Solar Electric Guide for Your Stadium or Arena

A guide to help professional and collegiate sports teams and venues develop successful on-site solar power generation

bef™

NRDC
THE EARTH'S BEST DEFENSE

GREEN SPORTS ALLIANCE

SECOND EDITION
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Foreword

In July 2010, the Bonneville Environmental Foundation (BEF) and the Natural Resources Defense Council (NRDC) published the first edition of *Solar Electric Energy for Your Stadium or Arena: A Guide to Understanding the Opportunities of On-Site Solar Power Generation.* That first-of-its-kind *Solar Guide* for the sports industry helped broaden and deepen the sports world's understanding of the potential that stadiums and arenas hold to reduce their reliance on fossil fuels and, equally important, contributed to the public's understanding about the urgent need to do so.

The first edition of the *Solar Guide* was tremendously well received. Commissioners of the major professional sports leagues in North America distributed it widely to team owners and stadium and arena operators. NHL Commissioner Gary Bettman appeared on CNN to publicize the release of the *Solar Guide*. During the broadcast, he stressed the importance of its message: It is urgent that we reduce our reliance on fossil fuels as rapidly as possible and there are financially viable ways for stadiums and arenas to do so. "We don't want to see the ice melt," he said. "That's not good for our game. Making our clubs aware about opportunities through the *Solar Guide* is good for our business."[1]

Since the first edition of the BEF/NRDC *Solar Guide* was published, the installation of solar arrays has proliferated at professional and collegiate sports facilities. As of this writing, there are 18 solar installations at pro sports facilities in North America (11 of which were installed since 2010) and many more around the world. Collegiate athletic and recreation facilities across the United States have installed more than three dozen solar arrays. Long overdue, a Golden Age of solar installation at sports facilities seems to be emerging. Numerous sports venue operators cite the BEF/NRDC *Solar Guide* as a useful tool they relied on to navigate the launch of their projects.

That same year, NRDC and BEF joined with Paul Allen's Vulcan Corporation and six professional sports teams to launch the Green Sports Alliance (the Alliance). Our intention in forming the Alliance was to create an organization dedicated to disseminating information about how sports leagues, teams, and venues might enhance their environmental performance. The Alliance has grown in size and influence since its creation in 2010, an indication of the sports industry's commitment to operating more responsibly and efficiently. As of this writing, its membership includes more than 175 teams and venues from 15 leagues.

Given the growth of the sports greening movement and Alliance's growing visibility and influence in particular, NRDC and BEF have updated the original *Solar Guide* in collaboration with our friends at the Alliance. This second edition benefits from research provided by the Pacific Northwest Pollution Prevention Research Center (PPRC), working under a generous grant from the U.S. Environmental Protection Agency.

Among other helpful changes, this second edition of the *Solar Guide* has been reorganized for ease of reading. The database of state incentive programs has been updated into a web-based, searchable database that will be updated on an annual basis. The new guide and database are accessible on the BEF website at **b-e-f.org/solarguide.**

The timeliness and importance of this *Solar Guide*, and the need to shift away from fossil fuels, has never been greater.

Since the end of the Second World War we have dumped one trillion tons of global warming pollution into the atmosphere, due overwhelmingly to our reliance on fossil fuels. Today we will emit another 90 million tons of global warming pollution into the atmosphere, and tomorrow we'll release slightly

more–because despite what we know is required to slow the loading of carbon into our atmosphere, humanity nevertheless emits more carbon into the atmosphere each day.

The effects are both costly and adverse: Since 2000, we have witnessed nine of the ten hottest years ever recorded; spring 2012 was the warmest since record-keeping began in 1985. And in 2012—in the first six months alone—24,000 heat records across the U.S. were broken.

Record droughts have ravaged critical food-growing regions of our nation. Monstrous storms like Katrina and Sandy–weather events made worse due to our warming atmosphere and seas–along with sea level rise, damage the lives and economies of coastal regions at scales unprecedented in human history.

What we do today, or don't do, to address global climate disruption will affect all life on Earth for thousands of generations after us. Because of the work of NRDC, BEF, the Alliance, and so many others—and because of the examples being set by all professional sports leagues and at college athletic facilities throughout the world—every day another sporting event demonstrates to millions of people from all walks of life how to be responsible environmental stewards.

Perhaps no ecological issue is more urgent than the need to shift away from our reliance on fossil fuels. Hopefully, this second edition *Solar Electric Guide for Your Stadium or Arena* will help accelerate the growing embrace of solar power by the sports world, and in so doing, continue to educate hundreds of millions of fans about our collective need to shift to renewable energy sources.

Allen Hershkowitz, Ph.D.
Director, Sports Greening Project
Natural Resources Defense Council

1 http://video.nhl.com/videocenter/console?id=81413

Why go solar?

More than 135 million adults and their families visit 130 professional sports stadiums each year to cheer on their team and experience the power of sport. Another 100 million visit nearly 700 major collegiate stadiums and arenas each year to do the same. The stadium itself has long served as an emotionally captivating space, inspiring life-long memories of sporting moments captured live, or even the rare opportunity to step out onto a field or court.

With the burgeoning greening of sports, the stadium experience is expanding —offering fans meaningful exposure to on-site solar power generation, energy- and water-efficient building design, zero-waste practices, recycling and composting programs, and much more. Many teams and venues nationwide are building interactive spaces into the stadium experience to engage fans in what it takes to minimize a stadium's environmental footprint, while inspiring fans to do the same at home. Other teams, venues and corporate sponsors take this commitment a step further by reaching out to the area community, or funding in-school educational programs to inspire the next generation of clean energy leaders.

