Solar Photovoltaic (PV) Project FAQs

For Wisconsin Schools

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Niels Wolter - 20-years helping grow Wisconsin's solar PV market

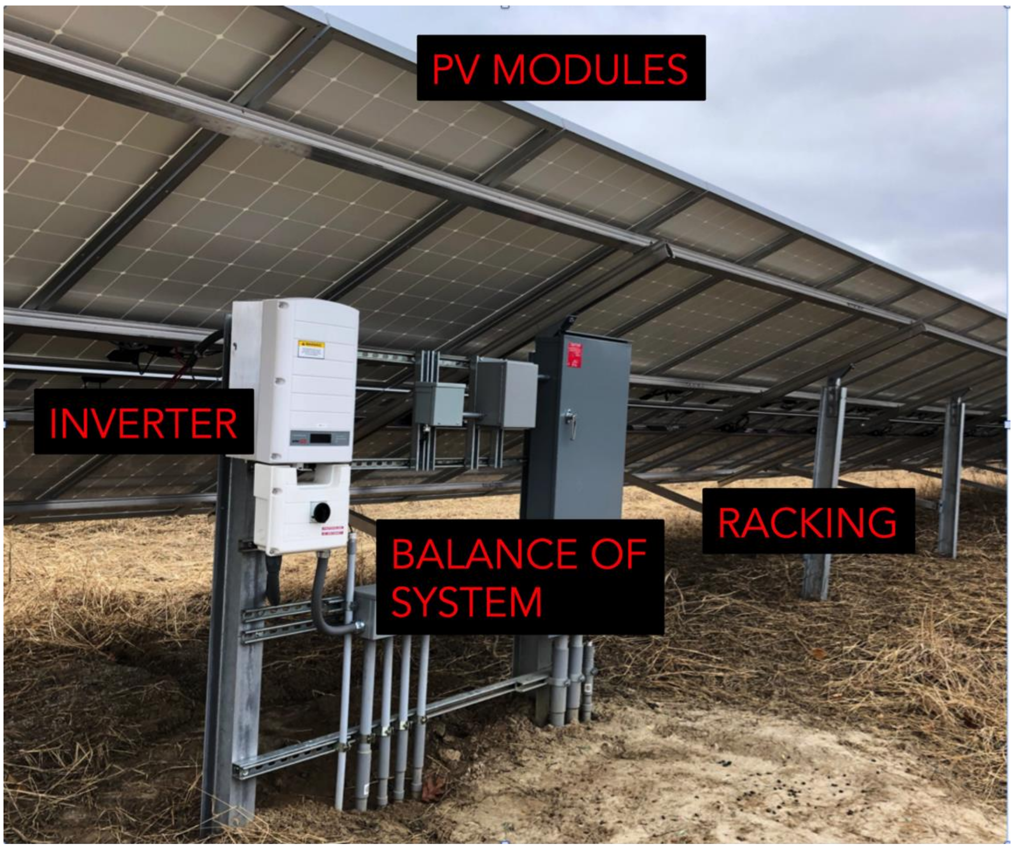
- Helps clients through the process of specifying, funding and installing PV systems
- Services include: site assessments, technical and economic feasibility studies, funding option analysis, grant writing, bid process, contractor selection, education, program design, etc.
- Clients: Milwaukee, Dane County, Magid Glove, Eau Claire, Wauwatosa, Componex, Bayfield County, Sinsinawa Dominicans, Sauk County, La Crosse, Northland Pines School District, Benjamin Plumbing, Holy Wisdom Monastery, Greater Bayfield Waste Water Treatment Plant, Winnebago Cohousing, Washburn School District, Madison, Wisconsin Foam Products, and many others
- Managed the Focus on Energy PV program for almost 10 years

FAQs - General

FAQ: What are the components of a PV system?

There are a few basic components:

- Photovoltaic modules - generate a direct current (DC) of electricity from sunshine
- Inverters – convert the DC power from the PV modules into alternating current (AC) power. The AC solar power can be used by the site's electric loads or placed onto the electric utility's grid. Inverters also provide system monitoring (of kWh generation and system faults) and can provide grid "power quality" services (e.g., frequency, voltage and power factor support)
- Racking system – hold the PV modules
- Balance of system – wire, conduit, combiner boxes, switches, etc.



