IOWA ENERGY CENTER

Home Series

Solar PV Energy Guide

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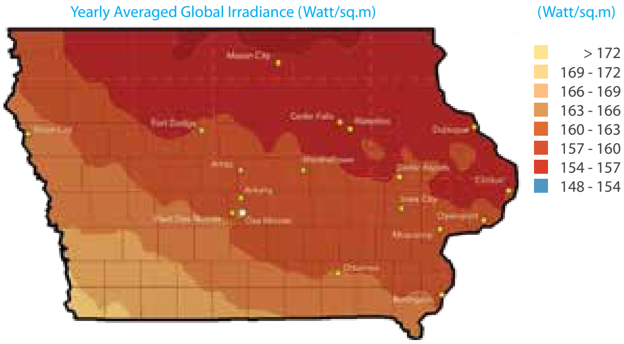
Solar PV Energy Guide

What is Solar Photovoltaic (PV) Technology and How Does It Work?

Solar PV technology is the process that converts sunlight into electrical current when it strikes suitable materials called semiconductors in a device. Sunlight is absorbed by semiconducting materials, such as silicon, releasing electrons from their atoms. The electrons flow through the semiconductor to produce direct current (DC) electricity.

The amount of Solar PV available to be converted to electricity can be impacted by various factors, including but not limited to seasonal conditions; the angle of the panel relative to the sun or number of daylight hours; atmospheric contaminants, including dust, humidity, and forest fires; cloud cover; and elevation.



Building Blocks of a PV Array

A PV array is composed of solar modules, which are made up of solar cells. A solar cell is a semiconductor that converts sunlight into electrical energy and is rated between 1 and 4 watts depending on its efficiency. A solar module is made up of multiple solar PV cells that are wired together and sealed. Typically, a solar module is between ten and 320 watts (operating at 6 to 36 DC volts). A solar array is made up of multiple solar modules that are electrically wired together in one structure to produce a specific amount of power. A solar array can operate at up to 600 DC volts.

Solar cell technologies have evolved over time, and new technologies are continuously emerging. Understanding the advantages and disadvantages of each type of solar cell will help to ensure that you consider the appropriate technology for a potential installation.

The primary types of cells include:

- **Monocrystalline solar cells** are a first-generation technology, meaning that the technology, installation, and performance issues are well documented due to a more frequent use of this type of cell. These cells are the most efficient and most common for residential solar installations. These cells are a good choice where space is limited, and they can convert more solar energy into electricity than most other types of solar cells. However, monocrystalline cells tend to have a higher up-front cost.
- **Multicrystalline or polycrystalline solar cells** tend to be less expensive but require more surface area than monocrystalline cells to produce the same amount of energy (lower efficiency).
- **Amorphous thin film solar cells** are flexible, have a shorter usage life, and are used where space is not an issue and in areas where high temperatures and shade are anticipated. These cells are more resistant to damage from elements, such as hail or rocks. However, they are less efficient in normal sunlight but more efficient in low light conditions as compared to the monocrystalline.

Purpose of This Guide

Are you considering adding a solar photovoltaic (PV) energy system to your home to generate electricity? If so, this guide is designed to provide information and resources to help you make an informed decision, whether you choose a turnkey system, a do-it-yourself approach, or a combination of both. The information is presented in a series of steps that will help you reach a well-informed conclusion if you decide to pursue making an investment in your own solar energy system.

The Iowa Energy Center created this document in collaboration with Alliant Energy, the Iowa Association of Electric Cooperatives, the Iowa Association of Municipal Utilities, and MidAmerican Energy with information from the Office of Consumer Advocate and the Iowa Utilities Board.

The contact information for each contributor along with a glossary are included at the back of this guide. When making a decision about a solar energy system, consumers also should consider including their trusted advisors, such as accountants, attorneys, and tax professionals, in their research to provide additional expertise in the decision-making process. In addition, this publication can be used in tandem with other checklists and resources, such as the Iowa Utilities Board's Information Guide for On-Site Generation.

https://iub.iowa.gov/sites/default/files/files/misc/IUB_Informational_Guide_Distributed_Generation.pdf

Getting Started

Monocrystalline solar cells

Multicrystalline or polycrystalline solar cells

Amorphous thin film solar cells

DID YOU **KNOW** ?

Off-grid or stand-alone systems are not connected to the utility grid but are typically connected to a battery bank that stores the energy for later use. Typically, these types of systems are located at remote sites where it is expensive to connect to the grid. In some situations, off-grid solar PV systems can be used as backup power in place of fuel-burning generators.

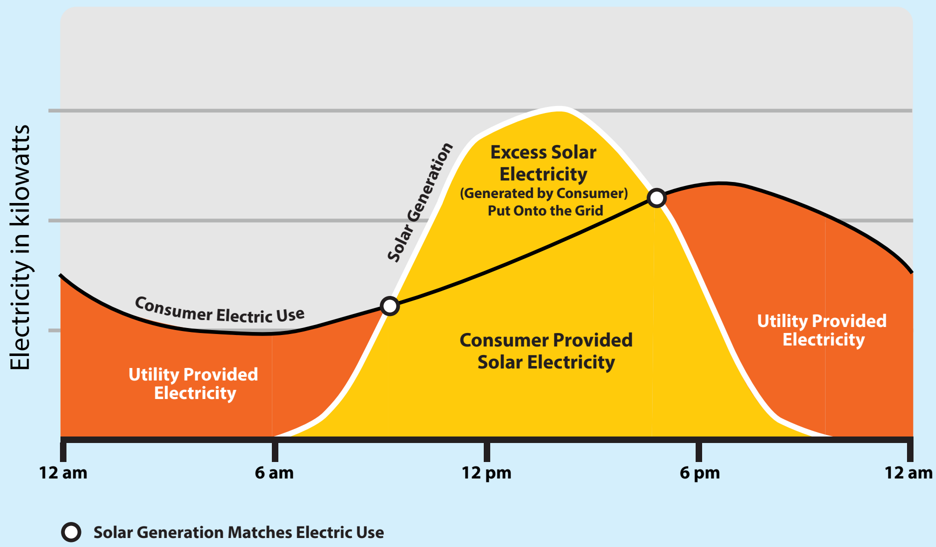
Solar arrays can be mounted to a building's roof or on the ground. Ground-mounted systems are typically near the building or point of consumption. With both roof-mounted and ground-mounted arrays, the system may be stationary, designed to have a fixed tilt, or have tracking capabilities to follow the sun as it moves across the sky.

Some solar generating systems include an energy storage component in which batteries are used to store energy produced during the day for use at night or other times of low production when the system isn't producing enough to meet the property owner's electricity needs. Battery storage also can be used to stabilize voltages and supply surge currents to electric loads and inverters.

Solar PV systems can be interconnected to the electric grid or can be operated as stand-alone (off-grid) systems. All grid-connected solar generating systems require an inverter, which safely and efficiently converts the direct current (DC) electricity generated by the solar array to alternating current (AC) electricity.

Most commonly, systems are connected to the utility electric lines and the solar energy produced replaces purchases from the interconnected utility, with any excess production being fed to the utility's electric grid. Data shows that consumers with typical solar generating systems need the grid to energize the solar generating system, to export the excess electricity or to import power from the grid to supplement solar production when the system is not generating enough to meet the consumer's needs. This is due to a mismatch between the timing of energy produced and energy usage.

Typical Iowa Residential Consumer with Onsite Solar System (Summer)



The technologies associated with the building blocks of a solar array project may seem complicated; however, the system design and construction are relatively simple and straightforward. There are no moving parts unless a sun tracking device is installed, and most of the electronics are self-contained and only require connection wires between components. Familiarity with the design and construction procedures is beneficial in becoming a more educated consumer and owner.

Setting Your Goals

Before designing a system or purchasing any materials, you should first identify why you are pursuing the installation of a solar array. Your goals for the project may impact several aspects of its design and construction. Some of the most common goals for constructing a PV array are:

- **Offsetting your personal electrical consumption.** By displacing a portion of the electrical power delivered by your local utility, you become less impacted by future rate changes and may be able to repay the initial capital investment with the avoided utility bill payments accumulated over the life of the project. Under this scenario, it's important to size the system to match your electrical needs without oversizing the system.

- **Managing future electrical costs.** If electricity costs are a substantial element of your monthly costs (e.g. livestock farming or in the commercial and manufacturing sectors), you may consider installing a solar energy system as a hedge against unknown future costs. By purchasing a solar energy system to supply a portion of your own electrical power needs you will incur an upfront cost; but you become somewhat immune to the unknown potential electrical rate escalations over the life of the system. You also may be in a better position to manage your costs knowing that a portion of your energy expense is fixed into the future.

- **Creating a new revenue stream.** You may want to install a solar energy system as a potential revenue source to supplement your income and offset your energy costs.

- **Going off the grid.** You may have a goal to sever your association with the utility serving your home or business. Designing your solar array will require prudent sizing with energy storage to provide electricity when the solar array is not generating power. Additionally, you will need to become an active manager of your energy consumption to balance your power needs with the capabilities of the solar array and energy storage device. Adding an energy storage device will significantly increase the cost of the solar system.

