A resource guide to help your school go solar

Solar Schools

Community Power Network

Community Power Network

Solar Schools Contents

What is solar energy?

Two main types of solar systems are available for schools to use:

1. **Solar photovoltaic (PV) systems**, which capture solar radiation and convert it directly to electricity (learn more), and
2. **Solar Thermal Systems**, designed to harness the sun's heat to provide for water heating or space heating or cooling (learn more).

Solar energy has been used since the 1950s and is a stable, clean, and abundant domestic energy source. The US has some of the best solar energy resource potential in the world.

Solar PV System (Wayne National Forest).

Why go solar?

Save money

Installing solar panels can reduce your school's electricity bill significantly. In many places, the cost of solar electricity is the same or lower than what your school is currently paying. With an average lifespan of 25 years, a solar panel investment can save millions of dollars in the long run. Just ask the Porterville United School District in California, which installed solar in six schools and expects to reduce energy costs by $44 million in the next 25 years.

By going solar your school can also protect against rising electricity costs. Signing a contract to purchase a solar system (or solar electricity) allows schools to guarantee their electricity prices for up to 20 years, saving districts money and making budgeting easier. In Colorado, the Boulder Valley School District recently installed 1.4 megawatts (more than 5,000 panels) on 14 schools in an effort to reduce energy expenditures. The District signed a 20-year Power Purchase Agreement (PPA) with a solar installer and will be paying less for solar power-generated energy than the conventionally sourced electricity that it currently uses.

More than 500 K-12 schools in 43 states have installed solar panels, many of them over the past three years, as solar-power costs have fallen by more than one-third.

Source: Wall Street Journal

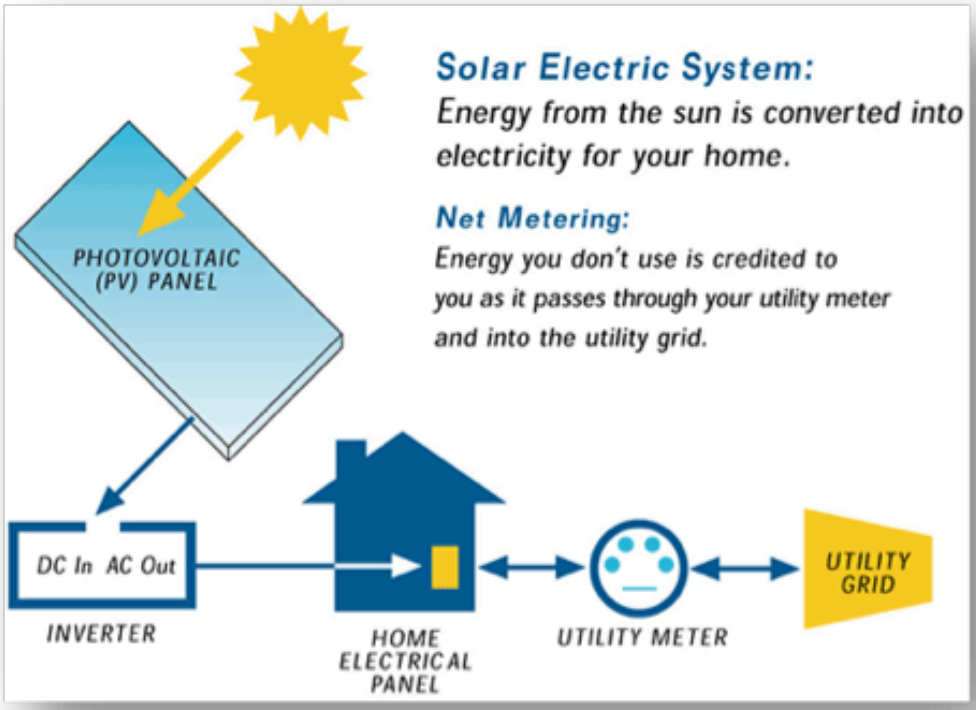
Create Educational Opportunities

Schools have enormous incentive to go solar, not just to save money, but to create an energy- and sustainability-conscious student body. Since it is important that students be aware of the huge environmental challenges we face this century, schools serve as stewards of sustainability and cornerstones of green initiatives that benefit their community. With solar systems, students are able to see first-hand how sunlight is converted to electricity and solar installations can be integrated into a school's math, science, and technologies programs to improve test scores in those fields.

In addition, Solar Energy Industries Association predicts that, by 2016, the surging demand for solar systems will add hundreds of thousands of green-collar jobs to the economy, including those in research, development, manufacturing, construction, sales, and marketing. Solar curricula help prepare students for these types of jobs.

Help Our Planet

According to the Environmental Protection Agency (EPA), generating electricity contributes over one-third of all greenhouse gas emissions in the United States. Solar power is a renewable substitute for fossil-fuel-burning power plants, which emit greenhouse



gases that lead to global warming. And solar energy is free and never runs out. Switching to solar energy is one of the biggest changes we can make in our communities to curb global warming. With rising concerns about our carbon footprint and the mounting cost of energy, solar is a wise investment for the health of the environment and generations to come.

Solar water heating system (NREL).

How does a solar system work?

The vast majority of school solar systems are grid-connected: the solar panels are connected to the local utility electricity grid and supplement your school's normal power. Grid-connected systems operate via a process called net metering.

Net Metering

When the sun is shining, the system produces electricity that runs through the inverter and then powers the building. If the solar panels produce more electricity than is needed, the excess power is sent out onto the electricty grid and your school receives a credit for that power (as if your electric meter were running backwards). At night and when the school's power demands exceed the solar system's production, your building continues to use electricity from the grid. At the end of the month the school's electric bill reflects the total energy your building used minus the electricity that was produced by the solar system. This process of calculating the total power used is called net metering. Specific rules governing the details of how net metering is calculated vary state by state. For more information, check DSIRE, a database of state renewable energy laws and incentives.

