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Financial Analysis Example for Photovoltaics on a Broiler Farm

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Adoption of photovoltaic (PV) solar technology by homeowners, businesses and non-profit organizations in Arkansas is on the rise in recent years. Deploying photovoltaic technology is a significant financial investment, so it is critical to understand the costs and benefits of solar installation. This article compares scenarios based on different assumptions of system costs, the price of electricity, tax credits and the availability of grant incentives.

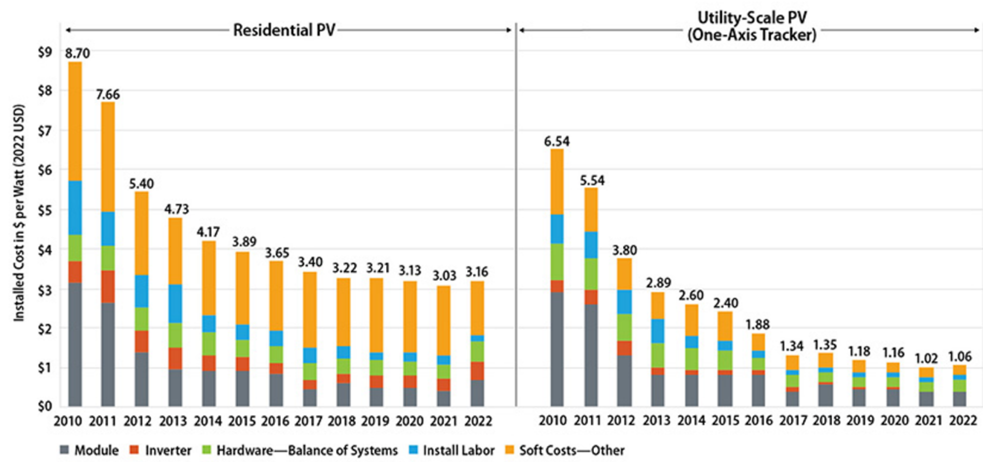
Main Drivers of Lower Costs

The No. 1 factor for driving down costs is the falling cost of solar PV installation and the improvement in photovoltaics efficiency. Solar module and inverter costs have dropped more than 60 percent over the past decade and the average cost of solar energy production in 2020 was one-tenth of what it was in 2000. Figure 1 displays the full cost benchmark of a residential PV system (with an average system size of 6 kW DC (direct current)) and a utility-scale PV system (with a baseline of 100 MW DC) over the past 12 years. The sharp decline makes photovoltaic systems the most financially viable source of energy among existing renewable energy applications. Additionally, economies of scale on the manufacturing and installation side have lowered project-level costs with the growth in number of projects and project sizes. Finally, as project developers, suppliers and equipment manufacturers all compete for renewables capacity, supply chain cost reduction plays an important role in lowering costs despite recent inflationary pressure.

Benefits of PV Solar

The biggest benefit of solar arrays is to reduce energy bills in the long run. The average retail rate of electricity (all sectors) in the United States increased from 7.29 cents per kilowatt-hour in 2001 to 10.74 cents

Figure 1. Residential and utility-scale PV system cost benchmark (inflation adjusted). Source: National Renewable Energy Laboratory, 2010-2022.



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per kilowatt-hour in 2020. Investing in a solar PV system will hedge against future energy price increases as installation costs are known and locked in up front. The levelized cost of electricity is around $0.03 for business owners, compared to the average cost of electricity of $0.1074 mentioned above, representing an approximate 70 percent reduction. Additionally, many home and business owners value the environmental benefits of significantly reducing air pollution and greenhouse gas emissions by replacing fossil fuels with renewable energy sources.

