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On-Site PV Guidance

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Green Proving Ground Program

The Green Proving Ground program leverages GSA's real estate portfolio to evaluate innovative sustainable building technologies and practices. Findings are used to support the development of GSA performance specifications and inform decision-making within GSA, other federal agencies, and the real estate industry. The program aims to drive innovation in environmental performance in federal buildings and help lead market transformation through deployment of new technologies.

DISCLAIMER

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I. Executive Summary

The U.S. General Services Administration (GSA) has established a significant portfolio of renewable energy projects on federal properties to fulfill its responsibility to lead by example in adopting sustainable practices, and also to meet goals for renewable energy and energy reduction set forth in federal legislation and executive orders (EOs). With the intent of optimizing how the agency locates, sizes and funds future projects for a maximum return on investment, GSA partnered with the National Renewable Energy Laboratory (NREL) in 2011 to conduct a study of the 63 newest additions to its portfolio of 94 solar photovoltaic (PV) projects. Supported by GSA's Green Proving Ground (GPG) program, the study was designed to collect critical knowledge gained in developing and implementing on-site PV projects. The goal was to share lessons learned and good practices with future project teams, and steer them to valuable resources that could help maximize their projects' chances for success and minimize the risk of underperformance. This document reports the study's findings, describes GSA case studies, and provides additional reference material as guidance for similar projects.

GSA's PV projects are quite diverse in terms of location, capacity, and funding source or mechanism. Each of these variables uniquely affects the considerations that inform project implementation – considerations such as policy, energy resource, development, engineering, financial, legal, procurement, construction, and operation and maintenance. The diversity of GSA's PV portfolio, combined with its project teams' collective experience and knowledge, provides a good opportunity for examining the challenges presented by these variables, and harvesting lessons learned and good practices.

The study results revealed that, despite the diversity of GSA's projects, most of the challenges faced by project teams fell into five categories: project management issues, site issues, interconnection issues, technical issues, and economic issues. No trends were identified based on project location; the same top five challenge areas were encountered in all regions throughout the United States. The majority of those projects impacted by challenges experienced delays or economic repercussions as a result.

GSA concluded that the most successful projects established an integrated project team at the outset, enabling early discovery of potential challenges and allowing for modifications in design and scheduling to be made at minimum cost to the project. When such adjustments are not feasible, using strategic decision points to curtail investment in known high risk or infeasible projects can prevent expending resources on projects that are unlikely to help meet renewable energy mandates and provide a good return on investment.

With more than 9,600 assets and over 354 million square feet of workspace, GSA has enormous potential for implementing renewable energy technologies, including solar PV, to reduce energy use and associated emissions. By taking into consideration the key lessons learned and guidance provided, GSA can expect to achieve a higher implementation rate while avoiding project pitfalls such as schedule delays, economic impacts, and reduced quality. The project considerations, lessons learned and good practices detailed here may also be applicable to other real estate organizations with national portfolios.

II. Introduction

In 2011, GSA contracted with the NREL to conduct a study of the 63 newest additions to its portfolio of 94 solar photovoltaic (PV) energy projects. This study, supported by GSA's Green Proving Ground (GPG) program, was designed to collect critical knowledge gained in developing and implementing on-site PV projects. The goal was to share lessons learned and good practices with future project teams, and steer them to valuable resources that could help maximize their project's success and minimize the risk of underperformance.

In conducting this study for GSA, NREL first reviewed existing literature to identify the broad set of policy challenges and risks involved in on-site PV deployments, then used this knowledge to design a survey for collecting information from experienced GSA PV project implementers about the specific challenges they faced and the lessons they learned. Additionally, NREL conducted interviews with a subset of the respondents and summarized and integrated the findings into lessons learned and recommended good practices from their other research. GSA supplemented NREL's research with case studies from its project managers and additional reference material.

This study stemmed from the recognition that renewable energy project developers face many challenges in ensuring the feasibility and operability of their installations. These projects can be risky investments because they are characterized by high up-front costs and slow capital recovery, dependence on cutting edge technology, and energy sources that are neither perfectly predictable nor controllable. Furthermore, developers face a diverse and dynamic policy landscape which warrants their attention at every step in the project development process in order to avoid project delays and increased costs. Any detail related to a policy, a contract term, project economics, or technical guidance that goes unnoticed or unresolved until after equipment is purchased or deployed can potentially have a very large impact on a project. Such oversights can result in waste that is irrecoverable, e.g., fully deployed but stranded equipment that fails to accomplish project goals, provide a financial return, or even recover invested capital.

One of the most remarkable findings from this study is the modest effort needed to identify and avoid these pitfalls; sometimes it is only a matter of ensuring early in the project that the right people are on the project team and talking to the appropriate experts. Keeping project considerations and potential challenges in mind, project teams can proactively plan and manage project risks to address issues before they arise, expedite implementation, and improve the quality of outcomes.

This document is designed with two pull-out sections for future PV project implementers to readily access for guidance. They are Appendix B: Photovoltaic (PV) Project Considerations Guide and Appendix F: GSA PV Project Lessons Learned and Good Practices.

III. Background

A. OVERVIEW OF THE GSA PV PROJECTS

As a federal agency, the GSA has the opportunity and responsibility to lead by example in adopting sustainable practices. GSA's Public Buildings Service (PBS) acquires space on behalf of the federal government through new construction and leasing, and acts as a caretaker for federal properties across the country. PBS manages or leases over 9,600 assets and maintains an inventory of more than 354 million square feet of workspace. Therefore, PBS has enormous potential for implementing renewable energy technologies, such as solar PV projects, to reduce conventional energy use and associated emissions and costs. Renewable energy projects also create jobs and boost the local economy.

Motivated by executive branch sustainability targets and a desire to lead by example, GSA announced its 'solar summer' in 2010, described as "a swift and aggressive push to get Americans back to work in long lasting green collar sectors like solar energy, by significantly ramping up our solar installation projects across the nation."[1] This initiative was fueled by the American Recovery and Reinvestment Act (ARRA) of 2009. ARRA followed closely on the heels of Executive Order (E.O.) 13514, which established sustainability goals for federal agencies, requiring them to set a greenhouse gas emissions reduction target and leverage federal purchasing power to promote environmentally responsible products and technologies. These EOs reinforced the Energy Policy Act of 2005 and Energy Independence and Security Act of 2007, legislation that established energy reduction and renewable energy targets for federal agencies.

By the end of 2011, GSA had 63 new PV projects completed or in progress across the United States, all but one funded by ARRA. The projects are diverse in terms of geographic distribution, capacity, and funding source or mechanism – variables which uniquely affect the considerations that inform project implementation. The diversity of GSA's PV portfolio, combined with the project teams' collective experience and knowledge, provided an opportunity for harvesting lessons learned and good practices. A list of the projects and basic characteristics of each can be found in Appendix A: GSA Photovoltaic (PV) Projects in NREL Study.

LOCATIONS

GSA's 63 new PV projects are located in several regions of the country, mostly near the east and west coasts, the southwestern states, and some sections of the Midwest. Figure 1, below, shows the geographic diversity of GSA's projects and the corresponding quality of solar resource. Labeled markers represent the project locations, and the map coloration indicates the average annual solar radiation available to solar panels with tilt angles equal to latitude. This map shows that the GSA PV projects were not concentrated in areas of the best solar resource, indicating that there are factors other than the quality of renewable energy resource that influence the placement of PV projects.

[1] GSA PV dedication at the Philadelphia Veterans Affairs Regional Office and Insurance Building, June 17, 2010.

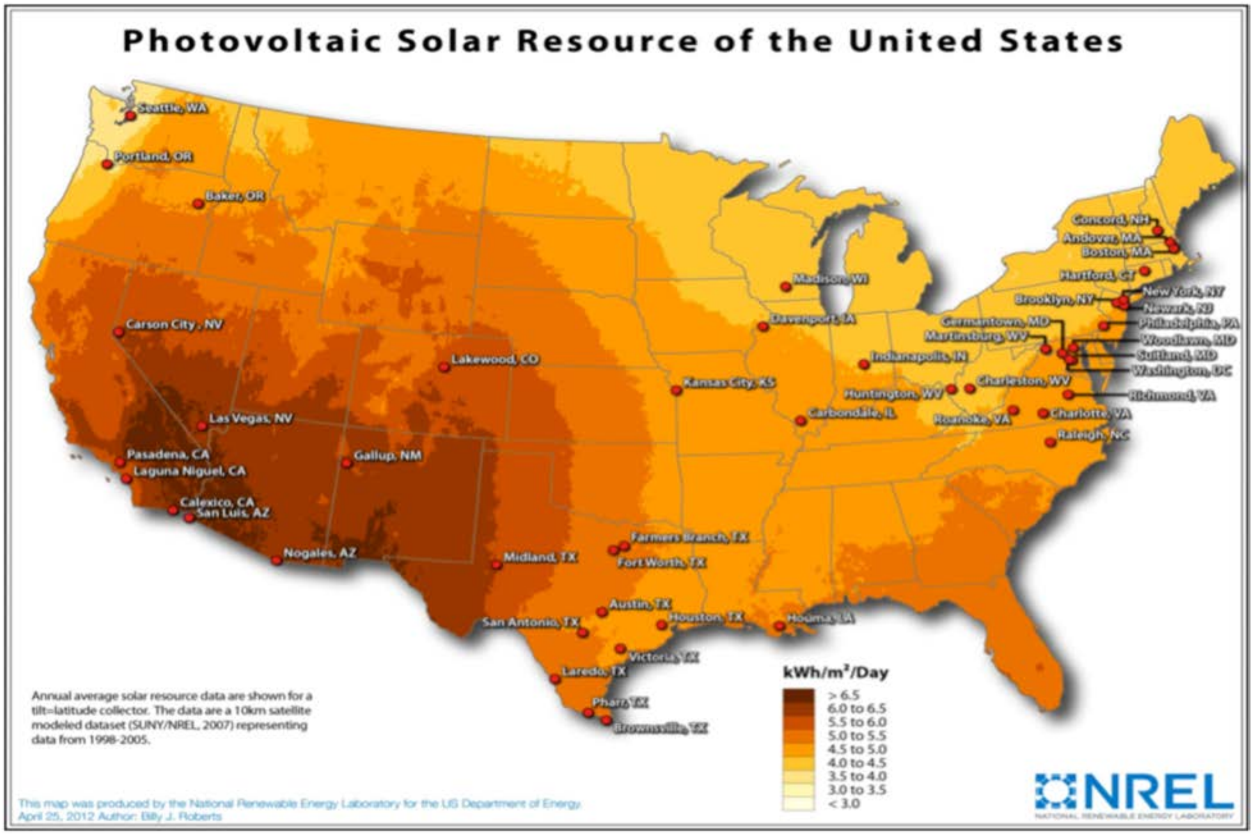
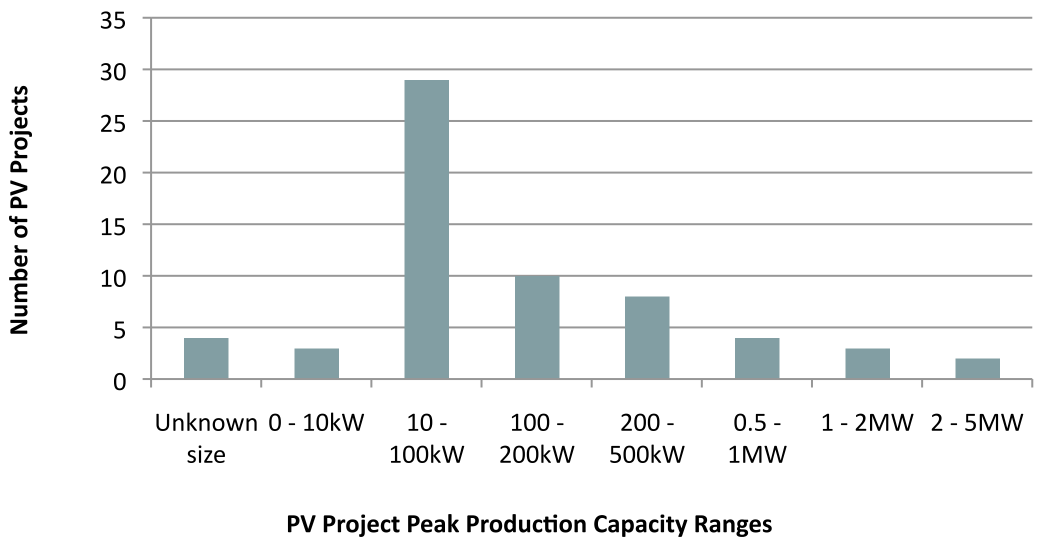


Figure 1: Annual average solar resource data, U.S.; GSA PV project locations shown[2]

CAPACITY

The 63 GSA PV projects vary widely in scale, with peak generating capacities ranging from less than 10 kilowatts (kW) up to the megawatt (MW) range.

[2] Credit: Billy Roberts, NREL



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below, shows the distribution of GSA projects by system capacity. The capacity ranges in this chart are based on breakpoints that typically delineate policy changes related to treatment of renewable energy projects. For example, many jurisdictions have a 2 MW upper limit on projects for which net metering is permitted. Some jurisdictions also have a different procedure for interconnection studies for systems over 2 MW in capacity. As the chart shows, the largest number of GSA projects falls within the 10-100kW capacity range.

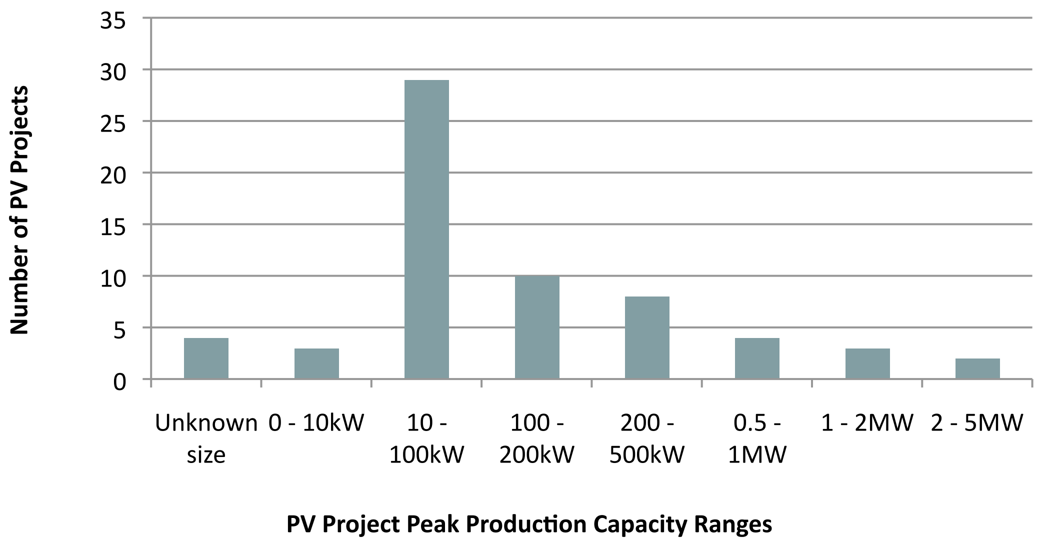


Figure 2: Number of GSA PV projects by system capacity[3]

This set of 63 projects represents a total of 21 megawatts (MW) of peak generating capacity, expected to generate 31 gigawatt hours (GWh) of electrical energy per year. To put it in perspective, this amount of energy would meet the electricity needs of about 2,700 average U.S. homes for one year.[4]

Table 1, below, summarizes basic statistics about peak generating capacity and the expected annual generation of 59 of the GSA PV systems. The capacities of four of the 63 projects were unknown at the time of the study.

Table 1: Statistical capacity and annual generation of GSA PV projects

	Capacity (kW)	Expected Annual Generation (kWh)
Average	344	500,000
Median	93	107,000
Total	21,000	31,000,000

[3] Source: GSA Energy Center of Expertise

[4] Calculated using formula from Energy Information Administration website: http://www.eia.gov/tools/faqs/faq.cfm?id=97&t=3, accessed April 19,2013

FUNDING

Every project in GSA's PV portfolio was funded by direct appropriations, in some cases combined with Energy Savings Performance Contract (ESPC) financing. Most of the projects were funded through ARRA. The ARRA funding came in the form of appropriations to GSA and other agencies, with the stipulation that it be committed by certain deadlines. These appropriations were made available during a time of federal economic stimulus; seldom will similar appropriations be available for federal PV projects.

GSA's Greater Southwest Region, Region 7, was the only region that utilized ESPCs to leverage ARRA funding with private investment in order to accomplish larger scale projects, perhaps setting a precedent for future GSA installations to use ESPCs for on-site renewable energy measures. This region believed that ESPCs were a great fit for delivering its projects in Texas, Louisiana, and New Mexico, as ESPCs are turn-key design/build contracts and have guaranteed savings and measurement and verification built in. The ESPC projects were delivered faster than traditional projects that are designed by one firm, advertised, and awarded to another firm for construction. GSA's combination of both approaches to project funding expanded the agency's collective knowledge and experience.

Although federal agencies have successfully executed power purchase agreements (PPAs) to finance the installation of PV projects, PPAs were not utilized for any of the GSA projects, likely because civilian agencies are generally limited to ten-year contract terms. None of the 63 projects utilized a utility energy service contract (UESC), though this could be a consideration for future projects.

B. TECHNOLOGY DESCRIPTION

PV is a mature, commercially available renewable energy technology. PV arrays convert sunlight to electricity without moving parts and without producing air pollution or greenhouse gases (GHG). They require very little maintenance, make no noise, and can be mounted on many types of buildings and structures. PV direct current (DC) electric power can be conditioned into grid-quality alternating current (AC) electric power using an inverter, or be used to charge batteries. Most GSA PV installations are grid-connected and therefore, very few use batteries. A schematic of the typical components of a grid-connected PV system is shown in Figure 3.

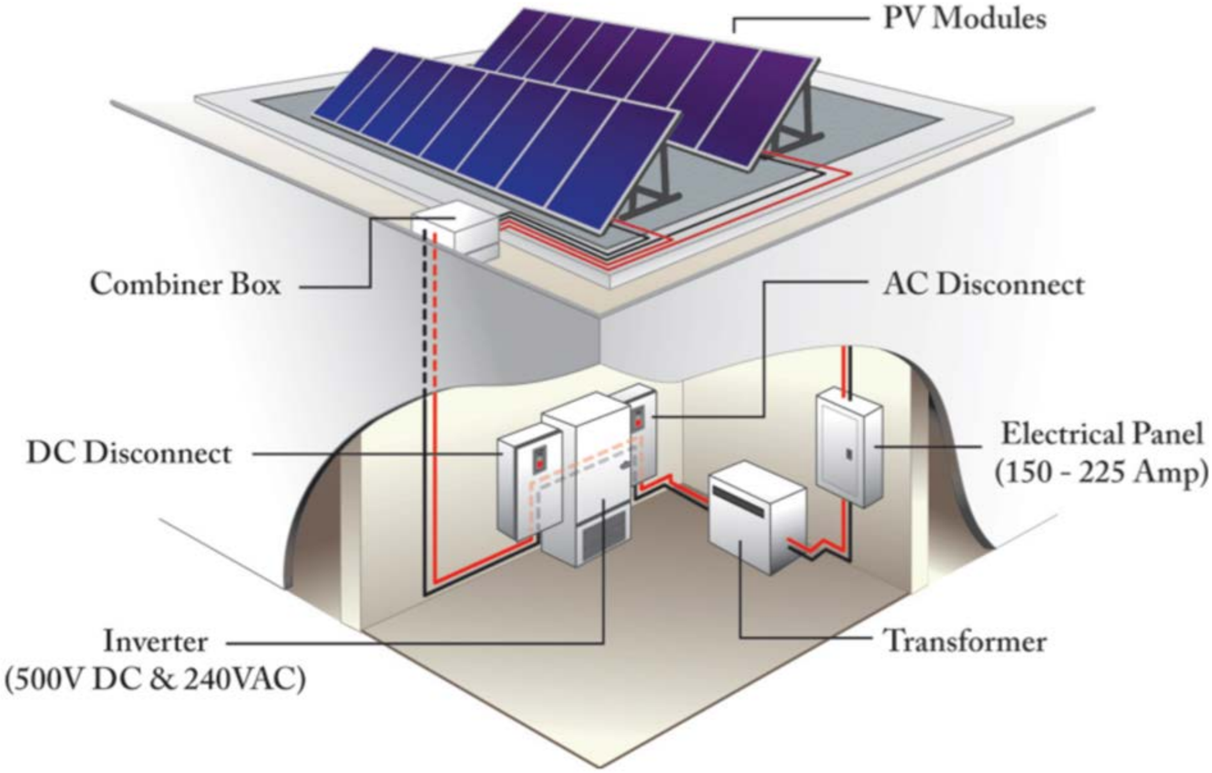


Figure 3: Typical components of a grid-connected PV system[5]

[5] Credit: Jim Leyshon, NREL

IV. Project Considerations

To successfully implement an on-site PV project, teams must make numerous decisions during the planning process. Each project is affected by a large number of factors, such as:

- availability of useable roof space or ground space for PV arrays
- solar resource
- availability of incentives to renewable energy facility owners or hosts
- site load
- unique policies, rules, and procedures that apply to each potential project location
- federal and agency-specific mandates and guidelines for energy efficiency, renewable energy, and sustainability

Not only is the number of considerations and potential implications great, any one or a combination of factors can have a substantial impact on outcomes such as project economics, quality, regulatory compliance, and even the authorization for the project to connect to the electrical infrastructure and begin operation. An overview of some of the major considerations is presented here, and a more in-depth discussion of these topics, plus resources for additional information, is provided in Appendix B: Photovoltaic (PV) Project Considerations Guide.

A. AVAILABLE APPROPRIATE SPACE

The requirement for a location or space may be the most fundamental consideration for implementation of a PV project. Locations vary in suitability for PV deployment, depending on goals and constraints for the project.

Site characteristics have implications for structure and orientation as well as economics of a PV system. If the project is to be sited on the ground, the slope of the land as well as the presence of obstacles and plant growth that might interfere with the system by creating maintenance or shading must be considered. There are a number of unconventional racking systems on the market which can be used to mount PV systems on uneven or steeply sloping terrain, but optimally a site should be level or only gently sloping.

Shading is particularly detrimental to the energy production of most PV panels, so a site that will not lead to shading of the arrays should be selected.

If a roof is under consideration as a project site, it should be relatively new so that the PV will not have to be removed early in the project life for roof service, and it should be structurally capable of supporting the additional weight of the PV system. Generally, the roof condition and 'solar-readiness' of the roof should be evaluated, as well as any possibility of impacting the roof warranty by mounting a PV system. If a site is in a historic district or near or on a historic property, care should be taken that approval for the project can be obtained.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

B. RESOURCE

The quality of the renewable energy resource at a location, i.e., the solar energy available for conversion into electricity, is the fundamental determinant of energy production potential for a PV system at that location, and is one of the factors determining project financial viability. For this reason, system energy production potential as a function of solar resource is a basic consideration in project screening.

A tool such as NREL's PVWatts online calculator is a convenient way to estimate system production for generic systems of various high level configurations and efficiencies in different geographic locations for which typical meteorological year (TMY) data is available. PVWatts Version 2 has an online interactive map as a front end to facilitate selection of available TMY data for the location closest to the site under consideration. Its basic interface allows input of system DC nameplate capacity, a 'derate' factor for energy losses through system components such as inverter and conductors, and tilt and azimuth angles. The tool outputs estimated energy production by month in kWh and an annual total for a TMY. It pulls the cost of electricity data for the area from a geographical information system for a preliminary guess at the economic value of the energy production.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

C. SITE LOAD OR CUSTOMER LOAD

For behind-the-meter PV systems, the site load, in terms of annual electricity consumption, and the load profile, in terms of 15 minute, 30 minute, or hourly interval consumption data, can be useful in determining an optimum upper limit on system capacity in light of the utility rate tariff and other available incentives, such as net metering or a feed-in tariff.

Where net metering or a feed-in tariff is concerned, for purposes of qualification for the incentive, there are almost always hard, policy-based upper limits on the size of the PV system. To qualify for the incentive, often the nameplate capacity of the system cannot exceed some particular value, and often the expected annual energy production cannot exceed some percentage of the site's annual consumption. The upper limit might, for example, be stated as "the lesser of 2MW DC or a capacity projected to generate no more than 120% of the site's previous 12 months' aggregate consumption."