And for good reason: it's no secret that stadiums require significant resources to operate, including energy. While more and more stadiums take the leap to develop on-site solar energy generation systems to minimize the environmental impact of their energy use while realizing the associated financial and brand benefits, there is significant potential to do more. Thankfully, with a variety of creative funding models and incentive programs to choose from, more and more stadium and arena owners are recognizing the value and benefit of on-site solar power generation.

In the pages that follow, you'll find essential guidance to navigate your way through the steps to develop on-site solar power generation for your stadium or arena. The case studies beginning on page 12 provide snapshots of a growing number of successful stadium and arena projects representing a wide range of system goals, designs, and financing strategies.

More than 135 million adults and their families visit 130 pro sports stadiums each year.

Another 100 million visit nearly 700 major collegiate stadiums and arenas each year.

How to succeed

Focus on production vs. capacity

When an array is labeled a "100 kilowatt system," that label refers only to the array's total ***power generation capacity,*** not the ***actual energy it will produce over time.*** Once installed, several factors affect a system's energy production, including its location, shading, the tilt of the system, and how much sun it receives throughout the year.

As you explore the feasibility and cost-effectiveness of your own on-site system, be sure to focus on ***energy production***—the actual estimated energy it will generate after all factors are considered—rather than the system's capacity. By doing so you will be more effective in aligning your goals with your actual system design.

Make friends with your utility

Your local utility is an important partner in building a cost-effective project, including ***net metering*** your system to receive credit for the electricity you generate but do not use.

Connect with your utility at the project start to establish a relationship and communicate your project intentions. Research the net-metering policies, local incentive programs, and other available services that could reduce your project cost. Some utilities are actually legally obligated to provide this type of support to their members. Ultimately the utility serves as your area expert on several aspects of your system development.

Get creative with your financing model

The most successful projects incorporate creative funding strategies that leverage a combination of options designed to reduce overall capital cost and minimize your system payback period. Go beyond tax incentives, loans, and grants in your financing model. Consider options that create win-win partnerships with corporate sponsors interested in reaching fans. Where viable, power purchase agreements will provide you with locked-in power rates while eliminating your capital costs.

Engage your community

Successful projects do more than generate clean energy—they leverage the system as an education and engagement tool for the community through in-stadium tours, on-site educational programs or partnerships with programs like Solar 4R Schools™, available through BEF.

Identify your community engagement strategy at the start of your project. Taking this step early could help attract potential corporate sponsors and will ensure you have the funding and plan in place to fulfill this essential step once the system is complete.

quick facts

Power Generation Capacity—The amount of power a generator will produce under specific operating conditions as determined by the manufacturer and identified on the generator's nameplate.

Projected Energy Production—The estimated energy a system will generate over a specific period of time after all factors are considered. Many generators do not operate at their full capacity at all times; energy production varies depending on a wide range of conditions.

Net Metering—The system that tracks the amount of energy that flows back into the grid from an on-site renewable energy source, such as a solar array; allows the owner of the solar array to accumulate an energy credit or payment. Net metering policies can vary greatly by geographic location.

It's important to note that net metering may not be available or appropriate for every installation. In fact, the utility industry is pressing hard for alternatives to net metering. Even states that include net metering mandates may include an upper limit on systems that can qualify, potentially ruling out systems of the size likely to be installed on stadiums and arenas. The bottom line is to be sure to conduct your research early in the process.

Power Purchase Agreement (PPA)—A financial agreement in which a third-party developer owns, operates, and maintains the system, and a host customer agrees to site the system on its property and purchases the system's electric output from the developer for a predetermined period.

Steps involved

1 Step 1: Conduct an energy audit

The cheapest (and greenest) electricity will always be the power a facility doesn't use. Before you dive in to confirm the cost-effectiveness of an on-site energy generation system, take steps to reduce your facility's energy needs first.

An energy audit will give you a clear picture of how your facility is using energy now. It can provide actionable steps to reduce energy waste through conservation and technology improvements. Because it measures your current energy load, the audit is an important starting point for scoping a potential on-site project in relation to your system goals.

On-site energy generation is a significant investment. Reducing your energy consumption through more efficient light fixtures or better monitoring systems will help shorten your financial payback period. Contact your local energy provider for information on free or low-cost energy audit services that may be available in your area.

2 Step 2: Confirm your system goals

An important step in building a successful on-site energy generation system of any type is to determine the outcomes you wish to achieve as a result of its installation. Delaying confirmation of your system goals could result in significant delays and challenges at the point of system design.

For instance, if your primary goal is to engage fans in your commitment to sustainability, it is important to design a system that is visible to people entering the stadium or arena. If that isn't feasible, consider incorporating a data monitoring kiosk or signage in a high traffic area. Such displays can show fans the system's real-time energy generation while engaging them in the benefits of renewable energy.

To determine your system goals, consider the following questions: Do you want your system to be a primary energy generation source for your facility? If so, how much energy does the system need to produce to meet this goal? Is your primary aim to leverage the system as a community engagement platform rather than a primary energy generator? Do you aim to achieve multiple goals? By confirming your goal(s) up front the remaining stages of the process will run far more smoothly.

3 Step 3: Determine eligibility for tax incentives

Exploring all available tax incentives—federal, state and local—is a critical precursor to system design. Why? Many programs incorporate design and system size requirements that limit eligibility. In some cases you can adapt your system design to meet these requirements. Still other programs require you to apply and obtain approval on the incentive before you ever break ground on your project.

Energy Audit Resources
A growing number of clean energy developers and consultants now offer a bundled suite of energy performance audit services, often including energy efficiency, energy management, on-site solar feasibility studies and incentive program research.