How large a system can we install?

The size of a solar installation is measured in kilowatts (kW). A solar system on a residential home is typically between 3 and 5 kW, depending on the size of the roof. This size system usually offsets about 40% to 60% of the home's electricity use. Solar installations on schools can be much larger if enough roof space is available. For example, many solar projects on schools are 50 kW to 250 kW, or more.

How does the process of going solar look?

The process of going solar will vary depending on the size of your school and how decisions are made. In general, the process of going solar includes:

- Looking at one year of electric bills for your school or district. This allows you to determine how much power your facility uses and how much a solar system could offset.
- Briefly assessing your school's roof and/or grounds to see if solar is a good fit. This involves making sure your roof isn't shaded, too old, or unable to support panels. The "Is Solar a Good Fit for my School?" section of this guide goes into more detail about the process.
- Reviewing the purchasing and/or financing options available to your school, which will depend on the type of solar financing your state allows and whether grants and incentives are available.
- Completing a rough financial analysis to give you a sense of the total costs, cost savings, and energy impacts of a solar project.
- Compiling findings and building public support for the project by presenting to students, parents, community members, and other key stakeholders.
- Presenting the results of your feasibility assessments to key decision-makers to get approval for the project.
- Issuing a Request For Qualifications (RFQ) or a Request For Proposals (RFP) to solicit bids for the project from local installers.
- Launching a fundraising campaign, if necessary, to offset some of the cost of the system.
- Reviewing project bids and selecting an installation company.
- Holding a community celebration and ribbon-cutting ceremony with stakeholders, elected officials, administrators, and community members to celebrate the new solar system!

kW vs kWh?

A kilowatt (kW) is a unit of power kW denotes how much power a PV system is generating at a given point.

A kilowatt-hour (kWh) is a unit of energy used over time.

kWh indicates how much energy has been generated or the average amount of power generated over a period of time. So, under ideal conditions, a 3-kW PV array that produces power for 3 hours will generate 9 kWh.

How much does solar cost?

The cost of solar varies by state and depends on whether any state or local incentives are available. In general, the cost of a system can range from $3,000 to $6,000/kilowatt installed. This includes the cost of the materials, installation, permits, and interconnecting the system to the electrical grid. So, the cost of a small demonstration solar system (1 to 5 kW) could range from $3,000 to $30,000. In contrast, a larger system meant to cover a significant portion of the school's energy could cost between $60,000 and $1.5 million, depending on its size.

Donovan Elementary in Donovan, IL installed a 1 kW ground-mounted system as a solar demonstration project (Illinois Solar Schools).

The HELiOS Project is an all-volunteer, grass-roots organization that is committed to reducing fossil fuel usage in every K-12 school in California. Their website provides all sorts of resources, tools, and examples of schools in California that have gone solar. They can also help your school start a solar project!

However, in many states, especially those with robust incentives, there are many options for going solar that do not require money upfront. These include loan programs and third-party financing options.

The Welsh-Hills School in Granville, OH has integrated its ground-mounted system into the existing science curriculum. (Ohio Solar Schools)

Is solar a good fit for my school?

Two key concerns for any school interested in going solar are the safety and quality of the installation. At minimum, your building should:

- **Face due south, to maximize the amount of sunlight the panels collect.**
  - If your pitched roof does not face south, you can still use a solar electric system, but the performance will be about 5% less with a southeast- or southwest-facing system. Eastern, western, and northern exposures are not recommended for solar electric systems. Flat roofs facing any direction are a good fit for solar, since the panels can be adjusted to face due south.

- **Remain unshaded between 9am and 3pm.**
  - The portions of the roof where solar will be installed should be free of shade for most of the day, as shade can significantly reduce electricity production.

- **Have adequate space for panels.**
  - A solar electric system needs about 100 square feet of unshaded south-facing roof or yard space for every kilowatt of system capacity. So, a 1 kW system requires 100 square feet, while a 15 kW system would need 1,500 square feet. Thin-film systems may require 175 square feet of space per kilowatt of capacity.

Scottsdale Unified School District in Scottsdale, AZ has installed solar shade structures on its parking lot (Raising Arizona Kids).

- **Have a roof that is in good repair and less than 15 years old.**
  - If your roof is more than 15 years old, your school may want to consider replacing it when you purchase the system. Most solar vendors recommend using roofing material that will last as long as the system, which is about 25 to 30 years.

- **Be up to code and able to handle the weight of solar panels.**
  - Some states have a site selection survey that can help in the decision process, and the EPA has a website guide with information about pre-screening a site for solar PV development.

If your roof is not a good fit for a system, it is possible to install ground-mounted panels in an open space or awnings to provide shade in your parking lot. These types of systems tend to be more expensive (about 20% more in total cost) than roof-mounted systems, but they have the added benefit of providing parking lot shade or allowing you to avoid having to upgrade your school's roof.

How do we find a solar installer?

The Solar Foundation and the U.S. Department of Energy have published information on best practices regarding the request for proposal and installation process.

In general, schools should issue a Request for Proposal (RFP) or a Request for Qualifications (RFQ) in order to solicit at least three bids from solar installers. This will help your school get a sense of how large a system can be installed on your building and how much it will cost. Some cities or states also maintain databases of certified contractors, which you can use to identify reputable installers.