Net metering and feed-in tariff policies allow a site to operate unconcerned about excess production going uncompensated or undercompensated by requiring the utility to compensate the site for excess production, usually at the retail rate with net metering, at the feed-in tariff rate with a feed-in tariff. On the other hand, in the absence of net metering or a feed-in tariff to provide better-than-wholesale remuneration for excess generation, in general, the marginal cost of excess power produced is greater than its value to the site. If the site is not contracted to be compensated for excess production, the excess production's economic value to the site is often zero. In such a scenario the system should be designed to strike a balance between minimizing excess generation (for which there is no economic benefit) while maximizing generation to offset site load.

Other considerations for sizing a system with regard to site load include:

- Will there be standby charges?
- Will there be a tariff change after the PV system is operational, due to a change in load from the utility perspective?
- Is there a competitive electric contract, and, if so, what is the contract term and does it include any provisions regarding guaranteed load?

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

D. PROJECT FUNDING

Carefully matching available funding tools with specific project needs can make the difference between a stalled, unfunded project and a successful project generating energy and providing cost savings. Often, appropriations are not available for a desired PV project. In those cases, other funding vehicles such as an energy savings performance contract (ESPC), utility energy service contract (UESC) or power purchase agreement (PPA) should be explored as alternatives. These funding mechanisms offer a number of benefits, such as absence of requirement for upfront capital, predictable energy pricing, and mitigation of operations and maintenance (O&M) risk for the agency.

The funding mechanism used for a PV project is significant because each funding approach has different risk implications for the government. Use of appropriated funding often allocates some development risk and most or all of the operating risk of the project to the government as project owner. On the other hand, the ESPC, UESC and PPA generally allocate more of the development and most of the operating risk to the contractor.

ESPC

An ESPC is a partnership between an energy service company (ESCO) and a customer, through which the ESCO identifies energy saving opportunities at the customer's facilities, often provides or arranges for financing, manages the installation of energy conservation measures (ECMs), and then recovers its expenditures and earns some return on its investment through the customer's periodic payments, which are based on the resulting savings from avoided conventional energy purchases. With an ESPC, the ESCO is often responsible for identifying and screening project opportunities, and typically bears the financial risk of the project failing to save money for the government, with some exceptions.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

UESC

In a UESC, a serving or franchised utility company agrees to provide a federal agency with services or products (or both) designed to make that agency's facilities more energy efficient. Federal facilities can also obtain project financing from a utility company through a UESC. During the contract period, the agency pays for the cost of the UESC from the avoided-cost savings resulting from the energy efficiency improvements. Experienced agency/utility teams may use excess-avoided-cost savings to cover the cost of a feasibility study for follow-on UESCs at their facilities. After the term of the contract, the energy and water efficiency improvements continue to realize the avoided-cost savings for the life of the improvements, and the savings can be used to do more projects.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

PPA

A PPA refers, in its simplest essence, to a contract to purchase power (usually electric) that establishes the purchase price for the power, the term of the agreement (usually a number of years), and other terms and conditions for the purchase and sale of the power. A PPA-funded project is a third-party ownership approach, and the project is usually designed so that the government only pays for power actually produced by the PV system; most of the risk of under- or non-performance of the system is borne by the third-party system owner.

In the context of an on-site PV project, the PPA is the agreement of the host site with the owner of the system to purchase all the power the system produces. The system owner often uses the stream of payments from the power sales as well as investment tax credits, accelerated depreciation, and other available incentives, to recover the capital that funded the purchase of the system and to make a return on its investment. In this sense, the PPA is the financing mechanism that facilitates the purchase and installation of the system. The owner may pass those benefits through to the site in the form of lower pricing of the power.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

COMMUNITY SOLAR FARM OR SOLAR GARDEN

Because a community solar farm is paid for and owned by an investor or investors often unaffiliated with the PV project site, it might be possible to utilize the policy for this unique form of third-party ownership of a PV project hosted on federal land. To the authors' knowledge, community solar has not been explored as a possible third-party ownership approach to funding PV projects hosted on federal land, and there could be complications or policy-specific impediments to the concept or to its practical application. Considerations would include:

- Is it possible for the federal host to claim the Energy Policy Act of 2005 (EPAct) double-bonus for 'use' of on-site generated renewable electricity from the project, even though it is not actually purchasing energy from the project (presumably the power flows from the project are largely feeding federal loads due to proximity in the circuit)?
- If the community solar farm participants have ownership of the project RECs, could the federal host claim on-site renewable electricity 'use' from the system by purchasing replacement RECs?
- Will the community solar farm rules in the state permit siting of the community solar farm behind-the-meter of the host without adversely affecting the production credits claimable by the solar farm participants?

- Would an EUL be the appropriate federal contracting authority to utilize for this type of project structure, or could the project be structured to appropriately utilize federal ESPC authority?

These and other questions should be thoroughly explored with advice of counsel and in light of DOE FEMP guidance on the applicable statutes and regulations before undertaking this type of funding approach.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

E. INCENTIVES

Governments and other authorities offer incentives and preferential treatment to distributed renewable energy projects, which can, in effect, reduce the cost of or increase the return on purchasing, installing, hosting, and owning renewable energy generating systems. A project properly designed and planned to utilize good incentives can be financially sound or profitable, whereas the same project may appear infeasible if a good incentive is overlooked. Even when an incentive is known to be available, however, not knowing its limits or constraints can be risky; expected cash flows may be diminished or fail to materialize altogether.

This section introduces the common categories of renewable energy incentives and highlights some opportunities and potential pitfalls of each. A good resource is the Database of State Incentives for Renewable Energy (DSIRE), which is a comprehensive source of information on state, federal, local, and utility incentives and policies that support renewable energy and energy efficiency.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

ACCELERATED DEPRECIATION

An accelerated depreciation is a tax or financial accounting method that depreciates a fixed asset in such a way that the amount of depreciation taken each year is greater during the earlier years of an asset's life. Some tax rules require depreciation of an asset in a straight line over an expected useful lifetime. Because depreciation is treated as a tax exempt expense, accelerated depreciation allows a taxable entity to realize a reduced tax burden sooner rather than later, enhancing early cash flows and overall project returns. There are a number of different accelerated depreciation approaches, with varying rules by jurisdiction and by type of asset.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

FEED-IN TARIFF (FIT)

A FIT is a type of production- or performance-based incentive that permits a purchase and sale agreement with a utility for the utility to purchase electric energy from qualifying renewable electric projects at a pre-set price, usually per kWh, for some period of years. FIT prices are intended to be more favorable to renewable energy projects than market wholesale power prices would be.

In the United States, some FIT rules require that utilities purchase only the electricity; other rules require utilities to purchase both the electricity and the renewable energy (RE) attributes from participating renewable energy generators. Upper limits on project capacity of qualifying projects also vary by jurisdiction and utility. Some jurisdictions or states may require direct interconnection of the project with the utility distribution system, as opposed to allowing behind-the-meter projects for participation in the FIT. Per-kWh pricing and the application of time-of-production rate multipliers, which vary the price of exported power from a base rate according to season and time of day, also vary by location.

Some FIT rules allow project rated capacity limits that are higher than those for net metering, so a FIT can represent an opportunity to build a larger project than might otherwise be feasible, based on the energy use at the host site or the net metering project capacity limit. Like net metering, by providing a revenue opportunity for exported electricity, the FIT improves the bottom line for renewable energy projects that might otherwise not receive adequate compensation for excess generated power.

If FIT requirements are not fully understood, the as-designed project could fail to meet requirements to qualify for the FIT, risking loss of the FIT revenue stream. Also, economic modeling of the impact of a FIT on a PV project can be complex, and simplifications, if optimistic, may qualify a project that will fail to provide anticipated returns, and if pessimistic, may lead to a missed opportunity.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

GRANTS AND REBATES

Grants and rebates represent opportunities for cash payments made either as partial refunds for the purchase of certain assets (rebates), or before or soon after project implementation (grants).

The essence of each of these incentives is upfront money to help with project costs. These programs are offered at the federal level, and by states, utilities and a few local governments, and may be administered and funded at any level or combinations of these levels. Accordingly, each program has its own qualification criteria and application process, variously dictating milestones, qualifying equipment, funding limits, and so forth.

Grants and rebates, as upfront cash, offer some of the lowest risk value to renewable energy projects, and, as such, provide value-rich opportunities. To ensure realization, planning and oversight should be based on carefully researched policy specifics. Responsibility for using these incentives can often be placed with the renewable energy project contractor.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

INVESTMENT TAX CREDIT

An ITC is a reduction in the amount of tax payable by a taxable entity for the tax year in which a renewable energy asset is purchased (though some ITCs have carry-forward provisions), and is based on the amount paid for the asset. The amount of the reduction is usually equal to some percentage of the entity's investment in the asset. ITCs are offered against federal income tax of businesses and are offered by a number of states.

For some eligible technologies, the federal credit is equal to 30% of expenditures, for others it is 10% of expenditures. Investment-based state tax credits vary and are often proportional to installed cost, often have ceilings per project or annual ceilings per entity, and often have finite state budget allocations to be disbursed on a first-come first-served basis.

The opportunities presented by investment tax credits are significant; because they are realized early in the project life, the investment-year tax discounts are similar to up-front cash or rebates against project investment. Unaccounted-for ITCs in project screening or economic modeling could lead to a large underestimation of a project's value or a false negative in a project feasibility assessment.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

PRODUCTION TAX CREDIT

A PTC is an amount to be deducted from the total amount that a taxpaying renewable energy project owner owes to a taxing authority (the credit), proportional to the amount of renewable energy produced by the renewable energy project (the production) during a tax accounting period.

There is currently a federal PTC and a number of states have PTCs. Different jurisdictions recognize different technologies; some even give credit for renewable thermal energy.

As an example, the federal PTC is a per-kilowatt-hour tax credit for electricity generated by qualified energy resources and sold by the taxpayer to an unrelated person during the taxable year. There are a number of technologies coved by the federal PTC, and the rules governing the PTC vary by resource and facility type.

The tax credit is reduced for projects that receive other federal tax credits, grants, tax-exempt financing, or subsidized energy financing.

The various PTCs offered by the federal and state governments offer opportunities for businesses and other entities (depending on the applicability of the PTC concerned) to stagger their receipt of tax benefits over a number of or many years.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

PRODUCTION-BASED INCENTIVE (PBI)

A production- or performance-based incentive compensates the renewable energy project owner according to the amount of energy produced by the project. Production tax credits are examples of production-based incentives, and even net metering and FITs could be said to be examples of PBIs because they compensate the owner according to how much renewable energy is produced and delivered.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

NET METERING

Net metering is a public policy incentive whereby electric utility customers who host small renewable energy facilities or V2G electric vehicles receive retail credit for at least a portion of the excess electricity they generate. The retail credit is based on deduction of metered energy outflows from metered energy inflows during a billing period. Net metering is considered an incentive for installation of renewable energy facilities because it is common for utilities to pay only a wholesale price for power they purchase whereas under net metering policies the utility is effectively paying a retail price for excess power generated by small renewable energy generators.

States and local utilities vary widely in the availability and specifics of the net metering programs they offer. Availability and program specifics often depend not only on the state but also on the type of utility (investor-owned, rural cooperative, municipal) and the degree of utility deregulation in the area.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

PROPERTY TAX CREDIT

A property tax credit is a credit, deduction, or exemption available to a renewable energy facility owner whereby the incremental value of the facility is disregarded or assessed at a discount for property tax purposes. Rules vary by renewable energy technology, by state, and by local area within states.

If the owner of the renewable energy property is not subject to property tax (e.g., federal entities are usually not subject to state or local taxes as a matter of the doctrine of intergovernmental tax immunity), then there is no corresponding benefit from a reduced effective assessment value, and a benefit should not be anticipated.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

RENEWABLE ENERGY CERTIFICATE (REC)

A REC is also known as a green tag or a tradable renewable certificate, and a solar REC is also known as an SREC. It is a tradable, non-tangible unit of energy commodity in the United States which constitutes proof that one megawatt-hour (MWh) of energy was generated and delivered by an eligible renewable energy resource.

RECs can be sold or swapped, and the holder of the REC can be said to have generated or purchased renewable energy. Thus, a REC represents the environmental attributes of the energy produced from a renewable energy project and can exist separately from the commodity electricity for ownership and accounting purposes. RECs can be a source of revenue to renewable energy project owners or can be retained and retired to justify a claim to have generated or consumed some quantity of renewable, or “green,” energy.

Certain utility policies, such as some net metering and some production incentive policies, explicitly grant the utility ownership of project RECs.

Holding title to and retiring RECs may help the holder meet sustainability goals. REC sales, on the other hand, may provide revenue to contribute to the economic feasibility of a renewable energy project. If the REC ownership terms of the incentives utilized are not known, the project host or owner may not be able to depend upon REC retention to meet sustainability goals or to provide revenues to support project economics. On the other hand, if use of a necessary incentive requires relinquishment of project RECs, it may be possible to meet objectives by purchasing replacement RECs at a low cost.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

SALES TAX CREDIT

A sales tax credit is an exemption from, or refund of, the state sales tax (or sales and use tax) for the purchase of renewable energy systems or equipment.

Some states offer tax holidays for these products, often one or two days a year, and some states offer these credits to corporations investing in PV projects.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

F. INTERCONNECTION

Interconnection standards specify the process and requirements for a generator or generating customer to connect electricity-generating systems to the electric utility transmission or distribution system. Electric utilities and utility regulatory bodies, such as the state utility commissions and the Federal Energy Regulatory Commission (FERC), implement these rules to help ensure that generating equipment is safe and compatible to interoperate with the utility systems, minimizing the risk of adverse system impact. Interconnection requirements vary with the utility line voltage level, nameplate capacity of the PV system, the utility, and the jurisdiction.

Interconnection standards include the technical and contractual terms which must be agreed upon by the system owners and utilities. State public utility commissions typically establish standards for interconnection to the utility distribution system, while the FERC has adopted standards for interconnection at the transmission level.

Interconnection procedures can be time-consuming and can have associated costs, potentially impacting project cost and schedule. They can also introduce contractual and risk allocation challenges for some implementers. A system impact study, which is often a prerequisite to interconnection, is used to determine the potential impacts and required upgrades to accommodate an on-site electricity generating plant. Detailed studies may identify feasible mitigation measures for problems identified, provide recommendations for facility modifications, and include good-faith estimates of cost and construction time.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

G. METERING

Often, for participation in a production-based incentive program, the administering authority requires a revenue-grade electric system output meter. This requirement for a production meter (or bi-directional meter) may apply to programs such as net metering, feed-in tariffs, or other production-based incentive programs.

While many inverters can display energy production, inverter meters are not designed to the tolerances required for revenue-grade meters. Installation of a utility- or program-approved meter is usually required, and typically the utility customer or PV system contractor is responsible for installation by qualified personnel and according to code. The utility customer or PV contractor is often responsible for any cost of procurement and installation of the meter, and utility coordination is often required.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

H. PERMITTING AND INSPECTIONS

Permitting refers to the process undertaken to meet requirements that may be imposed by governments and other authorities for land use, construction, safety, and environmental and cultural resources protection in order to gain authorization for project implementation. Permitting requirements must usually be met in order for a project to be implemented without risk of being shut down for non-compliance. For some types of permits inspections are a required part of the process. Permitting requirements fall into four general categories:

- Land use permits: Used to uphold zoning laws, which ensure that areas are developed consistently with local and national standards for land use, aesthetics, and other values.
- Environmental permits: Used to ensure the development of a project does not negatively impact the ecosystem where the project will be developed, that development will mitigate negative impacts, and that stakeholders will consider the environmental costs as well as the benefits of the development under consideration.
- Construction/operation permits: Required before building or operating a new facility.
- Electrical work permits: Required to perform installation, alteration, or maintenance of electrical systems.

Often, projects are not allowed to go forward to construction, completion, or into the operating phase before these permitting requirements are met, so if not managed properly, they can create delays or show-stoppers for some types of PV projects in certain geographic areas. Failure to obtain the correct permits can be costly in terms of construction delays related to stop work orders; foregone revenues, tax credits, and commencement of accelerated depreciation; and in today's regulatory climate, possibly penalties for failure to meet renewable portfolio standards. Managed properly, however, they can help ensure that the project is safe, interoperable with other systems, environmentally friendly and sustainable, and respectful of and in harmony with historical and cultural resources in the area.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

I. SUPPLEMENTARY TOPICS

In addition to funding, incentives, interconnection, and permitting, other considerations that may surface less frequently include community solar farms (or solar gardens), equipment certification, renewable contractor licensing, solar access and easements, and the renewable portfolio standard. These topics are considered supplementary because they may either concern the project host only indirectly, or, as is the case with community solar farms, not concern the project host or sponsor at all unless, for example, there is a constraint on available appropriate space to host a project and there is interest in participation in a project hosted off-site, or, as discussed under Project Funding, there is an interest in partnering with a community funder to host a PV project on federal land.

COMMUNITY SOLAR FARM OR SOLAR GARDEN

A community solar farm is a solar power installation, usually centrally located, that accepts capital from and provides credit for the output and tax benefits to individual and other investors. One popular use is to facilitate ownership participation (with the credit and tax benefits) for those who do not have an ideal location on their own property to host a solar facility. The power output is often credited to the investors in proportion to their interest (the output may be credited to the power bill of the participant), with periodic adjustments to reflect ongoing changes in capacity, technology, costs, and electricity rates. A company, cooperative, government, or non-profit may ultimately own and/or operate the facility.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

EQUIPMENT CERTIFICATION

In some jurisdictions there are standards for qualification of renewable energy equipment for various purposes. These standards are in place for a number of reasons, for example, to ensure electrical safety, to protect consumers from buying inferior equipment, or to ensure that an incentive to support renewable energy projects has the impact (production of clean energy) intended by the entity providing it.

It is important to check for any equipment standards or certification requirements, especially those related to incentives and interconnection, to ensure that the project, as designed and procured, will be permitted to interconnect to the utility and begin operation, and so that expected incentives will be realized.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

RENEWABLE PROJECT CONTRACTOR LICENSING

Some states have adopted licensure requirements for renewable energy project contractors. These requirements are designed to ensure that contractors have the necessary knowledge and experience to install systems properly. Licenses for solar contractors typically take the form of either a separate, specialized solar contractor's license, or a specialty classification under a general electrical or plumbing license. PV project managers should check to ensure that the selected contractor meets all licensure requirements.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

SOLAR ACCESS POLICIES

Solar and wind access policies, whether state or local, are designed to preserve (against local ordinances or home owners association rules) a right to install and operate a solar or wind energy system at a home or other facility, or to facilitate a system owner's assurance of access to sunlight, usually through an easement. Easement allowances, the most common form of solar access policy mechanism, are most often crafted so that the easement is requested of and granted voluntarily by a neighboring property owner and transferred with the property title. Easement allowances may also permit the contracting parties to include their own remedies for breach of contract.

Solar developers signing a PPA may require a recorded solar easement, or at least a provision in the PPA or any accompanying real property agreement ensuring that there will be no future development that will shade the solar project.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

RENEWABLE PORTFOLIO STANDARDS (RPS), SOLAR SET-ASIDES, AND SOLAR CREDIT MULTIPLIERS

An RPS is a legal requirement for utility companies or load serving entities to procure or produce a certain percentage of the energy used in the service territory from renewable energy sources, or otherwise permit or facilitate generation and/or use by its customers of energy from renewable energy sources.

Depending on policy specifics, a utility may meet its RPS requirements by building utility-scale renewable energy projects, entering into PPAs with renewable energy generators or aggregators, or by offering incentives to its customers to build projects and generate renewable energy for their own use and the use of others on the distribution system. The utility is usually required to purchase and retire RECs as a part of its requirements.

A "set-aside" or "carve-out" refers to a portion of a state's RPS that requires a specific renewable source, often solar energy, to account for a percentage of retail electricity sales or generating capacity. The solar credits multiplier was originally created to encourage the expansion of home solar units. Under the set-aside RECs generated by qualifying projects were to be valued at some five times their market rate for the first few years.

For more detailed information see Appendix B: Photovoltaic (PV) Project Considerations Guide.

V. Lessons Learned and Good Practices

A. SURVEY OF GSA PROJECT STAKEHOLDERS

SURVEY DESCRIPTION

NREL designed a survey to gather knowledge from experienced GSA PV project implementers about the specific challenges they faced and the lessons they learned in implementing PV projects. After GSA administered the survey, NREL processed and analyzed the results, then identified and ranked common challenge areas. The survey questions are listed in Appendix C: GSA PV Project Stakeholders Survey.

The survey was designed to capture both project specific and trend information about types of challenges experienced by PV project teams. The NREL researchers established categories of challenges based on their research of frequently encountered barriers to PV project deployment and also on their experience advising on development of federal renewable energy projects. The survey accommodated additional ad hoc categories for respondents who felt that the challenges they encountered did not fit any of the predefined categories.

The challenges encountered by respondents were organized into the following categories:

- project management issues
- site issues
- interconnection agreement and other interconnection issues
- technical issues
- economic issues
- weather
- lack of expertise
- procurement issues
- state or local laws and regulations
- conflicts with agency or site mission or plans
- net metering
- other utility issues
- incentives

Respondents were asked about the actual effects of each challenge they encountered on their projects, and whether there was an action, best practice, or key success factor implemented by the project team that lessened the impact of each challenge or issue. They were also asked to speculate about the likely effects on their projects had the challenges not been resolved.

Because the study was largely policy focused, the survey collected data on the state, local area, serving electric utility and PV system capacity. The location information, including the serving electric utility, determines jurisdiction, hence policies, rules, and contractual forms; and the PV system capacity often determines applicability of policy pieces and specific rules, such as interconnection process and whether or not net metering is available. It was thought that this type of project information might give insight into location or utility-specific challenges that might arise for certain types of projects.

The survey was administered via email to hundreds of GSA employees who served in diverse roles on PV project teams. The employee designations included:

- renewable energy project manager
- energy manager
- facility manager
- site manager
- facility master planner
- environmental expert
- renewable energy technology expert
- safety officer
- sustainability officer

Most respondents were project managers, energy managers, architects, engineers, and other specialists.

SURVEY FINDINGS

Survey results are summarized in Table 2: Summary of GSA PV project stakeholder survey results, below. As the table indicates, the survey captured information about the following:

- The types of challenges and the percentage of projects surveyed that encountered each type of challenge
- The locations where challenges of each type were encountered
- Survey respondents' speculation about the likely effects on their projects had the challenges not been resolved
- Corrective actions taken by the project teams to address and resolve the challenges they experienced

- Actual effects of the encountered challenges on the projects, despite team efforts to resolve the issues and despite resolution, if any

The distribution of challenges by category may alert future project implementers where to focus their attention, and correlation of the challenges with project locations might prove useful in further identification of focus areas. It should be noted, however, that the appearance of a challenge in a particular geographic region, with a particular utility, or at a particular site does not necessarily indicate that the same type of challenge will arise in similarly situated GSA projects in the future.

PV project team members elaborated on the challenges they faced in the survey questionnaire and in follow-up interviews. Detailed information is provided for a sample of the projects in Appendix D: Sample of GSA PV Project Challenges.

The survey revealed that most of the challenges faced by project teams fell into five categories: project management issues, site issues, interconnection issues, technical issues and economic issues. No challenges were reported for 13% of the projects, and the frequency of challenges in all projects was distributed as shown in Table 2. There were no trends identified based on project location, and the same top five challenge areas were encountered in all regions throughout the United States. In most cases, the project team was able to overcome the issue(s) it encountered, although many of the projects experienced delays or economic impacts. In a couple of instances, projects experienced reduced quality or were deemed infeasible, and development was halted.

