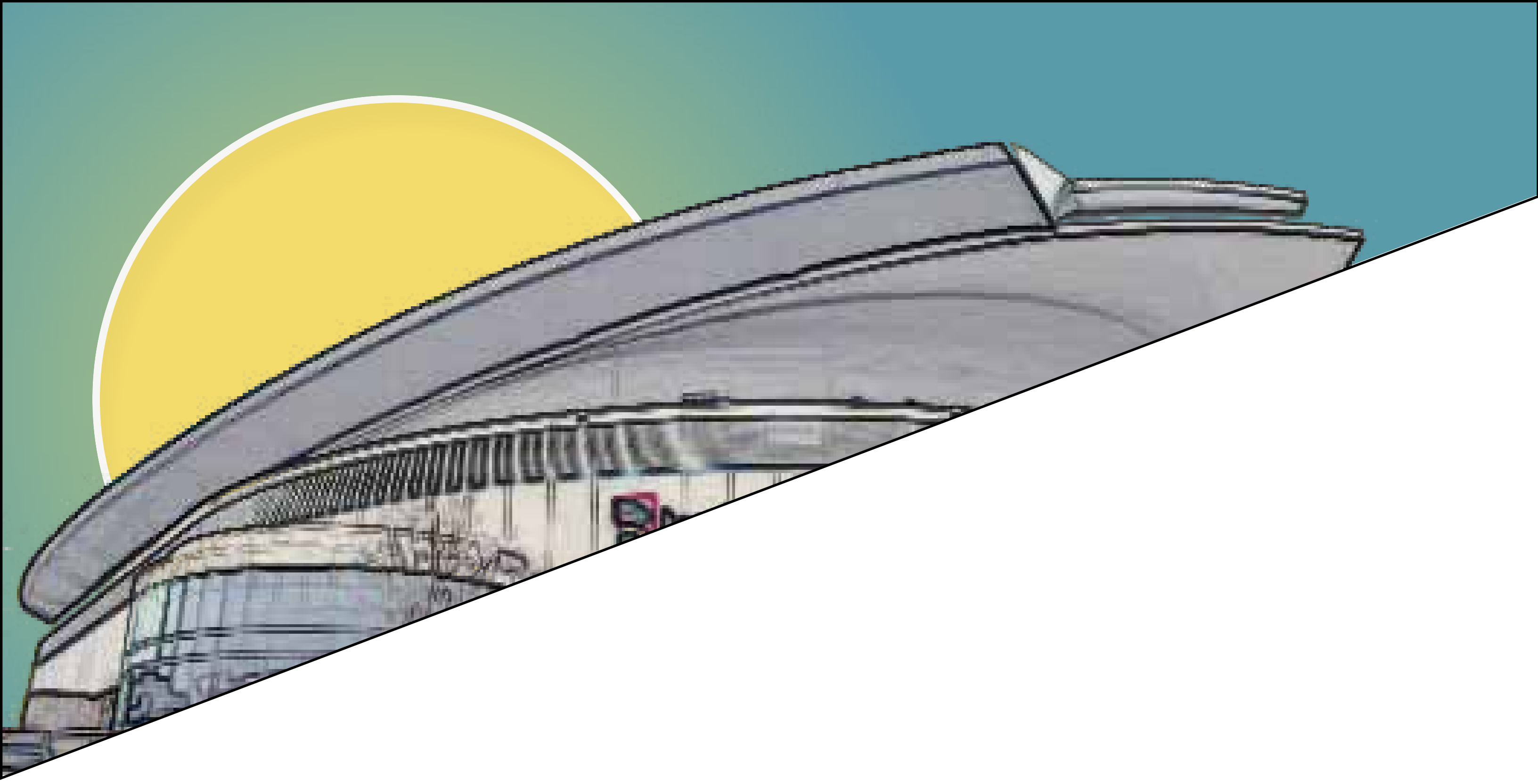

# Solar Electric Energy for your Stadium or Arena

A Guide to Understanding the Opportunities of On-Site Photovoltaic Solar Power Generation

BONNEVILLE ENVIRONMENTAL FOUNDATION

NRDC
THE EARTH'S BEST DEFENSE

July 26, 2010

## About NRDC

The Natural Resources Defense Council is an international nonprofit environmental organization with more than 1.3 million members and online activists. Since 1970, our lawyers, scientists, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment. NRDC has offices in New York City, Washington, D.C., Los Angeles, San Francisco, Chicago, Livingston, Montana, and Beijing. Visit us at www.nrdc.org.

## About the Bonneville Environmental Foundation (BEF)

Bonneville Environmental Foundation (BEF) is an entrepreneurial nonprofit that is creating a more sustainable future by investing now in clean energy and fresh water. When customers purchase BEF's independently certified carbon offsets and renewable energy certificates, they support the reduction of greenhouse gas emissions and the development of new renewable energy facilities. Additionally, their purchase supports long-term watershed restoration and renewable energy education for students and communities nationwide because BEF reinvests its net revenue to fund its Model Watershed and Solar 4R Schools programs. Since its inception in Portland, Ore. in 1998, BEF has been a pioneer in helping people and companies become better stewards of the environment. For more information, see http://www.b-e-f.org.

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# Executive Summary

**• There are many ways to lower the initial capital costs of installing solar.**

We know you've heard solar is expensive, but there are many ways to lower initial capital costs. Federal and State solar incentives are making solar installation more affordable, and some utilities and local governments have additional grant and rebate programs that could also help to subsidize the project. It may be possible to enter into a power purchase agreement so that your facility would host a solar array that was owned by a third party. However you decide to approach the project and the subsequent financing, this is the right time to be considering installing solar. With incentives currently making it more affordable and the movement still fresh enough to provide valuable leadership opportunities, there may never be a better time to act.

**• An Energy Audit is the first step.**

Before considering the installation of a solar array, it is worth looking at the way that your facility already uses energy. Understanding the energy efficiency of your building is the first step in any energy project. Therefore, it makes sense to start any project by getting an energy audit. These are often provided for free or at low cost by your local energy provider. An energy audit will provide a better sense of your facility's current energy use and what can be done to reduce energy costs. For your investment, reducing energy consumption will provide the greatest returns, and the financial returns from saving energy can be used to help fund your solar project.

**• Construction of the solar array can likely be completed in the off-season.**

While the design, permitting and installation schedules will vary greatly, the actual construction of the solar array can be accomplished with relative efficiency and could therefore likely be completed in the off-season, thereby creating minimal disruption to the functioning of the facility.

**• The Federal government offers tax incentives to install PV systems.**

As an incentive to install PV systems, the federal government offers a Business Energy Investment Tax Credit to the commercial and industrial sectors and to utilities. This credit covers 30% of the cost of the PV system, including labor and installation costs. There is no maximum for the federal incentive. It is scheduled to remain at the current 30% until December 31, 2016, when it will be reduced to 10% of system costs.

**• Power Purchase Agreements allow solar systems to be owned and maintained by third party.**

A power purchase agreement (PPA) allows your facility to host a solar installation and reap almost all of the benefits of solar without the initial cost outlay. In such an arrangement, the solar array is owned, operated and maintained by a third party, which then sells the energy back to your facility. The array, located on or near your property, still provides a powerful symbol of environmental commitment, and through the PPA, you are guaranteed a predictable energy price that may be less subject to future energy price increases. A PPA is a common arrangement for commercial applications of solar and may be well-suited to professional sports clubs who want to show their commitment to renewable energy but are not in a position to finance the installation of a photovoltaic system themselves.

**• In addition to solar installations, there are a number of ways to support green energy.**

The world of "green energy" is a sometimes complex one and can extend well beyond the simplicity of installing solar panels on the roof and tying them into the grid-system. Of course, that is a perfect example of green energy, but it often doesn't end there. There are three ways of obtaining the right to claim that your building is green-powered without owning a renewable energy system. One is to purchase green power from a utility. In such an instance, you will pay a premium above the usual cost of energy and thereby support the renewable systems that source the utility's green energy. A second method of purchasing claims and thereby supporting green energy is by buying renewable energy certificates (RECs). The last method of supporting renewable energy without an on-site system is through the purchasing of carbon offsets. Offsets are not exactly the same as renewable energy certificates. While RECs represent a bundled quantity of green energy (one REC is the equivalent of 1 MWh), offsets represent a bundled quantity of avoided carbon dioxide (one carbon offset is the equivalent of 1 metric ton of avoided greenhouse gases).

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✷ SOLAR ENERGY BECOMES MORE COST-EFFECTIVE OVER TIME, AND SINCE IT IS PRODUCED DURING THE DAY WHEN ENERGY PRICES ARE LIKELY TO BE AT A PREMIUM, SOLAR ELECTRIC PRODUCTION CAN REDUCE YOUR CONSUMPTION OF HIGH PRICED ENERGY.

# Why Go Solar?

There are many reasons that make this a good time to consider installing a solar energy system.

### • Reducing Your Environmental Impact

We are facing a planetary emergency. If we fail to reduce greenhouse gas emissions from burning fossil fuels such as oil and coal, adverse consequences will increase. Scientists predict that if we continue in the way we're going, the Earth could warm by 7.2 degrees Fahrenheit during the 21st century. The impacts of these changes will be far-reaching, affecting weather patterns, wildlife, air quality and human health.

### • Becoming a Leader in This Movement

This is an opportunity to lead by example locally and nationally. People pay attention when major league sports organizations take action.

### • Education and Public Relations

Your professional sports club is in a position to have a beneficial impact on these issues beyond the direct environmental benefits of reducing greenhouse gas emissions. A renewable energy initiative undertaken in your sports stadium or arena would provide an excellent opportunity to educate fans and to raise awareness about energy efficiency and renewable energy in your community.

### • Supporting Energy Independence and Local Commerce

As it currently stands, meeting our energy needs by conventional means is perpetuating our reliance on imported fuel. Additionally, hosting an on-site solar project means that you will not only be meeting part of your electricity load with a clean, local source of energy, but also supporting the local solar industry.

### • Potential Future Economic Benefits

The likelihood that energy costs will continue to rise is high. Alternatively, solar energy becomes more cost-effective over time, and since it is produced during the day when energy prices are likely to be at a premium, solar electric production can reduce your consumption of high priced energy.

We know you've heard solar is expensive, but there are many ways to lower initial capital costs. Federal and State solar incentives are making solar installation more affordable, and some utilities and local governments have additional grant and rebate programs that could also help to subsidize the project. It may also be possible to enter into a power purchase agreement so that your facility would host a solar array that was owned by a third party. However you decide to approach the project and the subsequent financing, this is the right time to be considering installing solar. With incentives currently making it more affordable and the movement still fresh enough to provide valuable leadership opportunities, there may never be a better time to act.

# The Process

### 1 Energy Audit

To get an accurate sense of the energy use and efficiency of the building, first get an energy audit. This is often free from local energy providers. While not strictly necessary for installing a solar array, it is useful to know if your facility is operating as efficiently as possible before undertaking any major renewable energy projects.

*See "Energy Efficiency and the Energy Audit," page 3.*

### 2 Incentive Determination

Identifying eligible incentives for the project will help to determine the feasible size and cost of the system and whether a power purchase agreement (PPA) would be possible.

*See Appendix C for information on state incentives, page 17.*

### 3 Site Survey and Feasibility Study

An on-site survey from someone knowledgeable in solar installation will provide more accurate system cost estimates, identify the most eligible and practical location and size for the system, and establish energy production projections.