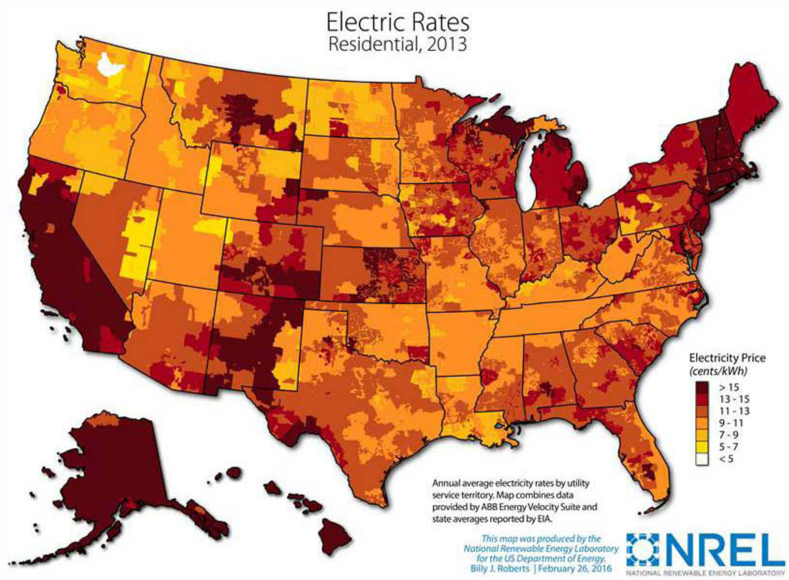

Figure 2. Annual electricity rates by utility service territory.

Value of Solar Electricity Production

Arkansas, together with other states in the Southwest Central region, enjoys one of the lowest electricity rates in the nation (Figure 2). However, lower rates present a disadvantage for on-site solar panels, as the solar-generated electrons are worth more in economic analysis if the electricity price is higher. The value of solar-generated electricity is the single largest factor impacting the payback period. It is critical to analyze what your home or business is billed regarding fixed charges, energy consumption and demand charges before deciding on a solar project.

Most commercial and industrial customers have utility bills that are divided into two major categories:

- Energy consumption: the amount of energy (kWh) consumed, multiplied by the relevant price of energy ($/kWh) during the billing period.
- Demand: the maximum amount of power (kW) drawn for any given time interval (typically 15 minutes) during the billing period, multiplied by the relevant demand charge ($/kW).

Demand charges, which account for peak electricity use during the month, are necessary because it is expensive for the utility to build and maintain the capacity to serve their territory's highest demand every month, even though that peak demand may occur only once. Fixed access charges cover overhead costs.

The electricity generated by a solar system will typically only offset the energy consumption (kWh) portion of the bills. Demand reduction may not be consistent, due to weather (for example, peak demand occurs during a cloudy day, or all fans operate on warm summer nights on a poultry farm). When calculating the value of electricity generated by PV systems, one has to be careful about which portion of a utility bill can be offset.

Another piece of the value of on-site solar electricity production is the availability and form of net metering policy. The traditional one-to-one net metering accounting method disregards the time of electricity generation or consumption. At the end of a billing cycle, if the amount of solar generation is larger than that of electricity consumption, the customer is credited so that the excess generation (in kWh) can be used in subsequent billing periods. This is similar to making an interest-free loan to the utility of your excess kilowatt-hours that you can use in the future. Under this policy, most on-site solar system owners can install a system with its annual solar generation close to the annual total electricity consumption.

In recent years, new policies have been proposed to replace the existing net metering policies in multiple states. In Arkansas, a deadline of September 30, 2024, was set to apply for "legacy net metering" status by the Arkansas Public Service Commission. Those who do not apply for legacy net metering will fall under the next compensation policy called "net energy billing," which will force the sale of power to the utility grid. The utilities will purchase the power at their avoided cost, generally 30-50 percent of the retail cost. In this scenario all net energy exports (those in excess of real-time consumption) are metered and converted to a monetary credit at an avoided cost rate the moment they are injected into the grid. By setting the sell rate at an avoided cost rate, net energy billing can discourage net export to the grid and reduce the value of a distributed solar system.