Utility or state-level incentive program administrators can also be a good entry point for a recommendation to a trusted energy audit contractor or consultant in your area. These organizations may be able to provide you with template RFPs for soliciting energy audit professionals.

The Honest Buildings network, housed at **HonestBuildings.com,** is the fastest-growing network of real estate professionals. While stadiums and arenas are certainly unique facilities, this is a great starting point to find pros in your area, read customer reviews, and more.

Federal photovoltaic tax credits

As an incentive to install a photovoltaic (PV) system, the federal government offers a ***Business Energy Investment Tax Credit*** to eligible facilities in the utility, commercial, and industrial sectors. This credit covers 30% of the cost of the PV system, including labor and installation costs, with no project cost cap. These incentives are scheduled to remain at 30% until December 31, 2016. After that date, it will be reduced to 10% of system costs.

State incentives

Many states offer their own incentives. These vary dramatically by the amount offered, calculation method, and payment schedule. Some are structured in the same way as the federal credit, in that they also reimburse a percentage of the system's cost.

Many state incentive programs have a cap or a maximum incentive amount. Other states have set incentives based on the wattage capacity rating of the array. Still others base their incentives on annual kilowatt-hour production.

Local incentives

To keep this guide simple and digestible, we've only included a list of available ***state level*** tax incentive programs. This list will be updated annually online at **b-e-f.org/solarguide.** We strongly encourage you to also research your eligibility for *local* incentives that can help reduce your up-front capital costs. Options can include feed-in tariffs, local incentives, and rebates available through your area utility. Contact your area utility for help identifying these.

4 Step 4: Conduct a site survey and feasibility study

With your system goals serving as your foundation, your next step is to conduct a thorough site survey to confirm the feasibility of your facility in hosting a PV system. Beyond confirming your facility's basic fit, you will answer several critical questions that will direct your system design, including:

- **Size and location**—Considering your goals, what is the best location for optimum energy generation, community engagement, etc.? What location receives the most sun? Will your roof support the load in the location you've selected?
- **Connectivity**—How manageable will it be to connect the system to your existing electrical infrastructure? Will the amount of electricity the system generates require significant infrastructure updates?
- **Data monitoring**—Do you plan to incorporate data monitoring of your system for educational purposes (such as through an interactive kiosk connected to your PV system)? If so, how will you leverage this production information to meet your outreach goals?

Many PV system installers will perform a site survey and feasibility study at a reasonable cost. There may also be consulting firms or renewable energy nonprofits in your area that would be able to perform that service for you.

Learn more about the ***Business Energy Investment Tax Credit*** online at:

http://energy.gov/savings/business-energy-investment-tax-credit-itc

View a searchable database of state incentive programs online now at b-e-f.org/solarguide

Many electrical utilities maintain databases of qualified installers who have done work in their service territory or may be able to recommend an appropriate party to consult. Most states have solar advocacy nonprofit groups whose mission it is to educate and support consumers in installing solar energy systems.

5 Step 5: Develop a funding strategy

Throughout the sports industry, creative funding strategies further the development of on-site solar power generation. Several options are available to support up-front capital costs and to minimize your system's payback period. Your next step toward developing a successful project is to explore these options to arrive at your own project funding strategy, beginning with estimating your system cost.

Most commercial scale systems are larger than 10 kilowatts (kw). According to a study by the Solar Energy Industries Association (SEIA), the average cost of installed PV in first quarter 2013 was $3.92 per watt (based on a blended average of commercial and residential scale systems). However, since the cost of a solar installation can vary greatly depending on the install size and location, your best route is to conduct your own site-specific estimate. Prices can be lower when materials are bought in volume. Per-watt costs decrease when equipment, development, and transaction costs are dispersed over a larger number of watts. Project costs will be affected by such factors as the the local solar market and the structural installation the site requires.

Figure 1 demonstrates the wide range of variability in pricing, including systems at about $8.00 per watt or as low as $2.00 per watt. The dashed vertical lines refer to the range of actual prices, whereas the solid bars indicate the overall cost average.