*See "Estimating Costs" and "System Ideas," pages 5 and 10; also see Appendix D, page 22, for city-specific estimates.*

### 4 Budget and Funding Strategies Development

Once the site survey is done, a budget can be worked up and funding strategies can be considered.

*See "Funding Ideas and Strategies" and "A Power Purchase Agreement," pages 6 and 7.*

### 5 Releasing a Request for Proposals

A request for proposals (RFP) can invite bids from either local contractors or potential partners for a power purchase agreement.

*See "Releasing a Request for Proposals," page 8.*

### 6 System Design and Installation

Once a proposal is accepted, the system can be designed and installed. At this time, the permits must be obtained, materials selected, and the system itself needs to be installed. This will include the construction of racking structures, panel installation, wiring and electrical work and tying the system into both the facility's electrical system and the grid. After that, an inspection will take place, and then system monitoring will begin.

### 7 Incentives and Accelerated Depreciation

Once the project is installed, any upfront tax credits or incentives can be claimed that year. Incentives that are based on the actual energy production of the system will often be applied after the system has begun to function. Additionally, the accelerated depreciation schedule will provide tax deductions on revenues for five years, ultimately amounting to about 30% of the system's cost.

*See Appendix C, page 17.*

✷ THE COST OF POWER FROM THE SYSTEM WILL REMAIN CONSTANT, IMMUNE TO FUTURE PRICE INCREASES.

## ENERGY EFFICIENCY AND THE ENERGY AUDIT

Before considering the installation of a solar array, it is worth looking at the way that your facility already uses energy. Understanding the energy efficiency of your building is the first step in any energy project. Therefore, it makes sense to start any project by getting an energy audit. These are often provided for free or at low cost by your local energy provider. An energy audit will provide a better sense of how your facility is using energy and what can be done to reduce energy costs. For your investment, reducing energy consumption will provide the greatest returns, and the financial returns from saving energy can be used to help fund your solar project. Ultimately, it is the implementation of all conservation options, such as efficient light fixtures or better monitoring systems, that will make your facility's energy consumption more cost-effective and environmentally responsible. Remember the "greenest" electricity is the power that we don't consume.

The energy audit is also useful in terms of sizing a potential on-site solar project. Knowing your electricity load helps to scope what's possible in terms of energy savings from power produced through your solar system.

## WHO HAS ALREADY GONE SOLAR?

In California, there are more than 50,000 residences with solar panels on their roofs, 100 times the number of ten years ago. In 2004 the state launched a "Million Solar Roof" initiative, which aims to create 3 million kilowatts of installed photovoltaic capacity by 2018.

> On top of the garage at the **US Airways Center** in Phoenix, AZ, an 18,000 sq. ft. solar array was installed in 2009. The project was made possible by a power purchase agreement with Tioga Energy, who invested the upfront costs, amounting to around $1.5 million, and is responsible for the solar system's upkeep for the next 20 years. Tioga Energy, in turn, gets the rebates from Arizona Public Service (APS), which have been estimated at between $60,000 to $85,000 a year.

> In January 2010, the **city of Minneapolis** entered a similar agreement with Best Power International. The system will be built on the roof of the Minneapolis Convention Center, taking up about half of the building's roof, consisting of just over 2,600 panels and supplying 5% to 8% of the convention center's total energy use. Best Power International will own the system and, working with Westwood Renewables, provide design, engineering and project management. A $2 million grant from Xcel's Energy Renewable Development Fund will go toward the cost of the system. The cost to the city of powering the building will increase from $18,000 to $21,500 annually, but the cost of power from the system will remain constant, immune to future price increases.

> **Fresno State University** entered another such agreement with MMA Renewable Ventures, and installed a 1.1 MW system at the campus in November 2007. The installation is comprised of 10 structures in parking areas, providing 700 covered parking stalls, generating more than 1.5 million kWh of energy annually (enough to power approximately 125 U.S. homes annually). The $11.9 million dollar initial cost was covered by MMA Renewable Ventures, which then received the federal tax incentives, totaling over $3.5 million dollars, as well as $2.8 million dollars in rebate money from PG&E under California's Self Generation Incentive Program. MMA Renewable Ventures now sells the energy back to the university at a fixed rate, and over its 30-year lifespan, the system is projected to save the university about $13 million in avoided utility costs.

> The corporate world has also begun looking toward solar energy as a way to cut down on energy costs, offset its environmental impact and improve public image. In January 2007, **Staples, Inc.** installed a 433.7 kW solar system on the roof of their Killingly, Connecticut distribution center. The system, which covers almost 74,000 square feet, produces about 412,218 kWh annually, enough to supply 14% of the facility's total energy use. The system was financed by SunEdison, who entered a power purchase agreement with Staples, and additionally by a grant from the Connecticut Clean Energy Fund, which totaled $1.7 million.

> In October 2009, **Dell** completed a 130 kW solar installation in the parking lot of their headquarters in Round Rock, Texas. The system is comprised of 516 photovoltaic modules set into 11 solar canopies. It produces approximately 131,000 kWh annually, provides shade for roughly 50 parking spaces, and includes plug-in stations for 2 electric vehicles.

However, while we have these and more examples from across the United States, this is still a young movement. Organizations are breaking new ground every year. The installation planned for the top of the Minneapolis Convention Center will be the largest in the upper Midwest to date, 50% larger than the next

✷ WHEN CONSIDERING THE COST OF SOLAR ENERGY, IT IS PROBABLY MOST HELPFUL TO THINK ABOUT THE PROJECTED PAYBACK PERIOD OF THE SYSTEM.

largest, built at St. John's University in the fall of 2009. There are therefore numerous ways to become a leader and to support this growing industry, and with incentives currently helping to lower costs, there has never been a better time to get involved.

## THE INSTALLATION TIMELINE

While the design, permitting and installation schedules will vary greatly, the actual construction of the solar array can be accomplished with relative efficiency and could therefore likely be completed in the off-season, thereby causing minimal disruption to the functioning of the facility.

For instance, when St. John's University and Abbey installed a 400-kW, 1,820-panel system at their site in Collegeville, Minnesota, construction began in mid-September 2009 and was completed by the end of November of that year.

When FedEx installed a 2.4 MW rooftop installation at their distribution facility in Woodbridge, NJ – a project consisting of 12,400 solar panels and covering 3.3 acres of rooftop – the installation was completed in less than four months. Construction began in August 2009 and was completed by November.

## SOLAR ENERGY AND LEED CERTIFICATION

LEED, which stands for Leadership in Energy and Environmental Design and was developed by the U.S. Green Building Council, is a sustainable building certification system that provides internationally recognized third-party verification for green building projects. Achieving LEED certification is an excellent and meaningful way to demonstrate that your building project is environmentally responsible.

Photovoltaic systems can help your building achieve LEED certification by supplying points under the LEED Energy and Atmosphere credit 2. As of LEED 2009 (version 3.0 of the accreditation system), it is possible to earn up to 7 points through the installation of an on-site renewable energy system.

LEED certification points are determined based on the percentage of the building's overall energy costs that are offset by the renewable energy system. The break down of credits to the percentage of cost displacement is shown in the table to the right.

| Percentage Renewable Energy | Points |
|---|---|
| 1% | 1 |
| 3% | 2 |
| 5% | 3 |
| 7% | 4 |
| 9% | 5 |
| 11% | 6 |
| 13% | 7 |

## CONSIDERING THE COST OF SOLAR

When thinking about the cost of installing a solar energy system, it is useful to note that costs are structured differently from a traditional energy purchase. When buying energy from a utility, consumers pay for the energy they consume in units of kilowatt-hours. However, with a solar energy system, costs are based on installed kilowatt capacity, and actual energy production (in kilowatt-hours) is dependent on system productivity. Therefore, when considering the cost of solar energy, it is probably most helpful to think about the projected payback period of the system. Variables in this calculation are the expected productivity of the system, the cost of energy at the site and available incentives. After the system has paid for itself, the energy generated is essentially free. However, payback can take anywhere from less than five years to more than forty, depending on the cost of conventional energy, the size of the array, the applicable PV incentives and the productivity of the system.

## FACTORS THAT IMPACT SYSTEM PRODUCTIVITY

The most obvious variable that affects the productivity of a solar array is the amount of sun to which the system is exposed. However, this isn't the entire story. While it is true that a sunny environment is good for producing solar energy, that doesn't mean that Southern California is the only place that solar energy makes sense or even that it is always the best place for a solar array. In fact, one of the less-considered factors is that solar electric panels become less productive as they heat up.

Furthermore, geographical location isn't the only factor that affects sun exposure. One important thing to keep in mind is the impact of shading. Shade from nearby buildings or other obstructions will have a very significant impact on the productivity of the system, and it is therefore important to choose a site carefully.

Another variable is the orientation of the system – whether the panels are set up in such a way as to absorb the most sunlight possible. For instance, the system that will be installed on top of the Minnesota Convention Center is designed so that the panels are set up in three slightly different directions to fill different demands. One-third of the array's panels are oriented for overall maximum energy capture, one-third for maximum capture at the time of the convention center's peak energy use, and one-third for maximum capture at the time of Xcel's peak demand.

Because of the way that orientation impacts productivity, some people opt to put tracking devices on their solar panels. This works particularly well on a pole-mounted array. This way, the photovoltaic modules actually follow the progress of the sun and maintain the highest productivity level possible as the sun moves throughout the day and year.

Another, often unconsidered factor is simply the cleanliness of the panels. Something as rudimentary as keeping the modules free from dirt makes a difference in how much energy a system produces.

## ESTIMATING COSTS

According to a study done by the Lawrence Berkeley National Laboratory, the average cost of installed PV in 2008 was $7.50 per watt. However, the cost of a solar installation can vary greatly. It is dependent on the size and location of the system. Prices can be lower when materials are bought in volume, and per-watt costs are decreased when equipment, development and transaction costs are dispersed over a larger number of watts. In addition, project costs will be affected by such factors as the structural installation that the site requires and the local solar market. The following table provides the average cost of installed solar per-watt for different system sizes. These numbers are estimates derived from information in the Lawrence Berkeley National Laboratory study *Tracking the Sun II: The Installed Cost of Photovoltaics in the U.S. from 1998-2008.*

| System Size | Average Per-Watt Cost | Cost Range |
|---|---|---|
| <2 kW | $9.00 | $7.00-$11.50 |
| 2-5 kW | $8.50 | $7.00-$10.00 |
| 5-10 kW | $8.00 | $6.50-$9.50 |
| 10-30 kW | $8.00 | $6.50-$9.50 |
| 30-100 kW | $8.00 | $5.75-$10.25 |
| 100-250 kW | $7.50 | $5.75-$9.75 |
| 250-500 kW | $7.50 | $5.50-$8.25 |
| 500-750 kW | $7.50 | $5.00-$7.75 |

By extrapolating from these numbers, it is possible to estimate the cost of a project according to its scale.

| System Size | Cost Estimate | With Federal Tax Credit |
|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 |
| 250 kW | $1,750,000 | $1,225,000 |
| 100 kW | $750,000 | $525,000 |
| 50 kW | $400,000 | $280,000 |
| 25 kW | $200,000 | $140,000 |
| 10 kW | $80,000 | $56,000 |

THE SAN FRANCISCO GIANTS, FOR INSTANCE, NOW HOUSE A SOLAR ARRAY FOR PG&E, WHICH OWNS THE SYSTEM AND USES THE ENERGY GENERATED TO HELP MEET THEIR RENEWABLE ENERGY PORTFOLIO REQUIREMENTS.