TABLE 2: SUMMARY OF GSA PV PROJECT STAKEHOLDER SURVEY RESULTS

Type of Challenge and % of Projects Which Encountered Challenge	Locations Where Challenge Arose	Likely Effect on Projects if Challenge Was Not Resolved	Corrective Action Taken by Project Teams to Address Challenge	Actual Effects on Deployed Projects
Project management 37%	Washington, D.C. Suitland, MD Martinsburg, WV Woodland, MD San Antonio, TX Charlotte, V.I. Lakewood, CO Texas New Mexico Louisiana	Schedule delay A no-go decision would have been made on the project Economic impact The project would have been deployed but could be non-operational	Integrated design team and delivery approach Engage inspectors and all state and local departments early Document all issues Require close oversight by the manufacturers providing the warranty Consider ESPC design-build contracting Pay close attention to the environmental regulations	Schedule delay Economic impact

Type of Challenge and % of Projects Which Encountered Challenge	Locations Where Challenge Arose	Likely Effect on Projects if Challenge Was Not Resolved	Corrective Action Taken by Project Teams to Address Challenge	Actual Effects on Deployed Projects
Site issues 30%	Seattle, WA Washington, D.C. New York, NY Lakewood, CO Texas New Mexico Louisiana	Schedule delay Quality Economic impact	Innovative design adjustments Established protocol for tenant communication Partnered with project team to resolve Integrated delivery approach, where all participants provided value in the development process	Schedule delay Quality Project development was halted
Interconnection agreement 27%	Portland, OR Washington, D.C. Davenport, IA Hartford, CT Philadelphia, PA Wilmington, DE San Antonio, TX Lakewood, CO Charlotte, V.I.	Schedule delay The project would have been deployed but could be non-operational The size of the array may be below what was originally planned Economic impact	Work w/ GSA legal to tailor standard interconnection agreement w/ Utility Improved pre-planning Start discussions early and be persistent Involve the local utility during design Using a design-build approach to the design and construction allows for greater flexibility	Schedule delay Economic impact Quality

Type of Challenge and % of Projects Which Encountered Challenge	Locations Where Challenge Arose	Likely Effect on Projects if Challenge Was Not Resolved	Corrective Action Taken by Project Teams to Address Challenge	Actual Effects on Deployed Projects
Technical issues 23%	Kansas City, KS Woodland, MD Brooklyn, NY Calexico, CA San Antonio, TX Lakewood, CO	Schedule delay Economic impact Quality	Require close oversight from the manufacturer providing the warranty Be fully aware of cost restrictions Be flexible with scope adds Clearly define monitoring and display requirements Good coordination Make sure the designer works with the contractor to lay out specific diagrams about how the system will work	Schedule delay System is generating power but monitoring not implemented yet
Economic issues 13%	Martinsburg, WV Carbondale, IL Newark, NJ	Economic impact Schedule delay	Correctly size systems for load Use the float funding wisely	Economic impact Schedule delay
No problems 13%	Laguna Niguel, CA Philadelphia, PA Indianapolis, IN	No significant impact	None	No significant impact

Type of Challenge and % of Projects Which Encountered Challenge	Locations Where Challenge Arose	Likely Effect on Projects if Challenge Was Not Resolved	Corrective Action Taken by Project Teams to Address Challenge	Actual Effects on Deployed Projects
Weather 10%	Calexico, CA Wilmington, DE Suitland, MD	Economic impact Schedule delay	Work with construction contractor to minimize construction delays Work with contractor to provide materials storage and site access Work with project team on alternative work schedules (nights and weekends)	Schedule delay
Lack of expertise 10%	Portland, OR Kansas City, KS New York, NY	Quality Schedule delay Economic impact	During the construction contractor solicitation, specify a knowledgeable installation crew Be willing to accommodate scope changes	No significant impact
Procurement issues 10%	Suitland, MD Hartford, CT Newark, NJ	Quality Schedule delay Economic impact	The scope of work was revised to fit the project budget Work with contractor to research all possible sources and substitutes for no longer available equipment	Schedule delay

Type of Challenge and % of Projects Which Encountered Challenge	Locations Where Challenge Arose	Likely Effect on Projects if Challenge Was Not Resolved	Corrective Action Taken by Project Teams to Address Challenge	Actual Effects on Deployed Projects
State or local laws and regulations 7%	Seattle, WA Washington, D.C.	Quality Project delay	Partnering with outside agencies and utility companies during the design process Experience	No significant impact
Net metering 7%	Davenport, IA Hartford, CT	Quality Energy performance goals would not have been met	Better job of pre-planning Work with utility and electrical contractor to correctly interface systems	Schedule delay Economic impact Quality
Conflicts with agency or site mission or plans 7%	Woodland, MD New York, NY	Quality Schedule delay Economic impact	Plan for security clearances if applicable Be aware and coordinate with concurrent projects.	No significant impact
Incentives 3%	Calexico, CA	Schedule delay	Better job of pre-planning	Schedule delay
Other utility issues 3%	Kansas City, KS	Schedule delay	Work with the utility company very early during design to make sure they understand what the project will entail Obtain necessary permissions early	No significant impact

The research affirmed that consequences, such as delays, lowered project quality, economic impacts, and forced “no-go” decisions after incurring significant unrecoverable costs can translate into missed opportunities, economic waste, negative public relations, and tainted perceptions about the feasibility of renewable energy technologies. On the other hand, early discovery of a potential challenge will often allow for project modification or influence initial design or scheduling to bring the project into conformance with policy or procedural requirements so that it remains a viable investment. When such adjustments are not feasible, using strategic decision points to curtail investment in known high risk or infeasible projects can prevent expending resources on projects that are unlikely to help meet renewable energy mandates and provide a good return.

B. GSA CASE STUDIES

Several of the GSA projects were documented as case studies to better illustrate lessons learned and good practices. The case studies describe projects in Carbondale, Illinois; Lawrence, Indiana; Raleigh, North Carolina; Denver, Colorado; Suitland, Maryland; and 13 sites throughout GSA's Southwest Region, including properties in Texas, Louisiana, and New Mexico. All of these projects were funded by ARRA or other appropriations, and in the Southwest Region, ESPCs were used to supplement the ARRA funding. For details, see Appendix E: GSA PV Project Case Studies. Categorized List of Lessons Learned and Good Practices

C. CATEGORIZED LIST OF LESSONS LEARNED AND GOOD PRACTICES

Lessons learned and good practices recommended by GSA project team members are listed here, so that future PV project implementers might benefit from the knowledge gained from these projects. They are organized by the top five challenge categories established by the NREL survey: project management, site, interconnection, technical, and economic. Challenges that fell into other survey categories have been folded into the top five categories, wherever they fit best. These categories include weather, lack of expertise, procurement, state or local laws and regulations, net metering, other utility issues, conflicts with agency or site mission, and incentives. This section of this document has been duplicated and attached as Appendix F: GSA PV Project Lessons Learned and Good Practices, so that it may be used as a reference tool.

PROJECT MANAGEMENT

LESSONS LEARNED

- **Conduct due diligence and feasibility study early in the planning process for PV project,** covering site characteristics (including facility load, solar resource, and utility rate), policy landscape, interconnection process and requisite agreement.
- **Form an integrated GSA project team early in the planning process.** The team should be capable of addressing technical and other potential issues that may be encountered. Key internal team members would include an architect, engineer, lawyer, contracting officer, estimator, energy expert, facility manager, and executive level champion. It is important to define roles and have a clear communication plan in place early in the process.
- **Notify state and local entities of the project early.** During the project planning phase, the team should notify state and local entities that will have an interest in the project, including inspectors, the fire department, and the serving electric utility, because they may have specific requirements such as setbacks and disconnects. For example, the Denver Federal

Center was under a state compliance order, which increased the cost and effort associated with the digging involved in locating PV systems in open fields.

- **Address safety and health concerns early.** Ideally, address all safety and health concerns during the pre-planning stage. For the Bean Center project in Indiana, safety and health issues were discussed prior to issuing the Notice To Proceed, and the GSA Occupational Safety and Health (OSH) Team was able to partner with the contractor's OSH Team and agree on solutions (sometimes unconventional ones) to significant potential problems, e.g., fall protection, debris removal, crane/helicopter lifting procedures, tenant impact, and electrical shutdown and switchover. This partnership increased project efficiency and reduced the time required for specific tasks.
- **Ensure that property managers are properly trained on O&M procedures for PV systems that are owned by GSA.** Introduce the property management staff to the PV system early, during the design phase, and make sure they receive training and operating manuals. They will need to know how to keep the system clean (e.g., from bird residue) and generally understand how to properly maintain the system.
- **Complete the design and a thorough scope of work before putting the project out to contractors for bidding.** Changes and modifications can be costly and delay the project.
- **Specify that the PV installation crew be knowledgeable** about the work involved, in the solicitation for the construction contractor. The contractor's submission should include proof of experience. It is possible for workers to learn on the job and complete the installation efficiently, but it is preferred that they are experienced and prepared.
- **Have the contractor and subcontractors submit work plans that focus on solutions for minimizing disruption to building tenants during the project.** Planning ahead is crucial for avoiding pitfalls.
- **Clearly define 'minimal disruption' in discussions with property management staff, and in specifications and presentations to construction contractors and subcontractors prior to bidding.** The definition may affect the contractors' means and methods, price, schedule, work shifts, and other variables.
- **Get commitments from suppliers.** The standard solar industry procurement process uses a "solar integration" company that designs, procures and installs the PV system. As a result, solar suppliers generally will not communicate directly with the Architect/Engineer (A/E) regarding design, costs, lead times, etc. It may be necessary for GSA and the A/E to visit solar supplier manufacturing facilities together to gain commitments from suppliers prior to completing 100% design documents. In some cases, the supplier may require a fee from the construction contractor to "manage" the solar panel installation process in an oversight role, as a prerequisite to their commitment.
- **Anticipate delays in supplier shop drawings.** The PV installer may not provide submittal information that conforms with the A/E's drawings because they prefer to do their own layouts. During the bidding process, the project team should communicate clearly with the

supplier about the project requirements and include enough time in the schedule for shop drawing submission, revision, and approval.

- **Allow ample time for product delivery.** For very large projects, the manufacturer will not always commit to a schedule for delivery of panels at the time they bid on a project. Be sure to add an appropriate amount of time for panel fabrication and delivery into the project schedule. For example, at the Bean Center, solar companies would not provide delivery dates until after the contract was signed, and then they refused to commit on an actual delivery date until 30 days before delivery. Order additional panels at bid time to replace panels broken in shipment, because replacement panels are not rushed through manufacturing and it can take months to receive replacements.
- **Build in time for GSA IT equipment scanning requirements.** The A/E and contractor should be made aware that GSA's Office of the Chief Information Officer (OCIO) requires scanning all equipment that will be connected to the GSA network. During the design phase, the A/E needs to understand exactly what equipment must be scanned by the OCIO and the time requirements involved.
- **Allow enough time for contractor's employees to obtain federal security clearances before beginning work.** This process can take months, so early planning is crucial.
- **Prepare for lobby display graphics early.** If a lobby or similar display will be part of the project, the design of the display screens should begin early in the project process.
- **Take into account cold weather considerations.** Installing solar panels in a cold climate can delay the schedule. Considerations include the safety issue of workers slipping on the roof, potential damage to the PV panels and roof, and potential work stoppages. Possible solutions include creating detailed work plans for solar panel installation in the event of snow and ice storms, and using a glycol system under blankets to melt thick ice. An R-50 roof does not allow the heat from below to melt snow or ice on the roof.
- **Take into account hot weather considerations.** Because of a project delay at the Calexico Border Station in California, the project had to be accomplished at the hottest time of the year, so the contractor did the work at night, when it was a bit cooler.

GOOD PRACTICES

- **Use the GSA Energy Center of Expertise for guidance in crafting the design and performance scope of work, and other technical aspects of the project.** PV is new territory for most project managers and every project is unique.
- **Add external consultants, who may be critical to a project's success, to the team.** These may be employees of the local utility company or state public utility commission, renewable energy developers or industry experts, renewable energy lawyers, and renewable energy experts at one of the national labs.
- **Request a project lead at GSA's OCIO.** For the sake of efficiency, the project team should designate a point of contact to work with OCIO. The project team should also request a project lead at OCIO, so the team does not have to coordinate with multiple individuals

about issues such as equipment scanning requirements, interconnection and net metering, and other IT requirements that may arise.

- **Educate building occupants in advance and during the project.** Before construction begins, the team should work with the property management staff to educate building occupants about the project plans, timing, and expected impacts, such as noise, smells, and parking issues. The project manager may issue progress reports and notification of anticipated smells or noise through the property manager via email or a newsletter.
- **Have the contractor and subcontractors submit work plans that address how they plan to work around potential weather issues.** For example, during re-roofing at the Bean Center, the contractor worked around rain days by working 12 hours every day it didn't rain, for a maximum of 14 days at a time. When installing solar panels there during the winter, the contractor worked overtime on weekends and developed a plan to remove snow off the roof and thaw ice buildup to enable work to continue.
- **Require subcontractors to provide a full-time on-site safety manager when there are over 25 workers.** Request that subcontractors maintain direct communication with the GSA safety & health expert throughout the project. Additional good practices include having subcontractors conduct frequent safety training for employees, and installing a safety railing around the perimeter of the roof in lieu of using tie-offs; installing such a railing on the NREL Research Support Facility saved time.
- **Inspect the site frequently.** For example, the PV project manager for the Amalie Ron De Lugo Federal Building in the Virgin Islands was located in Newark, NJ. A local GSA project manager was designated to make site visits, which eased collaboration and saved time and cost.
- **Conduct educational meetings for the project team** to present mock-ups of critical parts of the project and to invite material manufacturers to describe details of equipment and products and how quality tests are performed.
- **Utilize the Department of Energy's (DOE) expertise.** Try to involve DOE in the project from the very beginning or concept phase, to benefit from its pre-feasibility assessment expertise and in later stages its technical knowledge and support capabilities. Furthermore, DOE has strong industry relationships and can facilitate communication with solar suppliers.
- **Partner with other organizations.** One of the most innovative aspects of the Bean Federal Center project is the partnership with the DOE and Sandia National Laboratory. In addition to the main PV system, there are four smaller laboratory PV systems, each using a different photovoltaic material, construction or design. These small test labs don't generate much energy, but they do provide invaluable data for analyzing how different technologies perform in the Midwest climate.

SITE

LESSONS LEARNED

- **Evaluate the roof structure.** Conduct an engineering evaluation of the existing roof structure to make sure it is in good condition and can support the weight of new solar equipment. Such an analysis at the Bean Federal Center in Indiana determined that the PV panels should utilize light-weight framing and should be installed at a 5 degree angle.
- **Consider the roof's age and condition.** Ideally, a PV installation will coincide with the installation of a new roof. When a new roof is not immediately necessary, the project team must weigh the cost and benefits of an early roof replacement versus installing PV on an existing roof. At the Bean Center in Indiana, for example, GSA could have kept portions of the existing roof for an additional five years, but eventually a costly removal and reinstallation of the PV system would be required when the roof was replaced, so roof replacement was part of the PV project.
- **Maintain a safe roof for emergency responders.** Carefully locate and label disconnection switches and energized runs of conduit line. This must be done for the protection of emergency responders, such as firemen. Involve GSA fire protection engineers, GSA safety and health experts, and the local authorities to facilitate this process.
- **Conduct studies of solar orientation and shading on roofs where panels may be located.** These studies will yield additional information for planning system capacity and avoiding performance issues.
- **Be aware of physical space limitations, especially on roofs of high-rise buildings.** Allow the contractor access to the building and staging areas, particularly in urban settings where there is limited area around the building for contractor's storage, staging, and material handling. Bringing in cranes and chutes can be expensive and complicated.
- **Recognize that locating PV projects on the ground represents new development of undeveloped land.** Make sure that adequate time is allowed to work with local entities, such as the planning commission.
- **For ground arrays, keep the lowest point at least two feet above ground level so any plant life or snow build-up will not shade the panels.** Considerations will be affected by the specific installation location and type of system.
- **Specify restoration of ground cover around PV installations.** Where PV systems were installed in open fields at the Denver Federal Center, contract specifications did not call for restoration of native grasses under and around the array, and tall weeds grew around the panels and shaded them until a landscaping crew was hired to cut them down and restore the grasses. Maintenance costs were incurred.
- **Coordinate the project with other work planned or in progress at the site.** Other projects may create competition for parking, staging, storage and utility work, and good communication between the project teams is necessary to avoid conflicts.

- **Consult with GSA's Historic Preservation Specialist and Environmental Programs Expert.** Environmental and historic preservation considerations are generally addressed through the environmental assessment (EA) process, which should fulfill the statutory requirements imposed by the National Energy Policy Act (NEPA) on all federal and federally-funded projects. It is important to note the findings from the EA process and, ideally, to discuss them with regional historic preservation and environmental program experts. PV panels should be placed for optimal performance, while respecting sight lines and historical preservation constraints.

GOOD PRACTICES

- **When investigating possible locations for PV projects, give priority to geographic areas where they are most likely to be cost effective.** Locations with good solar resource, high electricity rates and attractive incentives such as rebates, production-based incentives, and valuable solar RECs are generally most attractive. Since system prices and state incentives have trended down recently, areas of excellent solar resource should also be a focus for investigation.
- **Consider the possibility of future high-rise construction in the vicinity of a planned PV project that could potentially shade a property.** Some states' laws allow filing of "solar easements or rights of way" to prevent a neighboring property owner from interfering with the sunlight falling on one's own property. Such real property interests can be useful for protecting sunlight access for a solar system, which is usually a considerable investment that only pays for itself if it is producing energy.

INTERCONNECTION, NET METERING, AND OTHER UTILITY

LESSONS LEARNED

- **Recognize that some electric utilities have little experience with PV.** Some electrical utilities have little or no experience with the design and equipment requirements, scheduling priorities, or interconnection agreements (ICA) associated with purchasing solar power.
- **Utilities and political jurisdictions vary widely in their favorability to PV.** Policies, rules, and technical considerations can introduce considerable delay and uncertainty in project implementation.
- **Work with the utility company from the project start to understand its interconnection process and technical requirements, as well as its net metering regulations and other policies.** In many cases, utility or public utilities commission standard contracts will contain terms that federal agencies cannot agree to without modification. Contractors generally lack experience working with utilities on these government-centric matters and they and their subcontractors often will merely pass along to the agency any agreements from the utility company that require the building owner's signature.
- **Start negotiating the ICA between GSA and the utility company during the design phase,** because it could take several months to complete. Most utilities require an ICA before PV

systems can be connected to the grid and operated. These agreements often contain provisions which can present challenging contracting barriers to federal government implementers, such as indemnification clauses, grants of rights of way, ownership of RECs, prices to be paid for excess generation, or other matters that may require legal approval prior to signing. Even with the full support of the utility company, it is very important to start working on the various agreements early enough so that the utility company lawyers and the government lawyers have enough time to agree on specific wording.

- **In deciding on the PV system capacity, consider the utility's policies about exporting power, in addition to the results of the system impact study.** In planning for a system that is expected to export power based on the site electric load profile and tentative system size, first consult the utility's policies and the system impact study to aid in determining what the actual system capacity should be.
- **Consult the utility company during the design process to be sure the correct equipment is included in the contract documents.** For example, at the Cotter Federal Building in Connecticut, the inverter that was originally ordered was too large for the utility's capacity, so another, smaller inverted had to be ordered, delaying the project.
- **Some utilities require one-line and wiring diagrams, and/or site sketches showing proposed equipment locations.** During the design phase, the designer should work with the construction contractor to lay out specific diagrammatic information that explains how the power generated by the PV system will feed into the building's power.
- **State or local rules or policies can constrain system capacity.** A net metering rule, for example, may state that systems must be 2MW in nameplate capacity or less to qualify for the net metering program.

GOOD PRACTICES

- **Identify a single point of contact at the utility company.** Working with one person who is knowledgeable about the PV project should ensure accountability and avoid delays and confusion.
- **During construction, invite the utility company contact to coordination meetings** in lieu of communicating via phone calls or email.
- **Fully engage the utility.** For the Simon Building project in Illinois, the local utility was engaged and specifically involved in the joint design, development, and commissioning of the interconnection and other utility-specific project components. This action enabled the team to avoid the delays and extra costs that would have been incurred had the completed system failed to meet the interconnection requirements of the local utility company.
- **Have agency lawyers and contracting officials review the interconnection agreement** and consult the GSA Energy Center of Expertise if there are concerns regarding ICA terms and conditions.

TECHNICAL

LESSONS LEARNED

- **Sizing and location of arrays is a primary design consideration.** Related design and installation considerations include setbacks from roof perimeters, angles of orientation, use of tracking or fixed arrays, access for firefighters, approach to monitoring for solar panel failure, tying into the electrical system, and metering and monitoring of generation output.
- **Protect the roof.** Coordinate closely with roofing contractors and installers so that roofing membrane warranties are not voided by putting solar equipment on the roof. Steps should be taken to protect the roof at all times.
- **Monitor roof installation and understand potential issues.** At the CMS HQ Complex in Maryland, the roof coating produced significant odors that disrupted tenants, and an extensive area of the coating delaminated due to improper preparation of the roof surface. Using a full-time roofing inspector is a good idea.
- **Pre-planning for technical details is important.** Resolve technical details before construction gets underway. At the Federal Courthouse in Davenport, Iowa, for example, trying to find an interior route to run the utility lines from the roof down to the location of the disconnect box at ground level was an unexpected challenge.
- **Know fire safety requirements.** If a PV system is installed out of compliance with fire safety requirements, additional costs for bringing it into compliance can arise. At some of the buildings in the Southwest Region, each system needed multiple disconnects to meet the requirements outlined by GSA fire protection engineers. See Appendix G: GSA Fire Safety Guideline for Photovoltaic System Installations.
- **Anticipate solar product upgrades and pricing changes.** Due to frequent changes in PV technology, types of solar panels and pricing available change quickly, and the solar suppliers may fail to notify PV project teams of these changes. Newer panels may be more efficient but also may be more expensive. During the design phase, the A/E should discuss this with the supplier and find out when the panels will be upgraded.
- **Obtain warranty information from solar product suppliers.** Solar product suppliers may not be forthcoming regarding warranty information, and in one project, the supplier initially refused to provide the A/E with required warranties. Understanding the details of the warranty is crucial.
- **Solar panel suppliers are reluctant to reveal their quality control procedures.** The solar panel suppliers may not want the PV project team to visit their manufacturing site and review their quality control procedures, due to proprietary concerns. Possible solutions include having the A/E include this requirement in the project specification, and/or having GSA and the A/E visit the solar manufacturing site during the design phase, to determine whether the solar supplier will be invited to bid on the project.

- **Solar panels should be kept clean and checked regularly for damage.** Extra attention to cleaning may be needed during bird migratory periods and after severe weather events. Periodic inspections should be conducted, especially after snow, hail or wind storms.
- **Engineers and system designers should confirm the solar panel and system wind uplift ratings, giving consideration to the climate where they will be installed.** This is crucial in areas of the country that are subject to high winds from tornados or hurricanes.
- **The SOW for the O&M contractor should include, at a minimum:**
    - Annual sweeps of the strings through I-V curve tracing, providing the data back to the owner
    - Thermal imaging of all electrical connections
    - Panel cleaning
    - Inverter inspections and diagnostics
    - Metering and monitoring (shared between the owner and the O&M contractor)
    - Filter cleaning for inverters equipped with cooling fans
    - System repairs

GOOD PRACTICES

- **Install advanced metering to monitor PV system performance.** For larger PV systems, it is advisable to specify a diagnostics system which will automatically alert the system manager if there is a problem with the system. On very large systems, it is advisable to establish monitoring capability down to the string level, or at least to the combiner box level. These additional systems can usually be justified by less down time and reduced O&M labor hours.
- **Conduct continual commissioning.** The specification for the PV system at the Simon Building in Carbondale, Illinois required a data analysis system, including a digital subscriber line (DSL) and initial one year basic service contract. Without this system, it would be difficult to know if a fault developed in a particular PV panel.
- **Specify an extended warranty.** The specification for the PV system at the Simon Building in Carbondale, Illinois required that, at a minimum, a three-year initial O&M service agreement be included in the contract. The O&M agreement covered all solar array equipment, inverters and other components needed to maintain total system operation. The government reserved the right to extend the O&M agreement beyond the initial three years. This action should be recognized as a best practice because remote locations such as Carbondale, Illinois are not likely to have an abundant supply of maintenance workers skilled in PV systems.
- **Specify a long-term guarantee.** The specification for the PV system at the Simon Building in Carbondale required a warranty which provided that the system would continue to be

capable of meeting a minimum of 80% of the intended DC output capacity for a period of no less than 20 years. This action is a good practice because GSA would want the PV system to last as long as the roof it is installed on.