Main Components of a PV System, Sinsinawa Dominicans, Sinsinawa WI (photo, Niels Wolter).

FAQ: Are batteries a normal part of a PV system?

Today, batteries are unlikely to be part of most solar PV systems. However, their price is falling and the services they provide to the utility grid are just beginning to be valued. Batteries and more PV modules can be added at a later date to cost-effectively meet more of the site's power needs. PV systems should be specified to be battery ready.

FAQ: How does the industry refer to the size of a solar PV system?

The solar industry refers to the size of the PV system either by the kilowatt rating of the solar modules, which is in kW direct current (DC) or of the inverter, which is in kW alternating current (AC). The DC rating of the system is typically 10% to 30% greater than the AC rating.

FAQ: How much power does one kW DC of PV generate?

For a system that is fix mounted, facing south, at a tilt of 10° to 40° from the horizontal, with normal snow shading and no obstacle shading, about 1,200 to 1,300 kWh/year for each kW DC of PV. I kW DC of modules has an area of 60 ft^2. The average detached single-family Wisconsin home uses about 10,000 kWh/year.

FAQ: What are the common ways that PV systems are sited?

Flat Rooftop Solar Arrays

Flat roof PV systems uses low profile racks. Low profile racks mount the solar PV modules with a 10° to 15 ° slope from the horizontal (see photo below). The low profile systems are less prone to suffer damage from wind events, do not require roof penetrations, and require less structural support from the building's roof to support wind, snow and ice loads. Low profile racking systems are also more cost effective; the extra cost of higher profile racking is generally greater than the extra value of the solar kWh generated.

PV System on the Roof of Holy Wisdom Monastery, Middleton WI (photo, Niels Wolter).

The low profile rack systems typically use concrete ballasts to weigh them down to the roof. If the roof has stone ballast, the stone ballast is moved aside during installation and then the ballast stones are laid into pans, which hold the PV system to the roof (instead of concrete blocks).

Ground Mounted Solar Array

Ground mounted arrays are very common. They generally have the greatest production per kW and lowest snow losses, but they require open ground-area and can be shaded by nearby trees, power poles and buildings. An example ground-mounted solar PV system is shown below.

Northland Pines School District, Eagle River, WI (photo, Niels Wolter).

Ground-mounted systems can be ideally sited to maximize their solar power generation - facing due south with a 20° to 30° slope from the horizontal. The rows are typically spaced 20' to 25' apart to reduce row-on-row shading of the PV modules.

Vandalism of ground-mounted solar PV systems is not common. Many system owners install a fence around the array.

FAQ: For a rooftop PV array what are some of the requirements for the roof?

First, the roof should be relatively new (less than five-years old). If the roof is aged, it should be replaced before installing the PV array.

Second, the roof must be able to support the weight of the PV array, the concrete block ballasts and wind and snow loading. Typically, a Professional Engineer (PE) completes a structural review of the roof and stamps the roof for supporting the PV array. It is rare for a flat roof in Wisconsin to not meet the added structural requirements of a PV system. If a flat roof previously had stone ballast, there should not be any structural concerns. A typical flat-roof ballasted PV system weighs between 3 and 7 pounds per square foot.

Third, the roof should have larger open areas without shading from nearby structures, rooftop mechanicals and trees.

FAQ: Will putting the solar array on the roof reduce the life of the roof or add other costs to the project?

A roof-sited solar array should be installed on a new or newer roof. If a PV system lasts 40 to 50 years, the roof will need to be replaced at least once. When the roof replacement is needed, the array will be disassembled, the parts moved to another roof area while the new roof is installed, and then re-assembled. This will have a significant cost.

On a flat roof, the PV array is not attached to the roof and there should not be any new roof penetrations. If any roof penetrations are needed they should be made with the oversight and approval of the firm that holds the roof warranty.

For flat roofs, a low tilt angle racking system (that holds the PV panels at a tilt angle of under 15°) will be weighted (or ballasted) to the roof using concrete blocks that sit in the racking system. A steeper tilt angle increases both wind and snow loading on the building's roof.