These averages encompass all costs associated with both materials and full installation, including racking structures, permitting, warranties, etc. However, it should be remembered that the numbers above should be taken only as estimates of what you might expect to pay. While these costs reflect full system components, actual costs will be affected by the amount of needed structural reinforcements and additional installation requirements. Also, permitting fees, codes for construction, and other factors dictated by the local solar market will vary by state and city. In general, states with larger PV markets will have more competitive installation costs and possibly a more streamlined permitting process.

It should also be noted that these numbers reflect cost averages from 2008. The trend has seen solar prices decreasing over time, and it is possible that current market prices are lower in your area.

## PHOTOVOLTAIC INSTALLATION INCENTIVES

As an incentive to install PV systems, the federal government offers a Business Energy Investment Tax Credit to the commercial and industrial sectors and to utilities. This credit covers 30% of the cost of the PV system, including labor and installation costs. There is no maximum for the federal incentive. It is scheduled to remain at the current 30% until December 31, 2016, when it will be reduced to 10% of system costs.

Enacted in February 2009, the American Recovery and Reinvestment Act of 2009 has made it possible to forego this tax credit in lieu of an upfront federal grant, offered by the US Department of Treasury in the renewable energy grants program. While this program currently only extends until the end of 2010, it is possible that the program will be extended.

Also, under the Modified Accelerated Cost-Recovery System (MACRS), the depreciation schedule is accelerated so that all the deductions can be claimed over the first five years, reducing the payback period substantially.

Additionally, many states offer their own incentives. These vary dramatically in amount, in the way they are calculated and in the schedule of payment. Some of them are structured in the same way as the federal credit, reimbursing a percentage of the system's cost. Many state incentive programs have a cap, creating a maximum incentive amount. Other states have set incentives based on the wattage capacity rating of the array, and still others base their incentives on annual kWh production. See appendix C for more information on state-by-state incentives.

## FUNDING IDEAS AND STRATEGIES

There are numerous approaches to financing the installation of a solar system, a few of which are discussed here. A power purchase agreement (PPA) might provide an excellent and convenient solution and will be explained in the next section.

Another financing approach involves partnering with a utility. The San Francisco Giants, for instance, now house a solar array for PG&E, which owns the system and uses the energy generated to help meet their renewable energy portfolio requirements.

A third approach involves partnering with a solar company. Particularly in areas where local solar markets are still up-and-coming, it is sometimes possible to get solar installers to donate or discount the labor associated with projects that will generate good publicity. In such an instance, much of the costs for the project would be limited to purchasing the materials.

Similarly, because of the unique and powerful position that professional sports clubs hold, it might be worth talking to solar providers about creating an educational or promotional opportunity within the sports facility in exchange for reduced costs. This would not only be a way to support the local solar market, but also to provide education about renewable energy to the community.

Other ideas include selling the project as a sponsorship package or having buy-ins within the community so that individuals or local businesses could own a piece of the system – such as a solar panel – and have their names posted.

You might also consider selling some piece of the renewable energy claims generated by the system to fans by having a "solar ticket" option. For instance, fans might be given the option of buying a special ticket whereby they would pay slightly more to support the solar electric system and to offset some of their own energy use or carbon impact.

✷ IF PR AND THE ASSOCIATED CLAIMS ARE A GOAL FOR SUPPORTING A SOLAR PROJECT AND YOU CHOOSE THE PPA APPROACH, THEN YOU SHOULD EXPECT TO NEGOTIATE (AND PAY A PREMIUM) FOR LEGAL RIGHTS TO "OWN" THE ENVIRONMENTAL BENEFITS AND TO MAKE PUBLIC CLAIMS.

There are additional loan and grant programs that might provide further funding opportunities. The Improvement and Extension Act of 2008, for instance, authorized the issuance of Qualified Energy Bonds (QECBs), which can be used by local governments to fund certain energy projects. Property-Assessed Clean Energy (PACE) is a property tax lien financing program that allows property owners to borrow money to pay for energy projects. The loan is then repaid over a period of 20 years according to an annual assessment on the property tax bill. To find out if your state has passed legislation allowing PACE financing, go to either the PACE or DSIRE website (www.pacenow.org or www.dsire.org).

The US Department of Energy has created the Energy Efficiency and Conservation Block Grant Program (EECBG), which provides grants to be used in a variety of energy efficiency and conservation projects including renewable energy installations on government buildings.

Financing options for solar projects are varied; some states, counties and cities have grant programs, and, of course, different communities may present their own funding possibilities.

## A POWER PURCHASE AGREEMENT

A power purchase agreement (PPA) allows your facility to host a solar installation and reap almost all of the benefits of solar without the initial cost outlay. In such an arrangement, the solar array is owned, operated and maintained by a third party, which then sells the energy back to your facility. The array, located on or near your property, still provides a powerful symbol of environmental commitment, and through the PPA, you are guaranteed a predictable energy price that may be less subject to future energy price increases, while upkeep on the system is maintained by a third party.

A PPA is a common arrangement for commercial applications of solar and may be well-suited to professional sports clubs who want to show their commitment to renewable energy but are not in a position to finance the installation of a photovoltaic system themselves. The Phoenix Suns, for instance, have entered into such an agreement for the 194-kilowatt solar array located on the US Airways Garage roof.

Another example is the San Diego Convention Center (SDCC). In December 2009, they announced a partnership with Alternative Energy Capital in the installation of a 538 kW photovoltaic solar system. The power purchase agreement came into being after the SDCC put out a request for proposals (RFP) and ultimately settled on Alternative Energy Capital to procure, install, own and maintain the system, which will consist of 1,900 solar panels and cover roughly 90,000 sq. ft. on the center's roof.

Although the project is estimated to cost $3.2 million, the SDCC will not expend any funds for installation. Instead, the San Diego Convention Center has agreed to buy the energy produced by the system for a period of 20 years at 18.8¢/kWh, which is less than the SDCC currently pays San Diego Gas & Electric for energy. The system will produce enough energy to cover approximately 10% of the convention center's energy consumption and is expected to save the SDCC about $1.7 million in electricity costs over the next two decades. At the end of twenty years, the center will have the option of buying the PV system outright from Alternative Energy Capital.

Similarly, in 2009 the Oregon Convention Center (OCC) entered into an arrangement with SunEdison. In the spring of 2010, SunEdison will be constructing a 1.184 MW PV system on the roof of the OCC. SunEdison is responsible for financing, constructing, and operating the system. The Oregon Convention Center will then buy the energy produced by the system from SunEdison at a fixed price at or below current retail rates. The PV array is projected to produce enough energy to account for 12% of the facility's current use.

In October 2009, Solar Tech, a group in California, released a contract template for power purchase agreements. More information can found at their website, www.solartech.org.

So what's the catch when using a PPA approach to solar? It's in the claims. Owning your own solar project allows you the right to make claims regarding the environmental benefits resulting from your project. For instance, you can state that some or all of your operations are "solar powered," and you can claim the greenhouse gas reduction benefits (e.g., your project reduced XX tons of carbon dioxide emissions).

Using a PPA approach means that you do not own the system, but rather you are a host for one. This also means that you are hosting a system that provides environmental benefits, but you don't own those

✷ A RFP WILL OFTEN STATE A DESIRED SYSTEM SIZE RANGE, THE PROJECTED TIME LINE FOR THE PROJECT, AND WHERE THE FACILITY OWNER WOULD LIKE THE ARRAY TO BE LOCATED. A RFP CAN ALSO EXPLICITLY LAY OUT EXPECTATIONS FOR BOTH THE PROJECT AND THE PROPOSER, INCLUDING WHO WOULD OWN THE ENVIRONMENTAL ATTRIBUTES PRODUCED BY THE PV SYSTEM.

and should not make any public claims around being "solar powered" or to the associated greenhouse gas reduction benefits. If PR and the associated claims are a goal for supporting a solar project and you choose the PPA approach, then you should expect to negotiate (and pay a premium) for legal rights to "own" the environmental benefits and to make public claims.

## RELEASING A REQUEST FOR PROPOSALS (RFP)

After deciding to pursue a solar project, the next step would typically be issuing a request for proposals. This can be done either to find a group to own and operate the system in a power purchase agreement or to get bids from designers and contractors to do the installation work.

If you decide to own the PV system, the request for proposals will be a fairly standard request for bids from contractors. However, it would not be unusual to engage in a partnership with a third party who would manage the development and oversee installation of the project. A project manager can help establish the basic blueprint of the project based on the site and your needs. The manager can issue the RFP, review the proposals that come back, and ultimately oversee the project.

The Bonneville Environmental Foundation (BEF), for instance, issued a RFP on behalf of the Snohomish Public Utility District Headquarters (a publicly-owned utility located in Washington State) in the spring of 2009, in which the project manager clearly stated the parameters of the project. The Utility stipulated the size, location, attributes of the materials to be used, and the specifics about the mounting system, and BEF indicated these requirements in the bidding document. BEF has also provided expertise to northwestern professional sports organizations who are actively pursuing various green initiatives, including large solar arrays.

If a Power Purchase Agreement is desirable, there are some things to keep in mind. Whether or not a PPA will ultimately work is greatly impacted by the incentives that are available at your site. In states with higher incentives or when dealing with meaningful utility incentives, you can obtain a better deal from potential partners.

While the third party in a PPA will ultimately be responsible for the materials, feasibility and design, it may be helpful for you to have determined some general things about the array before preparing the RFP. A RFP will often state a desired system size range, the projected time line for the project, and where the facility owner would like the array to be located. A RFP can also explicitly lay out expectations for both the project and the Proposer, including who would own the environmental attributes produced by the PV system.

For instance, the RFP issued by the Metropolitan Exposition-Recreation Commission (MERC) to get a PPA for the Oregon Convention Center states that the desired PV array will be between 1 MW and 1.25 MW and that it will be constructed on the southern portion of the Center's roof. The RFP also specifies that the successful Proposer will be responsible for obtaining all building and other permits, for constructing, insuring, operating and maintaining the system, for all necessary inspections, and for monitoring the systems performance. Furthermore, MERC stipulates that the expected cost of energy from the system will be equal to or less than the Convention Center's current energy costs. MERC entered into a PPA agreement with SunEdison in November of 2009.

## UNDERSTANDING GREEN ENERGY

The world of "green energy" is a sometimes complex one and can extend well beyond the simplicity of installing solar panels on the roof and tying them into the grid-system. Of course, that is a perfect example of green energy, but it often doesn't end there.

It is, for instance, possible to power a building with green energy without an on-site renewable energy system, and conversely, it is also possible to have an on-site renewable energy system without being able to claim that your building is "green powered."

There are three ways of obtaining the right to claim that your building is green-powered without owning a renewable energy system. One is to purchase green power from a utility. In such an instance, you will pay a premium above the usual cost of energy and thereby support the renewable systems that source the utility's green energy.

✷ CONNECTING TO THE GRID IS AN IMPORTANT PIECE OF INSTALLING A RENEWABLE ENERGY SYSTEM BECAUSE IT ENSURES THAT, EVEN IF YOU AREN'T CONSUMING THE ENERGY THAT THE SYSTEM IS PRODUCING AT THE TIME OF PRODUCTION, IT IS BEING DISTRIBUTED AND USED.