- **Being an environmental steward.** You may want to enhance your commitment to the environment by generating your electricity with a renewable energy source rather than relying on utility power that may be partially generated with fossil fuels.

- **Providing a backup power source.** You may have a need or desire to counter a blackout condition caused from a storm or other incident with your own source of power. A solar array alone cannot serve as a reliable backup power source as it sits idle when the sun is not shining and generates at reduced levels during cloudy and non-peak (early morning and night) periods. The addition of energy storage to your solar array may provide a limited backup source of power. Energy storage may be in the form of a battery bank, charged from the solar array and grid power; or a fossil-fueled (e.g. gas or diesel) portable generator.

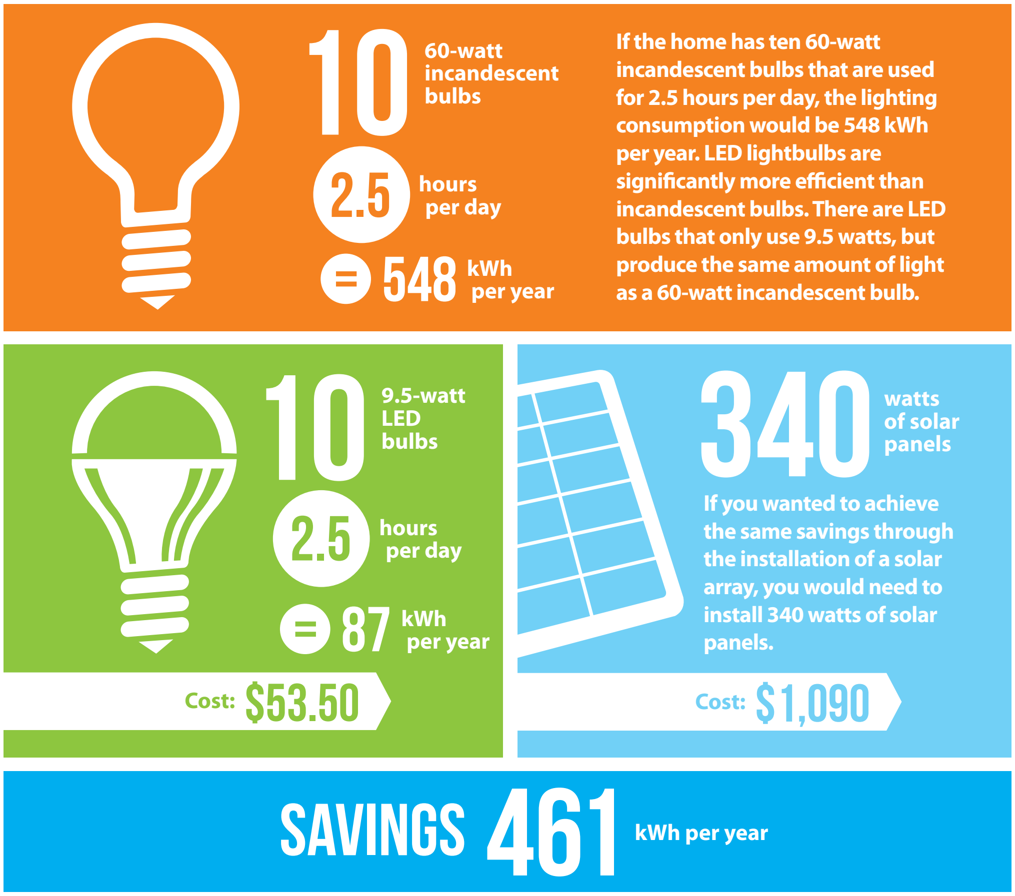
Preliminary Steps and Research

It is critical to do your homework and research throughout all phases of determining if an investment in a solar generating system is right for you.

Recommended Steps

1. **Maximize energy efficiency.** Completion of a thorough energy efficiency audit is an important precursor to considering a solar energy system. Implementing energy efficiency measures in advance of installing a solar energy system can save you money and reduce the size of the solar energy system you'll need to meet your energy needs.

EXAMPLE: To illustrate how energy efficiency can cost less than installing a solar array, consider an example of a consumer who uses incandescent lighting in their home. If the home has ten 60-watt incandescent bulbs that are used for 2.5 hours per day, the lighting consumption would be 548 kWh per year. LED lightbulbs are significantly more efficient than incandescent bulbs. There are LED bulbs that only use 9.5 watts, but produce the same amount of light as a 60-watt incandescent bulb. Purchasing ten LED bulbs would cost approximately $53.50, and save 461 kWh per year compared to the incandescent bulbs. If you wanted to achieve the same savings through the installation of a solar array, you would need to install 340 watts of solar panels. As an example, if the cost is $3.25 per watt, this would cost $1,090. In other words, in this example it costs $1,036 less to replace incandescent bulbs with LED bulbs than it does to install a solar array to achieve the same energy reduction.



DID YOU KNOW ?

Many energy efficiency improvements will save energy, reduce utility bills, and help the environment for a much lower cost than installing a solar generation system. Because energy efficiency improvements reduce your electric usage, they also may contribute to reducing the size and cost of a solar array needed to meet your energy needs.

How to make energy efficiency work for you:

Complete an Audit:

- Contact your utility for a professional energy audit (home or business)
- Take advantage of online tips, information, and resources:
  - **Iowa Energy Center Home Series:** *www.iowaenergycenter.org/home-series*
  - **Energy Star:** *www.energystar.gov*
  - **U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy:** *energy.gov/eere/efficiency/homes*
  - See Page 32 for a listing of the electric utilities in Iowa and visit your utility's website for online resources.

2. **Check with local authorities.** Plan a visit with your local authorities to learn the requirements for obtaining a building permit and to learn if there are any local ordinances that may either prevent the construction of a solar array or that limit its size, location, visibility, and setbacks. If your community has not addressed development of residential solar, you may experience delays while rules and requirements are developed. If you live in a platted development, you also should check any building restrictions and other requirements the covenants that may have been put in place by the developer of the plat. They can be found in the abstract to your property.

3. **Check with your local electric utility.** Schedule a personal visit with your electric utility. During your visit, obtain information that may affect the location, size and cost of the array; the value of the energy generated by the array; the safety issues that will need to be addressed; and any additional fees or costs that might be incurred with interconnection of a solar energy system. Iowa law (*legis.iowa.gov/docs/code/476.pdf*) requires that the owner must provide written notice to the utility no later than 30 days prior to the commencement of construction or installation of an alternate energy production facility, including a solar array. Iowa's utilities have an obligation to interconnect, and the Iowa Utilities Board has a streamlined process for interconnection of a solar energy system (see Pages 26-27 for more information).

   In addition, learn about the following:

   a. What will your electric rate be after the array is connected to the grid, and will the array change your usage rate and monthly service charge?

   b. How will you be compensated for excess generation, and what is the buy-back rate for excess generation sold back to the utility? For example, if net metering is offered, learn if banking of excess generation is allowed and how often the account is settled (monthly, annually, never). If settlement dates are applied annually, identify which month is used and if there are choices related to the settlement month. If net metering is not offered, learn what the selling and purchasing rates will be for the net billing policy and if the points of settlement are monthly or annual. It's imperative to talk to your utility to understand how your load profile will work with your settlement month. Note: Iowa's rate-regulated utilities file information about their avoided cost with the Iowa Utilities Board. Non-rate-regulated utilities will provide information about their avoided cost upon request to your local utility.

   c. What effect will the solar energy system have on the current rates under which you are purchasing electric service from your electric utility and on any end-use rates that you may be receiving, such as electric heat rates, geothermal rates, and higher block rates?

   d. If you're on a demand or time-of-use rate, will your bill be impacted?

   e. If you have multiple meters or submeters, how many meters do you anticipate may be offset by a single solar array interconnection? Or, how multiple meters and submeters may be combined as a means to offset more loads and what are the electric rate implications for doing so?

DID YOU **KNOW?**

Iowa law encourages the development of renewable energy sources. Iowa law does not allow gas or electric utility consumers to be subject to discriminatory, disadvantageous or prejudicial rates or terms for utility service based on a consumer's use or intended use of renewable energy resources.

f. Does your utility offer a community-based solar opportunity or green pricing program? A community-based solar program may afford you the benefits of your own solar array without the ownership and maintenance responsibilities.

g. Note that the information that you receive from your utility will represent current rates and tariffs. With the appropriate approval, rates, rate structures and tariffs may change over time to reflect changes in your utility's cost of providing service.

4. **Understand your electric utility bill and your electricity usage patterns.** Review one to two years of historical usage and cost records. The history will help you to understand how much and when you are using electricity. You also should talk to your utility to gain an understanding of the potential for future rate increases as this will affect the economics of your project.

   If you are looking to reduce your peak/demand with a solar installation, you will want to make sure you understand the time and duration of your historical peak/demand and understand if the expected output of your solar energy system will adequately serve that purpose. Before purchasing a system, it is critical to speak with your utility to understand how solar energy generation will be applied to your bill. This will help you to develop a realistic estimate of potential savings from a solar energy system.

5. **Prepare for a site assessment.** After completing your initial research, a preliminary site assessment will help to determine the parameters and constraints that need to be considered during the design, bidding and construction phases.