- **Provide a leak detection system.** The specification should require a leak detection system, such as an electric field vector mapping (EFVM) system, to ensure that the roof is 100% water tight. This type of system identifies the precise location of leaks without destructive testing of installed materials. It may be employed while the roofing subcontractor is still on site for the PV installation, or at anytime afterward.
- **Have a good temporary roof plan.** Consider whether the A/E should specify and detail the temporary roof approach or whether it should be left to the roofing subcontractor's means and methods. If the latter is elected, require the roofing subcontractors to submit a detailed description of a temporary roof approach with their bids. Ensure there is a detailed plan in place for covering all open roof areas in case of a surprise storm. Be sure the amount of temporary roof area is minimized at all times to mitigate leaks into the building during construction.

ECONOMIC

LESSONS LEARNED

- **Examine all project funding alternatives.** If appropriations are not available for a desired PV project, project funding vehicles such as ESPCs, UESCs, or PPAs should be explored as alternatives. They offer a number of benefits, such as absence of requirement for upfront capital, predictable energy pricing, and mitigation of O&M risk for the agency.
- **Understand the utility rates early in the process.** Opportunities and limitations presented by the local utility rate structure may significantly impact the financial viability of the project. For example, at the Bean Federal Center in Indiana, GSA was able to sell solar generated electricity to the utility, resulting in a low electricity bill for a building that size, 1.6 million sq ft.
- **Consider registering the project as a Qualified Facility (QF) with the Federal Energy Regulatory Commission (FERC).** A QF may sell energy to the utility company at either the utility company's avoided (wholesale) cost or at a negotiated rate, and may also purchase additional services from the utility company, such as back-up power. This is a good strategy for larger systems, up to 80 MW, that generate more energy than the host site consumes at any given time, and that are too large to be eligible for the utility's net metering program. Registration as a QF is actually an exemption from burdensome FERC reporting requirements (similar or equivalent to those imposed on public electric utilities) that are otherwise required for all exporting generators connected to the grid. GSA registered the Simon Building in Illinois as a QF to avoid restrictions under the utility's net metering policy.
- **In determining whether double shifts or night work is best for the project, realize that this is more expensive than daytime work.** Project management and construction staff will be needed to manage extra shifts.

- **Consider budgeting for the construction contractor to provide personnel with federal security clearances and badges to escort subcontractor workforce,** in case of delays in obtaining GSA security clearances.
- **Successful life cycle management of solar PV systems starts with establishing and clarifying the internal and external O&M responsibilities.** Successful PV investments are not simply the result of hiring a contractor to perform O&M and then expecting the system to deliver a return on investment over the next 25 years. Internal responsibilities include managing and tracking performance data after base-lining the performance of the system's individual strings, which is done during commissioning. This will provide the primary data for tracking the performance degradation of the panels during the system's life cycle.

GOOD PRACTICES

- **Research all available incentives, rebates and special rates.** Taking advantage of special rates, rebates, and incentives offered is crucial for providing taxpayers with the greatest return on investment for capital intensive renewable energy projects. With third-party ownership approaches, such as PPAs, the owner/contractor may be able to take advantage of investment tax credits, accelerated depreciation, and other available incentives, potentially passing those benefits on in the form of lower pricing for the site.
- **The project manager and construction contractor should review costs together on a weekly basis, to avoid escalation.** Track all costs and planned expenditures to avoid surprises.
- **Capture data about system performance in a GSA database and perform a comparative analysis against the previous baseline each time an annual or biannual baseline/I-V curve trace is performed.** This is essential to successfully managing the warranty and tracking performance of system components, specifically the panels.
- **Consider using a contracting venue such as a PPA, in which case** the system's performance rests on the shoulders of the PV contractor. In order to protect their investments, contractors depending on PPAs for their revenues ensure that life cycle management functions are performed on their systems. They get paid only for the energy actually delivered, which incentivizes ensuring optimum system functionality.

VI. Additional Resources

There are several excellent resources that should be explored by federal agencies and others who are contemplating implementing a PV project.

GUIDE TO INTEGRATING RENEWABLE ENERGY IN FEDERAL CONSTRUCTION, Federal Energy Management Program, U.S. Department of Energy, August 2012, www.femp.energy.gov/reconstructionguide/.

The Federal Energy Management Program (FEMP) recently launched this resource for federal agencies and private-sector partners. The FEMP guide walks users through renewable energy options to help select appropriate types of renewable energy technologies and integrate them into all phases of new construction or major renovation projects. Training information and additional resources are also provided, including technology pages containing crucial details, including design, cost, life-cycles, and more.

GUIDE TO DEVELOPING RENEWABLE ENERGY PROJECTS LARGER THAN 10MWS AT FEDERAL FACILITIES, Federal Energy Management Program, U.S. Department of Energy, March 2013, http://www1.eere.energy.gov/femp/pdfs/large-scalereguide.pdf.

This new comprehensive resource provides best practices and other helpful guidance for federal agencies developing large-scale renewable energy projects, including active project management strategies, common terms, and principles that reduce project uncertainties and promote partnerships between the federal government, private developers, and financiers.

PROCURING SOLAR ENERGY: A GUIDE FOR FEDERAL FACILITY DECISION MAKERS, U.S. Department of Energy, National Renewable Energy Lab, September 2010, http://www.nrel.gov/docs/fy10osti/47854.pdf.

This guide contains step-by-step guidance for planning and executing solar energy projects, a detailed description of the technology, agency-funded case studies using PPAs, ESPCs and UESCs, and a number of valuable tools and checklists, such as the:

- Summary of Preliminary Solar Energy Site Screening for Photovoltaics
- Solar Screening Evaluation Checklist
- PV Project Design Evaluation Checklist
- PV Commissioning Checklist

Solar Photovoltaic Financing: Deployment by Federal Government Agencies, U.S. Department of Energy, National Renewable Energy Lab, September 2009, www.nrel.gov/docs/fy09osti/46397.pdf.

This in-depth presentation of solar project financing for federal agencies includes a detailed discussion of the funding tools and analyzes the economics of federal PV projects in various locations, based on locally available incentives and payments.

Database of State Incentives for Renewables and Efficiency (DSIRE), www.dsireusa.org.

This website is a comprehensive source of information on state, federal, local, and utility incentives and policies that support renewable energy and energy efficiency. Established in 1995 and funded by the DOE, DSIRE is an ongoing project of the North Carolina Solar Center and the Interstate Renewable Energy Council, Inc.

U.S. DOE SunShot Initiative Home Page, http://www1.eere.energy.gov/solar/sunshot/.

The SunShot Initiative, sponsored by the DOE, seeks to make solar energy cost-competitive with other forms of electricity by 2020. It advances PV efforts by funding research and development and awarding funds to PV projects. Since the initiative was announced in February 2011, the Solar Office has funded more than 150 projects, including PV projects.

Department of Energy Federal Energy Management Program Website, http://www1.eere.energy.gov/femp/technologies/renewable_projectplanning.html.

The FEMP website provides excellent guidance, as well as information about various resources available to federal agencies, including project planning assistance. Renewable Energy Project Planning and Implementation details the nine steps involved in renewable energy projects.

VII. Appendices

APPENDIX A: LIST OF GSA PV PROJECTS IN NREL STUDY

#	Region	Building Location	Planned Sys Size (kW)	Solar Insolation (Sun Hrs/Day)	Estimated Annual kWh Generation	Project Start Date	Project Finish Date
1	R01	CT, Hartford William R. Cotter Federal Building	68	3.58	88855.6	4/1/2009	1/2/2011
2	R01	MA, Andover IRS Service Center	500	3.09	563925	6/9/2009	9/2/2013
3	R01	MA, Boston Thomas P. O'Neill Jr. Federal Building	30	2.99	32740.5	6/24/2009	3/31/2012
4	R01	NH, Concord James C. Cleveland Federal Building	65	3.09	73310.25	7/10/2009	9/2/2011
5	R02	NJ, Newark, Peter Rodino Federal Building	44.1	3.2	51508.8	7/16/2009	10/2/2015
6	R02	NY, Brooklyn General Post Office	7.7	3.03	8515.815	6/9/2009	3/1/2014
7	R02	NY, New York-Queens Joseph P. Addabbo Federal Building	80	3.03	88476	8/31/2009	10/19/2012
8	R02	PR, San Juan Degatau & Courthouse	93	5.59	189752.55	7/31/2009	10/2/2015
9	R02	PR, San Juan FBI Field Office Consolidation	180	5.59	367263	7/23/2009	1/2/2013
10	R02	VI, Charlotte Amalie Ron De Lugo Federal Building-St Thomas	48	5.59	97936.8	8/31/2009	11/1/2011
11	R03	Boggs FB	N/A	N/A	N/A	N/A	N/A
12	R03	MD, Woodlawn CMS HQ Complex	1115	3.37	1371505.75	4/30/2009	10/16/2011
13	R03	PA, Philadelphia Byrne-Green Complex	80	3.2	93440	7/9/2009	11/2/2011
14	R03	PA, Philadelphia Veterans Administration Center	455	2.79	463349.25	6/2/2009	1/3/2011
15	R03	VA, Roanoke Poff Federal Building	33	3.37	40591.65	4/21/2009	11/17/2015
16	R03	VA, Richmond Spottswood W. Robinson III and Robert R. Merhige, Jr. US Courthouse	119	3.37	146375.95	5/13/2009	12/1/2011
17	R03	WV, Huntington Federal Building	35		0	4/29/2009	6/2/2015
18	R03	WV, Charleston Robert C. Byrd Federal Building & Courthouse	40	2.47	36062	6/2/2009	10/17/2011
19	R03	WV, Martinsburg	341	1.45	180474.25	4/30/2009	6/1/2012

#	Region	Building Location	Planned Sys Size (kW)	Solar Insolation (Sun Hrs/Day)	Estimated Annual kWh Generation	Project Start Date	Project Finish Date
		244 Needy Rd					
20	R04	NC, Raleigh Terry Sanford Federal Building Facility	560	4	817600	3/3/2010	11/30/2010
21	R05	IL, Carbondale Senator Paul Simon Federal Building	101	3.24	119442.6	7/31/2009	8/2/2011
22	R05	IN, Indianapolis Major General Emmett J. Bean (Phase I – PV and Design)	1620	2.55	1507815	6/19/2009	3/2/2012
23	R05	WI, Madison U S Courthouse	23.4	3.28	28014.48	7/27/2009	8/1/2011
24	R06	IA, Davenport United States Courthouse	25	3.73	34036.25	9/14/2009	6/1/2011
25	R06	KS, Kansas City Robert J. Dole US Courthouse	30	3.62	39639	5/15/2009	2/22/2012
26	R07	LA, Houma Ellender Federal Building Post Office	80.8	3.63	107055.96	9/8/2009	11/1/2013
27	R07	NM, Gallup Gallup Federal Building	55	6.21	124665.75	9/2/2009	11/1/2013
28	R07	TX, Brownsville USBS Brownsville & Matamoros Inspection Facility	50	4.42	80665	3/31/2010	1/31/2011
29	R07	TX, Fort Worth Federal Center	552.7	4.8	848982	3/31/2010	5/1/2011
30	R07	TX, Laredo Juarez-Lincoln Border Station ROOF	50	4.42	80665	3/31/2010	5/1/2011
31	R07	TX, Pharr Kika de la Garza Port of Entry	100	4.42	161330	3/31/2010	4/30/2011
32	R07	TX, San Antonio Hipolito Garcia U.S. Courthouse	50	4.42	80665	7/27/2009	5/1/2012
33	R07	TX, Victoria ML King Jr Federal Building	26.5	4.42	42752.45	9/8/2009	11/1/2013
34	R07	TX, Midland G Mahon Post Office/Courthouse	133.5	5.23	216896	8/27/2009	11/1/2012
35	R07	TX, Fort Worth F. G. Lanham Federal Building	9.88	4.8	14231	9/1/2009	11/1/2012
36	R07	TX, Austin J.J. Pickle Federal Building	133.5	4.65	181442	3/31/2010	2/1/2011
37	R07	TX, Houston G.T. Leland Federal Building	185	4.42	298460.5	6/1/2009	8/1/2014
38	R07	TX, Farmers Branch The Centre Phase 5	65.8	4.8	85651	9/1/2009	11/1/2012
39	R07	TX, Farmers Branch The Centre	32.8	4.8	42062	9/1/2009	11/1/2012

#	Region	Building Location	Planned Sys Size (kW)	Solar Insolation (Sun Hrs/Day)	Estimated Annual kWh Generation	Project Start Date	Project Finish Date
		Phase 5					
40	R07	TX, Laredo Laredo Federal Building Courthouse	50	4.42	80665	3/31/2010	2/1/2011
41	R07	TX, Austin Finance and Auto Center	125	4.65	212156.25	9/16/2010	12/1/2012
42	R07	TX, Austin IRS SW Service Center	170	4.65	288532.5	1/25/2010	11/1/2013
43	R08	CO, Lakewood Denver Federal Center PV	3000	4.44	4861800	5/20/2009	7/2/2012
44	R08	CO, Lakewood Denver Federal Center PV	4677.2	4.44	7579870.32	5/20/2009	7/2/2012
45	R09	AZ, San Luis, San Luis II border station	250	6.01	548412.5	8/27/2010	8/2/2011
46	R09	AZ, Nogales Border Station	1800	6.01	3948570	N/A	N/A
47	R09	CA, Calexico B.S. Bulk/Hazmat. BL PV Project	335	5.35	654171.25	3/29/2010	12/31/2011
48	R09	CA, Laguna Niguel Chet Holifield Federal Building	800	5.03	1468760	12/29/2009	2/2/2012
49	R09	CA, Pasadena Richard H Chambers U.S. Courthouse	35	5.03	64258.25	3/29/2010	7/2/2011
50	R09	NV, Carson City FOB	10	3.31	12081.5	3/16/2010	6/2/2011
51	R09	NV, Las Vegas Lloyd D. George Courthouse	17	5.84	36237.2	1/7/2010	2/2/2012
52	R10	OR Portland Gus J. Solomon Courthouse	22	1.9	15257	3/1/2010	8/17/2011
53	R10	OR, Baker David J. Wheeler Federal Building	22	1.9	15257	7/23/2009	2/17/2012
54	R10	WA, Seattle Federal Center South Building 1201	230	1.6	134320	3/19/2010	3/26/2011
55	R10	WA, Seattle Federal Center South	200	1.6	116800	8/10/2009	8/2/2013
56	R11	DC, Washington Elijah Barrett Prettyman Building	191	3.37	234939.55	10/30/2009	6/3/2012
57	R11	DC Washington 1800 F Street	TBD 2011	3.37	0	9/16/2010	6/1/2015
58	R11	DC, Washington Mary Switzer	TBD 2011	3.37	0	3/1/2010	12/31/2011
59	R11	DC, Washington Theodore Roosevelt	93	3.37	114394.65	11/17/2009	2/2/2013
60	R11	DC, Washington Howard T. Markey National Courthouse	201	3.37	247240.05	10/30/2009	7/2/2013
61	R11	MD, Suitland		3.37	0	7/13/2010	1/23/2012

#	Region	Building Location	Planned Sys Size (kW)	Solar Insolation (Sun Hrs/Day)	Estimated Annual kWh Generation	Project Start Date	Project Finish Date
		Federal Center (Census Bureau Bldg)					
62	R11	MD, Germantown Department of Energy	352	3.37	432977.6	9/28/2010	8/31/2011
63	R11	MD, Suitland Federal Center; Project 2	504	3.37	619945.2	9/28/2010	8/31/2011

APPENDIX B: PHOTOVOLTAIC (PV) PROJECT CONSIDERATIONS GUIDE

To successfully implement an on-site PV project, teams must make numerous decisions during the planning process. Each project is affected by a large number of factors, such as:

- availability of useable roof space or ground space for PV arrays
- solar resource
- availability of incentives to renewable energy facility owners or hosts
- site load
- unique policies, rules, and procedures that apply to each potential project location
- federal and agency-specific mandates and guidelines for energy efficiency, renewable energy, and sustainability

Not only is the number of considerations and potential implications great, any one or a combination of factors can have a substantial impact on outcomes such as project economics, quality, regulatory compliance, and even the authorization for the project to connect to the electrical infrastructure and begin operation. Some of the major considerations are presented here, along with resources for additional information.

AVAILABLE APPROPRIATE SPACE

The requirement for a location or space may be the most fundamental consideration for implementation of a PV project. Locations vary in suitability for PV deployment, depending on goals and constraints for the project.

Site characteristics have implications for structure and orientation as well as economics of a PV system. If the project is to be sited on the ground, the slope of the land as well as the presence of obstacles and plant growth that might interfere with the system by creating maintenance or shading must be considered. There are a number of unconventional racking systems on the market which can be used to mount PV systems on uneven or steeply sloping terrain, but optimally a site should be level or only gently sloping.

Shading is particularly detrimental to the energy production of most PV panels, so a site that will not lead to shading of the arrays should be selected.

If a roof is under consideration as a project site, it should be relatively new so that the PV will not have to be removed early in the project life for roof service, and it should be structurally capable of supporting the additional weight of the PV system. Generally, the roof condition and 'solar-readiness' of the roof should be evaluated, as well as any possibility of impacting the roof warranty by mounting a PV system. If a site is in a historic district or near or on a historic property, care should be taken that approval for the project can be obtained.

From these considerations, a size and nameplate capacity estimate for the PV system can be made. A rule of thumb is five or six acres needed for one megawatt of DC nameplate capacity for standard crystalline silicon panels, four acres for high efficiency crystalline silicon panels (which tend to be more expensive, but may effect sufficient savings in balance of system costs to make up for the higher cost of panels). See Resource, below, for information on resource evaluation in terms of estimated energy production in light of estimated system capacity. Estimated energy production is a fundamental parameter in estimating the expected economic value of the system. Economic value comes from savings from offset consumption of conventional electricity from the utility, and from revenue from excess generated electricity to be sold.

If the PV system will be 'behind-the-meter,'[6] a key feature of the site is the baseline cost of the electricity which would be offset by the PV-produced electricity, as a parameter in the economic feasibility evaluation. Ideally, the cost of energy from the PV system should be compared to the cost of electricity during the time the PV system will be producing electricity, as opposed to comparison with a 'blended' rate which may include off-peak and other less relevant rates. Typically, the higher the cost of conventional electricity, the more competitive is PV. As for the demand component of an electric bill, a rule of thumb estimate is a 10% reduction in magnitude of demand. The rate structure should be scrutinized for any component or rule that would be favorable or detrimental to the value of the PV production.

A more detailed site evaluation can include assessment of proximity and capacity of electrical interconnection points, electrical or mechanical room proximity, capacity, and availability for equipment housing.

RESOURCE

The quality of the renewable energy resource at a location, i.e., the solar energy available for conversion into electricity, is the fundamental determinant of energy production potential for a PV system at that location, and is one of the factors determining project financial viability. For this reason, system energy production potential as a function of solar resource is a basic consideration in project screening.

A tool such as NREL's PVWatts online calculator is a convenient way to estimate system production for generic systems of various high level configurations and efficiencies in different geographic locations for which typical meteorological year (TMY) data is available. PVWatts Version 2[7] has an online interactive map as a front end to facilitate selection of available TMY data for the location closest to the site under consideration. Its basic interface allows input of system DC nameplate capacity, a 'derate' factor for energy losses through system components such as inverter and conductors, and tilt and azimuth angles. The tool outputs estimated energy production by month in

[6] 'Behind-the-meter' is a descriptive term for renewable energy generation projects that indicates that the project is interconnected to the electrical system on the utility customer's side of the utility revenue meter. Usually, behind-the-meter renewable energy systems offset the customer's consumption of electricity from the utility by supplying electricity to the customer load and reducing the amount of electricity the customer draws through the meter from the utility distribution system. Behind-the-meter is, for the most part, interchangeable with the term 'distributed' that also often indicates smaller-scale and an interconnection point on the customer facilities side of the utility revenue meter.

[7] PVWatts Version 2 can be found at http://gisatnrel.nrel.gov/PVWatts_Viewer/index.html.

kWh and an annual total for a TMY. It pulls the cost of electricity data for the area from a geographical information system for a preliminary guess at the economic value of the energy production.

The results page provides a link to formatted hourly production data as well. This data is also based on TMY resource information and is not necessarily indicative of what would be produced by an installed system; the weather in any given year will differ from a TMY, and the installed system will have different characteristics from the generic system being modeled. Nonetheless, the hourly production data can be used, for example, for comparison to a building electric load profile for insight into whether excess production can be expected, how closely production might conform to the load profile, and so forth.

SITE LOAD OR CUSTOMER LOAD

For behind-the-meter PV systems, the site load, in terms of annual electricity consumption, and the load profile, in terms of 15 minute, 30 minute, or hourly interval consumption data, can be useful in determining an optimum upper limit on system capacity in light of the utility rate tariff and other available incentives, such as net metering or a feed-in tariff.

Where net metering or a feed-in tariff is concerned, for purposes of qualification for the incentive, there are almost always hard, policy-based upper limits on the size of the PV system. To qualify for the incentive, often the nameplate capacity of the system cannot exceed some particular value, and often the expected annual energy production cannot exceed some percentage of the site's annual consumption. The upper limit might, for example, be stated as "the *lesser* of 2MW DC *or* a capacity projected to generate no more than 120% of the site's previous 12 months' aggregate consumption." For a site that had had 2,102MWh aggregate consumption over the past year, and in a location at which the PV system was expected to have a capacity factor of 20%, the AC nameplate power rating would be 2,102MWh x 120% / (20% x 365 days x 24 hrs) = 1.4MW AC, which, at a derate factor of 80% would mean a DC nameplate capacity of 1.8MW DC. The lesser of 2MW and 1.8MW is 1.8MW, so the system could be no larger than 1.8MW DC nameplate capacity if qualification for the incentive was intended.

Net metering and feed-in tariff policies allow a site to operate unconcerned about excess production going uncompensated or undercompensated by requiring the utility to compensate the site for excess production, usually at the retail rate with net metering, at the feed-in tariff rate with a feed-in tariff. On the other hand, in the absence of net metering or a feed-in tariff to provide better-than-wholesale remuneration for excess generation, in general, the *marginal* cost of excess power produced is greater than its value to the site. If the site is not contracted to be compensated for excess production, the excess production's economic value to the site is often zero. In such a scenario the system should be designed to strike a balance between minimizing excess generation (for which there is no economic benefit) while maximizing generation to offset site load. This balance should be based on the *expected* hour to hour cost of the site load and the expected *equivalent* year-to-year cost of power from the PV system, which can be calculated using financing and life-of-project assumptions in a tool such as NREL's System Advisor Model (SAM), freely available for download with email registration.[8]

Other considerations for sizing a system with regard to site load include:

- Will there be standby charges?
- Will there be a tariff change after the PV system is operational, due to a change in load from the utility perspective?
- Is there a competitive electric contract, and, if so, what is the contract term and does it include any provisions regarding guaranteed load?

PROJECT FUNDING

Carefully matching available funding tools with specific project needs can make the difference between a stalled, unfunded project and a successful project generating energy and providing cost savings. Often, appropriations are not available for a desired PV project. In those cases, other funding vehicles such as an energy savings performance contract (ESPC), utility energy service contract (UESC) or power purchase agreement (PPA) should be explored as alternatives. These funding mechanisms offer a number of benefits, such as absence of requirement for upfront capital, predictable energy pricing, and mitigation of operations and maintenance (O&M) risk for the agency.

The funding mechanism used for a PV project is significant because each funding approach has different risk implications for the government. Use of appropriated funding often allocates some development risk and most or all of the operating risk of the project to the government as project owner. On the other hand, the ESPC, UESC and PPA generally allocate more of the development and most of the operating risk to the contractor.

ESPC

An ESPC is a partnership between an energy service company (ESCO) and a customer, through which the ESCO identifies energy saving opportunities at the customer's facilities, often provides or arranges for financing, manages the installation of energy conservation measures (ECMs), and then recovers its expenditures and earns some return on its investment through the customer's periodic payments, which are based on the resulting savings from avoided conventional energy purchases. With an ESPC, the ESCO is often responsible for identifying and screening project opportunities, and typically bears the financial risk of the project failing to save money for the government, with some exceptions.