The PV array will protect the roof in two ways. First it will shade portions of the roof, protecting it from weather aging. Second, pieces of rubber membrane, or slip-sheets, are located between the base of the racking and the existing roof, protecting it from any wear and tear. However, foot traffic on the roof introduces wear and tear. Foot traffic increases during system installation, maintenance and repairs, and other visitors. Minimizing foot traffic on the roof and laying down extra roof mats will help protect the roof in high traffic areas.

FAQ: How safe are PV systems?

PV systems are very safe. The National Electric Code includes solar PV systems. All key components are UL certified. Many highly qualified licensed electricians with PV certification are available to design, specify, and install solar PV systems to code across Wisconsin. The International Fire Code also covers PV systems.

FAQ: What are the warranty periods for the components of a PV system?

The PV modules typically have a 25-year production guarantee (with at least 80% to 83% power output retained after 25 years) and have a 10-year product warranty. The PV system's inverters commonly have a 10- to 15-year product warranty. Racking systems also commonly have a 10 to 15-year product warranty.

Inverters tend to have the most issues during their warranty period. Most inverter manufacturers offer extended warranties for up to 20 years.

PV installers typically offer 1- to 5-year installation warranties.

FAQ: How long will the PV modules last?

The solar modules and the PV system (with maintenance and needed replacements) typically last 40-50 years, maybe longer.

The PV module's power output degrades slightly over time (about 0.5%/year). For example, after 25 years they are typically warrantied to still generate at least 80% of their new output. After 50 years the decision can be made if the reduced generation is still cost effective with 2070 technology.

FAQ: How much maintenance do PV systems require?

The beauty of solar PV is that, because there are no moving parts, there is little maintenance. The rain and snow typically keep the solar modules clean. An annual inspection is recommended to make sure all the nuts and bolts are securely fastened. Snow removal is usually accomplished by the sun. The installation firm can be contracted to provide maintenance services. The cost of maintenance is roughly 0.35% of the system's installed cost each year.

FAQ: What part of the PV system will require the most maintenance and replacements?

If the PV system needs maintenance, it is usually is related to problems with an inverter. Fortunately, inverters are like computers, electronic devices, that have decreased in cost and improved technologically over time but they have limited life. They are usually warrantied for 10 years, with extended warranties available to 15 or even 20 years. Plan on changing the inverters once or twice during the 40- to 50-year life span of the PV system.

FAQ: What happens if something damages the PV system?

The site's property insurance policy should cover the solar PV system. The cost of the additional insurance is roughly 0.35% of the system's installed cost each year.

FAQ: What about hail or other items damaging the PV panels?

Solar modules are made of the high-strength glass and are rated for large hail strikes (of up to 25 one inch spheres falling at approximately 50 miles per hour). If hail or some other "natural cause" damages the panels, it is covered by insurance.

FAQ: Will we need to wash the solar array or clear away snow?

With the amount of rain Wisconsin has, there is no need to wash or clear snow from the modules. Both snow cover and some "soiling" of the PV array is included in the system's power generation estimates.

FAQs – Economics

FAQ: How much does a solar PV system cost?

An installed PV system should cost between $3,000/kW DC and $1,000/kW DC – depending on its size. A small residential system (4 kW DC to 8 kW DC) will cost about $3,000/kW DC while a large utility scale solar project covering many acres of land (1 MW or more) could cost $1,000/kW DC. A good-sized (80 – 200 kW DC) commercial PV system should cost between $1,500 and $2,000/kW DC.

FAQ: What are the economics of a PV system in Wisconsin for a school?

The example project below assumes direct ownership by the site and no financing.

Assumptions

- PV system size: 100 kW AC and 120 kW DC
- PV system generates: 1250 kWh/kW DC per year
- Utility electricity price: 8 cents/kWh
- PV system reduces demand charges by: 10% of its kW AC rating
- Utility monthly demand charge: $12/kW AC
- PV system installed cost: $1,800 kW DC
- Focus on Energy competitive RECIP grant: 25% of system cost
- Other funding raising/grants: 25% of system cost
- School District pays: 50% of system cost

Value of Solar Generation
Year-one generation: 120 kW DC * 1250 kWh/kW DC = 150,000 kWh
Value of generation: 150,000 kWh/year * 8 cents/kWh = $12,000

Value of Demand Charge Savings
Year one monthly demand reduction: 100 kW AC * 10% = 10 kW AC
Value of demand savings: 10 kW AC *12 months/year * $12/kW ac = $1,440

<u>Year-One Electric Bill Savings: $13,440</u>

PV System Installed Cost: $1,800/kW DC * 120 kW DC = $216,000

Incentives
Focus on Energy RECIP grant: $54,000
Other grants and fund raising: $54,000

<u>Cost after incentives: $108,000</u>
Funded by School district

Simple payback period: 8 years

There are also insurance, O&M and replacement costs (relatively small)

FAQ: Other than Focus on Energy what are some other potential funding sources?