Understand Your Energy Bill and Rate Structure

Before investing in a solar energy system, it's critical that you talk to your utility and understand your rate structure. The rate structure that you're currently on may change once you install a solar energy system and should be factored into your calculations as it will impact your monthly bill. Below is a description of some of the charges that could be found on a utility bill.

FIXED CHARGE

The fixed part of the bill is often referred to as a service charge and is designed to cover the utility's cost to construct facilities and to connect your electric service.

ENERGY CHARGE

The variable components of the bill are those billed on an energy basis. These are designed to cover the costs associated with the actual monthly usage at your service location and appear as a per kilowatt-hour (kWh) charge. Some utilities also adjust the price of a kWh based on a seasonal rate or the time of day that kWhs are consumed.

DEMAND CHARGE

Some electric bills may include a demand charge, billed per kilowatt (kW). So, if your bill has a demand line item it is helpful to understand the difference between energy and demand. Energy is analogous to the odometer in your car. It tells you how far you've traveled, or on your electric bill, how much electricity you have used. If energy is the odometer, then demand is your speedometer. The speedometer tells you how fast you are traveling; similarly, demand tells you the rate in which you are using electricity at a particular point in time.

Conducting a Site Assessment

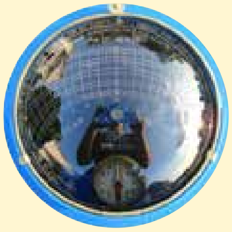
One of the most important decisions that you will encounter during the planning and construction of your solar array is determining the best location for the array. Will it be better situated as a roof-mounted system or in a more accessible ground-mounted location? There are several factors that may influence your decision.

Solar Array Orientation and Southern Exposure

In Iowa, the sun is visible in the southern sky. As such, a solar array should be oriented to the southern sky so that it is as nearly perpendicular to the sun's rays as possible. For a stationary array located in Iowa, orienting the solar array due south will provide the highest energy output. Arrays oriented east or west will have a 15-20% drop in performance while solar arrays oriented to the north will have an energy generation reduction of 30-45% as compared to an equally sized array that faces south. If your rate has a demand component that varies over time, you may need to consider whether something other than a due south orientation could be more beneficial by better aligning system production with periods of usage.

The site selection for the solar array should contain an unobstructed view of the southern sky. Buildings, trees or other obstructions that may cast a shadow on the solar array will reduce the potential of the system by the magnitude of hours under which the array is in a shadow. An instrument such as a Solar Pathfinder or Solmetric Suneye is useful in identifying sources of shadowing and is capable of predicting the annual hours in which the proposed site would endure a shadowed condition. An assessment is not completed until the effects of shadows on the proposed site have been determined. Every qualified solar contractor should use a solar shading instrument and its results in advising you of the best location for your array. See Pages 21-23 for additional information on selecting a qualified contractor.

Panels impacted by tree shading.



A Solar Pathfinder is an instrument that is useful in identifying sources of shading and predicting the annual hours a proposed site would endure a shadowed condition.

DID YOU **KNOW** ?

For a gabled roof on which the solar modules would be mounted parallel to and offset from the roof by a few inches, the measured roof area divided by the area of a single module (18-21ft²) will be useful to quickly determine the quantity of modules that can physically fit in the area and thus the potential capacity of the site. More specifically, the layout of the modules, either landscape or portrait, can be drafted using accurate roof measurements and module dimensions which can be estimated to be 66 x 40 inches to 78 x 40 inches.

For central Iowa, the ideal winter tilt angle is about 58°, whereas in the summer a flatter tilt of about 18° is optimal. A ground-mounted system offers the flexibility to set the tilt to any desired angle. An entirely stationary array in Iowa will perform the best year round with a set tilt angle of 32°.

Available Area

The area available for either a roof- or ground-mounted solar array is often the primary driver in selecting the best location for a solar array. Capturing the sun's energy is primarily dependent on the area of solar cells exposed to the sun's rays. Obtaining the energy required from the sun to meet your project goal is directly related to the quantity of solar modules required and the area that they will consume when installed. The unobstructed southern facing roof or ground area is a physical constraint that will dictate the site's potential for even the most efficient solar modules.

Tilt Angle

Identifying the range of tilt angles (the module angle from horizontal) available from a proposed site is essential in determining the potential generation of a solar array.

Since the sun's angle changes daily east to west and seasonally north to south, it is impossible to design an array that can reach its full potential unless a dual axis tracking device is incorporated into the design, which can improve the performance of an array by as much as 20-25%. Single axis tracking devices are available that can improve the performance of an array by as much as 12%. Mechanized tracking devices are typically applied only to ground-mounted arrays and the cost associated with any mechanized tracking device will determine whether it is an economically sound investment.

The tilt angle of a typical gabled roof-mounted array will normally take on the same angle as the pitch of the roof. A 4/12 pitched roof will have a tilt angle of 18.4º while a roof with a pitch of 6/12 will have a tilt angle of 26.6º. The ideal pitch angle will vary by season and the location latitude.

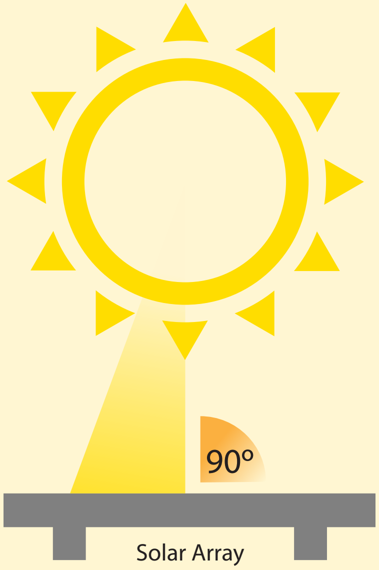
If time of year or seasonal electric rates differ substantially, this is an important consideration in calculating the return on investment. Therefore, incorporating a tilt angle that coincides closer to the seasonal sun angle is an important consideration.

Manually operated single axis tracking rack designs are commercially available and permit the tilt angle to be adjusted manually. By manually resetting the tilt angle as the seasons change, an 8-12% improvement in solar array performance can be realized. The initial cost for the additional mechanism and the labor cost associated with resetting the angles need to be accounted for when determining the return on investment.

This solar array has a mechanized tracking device incorporated into its design.

DID YOU KNOW?

Optimally, the energy output of a solar array is maximized if the angle of the solar module is perpendicular to the sun.



Roof-Mounted Considerations

When considering a roof-mounted system, the condition of the roof should be closely examined by a roofing professional for structural deficiencies, remaining life, and existing or the potential for leaks. Repairs and corrective measures must be completed prior to the solar array construction. The structural integrity of the roofing system should be examined by a qualified professional to determine whether the roof structure can carry the additional dead load that the solar array will impose. Unintended uplift forces, caused by high winds, can be imposed on the roof especially where the array is installed nonparallel to the roof. Roof and array racking fasteners need to be designed for the tensional forces that will be imposed when uplift forces are experienced. This phenomenon is particularly acute on flat roof installations where roof penetration anchors are utilized instead of using a ballasted anchor system. Regardless of the final design, any roof penetrations need to be performed with care and properly sealed to prevent premature wear and potential leaks.

Solar cells can reach high temperatures, which negatively impacts system performance, due to ambient conditions, reflected/radiated/convected heat from the roof. Partial shading of a cell/module also can have a negative performance impact by creating a phenomenon termed reverse bias. With reverse bias, the cell draws current from adjacent cells creating a "hot cell," which reduces the net current supplied by the module. Chimneys, dormers, other rooftop protrusions, trees, or utility poles can cause partial shading. In wet or high dew conditions, leaves can adhere to the solar module and cause reverse bias. Even bird droppings on a solar module can lead to shading and reverse bias issues. In rural areas, airborne dust

DID YOU KNOW ?

The performance of a solar array degrades as the temperature of the solar cell increases.

from roadways, animal operations, crop planting, or harvesting operations can settle on modules, especially wetted surfaces. (Note: See Page 14 for examples of shading caused by dust and bird droppings.) If dust collects at one end or corner of the module, the partial shading also can cause reverse bias. As such, adequate ventilation is desired around the solar modules to keep the surface temperatures moderate, and partially shaded modules should be avoided.

Ground-Mounted Considerations

Ground-mounted solar arrays present issues that require consideration during the site assessment phase. Aside from the area requirements and shading implications, ground-mounted systems require an examination of the soil conditions in which footings for the array racking system will be set. The analysis is performed to determine the soil type and bearing capacity, the water table level, and the location/depth of bedrock that may influence the type of footing that should be chosen. Zinc-plated, galvanized steel piles and concrete piers are the most common footing designs for PV arrays. The size and depth of the footings are dependent on the type of racking system that is chosen and the loads that will be borne by the soil. As the foundation of the entire system, a qualified geotechnical professional should perform the soil analysis and foundation design.

With a ground-mount solar array, maintaining vegetated areas beneath the solar array may be a difficult chore for certain framed racking system designs and less so for certain cantilever designs. Placement of gravel or another non-plant material beneath the array may alleviate this concern.