A wide array of energy efficiency and renewable energy measures can be financed through ESPCs, and the resulting financial savings from avoided conventional energy purchases used to repay the financing for the energy equipment, engineering services, installation, and O&M.

[8] Download and other information about SAM at https://sam.nrel.gov/.

UESC

In a UESC, a serving or franchised utility company agrees to provide a federal agency with services or products (or both) designed to make that agency's facilities more energy efficient. Federal facilities can also obtain project financing from a utility company through a UESC. During the contract period, the agency pays for the cost of the UESC from the avoided-cost savings resulting from the energy efficiency improvements. Experienced agency/utility teams may use excess-avoided-cost savings to cover the cost of a feasibility study for follow-on UESCs at their facilities. After the term of the contract, the energy and water efficiency improvements continue to realize the avoided-cost savings for the life of the improvements, and the savings can be used to do more projects.

PPA

A PPA refers, in its simplest essence, to a contract to purchase power (usually electric) that establishes the purchase price for the power, the term of the agreement (usually a number of years), and other terms and conditions for the purchase and sale of the power. A PPA-funded project is a third-party ownership approach, and the project is usually designed so that the government only pays for power actually produced by the PV system; most of the risk of under- or non-performance of the system is borne by the third-party system owner.

In the context of an on-site PV project, the PPA is the agreement of the host site with the owner of the system to purchase all the power the system produces. The system owner often uses the stream of payments from the power sales as well as investment tax credits, accelerated depreciation, and other available incentives, to recover the capital that funded the purchase of the system and to make a return on its investment. In this sense, the PPA is the financing mechanism that facilitates the purchase and installation of the system. The owner may pass those benefits through to the site in the form of lower pricing of the power.

While some federal agencies have successfully executed PPAs to finance the installation of PV projects, a number of challenges face project managers seeking PPA agreements, including a ten year contract length limitation,[9] state requirements imposed on entities which might otherwise sell power in incumbent utility service territories, limited government experience,[10] and the need for a land use or land access agreement to provide the PV developer or third-party project owner access to the PV equipment for operation and maintenance.

There are several options available for federal agencies to enter into a longer term PPA contract. One approach is to utilize the services of Western Area Power Administration (WAPA). WAPA is a Federal Power Marketing Administration and lends its authority (through the Economy Act) to enter into long-term contracts for electricity within its territory to other federal agencies. This service is available to GSA and other federal agency sites located within WAPA's service region, which covers most of the western United States.

[9] Under the GSA authority, 40 USC §501(b)(1)(B).

[10] Standardized approaches are in their infancy sometimes resulting in more involved and case-by-case negotiations and higher transaction and administrative costs for PPA-funded PV projects.

Another approach to implementing a longer term PPA is to utilize federal ESPC contracting authority. An "ESPC PPA" must meet all of the requirements that apply to federal ESPCs.[11] Department of Energy (DOE) has executed an ESPC Indefinite Delivery Indefinite Quantity (IDIQ) contract with sixteen ESCOs to provide energy services to federal agencies and has prequalified more contractors and listed them on a DOE qualified contractor list. An ESPC PPA can utilize the DOE ESPC IDIQ, or could utilize full and open competition for contracting directly with a PV provider. For an ESPC not utilizing the DOE ESPC IDIQ, the contractor selected must be on the DOE qualified list of contractors,[12] unless the agency qualifies its own list of ESPC contractors.

GSA could also work with the utility serving a particular site to negotiate a utility PPA, through which the utility purchases and owns the project, selling the generated power to the site. A PPA with the local utility is another option that is being explored by DOE's Federal Energy Management Program (FEMP) in collaboration with GSA's Energy Center of Expertise. In such a scenario, either the utility or a third-party partner would own the project.

FEMP supports federal agencies in identifying, obtaining, and implementing project funding for energy projects. Funding tools include:

- energy savings performance contracts
- ESPC Enable
- utility energy service contracts
- on-site renewable power purchase agreements
- energy incentive programs

Federal agencies can take advantage of these funding tools, choosing the best fit for their project needs. That often means a combination of project funding and agency appropriations.

The FEMP Project Funding Quick Guide provides an overview of funding options and strategies available to federal agencies: http://www1.eere.energy.gov/femp/pdfs/project_funding_guide.pdf

COMMUNITY SOLAR FARM OR SOLAR GARDEN

Because a community solar farm is paid for and owned by an investor or investors often unaffiliated with the PV project site, it might be possible to utilize the policy for this unique form of third-party ownership of a PV project hosted on federal land. To the authors' knowledge, community solar has not been explored as a possible third-party ownership approach to funding PV projects hosted on federal land, and there could be complications or policy-specific impediments to the concept or to its practical application. Considerations would include:

- Is it possible for the federal host to claim the Energy Policy Act of 2005 (EPAct) double-bonus for 'use' of on-site generated renewable electricity from the project,[13] even though it

[11] 40 USC §8287 et seq. and 10 CFR 436 Subpart B.

[12] See http://www1.eere.energy.gov/femp/financing/espcs_qualifiedescos.html for a list of qualified contractors.

[13] Codified at 42 USC 15852(c).

is not actually purchasing energy from the project (presumably the power flows from the project are largely feeding federal loads due to proximity in the circuit)?

- If the community solar farm participants have ownership of the project RECs, could the federal host claim on-site renewable electricity 'use' from the system by purchasing replacement RECs?
- Will the community solar farm rules in the state permit siting of the community solar farm behind-the-meter of the host without adversely affecting the production credits claimable by the solar farm participants?
- Would an EUL be the appropriate federal contracting authority to utilize for this type of project structure, or could the project be structured to appropriately utilize federal ESPC authority?

These and other questions should be thoroughly explored with advice of counsel and in light of DOE FEMP guidance on the applicable statutes and regulations before undertaking this type of funding approach.

INCENTIVES

Governments and other authorities offer incentives and preferential treatment to distributed renewable energy projects, which can, in effect, reduce the cost of or increase the return on purchasing, installing, hosting, and owning renewable energy generating systems. A project properly designed and planned to utilize good incentives can be financially sound or profitable, whereas the same project may appear infeasible if a good incentive is overlooked. Even when an incentive is known to be available, however, not knowing its limits or constraints can be risky; expected cash flows may be diminished or fail to materialize altogether.

This section introduces the common categories of renewable energy incentives and highlights some opportunities and potential pitfalls of each. A good resource is the Database of State Incentives for Renewable Energy (DSIRE), which is a comprehensive source of information on state, federal, local, and utility incentives and policies that support renewable energy and energy efficiency.

ACCELERATED DEPRECIATION

An accelerated depreciation is a tax or financial accounting method that depreciates a fixed asset in such a way that the amount of depreciation taken each year is greater during the earlier years of an asset's life. Some tax rules require depreciation of an asset in a straight line over an expected useful lifetime. Because depreciation is treated as a tax exempt expense, accelerated depreciation allows a taxable entity to realize a reduced tax burden sooner rather than later, enhancing early cash flows and overall project returns.

There are a number of different accelerated depreciation approaches, with varying rules by jurisdiction and by type of asset.

For taxable entity owners of covered renewable energy properties, accelerated depreciation at both federal and state levels represents a significant economic opportunity. For taxable entity owners with adequate tax appetite, economic modeling should reflect benefits of accelerated depreciation; otherwise a project could be inappropriately screened for not meeting economic objectives. On the other hand, the risk is economic underperformance if an economic model accounts for accelerated depreciation for a project or owner that is ineligible.

Further information:

DSIRE web page on the federal Modified Accelerated Cost-Recovery System (MACRS) + Bonus Depreciation:
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US06F&re=1&ee=1

For authoritative information, visit the websites of the Internal Revenue Service and the state website for state tax information in the state where the project is to be deployed. Your accountant and tax attorney are good sources of further information.

FEED-IN TARIFF (FIT)

A FIT is a type of production- or performance-based incentive that permits a purchase and sale agreement with a utility for the utility to purchase electric energy from qualifying renewable electric projects at a pre-set price, usually per kWh, for some period of years. FIT prices are intended to be more favorable to renewable energy projects than market wholesale power prices would be.

In the United States, some FIT rules require that utilities purchase only the electricity; other rules require utilities to purchase both the electricity and the renewable energy (RE) attributes from participating renewable energy generators. Upper limits on project capacity of qualifying projects also vary by jurisdiction and utility. Some jurisdictions or states may require direct interconnection of the project with the utility distribution system, as opposed to allowing behind-the-meter projects for participation in the FIT. Per-kWh pricing and the application of time-of-production rate multipliers, which vary the price of exported power from a base rate according to season and time of day, also vary by location.

Some FIT rules allow project rated capacity limits that are higher than those for net metering, so a FIT can represent an opportunity to build a larger project than might otherwise be feasible, based on the energy use at the host site or the net metering project capacity limit. Like net metering, by providing a revenue opportunity for exported electricity, the FIT improves the bottom line for renewable energy projects that might otherwise not receive adequate compensation for excess generated power.

If FIT requirements are not fully understood, the as-designed project could fail to meet requirements to qualify for the FIT, risking loss of the FIT revenue stream. Also, economic modeling of the impact of a FIT on a PV project can be complex, and simplifications, if optimistic, may qualify a project that will fail to provide anticipated returns, and if pessimistic, may lead to a missed opportunity.

Further information:

State search: http://www.dsireusa.org/. Search DSIRE by state and municipality to see if there are available feed-in tariffs or performance-based incentives in your area.

Feed-in Tariff Policy: Design, Implementation and RPS Policy Interactions: http://www.nrel.gov/docs/fy09osti/45549.pdf

State Clean Energy Policies Analysis (SCEPA) Project: An Analysis of Renewable Energy Feed-in Tariffs in the United States: http://www.nrel.gov/analysis/pdfs/45551.pdf

EPA State and Local Climate and Energy Program: http://www.epa.gov/statelocalclimate/state/topics/renewable.html

GRANTS AND REBATES

Grants and rebates represent opportunities for cash payments made either as partial refunds for the purchase of certain assets (rebates), or before or soon after project implementation (grants).

The essence of each of these incentives is upfront money to help with project costs. These programs are offered at the federal level, and by states, utilities and a few local governments, and may be administered and funded at any level or combinations of these levels. Accordingly, each program has its own qualification criteria and application process, variously dictating milestones, qualifying equipment, funding limits, and so forth.

Grants and rebates, as upfront cash, offer some of the lowest risk value to renewable energy projects, and, as such, provide value-rich opportunities. To ensure realization, planning and oversight should be based on carefully researched policy specifics. Responsibility for using these incentives can often be placed with the renewable energy project contractor.

Further information:

Residential Grants:

http://www.dsireusa.org/incentives/index.cfm?EE=1&RE=1&SPV=0&ST=0&searchtype=Grant&sh=1

Rebates:
http://www.dsireusa.org/incentives/index.cfm?EE=1&RE=1&SPV=0&ST=0&searchtype=Rebate&sh=1

The entities with administrative responsibility for these programs are often the best sources of practical guidance for utilization of grants and rebates for your project.

INVESTMENT TAX CREDIT (ITC)

An ITC is a reduction in the amount of tax payable by a taxable entity for the tax year in which a renewable energy asset is purchased (though some ITCs have carry-forward provisions), and is based on the amount paid for the asset. The amount of the reduction is usually equal to some percentage of the entity's investment in the asset. ITCs are offered against federal income tax of businesses and are offered by a number of states.

For some eligible technologies, the federal credit is equal to 30% of expenditures, for others it is 10% of expenditures. Investment-based state tax credits vary and are often proportional to installed cost, often have ceilings per project or annual ceilings per entity, and often have finite state budget allocations to be disbursed on a first-come first-served basis.

The opportunities presented by investment tax credits are significant; because they are realized early in the project life, the investment-year tax discounts are similar to up-front cash or rebates against project investment. Unaccounted-for ITCs in project screening or economic modeling could lead to a large underestimation of a project's value or a false negative in a project feasibility assessment.

Further information:

Federal Business Energy Investment Tax Credit:
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US02F

PRODUCTION TAX CREDIT (PTC)

A PTC is an amount to be deducted from the total amount that a taxpaying renewable energy project owner owes to a taxing authority (the credit), proportional to the amount of renewable energy produced by the renewable energy project (the production) during a tax accounting period.

There is currently a federal PTC and a number of states have PTCs. Different jurisdictions recognize different technologies; some even give credit for renewable thermal energy.

As an example, the federal PTC is a per-kilowatt-hour tax credit for electricity generated by qualified energy resources and sold by the taxpayer to an unrelated person during the taxable year.[14] There are a number of technologies coved by the federal PTC, and the rules governing the PTC vary by resource and facility type.

The tax credit is reduced for projects that receive other federal tax credits, grants, tax-exempt financing, or subsidized energy financing.

The various PTCs offered by the federal and state governments offer opportunities for businesses and other entities (depending on the applicability of the PTC concerned) to stagger their receipt of tax benefits over a number of or many years. This approach may be preferable for companies with smaller tax appetites, as it facilitates many smaller tax credits over a series of years rather than a single or a few large credits for which the entity does not have adequate tax appetite.

Risks are, for example, that a project owner could anticipate larger incentives awards than are allowed based on the rules for the PTC that the credit is reduced for projects that receive other federal tax credits, grants, tax-exempt financing, or subsidized energy financing; or that an

[14] http://dsireusa.org/incentives/incentive.cfm?Incentive_Code=US13F, accessed May 5, 2013.

otherwise eligible entity (for example, a business) might expect to receive the benefits of the PTC without arranging to meet the condition that the generated electricity must be sold by the taxpayer to an unrelated person during the taxable year.

Further information:

Federal Renewable Electricity Production Tax Credit (DSIRE):
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US13F&re=1&ee=1

PRODUCTION-BASED INCENTIVE (PBI)

A production- or performance-based incentive compensates the renewable energy project owner according to the amount of energy produced by the project. Production tax credits are examples of production-based incentives, and even net metering and FITs could be said to be examples of PBIs because they compensate the owner according to how much renewable energy is produced and delivered.

Because a PBI is based on energy production over some portion of the life of a renewable energy project, it typically provides cash over a series of years, instead of upfront. This reduces the present value of the overall award, and correspondingly, the present value of the project. It also increases the risk level of the expected receipts, pushing present values still lower (additional risk increases the appropriate discount rate).

All else being equal, to the project owner, upfront incentives are often preferable to PBIs, because they are like cash in hand, without the time-value discount and risk that expectations of future payments (sometimes contingent on tax appetite) carry.

Further information:

State production-based incentives listed by state:
http://www.dsireusa.org/incentives/index.cfm?SearchType=Production&EE=0&RE=1

Federal renewable electricity production tax credit (corporate tax credit):
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US13F&re=1&ee=0

NET METERING

Net metering is a public policy incentive whereby electric utility customers who host small renewable energy facilities or V2G electric vehicles receive retail credit for at least a portion of the excess electricity they generate. The retail credit is based on deduction of metered energy outflows from metered energy inflows during a billing period. Net metering is considered an incentive for installation of renewable energy facilities because it is common for utilities to pay only a wholesale price for power they purchase whereas under net metering policies the utility is effectively paying a retail price for excess power generated by small renewable energy generators.

States and local utilities vary widely in the availability and specifics of the net metering programs they offer. Availability and program specifics often depend not only on the state but also on the type of utility (investor-owned, rural cooperative, municipal) and the degree of utility deregulation in the area.

When considering the expected impact of a planned renewable energy facility on the customer electric bill, it is important to understand the details of the local net metering policy. Most policies have an upper limit on nameplate system capacity that can qualify for the net metering program. If a system exceeds this nameplate capacity, net metering is not available to that customer. In some areas this nameplate capacity is as low as 10kW DC, but it is more commonly one or two MW DC in renewable energy-favorable places. Often in parallel, there is a capacity limit based on the historic or projected annual electricity consumption. Net metering may be unavailable for systems projected (based on local resources) to generate in excess of 100% plus or minus some small percentage of the customer's annual electricity consumption.

Policies also vary in the way net excess generation is credited. Rarely is retail reimbursement available from the utility, though many regimes allow carry-forward from month-to-month or year-to-year of monthly credit for net excess generation to be applied to future electric bills.

Make sure to discuss the details with the appropriate utility staff to get the most up-to-date information. Important considerations include whether net metering applies to your customer class, the net metering size limit, how this limit is measured (i.e., ac vs. dc, inverter or PV project size), treatment of net excess generation and REC ownership. Also ask if there are any billing changes, and if there are any special metering requirements and who is required to pay for new equipment and installation.

The estimated PV generation should be compared to historical usage on an hourly and seasonal basis to determine the appropriate project nameplate capacity. Ask if your utility will allow "virtual net metering," allowing aggregation of meters at one site, or aggregation between different agency sites within its service territory. This might make a larger overall project possible.

Ask if your site must switch to a different tariff, such as a time-of-use (TOU) tariff, in order to participate. If so, ask how the usage is net metered within the different TOU categories (e.g., is peak usage net metered separately from non-peak usage? Can peak net energy generation (NEG) be rolled over to credit non-peak usage?). Analyze the effect of a different tariff on your utility bill, since changing to TOU rates could increase total electric bill even with the reduction in conventional electricity use due to PV production.

PROPERTY TAX CREDIT

A property tax credit is a credit, deduction, or exemption available to a renewable energy facility owner whereby the incremental value of the facility is disregarded or assessed at a discount for property tax purposes.

Most property tax incentives provide that the additional value of a renewable energy system is excluded from the valuation of the property for taxation purposes. For example, if a new heating system that uses renewable energy costs more than a conventional heating system, the additional cost of the renewable energy system (over what a conventional system would have cost) is not included in the assessment. Conventional energy systems, for purposes of the rule, are assigned some reference $/kW of capacity value, often depending on capacity range. In some areas, property tax incentives are available to the extent of the additional cost of a green building. Because property taxes are assessed locally, some states have granted local taxing authorities discretion in offering property tax incentives for renewables.

Rules vary by renewable energy technology, by state, and by local area within states. There may be rules dictating that energy systems of lower capacities are assessed locally while systems of higher capacities are assessed at the state level (removing local discretion for the larger systems).

The benefit to a project or project owner of a property tax incentive depends on the property tax rate and the specific rules of the incentive including any assigned value per capacity of conventional energy equipment, frequency of assessment, and property valuations. If the owner of the renewable energy property is not subject to property tax (e.g., federal entities are usually not subject to state or local taxes as a matter of the doctrine of intergovernmental tax immunity), then there is no corresponding benefit from a reduced effective assessment value, and a benefit should not be anticipated. If the project is privately owned, however, the owner entity will usually benefit from the incentive in the form of a reduction in the additional tax burden it will see from the acquisition of new renewable energy assets. For large, expensive projects, this benefit can be significant. The approach to financial modeling of property tax incentives is different from the approach to modeling performance and investment tax incentives, and the variety of local rules recommends a good understanding of the specific rules in effect before relying on an incentive as part of project economic performance.

Further information:

Property tax credits by state:
http://www.dsireusa.org/incentives/index.cfm?EE=1&RE=1&SPV=0&ST=0&searchtype=Property&sh=1

Please consult a tax professional to ensure that reliance and extent of reliance on any tax incentive is reasonable and appropriate.

RENEWABLE ENERGY CERTIFICATE (REC)

A REC is also known as a green tag or a tradable renewable certificate, and a solar REC is also known as an SREC. It is a tradable, non-tangible unit of energy commodity in the United States which constitutes proof that one megawatt-hour (MWh) of energy was generated and delivered by an eligible renewable energy resource.

RECs can be sold or swapped, and the holder of the REC can be said to have generated or purchased renewable energy. Thus, a REC represents the environmental attributes of the energy produced from a renewable energy project and can exist separately from the commodity electricity for ownership and accounting purposes. RECs can be a source of revenue to renewable energy project owners or can be retained and retired to justify a claim to have generated or consumed some quantity of renewable, or “green,” energy.

Certain utility policies, such as some net metering and some production incentive policies, explicitly grant the utility ownership of project RECs.

Holding title to and retiring RECs may help the holder meet sustainability goals. REC sales, on the other hand, may provide revenue to contribute to the economic feasibility of a renewable energy project. If the REC ownership terms of the incentives utilized are not known, the project host or owner may not be able to depend upon REC retention to meet sustainability goals or to provide revenues to support project economics. On the other hand, if use of a necessary incentive requires relinquishment of project RECs, it may be possible to meet objectives by purchasing replacement RECs at a low cost.

SALES TAX CREDIT

A sales tax credit is an exemption from, or refund of, the state sales tax (or sales and use tax) for the purchase of renewable energy systems or equipment.

Some states offer tax holidays for these products, often one or two days a year, and some states offer these credits to corporations investing in PV projects.

An exemption from sales tax can be a sizeable percent reduction in what would otherwise be the gross cost of a project. On the other hand, the benefit should not be modeled as a reduction in the base price of the asset; instead the model should simply not account for sales tax as a component of the cost basis of the project. An entity not subject to the sales tax would receive no benefit from the incentive (only sales-taxable entities benefit).

Further information:

Sales tax credit:
http://www.dsireusa.org/incentives/index.cfm?EE=1&RE=1&SPV=0&ST=0&searchtype=Sales&sh=1

Consult a tax professional to determine implications of these incentives for your project and ownership approach.

INTERCONNECTION

Electric utilities and utility regulatory bodies, such as the state utility commissions and the Federal Energy Regulatory Commission (FERC), implement rules governing the interconnection or linking of their electric transmission and distribution systems with the electrical systems and components of their generators and generating customers. These rules, requirements, and procedures most often come into play when a utility customer interconnects or links an energy-producing device to its electrical system. Interconnection procedures and requirements help ensure that generating equipment is safe and compatible to interoperate with the utility distribution and transmission systems, thereby minimizing the risk of adverse system impact. Interconnection requirements vary with the utility line voltage level, nameplate capacity of the PV system, the utility, and the jurisdiction. The procedures can be time consuming and can have associated costs, potentially impacting project cost and schedule. They can also introduce contractual and risk allocation challenges for some implementers.

INTERCONNECTION STANDARDS

Interconnection standards specify the process and requirements for a generator or generating customer to connect electricity-generating systems to the electric utility transmission or distribution system. Such standards include the technical and contractual terms agreed upon by the system owners and utilities.

State public utility commissions typically establish standards for interconnection to the utility distribution system, while the FERC has adopted standards for interconnection at the transmission level. The FERC standards provide a thorough set of technical screens that has been copied by many jurisdictions. Many states have adopted interconnection standards, but some states' standards apply only to investor-owned utilities, not to municipal utilities or electric cooperatives; therefore, it is crucial to talk to your utility directly about its specific requirements.

FERC standards generally apply to transmission-level interconnection while state and utility standards apply to distribution-level interconnection. FERC has adopted "small generator" interconnection standards for distributed energy resources up to 20 MW, which can be used as a model for state-level standards. FERC's standards for larger generators greater than 20 MW include standard Large Generator Interconnection Procedures (LGIP) and a standard Large Generator Interconnection Agreement (LGIA). The interconnection process and requirements vary depending on the renewable energy project size, the utility and other factors. The Large Generator Interconnection Procedures (LGIP), for projects greater than 20 MW, is a more complex, time consuming, and costly process.

Some utilities have interconnection limitations, especially in areas with high renewable penetration.

If the system will be connected to a utility network distribution system, there may be complex electrical issues to be resolved before connection. Network protectors for each feeder will only allow current to flow from the utility to the load. If current flows in the reverse direction, the network protectors will open and shut off power to the building. Some potential solutions include: 1) load analysis to ensure no back-feed, 2) use of reverse power relay or 3) inverter settings. An electrical engineer who is familiar with your site's electrical distribution system should be consulted, as should be the utility, to determine the best solution for your site.

Further information:

The IEEE 1547 standard "establishes criteria and requirements for interconnection of distributed resources with electric power systems" [in order to] "provide a uniform standard for interconnection of distributed resources with electric power systems. It provides requirements relevant to the performance, operation, testing, safety considerations, and maintenance of the interconnection."[15] The standard was approved in 2003.

Additional information on grid-connected renewable generation at: http://www.nrel.gov/docs/fy09osti/45061.pdf

[15] http://grouper.ieee.org/groups/scc21/1547/1547_index.html, accessed May 5, 2013.