Possible funding sources include:

Solar on Schools program: funded by the Couillard Solar Foundation. The Couillard Solar Foundation donates solar PV modules to schools. For PV systems:

- Up to 75 kW, the Foundation will donate up to 3 pallets, or 75 modules, rated from 345 to 370 watts each (for a total of 26 to 28 kW DC). Three pallets of modules are valued at $10,000.
- Larger than 75 kW, the Foundation will donate up to 6 pallets of (or 150 modules) solar panels (for a total of 52 to 56 kW DC). Six pallets of modules are valued at $20,000.

For more information: couillardsolarfoundation.org/solar-on-schools/

Office of Energy Innovation (OEI), Energy Innovation Grant Program: funded by the US DOE

- In 2018 OEI offered the first of four annual rounds of competitive funding for innovative energy projects including solar PV projects at schools
- The rules for the 2019 funding round have not been released
- For more information: psc.wi.gov/Pages/Programs/OEI/EnergyInnovationGrantProgram.aspx

Local Community Foundations, Businesses and Parents

- Madison's West High, Green Club raised funds from:
  - Parents and families
  - Local businesses
  - West High Class of 1982, Madison Trust, Regent Neighborhood Association, Student Support Foundation, Microsoft, and Madison4Kids

FAQ: How are school-owned PV projects typically funded?

Ans: A school has two basic options for funding their PV system:

- Ownership without financing (i.e., "direct ownership")
- Ownership with financing

FAQs – Project Timeline

FAQ: What might be a project timeline for a PV project?

Example aggressive PV project timeline

Complete feasibility study	Month 1
Apply for Focus on Energy and other grant funding	Month 2
Notification of receiving grant	Month 3
Develop and issue bid	Month 4
Receive bids	Month 5

Select installation firm and negotiate contract	Month 6
PV system installation	Months 7 – 11
System commissioning, interconnection	Month 12
Grant payment	Month 13

FAQs – Solar PV Power Generation and Value

FAQ: How does an electric utility charge for electric power?

For larger electricity customers there are two charges that vary from month to month. The first is power use, or kilowatt-hours (kWh), which is simply the amount of power (in kWh) used over the billing period. Typical kWh charges for a commercial customer range from 5 to 10 cents/kWh.

The second is the demand charge, which is measured in kilowatts (kW). Electric utilities measure larger customer's power-use over 15 minute intervals all year long. The monthly demand charge is set by the customer's peak 15-minute power use during on peak periods (usually business day hours) over the billing period. The annual demand charge is set by the site's peak 15-minute demand during the previous 12 billing periods. A site's demand charges can account for 40% of their electric bill.

The rational behind the demand charge is that the utilities need to build their infrastructure (power plants, transmission and distribution lines, etc.) to meet their customer's peak demand for power (usually on a hot summer afternoon – when everyone's air conditioners are running). While the kWh charge covers variable costs, like fuel. Not all utilities have both monthly and annual demand charges and they have different names for them.

FAQ: How does a PV system reduce electricity costs?

Solar PV systems reduce power use, or kWh charges, simply by offsetting, or taking the place of, power that was purchased from the electric utility. PV systems reduce demand charges only when the sun is out and the PV system is producing power at the times when the site's demand is peaking for the month or year.

FAQ: What is net metering (also known as "net energy billing")?

State law allows smaller PV system owners to use their electric utility's grid as a battery. Or in other words, when a net metering PV system makes more solar power than the site needs the power is put onto the grid. Any power placed onto the grid is valued at the customer's retail electric rate. Then later, when for example, the sun isn't shining the customer can use grid power.