Flat roofs and ground-mount systems offer slightly more flexibility in the orientation and layout of the solar array. In these situations, multiple rows of single or stacked modules can be used to accommodate the area while meeting the desired energy generation goals. Consideration for any elevation deviations and the distance between adjacent rows are necessary to ensure that a southern row will not cast a shadow on the adjacent row to its north. Basic geometry and the knowledge of the sun's angle at its lowest point permit a calculation for determining the minimum row spacing that will avoid shadowing.

Designing the Solar PV Array

After completing the research and site assessment phases, you can begin to formulate a solar array design that will meet your intended goals and conform to any of the site constraints that may exist. While you may be interested in completing the design phase on your own, you'll likely need to rely on the expertise of a contractor that specializes in solar array site assessment, design, and construction. Having the basic knowledge of the system design will help you converse with the potential contractor(s), ask substantive questions, and be better prepared to decipher whether the answers are technically credible, or strictly sales based. While this section will not make you an expert in PV design, it is intended to provide you with a foundation of knowledge necessary to go into the project as an informed consumer.

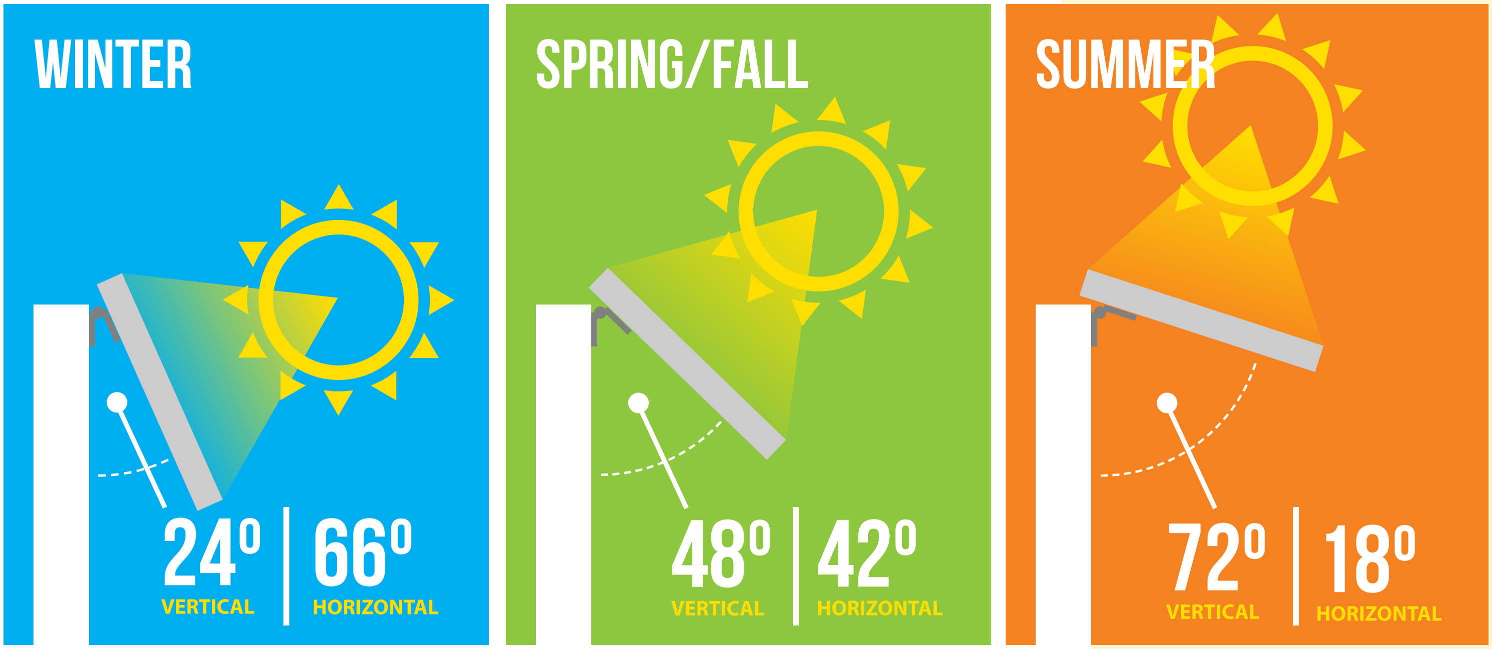
Sizing the System

STEP 1: **Calculate your energy (kWh) needs by obtaining the energy usage requirements from your historic electric bills.** Averaging the most recent two or three consecutive years of energy usage will define your needs more accurately than using just the past year, because weather-related peaks will be smoothed. In addition, make any adjustments for recent energy efficiency improvements that have been or will be made at the property. Data representing periods of energy usage that no longer exists should be discounted or adjusted to account for the changes (e.g. additions or expansion of home/business; installation or removal of electric heating/cooling systems including ground source heat pumps; addition or reduction of the number of dwelling occupants;

DID YOU KNOW ?

The number of daily hours in a month or year that is equivalent to the full sun intensity is referred to as the solar radiation. The Department of Energy's National Renewable Energy Laboratory (NREL) has compiled the solar radiation for sites across the U.S. on both a monthly and annual basis for different tilt angles. For example, the annual radiation in Des Moines, Iowa at a tilt angle equal to its latitude (about 42º) is 4.8 hours – meaning that a 1 kW solar array could generate 4.8 kWh/day or expressed annually as 365 days x 4.8 kWh/day = 1,752 kWh/year assuming no system losses.

Optimum Tilt Angle – Des Moines, IA (vertical/horizontal)



Angles(V/H)											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
32°/58°	40°/50°	48°/42°	56°/34°	64°/26°	72°/18°	64°/26°	56°/34°	48°/42°	40°/50°	32°/58°	24°/66°

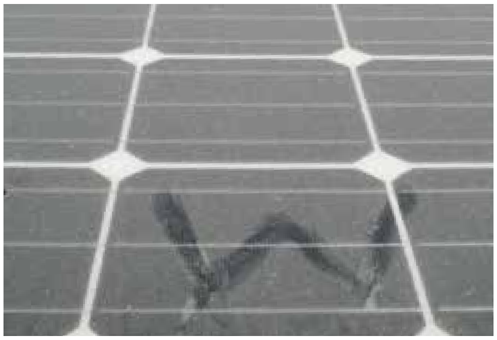
An experienced site assessor can calculate a more precise estimation, although the typical losses will provide a very good design level. Particularly dirty locations where soiling is expected to be above average and regular cleanings are not forthcoming should be accounted for by adjusting the loss factor proportionally higher.

partial year occupancy). If you will be interconnected to your servicing utility, and they offer a net metering with banking policy the average annual usage calculation is sufficient. If the policy does not include net metering with banking – such as a utility payment for any excess generation or a net metering without banking policy – more frequent interval information would be important (e.g., monthly rather than annual usage data).

STEP 2: **Match the solar resource to your energy usage requirements.** In Iowa, the solar irradiance – often referred to as the solar intensity – on a cloudless summer day is approximately 1,000 watts per square meter. This intensity level also is the international standard by which all solar modules are rated. For example, a 300-watt rated solar module will produce 300 watts of power when 1,000 watts per square meter of light intensity hits the solar module surface at the standard temperature of 77° F (solar module efficiency will fall as the temperature increases above 77° F). The module will produce more energy when the solar intensity rises above the standard level and produce less when lower levels of solar intensity are experienced. The actual level of solar intensity is dependent on the sun's position and the angle of the receiving solar module relative to the sun. The highest absorption of the sun's energy occurs when the receiving surface is perpendicular to the sun. As the angle to the sun deviates from perpendicular more light is reflected off the solar module rather than being absorbed, resulting in lower module performance.

STEP 3: **Anticipate system losses from reduced solar output.** System losses of the solar energy system can be estimated to determine an appropriate system derate/loss factor. The system losses are the combination of many sources, including soiling, shading, inverter efficiency, snow, mismatched modules, wiring, connections, light-induced cell degradation, nameplate rating tolerance, and age. Typical system losses of 15-20% should be used when sizing the system. An experienced site assessor can calculate a more precise estimation, although the typical losses will provide a very good design level. Particularly dirty locations where soiling is expected to be above average and regular cleanings are not forthcoming should be accounted for by adjusting the loss factor proportionally higher. More information regarding the system loss components can be found at *rredc.nrel.gov/solar/calculators/PVWATTS/change.html#derate.*

These panels show soiling from dust, debris and bird droppings.