Once your school has received bids, don't hesitate to ask the installers to sit down and explain each component of their bids. They should be able to tell you the cost per watt installed solar ($/W) before and after incentives. You can compare the cost per watt in each bid, but bids may differ depending on the type of equipment the installers plan on using, or on how the system is financed (if your school would like to pursuing financing).

In general you want a solar installer with experience in your jurisdiction and who is familiar with local permitting and interconnection requirements. You also want an installer that matches your values. Many schools embed social values in their installer-selection criteria, such as favoring locally based installers, panels made in the United States, or installers that provide training for local community members.

How do we pay for a system?

Schools have two options for paying for their solar systems: (1) direct ownership, or (2) third-party ownership. With third-party ownership, another entity, such as a solar developer or a group of community investors, actually owns and operates the PV systems on behalf of the school.

Direct ownership of a system makes sense for your school if you are able to fundraise the cost of the project, or if you have access to specific state incentives, grants, or if community members are able to fund the project or donate in-kind goods and services. Third-party ownership makes sense in states where it is allowed, since a for-profit entity is able to take advantage of solar tax incentives and pass those savings onto you. Third-party ownership can be a great option where available as many arrangements allow a school to go solar with no money down.

Which approach should your school use? To make that decision you need to understand your state's rules and incentives. The following is a more detailed explanation of both options. This guide from the Na-

tional Renewable Energy Laboratory also outlines the different ownership options for schools.

Direct Ownership

About Direct Ownership

Some schools choose to purchase their solar systems outright. They then receive all of the electricity savings and available rebates for the systems. The district also retains rights to all of the associated solar renewable energy certificates (SRECs) or other local incentives, which can be sold to offset the cost of going solar or kept by the school so it can declare that the facility is powered by renewable energy.

Rooftop solar installation at Richardsville Elementary School in Bowling Green, KY. (SCB Architects)

The biggest benefit of direct ownership is that the school will see immediate savings on its utility bills. A disadvantage of the direct ownership model is that it requires that schools provide the funds for the system upfront, which may be difficult for districts that do not have large cash reserves. Direct ownership also means that, because schools do not pay taxes, they cannot take advantage of significant federal (and possibly state) tax credits. Federal tax credits can reduce the cost of a solar system by up to 50%.

Direct Ownership Models

Several different models exist for schools to own their systems outright.

Bake Sale Model

This approach uses a combination of grants and fundraising to cover the entire cost of a solar system. Once you've raised the funds, you contract with an installer to have the system installed. Your school does not sign any long-term contracts with the installer and you see an immediate decrease in the building's electric bills that is proportional to the amount of energy offset by the solar system.

Rooftop solar system. (Snohomish County)

The bake sale model is a good fit for your school if:

- Your proposed system is relatively small or your goal is to have a solar demonstration project (rather than offset a significant portion of your building's electric use with solar). With small systems the total cost isn't as high and it may be possible to fundraise the entire amount.
- There are grants available to your school that would cover a significant portion of the cost. Sometimes local utilities, municipalities, or states offer grants for schools or nonprofits to go solar.
- You are confident in your school's ability to fund-

Parking lot solar installation at Richardsville Elementary School in Bowling Green, KY. (Warren County Schools)

raise the cost of the system from parents, students, community members, local businesses, and other entities. Sometimes you only need to find a few large donors who are willing to make a significant contribution. Or a lot of small donors!

Examples of schools that have used this approach:

- Rochester School District, profiled in the Minnesota Student Energy Project's Renewable Energy and Schools Guidebook

Do-It-Yourself Model

Similar to the bake sale model, the DIY approach involves fundraising the cost of the system. Instead of paying an installer to put up the panels, though, a group of community members, parents, and teachers installs the panels themselves with the help of an installer.

This approach is a good fit for your school if:

- A local installer is interested and willing to provide a discount on the system cost in exchange for help from community members during the installation.
- Community members with solar installation or electrical experience are interested in helping with the project.

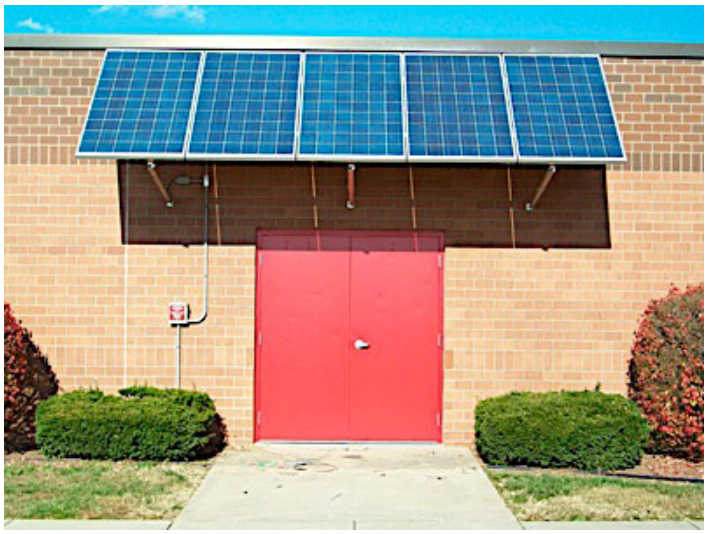
Examples of schools that have used this approach:

- New Hampshire Plymouth Area Renewable Energy Initiative

State or Utility Solar Schools Programs

Some states, such as California, offer state-sponsored or utility-sponsored programs that provide schools with grants for solar systems. In the past, the PG&E Foundation, TXU Energy, and the Illinois Clean Energy Community Foundation (ICECF) have contributed toward solar school installations around the US. Some of the installations are connected to teacher training and educational workshops. You can visit your local utility's website or check out http://www.dsireusa.org to see if they offer any utility grant programs for schools.