The maximum net metering PV system size depends on the electric utility:

- Alliant, WPS, and most rural electric coops and municipal utilities: 20 kW AC
- MGE and Xcel: 100 kW AC
- We Energies: 300 kW AC

When PV systems, that are larger than net metering, the solar power put onto the grid, in any 15-interval of the year, is typically valued a the utility's avoided cost. The avoided cost is generally ½ to 1/5th of the site's retail electric rate.

FAQ: Will the solar PV project meet all of the site's daily electrical needs?

If a site's annual electricity use is <u>less</u> than what a net metering PV system can provide, then, yes, a PV system can meet all of a site's electricity needs.

If however a site's annual electricity use is <u>greater</u> than what a net metering PV system can provide, then a PV system can't meet all of a site's electricity needs – in a cost effective manner.

As noted above, for a larger-than-net-metering PV system, any solar power put onto the utility grid during any 15-interval of the year, is valued a the utility's avoided cost. The reduced value of power put onto the grid, rapidly reduces the PV project's economics.

Very generally a larger-than-net-metering PV system can meet between 10% and 20% of a site's power needs without sending significant solar power to the grid.

Most medium to large schools will use more power than is allowed by net metering.

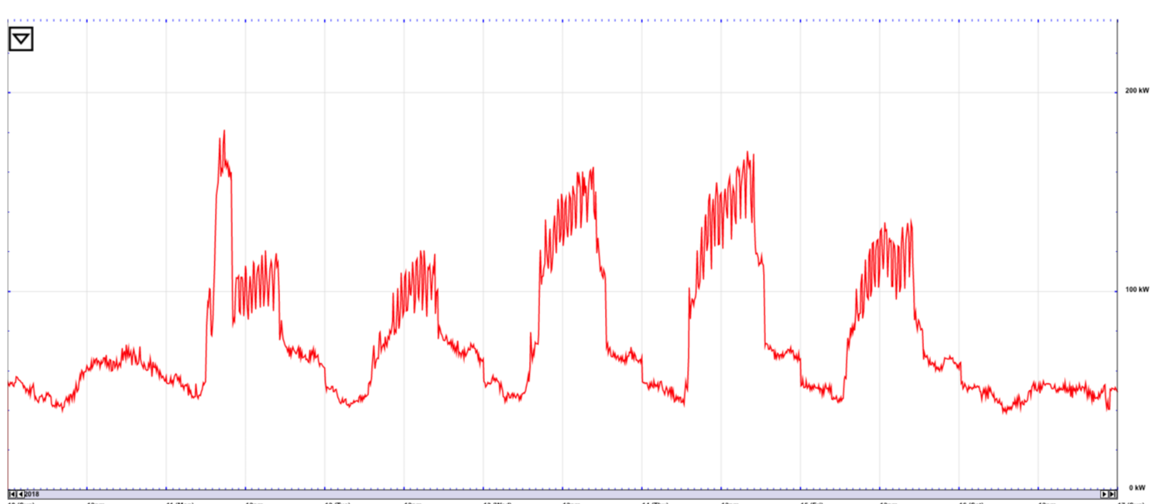
FAQ: How does a PV system reduce kilowatt (kW) or demand charges?

A PV system's kW output will directly offset retail demand charge only when solar generation coincides with the customer's monthly or annual peak demand period.