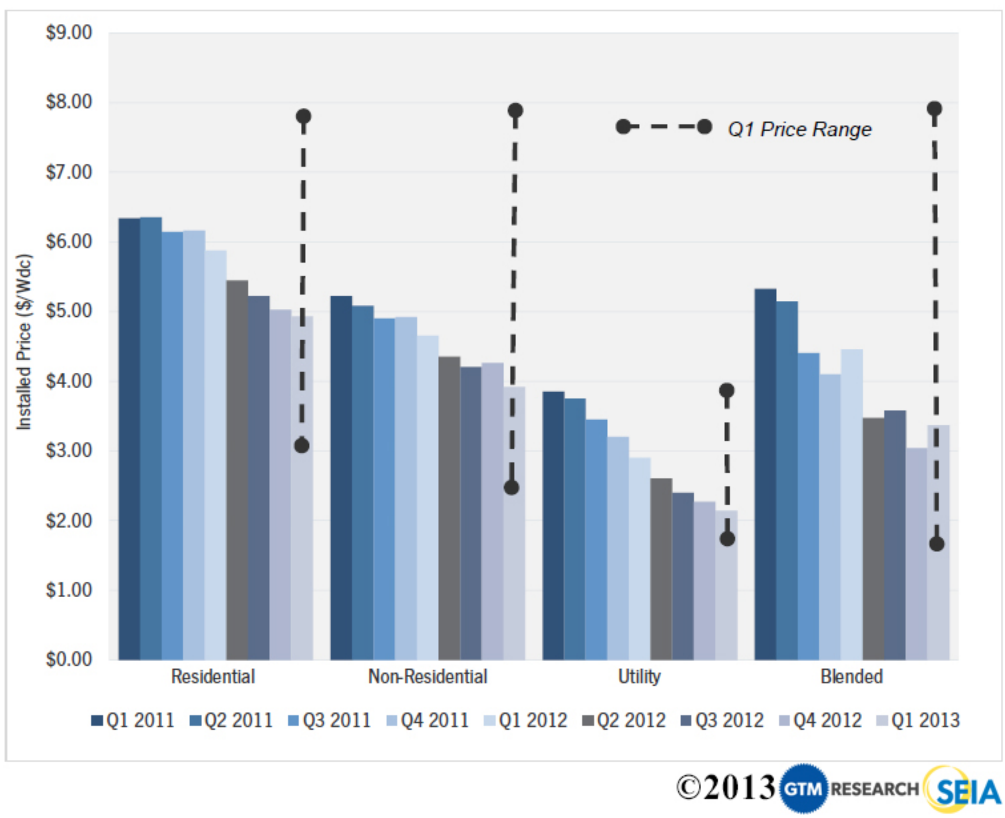

Figure 1: Average Installed Price by Market Segment
SOURCE: Solar Energy Industry Association,http://www.seia.org/research-resources/us-solar-market-insight-q1-2013 / Figure 2.6.

In addition to available tax incentives and feed-in tariffs described in step 3, there are numerous approaches to financing the installation of a solar array, a few of which are discussed here.

Form win-win strategic partnerships

- **Partner with a local utility as your system owner**—Your team or venue can host the PV system while the utility becomes the official owner. In such a partnership, you can engage fans and the community with renewable energy education programs while the utility meets their renewable energy portfolio requirements.
- **Partner with a solar manufacturer**—It may be possible to receive discounted rates from solar manufacturers or installers for projects that will generate good publicity. Because of the unique and powerful position 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 their reduced costs or donated materials. Such a partnership would allow the manufacturer to support the local solar market, while also providing renewable energy education to their surrounding community.
- **Explore a community-owned solar model**—Community-owned renewable energy projects have become a viable pathway for communities, small businesses, and individuals to participate directly in a clean energy future. They can be an equally viable funding model for stadium system financing. These collaboratively-owned projects use financing models that leverage a wide range of tax incentives and feed-in tariffs to mitigate financial risk and reduce project capital costs.

Seek out corporate sponsorships

Corporate sponsorships can be an effective component of a stadium solar financing model, particularly where community engagement is a key goal associated with your project and your facility and/or system design can accommodate this goal.

In some cases, corporate sponsors will become official owners of the solar array, retaining the rights to the power generation to balance the carbon footprint of a nearby corporate headquarters or manufacturing facility. In other cases, corporate sponsors can provide the financial support necessary to leverage a system for public engagement or educational purposes only: providing branding benefits to both parties. Whatever the approach, stadiums offer a unique value to corporate sponsors who wish to support renewable energy development and reach fans within a given market.

Consider loan and grant opportunities

Additional loan and grant programs provide further funding opportunities. The Improvement and Extension Act of 2008, for instance, authorized the issuance of Qualified Energy Conservation 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, with 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 website at **www.pacenow.org** or the Database of State Incentives for Renewables and Efficiency (DSIRE) website at **www.dsireusa.org**.

Another example is the ***Energy Efficiency and Conservation Block Grant Program (EECBG)*** created by the U.S. Department of Energy. This program provides grants for energy efficiency and conservation projects, such as renewable energy installations on government buildings.

Power Purchase Agreement

A Solar Power Purchase Agreement (SPPA) is a financial agreement in which a third-party developer owns, operates, and maintains the photovoltaic (PV) system, and a host customer agrees to site the system on its property and purchases the system's electric output from the developer for a predetermined period. PPAs provide the host customer with stable, sometimes more cost-effective, electricity while the developer or another party acquires valuable financial benefits such as tax credits, income generated from the sale of electricity to the host customer and the environmental attributes.

SPPAs remove many of the barriers for organizations looking to install solar systems: high up-front capital costs; system performance risk; and complex design and permitting processes. In addition, SPPA arrangements can be cash flow positive for the host customer from the day the system is commissioned.

When using an SPPA it is important that the host customer be aware of what claims it may or may not make about the production of electricity from the system.The updated Federal Trade Commission (FTC) Green Guides provide recommendations for solar hosts and how to make environmental claims. It is also recommended that the host customer consult with an industry professional.

Renewable Energy Certificates (RECs)

Renewable Energy Certificates (also known as Renewable Energy Credits or RECs) represent the non-electricity environmental attributes produced by renewable energy facilities. One REC represents the non-power environmental attributes of 1,000 kWh (1 megawatt-hour) of renewable energy.

RECs can be produced from any grid-connected renewable energy project—everything from large utility wind farms to residential-scale solar. RECs can be sold as a bundled product. A bundled product is the combination of the electricity generated and the environmental attributes associated with that renewable energy generation. In some cases, project developers have leveraged incentive programs available from their local utility whereby the utility unbundles the electricity from its environmental attributes, creating unbundled RECs. Once the RECs are unbundled, they may be retained by the project owner or sold depending on the financing package for the project. If a renewable energy project owner sells the RECs, it surrenders the right to claim any of the environmental benefits from the project (the REC purchaser now owns those rights).

If the project owner opts to sell the RECs from the solar project but wants to be able to make environmental claims, the project owner may elect to purchase RECs from a different renewable energy project. REC prices vary by region and technology, therefore it is recommended that the project owner consult with an industry professional when purchasing RECs. Project owners should consult the FTC Green Guides for definitive guidance on making environmental claims.