The Wisconsin K-12 Energy Education Program (KEEP) has a great website that provides a good introduction to renewable energy technologies. The site also includes information on solar costs, opportunities for professional development for teachers, curriculum resources, funding sources, and information on how to get students involved.



Allendale Elementary School in Allendale, IL installed a 1 kW system as a roof awning. Although it won't offset a significant portion of the school's energy, the benefit of this system is that it is highly visible and easy to incorporate into educational initiatives. (Illinois Solar Schools).

Third-Party Ownership

About Third-Party Ownership

Third-party-financed PV installations are owned and operated by another entity, usually a solar developer or its investors. The school then pays the developer or investors for the electricity produced by the panels, sometimes at a rate lower than what they pay their utility.

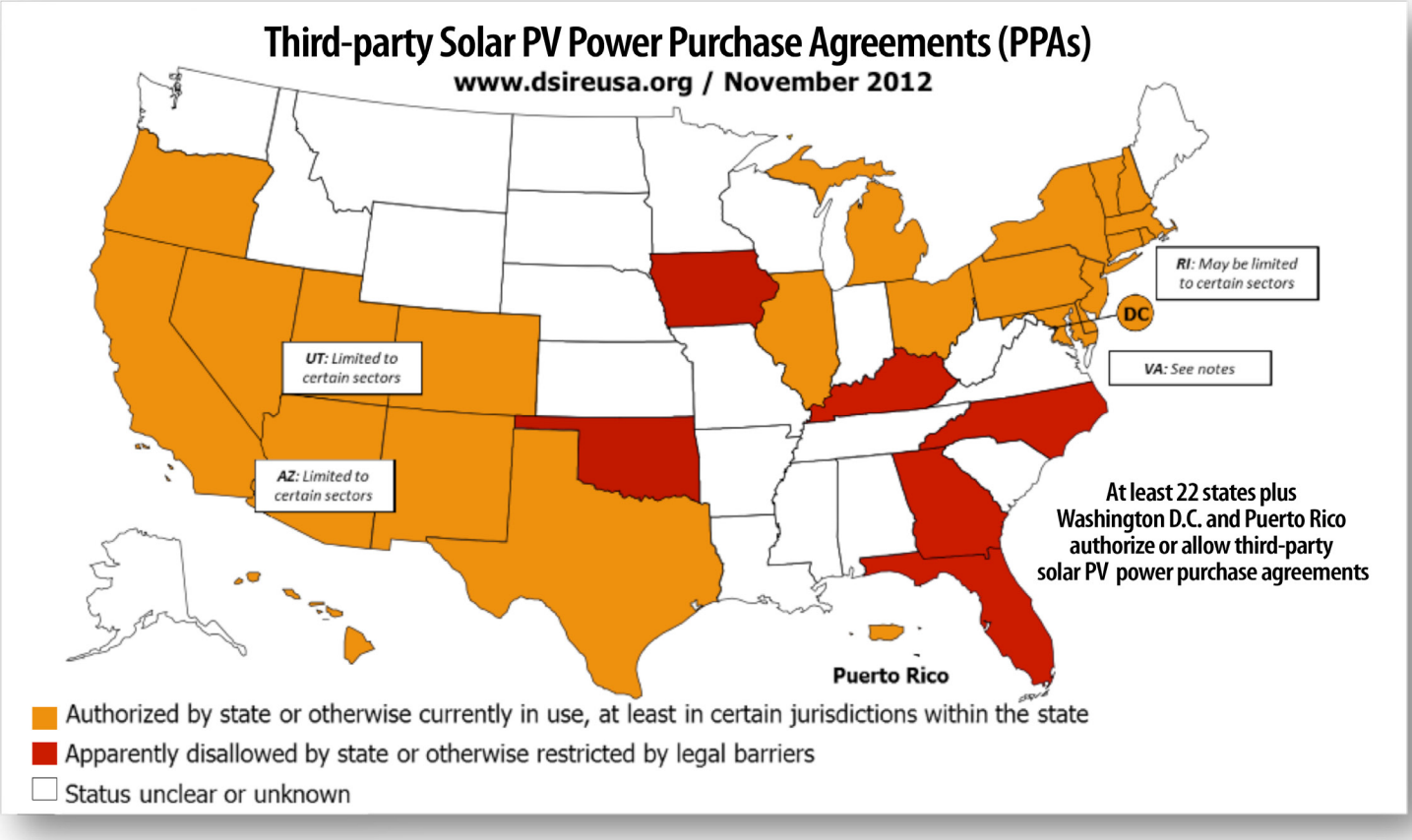
Third-Party Ownership Models

A number of different third-party ownership models exist, most of them based on Power Purchase Agreements.

Power Purchase Agreement

The most common third-party ownership approach is called a Power Purchase Agreement (PPA). This approach is advantageous for schools because:

- PPAs allow the school to go solar without a large initial capital outlay;



The project developer is responsible for maintaining the system for the length of the contract; and

- As private entities, developers are able to take state and federal tax incentives and pass those savings onto the school.

Third-party ownership does have some disadvantages, however:

- A PPA is a complicated transaction and schools must dedicate time and money to ensuring that they negotiate a fair and equitable contract with the solar developer.
- Under a PPA agreement, the solar system's SRECs are usually allocated to the investor. The school is therefore not able to claim the environmental benefits associated with clean electricity production (i.e., claim that the school is 100% powered by solar energy).