A second method of purchasing claims and thereby supporting green energy is by buying renewable energy certificates (RECs). This will be explained more fully in the following section. It is very similar to purchasing green utility power, except that you pay the premium above the usual cost of energy to a third party in a separate transaction from purchasing your actual energy.

Conversely, if you own a grid-tied renewable energy system such as a solar array, you would also own the renewable energy certificates that the system generates, and these would become a separate commodity from the energy itself. You could then sell the RECs to help finance the system. In such a case, you would be selling the environmental claims to another party and might therefore actually be using the energy created by the solar array without legally being able to claim that your facility was "solar-powered."

## RENEWABLE ENERGY CERTIFICATES

Renewable Energy Certificates (also known as Renewable Energy Credits, Green Tags or RECs) represent legal title to the non-electricity benefits produced from renewable energy facilities. In terms of measurement, one REC represents the benefits produced from one megawatt-hour's worth of renewable energy. On average in the United States, this is approximately 1,500 pounds of greenhouse gas emissions avoided by not using electricity that would have been produced on the power grid by burning fossil fuels.

The equivalent to purchasing utility green power, buying RECs allows the purchaser to make claims of ownership for the environmental benefits that can be used to mitigate greenhouse gas emissions from their own activities. For instance a building may calculate that they have a "carbon footprint" resulting from their consumption of 10,000 MWh of electricity in a year. That building could elect to purchase 10,000 RECs in order to "offset" their carbon footprint resulting from that electricity use.

RECs are produced from any grid-connected renewable energy project (everything from large utility wind farms to residential-scale solar). When considering an on-site solar project, one should consider the RECs an asset to be produced by the solar system in the same way they would consider the electricity production.

RECs may be retained by the project owner or sold depending on the financing package for the project. If a renewable energy project owner sells its RECs, then it sells the right to claim any of the environmental benefits from their project (those rights have been purchased by another party). At the most basic level, it means that if I own a solar project and then sell the RECs to my neighbor, I don't get to make any claims about offsetting my carbon emissions or being "solar-powered." Those rights now belong to my neighbor whose dollars helped the project be funded (through buying the RECs).

As an entity considering a solar project, keep in mind that the RECs should be a point of financial negotiation. And if you intend to make any claims about being "solar-powered" or "offsetting emissions," then you need to retain or pay for the RECs generated from the system.

## GRID INTERCONNECTION AND NET METERING

Connecting to the grid is an important piece of installing a renewable energy system because it ensures that, even if you aren't consuming the energy that the system is producing at the time of production, it is being distributed and used. In most cases, whatever energy is distributed across the grid will then be credited to your energy bill by the utility. This is done through a net-metering process. However, net-metering policies vary by state and even sometimes by utility, and so it is important to know how the system works in your area. The Interstate Renewable Energy Council (IREC) maintains an online table that sets out net-metering laws, regulations and utility programs state-by-state at http://www.irecusa.org. This may be a useful resource to consult, as it may affect what system size is most desirable or feasible.

# SYSTEM IDEAS

There are many potential locations for installing solar panels, and each is site-dependent. The following are some possible locations to consider, including case studies of some existing installations.

## ARENA ROOF

One potential installation location is the roof of your facility. This location has the advantage of requiring minimal racking structures to hold the solar panels, which may cut down on the cost of the array. Barring the existence of taller buildings in the immediate vicinity, there is less of a chance that roof solar panels will be shaded out. However, some facilities may not have roofs with the load-bearing capacity necessary to support the additional weight of a PV array. One 2.5'x5' crystalline silicon solar module with a DC rating of between 130 and 230 W (usually about 170 W) weighs roughly 35 lbs, not including the racks or other structures required to hold them.

Another option for a roof installation where weight is a concern is thin-film solar cells. Thin-film cells are much lighter weight than the more traditional crystalline silicon solar panels and would have little impact on the existing roof. They would also be laid out directly on the roof, eliminating the need for racking structures. The disadvantage to thin-film cells is that the technology is not yet as efficient as crystalline silicon panels, and they therefore do not produce as much energy.

## PARKING LOTS AND GARAGES

For arenas with parking garages or unshaded parking lots, carport-like installations may be a good option. While the racking structures that cover parking spaces will add to the cost of the installation, they may provide other benefits such as shaded parking for cars and a reduction in the urban heat island effect created by large asphalt lots. Such installations are also highly visible, which is advantageous in creating an educational tool, in raising awareness in the community, and as a tangible symbol of environmental commitment. Additionally, as electric plug-in vehicles become more prevalent, it would be possible to incorporate charging stations in these arrays.

## CANOPY MOUNTED

Another possible site is a canopy over a pedestrian area. Both the San Francisco Giants and the Cleveland Indians installed such arrays at their ballparks: the Giants over the Willie Mays pedestrian ramp, and the Indians over a pavilion on the upper deck. Although this solution has the added cost of the canopy, it has the potential advantage of being highly visible and is well suited to a small demonstration installation.

# OFFICE BUILDING ROOF

Another option to consider is on the roof of a nearby building. As a part of their installation, the San Francisco Giants put an array on top of the Giants Building, an office building, which is a part of the stadium complex. This option could eliminate the cost of racking systems without raising any of the structural concerns that an arena roof might. The array would be a traditional rooftop installation.

# POLE MOUNTED

If a rooftop installation is not viable and a parking structure or canopy-mounted installation is either not feasible or not desirable, a pole-mounted array is another option. While such an array would entail mounting costs, one advantage of this type of system is that it can be adjusted seasonally to maximize energy production. It is also possible to take this principle one step further and install a tracking device on a pole-mounted system so that the solar modules follow the sun, increasing the array's output. This is a highly visible and space-efficient option, ideally suited for a demonstration or educational installation, and could be placed in almost any spot that does not get shaded.

# SAMPLE PV SYSTEM PROFILES

The following are a few examples of PV installations operating at professional sports arenas.

## STAPLES CENTER - ROOF INSTALLATION

**SYSTEM SIZE:**

345.6 kW DC

**SYSTEM SCHEMATICS:**

1,728 solar panels

approx. 25,000 sq. ft.

**ANNUAL ENERGY PRODUCTION:**

approx. 525,000 kWh

**SYSTEM COST:**

approx. $3.3 million

**PER-WATT COST:**

approx. $9.55

In December of 2008, an installation was completed on the roof of the STAPLES Center in Los Angeles, California. The system is comprised of 1,728 solar panels, creating an array rated at 345.6 kW DC capacity and covering about 25,000 sq. ft., half of the total area of the roof. This was the largest array that could be installed given the load-bearing capacity of the roof. Some structural reinforcement to the building was required. The system cost approximately $3.3 million dollars before incentives, placing the per-watt cost at about $9.55.

## US AIRWAYS CENTER – GARAGE ROOF INSTALLATION

**SYSTEM SIZE:**

194 kW DC

**SYSTEM SCHEMATICS:**

1,100 solar panels

approx. 18,000 sq. ft.

**ANNUAL ENERGY PRODUCTION:**

approx. 331,233 kWh

**SYSTEM COST:**

approx. $1.5 million

**PER-WATT COST:**

approx. $7.73

At the US Airways Center in Phoenix, Arizona, 1,100 panels were installed on the garage roof in July of 2009. The array is on the fifth level of the garage. This was chosen as the best location because the roof of the arena itself could not support the weight of the PV system. The array takes up about 18,000 sq. ft., is rated at 194 kW DC capacity, and provides shade for the cars parked on top of the garage roof. The system cost approximately $1.5 million before incentives, placing the per-watt cost at about $7.73. The annual incentives from APS were estimated to be between $60,000 and $85,000 annually, on top of the federal and Arizona state incentives, which were roughly $475,000.

## PROGRESSIVE FIELD – CANOPY INSTALLATION

**SYSTEM SIZE:**

8.4 kW DC

**SYSTEM SCHEMATICS:**

42 solar panels

86 ft. long

15 ft. high

**ANNUAL ENERGY PRODUCTION:**

approx. 9,400 kWh

**SYSTEM COST:**

approx. $180,000

**PER-WATT COST:**

approx. $15.48

Photo of the Progressive Field array, taken from http://www.easywaystogogreen.com/urban-and-city-green-living/solar-panels-and-major-league-baseball/

In June of 2007, the Cleveland Indians installed a PV array on a canopy. It is a part of a concession stand on the upper deck of the ballpark and provides shade over a pedestrian pavilion. The array is comprised of 42 solar panels and is rated at 8.4 kW DC capacity. Additionally, the installation has an educational component, equipped with a slideshow that runs constantly, giving current, real-time energy production information and suggesting ways for fans to get involved in renewable energy initiatives. The array is 86 ft. long and 15 ft. high. The total cost of the system, including the education component, was approximately $180,000. Roughly $50,000 of this was dedicated to the educational piece, which places the per-watt cost of the solar installation alone at about $15.48. Of the remaining $130,000, $30,000 was covered by grants and tax credits from the Ohio Department of Development.

## Appendix A – Glossary

### *General Energy Terms*

**Alternating Current (AC) electricity –** the form of electricity produced and transmitted over the power grid and most commonly used in day-to-day life.

**Direct Current (DC) electricity –** another form of electricity, which must then be converted into AC in order to be grid compatible; solar systems produce DC energy and photovoltaic module capacity is rated in DC.

**Greenhouse effect –** the buildup of greenhouse gases causing solar heat to become trapped within the atmosphere; human activity, such as the burning of fossil fuels, contributes to this phenomenon, creating an enhanced greenhouse effect that causes climate change.

**Greenhouse gases** – gases that contribute to the greenhouse effect; carbon dioxide, methane, nitrous oxide, water vapor, and halocarbons; carbon dioxide makes the largest net contribution to atmospheric changes that threaten disruptive global climate change.

**Grid –** the network of transmission lines, substations, and transformers that collect and distribute electricity across the country.

**Kilowatt (kW) –** a measure of power or rate of energy transmission equivalent to 1,000 watts.

**Kilowatt Hour (kWh) –** a unit used by utility companies to determine how much energy has been used over time; one kWh is equivalent to the energy it takes to run a 100-watt light bulb for 10 hours.

**Megawatt (MW)** – a measure of power or rate of energy transmission equivalent to 1,000 kilowatts.

**Megawatt Hour (MWh)** – 1,000 kWh; 1 MWh is roughly the amount of energy than an average home consumes in one month.

**Renewable energy – (**also referred to as green power), energy (or power) that is generated from renewable resources, such as a solar array or wind turbine; typically represents a decrease in greenhouse gas emissions over traditional fossil fuel-derived energy.

**Renewable portfolio standard –** regulations requiring that a utility provide a specified amount or percentage of electricity from renewable resources.

**Urban heat island effect** – an increase in temperature caused by land modification due to urban development, which reduces vegetation, prevents natural heat radiation, and introduces heat-retaining materials such as concrete and asphalt.

### *Solar Terms*

**Crystalline silicon panels** – (also called wafer silicon panels) solar modules consisting of silicon crystals; currently the most widely used solar panels.

**Inverter –** a piece of equipment that converts the DC electricity produced by the solar array into AC electricity.

**Net metering –** the system that tracks the amount of energy that flows back into the grid from an onsite renewable energy source, such as a solar array; allows the owner of the solar array to accumulate an energy credit or payment.

**Photovoltaic (PV) –** describes a technology capable of producing voltage when exposed to light energy; solar-electric.