Spreadsheet Model

We created the Poultry Solar Analysis (PSA) model to allow potential system owners to estimate the production and financial impacts of solar energy projects as a commercial user. The model evaluates variables including system cost, production, operation and maintenance, project incentives, tax implications and the value of electricity generated by the system. The spreadsheet model simulates after-tax cashflows over the system's lifetime with and without solar investment. The spreadsheet is available for download at no cost from https://agribusiness.uark.edu/decision-support-software.php#PSA along with a user guide that explains how the tool estimates demand and fixed access charges compared to variable electricity consumption cost from electric bills the user enters. It also allows the user to specify financial lending options and how much of project costs may be reimbursed with a Rural Energy for America Program grant and other tax incentives such as depreciation.

A rule of thumb of annual solar generation resource is around 1,450 kWh per installed kW in Arkansas for a fixed-tilt system angled at 25 degrees due south, although it can vary slightly based on exact loation. The generation can also vary widely if the orientation and tilt differ from the above assumption or if there is significant shading on modules. This value is used as a default in the spreadsheet and the calculation below but can be replaced by actual output values using a PV production prediction tool, such as the PVWatts Calculator (https://pvwatts.nrel.gov/) that is contained in the above-mentioned online PSA tool.

An Example of PV Solar on a Broiler Farm

To illustrate the cost and benefit of a solar PV project under the existing net metering policy, let's consider an example of a 100-kW photovoltaic solar project on a broiler farm. The farm owns four 40 × 400-foot broiler houses and grows broiler chickens to eight weeks old. The operation has gas heaters in each barn, follows standard lighting schedules, runs ventilation fans throughout the year, and uses electric feed motors on feed lines. The average annual electricity usage is about 150,000 kWh. According to the estimates from the model, a 100-kW solar array will generate 145,000 kWh of electricity in the first year after installation.

The **Discount Rate** is the minimum rate of return expected to be earned on an investment given its risk profile. The **present value** of the future cash flows generated by an investment is estimated using an appropriate discount rate – i.e. the opportunity cost of capital – which reflects the riskiness of the underlying investment. **Net present value** is widely used to determine the perceived profitability of a potential investment to help guide critical capital budgeting and allocation decisions.

Table 1. PV solar example of a 100-kW photovoltaic solar project with two scenarios.

Variables	Scenario 1 (Conservative)	Scenario 2 (Aggressive)
System cost	$165,000	$150,000
System cost in $/Watt	$1.65	$1.50
30% federal investment tax credit (ITC)	$49,500	$45,000
PV performance degradation rate	0.5%	0.3%
Operation & maintenance costs	$7.5 / kW-year	$7.5 / kW-year
Utility rate ($/kWh)	0.08	0.11
Utility rate escalation - inflation	2%	2%
Discount rate (for NPV* calculation)	5%	5%

*NPV- Net present value

We constructed two scenarios using the model, both assuming the farm operation will provide 100 percent equity toward the project. The first scenario assumes conservative assumptions while the second implements aggressive assumptions (Table 1). The conservative scenario assumes a higher system cost, a worse system performance degradation rate, and lower utility rates as input assumptions of the model. This article will use the example to illustrate how different assumptions influence the financial performance of the project, demonstrating how small changes in inputs of a model can influence estimated payback period.

Solar Generation

As shown in Figure 3, scenario 1 assumed an annual degradation of 0.5 percent, yielding an average production of 135,000 kWh annually and 3,904,000 kWh over the 30-year project lifecycle. In comparison, scenario 2 used an annual system degradation of 0.3 percent, generating an average production of 139,000 kWh annually and 4,021,000 kWh over the 30-year project lifecycle. The performance degradation rate is largely determined by the selection of PV modules and inverters, and directly influences the generated electricity of the life time and return on investment.

System costs

When evaluating project proposals, pay attention to both initial system costs and ongoing costs. In the example, scenario 1 (conservative) assumed a system cost of $1.65 per watt of installed PV capacity, while scenario 2 (aggressive) assumed a system cost of $1.50 per watt of installed PV capacity. The operation & maintenance expenses are estimated as $7.5/kW-yr and an inverter replacement expense at Year 15 in both scenarios are as indicated in the Sunshot report (DOE, 2012). Taking into account the operating expenses such as insurance and maintenance is essential to the financial analysis because they represent real ongoing costs and cannot be ignored.