Step 6: Release a request for proposals

The next step toward getting your project off the ground is to release a request for proposals. The focus of your RFP will depend on the ownership model you've selected (per your system funding strategy).

If you've decided to own the PV system, you will use a fairly standard request for bids from system designers and installation contractors. However, it would not be unusual to engage in a partnership with a third-party project manager to help establish the basic blueprint of the project based on the site and your needs. The project manager can issue the RFP, review the proposals, and ultimately oversee the project.

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

An RFP will often state a desired system size range, the projected timeline for the project, and where the facility owner would like the array to be located. An RFP can also explicitly lay out expectations for both the project and the proposer, including who would own environmental attributes produced by the PV system.

Step 7: Design and install your system

System location

There are many potential locations for a PV system; each is site-dependent. Pages 9-10 provide descriptions and samples of some possible locations to consider.

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 sometimes by utility, 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 on a state-by-state basis at **www.irecusa.org**. This may be a useful resource to consult, as it may affect what system size is most desirable or feasible.

RFP examples

BEF and Snohomish County PUD

Serving as a consultant project manager, BEF issued an RFP on behalf of their partner Snohomish Public Utility for a solar installation at their district headquarters (a publicly-owned utility located in Washington State) in the spring of 2009. Within the RFP, 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.

Metro and the Oregon Convention Center

The RFP issued by the Metropolitan Exposition and Recreation Commission (Metro) to get a Power Purchase Agreement (PPA) for the Oregon Convention Center stated that the desired PV array would be between 1 MW and 1.25 MW and that it would be constructed on the southern portion of the Center's roof. The RFP also specified that the successful Proposer would 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 system's performance. Furthermore, Metro stipulated that the expected cost of energy from the system would be equal to or less than the Convention Center's current energy costs. As a result of this RFP, Metro entered into a PPA agreement with SunEdison in November of 2009.

System location options

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. However, some facilities may not have roofs with the load-bearing capacity necessary to support the additional weight of a PV array. As an example, a 3.25' by 5.5' SolarWorld Monocrystalline solar module with a DC rating of 250 watts weighs 46.7 lbs (or roughly 2.6 lbs/sq. ft.), not including the racks or other structures required to hold them.

Arena roof system on the Staples Center, Los Angeles, California. Photo provided by Staples Center.

If weight is a concern, thin-film cells are much lighter in weight than the more traditional crystalline silicon solar panels and would have little impact on the existing roof. They would be laid out directly onto the roof membrane, eliminating the need for racking structures. Laminate modules are not compatible with all roofing materials. This technology is not yet as efficient as crystalline silicon panels and therefore requires more roof area for the same system capacity. Additionally, because they adhere directly to the roof, they must be installed at the roof pitch and cannot be tilted to optimize production.

An option for a more traditional crystalline array would be to attach the solar module racking to the roof. This system is not as heavy as a ballasted system, where the racking is held down by weights, but does require several more roof penetrations than a ballasted or laminate system. Your specific options will depend on local zoning requirements, how windy your location is, how much snow you receive, the materials your roof is made of, and how much additional weight your roof can support. If you are considering installing a system on an existing membraine roof, consider consulting a roofing expert. It's often advisable to replace the roof as part of the solar installation project rather than be forced to remove the array years later at the time of a scheduled roof replacement.

Parking lots and garages

For arenas with parking garages or unshaded parking lots, carport-like installations may be a viable location 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, 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 into these arrays.

Solar trees on Hopkins parking structure, UC San Diego, San Diego, CA. Photo provided by UC San Diego.

System location options, continued

Canopy-mounted systems

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.

Canopy mounted system over a pavilion on the upper deck of Progressive Field. Photo provided by the Cleveland Indians.

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 Giants Building, the part of the stadium complex where the administrative offices are housed. 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 system

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 design option. A tracking device can be integrated into 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 location that does not get shade.

Pole mounted system. Photo provided by iStockphoto.

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Step 8: Engage your fans and community

Your solar energy generation system is a physical, often publicly-viewable demonstration of your commitment to operating an environmentally sustainable venue. The most successful projects leverage their system as a community and fan engagement tool to build brand equity for their team or venue. In the case where a corporate sponsor has been engaged to support project capital costs, your engagement component could serve as a valuable benefit to this partner.

A wide range of engagement strategies have been implemented in stadiums and arenas nationwide, including public events to mark the project's completion, stadium tours, educational signage placed near the solar array, and even leveraging the system as a complete STEM (science, technology, engineering and math) based educational tool for local schools.

One option for community engagement around your solar projects is the BEF Solar 4R Schools™ program. BEF believes education plays a critical role in securing a clean energy, low carbon future. They aim to partner with professional and collegiate sports teams and their sponsors nationwide to build a network of solar energy education programs that will inspire a new generation of clean energy leaders. BEF offers a turnkey package that is highly attractive to corporate sponsors, including unique opportunities to meaningfully engage with students, teachers, and fans in communities of interest.

Through the Solar 4R Schools™ program, BEF can transform a venue's on-site solar technology into a complete system of STEM education for schools right in the community—allowing teams and sponsors to reach thousands of students each year with hands-on renewable energy education. Partner educators are empowered with training, teacher-generated activities, hands-on science kits, and access to the most robust online solar data monitoring system, helping them bring renewable energy education to life in their classroom.

Through co-branded educational kiosks, teams can bring the solar-powered stadium experience right into each partner school—connecting students with how solar power works, what it takes to power a stadium, and simple steps students can take to reduce their carbon footprint at home. By using school stadium tours and in-stadium interactive educational displays, teams can further inspire the next generation of clean energy leaders.

Learn more at **Solar4RSchools.org.**

Students engaged in an engineering challenge.