EXAMPLE

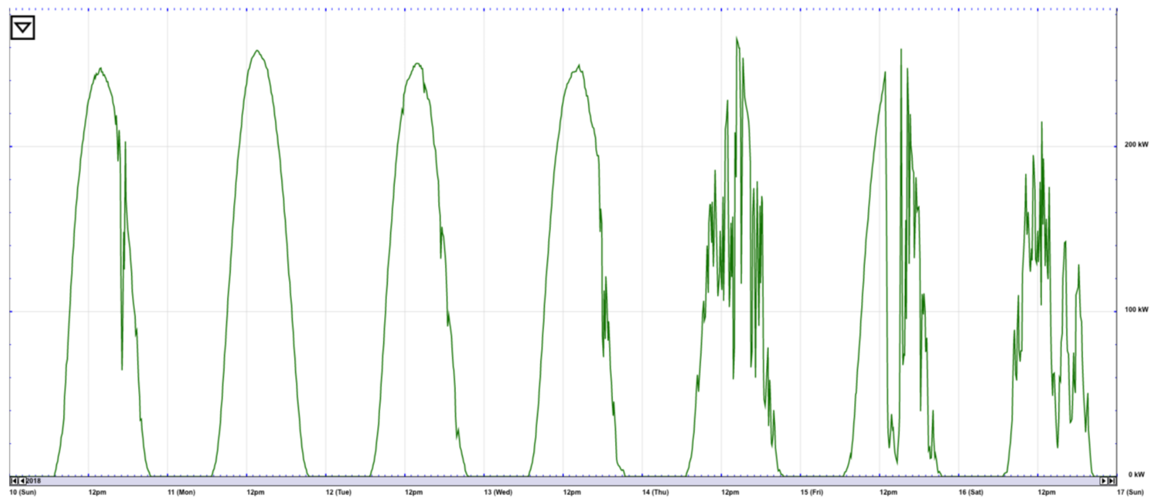
A customer's daily power demand is typically shown as a curve, time on the x-axis and power use on the y-axis (see Graph 1, below). The example below is from a school, an office building's load shape could be similar.

Graph 1. Erie Middle School's power use (red curve) over a week. The graph covers from Sunday June 10th to Sunday June 17th, 2018. Source: http://sv-erie-m.egaug.es/5AD4A/



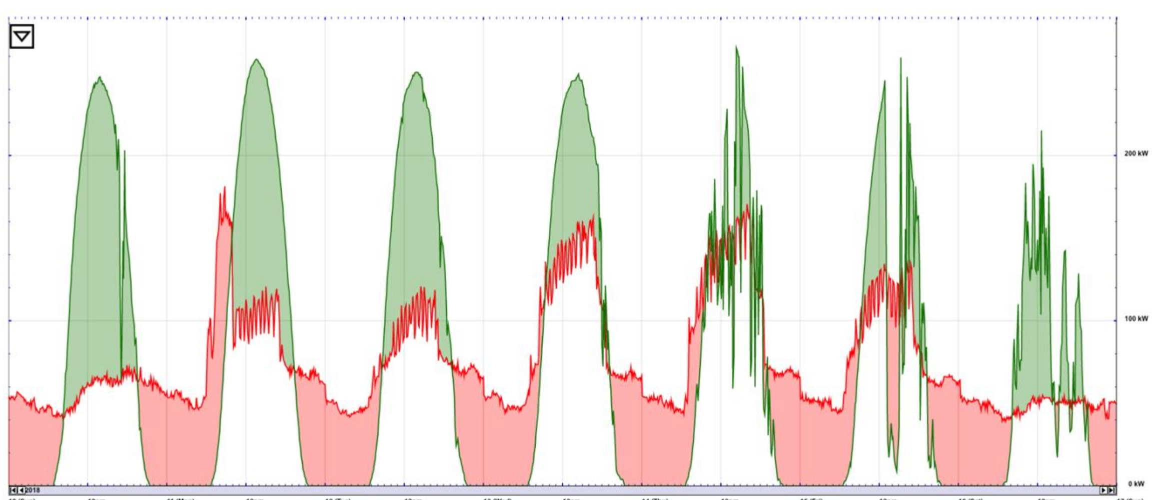
The solar production curve from a PV system, Graph 2 below, shows cloudy days (the last three days), no power generation at night, and the daily solar cycle. Note that the last day is cloudy but still generates solar power.

Graph 2. Erie Middle School's solar generation (green curve) from a ~250 kW PV system. The graph covers from Sunday June 10th to Sunday June 17th, 2018. Source: http://sv-erie-m.egaug.es/5AD4A/



Combining Graphs 1 and 2, creates Graph 3 (below). In Graph 3 the site's demand savings (shown in white areas under the red curve) is the difference between the site's demand without solar (red curve) and with solar (as shown by the red area in the image below).

Graph 3. Erie Middle School's power use (red curve) and solar generation (green curve) from a ~250 kW PV system. The graph covers from Sunday June 10th to Sunday June 17th, 2018. Source: http://sv-erie-m.egaug.es/5AD4A/



As shown in Graph 3, much of the demand for electricity was met during daytime (daylight). However, on the second day (a Monday), the site's peak demand occurred early in the morning before sunrise, and thus that demand was not reduced by solar generation[1]. So, for this week, the PV system did not reduce the site's demand charge.