Value of Electricity

It is important to separate electricity bills into the variable rate component for electricity use (kWh) vs. fixed access and demand charges. The values of solar PV projects differ with the electricity retail rates charged by the electric utility. In the example, scenario 1 (conservative) assumes a rate structure including a fixed monthly charge of $25 and an energy retail price of $0.08 per kWh. Both scenarios used a similar energy escalation or inflation rate of 2 percent. In scenario 2 (aggressive), the energy savings were calculated based on a retail rate of $0.11 per kWh. Hence the aggressive assumption used in scenario 2 leads to a greater value of energy from the project (Figure 4), estimating higher total energy savings of $186,000 over the 30-year project. In comparison, the simulation for scenario 1 results in 35 percent less total energy savings. When analyzing the decision to invest in solar panels or not, it is critical to look closely at the actual bills with various charges.

Tax Credit, Federal Grant and Financing

Both federal investment tax credits and Rural Energy for America Program (REAP) grants and loans can be critical to the cost-effectiveness of a renewable energy project, potentially offsetting the initial capital investment (Figure 5, scenario 2b). In the example, we applied the federal Investment Tax Credit (ITC) to both scenarios. The ITC is a dollar-for-dollar reduction of the income taxes that a person or business would otherwise pay the federal government (liability), and is at 30% of project costs until 2034. Additional tax credit bonus such as Energy Community (10 percent DoE, n.d.) or Low-Income Community (10 percent DoE, n.d.) programs will allow up to 50 percent of project costs, and poultry farms could likely meet one of the requirements. USDA REAP grants, on the other hand, are competitive and only available to farmers, ranchers and rural small businesses to support the purchase of wind, solar or other renewable energy systems. REAP grants are taxable income, so an after-tax contribution is shown for the REAP portion of the initial investment in Figure 5. REAP grants are awarded quarterly or semi-annually using a ranking system and are subject to availability of funds. When making the financial analysis, assuming grant funding will significantly decrease the net system cost, leading to a shorter payback period.

Simple Payback

An easy-to-understand, simple payback formula is a commonly-used evaluation metric for solar installers. Simple payback is one of the most requested measures of a project'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. The key payback terms include initial cost, annual production, the value of electricity generation and ongoing costs over the life of the system.

The simple payback calculation ignores several critical investment characteristics, including the time value of money (to account for alternative investment

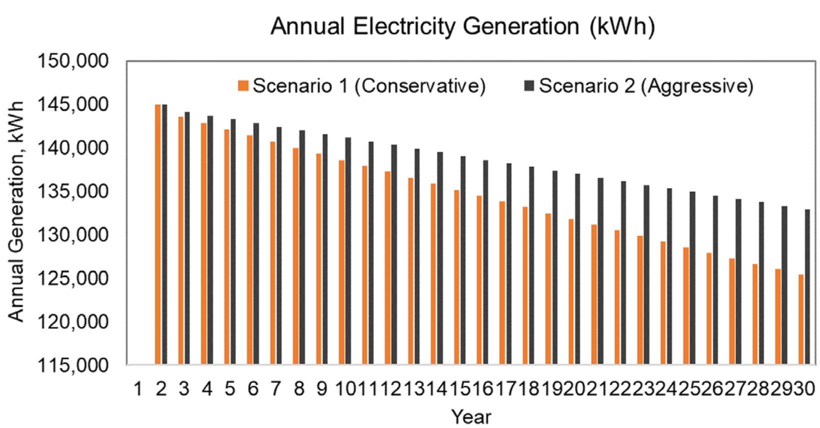

Figure 3. Annual electricity generation using conservative (scenario 1) and aggressive (scenario 2) solar generation output degradation rates.