SYSTEM IMPACT STUDY OR UTILITY INTERCONNECTION STUDY

A system impact study determines the potential impacts and required upgrades to the utility electrical distribution system as a result of an on-site electricity generating plant.

Detailed system impact studies may include analyses of power flow, short circuit conditions, voltage drop and flicker, protection and control coordination, and grounding to identify potential system reliability criteria violations, equipment overstress, power quality impacts, stability problems, and other issues relevant to the proper operation of the area electric power system. Furthermore, detailed studies may identify feasible mitigation measures for identified problems, provide recommendations for facility modifications, and include good-faith estimates of cost and construction time.

METERING

Often, for participation in a production-based incentive program, the administering authority requires a revenue-grade electric system output meter. This requirement for a production meter (or bi-directional meter) may apply to programs such as net metering, feed-in tariffs, or other production-based incentive programs.

While many inverters can display energy production, inverter meters are not designed to the tolerances required for revenue-grade meters. Installation of a utility- or program-approved meter is usually required, and typically the utility customer or PV system contractor is responsible for installation by qualified personnel and according to code. The utility customer or PV contractor is often responsible for any cost of procurement and installation of the meter, and utility coordination is often required.

Metering and related requirements may involve unanticipated costs for a project if they are not understood and accounted for during project development, and utility coordination for installation and any required inspections could create project delays if not planned, coordinated, and, managed properly.

Further information:

The serving utility and the websites of programs in which the project will participate are the best sources of information and coordination on metering requirements for on-site PV.

PERMITTING AND INSPECTIONS

Permitting refers to the process undertaken to meet requirements that may be imposed by governments and other authorities for land use, construction, safety, and environmental and cultural resources protection in order to gain authorization for project implementation. Permitting requirements must usually be met in order for a project to be implemented without risk of being shut down for non-compliance. For some types of permits inspections are a required part of the process. Permitting requirements fall into four general categories:

- Land use permits: Used to uphold zoning laws, which ensure that areas are developed consistently with local and national standards for land use, aesthetics, and other values.

- Environmental permits: Used to ensure the development of a project does not negatively impact the ecosystem where the project will be developed, that development will mitigate negative impacts, and that stakeholders will consider the environmental costs as well as the benefits of the development under consideration.
- Construction/operation permits: Required before building or operating a new facility.
- Electrical work permits: Required to perform installation, alteration, or maintenance of electrical systems.

Often, projects are not allowed to go forward to construction, completion, or into the operating phase before these permitting requirements are met, so if not managed properly, they can create delays or show-stoppers for some types of PV projects in certain geographic areas. Failure to obtain the correct permits can be costly in terms of construction delays related to stop work orders; foregone revenues, tax credits, and commencement of accelerated depreciation; and in today's regulatory climate, possibly penalties for failure to meet renewable portfolio standards.[16] Managed properly, however, they can help ensure that the project is safe, interoperable with other systems, environmentally friendly and sustainable, and respectful of and in harmony with historical and cultural resources in the area.

CONSTRUCTION AND OPERATION PERMITS

A construction or building permit is an authorization to install a PV system and may be required as a safety or building-code compliance measure. An operation permit, likewise, is an authorization to bring a facility online, and may be required for safety or interoperability.

These permits may be required of the site owner or the installer, or the installer may handle permitting as a service to the property owner. Permits are often administered and awarded at the local level, i.e., by counties and municipalities.

There are often fees associated with permitting, and these may vary widely with jurisdiction. Also, local authorities may determine the specifics of the permitting standards in effect. Local fees and standards can constitute impediments sufficient to discourage a PV installation. In some states, however, permitting is being standardized at the state level in the interest of harmonization of standards and implementation of best practices and efficiency.

Further information:

Information regarding construction/operation permitting:

http://www.dsireusa.org/incentives/index.cfm?EE=1&RE=1&SPV=0&ST=0&searchtype=Permit&sh=1

ENVIRONMENTAL PERMITTING

Environmental permitting serves to ensure that the development of a project does not negatively impact the ecosystem where the project will be developed, that negative impacts will be mitigated,

[16] LEX HELIUS The Law of Solar Energy: A Guide to Business and Legal Issues, Third Edition; Stoel Rives, LLP; 2011.

and that stakeholders will consider the environmental costs as well as the benefits of the development under consideration.

For most projects involving the expenditure of federal dollars, the NEPA requires an assessment of the environmental effects of proposed actions prior to "significant action." In summary, actors must document the decision to either categorically exclude from or to prepare an environmental assessment (EA) or environmental impact statement (EIS). The EA and EIS are triggered when there will be impacts to land resources. When preparing the EA or EIS, other stakeholders are usually granted an opportunity to review and comment on the proposal and environmental analysis, and comments must be taken into account.

Siting a project in or near wetlands or a body of water may trigger additional federal environmental permitting considerations. The Army Corps of Engineers administers permitting under Section 10 of the Rivers and Harbors Act of 1899, Section 404 of the Clean Water Act (CWA), and Section 103 of the Marine Protection, Research & Sanctuaries Act of 1972.

The state and local authorities may have environmental procedural or permitting requirements in parallel and in addition to federal requirements. These requirements may parallel local construction requirements or may be special for PV mounting structures and may be designed in consideration of erosion and stormwater pollution control, hazardous materials, noise, sensitive habitat and endangered species, tree protection, and watershed and wetlands protection.

For federal actors, the major consideration for environmental permitting is NEPA, and federal environmental and permitting experts are usually familiar with federal, state, and local entities, authorities, and associations and sources of information to be consulted and engaged. Make sure your environmental expert is engaged early.

Further information:

State/Territory: https://acs.nrel.gov/epahome/,DanaInfo=www.epa.gov+state.htm

NEPA Citizens Guide:
https://acs.nrel.gov/nepa/,DanaInfo=ceq.hss.doe.gov+Citizens_Guide_Dec07.pdf

FWS: http://www.fws.gov/endangered/permits/index.html

NOAA's NMFS: http://www.nmfs.noaa.gov/pr/permits/

State Wildlife Agencies: http://www.fws.gov/offices/statelinks.html

LAND USE PERMITTING

Land use permitting typically helps ensure that instituted goals for the way land is to be used are realized.

Although there are federal designations for the use of certain lands, often land use requirements come into play at the state and local levels. Some jurisdictions have numerous land use goals with various prohibitions. Exceptions can be granted by the review process but may be hard fought in certain jurisdictions. A solar facility may be predetermined unconditionally compatible with the zoning codes or may be conditionally allowed. If the latter, the environmental assessment may provide conditions to be imposed on the facility to render it more compatible with the zone.

The county commission or a similar body and less frequently a land use commission or planning agency administrators is the body to approve a project.[17]

Further information:

Hawaii RE Permits and Approvals Guidebook: Federal and State Approvals for Solar:

http://energy.hawaii.gov/wp-content/uploads/2011/11/solar_guidebook.pdf

ELECTRICAL WORK PERMITTING AND INSPECTION

State and local entities license, register, and regulate electricians, apprentices, and electrical contractors and regulate their electrical work, often requiring and issuing permits for electrical work to be performed. Electrical work can include wiring and installation, alteration, or maintenance of electrical systems or equipment. Permitting and inspection of electrical work related to PV systems is a special instance of these general permitting and inspection requirements.

Permitting is usually required before or shortly after commencing certain kinds of electrical work, and may involve design approvals. Inspection of completed work may also be required before an operating permit is issued.

Scheduling requirements and prerequisites vary from jurisdiction to jurisdiction but the installer should be familiar with local requirements and administering authorities and able to assist with planning and coordination for the best use of time. Often the state public utilities commission (PUC) or public service commission (PSC), the state electrical board, the state department of labor and industries, the serving utility, and the municipality will have information on permitting and inspection requirements, scheduling, and fees. Understanding and planning around these requirements can help ensure the installation is completed and brought online in a timely fashion, and that potentially expensive and inconvenient delays are avoided.

SUPPLEMENTARY TOPICS

In addition to funding, incentives, interconnection, and permitting, other considerations that may surface less frequently include community solar farms (or solar gardens), equipment certification, renewable contractor licensing, solar access and easements, and the renewable portfolio standard. These topics are considered supplementary because they may either concern the project host only indirectly, or, as is the case with community solar farms, not concern the project host or sponsor at all unless, for example, there is a constraint on available appropriate space to host a project and there is interest in participation in a project hosted off-site, or, as discussed under Project Funding, there is an interest in partnering with a community funder to host a PV project on federal land.

[17] *Ibid.*

COMMUNITY SOLAR FARM OR SOLAR GARDEN

A community solar farm is a solar power installation, usually centrally located, that accepts capital from and provides credit for the output and tax benefits to individual and other investors.[18] One popular use is to facilitate ownership participation (with the credit and tax benefits) for those who do not have an ideal location on their own property to host a solar facility. The power output is often credited to the investors in proportion to their interest (the output may be credited to the power bill of the participant), with periodic adjustments to reflect ongoing changes in capacity, technology, costs, and electricity rates. A company, cooperative, government, or non-profit may ultimately own and/or operate the facility.

In GSA facilities locations where there is not adequate appropriate space for a desired PV project, a community solar farms program may present an opportunity for GSA to meet its renewable energy usage goals in a way other than hosting a solar power facility on GSA property. An off-site PV project[19] would not, however, permit GSA to receive the EPAct renewable electricity 'double bonus' available to agencies for using electricity generated by renewable electric projects located on federal or Native American Tribal lands.

A federal agency might alternatively use a community solar farms policy to host a community-owned PV project on federal property.[20]

Further information:

Interstate Renewable Energy Council newsletter announcing Colorado's Community Solar Gardens Act:

http://www.irecusa.org/2011/11/november-connecting-to-the-grid-newsletter/

For information on programs in California, Washington, Colorado, Massachusetts, Maine, Vermont, Rhode Island and Delaware, see:

http://www.nrel.gov/applying_technologies/state_local_activities/pdfs/tap_webinar_20110126_weidman.pdf (slides 7 & 8).

EQUIPMENT CERTIFICATION

In some jurisdictions there are standards for qualification of renewable energy equipment for various purposes. These standards are in place for a number of reasons, for example, to ensure electrical safety, to protect consumers from buying inferior equipment, or to ensure that an incentive to support renewable energy projects has the impact (production of clean energy) intended by the entity providing it.

It is important to check for any equipment standards or certification requirements, especially those related to incentives and interconnection, to ensure that the project, as designed and procured, will

[18] Galbraith, Kate (March 15, 2010). "For Renters, Solar Comes in Shares." New York Times.

[19] By 'off-site' for purposes of the EPAct double bonus, we mean a project not located on federal or Indian Tribal land.

[20] See the Community Solar topic under Project Funding for discussion of this approach.

be permitted to interconnect to the utility and begin operation, and so that expected incentives will be realized.

RENEWABLE PROJECT CONTRACTOR LICENSING

Some states have adopted licensure requirements for renewable energy project contractors. These requirements are designed to ensure that contractors have the necessary knowledge and experience to install systems properly. Licenses for solar contractors typically take the form of either a separate, specialized solar contractor's license, or a specialty classification under a general electrical or plumbing license. PV project managers should check to ensure that the selected contractor meets all licensure requirements.

SOLAR ACCESS POLICIES

Solar and wind access policies, whether state or local, are designed to preserve (against local ordinances or home owners association rules) a right to install and operate a solar or wind energy system at a home or other facility, or to facilitate a system owner's assurance of access to sunlight, usually through an easement. Easement allowances, the most common form of solar access policy mechanism, are most often crafted so that the easement is requested of and granted voluntarily by a neighboring property owner and transferred with the property title. Easement allowances may also permit the contracting parties to include their own remedies for breach of contract.

Solar developers signing a PPA may require a recorded solar easement, or at least a provision in the PPA or any accompanying real property agreement ensuring that there will be no future development that will shade the solar project.

RENEWABLE PORTFOLIO STANDARDS (RPS) SOLAR SET ASIDES AND SOLAR CREDITS MULTIPLIERS

An RPS is a legal requirement for utility companies or load serving entities to procure or produce a certain percentage of the energy used in the service territory from renewable energy sources, or otherwise permit or facilitate generation and/or use by its customers of energy from renewable energy sources.

Depending on policy specifics, a utility may meet its RPS requirements by building utility-scale renewable energy projects, entering into PPAs with renewable energy generators or aggregators, or by offering incentives to its customers to build projects and generate renewable energy for their own use and the use of others on the distribution system. The utility is usually required to purchase and retire RECs as a part of its requirements.

A "set-aside" or "carve-out" refers to a portion of a state's RPS that requires a specific renewable source, often solar energy, to account for a percentage of retail electricity sales or generating capacity. The solar credits multiplier was originally created to encourage the expansion of home solar units. Under the set-aside RECs generated by qualifying projects were to be valued at some five times their market rate for the first few years.

The type of qualifying solar technologies and incentives vary by state. Furthermore, the incentives are designed so that value of the set-aside or credit multiplier typically decreases over time, so it's good to understand the details of the state's RPS solar set-aside or credit multiplier before counting on one of them for project revenues or savings.

Further information:

U.S. RPS Policies: http://www.dsireusa.org/incentives/index.cfm?SearchType=RPS&&EE=0&RE=1

APPENDIX C: GSA PV PROJECT STAKEHOLDERS SURVEY

This appendix reproduces the questions that were included in the survey taken by PV project stakeholders at GSA. Survey participation was solicited by email and the survey was taken online. Although much of the survey was multiple-choice, the multiple-choice answers are not reproduced here.

1. What is your name?
2. Please select the answer closest to your job title at GSA. If none is a good match, please select "Other" and specify.
3. At what GSA facility was this PV project sited?
4. What was the electric utility serving the facility where the project was sited?
5. How was the project funded?
6. If you know of a technical expert who might provide more information on the overall project, please provide the name and email:
7. How would you categorize the greatest challenge faced by the project?
8. Please describe the challenge.
9. If there was an action, best practice, or key success factor implemented by the project team that lessened the impact on the project of this challenge or issue, please describe the action, best practice, or key success factor:
10. What, finally, as a result of the team's efforts, were the impacts of this issue on the project?
11. What might have been the impact of the issue on the project had the corrective action or best practice not been taken?
12. If you know of a person who may provide more information about this particular challenge, please provide name and email:
13. How would you categorize the second greatest challenge faced by the project? (Optional)
14. Please describe the challenge.
15. If there was an action, best practice, or key success factor implemented by the project team that lessened the impact on the project of this challenge or issue, please describe the action, best practice, or key success factor:
16. What, finally, as a result of the team's efforts, were the impacts of this issue on the project?
17. What might have been the impact of the issue on the project had the corrective action or best practice not been taken?
18. If you know of a person who may provide more information about this particular challenge, please provide name and email:
19. How would you categorize the third greatest challenge faced by the project? (Optional)
20. Please describe the challenge.

21. If there was an action, best practice, or key success factor implemented by the project team that lessened the impact on the project of this challenge or issue, please describe the action, best practice, or key success factor:
22. What, finally, as a result of the team's efforts, were the impacts of this issue on the project?
23. What might have been the impact of the issue on the project had the corrective action or best practice not been taken?
24. If you know of a person who may provide more information about this particular challenge, please provide name and email.

APPENDIX D: SAMPLE OF GSA PV PROJECT CHALLENGES

Project Site	Joseph P. Addabbo Federal Building Queens, NY
Utility	Con Edison
Funding Source	ARRA
Greatest Challenge	GSA process/changing directives/security clearances
Description of Challenge	This was initially planned as a PV panel project; however, sole tenant SSA requested GSA to include replacing the roof. To meet award deadlines, changes to the acquisition planning were required. Bids were made available to only IDIQ contractors. There was not enough time for security clearance for contractors to provide invasive investigation.
Key Action to Overcome Challenge	As-built drawings were relied upon for conveying existing conditions to the bidders. After award, the contractor performed invasive testing and found the as-built information to be incorrect. While this added cost to the project, the total project cost ended up below the government estimate because the original award amount was low. Regarding security clearances, we dedicated at least one person plus the GSA project manager and an SSA facility employee to track the accuracy of the submitted paperwork before sending it in.
Outcome as Result of Challenge	No significant impact
Implications of Challenge if Not Corrected	Quality, Delay, Economic impact
2nd Greatest Challenge	Lack of expertise
Description of Challenge	The contractor, being a small IDIQ, had limited experience with work of this scope and relied heavily on its roofing subcontractor.
Key Action to Overcome Challenge	GSA and SSA worked well together in presenting a unified voice when dealing with the contractor. SSA accommodated the contractor with more access and use of the building than originally scoped.
Outcome as Result of Challenge	No significant impact
Implications of Challenge if Not Corrected	Quality, Delay, Economic impact
3rd Greatest Challenge	Site issues

Project Site	Joseph P. Addabbo Federal Building Queens, NY
Description of Challenge	As an urban setting, there is limited area around the building for contractor storage, staging and material handling. The contractor was to use a crane and chutes but both proved to be too expensive, complicated and not well planned/scheduled by the contractor.
Key Action to Overcome Challenge	SSA was very accommodating and allowed the contractor access within the building and use of the loading dock beyond the confines of the original scope
Outcome as Result of Challenge	No significant impact
Implications of Challenge if Not Corrected	Quality, Delay, Economic impact

Project Site	J. Caleb Boggs Federal Building and U.S. Courthouse Wilmington, DE
Utility	Delmarva Power
Funding Source	Appropriations
Greatest Challenge	Interconnection agreement
Description of Challenge	The process for the contractor to complete the interconnection agreement was long.
Key Action to Overcome Challenge	Using a design-build approach to the design and construction of the system allowed for flexibility in the installation of the PV array.
Outcome as Result of Challenge	No significant impact
Implications of Challenge if Not Corrected	The size of the array may be below what was originally planned.
2^{nd} Greatest Challenge	Weather
Description of Challenge	Snow during the installation period resulted in some delays.
Key Action to Overcome Challenge	

Project Site	**J. Caleb Boggs Federal Building and U.S. Courthouse Wilmington, DE**
Outcome as Result of Challenge	No significant impact
Implications of Challenge if Not Corrected	Economic impact (project cost or economic return could have been negatively affected)

Project Site	**Brooklyn General Post Office Brooklyn, NY**
Utility	Con Edison
Funding Source	Appropriations
Greatest Challenge	Connection to GSA Network for monitoring of Energy Production
Description of Challenge	
Key Action to Overcome Challenge	
Outcome as Result of Challenge	PV Panels are generating power but monitoring has not been implemented yet
Implications of Challenge if Not Corrected	

Project Site	**Byrne-Green Federal Complex Philadelphia, PA**
Utility	PECO
Funding Source	Appropriations
Greatest Challenge	Interconnection agreement
Description of Challenge	Getting the utility to approve the proposed design; however, this was a minimal issue.
Key Action to Overcome Challenge	

Project Site	Byrne-Green Federal Complex Philadelphia, PA
Outcome as Result of Challenge	No significant impact
Implications of Challenge if Not Corrected	Delay (project schedule could have been negatively affected)

Project Site	Davenport United States Courthouse Davenport, IA
Utility	MidAmerican Energy
Funding Source	ARRA
Greatest Challenge	Interconnection agreement
Description of Challenge	Wanted exterior disconnect on ground level, not at roof penthouse. Trying to find an interior route to run the lines from the roof down to the location of the disconnect box was a challenge. No one was comfortable running the lines down the exterior of the building.
Key Action to Overcome Challenge	Contractor needs to do a better job at pre-planning. However, GSA added the PV on this project as a modification during this project. GSA needed to do better preplanning as well.
Outcome as Result of Challenge	Delay, Economic impact
Implications of Challenge if Not Corrected	There would not have been any significant impact.
2nd Greatest Challenge	Net metering
Description of Challenge	GSA and OCIO did not have the metering requirements pre-planned. This created delays and modifications when there was a change in direction/requirements.
Key Action to Overcome Challenge	GSA needed to do better preplanning.
Outcome as Result of Challenge	Quality, Delay, Economic impact

Project Site	Davenport United States Courthouse Davenport, IA
Implications of Challenge if Not Corrected	There would not have been any significant impact

Project Site	Calexico Border Station Bulk/Hazmat Building Calexico, CA
Utility	Imperial Water and Irrigation District
Funding Source	ARRA
Greatest Challenge	Incentives
Description of Challenge	The project had to be delayed 8 months in order to qualify for the incentive. The utility had a requirement that the project could not be started before the incentive was approved.
Key Action to Overcome Challenge	None
Outcome as Result of Challenge	Delay (project schedule negatively affected)
Implications of Challenge if Not Corrected	There was no way to avoid this issue.
2nd Greatest Challenge	Weather
Description of Challenge	Due to the delay, the project had to be accomplished during the hottest time of the year; temperatures exceeded the century mark every day.
Key Action to Overcome Challenge	We were forced to do the work at night, when it was a little cooler but still extremely hot.
Outcome as Result of Challenge	Delay (project schedule negatively affected)
Implications of Challenge if Not Corrected	Delay
3rd Greatest Challenge	Technical issues

Project Site	Calexico Border Station Bulk/Hazmat Building Calexico, CA
Description of Challenge	It took a long time to resolve structural concerns during the design phase.
Key Action to Overcome Challenge	Economics forced this situation. There were very good designs available, but they were cost prohibitive.
Outcome as Result of Challenge	Delay (project schedule negatively affected)
Implications of Challenge if Not Corrected	Economic impact (project cost or economic return could have been negatively affected)

Project Site	Census Bureau Office Complex Suitland, MD
Utility	Pepco
Funding Source	Appropriations
Greatest Challenge	Procurement issues
Description of Challenge	Project was delayed due to scope changes and change order processing.
Key Action to Overcome Challenge	The scope of work was revised to fit the project budget.
Outcome as Result of Challenge	Delay of 6 months before project was able to proceed
Implications of Challenge if Not Corrected	Quality, Delay, Economic impact
2nd Greatest Challenge	Site issues
Description of Challenge	Unforeseen conditions were encountered that included multiple electric distribution lines that were severed or damaged.
Key Action to Overcome Challenge	The project team collaborated to resolve.
Outcome as Result of Challenge	Project experienced some delays. The overall project quality was not affected.

Project Site	Census Bureau Office Complex Suitland, MD
Implications of Challenge if Not Corrected	Delay
3rd Greatest Challenge	Weather
Description of Challenge	While the project was under construction, multiple hurricanes and an earthquake were experienced.
Key Action to Overcome Challenge	The construction contractor scheduled work to minimize construction delays. The GSA building manager was instrumental in project success by providing areas where the contractor could store materials and site access.
Outcome as Result of Challenge	Construction was not delayed
Implications of Challenge if Not Corrected	Delay

Project Site	Centers for Medicare and Medicaid Services (CMS) Complex Woodlawn, MD
Utility	Baltimore Gas and Electric
Funding Source	Appropriations
Greatest Challenge	Roofing restoration prior to PV installation
Description of Challenge	Prior to the PV installation, the roof restoration had to occur. The coating product utilized produced significant odors that were disruptive to the tenants.
Key Action to Overcome Challenge	Research all of the different coating products. Clearly understand any air quality issues that could result from work in an occupied facility. Utilize IH services and air testing to provide quantifiable data of the impacts.
Outcome as Result of Challenge	Delay (project schedule negatively affected)
Implications of Challenge if Not Corrected	Quality, Delay, Economic impact

Project Site	Centers for Medicare and Medicaid Services (CMS) Complex Woodlawn, MD
2nd Greatest Challenge	Project management
Description of Challenge	The contractor did not provide the necessary coordination and supervision of the onsite roofing contractor during the required weekend work.
Key Action to Overcome Challenge	Utilize full time roofing inspector. Document all issues. Require close oversight by the manufacturer providing the warranty.
Outcome as Result of Challenge	Delay (project schedule negatively affected)
Implications of Challenge if Not Corrected	Delay
3rd Greatest Challenge	Technical issues
Description of Challenge	On approximately 40% of the roofing areas, the top coating delaminated after application. This was caused by improper preparation of the roofing surfaces.
Key Action to Overcome Challenge	Require close oversight from the manufacturer providing the warranty. Utilize full time roofing inspector.
Outcome as Result of Challenge	Delay (project schedule negatively affected)
Implications of Challenge if Not Corrected	Delay

Project Site	William R. Cotter Federal Building Hartford, CT
Utility	Connecticut Light & Power
Funding Source	ARRA
Greatest Challenge	Interconnection agreement

Project Site	William R. Cotter Federal Building Hartford, CT
Description of Challenge	Local utility owned a substation in the basement of the Federal Building that was limited to 50 kWh, less than the design output of the installation (75 kWh). Interconnection agreement could not be completed without reduction of inverter capacity to 50 kWh, necessitating reordering of inverter and incurring manufacturing and delivery delays.
Key Action to Overcome Challenge	It was helpful to have our legal team and environmental team involved in negotiations with the local utility, but we still had to reduce effective output below what the system is designed to produce. It would have been better to involve the local utility during design.
Outcome as Result of Challenge	Quality (project quality negatively impacted – project requirements or expectations unmet), Delay (project schedule negatively affected)
Implications of Challenge if Not Corrected	The project would have been deployed but could be non-operational
2nd Greatest Challenge	Procurement issues
Description of Challenge	Related to first challenge. Inverter with less capacity had to be ordered to replace the originally specified inverter. Because similar projects were taking place simultaneously all over the country, we encountered significant delays in manufacture and delivery of the replacement inverter.
Key Action to Overcome Challenge	Contractor researched all possible sources, and substituted a different manufacturer for the originally specified inverter.
Outcome as Result of Challenge	Delay (project schedule negatively affected)
Implications of Challenge if Not Corrected	Delay (project schedule could have been negatively affected)
3rd Greatest Challenge	Net metering
Description of Challenge	We encountered some minor delays in being able to read output remotely.
Key Action to Overcome Challenge	GSA personnel worked with Schneider electric to correct interface.
Outcome as Result of Challenge	No significant impact

Project Site	William R. Cotter Federal Building Hartford, CT
Implications of Challenge if Not Corrected	Quality – Our goal of monitoring building energy performance would not have been met.