Case Study: Progressive Field

Home of the Cleveland Indians

Venue Location: Cleveland, Ohio

Venue Ownership: Gateway Economic Development Corporation

Total System Size: 8.4 kW — DC

Date of Completion: 2007

Panel Size and Type: 200 W, GE panels

Number of Panels: 42

Estimated Annual Energy Production: 10,000 kWh

Actual Production: 8,500 kWh

System Cost: $180,000 ($100,000 after grants and incentives)

Cost Per Watt: $21.42 ($11.90 after incentives)

System Installer: RePower Solutions

System Owner: Cleveland Indians

Financing Method: The team supplied $100,000.00 and grant funding was provided for the remaining $80,000.00 by Green Energy Ohio, The Cleveland Foundation, and the Ohio Department of Development.

Solar Energy Utilization: Solar Energy is used on-site to displace purchased power.

Progressive Field, Cleveland, Ohio. Photo provided by Progressive Field.

Case Study: Chase Field

Home of the Arizona Diamondbacks

Venue Location: Phoenix, Arizona

Venue Ownership: Maricopa County Stadium District

Total System Size: 77.3 kW — DC

Date of Completion: 2011

Panel Size and Type: 230 W, Solon Panels

Number of Panels: 336

Estimated Annual Energy Production: 101,000 kWh

Actual Production: 100,000 kWh

System Cost: Information not available

Cost Per Watt: Information not available

System Installer: Renewable Energy Contracting

System Owner: Arizona Public Service (APS, the local investor-owned utility)

Financing Method: APS owns the system; solar power is fed into the grid and is part of the generation mix that the utility owns. The utility owns both the energy and the Solar Renewable Energy Credits (SRECs) produced by the system.

Solar Energy Utilization: While Chase Field serves as the system host, the energy and SRECs feed directly into the APS grid and are used to meet the utility's state renewable mandates.

Chase Field, Phoenix, Arizona

Photo provided by Chase Field.

Case Study: US Airways Center

Home of the Phoenix Suns

Venue Location: Phoenix, Arizona

Venue Ownership: City of Phoenix

Total System Size: 234 kW — DC

Date of Completion: 2011

Panel Size and Type: 235 W, Kyocera Panels

Number of Panels: 966

Estimated Annual Energy Production: 378,000 kWh

Actual Production: 320,000 kWh (NOTE: a system inverter failure caused the shortfall)

System Cost: Information not available

Cost Per Watt: Information not available

System Installer: Sky Engineering

System Owner: Arizona Public Service (APS, the local investor-owned utility)

Financing Method: APS owns the system; solar power is fed into the grid and is part of the generation mix that the utility owns. The utility owns both the energy and the Solar Renewable Energy Credits (SRECs) produced by the system.

Solar Energy Utilization: While US Airways Center serves as the system host, the energy and SRECs feed directly into the APS grid and are used to meet the utility's state renewable mandates.

US Airways Center, Phoenix, Arizona

Photo provided by US Airways Center.

Case Study: Weatherup Center

Arizona State University

Venue Location: Tempe, Arizona

Venue Ownership: Arizona State University

Total System Size: 141.1 kW

Date of Completion: 2010

Panel Size and Type: 210 W, Kyocera Panels

Number of Panels: 672

Estimated Annual Energy Production: 235,670 kWh

Actual Production: 249,528 kWh

System Cost: $1,186,469

Cost Per Watt: $8.41

System Installer: APS Energy Services Company (Ameresco Southwest, Inc.)

System Owner: Solar Power Partners, Inc. (NRG Solar)

Financing Method: The system is owned by Solar Power Partners, Inc. through a Power Purchase Agreement with ASU. ASU purchases the power from Solar Power Partners, Inc. for on-site usage. Arizona Public Service (APS, the local electric utility) purchases the Solar Renewable Energy Credits (SRECs) produced by the system from the system owner at $0.18/kWh. These SRECs are retired by APS to meet their state renewable mandate.

Solar Energy Utilization: Solar energy produced by the system is sold by the system owner to ASU under a Power Purchase Agreement.

Weatherup Center, Tempe, Arizona

Photo provided by Weatherup Center.

Case Study: Wells Fargo Arena

Arizona State University

Venue Location: Tempe, Arizona

Venue Ownership: Arizona State University

Total System Size: 497.3 kW — DC

Date of Completion: 2011

Panel Size and Type: 240 W, Kyocera Panels

Number of Panels: 2,072

Estimated Annual Energy Production: 798,029 kWh

Actual Production: 775,740 kWh

System Cost: $2,531,760

Cost Per Watt: $5.09

System Installer: Ameresco Southwest, Inc.

System Owner: Solar Power Partners, Inc. (NRG Solar)

Financing Method: The system is owned by Solar Power Partners, Inc. through a Power Purchase Agreement with ASU. ASU purchases the power from Solar Power Partners, Inc. for on-site usage. Arizona Public Service (APS, the local electric utility) purchases the Solar Renewable Energy Credits (SRECs) produced by the system from the system owner at $0.18/kWh. These SRECs are retired by APS to meet their state renewable mandate.

Solar Energy Utilization: Solar energy produced by the system is sold by the system owner to ASU under a Power Purchase Agreement.

Wells Fargo Arena, Tempe, Arizona

Photo provided by Wells Fargo Arena.

Case Study: STAPLES Center

Home of the Los Angeles Clippers, Los Angeles Lakers, Los Angeles Kings, and Los Angeles Sparks

Venue Location: Los Angeles, California

Venue Ownership: L.A. Arena Company, LLC

Total System Size: 346 kW – DC

Date of Completion: 2009

Panel Size and Type: 200 W, SPI 200 Panels

Number of Panels: 1,727

Estimated Annual Energy Production: 456,000 kWh

Actual Production: 498,000 kWh

System Cost: Information not available

Cost Per Watt: Information not available

System Installer: Solar Power, Inc.