**Photovoltaic module –** a packaged, interconnected group of photovoltaic cells; essentially, a solar panel.

**Solar array –** the entire system of connected photovoltaic modules.

**Solar water heating –** a system or method in which solar energy is used to heat water.

**Thin-film cells** – solar cells that are usually made by thin-film laminating photovoltaic materials; a thinner, lighter, but as of this time less efficient alternative to the more traditional crystalline silicon solar panel.

### *Federal Incentive Terms*

**Accelerated depreciation deductions –** allows businesses to recover investments through tax deductions on certain kinds of property as their value depreciates; for solar arrays, this schedule is accelerated to span a five year period.

**Business Energy Investment Tax Credit –** federal tax credit providing incentive money based on the initial investment in a renewable energy system; it covers 30% of project costs for photovoltaic solar. Originally available under 26 USC § 48, it was later expanded first in the *Energy Policy Act of 2005*, increasing the 10% credit to a 30% credit, and then by the *Energy Improvement and Extension Act of 2008* and *The American Recovery and Reinvestment Act of 2009*. The current 30% credit will remain in place until December 31, 2016, when it will revert back to 10%.

**Renewable Electricity Production Tax Credit –** federal production tax credit providing incentives on a per kWh basis; however, while this production incentive covers many renewable technologies, photovoltaic solar is not one of them.

**US Department of Treasury Renewable Energy Grants** – grant money that can be taken in lieu of the Business Energy Investment Tax Credit.

### *Environmental Benefit Terms*

**Double counting –** credit for the environmental benefits associated with a single unit of carbon credit or offset claimed by more than one party.

**Greenwashing –** promoting or exaggerating environmental benefits of a product or service that are not really present.

**Renewable energy certificate (REC) –** a property right representing a claim to the environmental benefits (i.e. greenhouse gas emission displacement) associated with the production of 1,000 kWh (or 1 MWh) of clean, renewable energy; also referred to as a green tag or a renewable energy credit.

**Verification** – third party oversight of a REC or offset product which involves the determination that each kilowatt sold to an entity is only sold once and originates from a qualifying project.

### *Other Important Concepts*

**Green building –** building design, construction, and operation that conforms to principles of sustainability and energy efficiency, most commonly known as the US Green Building Council's LEED program (Leadership in Energy and Environmental Design).

**Power purchase agreement (PPA) –** an agreement whereby a third party owns and maintains the solar installation and sells the energy produced back to the property owner or tenant.

## APPENDIX B – PHYSICAL DIMENSIONS OF PV MODULES

As a generalization, a standard crystalline silicon 2.5'x5' solar module (or panel) has a DC capacity rating of between 130 and 230 watts and weighs approximately 35 lbs. The chart below gives general weight and spatial dimensions for different size systems using an average weight of 35 lbs per 170-watt module. However, it should be remembered that these numbers reflect only the size and weight of the solar panels and that the actual array will require additional racking structures and spacing between the panels.

| System Size | Required Number of 170-W Panels | Estimated Weight of Modules | Estimated Spatial Dimensions of Modules |
|---|---|---|---|
| 500 kW | 2,941 | 102,935 lbs | 36,763 sq. ft. |
| 250 kW | 1,470 | 51,450 lbs | 18,375 sq. ft. |
| 100 kW | 588 | 20,580 lbs | 7,350 sq. ft. |
| 50 kW | 294 | 10,290 lbs | 3,675 sq. ft. |
| 25 kW | 147 | 5,145 lbs | 18,38 sq. ft. |
| 10 kW | 59 | 2,065 lbs | 738 sq. ft. |

## APPENDIX C – STATE INCENTIVES

The table below provides state-by-state incentive information, current as of March 2010, for all states in the US that have MLB, NBA, NHL, NFL or MLS teams. The incentives summarized here do not include the utility rebate programs of individual utility companies, production incentives that would require the sale of renewable energy credits or potential grant money. This information can be found in the Database of State Incentives for Renewables and Efficiency (DSIRE) at www.dsireusa.org. As state incentives change often, it is important to check that you have the most up to date information.

| State | Incentives | Contacts |
|---|---|---|
| Arizona | • Arizona State Corporate Tax Credit: 10% of installed cost, not to exceed $25,000 in one year, expires 12/31/2010. | Arizona Department of Commerce Energy Office<br>(602) 771-1100<br>solarenergy@azcommerce.com<br>www.azcommerce.com/Energy/ |
| California | • California Solar Initiative: incentives are scaled to decrease as demand increases based on district; as of the end of March, 2010 incentives were at $0.15 per kWh in the PG&E and SDG&E service areas and at $0.22 per kWh in the SCE service area.<br>• *For San Francisco solar installations only:* San Francisco Solar Energy Incentive Program: $1,500 per kW, maximum incentive of $10,000. | Pacific Gas & Electric (PG&E)<br>(877) 743-4112<br>solar@pge.com<br>www.pge.com/solar<br><br>California Center for Sustainable Energy (CCSE)<br>(858) 244-1177<br>csi@energycenter.org<br>www.energycenter.org<br><br>Southern California Edison (SCE)<br>(800) 799-4177<br>greenh@sce.com<br>www.sce.com<br><br>San Francisco Public Utilities Commission<br>(415) 551-4318<br>solarincentive@sfwater.org<br>http://sfwater.org/home.cfm |
| Colorado | • No current state-wide incentives | |
| Florida | • State Incentive Program: $4 per watt, maximum of $100,000, expires 6/20/2010. | Florida Energy Office<br>(850) 487-3800<br>energy@eog.myflorida.com<br>http://www.myfloridaclimate.com |

| | | |
|---|---|---|
| Georgia | • Clean Energy Tax Credit: 35% of system cost, maximum incentive of $500,000, expires 12/31/2012. | Georgia Department of Revenue<br>(404) 417-4480<br>taxpayer.services@dor.ga.gov<br>https://etax.dor.ga.gov/ |
| Illinois | • State Rebate Program: 30% of system cost, maximum incentive of $50,000, minimum system size of 1 kW. | Scott Henkel<br>Dept. of Commerce & Economic Opportunity<br>(217) 785 3968<br>scott.henkel@illinois.gov |
| Indiana | • No current state-wide incentives | |
| Louisiana | • No current state-wide incentives | |
| Maryland | • Clean Energy Production Tax Credit: $0.0085 per kWh, maximum of $2.5 million over five years, expires 12/3/2010.<br>• State Rebate Program: $1.25 per Watt for first 2 kW; $0.75 per Watt for next 6 kW; and $0.25 per Watt for next 12 kW, to maximum of $10,000 (maximum qualifying system size is 20 kW). | Chris Rice<br>Maryland Energy Administration<br>(410) 260-7207<br>CRice@energy.state.md.us<br>http://www.energy.state.md.us/<br><br>Public Information Officer<br>Maryland Energy Administration<br>(410) 260-7655<br>meainfo@energy.state.md.us<br>http://www.energy.state.md.us/ |
| Massachusetts | • Commonwealth Solar Stimulus: $1.50 per watt for the first 25 kW, $1.00 per watt for the next 75 kW, $0.50 per watt for the final 100 kW, minimum system size of 5 kW, maximum size 200 kW. | Massachusetts Clean Energy Center<br>cs@masscec.com<br>www.commonwealthsolar.org/ |
| Michigan | • No current state-wide incentives | |
| Minnesota | • No current state-wide incentives | |
| Missouri | • No current state-wide incentives | |
| New Jersey | • New Jersey Customer-Sited Renewable Energy Rebates: $0.90 per Watt, 50 kW system maximum, funding cycle closes tri-annually.<br>• State loan/grant program could provide up to 50% of project | New Jersey Board of Public Utilities<br>Office of Clean Energy<br>(866) 657-6278<br>www.njcleanenergy.com/renewable-energy/home/home |

| | | |
|---|---|---|
| | costs, 80% of which could be grants. *If RECs were going to be sold, it would be loan only, loan has 0% interest for a term of up to 10 years* | New Jersey Economic Development Authority<br>(866) 534-7789<br>CESCI@njeda.com<br>www.njeda.com/ |
| New York | • NYSERDA -- PV Incentive Program: $1.75 per watt, maximum incentive of $112,500, expires 6/30/2010. *Generated RECs would be owned by NYSERDA for the first 3 years* | New York State Energy Research and Development Authority<br>(518) 862-1090<br>info@nyserda.org<br>http://www.nyserda.org |
| North Carolina | • Renewable Energy Tax Credit: 35% of system cost, $2.5 million maximum, expires 12/31/2015. | Brian Lips<br>North Carolina Solar Center<br>(919) 515-3954<br>brian_lips@ncsu.edu<br>http://www.ncsc.ncsu.edu<br><br>Department of Revenue<br>(877) 252-3052<br>(877) 308-9103<br>www.dornc.com/ |
| Ohio | • ODOD - Advanced Energy Program Grants: *(Customers must be in the service area of one of the following utilities -- American Electric Power, Dayton Power & Light, Duke Energy, or FirstEnergy.)* $3.50 per watt, minimum system size is 10 kW (DC) for traditional systems and 50 kW for third-party systems, maximum grant award is the lesser of 50% of project costs, or $150,000 for traditional systems and $200,000 for third-party systems | Preston Boone<br>Ohio Department of Development Energy Office<br>Preston.Boone@development.ohio.gov<br>www.odod.state.oh.us/cdd/oee/ |
| Oklahoma | • No current state-wide incentives | |

| | | |
|---|---|---|
| Oregon | • Business Energy Tax Credit: 50% of eligible project costs, distributed over 5 years (10%/year), $10 million maximum, expires 5/1/2010. | Matt Hale<br>Oregon Department of Energy<br>(503) 378-4040<br>Matt.Hale@state.or.us<br>www.oregon.gov/energy<br><br>Oregon Department of Revenue<br>(503) 378-4988<br>http://www.oregon.gov/DOR/ |
| Pennsylvania | • No current state-wide incentives | |
| Tennessee | • Tennessee Clean Energy Technology Grant: 40% of system cost, maximum of $75,000 | Ryan Gooch<br>Tennessee Department of Economic & Community Development<br>Energy Division<br>(615) 741-2994<br>Ryan.Gooch@state.tn.us<br>www.tennessee.gov/ecd/CD_energy.html<br><br>Gil Melear-Hough<br>Southern Alliance for Clean Energy<br>(865) 637-6055 Ext.15<br>gil@cleanenergy.org<br>www.cleanenergy.org/ |
| Texas | • No current state-wide incentives | |
| Utah | • Renewable Energy Systems Tax Credit: 10% of system cost, maximum set at $50,000. | Elise Brown<br>State Energy Program<br>(801) 537-3365<br>elisebrown@utah.gov<br>http://geology.utah.gov/sep/<br><br>Utah State Tax Commission<br>(801) 297-2200<br>tax.utah.gov/index.html |
| Washington | • Washington Renewable Energy Production Incentive: $0.12 per kWh - $0.54 per kWh through 6/30/2020, not to exceed $5,000 per year; higher incentive rate is applicable if all array materials were manufactured in Washington State. | Phil Lou<br>Washington State University<br>The Northwest Solar Center<br>(206) 629-8017<br>http://northwestsolarcenter.org |

| | | |
|---|---|---|
| Wisconsin | • Focus on Energy - Renewable Energy Cash-Back Rewards: *(System must be in the service territory of a participating electric provider.)* $1.00 per kWh produced annually, for lesser of 25% of system costs or $50,000, minimum system size is 0.5 kW, maximum is 50 kW. | Focus On Energy - Renewable Energy Program<br>(800) 762-7077<br>renewableapplications@focusonenergy.com<br>www.focusonenergy.com |

## APPENDIX D – LOCATION SPECIFIC ESTIMATES

Following are cost estimates for systems of different sizes, adapted to select cities. These location-specific estimates include state incentives, approximate energy production based on the location's sun exposure, and payback calculations using average state energy costs. As these numbers use state averages to estimate energy costs, they are here to provide a general sense of payback time, and do not reflect definite projections. Additionally, it should be remembered that because solar energy is produced during peak-demand hours, payback periods could be shorter than these estimates reflect.