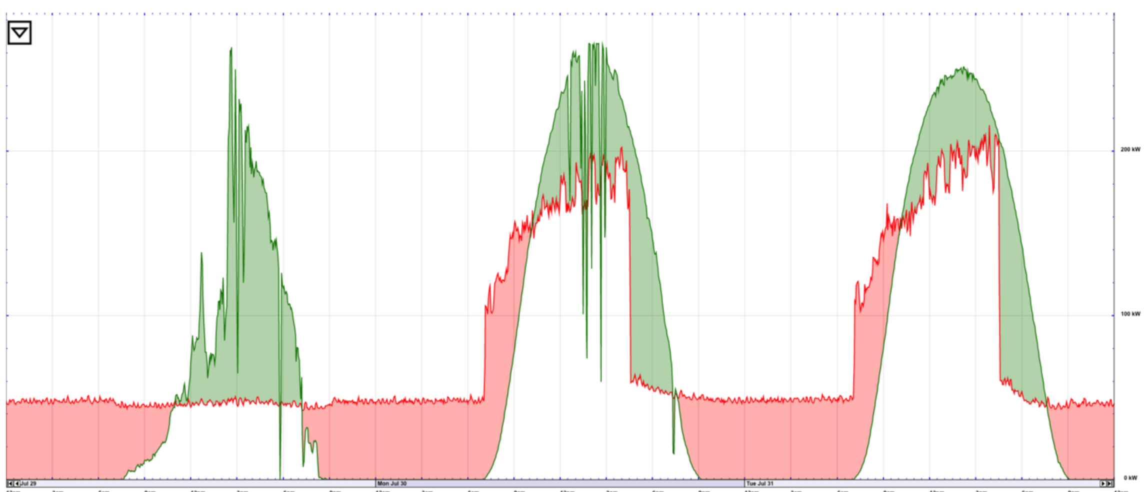
FAQ: How are the savings from a larger-than-net-metering PV system best determined?

To accurately determine electric bill savings for a larger-than-net-metering PV systems, 15-minute energy use and solar generation analysis is needed. Ideally, a year or two of 15-minute power consumption data is compared to concurrent 15-minute solar generation data from a nearby PV system (with similar array orientation and shading). The 15-minute analysis can be used to size the PV system (to limit power to the grid, which is valued at avoided cost), and determine the value of the usage (kWh) and demand (kW) savings.

FAQ: What else can the building power use and solar generation graphs show?

Please refer to the example Graph below.

Graph 4. Erie Middle School's power use (red curve) and solar generation (green curve) from a ~250 kW PV system. The green area shows excess solar generation that went to the utility grid. The red area shows the site's power purchases. The white areas shows the power at retail cost that the PV system offset. The graph covers from Sunday July 29th to Tuesday August 31st 2018. Source: http://sv-erie-m.egaug.es/5AD4A/



To note from the graph above:

- Solar generation occurs during daylight hours, peaking at the middle of the day
- Day one was somewhat cloudy, day two had some clouds around mid-day, day three was completely sunny

[1] If the school had precooled on Sunday night, that early morning peak would not have occurred.

- The site has a constant base-load 24-7 power consumption of about 50 kW and peaks at about 200 kW.
- The site's power use is flat during Sunday (and Saturday) when the site isn't in use (and the air conditioning is turned off).
- Before the solar was installed the site's peak use was in the later afternoon. It isn't shown but on cloudy weekdays – the site's peak demand will still occur on late afternoons
- After the solar was installed, and on sunny days, the site's peak demand occurs in the early/mid morning
- If batteries were cost effective, excess solar generation (green areas) could be stored and then used to offset the morning demand peaks (red areas on Monday and Tuesday)
- If the system were larger than what is allow under the utility's net-energy billing tariff, any solar power shown in green would be valued at the electric utility's avoided cost, all other solar generation offsets the site's retail electric usage (kWh) rate.
    - Given Wisconsin's solar policies, this system is over-sized.

As battery prices fall[2], batteries will be added to PV systems, storing power during excess generation and using it to reduce demand charges.

[2] And battery services (such as frequency regulation) are valued in Wisconsin (expected winter 2019/20)