The following example illustrates a simplified PV sizing design for a site where net metering with banking is applicable:

EXAMPLE 1: SITE ASSESSMENT AND SIZING STEPS

Site Assessment Data:

- Location: Des Moines, Iowa
- Averaged full energy usage requirement goal after implementing energy efficiency measures = 900 kWh/month or 10,800 kWh/yr.
- Roof-mounted array with southern exposure, no shading and a roof pitch of 6/12 (26.5º) having total roof size of 45 ft. long x 16 ft. wide and a usable roof area = 42 ft. long x 13 ft. wide = 546 ft^2 (assume 3 ft. peak edge and 1.5 ft. side edges for National Fire Protection Code compliance)
- Assumed system losses = 15%
- Assume 72-cell solar modules having nominal area of 21 ft^2 and dimensions of 39"x78"

Sizing Steps:

1. Look up the appropriate solar radiation for the location at a tilt angle equal to the latitude less 15º (42º – 15º = 27º) = 4.8 kWhr/kW/day
2. Calculate the size of the solar array (10,800 kWh/yr.)/[(4.8 kWh/kW/day)(365 day/yr.)(0.85 losses)] = 7.25 kW
3. Calculate the minimum solar module rating (7.25kW)(21 ft^2/module)/(546 ft^2) = 0.279 kW/module
4. Choose a commercially available solar module = 300 watts
5. Calculate the quantity of modules required = (7.25 kW)/(0.300 kW/module) = 24.1 modules
   a. Lay out the modules – try two rows of 12 modules arranged in portrait
   b. Array length = (12 modules)(39 inches)(1 ft./12 inches) = 39 ft.
   c. Array width = (2 modules)(78 inches)(1 ft./12 inches) = 13 ft.

DID YOU KNOW?

When it comes to solar energy, bigger isn't always better. Oversizing a solar array can have a negative financial affect. Overproducing under a net metering with indefinite energy banking policy can lead to large energy credit balances that if not consumed provide no financial benefit. Similarly, significant energy overproduction can diminish the return on investment for cases where a net metering with annual settlement policy is used and the excess energy is purchased at the utility's avoided cost. If a system is sized conservatively (smaller), it can incrementally be added to if conditions warrant it in the future.

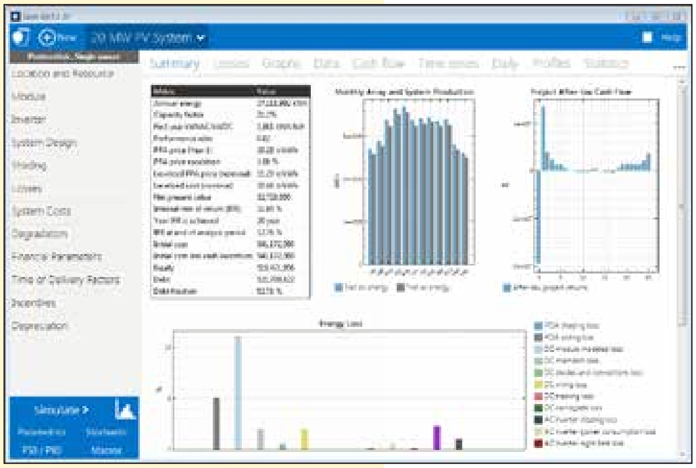
Sizing a PV solar array for a situation where any of the following may occur could result in a much different design from the situation described in Example 1: 1) payments are received for excess energy generation (based on the utility's avoided cost rate) instead of being banked; 2) a net metering policy requiring monthly settlements is offered; or 3) electric heat rates are used. The simple analysis used in Example 1 is based on annual consumption and generation numbers, must be replaced with a more detailed monthly analysis using the applicable purchasing and selling values of energy. Generally, the most cost-effective array size for that situation will be smaller in array size, by as much as 30-40% in extreme cases, since the solar resource in Iowa during the winter months is only about 60% of the summer months.

Software-Based Calculators

There are several software-based calculators that can quickly aid in sizing a solar PV array. NREL offers two online calculators – PVWatts and System Advisor Model (SAM) and the Iowa Energy Center provides an Iowa-based resource. All of the calculators provide comparable results for similar input assumptions.

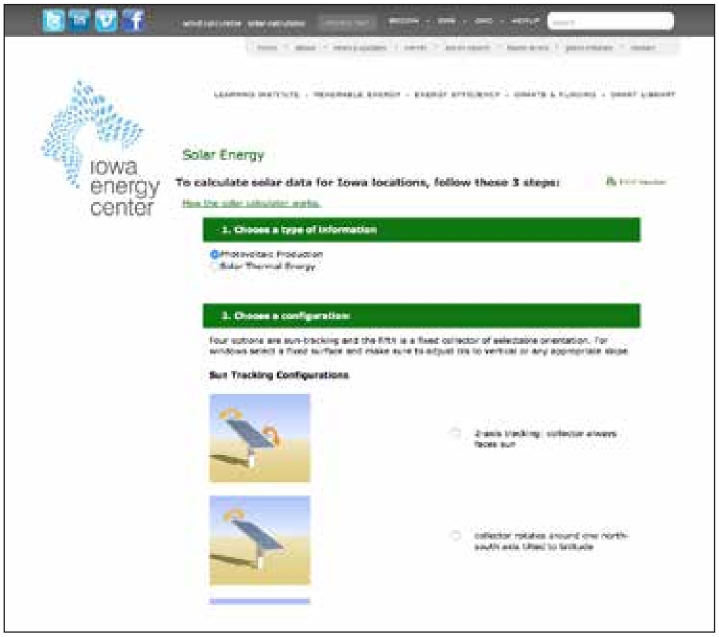
PVWatts uses a trial and error process to narrow the rating of the array to match your desired annual energy output. Care must be exercised in choosing realistic system loss factors as defined by the integral derate factor subcalculator. PVWatts also offers a simplified financial calculator providing the benefit of the solar array based on an assumed fixed value of energy.

pvwatts.nrel.gov



SAM is a downloadable calculator application, which is used as a stand-alone tool. The SAM calculator offers greater flexibility and level of input detail and includes a substantial financial modelling aspect.

sam.nrel.gov



The **Iowa Energy Center's Solar Calculator** provides the solar resource potential for any location in Iowa but does not have a provision for incorporating the system losses. System losses must be applied externally from the calculator. The calculator does not contain a financial modelling component.

iowaenergycenter.org/solar-calculator-tool

Example 2 (below) assumes the same conditions described in the previous example but replaces the net metering with banking policy with a net metering with monthly settlements policy (without banking). Additionally, it assumes the household uses electricity for their winter space heating, for which they receive a lower electric rate, which the customer will not be eligible for after the construction of a solar energy array.

EXAMPLE 2: SITE ASSESSMENT AND SIZING STEPS

Site Assessment Data*:

- Location: Des Moines, Iowa
- Averaged full usage requirement goal = 900 kWh/month or 10,800 kWh/yr.
  - 4,900 kWh @ electric heat rate; 5,900 kWh @ regular house rate
- Electric heat rate = $0.05/kWh
- Regular house rate = $0.12/kWh
- Electric utility avoided cost purchase price for excess energy generation = $0.04/kWh
- Initial solar energy array construction cost = $3,000**/installed kW-DC

***Government incentives are not included in this example.*

Sizing Steps:

1. Calculate the total electric costs before the solar energy installation disregarding fixed costs like the standard meter charge = (4,900 kWh*$0.05)+(5,900*$0.12) = $953.00/yr.
2. Using one of the solar resource assessment tools, determine the monthly generation of the solar array sized (7.25 kW in this example)
3. Calculate the new monthly cost or credit after the solar array is installed. (See table below)
   a. January: (1,400 kWh consumed – 685 kWh solar generated) * $0.12/kWh = $85.80 cost
   b. April: (1,005 kWh solar generated – 800 kWh consumed) * $0.04/kWh = $8.20 credit
4. Calculate the annual utility bill savings: $953.00 – 201.76 = $751.24
5. Calculate the simple payback period (initial cost divided by the annual benefit): (7.25 kW * $3,000/kW)/$751.24/yr. = 28.95 yr.
6. By trial and error, choose different array sizes and repeat steps 1-5 to find the solar array size the minimizes the simple payback period
   a. 9 kW – 29.35 yr.
   b. 6 kW – 28.68 yr.
   c. 5.8 kW – 28.63 yr.
   d. 5.6 kW – 28.67 yr.
7. Choose a 5.8 kW solar energy array (20% smaller than in the 7.25 kW determined in the first example)
8. Choose a commercially available solar module = 290 watts
9. Calculate the quantity of modules required = (5.8 kW)/(0.290 kW/module) = 20 modules
   a. Lay out the modules in two rows of ten modules arranged in portrait
   b. Array length = (10 modules)(39 inches)(1 ft./12 inches) = 32.5 ft.
   c. Array width = (2 modules)(78 inches)(1 ft./12 inches) = 13 ft.

**Your data may vary depending on your situation.*

This table depicts the month-by-month cost analysis and utility bill savings for Example 2, which is provided on Page 17.

Utility Bill Savings for a 7.25 kW-DC Solar Energy Array

Month	Electric Heat Load (kWh)	House Load (kWh)	Pre-Solar Cost	Solar Array Generation (kWh)	Post-Solar Cost/ Credit
January	1,000	400	$98.00	685	$85.80
February	900	400	$93.00	788	$61.44
March	700	400	$83.00	937	$19.56
April	400	400	$68.00	1,005	-$8.20
May	200	400	$58.00	1,098	-$19.92
June	0	600	$72.00	1,128	-$21.12
July	0	800	$96.00	1,181	-$15.24
August	0	800	$96.00	1,059	-$10.36
September	0	500	$60.00	923	-$16.92
October	200	400	$58.00	828	-$9.12
November	600	400	$78.00	593	$48.84
December	900	400	$93.00	575	$87.00
Total	**4,900**	**5,900**	**$953.00**	**10,800**	**$201.76**

Pre-Solar Cost **$953.00** – Post-Solar Cost **$201.76** = **Annual Utility Bill Savings** **$751.24**

Equipment Selection

Taking some time to learn about the significant components of a solar array (modules, inverters, and racking system) will be helpful as you work with your contractor.