Annual Energy Production was calculated assuming a fixed tilt array facing due south at a tilt equal to location's latitude and a DC to AC derate factor of 0.8, which represents the amount of energy lost during conversion from direct to alternating current. Avoided $CO_2$ Emissions were calculated using an average national approximation of 1,500 lbs per kWh; actual avoided emissions will vary based on local energy systems. Pay back period was calculated based on state-average energy cost.

Anaheim, California

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 764,003 kWh | 5 years | 1,146,000 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 382,002 kWh | 6 years | 573,000 lbs/yr |
| 100 kW | $750,000 | $525,000 | 152,801 kWh | 7 years | 229,200 lbs/yr |
| 50 kW | $400,000 | $280,000 | 76,400 kWh | 8 years | 114,600 lbs/yr |
| 25 kW | $200,000 | $140,000 | 38,200 kWh | 8 years | 57,300 lbs/yr |
| 10 kW | $80,000 | $56,000 | 15,280 kWh | 8 years | 22,920 lbs/yr |

**Calculated using incentive rates current as of March 2010 for the SCE district: $0.22 per kWh and the state average energy cost of $0.125 per kWh.*

Arlington, Texas

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 729,620 kWh | 18 years | 1,094,430 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 364,810 kWh | 20 years | 547,215 lbs/yr |
| 100 kW | $750,000 | $525,000 | 145,920 kWh | 21 years | 218,880 lbs/yr |
| 50 kW | $400,000 | $280,000 | 72,960 kWh | 23 years | 109,440 lbs/yr |
| 25 kW | $200,000 | $140,000 | 36,480 kWh | 23 years | 54,720 lbs/yr |
| 10 kW | $80,000 | $56,000 | 14,590 kWh | 23 years | 21,885 lbs/yr |

**Calculated using the average state energy cost of $0.097 per kWh.*

Atlanta, Georgia

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $1,775,000 | 699,425 kWh | 14 years | 1,049,140 lbs/yr |
| 250 kW | $1,750,000 | $725,000 | 349,713 kWh | 7 years | 524,570 lbs/yr |
| 100 kW | $750,000 | $262,500 | 129,885 kWh | <5 years | 194,830 lbs/yr |
| 50 kW | $400,000 | $140,000 | 69,943 kWh | <5 years | 104,910 lbs/yr |
| 25 kW | $200,000 | $70,000 | 34,491 kWh | <5 years | 51,740 lbs/yr |
| 10 kW | $80,000 | $24,000 | 13,989 kWh | <5 years | 20,980 lbs/yr |

**Calculated using the average state energy cost of $0.079 per kWh.*

Baltimore, Maryland

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 638,599 kWh | 26 years | 957,900 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 319,300 kWh | 28 years | 478,950 lbs/yr |
| 100 kW | $750,000 | $525,000 | 127,720 kWh | 30 years | 191,580 lbs/yr |
| 50 kW | $400,000 | $280,000 | 63,860 kWh | 32 years | 95,790 lbs/yr |
| 25 kW | $200,000 | $140,000 | 31,930 kWh | 32 years | 47,895 lbs/yr |
| 10 kW | $80,000 | $48,500 | 12,772 kWh | 24 years | 19,160 lbs/yr |

**Calculated using the average state energy cost of $0.078 per kWh.*

Boston, Massachusetts

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 646,768 kWh | 17 years | 970,150 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 323,384 kWh | 18 years | 485,080 lbs/yr |
| 100 kW | $750,000 | $450,000 | 129,354 kWh | 15 years | 194,030 lbs/yr |
| 50 kW | $400,000 | $217,500 | 64,677 kWh | 13 years | 97,015 lbs/yr |
| 25 kW | $200,000 | $102,500 | 32,338 kWh | 11 years | 48,510 lbs/yr |
| 10 kW | $80,000 | $41,000 | 12,935 kWh | 11 years | 19,400 lbs/yr |

**Calculated using the average state energy cost of $0.118 per kWh.*

Buffalo, New York

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,162,500 | 559,483 kWh | 15 years | 839,225 lbs/yr |
| 250 kW | $1,750,000 | $1,112,500 | 279,741 kWh | 14 years | 419,610 lbs/yr |
| 100 kW | $750,000 | $412,500 | 111,897 kWh | 12 years | 167,845 lbs/yr |
| 50 kW | $400,000 | $192,500 | 55,948 kWh | 9 years | 83,920 lbs/yr |
| 25 kW | $200,000 | $96,250 | 27,974 kWh | 9 years | 41,960 lbs/yr |
| 10 kW | $80,000 | $38,500 | 11,190 kWh | 9 years | 16,785 lbs/yr |

**Calculated using the average state energy cost of $0.145 per kWh.*

Chicago, Illinois

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,225,000 | 611,661 kWh | 24 years | 917,490 lbs/yr |
| 250 kW | $1,750,000 | $1,175,000 | 305,831 kWh | 25 years | 458,750 lbs/yr |
| 100 kW | $750,000 | $475,000 | 122,332 kWh | 24 years | 183,500 lbs/yr |
| 50 kW | $400,000 | $230,000 | 61,166 kWh | 21 years | 91,750 lbs/yr |
| 25 kW | $200,000 | $90,000 | 30,583 kWh | 12 years | 45,875 lbs/yr |
| 10 kW | $80,000 | $32,000 | 12,233 kWh | 8 years | 18,350 lbs/yr |

**Calculated using the average state energy cost of $0.084 per kWh.*

Charlotte, North Carolina

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $1,137,500 | 685,324 kWh | <5 years | 1,027,990 lbs/yr |
| 250 kW | $1,750,000 | $612,500 | 342,662 kWh | <5 years | 513,990 lbs/yr |
| 100 kW | $750,000 | $262,500 | 137,065 kWh | <5 years | 205,600 lbs/yr |
| 50 kW | $400,000 | $140,000 | 68,532 kWh | <5 years | 102,800 lbs/yr |
| 25 kW | $200,000 | $70,000 | 34,266 kWh | <5 years | 51,400 lbs/yr |
| 10 kW | $80,000 | $28,000 | 13,706 kWh | <5 years | 20,560 lbs/yr |

**Calculated using the average state energy cost of $0.085 per kWh.*

Cincinnati, Ohio

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,125,000 | 609,140 kWh | 22 years | 913,710 lbs/yr |
| 250 kW | $1,750,000 | $1,075,000 | 304,570 kWh | 21 years | 456,855 lbs/yr |
| 100 kW | $750,000 | $365,000 | 121,830 kWh | 14 years | 182,745 lbs/yr |
| 50 kW | $400,000 | $130,000 | 60,910 kWh | <5 years | 91,365 lbs/yr |
| 25 kW | $200,000 | $40,000 | 30,460 kWh | <5 years | 45,690 lbs/yr |
| 10 kW | $80,000 | $16,000 | 12,180 kWh | <5 years | 18,270 lbs/yr |

**Calculated using the average state energy cost of $0.085 per kWh.*

Cleveland, Ohio

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,125,000 | 569,332 kWh | 23 years | 854,000 lbs/yr |
| 250 kW | $1,750,000 | $1,075,000 | 284,666 kWh | 22 years | 427,000 lbs/yr |
| 100 kW | $750,000 | $365,000 | 113,866 kWh | 14 years | 170,800 lbs/yr |
| 50 kW | $400,000 | $130,000 | 56,933 kWh | <5 years | 85,400 lbs/yr |
| 25 kW | $200,000 | $40,000 | 28,467 kWh | <5 years | 42,700 lbs/yr |
| 10 kW | $80,000 | $16,000 | 11,387 kWh | <5 years | 17,080 lbs/yr |

**Calculated using the average state energy cost of $0.085 per kWh.*

Columbus, Ohio

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,125,000 | 584,935 kWh | 23 years | 877,400 lbs/yr |
| 250 kW | $1,750,000 | $1,075,000 | 292,467 kWh | 22 years | 438,700 lbs/yr |
| 100 kW | $750,000 | $365,000 | 116,987 kWh | 14 years | 175,480 lbs/yr |
| 50 kW | $400,000 | $130,000 | 58,493 kWh | <5 years | 87,740 lbs/yr |
| 25 kW | $200,000 | $40,000 | 29,247 kWh | <5 years | 43,870 lbs/yr |
| 10 kW | $80,000 | $16,000 | 11,699 kWh | <5 years | 17,550 lbs/yr |

**Calculated using the average state energy cost of $0.085 per kWh.*

Dallas, Texas

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 729,620 kWh | 18 years | 1,094,430 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 364,810 kWh | 20 years | 547,215 lbs/yr |
| 100 kW | $750,000 | $525,000 | 145,920 kWh | 21 years | 218,880 lbs/yr |
| 50 kW | $400,000 | $280,000 | 72,960 kWh | 23 years | 109,440 lbs/yr |
| 25 kW | $200,000 | $140,000 | 36,480 kWh | 23 years | 54,720 lbs/yr |
| 10 kW | $80,000 | $56,000 | 14,590 kWh | 23 years | 21,885 lbs/yr |

**Calculated using the average state energy cost of $0.097 per kWh.*

Denver, Colorado

| Array Rating Size | Flat Cost | With Incentives* | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,075,000 | 758,283 kWh | 15 years | 1,137,420 lbs/yr |
| 250 kW | $1,750,000 | $1,025,000 | 379,142 kWh | 16 years | 568,710 lbs/yr |
| 100 kW | $750,000 | $325,000 | 151,657 kWh | 18 years | 227,485 lbs/yr |
| 50 kW | $400,000 | $180,000 | 75,828 kWh | 19 years | 113,740 lbs/yr |
| 25 kW | $200,000 | $90,000 | 37,914 kWh | 19 years | 56,870 lbs/yr |
| 10 kW | $80,000 | $36,000 | 15,166 kWh | 19 years | 22,750 lbs/yr |

**Includes Xcel Utility Rebate and calculated using the average state energy cost of $0.084 per kWh.*

Detroit, Michigan

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 596,108 kWh | 26 years | 894,160 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 298,054 kWh | 28 years | 447,080 lbs/yr |
| 100 kW | $750,000 | $525,000 | 119,222 kWh | 30 years | 178,830 lbs/yr |
| 50 kW | $400,000 | $280,000 | 59,611 kWh | 32 years | 89,420 lbs/yr |
| 25 kW | $200,000 | $140,000 | 29,805 kWh | 32 years | 44,710 lbs/yr |
| 10 kW | $80,000 | $56,000 | 11,922 kWh | 32 years | 17,880 lbs/yr |

**Calculated using the average state energy cost of $0.083 per kWh.*

East Rutherford, New Jersey

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 615,377 kWh | 19 years | 923,065 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 307,688 kWh | 20 years | 461,530 lbs/yr |
| 100 kW | $750,000 | $525,000 | 123,075 kWh | 22 years | 184,610 lbs/yr |
| 50 kW | $400,000 | $235,000 | 61,538 kWh | 17 years | 92,310 lbs/yr |
| 25 kW | $200,000 | $117,500 | 30,769 kWh | 17 years | 46,150 lbs/yr |
| 10 kW | $80,000 | $47,000 | 12,308 kWh | 17 years | 18,460 lbs/yr |