System Owner: L.A. Arena Company, LLC

Financing Method: Direct ownership

Solar Energy Utilization: Solar energy is used on site to offset need to purchase electricity from the grid

STAPLES Center, Los Angeles, California

Photo provided by STAPLES Center.

Case Study: Gordon Indoor Track and Tennis Center

Home to Harvard Athletics

Venue Location: Cambridge, Massachusetts

Venue Ownership: Harvard Athletics

Total System Size: 591 kW — DC

Date of Completion: May 25, 2012

Panel Size and Type: 260 W, Yengli Panels

Number of Panels: 2,275

Estimated Annual Energy Production: 650,000 kWh

Actual Production: 851,160 kWh (through July 31, 2013; 14 months)

System Cost: $2,132,260

Cost Per Watt: $3.60

System Installer: Borrego Solar

System Owner: Harvard Athletics

Financing Method: Financed by Harvard University

Solar Energy Utilization: Solar energy is used on campus to offset purchased grid power. Solar Renewable Energy Certifificates (SRECs) are sold into the Massachusetts SREC program.

Gordon Indoor Track and Tennis Center, Cambridge, Massachusettes Photo provided by Harvard Athletic Department.

Case Study: Pocono Raceway

Solar Farm

Venue Location: Long Pound, PA

Venue Ownership: Maggioli Family

Total System Size: 2.99 Megawatts

Date of Completion: 2010

Panel Size and Type: 75 W, First Solar Thin Film

Number of Panels: 39,960

Estimated Annual Energy Production: 3,600,000 kWh

Actual Production: 4,043,965 kWh/Yr.

System Cost: $15,600,000

Cost Per Watt: $5.20

System Installer: enXco (now EDF Renewable Energy) and VElectric

System Owner: Pocono International Raceway, Inc.

Financing Method: Financed by the Maggioli Family

Solar Energy Utilization: Solar Energy is utilized on-site to offset grid purchased electricity. Excess energy of about 2,000,000 kWh/year is sold back to the Pennsylvania Power & Light at about $.09 kWh under a state operated program. Solar Renewable Energy Credits (SRECs) are also sold into the Regional SREC market, which as of August 2013 was pricing SRECs at about $14.00/SREC.

Pocono Raceway, Long Pound, Pennsylvania

Photo provided by Pocono Raceway.

Available state financial incentives

The link below leads to a searchable database of state-by-state incentive information (current as of July 2013) for all states in the U.S. This database will be updated annually. As state incentives change often, it is important to check that you have the most up-to-date information.

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.**

View a searchable database of state incentive programs online now at b-e-f.org/solarguide

Appendices

List of web resources

Publication Partners

Bonneville Environmental Foundation (BEF)
www.b-e-f.org

Green Sports Alliance
www.greensportsalliance.org

Natural Resources Defense Council
www.nrdc.org/sports

NRDC Greening Advisor

www.greensports.org

Solar Research Resources

Lawrence Berkeley National Laboratory
www.lbl.gov

National Renewable Energy Laboratory (NREL)
www.nrel.gov

Online Tools

Annual Insolation (Calculator for finding tilt and orientation)
www.solmetric.com/annualinsolation-us.html

PVWatts (Solar calculator developed by NREL)
www.nrel.gov/rredc/pvwatts/grid.html

Incentives and Financing Information

Database of State Incentives for Renewables and Efficiency
www.dsireusa.org

Property Assessed Clean Energy Bonds (PACE)
www.pacenow.org

Solar Organizations

American Solar Energy Society
www.ases.org

Solar Energy Industries Association
www.seia.org

Other Resources

FTC Green Guides
www.ftc.gov/os/2012/10/greenguides.pdf

Interstate Renewable Energy Council
www.irecusa.org

U.S. Department of Energy: Energy Efficiency and Renewable Energy
www.eere.energy.gov

U.S. Environmental Protection Agency: Solar Power Purchase Agreements
www.epa.gov/greenpower/buygp/solarpower.htm

U.S. Green Building Council
www.usgbc.org

Publication partners

About Bonneville Environmental Foundation

Bonneville Environmental Foundation (BEF) believes addressing the planet's most pressing environmental challenges requires innovation, creative problem solving, and discovering a new way of doing business that values the natural resources we depend on. We are entrepreneurs for the planet. Through a full suite of innovative energy, carbon, and water solutions, BEF helps its partners—from the farmer to the corporation—redefine how business gets done. BEF leads its partners to meaningfully balance their environmental impact, invest in clean energy and carbon reduction, educate the next generation of clean energy leaders, and effectively and sustainably restore the health of freshwater resources.
Learn more at **www.b-e-f.org**

About the Natural Resources Defense Council

The Natural Resources Defense Council (NRDC) is an international nonprofit environmental organization with more than 1.4 million members and online activists. Since 1970, their 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, Bozeman, and Beijing. Learn more at **www.nrdc.org/sports**

About the Green Sports Alliance

The Green Sports Alliance is a nonprofit organization with a mission to help sports teams, venues and leagues enhance their environmental performance. Since launching nationally in March 2011 with six professional teams and five venues as founding members, the Green Sports Alliance has grown to more than 170 professional and collegiate teams and venues from 16 sports leagues. With the support of its partners, the Alliance helps its members reach their environmental goals through direct support and focused research, facilitated networking with recognized leaders in the industry, compilation and sharing of better practices in venue operations and team communications, a monthly webinar series, the annual Green Sports Alliance Summit, and much more. Learn more at **www.greensportsalliance.org**

About the Pacific Northwest Pollution Prevention Resource Center

The Pacific Northwest Pollution Prevention Resource Center (PPRC) provides technical assistance and information services to those interested in reducing their source pollution—particularly small and medium-sized businesses in need of support. PPRC works collaboratively with businesses, government, and non-government organizations to: improve production processes, incorporate non-toxic or less-toxic substances, and use resources sustainably. PPRC believes that pollution prevention plays a crucial role in sustainability by promoting environmental and economic vitality. Learn more at **www.pprc.org**

Glossary of 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.