Solar Modules

All legitimate solar modules are designed and manufactured to a set of international standards that ensure the performance of the solar module and the manufacturing quality. At a minimum, the modules should be certified to meet the appropriate standards developed by the International Electrotechnical Commission (IEC,) including IEC 61853 and IEC 61215, which addresses the performance testing of the module. The module also should be certified by the Underwriters Laboratories (UL) Standard 1703, which addresses the fire safety aspects of roof-mounted solar arrays. These standards protect the consumer by placing all modules on an even playing field. This means that a solar module from one manufacturer having a rating of 300 watts is comparable to a solar module from a different manufacturer with the same rating. As such, the consumer can make a purchasing decision based primarily on price. Differences in warranties or origin of the manufacturer may be considerations that sway the final choice when prices are comparable.

Inverters

Similar to solar modules, grid-tied inverters are manufactured to exacting standards. The primary standards for grid-tied inverters are the Institute of Electrical and Electronics Engineers Standard 1547 and Underwriters Laboratories Standard 1741. Unlike the solar module industry, there are two distinctly different inverter products used in the PV industry; string inverters and micro-inverters. Either technology can offer exceptional performance when best practices have been incorporated into the overall system design.

String inverters combine the capacity of multiple solar modules by "stringing" the modules together electrically prior to inverting the DC module power to AC grid power. The micro inverter technology pairs a single inverter to a single or paired set of solar modules and is generally mounted on the back side of the module. Both technologies have their advantages and disadvantages; however, the most important consideration is how closely the inverter rating matches the power output of the connected solar modules. When the DC rating of the solar module(s) is greater than the rated input power of the inverter, the excess DC power is "clipped" or wasted in the form of heat. Conversely, inverters that are rated significantly higher than the total DC rating of the solar module(s) will operate at a lower efficiency.

A set of string inverters

A micro inverter

For example, a 300-watt rated solar module connected to a micro-inverter having a maximum DC input rating of 250 watts will clip the energy delivered by the module in excess of 250 watts. A 3-kW string inverter connected to a series of ten 300-watt solar modules will perform at a low efficiency during the early morning and late evening hours when the solar intensity is substantially lower than midday. When using an underrated inverter in one of the solar PV calculators, the rating of the inverter should generally be used instead of the module ratings. Several leading string inverter manufacturers have Web-based design aid calculators that allow specific solar module model numbers as an input for which the calculator provides the quantity of modules that can be safely connected to it and a series of wiring configurations with corresponding power levels that can be used.

Racking Systems

The materials and design of the racking system incorporated to support the solar array are a crucial part of the solar array. Both roof- and ground-mounted pre-engineered racking systems are available on the market and are widely used.

Ground-mounted racking systems can be constructed of pressure treated timbers, lightweight corrosion-resistant coated metal or aluminum. Both framed and cantilevered designs are common and equally effective in supporting the array when designed in accordance with good engineering practices. Framed racks may inhibit your ability to maintain vegetation beneath the structure more than a cantilevered design. The area beneath the array can be covered with gravel to reduce

Adequate clearance between the ground and lower edge of the array is necessary to allow melted snow to easily slide off and not pile up on the lower edge. These photos show inadequate clearance and snow piled up on the lower edge, ten days after a snowstorm.

maintenance concerns. Adequate clearance between the ground and the lower edge of the array is necessary to allow melted snow to easily slide off and not pile up on the lower edge. Ground-mounted racking systems are anchored into the ground with footings that are sized based on the loads imposed by the array and the bearing strength of the soil. Footings should always extend above the surrounding ground and safely beneath the frost depth at the location. A geological boring and soil sample should be completed to determine the soil properties and water table level.

Roof-mounted racking systems should be constructed of lightweight corrosion-resistant coated metal or aluminum and carry a UL2703 certification. The roof-mounted system can be anchored to the roof, typical for inclined roofs, or can be anchored or ballasted for flat roof installations. Typical roof-mounted PV arrays can add approximately 3-6 lb./ft^2 of dead load to the roof. Particular attention should be given to the roof penetration details associated with an anchored design to avoid future leak problems. The roof's structural members and its fasteners should be evaluated by a professional to assess the roof's ability to withstand any uplift forces that may be induced by the wind as a result of the solar array. Arrays tilted beyond the roof pitch are particularly vulnerable to uplift loads. The additional weight associated with a ballasted system will vary with the array size and needs to be accounted for when checking against the roof's load capacity. In Iowa, the racking design should account for snow accumulation and have enough clearance at the bottom edge to permit melted snow to easily slide clear of the modules and not pile up on the lower edge that will cause shading and ultimately poorer performance.

Racking systems for both roof- and ground-mounted arrays may be designed to allow manual adjustments of the array tilt angle. An energy generation increase of 8-12% might be realized by being diligent in making the adjustments as the seasons change. Mechanized single or dual axis solar trackers can also be considered. Dual axis trackers are generally mechanized structures that may generate an additional 20-25% energy generation annually. The feasibility of a tracker device is an economical decision based on the comparison value of the additional energy generated against the additional upfront cost.

A battery bank

Energy Storage

Battery banks are the most common type of energy storage device connected to PV solar arrays. When charged, the energy stored in a battery may be used during periods when the solar array is not generating energy (e.g., night, cloudy days, power interruptions). The motive for installing a battery bank needs to be carefully understood as it may add considerable cost to the system. While a PV solar array connected to a battery bank may be an ideal solution for a remote site where the cost of bringing in grid power is prohibitive, such as a lake cabin, battery banks are generally not considered as an ideal backup power supply since they have a limited energy capacity and cannot be rapidly recharged by the solar array. Proceeding with your own independent energy storage bank requires that the size of the battery bank be balanced against the critical loads that it will be expected to serve and that diligent energy management of those same loads when the battery bank is enlisted is necessary to ensure that the energy capacity of the battery bank is not fully exhausted. Contact your electric utility if you are adding storage to an already installed system or have plans to do so in the future. It's worth noting that energy storage technologies are constantly evolving.

A battery bank

Monitoring System

Regular monitoring of the PV array for performance is a primary operational requirement. Software packages are available that monitor real-time performance and maintain a historical record. The monitoring system is generally interfaced through the inverter and accessed through a computer. Micro-inverter monitoring technology is capable of monitoring each solar module individually since they are paired individually, which quickens troubleshooting problems. Partially shaded, soiled, or damaged modules can be quickly isolated and corrected. String inverters can only monitor the string of connected modules as a group. In the event of a problem, trial and error testing of individual modules is required. Single module problems can be difficult to notice as the underperformance of an individual module may be masked by the string as a whole.

Selecting a Contractor

Selecting a contractor to install your solar array is a critical aspect of your project. The selection should be made after evaluating credentials, work experience, business-related references, business integrity, and pricing. Multiple contractors should be interviewed, and written proposals/quotes for turnkey services should be obtained. A thorough due diligence assessment/evaluation of the contractor must be similar to the type of assessment you would conduct on home builders and home improvement contractors who perform significant work on your home or property. Your assessment should also include the company's rating with the Better Business Bureau and any pertinent reviews.

Evaluating Bids

Evaluating a proposal for the construction of a solar PV array may seem complicated but can be simplified by utilizing a few standard metrics. The metrics permit you to quickly compare the merits of multiple bids where the array ratings may be different. The installed cost metric is calculated by dividing the turnkey contract price by the DC rating of the array.

TURNKEY COST $

÷ INSTALLED KW-DC

All other aspects being equal, the lowest installed cost metric is the most economical. This metric works since the DC performance ratings of solar modules are standardized. More importantly, the cost of energy metric, derived by dividing the turnkey contract price by the product of the annual energy generation and the expected life of the array ($/kWhr-yr./yr.), provides the levelized energy unit cost that can be compared against the cost paid to your electric utility.

The cost of energy metric should be scrutinized to ensure that the annual energy generation and array life expectations are reasonable and not exaggerated. Small array performance improvements can be achieved by minimizing the system losses although it is necessary to understand that optimizing losses year-round may not be possible (e.g., assuming that soiling losses will be minimized year round may not be realistic at a rural setting on a gravel road). Include a requirement that each bid contains the worksheet used to calculate the annual energy generation with all of the assumptions used to calculate the system losses.

Credentials

Contractors specializing in the PV solar site assessment, design, and construction services should have adequate credentials that demonstrate completion of a minimum level of training.

The North American Board of Certified Energy Practitioners (NABCEP) offers entry level knowledge assessment, professional certification, and company accreditation programs to renewable energy professionals throughout North America. Contractors who have earned the NABCEP certification have passed a rigorous exam and have demonstrated a high level of training and experience. The NABCEP PV Installation Professional Certification has been accredited to the ISO/IEC 17024 standard by the American National Standards Institute. NABCEP certified professionals can be located with complete contact information from their website at *www.nabcep.org.*

The Midwest Renewable Energy Association (MREA) offers a certification program that provides proof of completion of the educational competences and skills needed to conduct high-quality site assessments to future clients and employers. The certificate verifies MREA site assessment course completion including satisfactory completion of the MREA training course, two practice assessments and a site assessment exam.