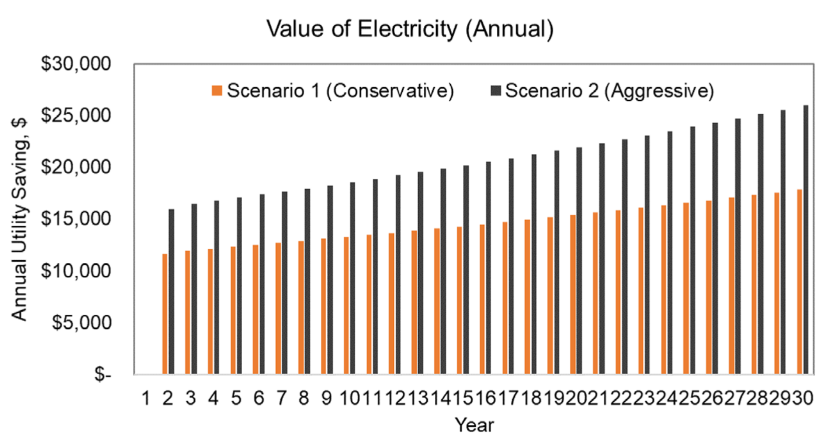

Figure 4. Value of annual electricity using conservative (scenario 1) and aggressive (scenario 2) assumptions about variable electricity rates.

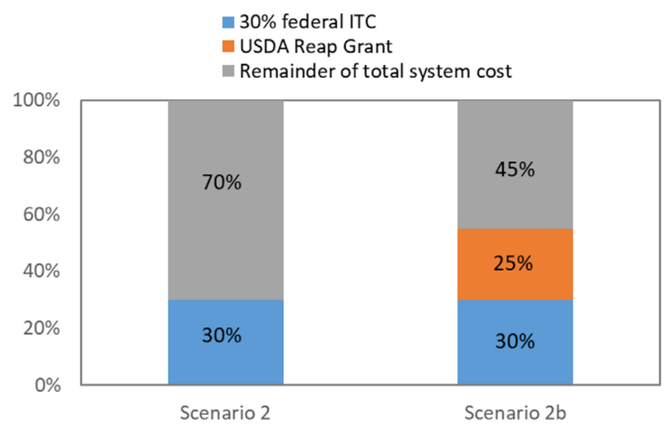

Figure 5. Effect of federal investment tax credit and potential after-tax REAP grant as contribution to reduce the total project cost.

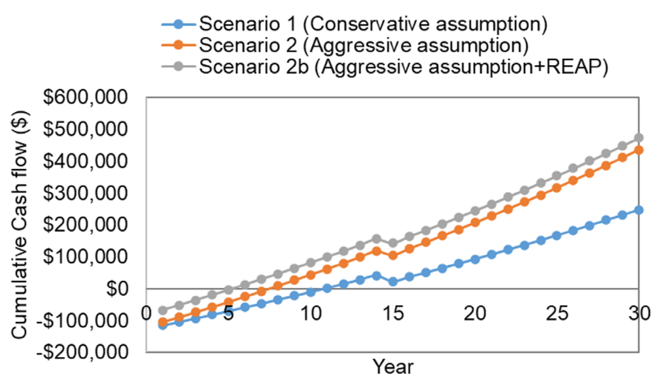

Figure 6. Comparison of the cash flow of a 100-kW PV system under scenarios 1, 2, and 2b. All scenarios included the 30% federal ITC and the same utility rate inflation. Scenario 1 used a slightly higher installation price per kW, worse lifecycle system performance, and a lower utility rate. Scenario 2 used a slightly lower installation price per kW, better lifecycle system performance, and a higher utility rate. Scenario 2b added a REAP grant to lower system cost for scenario 2. The dip on curves resulted from a projected capital of inverter replacement around Year 14.

options), and what happens after payback. Ignoring the time value of money leads to an underestimation of a project's real payback time. Secondly, 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 a solar PV system with a life of more than 25 years as equal. The economic worth of an investment is critically impacted by the net benefits after payback. Despite the simple payback's several drawbacks, it is still a useful tool to effectively screen undesirable investments that have extremely long payback periods. Better evaluation metrics such as net present value are available to make a more accurate prediction for decision making and is used in the online PSA tool mentioned above.