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

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%.

Crystalline Silicon Panels—Solar modules consisting of silicon crystals; currently the most widely used solar panels (also referred to as wafer silicon panels).

Direct Current (DC) Electricity—A form of electricity that must be converted into AC in order to be grid-compatible. Solar systems produce DC energy and photovoltaic module capacity is rated in DC.

Double Counting—When more than one party claims credit for the environmental benefits associated with a single unit of carbon credit or offset. Double counting is an activity that the carbon market aims to avoid.

Green Building—Building design, construction, and operation that conforms to principles of sustainability and energy efficiency, most commonly known through the U.S. Green Building Council's LEED program (Leadership in Energy and Environmental Design).

Green Building Council—A 501(c)(3) nonprofit organization committed to a prosperous and sustainable future for the nation through cost-efficient and energy-saving green buildings. USGBC works toward its mission of market transformation through its LEED® green building program, robust educational offerings, a nationwide network of chapters and affiliates, the annual Greenbuild International Conference & Expo, and advocacy in support of public policy that encourages and enables green buildings and communities.

Greenhouse Effect—The trapping and build-up of heat in the atmosphere near the Earth's surface. Some of the heat flowing back toward space from the Earth's surface is absorbed by water vapor, carbon dioxide, ozone, and several other gases in the atmosphere and then re-radiated back toward the Earth's surface. If the atmospheric concentrations of these greenhouse gases rise, the average temperature of the lower atmosphere will gradually increase. Source: U.S. Environmental Protection Agency

Greenhouse Gas (GHG)—A greenhouse gas is any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons, hydrochlorofluorocarbons, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. Source: U.S. Environmental Protection Agency

Greenwashing—The deceptive or misleading use of advertising and marketing to overstate an organization's environmental or sustainable practices.

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

Insolation—Also referred to as solar radiation or irradiance, the amount of solar radiation that reaches a specified area or location.

Kilowatt (kw)—A measure of power or rate of energy transmission equivalent to 1,000 Watts.

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

LEED—Leadership in Energy and Environmental Design, an environmental rating and certification system for residential and commercial buildings from the U.S. Green Building Council. LEED provides benchmarks for the design, construction and operation of a property and covers site makeup, building materials, water and energy efficiency, as well as indoor environmental quality. It also provides certification for people who demonstrate an understanding of green building practices.

Inverter—A piece of equipment that converts the DC electricity produced by the solar array into AC electricity, compatible with the utility electrical grid.

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 that an average home consumes in one month.

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 Solar Panel—Cells that convert energy from the sun into direct current electricity.

Photovoltaic Module—A packaged, interconnected group of photovoltaic cells; essentially, a solar panel.

Power Generation Capacity—The amount of power a generator will produce under specific operating conditions as determined by the manufacturer and identified on the generator's nameplate.

Power Purchase Agreement (PPA)—A financial agreement in which a third-party developer owns, operates, and maintains the system, and a host customer agrees to site the system on its property and purchases the system's electric output from the developer for a predetermined period. US EPA, www.epa.gov/greenpower/buygp/solarpower.htm.

Projected Energy Production— The estimated energy a system will generate over a specific period of time after all factors are considered. Many generators do not operate at their full capacity at all times; energy production varies depending on a wide range of conditions.

Renewable Energy—Energy derived from natural resources (such as sunlight, wind, water flow, geothermal heat, etc.) whose supply is naturally replenished.

Renewable Energy Certificates (RECs)—A tradable mechanism that represents the environmental benefits associated with one megawatt hour of electricity generated from a renewable energy resource. These certificates may be sold and traded and the owner of the REC can legally claim to have purchased renewable energy. RECs promote the production of renewable energy by providing a source of revenue to electricity generated from renewable sources.

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.

Renewable Portfolio Standard—Regulations requiring that a utility provide a specified amount or percentage of electricity from renewable resources.

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 made by laminating photovoltaic material onto a thin substrate; a thinner, lighter (but as of this time less efficient) alternative to the more traditional crystalline silicon solar panel.

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.

U.S. Department of Treasury Renewable Energy Grants—Grant money that can be taken in lieu of the Business Energy Investment Tax 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.

Physical dimensions of PV

A single 250-watt Monocrystalline SolarWorld module is roughly 3.25 ft by 5.5 ft and weighs 46.7 lbs. without any racking or framing.

The chart below gives spatial dimensions for different size systems using these 250-watt modules to give you a general sense of scale. It is important to understand that these numbers reflect only the size of the solar panels themselves and do not incorporate the required racking structures or any spacing between them. Additionally, in almost all crystalline module arrays, the panels are installed at a tilt, which will reduce the total footprint of the system to below the numbers given here.

SYSTEM SIZE	REQUIRED NUMBER OF 250-W SolarWorld PANELS	ESTIMATED SPATIAL DIMENSIONS OF MODULES
10 kW	40	715 sf
25 kW	100	1,787.5 sf
50 kW	200	3,575 sf
100 kW	400	7,150 sf
500 kW	2,000	35,750 sf

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