Other credentials that may be required or desirable include an Iowa electrical license and Iowa Professional Engineer or the ability to hire one. The contractor should also have the minimum "tools of the trade," including a solar shading instrument as described on Page 9.

Work Experience

The contractor's work experience should be relevant to the type (roof- or ground-mounted) and size of PV solar array that is being proposed. References provided by the contractor should be checked to validate their work experience. Determine the reference consumer's level of satisfaction with the contractor's site assessment, design, and construction phases. Learn whether the promised array performance was met and if any problems occurred after the commissioning. If possible, make site visits to the contractor's references to evaluate the quality of work.

DID YOU **KNOW** ?

All Iowans are required by law to notify the Iowa One Call System at least 48 hours (excluding Saturdays, Sundays and legal holidays) prior to engaging in any type of digging or excavating. Homeowners and private residents are not exempt from making this important notification.

IOWA ONE CALL
800-292-8989
www.iowaonecall.com
811

Questions to Ask a Qualified Contractor or a Solar Vendor

- ☐ What is the total installed (turnkey) cost of the system?
- ☐ How much money is due upfront, and what is the schedule of payments?
- ☐ If my energy usage changes, will I be able to add more panels later?
- ☐ Do I need a new roof now in order to install? Is my roof suitable to carry the additional live, dead and uplift load forces that the solar array will exert?
- ☐ When was your company established and how much solar has it installed to date? Can your company provide a list of the projects and references for them?
- ☐ Is your company affiliated with other parties to deliver the installation and who are they?
- ☐ Does your company have a Standard Insurance Certificate with adequate General Liability coverage of $1 million or more? (Ask for a copy and keep it with your records.)
- ☐ Does your company have Professional Liability Insurance? (Ask for a copy and keep it with your records.)
- ☐ Does your company carry Workers Compensation? (Ask for a copy and keep it with your records.)
- ☐ Do you have the ability to cover me as an "Additional Insured"?
- ☐ Are your solar installers North American Board of Certified Energy Practitioners (NABCEP) Solar Photovoltaic (PV) Electric trained and certified?
- ☐ Do you have a licensed Iowa Professional Engineer on staff to review and approve drawings for submission to city/county building code and fire department officials?
- ☐ Are you accredited with the Better Business Bureau? If so, what is your rating?
- ☐ In which country are the solar panels and inverters you are selling made?
- ☐ Will the company honor your manufacturer's multiyear performance warranty?
- ☐ Does the company have a Master Electrician on staff to obtain the required electrical permits and to supervise the electrical work for your project? (Ask for a copy and keep it with your records.)
- ☐ Is your solar installer company a Licensed Electrical Contractor which is required to install Solar Electric Systems? May I see your company's license?
- ☐ Who will be working on my roof, and how much experience do they personally have installing solar?
- ☐ How does your company handle projects during busy times? Do you work with sub-contractors?
- ☐ How long will the installation take?
- ☐ Will the age or type of my roof affect the cost of installation?
- ☐ How will installation affect my roof? Will it create leaks? What if it does create leaks, are you then responsible for repairs?
- ☐ If I'm planning on re-doing my roof, should I install panels before or after?
- ☐ How much of my energy usage would my solar system cover?
- ☐ How much would my monthly energy bills be after installation? From you and from my utility?
- ☐ How long will my payback period be on my solar system? What are the key assumptions associated with my payback that may impact that result? (Ask for a copy of the calculations and keep the data with your records.)
- ☐ How will solar affect my homeowner's insurance?
- ☐ Will you complete all of the paperwork associated with getting the permits and financing?

Calculating the System ROI

DID YOU **KNOW** ?

Electric utilities are generally required to: (1) interconnect with renewable energy generation facilities and transmit renewable energy to another electric utility on reasonable and non-discriminatory terms and conditions; (2) sell to renewable energy generation facilities on terms that are reasonable and non-discriminatory; and (3) purchase from renewable energy generation on terms that are consistent with the utility's avoided cost.

Avoided cost and interconnection topics are addressed more comprehensively in The PURPA Title II Compliance Manual, co-sponsored by the National Association of Regulatory Utility Commissioners, the National Rural Electric Cooperative Association, the American Public Power Association, and the Edison Electric Institute. See *publicpower.org/files/ PDFs/PURPA%20 Title%20II%20Manual%20 Final_w-cover.pdf.*

There are several ways to determine if an investment in a solar energy system makes financial sense for you. Two of the most common are estimating a return on investment and determining the payback period for an investment. A return on investment is estimated by dividing the value of the net savings from an investment by the costs of the investment. Usually, the estimate is made over the expected life of the investment, factoring in the time value of money. A payback period is calculated when there is a large upfront cost for an investment and estimates at what point in time, if any, the net savings received will outweigh the initial cost.

To estimate the return on your potential solar investment, you will need to pull together all the estimated savings and costs of the project and consider the time-value of those savings and costs over the life of the investment. The cost portion of the analysis will be somewhat different if you purchase solar panels rather than leasing them. Talk with your electric utility so that you understand the following items, as applicable, and how they will impact your investment:

- Avoided Cost Credit
- Net Metering
- Demand Charge
- Fixed Monthly Service Charge
- Flat Energy Charge
- Blocked Energy Charge
- Escalation of Savings
- Degradation of Solar Production

Solar Energy System Purchase. If you are purchasing your solar panel(s), inverter, mounting hardware and accessories you will have a substantial upfront cost. There may be federal or state tax credits or other incentives*, grants or low-interest loans, available to you to help reduce this initial cost. **Refer to the following section on incentives.*

Solar Panel Lease. If you are leasing your solar panel(s), inverter, mounting hardware and accessories, you will likely have small, if any, upfront costs, but will instead pay for the investment over time. It will be important to know what is covered in your lease agreement, so you will be able to accurately determine what additional costs you may incur.

Interconnection and Electric Service Upgrades. Two important questions need to be asked prior to purchasing a solar generation system:

1. Will the installation require me to upgrade my existing electric service?
2. Will the installation require my local electric utility to upgrade their facilities?

In many cases, upgrades will not be required because the solar generation will simply offset your current electricity needs, and there is capacity available in the electric panel.

In some cases, it is possible for the solar generation to require that your electric utility upgrade or change your electric service or the local electric distribution grid. To find out whether this will be required of your project, contact your electric utility very early in your project investigation.

In most instances, the costs to upgrade your electrical equipment, your electric service, or the local grid, will be your responsibility. There may be fees associated with interconnection.

Operations and Maintenance Costs. There may be additional costs of owning and maintaining your solar investment that you will need to consider. For a solar panel to operate efficiently in the winter months, snow removal may be required. Periodic maintenance of the structures may also be needed, particularly if the panel is equipped to track the sun. In addition, you may wish to insure your investment against potential damage. These costs will likely escalate over the life of your investment and should be factored into your financial analysis.

Property Taxes and Insurance. The property taxes and insurance on your home may also change as a result of a solar investment. These costs will need to be included in your financial analysis.

Incentives

There are currently many federal and state financial incentives for the construction of solar energy systems that can offset a portion of the initial investment and improve the project's simple payback or return on investment. The incentives may be tax credits, grants, utility rebates or low-interest loans. While you may be eligible for one or more of the incentives it is important to recognize that the incentives may interact with one another, so you cannot simply sum the incentives to calculate their total value. For example, a grant will either reduce the tax basis on which a tax credit might be applied or alternatively may be considered taxable income from which your Adjusted Gross Income will be increased. Further, a state tax credit will generally increase the federal tax liability thus lessening the sum of the two individually. It is advisable that you visit with a qualified tax advisor to determine the true value of the incentives rather than relying solely on the contractor's estimate of what the incentive value will be. A comprehensive listing with detailed descriptions can be found at the Database of State Incentives for Renewables and Efficiency (DSIRE) website at *dsireusa.org*.

Constructing the Solar PV Array

After receiving written proposals – preferably from several companies – and comparing the detailed specifications, costs, estimated annual energy generation (and how it was derived), and their references, you are ready to select a contractor for your project.

A signed written contract for the installation of the solar array is the binding document that specifies what equipment will be purchased, where it will be located, when it will be constructed, who is responsible for the different tasks, and how much it will cost.

The contract will often be offered as a "turnkey" contract in which all of the design services, permitting, materials, and labor are included as a single price. In addition to listing the components and costs, the contract should clearly outline:

- Payment schedule and terms
- Timeline for completion
- Statement of workmanship
- Code compliance
- Warranties and guarantees
- Responsibilities for replacement of any components under warranty
- Lien waiver to protect you in the event suppliers have claims against the contractor

Under no situation should you be rushed by the contractor to sign the contract. Be careful to ask questions of areas that you don't understand and consult with your attorney before signing the contract and other legal documents.

Interconnection. Every utility in Iowa has interconnection policies and procedures that you will need to follow, including the completion of an application for an interconnection agreement. Generally, the complexity of this process will depend on the size of the solar energy system that is being installed. The larger the installation, the more reviews, studies, and documentation will be required.