- At the end of the PPA contract period (usually 10 to 20 years), the school will not own the PV system (this is required by law so the owner can take the federal tax incentive). As a result the school must either choose to purchase the panels at fair market value or have the panels removed by the developer. Schools should make sure their PPA contract includes language that requires the developer to remove the system at no additional cost at the end of their contract, to avoid additional expense if they choose not to purchase the system at the end of the contract.

- Most PPAs apply an escalation rate to the solar-produced energy they will be providing. Sometimes those escalation rates are very steep, so make sure you look very closely at the fine print of the contract.

- This approach to financing solar is only available in states where PPAs have been authorized.

As with any financing arrangement, it is important to have a committee in place to ask the right questions. Issues to address when considering a PPA include: Who owns the system? Who will maintain it? What happens to the system at the end of the 20-year contract period? What rates will the school pay for electricity over the life of the contract?

Richardsville Elementary School in Bowling Green, KY (SCB Architects)

Richardsville Elementary School in Bowling Green, KY has been designated as the first zero energy school in the United States. In addition to energy efficiency features throughout the school, including a super insulated roof and insulated concrete walls, the school boasts a 394 kW solar system. Some of the panels are installed on the school's roof, while others are located on a shade structure over the school's parking lot. The solar panels, in combination with the school's efficiency measures, are generating more power than the facility uses.

A number of national companies frequently offer PPAs for schools, community organizations, and businesses. These include SolarCity, SunPower, and Sungevity.

Community-Owned Power Purchase Agreements

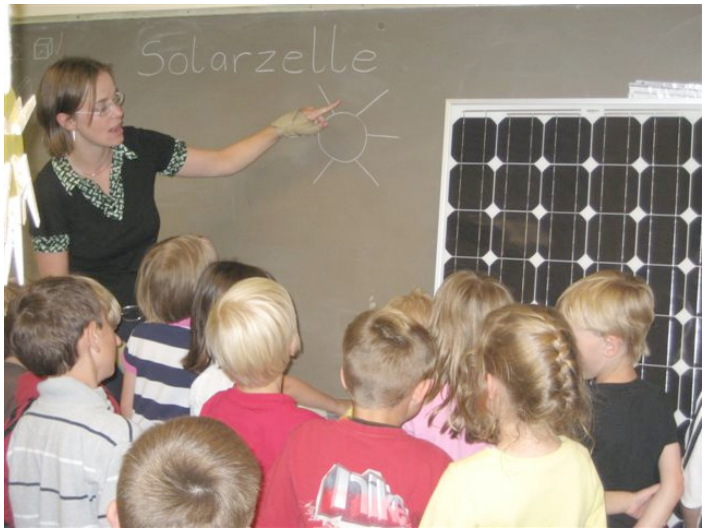
Community-owned PPAs are similar to traditional PPAs, with the exception that members of the community create a third-party entity to own the system on behalf of the school in order to take advantage of tax incentives. This third-party entity (made up of community members) owns and operates the solar system and the school pays this entity for the electricity produced by the panels on its building.

The benefit of a community-owned PPA is that members of the community can support a solar project financially while still earning a modest return on their investment. Walnut Gulch School in California was one of the first schools to pioneer the community-owned investment approach and many others have since followed. Sidwell Friends School in Washington, DC teamed up with Common Cents Solar of Chevy Chase to install 120 solar panels on its gym roof. To fund the $200,000 cost of the project, members of Sidwell Friends Community were invited to purchase solar bonds in increments of $5,000, on which they earn a modest rate of return for about 10 years. Sidwell Friends will purchase the solar-generated electricity at fixed rates that protect it against inflating energy costs. After the investors are repaid, the school will reap solar energy at no cost for the rest of the predicted 30-year life of the system. The solar panels will also offset approximately 1 million tons of greenhouse gases, fulfilling the school's commitment to a reduced carbon footprint.

This approach was also used to install solar on a church in University Park, MD. If your school is interested in this model, the University Park Solar LLC can provide technical assistance and some of the documents necessary to create the third-party entity.

Morris Model

Similar to a Power Purchase Agreement, the "Morris Model" (so named because it was developed in Morris County, New Jersey) is a hybrid approach that allows a private solar developer to become the owner of the



Solar 4R Schools is an organization dedicated to helping schools go solar and providing teachers, community members, and students with information about the benefits of going solar. Organizations like Solar 4R Schools can be good resources if you're interested in taking your school solar but aren't sure where to start (Solar 4R Schools).

project. The state or local government then provides the solar developer with low-cost project capital by issuing debt (such as bonds). By providing low-cost capital to the developer, the local or state government is able to negotiate for much lower rates on the electricity produced by the solar panels.

Since Morris County's first bond issue in 2010, the model has also been replicated and refined in Somerset County, NJ. Eight other New Jersey counties are also setting up their own programs. The Morris County schools district also went solar using this approach.

What are some of the challenges for schools going solar?

Schools interested in going solar face a few unique challenges. Most significantly, because schools are nonprofit entities that do not pay taxes, they cannot take advantage of federal and state tax credits for solar systems. Because federal tax credits can amount to almost 50% off the total cost of a system, this can be a lot of money to leave on the table, particularly for large projects. To get around this issue many schools have gone solar via a Power Purchase Agreement (PPA), in which a for-profit entity owns the solar system installed on a school and the school pays that entity for the solar electricity that the panels produce. The for-profit entity is able to take the tax credits for the solar system and pass those savings onto the school via a lower cost of electricity. PPAs are a good option for schools, too, because the system owner is responsible for any maintenance or repairs for the lifetime of the contract.

Each state also has different regulations and incentives regarding solar installations, so it is important to research your state's the rules, regulations, policies, and incentives.

