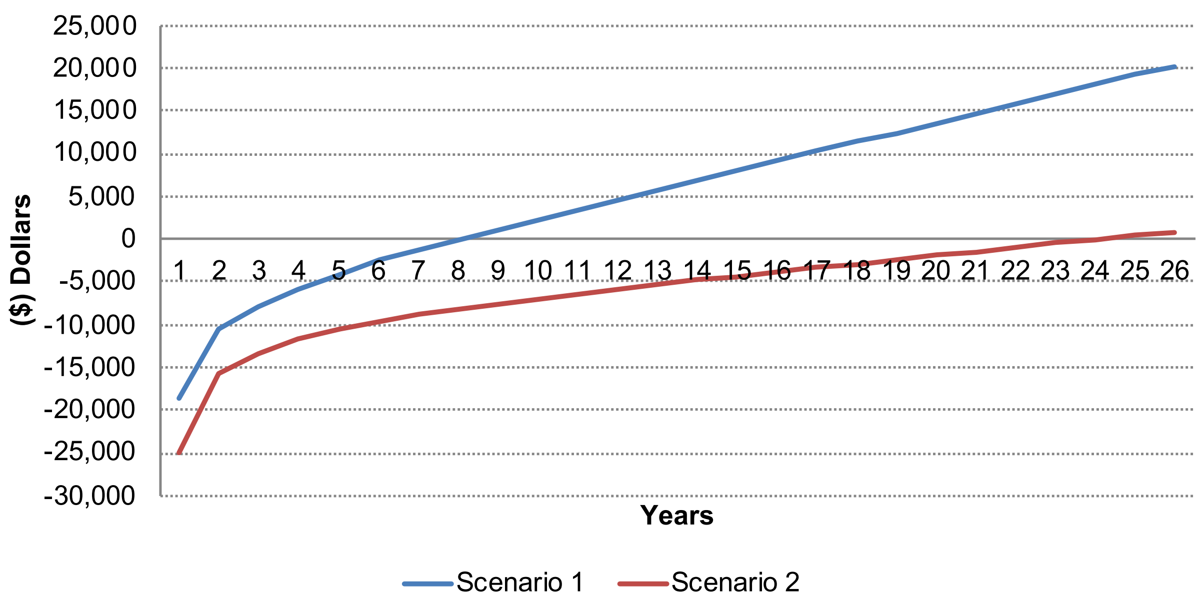


Figure 16.Comparison of System Cash Flow (cumulative)



ignores several real variables, such as time value of money, energy escalation rates, rate structure, and opportunity costs. When applying the aggressive assumptions from scenario 1, the SAM forecasts a simple payback of 5.4 years which means the electricity savings generated will offset the installation costs in about 5.4 years; however, this analysis does not account for critical factors such as system degradation, operation and maintenance, and insurance costs. Furthermore, scenario 1 assumed funding from the USDA Rural Energy for America (REAP) grant, which is a non-guaranteed competitive grant. In comparison, when we account for these variables in the simulation of scenario 2, we get widely different payback estimates. For instance, simply removing the REAP grant, which is not guaranteed funding, extends the project payback time by 2.3 years from 5.4 with the REAP grant to 7.7 years without. The more conservative scenario 2 has a payback of 15.3 years which is significantly higher than the 5.4 years of scenario 1. These two projects are identical in everything but the financial assumptions. The vast difference in paybacks indicate how assumptions can be manipulated to give favorable results. Net present value is described previously as a more robust measure than payback. For our scenarios the net present value was $17,000 for scenario 1 and -$5,500 for scenario 2. All financial metrics including payback and net present value are only as good as the assumptions used. A negative net present value does not always indicate loss only that the rate of return is below the discount rate. For our example the rate of return for the conservative scenario 2 is closer to 2% while the discount rate was 6%. Figure 16 illustrates a comparison of the cash flow between the two scenarios. Using tools such as the System Advisor Model (SAM) to evaluate the viability of a PV solar proposal will provide multiple metrics to accurately evaluate a project, including simple payback, a detailed cash flow analysis, net present value, and the levelized cost of energy. As with any financial matter, consulting a qualified tax professional is encouraged to ensure eligibility for tax deductions, incentives, and grants programs. If the System Advisor Model seems a bit overwhelming, please contact a local extension educator to work together to evaluate potential PV installations.

Figure 17: Photo by Dennis Schroeder / NREL

For questions regarding the information in this publication please contact

F. John Hay
Extension Educator - Energy
Department of Biological Systems Engineering
University of Nebraska–Lincoln
250 L. W. Chase Hall, P.O. Box 830726, Lincoln, NE 68583-0726
402-472-0408 | jhay2@unl.edu | http://bioenergy.unl.edu

Eric Romich
Extension Field Specialist
College of Food Agriculture and Environmental Sciences
Ohio State University
109 S. Sandusky Ave. (Room 16), Upper Sandusky, OH 43351
419-294-4931 | romich.2@osu.edu | www.energizeohio.osu.edu

NORTH CENTRAL SARE
Sustainable Agriculture Research & Education

Acknowledgment

This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number ENC18-172 through the North Central Region SARE program under project number XNC16-XXX. USDA is an equal opportunity employer and service provider. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.