When applying the conservative assumptions from scenario 1, the model predicts a simple payback of 11 years (Figure 6). This means that the electricity savings generated will offset the installation costs in about 11 years.

In comparison, when applying the aggressive assumptions from scenario 2, the model predicted the payback to occur in year 7, four years shorter than scenario 1. As a matter of fact, a proposal can be even more aggressive if the REAP grant of 25 percent of project cost is factored in the scenario 2 of model simulation (scenario 2b), resulting in a five-year payback time, widely different from the conservative scenario 1. Figure 6 illustrates a comparison of the cash flow of the three scenarios.

Payback periods for different initial project costs and electricity rates of commercial solar systems are given in Table 2. Values in Table 2 were calculated by assuming federal ITC of 30 percent, federal tax rate of 30 percent, AR state tax rate of 4.70 percent and the value of depreciation of 25.5 percent. As mentioned above, the payback is sensitive to the electricity rates, ranging from 3.33 to 6.93 years for electricity rate of $0.11/kWh under different project costs between $1.2 and $2.5 per Watt.

Summary

Many economic factors are to be considered when making decisions regarding an investment. Using a financial analysis tool such as the Poultry Solar Analysis spreadsheet tool to evaluate the viability of a PV solar proposal will provide metrics as the basis

Table 2. Payback periods (in years) for commercial solar systems with different solar project installed costs ($/Watt) and electricity rates ($/kWh).

	Solar Payback Period in Years for Commercial Systems *													
Cost per kWh ($/kWH)														
0.11	3.33	3.60	3.88	4.16	4.44	4.71	4.99	5.27	5.55	5.82	6.10	6.38	6.65	6.93
0.10	3.66	3.96	4.27	4.57	4.88	5.18	5.49	5.79	6.10	6.40	6.71	7.01	7.32	7.62
0.09	4.07	4.41	4.74	5.08	5.42	5.76	6.10	6.44	6.78	7.12	7.46	7.79	8.13	8.47
0.08	4.57	4.96	5.34	5.72	6.10	6.48	6.86	7.24	7.62	8.01	8.39	8.77	9.15	9.53
0.07	5.23	5.66	6.10	6.54	6.97	7.41	7.84	8.28	8.71	9.15	9.59	10.02	10.46	10.89
0.06	6.10	6.61	7.12	7.62	8.13	8.64	9.15	9.66	10.17	10.67	11.18	11.69	12.20	12.71
0.05	7.32	7.93	8.54	9.15	9.76	10.37	10.98	11.59	12.20	12.81	13.42	14.03	14.64	15.25
0.04	9.15	9.91	10.67	11.44	12.20	12.96	13.72	14.49	15.25	16.01	16.77	17.54	18.30	19.06
	1.2	**1.3**	**1.4**	**1.5**	**1.6**	**1.7**	**1.8**	**1.9**	**2**	**2.1**	**2.2**	**2.3**	**2.4**	**2.5**
	Installed Cost-per-Watt ($/W)													

*Based on assumption of federal ITC of 30%, federal tax rate of 30%, AR state tax rate of 4.70% and the value of depreciation of 25.5%.

of the evaluation. Consultation with a qualified tax professional is encouraged to ensure eligibility for tax deductions, incentives and depreciation options are accounted for appropriately.

Electricity is one of the major costs for poultry production, and has seen substantial increase in recent years. Results of this analysis illustrate that government programs and policies are important not only in growing renewable energy sectors, but also in enhancing the financial sustainability of a poultry operation. Access to the incentives, rebates, and grants will be critical to further growth of renewable energy generation that mitigate greenhouse gas emissions to meet climate goals.

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