Another challenge for schools interested in going solar involves contracting. Public schools are often subject to a "deficiency clause" that prevents them from entering into multi-year contracts that appropriate funds. This is the case because only state or federal legislatures are allowed to appropriate funds (so school districts don't have the authority to make multi-year commitments).

In 2006, Head-Royce School, a K-12 prep school in Oakland, CA, developed a Green Council comprising of student representatives, faculty, and staff. In 2008 they installed a 73-kW solar electric power system and developed lessons about renewable energy, using their own solar energy system as a teaching tool.

The good news is that many federal and state agencies have now signed PPAs and by working with a good lawyer your school may also be able to do so. Many schools have succeeded in signing PPAs because they present them as another form of utility contract. Schools have been signing contracts to pay for electricity and gas for years, so doing so with a PPA should not be a problem. The challenge is making sure that your solar PPA is treated as a utility contract.

Finally, once your school has installed solar it may be difficult for your building to capture the money that it is saving by going solar—especially if you are a public school. This is because solar offsets electricity bills that are usually paid out of the district's general fund. If

that money isn't used to pay electric bills, it is usually allocated for other uses. When getting approval to install a solar system from the school board you should have them agree to set aside some or all of the saved money for your school. This is often a great way to get the PTA or parents involved in advocating for a solar system, since the solar system will create a pot of funds that can be used by the PTA for other initiatives.

This guide from the Clean Energy Resource Teams gives a good overview of some best practices schools in Minnesota have used to both acquire and finance solar systems.

Beecher City Jr. Sr. High School installed a 1 kW awning system on the south side of its building (Illinois Solar Schools).

How do I convince my school or district to go solar?

It can be a little overwhelming to think about taking your school or district solar, especially if your building is large or there is a lot of bureaucracy. But never fear! You can make the process easier by being strategic about how you approach the project. The following are some general suggestions for getting started. This guide by the Minnesota Renewable Energy Society is also an excellent resource.

Step One: Join forces.
Taking a school solar is a fairly involved process. You'll need to get buy-in from various entities within the school district, such as the schools administration, the school board, community members, and facilities personnel. It is therefore a good idea to create a committee of solar champions who can work on this project together. Spread the word that you're interested in exploring solarization and see who wants to join you. It's likely that some teachers, parents, community members, administrators, or others in your community already share your vision. Also, don't forget to include students. They are the best advocates for a project like going solar—and the process of being involved will be inspiring and educational for them and keep the grownups focused and committed!

Holding a meeting to gauge community interest and connect with other solar supporters is a good first step.

Step Two: Identify your goal and create a plan.
Once you've assembled a group of dedicated solar champions, identify what you would like to accomplish by going solar. Do you want to create a demonstration panel so students can see how solar works? Or do you want the school to get a significant portion of its energy from solar? Your goal might impact the size and scope of the project. For example, you could have a demonstration panel installed on the front lawn of the school for classes to use in their curriculum. This would be a much smaller (and less expensive) project than covering the entire roof with enough solar panels to offset much of the school's electric bills.

Once you've identified your goal, take a few minutes to outline a plan for achieving this goal. Who needs to approve and sign off on the project before it can start? Is there anyone in the school's administration you think would be a champion for solar? Anyone who might be a barrier? Is your building going to be renovated soon, or are there other structural issues that might get in the way of a project?

A 1kW ground-mounted system at Worthingway Middle School in Worthington, OH (Ohio Solar Schools).

It doesn't make sense plan the entire project, since things will change as you start moving forward, but it's useful to begin thinking strategically about how to be most effective as you begin the solarization process.

Step Three: Do a basic site assessment to see if solar is a good fit for your building.
It's good to get a general sense of whether or not your building will be a good fit for solar. Before installing a system, a solar installer will do a more thorough engineering assessment of the roof, but your building needs to meet a few basic criteria before you reach that point. Check out the "Is Solar A Good Fit For My School" section of the guide for more details.

It is also useful to look at one year of electric bills for your school or district. This allows you to determine how much power your facility uses and how much a solar system could offset.

Step Four: Hold some exploratory meetings.
Once you've made sure your building meets the basic requirements for going solar, hold some exploratory meetings with school administrators and facility managers to present the idea of going solar. This is a good opportunity to get their feedback on solarization and whether they might be interested in exploring a project. This initial meeting is also a chance to identify any clear barriers that would make a project insurmountable (such as major issues with the roof, or plans to renovate the building in a few years). The meeting will give you a sense of any concerns the administration might have about solar, as well as questions they will need answered in order to consider a project.

For exploratory meetings you should bring basic information on solar energy and how solar panels can help schools save money on utility bills.

Step Five: Gather information about the project to present to decision makers.
Compiling and presenting financial and technical information about a potential solar installation will be helpful in convincing your school's administration to go solar. Topics to cover include: the cost of a system, payback period, incentives, solar technologies, and why your school's roof is a good fit for solar. You may need to have multiple meetings with administrators to provide them information, answer questions and identify concerns, and then return later with follow-up information.

Holding an exploratory meeting and presenting information about going solar is a good way to gauge the community's interest in a project and to identitfy and any concerns stakeholders may have.

Step Six: Build public support for the project.
As you are meeting with school administrators and decision-makers, you also need to build public support for the project. Your group can hold public meetings, present information about solar energy to students and parents, community members, and other key stakeholders, and solicit feedback. This is also a good time to launch a fundraising campaign, if necessary.