**Calculated using the average state energy cost of $0.112 per kWh.*

Green Bay, Wisconsin

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 627,947 kWh | 23 years | 941,920 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 313,974 kWh | 24 years | 470,960 lbs/yr |
| 100 kW | $750,000 | $525,000 | 125,589 kWh | 26 years | 188,380 lbs/yr |
| 50 kW | $400,000 | $280,000 | 62,795 kWh | 19 years | 94,190 lbs/yr |
| 25 kW | $200,000 | $140,000 | 31,387 kWh | 11 years | 47,095 lbs/yr |
| 10 kW | $80,000 | $56,000 | 12,559 kWh | 11 years | 18,840 lbs/yr |

**Calculated using the average state energy cost of $0.091 per kWh.*

Houston, Texas

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 634,499 kWh | 21 years | 951,750 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 317,250 kWh | 22 years | 475,875 lbs/yr |
| 100 kW | $750,000 | $525,000 | 126,900 kWh | 24 years | 190,350 lbs/yr |
| 50 kW | $400,000 | $280,000 | 63,450 kWh | 26 years | 95,175 lbs/yr |
| 25 kW | $200,000 | $140,000 | 31,725 kWh | 26 years | 47,590 lbs/yr |
| 10 kW | $80,000 | $56,000 | 12,690 kWh | 26 years | 19,035 lbs/yr |

**Calculated using the average state energy cost of $0.097 per kWh.*

Indianapolis, Indiana

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 636,483 kWh | 28 years | 954,725 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 318,241 kWh | 30 years | 477,360 lbs/yr |
| 100 kW | $750,000 | $525,000 | 127,297 kWh | 32 years | 190,945 lbs/yr |
| 50 kW | $400,000 | $280,000 | 63,648 kWh | 34 years | 95,470 lbs/yr |
| 25 kW | $200,000 | $140,000 | 31,824 kWh | 34 years | 47,740 lbs/yr |
| 10 kW | $80,000 | $56,000 | 12,730 kWh | 34 years | 19,095 lbs/yr |

**Calculated using the average state energy cost of $0.073 per kWh.*

Jacksonville, Florida

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,175,000 | 668,630 | 20 years | 584,935 lbs/yr |
| 250 kW | $1,750,000 | $1,125,000 | 334,315 | 20 years | 292,467 lbs/yr |
| 100 kW | $750,000 | $425,000 | 133,726 | 17 years | 116,987 lbs/yr |
| 50 kW | $400,000 | $180,000 | 66,863 | 10 years | 58,493 lbs/yr |
| 25 kW | $200,000 | $40,000 | 33,432 | <5 years | 29,247 lbs/yr |
| 10 kW | $80,000 | $16,000 | 13,373 | <5 years | 11,699 lbs/yr |

**Calculated using the average state energy cost of $0.090 per kWh.*

Kansas City, Missouri

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 682,360 kWh | 27 years | 1,023,540 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 341,180 kWh | 29 years | 511,770 lbs/yr |
| 100 kW | $750,000 | $525,000 | 136,470 kWh | 31 years | 204,705 lbs/yr |
| 50 kW | $400,000 | $280,000 | 68,236 kWh | 34 years | 102,354 lbs/yr |
| 25 kW | $200,000 | $140,000 | 34,120 kWh | 34 years | 51,180 lbs/yr |
| 10 kW | $80,000 | $56,000 | 13,650 kWh | 34 years | 20,475 lbs/yr |

**Calculated using the average state energy cost of $0.070 per kWh.*

Los Angeles, California

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 764,003 kWh | 5 years | 1,146,000 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 382,002 kWh | 6 years | 573,000 lbs/yr |
| 100 kW | $750,000 | $525,000 | 152,801 kWh | 7 years | 229,200 lbs/yr |
| 50 kW | $400,000 | $280,000 | 76,400 kWh | 8 years | 114,600 lbs/yr |
| 25 kW | $200,000 | $140,000 | 38,200 kWh | 8 years | 57,300 lbs/yr |
| 10 kW | $80,000 | $56,000 | 15,280 kWh | 8 years | 22,920 lbs/yr |

**Calculated using incentive rates current as of March 2010 for the SCE district: $0.22 per kWh and using the state average energy cost of $0.125 per kWh.*

Memphis, Tennessee

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,200,000 | 695,770 kWh | 26 years | 1,043,655 lbs/yr |
| 250 kW | $1,750,000 | $1,150,000 | 347,880 kWh | 26 years | 521,820 lbs/yr |
| 100 kW | $750,000 | $450,000 | 139,150 kWh | 23 years | 208,725 lbs/yr |
| 50 kW | $400,000 | $205,000 | 68,580 kWh | 17 years | 102,870 lbs/yr |
| 25 kW | $200,000 | $65,000 | 34,790 kWh | <5 years | 52,185 lbs/yr |
| 10 kW | $80,000 | $24,000 | 13,915 kWh | <5 years | 20,870 lbs/yr |

**Calculated using the average state energy cost of $0.069 per kWh.*

Miami, Florida

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,175,000 | 696,548 kWh | 19 years | 1,044,820 lbs/yr |
| 250 kW | $1,750,000 | $1,125,000 | 348,274 kWh | 19 years | 522,410 lbs/yr |
| 100 kW | $750,000 | $425,000 | 139,310 kWh | 15 years | 208,965 lbs/yr |
| 50 kW | $400,000 | $180,000 | 68,655 kWh | 9 years | 102,980 lbs/yr |
| 25 kW | $200,000 | $40,000 | 34,827 kWh | <5 years | 52,240 lbs/yr |
| 10 kW | $80,000 | $16,000 | 12,931 kWh | <5 years | 19,400 lbs/yr |

**Calculated using the average state energy cost of $0.090 per kWh.*

Milwaukee, Wisconsin

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 638,338 kWh | 22 years | 957,507 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 319,169 kWh | 24 years | 478,750 lbs/yr |
| 100 kW | $750,000 | $525,000 | 123,668 kWh | 26 years | 185,500 lbs/yr |
| 50 kW | $400,000 | $280,000 | 63,834 kWh | 19 years | 95,750 lbs/yr |
| 25 kW | $200,000 | $140,000 | 31,917 kWh | 11 years | 47,875 lbs/yr |
| 10 kW | $80,000 | $56,000 | 12,767 kWh | 11 years | 19,150 lbs/yr |

**Calculated using the average state energy cost of $0.091 per kWh.*

Minneapolis, Minnesota

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 668,494 kWh | 24 years | 1,002,740 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 334,247 kWh | 26 years | 501,370 lbs/yr |
| 100 kW | $750,000 | $525,000 | 133,699 kWh | 28 years | 200,550 lbs/yr |
| 50 kW | $400,000 | $280,000 | 66,849 kWh | 30 years | 100,270 lbs/yr |
| 25 kW | $200,000 | $140,000 | 33,425 kWh | 30 years | 50,140 lbs/yr |
| 10 kW | $80,000 | $56,000 | 13,370 kWh | 30 years | 20,055 lbs/yr |

**Calculated using the average state energy cost of $0.079 per kWh.*

Nashville, Tennessee

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,200,000 | 664,402 kWh | 27 years | 996,600 lbs/yr |
| 250 kW | $1,750,000 | $1,150,000 | 332,201 kWh | 27 years | 498,300 lbs/yr |
| 100 kW | $750,000 | $450,000 | 132,880 kWh | 25 years | 199,320 lbs/yr |
| 50 kW | $400,000 | $205,000 | 66,440 kWh | 19 years | 99,660 lbs/yr |
| 25 kW | $200,000 | $65,000 | 33,220 kWh | <5 years | 49,830 lbs/yr |
| 10 kW | $80,000 | $24,000 | 13,288 kWh | <5 years | 19,932 lbs/yr |

**Calculated using the average state energy cost of $0.069 per kWh.*

New Orleans, Louisiana

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 664,238 kWh | 24 years | 996,360 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 332,119 kWh | 26 years | 498,180 lbs/yr |
| 100 kW | $750,000 | $525,000 | 132,848 kWh | 27 years | 199,270 lbs/yr |
| 50 kW | $400,000 | $280,000 | 66,424 kWh | 29 years | 99,640 lbs/yr |
| 25 kW | $200,000 | $140,000 | 33,212 kWh | 29 years | 49,820 lbs/yr |
| 10 kW | $80,000 | $56,000 | 13,285 kWh | 29 years | 19,930 lbs/yr |

**Calculated using the average state energy cost of $0.081 per kWh.*

New York City, New York

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,162,500 | 633,758 kWh | 13 years | 950,640 lbs/yr |
| 250 kW | $1,750,000 | $1,112,500 | 316,879 kWh | 13 years | 475.320 lbs/yr |
| 100 kW | $750,000 | $412,500 | 126,752 kWh | 10 years | 190,130 lbs/yr |
| 50 kW | $400,000 | $192,500 | 63,376 kWh | 8 years | 95,060 lbs/yr |
| 25 kW | $200,000 | $96,250 | 31,688 kWh | 8 years | 47,530 lbs/yr |
| 10 kW | $80,000 | $38,500 | 12,675 kWh | 8 years | 19,010 lbs/yr |

**Calculated using the average state energy cost of $0.145 per kWh.*

Oakland, California

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 751,608 kWh | 8 years | 1,127,410 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 375,804 kWh | 9 years | 563,700 lbs/yr |
| 100 kW | $750,000 | $525,000 | 150,322 kWh | 10 years | 225,480 lbs/yr |
| 50 kW | $400,000 | $280,000 | 75,161 kWh | 11 years | 112,740 lbs/yr |
| 25 kW | $200,000 | $140,000 | 37,580 kWh | 11 years | 56,370 lbs/yr |
| 10 kW | $80,000 | $56,000 | 15,032 kWh | 11 years | 22,550 lbs/yr |

**Calculated using incentive rates current as of March 2010 for the PG&E district: $0.15 per kWh and using the average state energy cost of $0.125 per kWh.*

Oklahoma City, Oklahoma

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 741,450 kWh | 23 years | 1,112,175 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 370,730 kWh | 25 years | 556,095 lbs/yr |
| 100 kW | $750,000 | $525,000 | 148,290 kWh | 26 years | 222,435 lbs/yr |
| 50 kW | $400,000 | $280,000 | 74,145 kWh | 28 years | 111,220 lbs/yr |
| 25 kW | $200,000 | $140,000 | 37,070 kWh | 28 years | 55,605 lbs/yr |
| 10 kW | $80,000 | $56,000 | 14,830 kWh | 28 years | 22,245 lbs/yr |

**Calculated using the average state energy cost of $0.077 per kWh.*

Orlando, Florida

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,175,000 | 709,210 kWh | 19 years | 1,063,815 lbs/yr |
| 250 kW | $1,750,000 | $1,125,000 | 354,606 kWh | 19 years | 541,910 lbs/yr |
| 100 kW | $750,000 | $425,000 | 141,840 kWh | 16 years | 212,760 lbs/yr |
| 50 kW | $400,000 | $180,000 | 70,920 kWh | 9 years | 106,380 lbs/yr |
| 25 kW | $200,000 | $40,000 | 35,460 kWh | <5 years | 53,190 lbs/yr |
| 10 kW | $80,000 | $16,000 | 14,180 kWh | <5 years | 21,270 lbs/yr |