There may be limitations on the amount of generation that can be interconnected on a given circuit, feeder, substation, or overall system. If certain limits are reached, you may be required to pay for upgrades to the distribution system so that the system can accommodate the generation. This is a key reason why it's critical you meet with your utility at the outset of your research process.

DID YOU KNOW ?

Iowa Administrative Code Chapter 45 contains detailed rules that rate-regulated utilities must follow for interconnecting solar and other distributed generation facilities. These rules contain standard interconnection application forms and interconnection agreements. You can find a copy of chapter 45 rules at: *www.legis.iowa.gov/docs/iac/chapter/03-02-2016.199.45.pdf.* To obtain forms and agreements applicable for your interconnection contact your electric utility.

Each utility's interconnection policies, which are available upon request, must be in compliance with applicable federal and state requirements. The standards for interconnection, safety, and operating reliability applicable to all electric utilities in Iowa can be found in Iowa Administrative Code 199.15.10. You can find a copy of 199.15.10 at *legis.iowa.gov/docs/iac/rule/199.15.10.pdf.*

You may also wish to consult with a trusted advisor/attorney on these matters, which can be complex. Or if you have a question about interconnection requirements on electric utilities in Iowa, you can contact the Iowa Utilities Board at 515-725-7321 or send an e-mail to *customer@iub.iowa.gov*.

Inspection. All systems are subject to inspection by a local inspection authority or the state of Iowa, depending on who has jurisdiction. You will need to check with the local municipal or county authorities for more information about electrical permits and inspections. Your utility also may be able to inform you about the need for permits and inspections. Regardless of whether the installation will require an electric permit or inspection, it is always a good idea to consider having the work inspected. Your insurance provider may require an inspection and it also is a good idea for safety reasons.

Your utility also may perform an inspection of the interconnection and test the operation of the generation equipment to ensure the safety of their personnel. The utility may refuse to interconnect if they find that it is constructed or performs in an unsafe manner.

Notifications, Monitoring and Follow-Up

Notifications

As of July 1, 2015, Iowa law requires these notifications or devices be used related to distributed generation systems, which includes solar energy systems.

- **Disconnect device at meter required from July 1 going forward**
  For distributed generation systems interconnected on or after July 1, 2015, a disconnect switch or other device capable of disconnecting and de-energizing a distributed generation system must be visible and adjacent to an interconnection consumer's electric meter.

- **Permanent placard required for interconnections prior to July 1**
  For installations placed in service prior to July 1, 2015, consumers with an interconnected system must provide and attach a permanent placard at the electric meter that clearly identifies the presence and location of a disconnect device for distributed generation facilities on the property.

- **Notification of local fire department**
  Consumers who have a system interconnected must notify local paid or volunteer fire departments of the location of distributed generation facilities and associated disconnection devices upon completion of the installation.

Notifications, Monitoring and Follow-Up of Your Solar Energy System

Monitoring

On a monthly basis, review the production of your solar energy system. Compare this production to the expected production that was provided by the solar installer. If the production is not closely resembling the expected production, contact your installer to review the system to determine why the generation is not as expected and identify any possible fixes.

Maintenance

Make sure to follow any manufacturer recommended maintenance to ensure continued proper performance.

A program of inspection to determine the necessity for any replacement or repair is required to be developed by the generator owner/operator. Representatives of your electric utility must have access to the solar generator and related equipment at all reasonable times for their own inspection and testing.

Additions or Modifications

Contact your electric utility to discuss any additions or modifications to your solar energy system, including energy storage. Changes to your system may necessitate additional applications and upgrades to electric utility facilities. The electric utility can evaluate the proposed changes to determine what upgrades would be needed and estimate the costs of the upgrade. If modifications are made to the solar system without contacting the electric utility, you could create a safety hazard and cause damage to the distribution system. You could be liable for any damages caused and could be subject to disconnection without notice.

Glossary

Application Fee
A charge collected by the electric utility to process the interconnection application. This fee is intended to recover the utility's cost of processing the application for interconnection but not any applicable interconnection costs to connect your solar to the grid.

Avoided Cost
The incremental cost for a utility to produce one more unit of power. For example, because a qualifying facility (QF) as defined under the Public Utilities Regulatory Policies Act or an Alternate Energy Production Facility and as defined in Iowa Code §476.42, reduces the utility's need to produce this additional power themselves, the price utilities pay for QF power has been set to the avoided or marginal cost.

Backup Generator
A generator that is used only for test purposes, or in the event of an emergency, such as a shortage of power needed to meet consumer load requirements.

Backup Power
Electric energy supplied by a utility to replace power and energy lost during an unscheduled equipment outage.

Commissioning Test
A highly specialized activity where a power installation is tested to ensure it meets exacting standards through the integrated application of a set of engineering techniques and procedures to check, inspect and test every operational component of the project, from individual functions, such as instruments and equipment, up to complex amalgamations such as modules, subsystems, and systems.

Consumption (also Energy Consumption)
The use of energy as a source of heat or power or as a raw material input to a manufacturing process.

Dead Load
Dead loads are those that are constant in magnitude and fixed in location throughout the lifetime of the structure. Usually the major part of the dead load is the self-weight of the structure. The dead load can be calculated accurately from the design configuration, dimension of the structure and density of the material. The loads of the beams, columns, foundations, slabs, etc. are the dead loads of a structure.

Electricity Generation
The process of producing electric energy or the amount of electric energy produced by transforming other forms of energy, commonly expressed in kilowatt-hours (kWh) or megawatt-hours (MWh).

Electric Power Grid
A system of synchronized power providers and consumers connected by transmission and distribution lines and operated by one or more control centers. In the continental U.S., the electric power grid consists of three systems: the Eastern Interconnect, the Western Interconnect, and the Texas Interconnect. In Alaska and Hawaii, several systems encompass areas smaller than the State (e.g., the interconnect serving Anchorage, Fairbanks, and the Kenai Peninsula; individual islands).

Energy
The capacity for doing work as measured by the capability of doing work (potential energy) or the conversion of this capability to motion (kinetic energy). Energy has several forms, some of which are easily convertible and can be changed to another form useful for work. Most of the world's convertible energy comes from fossil fuels that are burned to produce heat that is then used as a transfer medium to mechanical or other means in order to accomplish tasks. Electrical energy is usually measured in kilowatt hours while heat energy is usually measured in British thermal units (Btu).

Energy Demand
The requirement for energy as an input to provide products and services.

Energy Efficiency
A ratio of service provided to energy input (e.g., lumens to watts in the case of light bulbs). Services provided can include buildings-sector end uses such as lighting, refrigeration, and heating; industrial processes; or vehicle transportation. Unlike conservation, which involves some reduction of service, energy efficiency provides energy reductions without sacrifice of service. May also refer to the use of technology to reduce the energy needed for a given purpose or service.

Grid
The layout of an electrical distribution system.

Grid-Tie Inverter
A power inverter that converts direct current (DC) electricity into alternating current (AC) with an ability to synchronize to interface with a utility line. Its applications are converting DC sources such as solar panels or small wind turbines into AC for tying with the grid.

IEEE
Institute of Electrical and Electronics Engineers

Interconnection
Two or more electric systems having a common transmission line that permits a flow of energy between them. The physical connection of the electric power transmission facilities allows for the sale or exchange of energy.

Interconnection Agreement
A legal contract for the connection of the solar energy facility to the utility's electric distribution lines, specifying the location, size, cost, manner of payment, terms of operation, and respective responsibilities of the utility and the solar energy consumer.

Interconnection Costs
The reasonable costs of connection, switching, metering, transmission, distribution, safety provisions, and administrative costs incurred by the utility directly related to the installation and maintenance of a consumer's solar energy facility.

IUB
Iowa Utilities Board

Kilowatt
A unit of power equal to 1,000 watts.

Kilowatt Hour (kWh)
A measure of electricity defined as a unit of work or energy, measured as 1 kilowatt (1,000 watts) of power expended for 1 hour. One kWh is equivalent to 3,412 Btu.

Load
An end-use device or consumer that receives power from the electric system.

Load Profile
A graph of the variation in the electrical load vs. time. A load profile will vary according to consumer type (typical examples include residential, commercial and industrial), temperature and holiday seasons.

Net Metering
A service to an electric consumer under which electric energy generated by that electric consumer from an eligible on-site generating facility and delivered to the local distribution facilities may be used to offset electric energy provided by the electric utility to the electric consumer during the applicable billing period.

Output
The amount of power or energy produced by a generating unit, station, or system.

Photovoltaic (PV)
Energy radiated by the sun as electromagnetic waves (electromagnetic radiation) that is converted into electricity by means of solar (photovoltaic) cells or concentrating (focusing) collectors.

Settlement Date
The date your utility uses to settle or reconcile an account for purchases that have been made from the grid and excess energy a solar panel has delivered to the grid.

Solar Energy
The radiant energy of the sun, which can be converted into other forms of energy, such as heat or electricity.

Storage Capacity
The amount of energy a storage device or system can store.

Usage
The amount of energy or electricity used by a consumer.

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