Step Seven: Secure approval for the project.
After you've held a number of exploratory meetings

with school and district administrators, your next step will be to secure administrative or board approval for the solar project. The level of approval you'll need depends on the school; during one of your initial exploratory meetings with administrators you should ask them about the process for getting a project approved. Don't be discouraged if this takes a while. Often administrators or decision makers support the idea of going solar, but are busy with more pressing issues and can't devote the time or energy necessary to drive the process forward. Your group of solar supporters should keep this in mind as you gently push to move things forward. It is possible to go solar!

Solar Curriculum, Activities, Events and Resources

A number of excellent solar curriculum and teacher-training resources are available for all grade levels. The most important educational opportunity is involving your kids in the process of taking the school solar. From assessing the site to selling cupcakes to raise money, or giving presentations to school officials, kids can play a powerful role.

Curriculum Resources

- The US Department of Energy has put together an Energy Education program that includes a database of lesson plans, labs, projects, and other activities for grades K-12 on energy-related topics.
- The Florida Solar Energy Center has produced curricula on solar. The center also provides educational tours so students can interact with researchers.
- The US Energy Information Administration is a good general resource: it manages a website with information about energy sources.
- The US Department of Energy (DOE) has a website devoted to the basics of renewable energy technologies, including how they work, what they're used for, and how they can improve our lives, homes, businesses, and industries. DOE also curates a YouTube channel with similar content.
- Solar Oregon has compiled curriculum resources for students. It also provides support to Oregon teachers to implement comprehensive solar curriculum in key districts.

Environment California recently released Making the Grade With Clean Energy: Case Studies of California Solar Schools, a report that provides an excellent overview of solar projects in California schools. The guide details a number of projects and how students have benefitted from hands-on solar learning opportunities. The report also includes recommendations for policy changes that would allow more California schools to benefit from going solar.

Activities and Resources for Students

Elementary School

- Energy & Kids gives a great introduction to all forms of renewable energy for children, and links to teacher resources on energy curriculum and related classroom activity ideas such as field trips and science fair projects.
- Some companies sell solar energy kits that you can use to demonstrate solar energy concepts.
- The Florida Solar Energy Center gives a great example of an easily adoptable solar energy curriculum for elementary schools through college:
  - Solar 1, K-2: Kids explore the fundamental benefits of solar energy, interdependence in the ecosystem, and the basics of UV rays through arts and crafts, such as making posters that share information.
  - Solar 2, 3-5: Kids build upon their previous

Students participate in a science fair event that includes energy demonstration tables (MN CERTs).

knowledge to explain what solar energy means for the sustainability of the earth through visual projects, constructing their own photovoltaic cells, and investigating forms of alternative energy in the world around them.

- The National Wildlife Federation has an Eco-Schools Program using teams of students, administrators, educators, and community volunteers to combine effective "green" management of the school grounds and facilities with curriculum.

Middle School

- Solar Energy International provides excellent hands-on labs, solar training, and renewable energy education for older kids. At the intermediate grade level, students will develop critical thinking skills and build upon foundational knowledge of math, science and technology to do hands-on projects, games, constructions, investigations and experiments with renewable energy.
- Florida Solar Energy Center also provides solar energy curricula for middle schoolers:
  - Solar 3, 6-8: (middle school) Kids learn about common misconceptions about the sun, the science of Earth's rotation, the electromagnetic spectrum, and the anatomy of a solar panel and how it is constructed. They do this through poster contests, hands-on science experiments, field trips, computer programs, and making their own energy cells.
- NEED (National Energy Education Development Project) has compiled a guide for middle school solar education standards that schools everywhere can adopt.
- Schools and students can form after-school clubs to help engage students on solar energy on an ongoing basis.
- In 2005 Sierra Middle School in Bakersfield, CA created the Kids for Solar Energy Club for students in grades 6 to 8. The club explores ways to use solar power to reduce greenhouse gases and climate change. Students use solar energy to prepare foods such as bread, pizza, chicken, and cookies. They also learn how to convert solar radiation into electricity to power model cars, fans, and lights, and they explore electric energy consumption by monitoring the amount of electricity appliances consume and making recommendations on using power strips or unplugging unused appliances. The club has actively promoted solar energy and green projects via presentations at a number of local schools, Earth Day festivals, the Green Expo, and other events.

Solar Energy Science Projects

NREL has put together a booklet of solar science fair projects.

- Illinois Solar Schools Program, sponsored by Illinois Clean Energy Community Foundation, teaches the value of renewable energy to K-12. Students see firsthand how sunlight is converted into electricity by watching online monitoring of real-time data on the daily amount of electricity generated. Since program launch in 2006, the foundation has awarded over $2 million in grants to over 220 Illinois schools for 1 kW PV systems. Each solar installation will generate 1,200 kWh of electricity and help avoid 1,350 lbs of CO_2 emissions.

High School

- NEED has compiled a guide for high school solar education standards that schools everywhere can adopt.
- Wisconsin Public Service hosts an annual Solar Olympics, a one-day event for high school students to learn about renewable energy and project management.
- Make It Solar has a list of solar-related science fair projects students can undertake.

- The Florida Solar Energy Center hosts the Energy-Whiz Olympics with opportunities for students to demonstrate their knowledge of science, technology, mathematics, and engineering.
- Porterville Unified School District (CA) was named a recipient of a $1 million grant from the James Irvine Foundation. The grant's purpose was to create a district-wide system of career-themed pathways. SunPower (a company that designs, manufactures, and delivers solar technologies) is collaborating with PUSD on the program to provide both classroom learning and real-work experience to prepare kids for careers in technology, engineering, and other fields. One of the pathways is in Environmental Science, which integrates rigorous technical courses and college-prep curricula. The emphasis is on work-based learning. Students learn from local professionals through hands-on projects and studying current events relevant to sustainability. This "linked learning approach" brings together strong academics, demanding technical education, and real-world experience. Students follow industry-themed "pathways," multi-year comprehensive high school programs of integrated academic and career technical study organized around a theme, industry area, or industry sector.
- Ohio Solar Schools Program has installed solar panels in visible places and developed intensive teacher training to allow the district to turn its schools into laboratories. Ohio Solar Schools Initiative began partnering with American Electric Power's Learning from Light Initiative at Bluffsview Elementary in Worthington, OH in 1998. The system at Upper Arlington High School, OH in 2007 was their latest installation.