Project Site	Denver Federal Center – 1.2MW Ground Mount Array 2007 Denver, CO
Utility	Xcel Energy
Funding Source	Appropriations
Greatest Challenge	Interconnection agreement
Description of Challenge	This was one of the first interconnection agreements this utility did with a federal agency. GSA legal counsel did not find the utility's standard clauses and indemnification requirements to be a good fit, so took 12 months to work out an acceptable compromise.
Key Action to Overcome Challenge	Start discussions with utility on the interconnection agreement early. Get GSA legal counsel to assist and conduct negotiations on what will be allowable.
Outcome as Result of Challenge	No significant impact
Implications of Challenge if Not Corrected	Delay, Economic impact
2nd Greatest Challenge	Web Based monitoring system
Description of Challenge	This project team wanted a publicly accessible web-based monitoring system for public education outreach and also for real-time monitoring of renewable energy. It was a challenge to get the right mix of layman's education and good data with the security “walls” that both the monitoring company and GSA had in place.

Project Site	Denver Federal Center – 1.2MW Ground Mount Array 2007 Denver, CO
Key Action to Overcome Challenge	Put clearer description of web-based monitoring system requirements in contract and include length of time that will be required to provide this service. We did not want the public side of the website to require a password and that is what was planned by the contractor. It also was not clear that we wanted this site up for 20 years. We negotiated a 2 year settlement and then were going to pay a yearly fee after that. Also wanted site to have logic to notify GSA of problems with energy production based upon historic performance and solar radiation monitoring.
Outcome as Result of Challenge	No significant impact
Implications of Challenge if Not Corrected	Would not have had web based monitoring, and education & outreach would have been minimal. GSA's tracking of Solar Renewable Energy Credit sales would have been compromised.
3rd Greatest Challenge	Site issues
Description of Challenge	Restoration of native grasses under and around array was not well specified. As a result, tall invasive weeds grew around panels and shaded them until a maintenance crew could be hired to cut the weeds. Maintenance was higher as a result of not properly specifying grass restoration.
Key Action to Overcome Challenge	Future projects required sustainable grass restoration in the contract, with temporary watering to get the grass established.
Outcome as Result of Challenge	Shading of PV panels due to tall weeds till crews could be hired to remove weeds.

Project Site	Denver Federal Center – Roof and Ground Phases Denver, CO
Utility	XCEL Energy
Funding Source	ARRA
Greatest Challenge	Conflicts with other Large Projects
Description of Challenge	We had a DFC-wide utility Project and a large Data Center project that competed for sites for parking, staging and utility work.
Key Action to Overcome Challenge	Lots of coordination

Project Site	Denver Federal Center – Roof and Ground Phases Denver, CO
Outcome as Result of Challenge	No significant impact
Implications of Challenge if Not Corrected	Delay
2nd Greatest Challenge	Technical issues
Description of Challenge	We had to relocate one site and virtually all tie in points due to conflicts (after award).
Key Action to Overcome Challenge	Coordination – the actual project was a fun challenge
Outcome as Result of Challenge	No significant impact
Implications of Challenge if Not Corrected	Delay
3rd Greatest Challenge	Environmental
Description of Challenge	The DFC is under a state compliance order – this dramatically increased the cost and effort anytime we dug.
Key Action to Overcome Challenge	Pay close attention to the regulations and you should not have a problem.
Outcome as Result of Challenge	No significant impact
Implications of Challenge if Not Corrected	Delay, Economic impact

Project Site	Department of Energy – Main Building Germantown, MD
Utility	Potomac Electric Power Company (Pepco)
Funding Source	ARRA
Greatest Challenge	State or local laws and regulations

Project Site	Department of Energy – Main Building Germantown, MD
Description of Challenge	National Capital Planning Commission – Maryland Department of Environment – erosion and sediment control and stormwater management
Key Action to Overcome Challenge	Experience, Experience, Experience
Outcome as Result of Challenge	Project is a success
Implications of Challenge if Not Corrected	Quality (project quality could have been negatively impacted – project requirements or expectations could have been unmet)
2nd Greatest Challenge	Site issues
Description of Challenge	All new PV placed on the ground represent new development of undeveloped land.
Key Action to Overcome Challenge	PM must have through understanding of environmental, historical, archaeological, site master plans, etc.
Outcome as Result of Challenge	No significant impact

Project Site	1800 F Street (Phase I) Washington, D.C.
Utility	Potomac Electric Power Company (Pepco)
Funding Source	ARRA
Greatest Challenge	Changes
Description of Challenge	Changes due to multiple design issues not having been completed before bid time.
Key Action to Overcome Challenge	Finish the complete design before bidding of the project.
Outcome as Result of Challenge	Delay (project schedule negatively affected), Economic impact (project cost or economic return negatively affected)
Implications of Challenge if Not Corrected	Delay (project schedule could have been negatively affected), Economic impact (project cost or economic return could have been negatively affected)

Project Site	Federal Building – 244 Needy Road Martinsburg, WV
Utility	Allegheny Power
Funding Source	ARRA
Greatest Challenge	Contingency funding.
Description of Challenge	This project was funded via ARRA and the biggest challenged that faced was the removal of flexibility in regards to the project's contingency funding.
Key Action to Overcome Challenge	None
Outcome as Result of Challenge	Alternate funding was required from BA54
Implications of Challenge if Not Corrected	Delay (project schedule could have been negatively affected)
2nd Greatest Challenge	Lack of planning
Description of Challenge	Since these projects were quickly developed, adequate time to further investigate appropriate solutions were not explored.
Key Action to Overcome Challenge	Since this project was a design build contract, we worked collaboratively with the contractor during design to investigate alternate ideas.
Outcome as Result of Challenge	No significant impact
Implications of Challenge if Not Corrected	Quality (project quality could have been negatively impacted – project requirements or expectations could have been unmet)

Project Site	Robert J. Dole U. S. Courthouse Kansas City, KS
Utility	BPU
Funding Source	Appropriations
Greatest Challenge	Technical issues

Project Site	Robert J. Dole U. S. Courthouse Kansas City, KS
Description of Challenge	The contractor had a hard time understanding that we needed a one-line diagram explaining how the power generated by the PV system would feed into the building's power. Also had some complexities with how and where the inverter would be placed, how the power lines would enter the building and how it was all hooked up. The contractor had not worked with the federal government before; was used to private sector work where they figured out things as they went.
Key Action to Overcome Challenge	During design, have the designer work with the contractor to lay out specific diagrammatic information about how the system will work.
Outcome as Result of Challenge	No significant impact
Implications of Challenge if Not Corrected	Delay
2nd Greatest Challenge	Other utility issues
Description of Challenge	The local utility provider was startled to hear that we were installing a PV system in their neighborhood and had a hard time understanding how it would work. Communication was difficult.
Key Action to Overcome Challenge	Work with the utility company very early on –- during design –- to make sure they understand what the project will entail. Obtain whatever permissions are necessary early. Invite them to visit the site when the project is complete.
Outcome as Result of Challenge	No significant impact
Implications of Challenge if Not Corrected	Delay
3rd Greatest Challenge	Lack of expertise
Description of Challenge	The contractor used workers with little or no training, although they learned on the job and installed the system efficiently. Building occupants and staff had little or no knowledge of PV systems and weren't familiar with how to keep it clean or generally maintain it, despite having been given instructions, training and operating manuals.
Key Action to Overcome Challenge	Introduce the PV system to the building staff during design and make sure they know what they're getting into. During the construction contractor solicitation, include language that specifies a knowledgeable installation crew.

Project Site	Robert J. Dole U. S. Courthouse Kansas City, KS
Outcome as Result of Challenge	No significant impact
Implications of Challenge if Not Corrected	Quality

Project Site	Hipolito F. Garcia Federal Building and U.S. Courthouse San Antonio, TX
Utility	CPS
Funding Source	Appropriations
Greatest Challenge	Interconnection agreement
Description of Challenge	We had some difficulty sorting out the utility's boilerplate interconnection agreement and getting them to modify it to terms acceptable to GSA.
Key Action to Overcome Challenge	We just kept working with them and had several discussion sessions. It was resolved successfully but took a long time.
Outcome as Result of Challenge	Delay (project schedule negatively affected)
Implications of Challenge if Not Corrected	The project would have been deployed but could have been non-operational
2nd Greatest Challenge	Technical issues
Description of Challenge	Sorting out the best way to mount the equipment, lay out the array, and tie into the electrical system was a little complicated, but not insurmountable.
Key Action to Overcome Challenge	This was done as a modification to an ongoing construction contract, so we were able to work out the issues collaboratively with the contractor, the PV supplier/expert, and the design team.
Outcome as Result of Challenge	No significant impact

Project Site	Hipolito F. Garcia Federal Building and U.S. Courthouse San Antonio, TX
Implications of Challenge if Not Corrected	Quality (project quality could have been negatively impacted – project requirements or expectations could have been unmet)
3rd Greatest Challenge	Project management
Description of Challenge	As noted, this was done as a modification to an ongoing construction contract, so integrating the design, the contracting, and then the construction – all was a bit of a challenge, but ended up being do-able.
Key Action to Overcome Challenge	There didn't seem to be a single key action; it was just a matter of getting all the members of the team to co-operate and work together and pursuing the issue persistently.
Outcome as Result of Challenge	No significant impact
Implications of Challenge if Not Corrected	A no-go decision would have been made on the project

Project Site	Multiple locations Texas, New Mexico and Louisiana
Utility	Multiple utility companies for multiple sites
Funding Source	ESPC projects, ARRA
Greatest Challenge	Getting approval for ESPCs under ARRA
Description of Challenge	Convincing our headquarters to allow our region to deliver our High Performing Green Buildings under the ARRA program using ESPC contracts. We were the only region (of 11) to be approved for this.
Key Action to Overcome Challenge	ESPCs were a great fit for delivering these projects, as they are turn-key design-build, have guaranteed savings, and have measurement & verification.
Outcome as Result of Challenge	The projects were delivered faster than traditional projects that are designed by one firm, advertised, and then awarded to another firm for construction.
Implications of Challenge if Not Corrected	Delay

Project Site	Multiple locations Texas, New Mexico and Louisiana
2nd Greatest Challenge	Fire safety
Description of Challenge	Each PV system needed multiple disconnects to meet the requirements outlined by our fire protection engineers.
Key Action to Overcome Challenge	Since ESPCs are performance-based contracts, we were able to get the required disconnects at no additional cost to the government.
Outcome as Result of Challenge	No significant negative impacts.
Implications of Challenge if Not Corrected	If systems were installed without meeting fire safety requirements, there would be additional cost for compliance later.
3rd Greatest Challenge	Site issues
Description of Challenge	Physical limitations due to the available space on roofs of high-rise federal buildings.
Key Action to Overcome Challenge	The ESCOs worked within the space limitations available.
Outcome as Result of Challenge	No significant impact, There was no driving factor to install larger PV systems, as none could provide net-zero energy conditions for the buildings.
Implications of Challenge if Not Corrected	There would not have been any significant impact

Project Site	Ron De Lugo Federal Building and U.S. Courthouse Charlotte Amalie, Virgin Islands
Utility	WAPA
Funding Source	ARRA
Greatest Challenge	Interconnection agreement
Description of Challenge	"Hold harmless" language in the utility agreement – to which GSA is exempt – required coordination between GSA legal and the utility company's legal teams.

Project Site	Ron De Lugo Federal Building and U.S. Courthouse Charlotte Amalie, Virgin Islands
Key Action to Overcome Challenge	Getting the legal team leaders to communicate with each other directly as opposed to the GSA PM and the contractor PM being the “middle men”
Outcome as Result of Challenge	No significant impact
Implications of Challenge if Not Corrected	The project would have been deployed but could be non-operational, Delay, Economic impact
2nd Greatest Challenge	Project manager’s distance from worksite
Description of Challenge	Since the GSA PM was located in Newark and the project was located in the Virgin Islands, the PM had limited knowledge as to the daily progress and also a slight language barrier.
Key Action to Overcome Challenge	The local GSA office in the VI provided a PM to assist by making site visits and be the PM’s “eyes” in the field. We used teleconferencing and photos sent via handheld devices.
Outcome as Result of Challenge	No significant impact
Implications of Challenge if Not Corrected	Quality, Delay, Economic impact

Project Site	Senator Paul Simon Federal Building Carbondale, IL
Utility	Ameren
Funding Source	Appropriations
Greatest Challenge	Economic issues
Description of Challenge	Project often produces more electricity than the building uses.
Key Action to Overcome Challenge	Registered building as Qualified Facility with Federal Energy Regulatory Commission. The excess power is sold to the utility company at a low rate.

Project Site	Senator Paul Simon Federal Building Carbondale, IL
Outcome as Result of Challenge	Economic impact

Project Site	Seattle Federal Center South Building Seattle, WA
Utility	Seattle City Light
Funding Source	ARRA
Greatest Challenge	State or local laws and regulations
Description of Challenge	Working with the utility to approve the system, being that it was the largest PV array in the State of Washington. The utility had difficulty understanding that the system would not be on the grid.
Key Action to Overcome Challenge	Partnering with outside agencies and utility companies during the design process
Outcome as Result of Challenge	No significant impact
Implications of Challenge if Not Corrected	Delay (project schedule could have been negatively affected)
2nd Greatest Challenge	Site issues
Description of Challenge	Working on an occupied building with noise and adhesive smells.
Key Action to Overcome Challenge	PM established a newsletter with photos for tenants, with progress report and one week look ahead, so they could make arrangements for noises and smells.
Outcome as Result of Challenge	No significant impact
Implications of Challenge if Not Corrected	Delay (project schedule could have been negatively affected)

Project Site	Theodore Roosevelt Building Washington, D.C.
Utility	Pepco
Funding Source	Appropriations
Greatest Challenge	Interconnection agreement
Description of Challenge	1. Language in utility's agreement suited for generic customer doing possible net metering; not suited for federal government – FAR (Federal Acquisition Regulations) & Liability concerns 2. Fees not budgeted
Key Action to Overcome Challenge	Work w/ GSA legal office to tailor standard interconnection agreement w/ Pepco so that it can be used on all GSA projects. Agreements on future projects should be just simple – fill in the blanks.
Outcome as Result of Challenge	Delay (project schedule negatively affected)
Implications of Challenge if Not Corrected	Delay (project schedule could have been negatively affected)

Project Site	Gus J. Solomon U.S. Courthouse Portland, OR
Utility	Pacific Power
Funding Source	ARRA
Greatest Challenge	GSA OCIO co-wrote the performance specs yet wouldn't approve the system being interconnected due to security concerns.
Description of Challenge	
Key Action to Overcome Challenge	
Outcome as Result of Challenge	Delay
Implications of Challenge if Not Corrected	The project would have been deployed but could be non-operational

Project Site	Gus J. Solomon U.S. Courthouse Portland, OR
2nd Greatest Challenge	Lack of expertise
Description of Challenge	Minimal expert guidance was given to region and from within region.
Key Action to Overcome Challenge	This resulted in project managers having to create design and performance scope of work and technical aspects.
Outcome as Result of Challenge	Project was successful

Project Site	Mary Switzer Building (Phase II) Washington, D.C.
Utility	Pepco
Funding Source	Appropriations
Greatest Challenge	Site issues
Description of Challenge	The placement of the panels for optimal performance while respecting sight lines and historical preservation constraints.
Key Action to Overcome Challenge	Integrated delivery approach, where all participants provided value in the development process.
Outcome as Result of Challenge	A no-go decision was made on the project
Implications of Challenge if Not Corrected	Economic impact
2nd Greatest Challenge	Project management
Description of Challenge	Coordinating all the input provided by the team members.
Key Action to Overcome Challenge	Integrated delivery approach.
Outcome as Result of Challenge	

Project Site	Mary Switzer Building (Phase II) Washington, D.C.
Implications of Challenge if Not Corrected	

Project Site	Suitland Federal Office Complex Suitland, MD
Utility	Pepco
Funding Source	BA54 Repair & Alterations
Greatest Challenge	Proper feasibility planning
Description of Challenge	No time allocated to perform a proper feasibility study to determine a location to install the system
Key Action to Overcome Challenge	Persistence
Outcome as Result of Challenge	Delay (project schedule negatively affected), Economic impact (project cost or economic return negatively affected)
Implications of Challenge if Not Corrected	A no-go decision would have been made on the project

APPENDIX E: GSA PV PROJECT CASE STUDIES

CASE STUDY 1: TERRY SANFORD FEDERAL BUILDING, SOUTHEAST SUNBELT REGION (REGION 4)

Facility name:	Terry Sanford Federal Building
Location:	Raleigh, North Carolina
Construction year:	1969
Size:	426,000 gsf; 10 floors
Construction style:	Reinforced concrete with aggregate masonry and glass
Roof:	Built-up roof with a gravel top; 5 years old at time of PV installation
Project funding:	American Recovery and Reinvestment Act (ARRA)
Project inception:	March 2010
Project completion:	November 2010
Project features:	2,302 Monocrystalline panels, each rated at 245 Watts, mounted to rack system with a 10 degree tilt
Considerations:	10 degree tilt angle selected to minimize wind uplift and ballasting requirements
PV area (m^2):	3,765
System capacity (kWp)	564 kW
Estimated energy output (kWh/year):	772,000 kWh/year
PV yield (kWh/kWp/year):	1,368
Impact:	Projected to offset 18% of the building's electric use
Warranty:	5 yrs for installation, 5 yrs for panel repair & replacement, 12 yrs for PV panel 90% power output, 25 years for PV panel 80% power output, 10 yrs for inverter (extended from standard 5-yr warranty), 15 yrs for racking system
Maintenance:	Not included in contract, but training was provided to existing building operations and maintenance team.
Incentive(s) and revenue for excess generation:	Net metering arrangement with utility to purchase excess generation at the utility's normal generation rate.
Utility rates:	The blended rate is approximately $0.075/kWh

PV array on the Old Post Office Warehouse adjoined to the Courthouse Building at the Terry Sanford Federal Building

PROJECT DESCRIPTION

The Terry Sanford Federal Building is a 10-story courthouse and office building with 426,000 gsf, located in Raleigh, North Carolina. The building was constructed in 1969 of reinforced concrete with an aggregate masonry and glass exterior. Adjacent to the courthouse is an old postal warehouse that is currently vacant.

In 2010, a 564 kW direct-current (dc) photovoltaic (PV) array was designed and constructed on the rooftop of the old post office. This project was funded by ARRA, with a budget of $3.2 Million. No federal, state, local, or utility incentives were applicable for this project. This large system was completed under budget, and the remaining funds were used to construct an additional 15 kW dc PV system on the carport in September 2011. The carport is located on the south side of the building and provides eight covered parking spaces for employees. This system uses monocrystalline panels manufactured by Suniva, rated at 235 watts each. The performance of this system is not included in this case study.

The post office warehouse has approximately 116,000 sq ft of open roof area, and was re-roofed about five years prior to the PV installation. Monocrystalline panels manufactured by Suniva were selected; 2,302 total panels were used, rated at 245 watts each. Monocrystalline panels typically have higher efficiencies compared to other types of photovoltaic panels, such as polycrystalline (multicrystalline) and amorphous.

The system was designed with several strings connected in parallel, feeding a 500 kW inverter manufactured by Advanced Energy. The panels are mounted to a rack system manufactured by SunLink, with a 10 degree tilt. The system is ballasted, and requires no roof penetrations. Per the design, it was estimated to produce approximately 772 MWh/yr.

During the installation of the PV system, the site was only minimally impacted. Two parking spaces had to be relocated due to construction. Storage space for construction equipment and inventory was readily available in the vacant post office warehouse.

This PV system was contracted as design-build project delivery, a method which reduced the number of contractors for GSA, expedited the schedule, and reduced owner risk. The primary contractor responsible for the design and construction, as well as managing all subcontractors for the project, was Standard Solar. The project schedule was as follows:

- Solicitation – March 2010
- Project awarded and kick off – August 2010
- Estimated completion – December 2010
- Substantial completion and operation – November 2010

Several factors contributed to the early completion of this project. For example, good project planning and involvement from all stakeholders early in the project allowed the project team to anticipate issues and allot extra time for resolution. Good participation from onsite building management and the operations and maintenance (O&M) team contributed to easy resolution of logistics and site access issues.

PROJECT CHALLENGES

The original design called for a 235-watt monocrystalline panel manufactured by Sharp. However, product availability proved to be a challenge and jeopardized the project schedule. The project team worked together to find a similar product, made by Suniva, to meet project goals and remain on schedule.

Project leaders experienced challenges with the utility (Progress Energy) when developing the contract language for the interconnection agreement. Valuable time was spent participating in negotiations, which put the project schedule at risk. However, through persistence and good communication, both parties were able to come to an agreement without any significant impact on the schedule.

In addition, the time required for contractors to obtain security clearances took longer than expected and threatened the project schedule. However, the project team was able to work with the contractors to coordinate escorts while the necessary personnel obtained clearances.

PERFORMANCE

Overall, the rooftop PV system has performed close to projections. The actual annual production in 2011 was 765 MWh, compared with 772 MWh predicted production. The system has a real-time monitoring website (through Locus Energy) with good graphics and reporting, which allows site staff to monitor performance and respond to any alarms that may occur.

Since project inception, a few problems with performance have occurred but have been resolved. In July 2011, an inverter ground fault caused the system to go down for three days. This problem was covered under the inverter warranty and was resolved by the manufacturer. Also in July 2011, 25 modules were damaged by flying debris from strong winds caused by a tornado nearby. However, the contractor supplied an excess panel stock of 1% of total panels as part of the contract requirements, which allowed for replacement of damaged panels. In August 2011, some electrical wires were observed to be damaged, but the installer replaced the damaged components under the five-year installation warranty. Lastly, in June 2012, there was a component failure in a logic board within the inverter, causing the system to go down for 18 days. The inverter manufacturer replaced the failed component under the warranty.

O&M

As part of the contract requirements, the contractor held training for the owner and staff at substantial completion of the project. In addition, the contractor compiled an O&M manual and provided it to site staff. No O&M issues have been reported that were not covered under the installation warranty.

COMMISSIONING

A 3rd Party commissioning agent (CxA) was hired and integrated into the project team at the beginning of design. The CxA reviewed submittals and conducted functional testing to ensure that the system was installed and operating as intended in the design.

LESSONS LEARNED

Several lessons were learned from this project including:

- ARRA funds required extra reporting requirements, and a large effort to work in a timely manner.
- Plan extra time for contractors to obtain security clearances.
- Work with the utility early on the interconnection agreement to avoid schedule delays.