**Calculated using the average state energy cost of $0.090 per kWh.*

Phoenix, Arizona

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,250,000 | 840,277 kWh | 18 years | 1,260,415 lbs/yr |
| 250 kW | $1,750,000 | $1,200,000 | 420,139 kWh | 19 years | 630,208 lbs/yr |
| 100 kW | $750,000 | $500,000 | 168,055 kWh | 19 years | 252,082 lbs/yr |
| 50 kW | $400,000 | $255,000 | 84,028 kWh | 19 years | 126,042 lbs/yr |
| 25 kW | $200,000 | $120,000 | 42,014 kWh | 17 years | 63,021 lbs/yr |
| 10 kW | $80,000 | $46,000 | 16,806 kWh | 17 years | 25,209 lbs/yr |

**Calculated using the average state energy cost of $0.085 per kWh.*

Philadelphia, Pennsylvania

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 627,316 kWh | 22 years | 940,975 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 313,658 kWh | 23 years | 470,490 lbs/yr |
| 100 kW | $750,000 | $525,000 | 125,463 kWh | 25 years | 188,195 lbs/yr |
| 50 kW | $400,000 | $280,000 | 62,732 kWh | 27 years | 94,100 lbs/yr |
| 25 kW | $200,000 | $140,000 | 31,366 kWh | 27 years | 47,050 lbs/yr |
| 10 kW | $80,000 | $56,000 | 12,546 kWh | 27 years | 18,820 lbs/yr |

**Calculated using the average state energy cost of $0.096 per kWh.*

Pittsburg, Pennsylvania

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 571,590 kWh | 24 years | 857,385 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 285,800 kWh | 26 years | 428,700 lbs/yr |
| 100 kW | $750,000 | $525,000 | 114,320 kWh | 27 years | 171,480 lbs/yr |
| 50 kW | $400,000 | $280,000 | 57,160 kWh | 29 years | 85,740 lbs/yr |
| 25 kW | $200,000 | $140,000 | 28,580 kWh | 29 years | 42,870 lbs/yr |
| 10 kW | $80,000 | $56,000 | 11,430 kWh | 29 years | 17,145 lbs/yr |

**Calculated using the average state energy cost of $0.096 per kWh.*

Portland, Oregon

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $650,000 | 529,569 kWh | <5 years | 794,350 lbs/yr |
| 250 kW | $1,750,000 | $350,000 | 264,784 kWh | <5 years | 397,180 lbs/yr |
| 100 kW | $750,000 | $150,000 | 105,914 kWh | <5 years | 158,870 lbs/yr |
| 50 kW | $400,000 | $80,000 | 52,957 kWh | <5 years | 79,453 lbs/yr |
| 25 kW | $200,000 | $40,000 | 26,478 kWh | <5 years | 39,720 lbs/yr |
| 10 kW | $80,000 | $16,000 | 10,591 kWh | <5 years | 15,890 lbs/yr |

**Calculated using the average state energy cost of $0.072 per kWh.*

Raleigh, North Carolina

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $1,137,500 | 682,428 kWh | <5 years | 1,023,640 lbs/yr |
| 250 kW | $1,750,000 | $612,500 | 341,214 kWh | <5 years | 511,820 lbs/yr |
| 100 kW | $750,000 | $262,500 | 136,486 kWh | <5 years | 204,730 lbs/yr |
| 50 kW | $400,000 | $140,000 | 68,243 kWh | <5 years | 102,365 lbs/yr |
| 25 kW | $200,000 | $70,000 | 34,121 kWh | <5 years | 51,180 lbs/yr |
| 10 kW | $80,000 | $28,000 | 13,649 kWh | <5 years | 20,470 lbs/yr |

**Calculated using the average state energy cost of $0.085 per kWh.*

Sacramento, California

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 727,450 kWh | 8 years | 1,091,175 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 363,770 kWh | 9 years | 545,655 lbs/yr |
| 100 kW | $750,000 | $525,000 | 145,510 kWh | 10 years | 218,265 lbs/yr |
| 50 kW | $400,000 | $280,000 | 72,750 kWh | 12 years | 109,125 lbs/yr |
| 25 kW | $200,000 | $140,000 | 36,380 kWh | 12 years | 54,570 lbs/yr |
| 10 kW | $80,000 | $56,000 | 14,550 kWh | 12 years | 21,825 lbs/yr |

**Calculated using current incentive rates as of March 2010 for the PG&E district: $0.15 per kWh and using the average state energy cost of $0.125 per kWh.*

Salt Lake City, Utah

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,225,000 | 727,244 kWh | 24 years | 1,090,870 lbs/yr |
| 250 kW | $1,750,000 | $1,175,000 | 363,622 kWh | 25 years | 545,430 lbs/yr |
| 100 kW | $750,000 | $475,000 | 145,449 kWh | 24 years | 218,170 lbs/yr |
| 50 kW | $400,000 | $240,000 | 72,724 kWh | 23 years | 109,090 lbs/yr |
| 25 kW | $200,000 | $120,000 | 36,362 kWh | 23 years | 54,540 lbs/yr |
| 10 kW | $80,000 | $48,000 | 14,545 kWh | 23 years | 21,820 lbs/yr |

**Calculated using the average state energy cost of $0.072 per kWh.*

San Antonio, Texas

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 717,440 kWh | 19 years | 1,076,160 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 358,720 kWh | 20 years | 538,080 lbs/yr |
| 100 kW | $750,000 | $525,000 | 143,490 kWh | 22 years | 215,235 lbs/yr |
| 50 kW | $400,000 | $280,000 | 71,740 kWh | 23 years | 107,610 lbs/yr |
| 25 kW | $200,000 | $140,000 | 35,870 kWh | 23 years | 53,805 lbs/yr |
| 10 kW | $80,000 | $56,000 | 14,350 kWh | 23 years | 21,525 lbs/yr |

**Calculated using the average state energy cost of $0.097 per kWh.*

San Diego, California

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 778,940 kWh | 7 years | 1,168,410 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 389,470 kWh | 8 years | 584,205 lbs/yr |
| 100 kW | $750,000 | $525,000 | 155,790 kWh | 9 years | 233,685 lbs/yr |
| 50 kW | $400,000 | $280,000 | 77,890 kWh | 10 years | 116,835 lbs/yr |
| 25 kW | $200,000 | $140,000 | 38,950 kWh | 10 years | 58,425 lbs/yr |
| 10 kW | $80,000 | $56,000 | 15,580 kWh | 10 years | 23,370 lbs/yr |

**Calculated using incentive rates current as of March 2010 for the SDG&E district: $0.15 per kWh and the average state energy cost of $0.125 per kWh.*

San Francisco, California

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,265,000 | 751,608 kWh | 8 years | 1,127,410 lbs/yr |
| 250 kW | $1,750,000 | $1,215,000 | 375,804 kWh | 9 years | 563,700 lbs/yr |
| 100 kW | $750,000 | $515,000 | 150,322 kWh | 9 years | 225,480 lbs/yr |
| 50 kW | $400,000 | $270,000 | 75,161 kWh | 10 years | 112,740 lbs/yr |
| 25 kW | $200,000 | $130,000 | 37,580 kWh | 9 years | 56,370 lbs/yr |
| 10 kW | $80,000 | $46,000 | 15,032 kWh | 6 years | 22,550 lbs/yr |

**Calculated using incentive rates current as of March 2010 for the PG&E district: $0.15 per kWh and the average state energy cost of $0.125 per kWh.*

Seattle, Washington

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 504,574 kWh | 39 years | 756,860 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 252,287 kWh | 40 years | 378,430 lbs/yr |
| 100 kW | $750,000 | $525,000 | 100,915 kWh | 39 years | 151,370 lbs/yr |
| 50 kW | $400,000 | $280,000 | 50,557 kWh | 34 years | 75,835 lbs/yr |
| 25 kW | $200,000 | $140,000 | 25,229 kWh | 19 years | 37,840 lbs/yr |
| 10 kW | $80,000 | $56,000 | 10,091 kWh | <5 years | 15,140 lbs/yr |

**Calculated using the average state energy cost of $0.064 per kWh.*

St Louis, Missouri

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,275,000 | 657,820 kWh | 28 years | 986,730 lbs/yr |
| 250 kW | $1,750,000 | $1,225,000 | 328,910 kWh | 30 years | 493,365 lbs/yr |
| 100 kW | $750,000 | $525,000 | 131,564 kWh | 32 years | 197,350 lbs/yr |
| 50 kW | $400,000 | $280,000 | 65,782 kWh | 34 years | 98,670 lbs/yr |
| 25 kW | $200,000 | $120,000 | 32,891 kWh | 34 years | 49,340 lbs/yr |
| 10 kW | $80,000 | $56,000 | 13,156 kWh | 34 years | 19,730 lbs/yr |

**Calculated using the average state energy cost of $0.070 per kWh.*

Tampa, Florida

| Array Rating Size | Flat Cost | With Incentives | Annual Energy Production | Pay Back Period* | Avoided $CO_2$ Emissions |
|---|---|---|---|---|---|
| 500 kW | $3,250,000 | $2,175,000 | 709,210 kWh | 19 years | 1,063,815 lbs/yr |
| 250 kW | $1,750,000 | $1,125,000 | 354,606 kWh | 19 years | 541,910 lbs/yr |
| 100 kW | $750,000 | $425,000 | 141,840 kWh | 16 years | 212,760 lbs/yr |
| 50 kW | $400,000 | $180,000 | 70,920 kWh | 9 years | 106,380 lbs/yr |
| 25 kW | $200,000 | $40,000 | 35,460 kWh | <5 years | 53,190 lbs/yr |
| 10 kW | $80,000 | $16,000 | 14,180 kWh | <5 years | 21,270 lbs/yr |

**Calculated using the average state energy cost of $0.090 per kWh.*

## INTERNET RESOURCES

| | |
|---|---|
| Natural Resources Defense Council | http://nrdc.org/ |
| NRDC Greening Advisors<br>For Major League Baseball<br>For the National Basketball Association | <br>http://www.greensports.org/mlb/<br>http://www.greensports.org/nba/ |
| Bonneville Environmental Foundation | http://www.b-e-f.org/ |

**Solar Research Resources**

| | |
|---|---|
| National Renewable Energy Laboratory (NREL) | http://www.nrel.gov/ |
| Lawrence Berkeley National Laboratory | http://www.lbl.gov/ |

**Online Tools**

| | |
|---|---|
| PVWatts<br>(Solar calculator developed by the NREL) | http://www.pvwatts.org/ |

**Incentives and Financing Information**

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|---|---|
| Database of State Incentives for Renewables and Efficiency | http://www.dsireusa.org/ |
| Property Assessed Clean Energy Bonds<br>(PACE) | http://pacenow.org/ |

**Solar Organizations**

| | |
|---|---|
| American Solar Energy Society | http://www.ases.org/ |
| Solar Energy Industries Association | http://www.seia.org/ |
| Solar Tech | http://www.solartech.org/ |

**Other Resources**

| | |
|---|---|
| US Department of Energy:<br>Energy Efficiency and Renewable Energy | http://www.eere.energy.gov/ |
| Interstate Renewable Energy Council | http://irecusa.org/ |
| U.S. Green Building Council | http://www.usgbc.org/ |