Students from all over the country compete in the Solar Car Challenge, in which they construct solar powered cars and compete on closed racetracks or along a designated racecourse (Solar Car Challenge).

Teacher Training

- The Solar Energy International (SEI) runs a Solar in the Schools program that includes teacher training workshops and a free online course providing an introduction to solar energy for educators.
- The National Energy Education Development Project (NEED) designs and delivers energy curricula for any classroom and any grade. It encompasses a curriculum portfolio of over 130 teacher and student guides and provides hands-on, inquiry-based training for teachers and school district energy personnel.
- Pacific Gas & Electric (PG&E) also offers teacher training workshops for K-12 public school teachers in its service area (California).

Solar and Eco Fairs

- Students can have fun while learning about solar technologies at solar and eco fairs. The group DC Solar United Neighborhoods has put together a list of great solar-specific kids activities.

Solar FAQs

How big are the panels?

The size of the panels varies depending on the manufacturer, but a single panel is generally 3-4 feet by 10-12 feet. The total space that a solar installation will occupy depends on the number of kW installed. A typical home will use 10 to 20 solar panels, while a system on a school could be much larger.

Cascade Power Group recently worked with a school district in Kirkland, WA, to help it go solar and save on its utility bills. District administrators were initially hesitant about the project because they felt their role was not to become energy producers. But when administrators reviewed their budgets and were presented with concrete information about the savings they could realize by going solar, they were much more interested in a project. Cascade helped the district incorporate a solar system into existing plans to build a new middle school, since schools often have separate funds available for building projects, beyond the annual operating budget.

Will a solar system include batteries?
No, the vast majority of solar systems are grid-connected. This means the solar panels are connected to your local utility electric grid to complement your normal power supply. On days when you produce more power than you consume you will send the excess power back to the grid and your school will receive a credit on your electric bill for that power (i.e. when you send electricity to the grid, your meter runs backwards).

What happens when the power goes out? Will the panels power the building?
When the power goes out, your solar panel will also automatically shut off. This is to prevent the system from sending electricity onto the grid, where line workers may be working and could be injured.

Will my solar energy system generate power only during the summer months?
No, your solar energy system will produce energy whenever the sun shines. But, because the days are shorter in the winter, you will produce less energy than during the summer.

Who insures or maintains the panels?
Once installed, the system becomes another part of the school that would be covered by the district's insurance policy as any other item on the school grounds. Depending on the manufacturer, warranties cover various parts of the system. If a school uses a third party and signs a PPA, then the third party owns, maintains, and insures the panels.

What are solar panels made of?
PV modules are usually made of crystalline silica – derived from sand or quartz – that is refined into metallurgical-grade silicon, then sliced into very thin wafers, which become the main component of photovoltaic panels.

Do solar panels generate noise?
No. Solar panels are completely quiet. The only sound in a solar installation is the junction box, located away from the panels themselves, where the collected DC energy is converted into usable AC electricity.

What about glare?
Solar panels are designed to absorb light and heat, not reflect it. The Federal Aviation Administration (FAA) even allows solar systems near airports because reflected glare is not a significant concern. FAA studies concluded solar panels with anti-reflective coatings reflect only about 2% of incoming light. Solar-panel glass is formulated to reduce reflection and facilitate maximum absorption of solar energy.

What about radiated heat?
Solar arrays collect no more heat than any other struc-

A solar powered fountain is a good activity for an outdoor fair or event. Students can see how the panels power the fountain and what happens when they shade the panel (DC SUN).

Students competing at a science fair with their solar project (Isaac Schools).

ture standing in the sun. Solar panels generate no net heat and there is no data to substantiate any claim to change in ambient temperature.

Is there a danger when a panel breaks?

Solar panels pose no significant danger of breakage. The panels are covered with highly durable tempered glass. In the event a panel breaks, workers responding to the break would exercise normal care when working around broken glass or electrical components.

Are fire or harmful fumes a danger?

Solar panels pose very minimal danger of fire because they are made of metal and glass and are sealed units. According to the Electric Power Research Institute, it is theoretically possible for hazardous fumes to be released in case of fire, and inhalation of these fumes could pose a risk to human health, but researchers generally do not believe these risks to be substantial given the short duration of fires and the relatively high melting point of the materials in the solar modules.

The Milpitas School District in California installed solar parking lot canopies on 14 properties. The district will save an estimated $12 million on electric bills over the 25-year lifetime of the system (ILSR).

Conclusion

Although the process will require your time and effort, it is possible to solarize your school. You can tailor your project to meet the needs of your facility, whether that means fundraising for a small demonstration project, using third-party financing for a very large system, or taking advantage of a model that falls somewhere in between. The model that will work for your school will depend on your administration, your district's financial resources, the state of your building, and what your school hopes to accomplish by going solar.

Regardless of the approach you take for going solar, though, it is important to remember that this process takes perseverance. Teachers, parents, and school administrators are busy and, while they may support a solar project, they may not have the time or energy to devote to making a project happen. Your role is therefore to guide your supporters and help gently drive the project forward. It will require persistence, but it is possible to take your school solar!