GOOD PRACTICES

This project employed several good practices that led to its successful completion ahead of schedule and under budget, including:

- Design-build project delivery reduces risk and expedites schedule.
- Involve all stakeholders as early as possible, including the design team, installers, property managers, building managers, utility, and other.
- It is important to involve property managers when coordinating logistics, to allow weekend deliveries, site access, etc.

- Good teamwork and commitment from the project manager, contracting officer, and contracting officer's representative was critical to project success.
- Project team was flexible and collaborated to resolve issues when the original panel was unavailable. By quickly finding a comparable product, they avoided schedule delays.
- Use proven technologies that have multiple vendors/manufacturers.
- Consult roof manufacturer to confirm that PV installation does not void warranty and ensure that system is installed on a roof that is in good condition and has at least 20 years of lifetime left.
- Be creative with site planning to avoid occupant disruption during construction, such as storing equipment in vacant spaces.
- Request warranties on all equipment and services.

CONCLUSION

Overall this project was very successful, and it represented the first major PV project for GSA in the southeast. It received lots of positive press, including an article in May 2011 in Solar Today. It was also presented at the Renewable Energy Conference in February 2011. The success of this project created a lot of internal excitement and momentum for future PV projects.

CASE STUDY 2: SENATOR PAUL SIMON FEDERAL BUILDING, GREAT LAKES REGION (REGION 5)

Facility name:	Senator Paul Simon Federal Building
Location:	Carbondale, Illinois
Construction year:	1978
Size:	39,000 gsf; three floors
Construction style:	Reinforced concrete designed with visible solar roof; three modules inter-connected by a multi-level ramped corridor system in lieu of an elevator
Roof:	42 degree "shed-roofed" sections oriented for solar collection at building's latitude
Project funding:	American Recovery and Reinvestment Act (ARRA)
Project inception:	October 2010
Project completion:	October 2011
Project features:	Originally solar-thermal demonstration project. 495 mono- and multi-crystalline panels, implemented with new R50 roof, data acquisition system, weather station, and lobby display
Considerations:	Presume tilt at 42 degrees equal to latitude, no structural or tenant disruption concerns
PV area (m^2):	727
PV system capacity(kWp):	101.475 kW
Estimated energy output (kWh/year):	129,688 kWh/year
PV yield (kWh/kWp/year)	1,278
Impact:	Generated 27.1% more electricity than the building used in 2011, and sold excess to the local utility
Warranty:	20 year
Maintenance:	3 year
Incentive(s) and revenue for excess generation:	Registered with FERC as Qualified Facility; originally sold power at fixed rate; switched to variable rate in September 2012
Utility rates:	Real Time Pricing

The Senator Paul Simon Federal Building in Carbondale, Illinois

PROJECT DESCRIPTION

The Simon Federal Building is a three-story 39,000 gsf concrete structure originally designed and constructed as a solar-thermal demonstration project in 1978. As part of its original design, it has three 42 degree angle “shed-roofed” sections for solar collection ideally oriented at the building’s latitude.

Although the Simon building was designed to be a solar energy collector test building, the use of that technology did not result in energy savings. Sandia National Laboratory studied the solar collector system in the 1990’s and recommended replacing it with gas-fired boilers and electric chillers, which was accomplished shortly thereafter.

Since the building was designed as a solar demonstration project and its architectural expression would be lost if a traditional roof were installed, the decision was made to install a new photovoltaic roof when the roof began to fail. In October 2010, the Simon Federal Building received a new R50 roof and 100kW photovoltaic system, including a data acquisition system, weather station, lobby display, 3 year maintenance agreement, and 20 year warranty, as part of a $1.8 million ARRA project. Advanced metering was also installed with ARRA funding.

PROJECT CHALLENGES

Because the building’s PV system is fully visible from street level, the appearance of the project was just as significant as its engineering. Given its esthetic constraints, the size of the PV system was influenced by the building’s initial design for solar demonstration and the understanding that excess power would be sold back to the utility company. In its 2004 analysis of the PV potential, the Department of Energy (DOE) concluded that excess electric generation would occur and would need to be sold, based on assumptions for the hypothetical system that formed the original concept for the present design.

Opportunities and limitations presented by the local utility rate structure significantly impacted the financial viability of this project. The local utility company, Ameren, allowed a maximum system capacity of 40 kWh for net metering, and the Simon system capacity is about 100 kWh. So, in order to avoid restrictions on size under Ameren's net metering rider, GSA registered the Simon Federal Building as a Qualified Facility with the Federal Energy Regulatory Commission (FERC). As a Qualified Facility, the Simon Building (GSA) may sell energy to the utility company at either the utility company's avoided (wholesale) cost or at a negotiated rate, and may purchase additional services from the utility company, such as back-up power.

In the first year after the project was completed, GSA purchased and sold power according to a rate structure with separate on-peak and off-peak prices under summer and winter rates, but in September 2012 converted to a "real time pricing" electric rate. Under this pricing structure, GSA pays a variable hourly price that fluctuates based on the electric market, so GSA's cost at any given time more closely matches the wholesale price of electricity. After collecting a few months of data under the variable hourly rates, GSA has found this alternative more beneficial, realizing a reduction of 42% in electric costs compared with the same period in the previous year. GSA's electric costs for this 40,000 gsf federal building are comparable to those for a midsize residence.

PERFORMANCE

The new photovoltaic array has been highly successful. Energy consumption was reduced by almost 12% from the time the PV system was completed in October 2010 through March 2011.

There have been many times when the output of this building's PV system has exceeded the electrical needs of the building. During fiscal year 2011, the photovoltaic panels produced 129,688 kWh of electricity (442,512,426 BTUs). Of this generation, 94,499 kWh was used onsite and the remaining 35,189 kWh, comprising 27.1% of the total electricity produced, was sold to the utility company and did not contribute to the building's energy intensity reduction goals. The 27.1% did, however, contribute to GSA's renewable energy obligations under EPAct, Energy Independence and Security Act of 2007 and E.O. 13423.

O&M

The specification for the PV system required an initial operations and maintenance service agreement with a minimum three-year term. The O&M agreement covered all solar array equipment, inverters and other components needed to maintain total system operation. The government reserved the right to extend the O&M agreement beyond the initial three years.

COMMISSIONING

The specification for the PV system required a Data Analysis System, including a DSL service line and initial one-year basic service contract. Without this system, it would be difficult to determine when a fault develops in a particular photovoltaic panel.

LESSONS LEARNED

- Start negotiating the interconnection agreement between GSA and the utility company during design, as it could take months. Even with the full support of the local utility company, it is very important to start working on the various agreements related to interconnection early enough so that the utility company lawyers and the government lawyers have enough time to agree on specific wording.

- Electric utilities may have little experience with PV. Some electrical utilities don't have a lot of experience with the design/equipment requirements, schedule priorities, interconnection agreement associated with purchasing solar power. The utility company should be consulted during the design to be sure correct equipment is included in the contract documents.
- Understand the local utility rates early in the PV project process, in order to select the most advantageous rate structure.
- Learn about local policy and the options available. For example, after GSA learned that the PV system would be too large for the utility company's net metering program, registering the facility with FERC paved the way for GSA's being able to sell electricity back to the utility.

GOOD PRACTICES

- Specify a long-term guarantee. The specification for the PV system required a warranty which provided that the system would continue to be capable of meeting a minimum of 80% of the intended DC output / capacity for a period of no less than 20 years. This action is a good practice because GSA would want the photovoltaic system to last as long as the roof it is installed on.
- Fully engage the utility. The local utility was engaged and specifically involved in the joint design, development and commissioning of the interconnection and other utility-specific project components. This action enabled the team to avoid the delays and extra costs that would have been incurred if the completed system failed to meet the interconnection requirements of the local utility company.
- During construction, the team should invite the utility to coordination meetings, in lieu of communicating only by phone. Have utility company identify one person as their competent project contact in lieu of multiple people, to ensure accountability.
- Specify an extended warranty. The requirement that a minimum three-year initial operations and maintenance service agreement be included in the contract should be recognized as a good practice because remote locations such as Carbondale, Illinois are not likely to have an abundant supply of maintenance workers skilled in photovoltaic systems.

CONCLUSION

This project illustrates the need to understand the local utility rates early in the PV project process. Switching to real time pricing has proven to be a smart move for GSA. Electricity costs less during the winter, but since it's darker outside at that time of year, more electric power is needed for lighting. During the summer, electricity costs more and is needed to power air conditioning, but since there's more sunlight than there is during the winter, the PV system is producing more power, which offsets the higher electricity costs.

CASE STUDY 3: MAJOR GENERAL EMMETT J. BEAN FEDERAL CENTER, GREAT LAKES REGION (REGION 5)

Facility name:	Major General Emmett J. Bean Federal Center
Location:	Lawrence, Indiana
Construction year:	1953
Size:	1.6 million gsf; three floors
Construction style:	Concrete frame with brick and stone exterior walls
Roof:	Flat reinforced concrete roof and wide column spacing beneath the roof
Project funding:	American Recovery and Reinvestment Act (ARRA)
Project inception:	July 2009
Project completion:	April 2011
Project features:	2MW system with 6,152 high-efficiency crystalline panels, implemented in conjunction with new R50 roof Plus a PV lab with 148 panels, using four different technologies being monitored by New Mexico State University under contract to Sandia National Laboratory: four additional 3kW PV systems, data acquisition system, weather station, two different types of solar thermal collectors, two lobby displays
Considerations:	Due to concerns over the cost, complexity and potential tenant disruption that adding structural support would entail, the tilt of the panels was set at only 5 degrees.
PV area (m^2):	19,510
PV system capacity (kWp)	1,956 kW
Estimated energy output (kWh/year):	2,290,231 kWh
PV yield (kWh/kWp/year):	1,171
Impact:	Projected to offset 7% percent of building's electric use
Warranty:	25 years for PV panels, 20 years for inverters PV Lab – There is a 10 year material workmanship warranty and a 25 year output warranty.

Maintenance:	Undetermined
Incentive(s) and revenue for excess generation:	Indianapolis Power and Light's (IPL) Rate Renewable Energy Production incentive – IPL buys excess production, including SRECs, at $0.204 per kWh
Utility rates:	$0.0207 per kWh; $10.57 per peak kW

PV system on the Bean Federal Center roof

PV laboratory with four different technologies on the Bean Federal Center roof

PROJECT DESCRIPTION

The Bean Federal Center is a three-story, 1.6 million gsf concrete, brick and stone structure built in 1953 as part of the former Fort Benjamin Harrison. The building has a flat roof with wide column spacing beneath the roof.

In late April 2011, the Bean Federal Center received a new R50 roof with 6,152 photovoltaic panels comprising a 2MW system; each panel is 318 Watts and 3 ft by 5 ft in size. An additional 148 panels were installed in a PV laboratory with four 3kw PV systems, a data acquisition system and a weather station. The project included two different types of solar thermal collectors as well as two lobby displays which are used to communicate the system performance and output to building occupants. The PV laboratory is being monitored by New Mexico State University under contract to Sandia National Laboratory, to gather data about the efficiency of different types of photovoltaic panels in a Midwestern climate. GSA will benefit from the knowledge gained from this study, when implementing projects in the future. The project was funded by ARRA and is expected to offset 7% percent of the building's electric use.

GSA could have kept the existing roof for an additional five years, but eventually would have needed to remove and reinstall the PV system when the roof was replaced, so roof replacement was part of the PV project. Approximately 280,000 square feet of roof was replaced as part of the project; this represents 61% of the total roof and is approximately the southern three-fifths of the roof. The new PV panels cover most of the new roof area, minus stand-off distances from the edge of the roof, walking aisles between array sections, areas where panels were not installed because of shadow lines from the penthouse structures on the roof, and the PV lab area at southeast corner of the roof.

PROJECT CHALLENGES

The roof was not strong enough to support the PV panels at their optimal angle. Providing additional structural support would not only have been costly, it also would have been very disruptive to the tenants. Due to concerns over the cost, complexity and potential tenant disruption, the tilt of the PV panels is only 5 degrees.

Opportunities and limitations presented by the local utility rate structure significantly impacted the financial viability of this project. The cost of electricity for the Bean Federal Center in Indianapolis is among the lowest in the country. According to the Institute for Energy Research, http://www.instituteforenergyresearch.org/states/indiana/, this is primarily attributable to the state's 93.1% reliance on coal.

The Bean Federal Center is on the Indianapolis Power and Light (IPL) industrial rate HL. Under this rate, demand is $10.57 per peak kW and energy is $0.0207 per kWh. This low kWh rate would have made the PV project unattractive, but GSA was able to take advantage of IPL's Rate REP (Renewable Energy Production), under which IPL would buy solar generated electricity from GSA at $0.20 per kWh, provided GSA sold IPL the Renewable Energy Credits (REC) along with the power. To ensure GSA received credit for the renewable energy production under EPAct and E.O. 13423, the SRECs (Solar Renewable Energy Credits) that GSA sold could be offset by following the DOE's REC Swap procedures and purchasing less expensive RECs from landfill gases.

The utility company, IPL, provides meters to measure the power generated by the system. This includes a "net" meter that is capable of giving GSA 'credit' for the power produced by the system. GSA installed a similar net meter to determine the amount of power both generated and sold back to IPL. GSA will be able to use this information in various ways, such as modeling future building power production and use, to determine optimal operations performance.

PERFORMANCE

During the first full fiscal year of operation, the PV system reduced electricity costs by 25%, or approximately $500,000.

O&M

The maintenance of the PV system is provided by both the installer and the O & M contractor at the facility. Portions of the main equipment, including the system transformers and inverters, are under a 20 year warranty which includes annual testing and maintenance by the installer.

The O & M contractor for the Bean Federal Center is under contract to provide more general maintenance for the panels and the associated connector boxes within the system, including panel cleaning and visual inspection. This routine maintenance entails a small cost in relationship to overall O & M costs for the building.

COMMISSIONING

The commissioning company was Sebesta Blomberg, which was contracted under a separate contract with ARRA funds.

The Building Automation System (BAS) is able to collect data from the PV inverters and from the DOE data acquisition system.

LESSONS LEARNED

- Weigh the cost and benefits of an early roof replacement versus installing PV on an existing roof.
- Carefully coordinate PV installation with the roofing contractor and installer so that roofing membrane warranties are not voided by putting solar equipment on a roof. Obtain letters/directions on protection of the roof and its warranties.
- Ideally, address all safety and health concerns during the pre-planning stage. Safety and health issues were discussed prior to issuing the Notice To Proceed, and the GSA Occupational Safety and Health (OSH) Team was able to partner with the contractor's OSH Team and agree on solutions (sometimes unconventional ones) to significant potential problems, e.g., fall protection, debris removal, crane/helicopter lifting procedures, tenant impact, electrical shutdown and switchover. This partnership increased project efficiency and reduced the time required for specific tasks.
- Get commitment from suppliers. The standard solar industry procurement process uses a "solar integration" company that designs, procures and installs the PV system. As a result, solar suppliers generally will not communicate directly with the A/E regarding design, costs,

lead times, etc. It may be necessary for GSA and the A/E to visit solar supplier manufacturing facilities together to gain commitments from suppliers, prior to completing 100% construction documents. In some cases, the supplier may require a fee from the construction contractor to "manage" the solar panel installation process in an oversight role, as a prerequisite to their commitment.

- Anticipate delays in supplier shop drawings. Solar companies might not commit to a schedule for shop drawings. Because they like to do their own layouts, regardless of what the A/E provides in the drawings, they might not read the A/E specifications and therefore, may not provide the correct submittal information. During the bidding process, the project team needs to communicate with the supplier in detail about the project requirements, and include enough time in the schedule for shop drawing submission, revision and approval.
- Allow ample time for product delivery. Solar companies will not always commit to a schedule for manufacturing and delivery of panels at the time they bid on a project. Be sure to add an appropriate amount of time for panel fabrication and delivery into the project schedule. At the Bean Federal Center, solar companies would not provide delivery dates until after the contract was signed, and then refused to commit on an actual delivery date until 30 days before delivery.
- Order additional panels at bid time to replace panels broken in shipment, because replacement panels are not rushed through manufacturing and it may take months to get replacements.
- Solar suppliers may not be forthcoming regarding warranty information. Solar suppliers initially refused to provide the A/E required warranties.
- Solar panel suppliers will not reveal their quality procedures. The solar panel suppliers may not want the team to visit their manufacturing site and review their plant quality control procedures; they were worried about confidentiality issues. Possible solutions include having the A/E include in the specification in a clear manner the requirement of inviting the team to visit the solar manufacturing site during production to review quality control procedures and having GSA and the A/E visit the solar manufacturing site during design to determine whether the solar supplier will be invited to bid on the project.
- Anticipate delays due to GSA IT equipment scanning requirements. The A/E and contractor need to be aware that GSA's Office of Chief Information Officer (OCIO) requires scanning all equipment to be connected to the GSA network. During design, the A/E needs to understand exactly what equipment must be scanned by GSA and the time requirements. Request a project lead at OCIO so the team does not have to coordinate with multiple people.
- Have a good temporary roof plan. Consider whether the A/E should specify and detail the temporary roof approach or whether it should be left to the roofing subcontractor's means and methods. Require the roofing bidders to submit a detailed temporary roof approach with their bids. Ensure there is a detailed plan in place for covering all open roof areas in

case of a surprise pop-up storm. Be sure the amount of temporary roof area is minimized at all times to mitigate leaks into the building during construction.

- Start early with lobby display graphics. If a lobby display will be part of the project, the design of the display screens should not wait until the end of the project.
- Installing solar panels in cold climates can delay the schedule. Considerations include safety issues of workers slipping on the roof, potential damage to panels and roof, and potential work stoppages. Possible solutions include having detailed work plans for solar panel installation in anticipation of snow and ice storms, and using a glycol system under blankets to melt thick ice. Note that an R-50 roof will not allow the heat from below to melt snow or ice on the roof.

GOOD PRACTICES

- Research all available incentives, rebates and special rates. Taking advantage of special rates, rebates, and incentives offered by the private sector is crucial for providing taxpayers with the greatest return-on-investment for capital intensive renewable energy projects. The research and negotiation that went into obtaining the Renewable Energy Purchase (REP) rate offered by the Indianapolis electric utility for the Bean Federal Center made this project far more economical than it would have been otherwise.
- Partner with other organizations. One of the most innovative parts of the Bean Federal Center project is the PV laboratory and partnership with the Department of Energy (DOE). These small test labs don't generate much energy, but they do provide invaluable data for analyzing different technologies in the Midwest climate.
- Have the contractor and subcontractors submit work plans that address how they plan to work around potential weather issues. For example, during re-roofing at the Bean Center, the contractor worked around rain days by working 12 hours every day it didn't rain, for a maximum of 14 days at a time. When installing solar panels there during the winter, the contractor worked overtime on weekends and developed a plan to shovel snow off the roof and melt ice buildup, to enable work to continue.
- Provide a leak detection system. The scope should provide for a leak detection system such as an Electric Field Vector Mapping (EFVM) system (about $0.16/sf) to ensure that the roof is 100% water tight. Such a system identifies leaks to a precise location, allows leaks to be found while roofing subcontractor is still on site or anytime afterward, and allows leaks to be found without destructive testing of installed materials.
- Utilize DOE. Try to involve DOE in the project from the beginning of design. DOE has great industry relationships and can facilitate communication with solar suppliers.

CONCLUSION

This project illustrates the need to understand the local utility rates and incentives such as Renewable Energy Credits (REC) early in the PV project process.

CASE STUDY 4: THIRTEEN SITES IN THE GREATER SOUTHWEST REGION (REGION 7)

Facility name:	Multiple sites throughout Region 7
Location:	Texas, New Mexico, Louisiana
Construction year:	Various
Size:	Ranges from a 44,000 gsf land port of entry to a 768,000 gsf high-rise building, and one ground installation
Construction style:	Generally, reinforced concrete with aggregate masonry and glass exterior
Roof:	Generally, built-up type or single ply membrane
Project funding:	Energy Savings Performance Contracts (ESPC) using American Recovery and Reinvestment Act (ARRA) Funds
Project inception:	July 2009
Project completion:	The last system was completed in October 2012.
Project features:	12 monocrystalline panel systems in Texas and New Mexico, and one amorphous, thin-film system in Louisiana. 12 are roof-mounted, one is ground-mounted.
Considerations:	Limitations of available roof surface or land area; limitations due to shading from other buildings
PV area (m^2):	11,200 total for all systems
PV system capacity (kWp):	1,535 kW
Estimated energy output (kWh/year):	2,181,000 kWh/year
PV yield (kWh/kWp/year):	1,420
Impact:	Significant reduction (offset) of electric consumption at the sites where the systems were installed. Double counting towards the region's target of electricity generated from renewables (due to being on-site).
Warranty:	25-year production warranty on the panels.
Maintenance:	Minimal, but performed by the local maintenance contractors.
Incentive(s) and revenue for excess generation:	None of the PV systems generate more electricity than the facility uses.
Utility rates:	Vary by facility from approximately $.09/kWh to $0.13/kWh

66 kW total, PV carports on the rooftop parking area of the Centre Phase Five Federal Building in Farmers Branch, Texas

131 kW PV array on the rooftop of the VA Automation Center, Austin, Texas

PROJECT DESCRIPTION

General Services Administration's (GSA's) Greater Southwest Region installed 13 photovoltaic (PV) systems between 2010 and 2012, using Energy Savings Performance Contracts (ESPC), which combined ARRA funds with third-party financed (borrowed) funds. The PV systems were all installed at facilities that had only ARRA funding. The borrowed funds were used to implement energy conservation measures in other buildings.

The PV systems were located in Texas, New Mexico, and Louisiana, with12 installed on rooftops, and one on the ground:

- Fort Worth, Texas (2 systems: ground mounted and roof top mounted)
- Farmers Branch, Texas (2 systems: roof top and carport mounted)
- Austin, Texas (2 systems: Pickle and Thornberry buildings)
- Austin, Texas (VA data center)
- Houma, Louisiana (thin film roof)
- Midland, Texas
- Gallup, NM
- Victoria, Texas
- Pharr, Texas
- Laredo, Texas

The 13 PV installations totaled 1,535 kW in peak capacity. Monocrystalline panels were selected for 12 of the 13 systems, and amorphous thin-film panels were selected for the site in Houma, Louisiana. The Louisiana project included the replacement of the old, deteriorated roof with a new R-50 "cool roof" with a white, reflective surface. Thin-film panels were selected in this case because they can be integrated into the roofing structure, and it makes the most sense to do this when installing a new roof.

The 12 rooftop systems ranged from a 44,000 gross square foot land port of entry (Texas/Mexico border station) to a 768,000 square foot high-rise federal office building. The largest system was installed as a ground-mounted system at the Fort Worth Federal Center, a multi-acre, multi-building complex measuring over 2 million gross square feet. That PV system was located in an open field area of the complex and did not displace any parking spaces. It is a monocrystalline panel installation with a capacity of 553 kW and more than 2,300 individual panels. The panels were mounted on steel structures tilted at the optimal angle to maximize sun exposure throughout the year.

One of the systems was integrated into new carport structures on the roof of a parking garage in Farmers Branch, Texas, a Dallas suburb. (See photo.) The carport configuration was chosen due to the additional benefit of providing shade for building tenants who park on the roof of the garage. In

North Texas, the interior of a parked vehicle can reach 140 degrees in full sun, so the carports provide a welcome relief from the heat.

FINANCING

GSA's Greater Southwest Region was the only region to successfully execute contracts utilizing third-party financing to fund its PV projects. ESPCs are a form of alternative financing that pay for themselves out of the financial savings they bring about through increased energy efficiency, water savings, and savings on maintenance and operations and other energy- and water-related costs. ESPCs are specifically authorized for use by federal agencies by federal law.

The Region used three energy service companies (ESCOs) to provide ESPC services: Siemens, Honeywell, and Schneider Electric. With projects spread across five states, each ESCO was assigned a bundled group of buildings in which to provide energy efficiency services, including work on building automation systems and advanced metering of utility use. As a small part of this work, Honeywell installed four PV systems and one wind turbine. Schneider Electric installed five PV systems, including one carport-mounted system and a large 553 kW ground-mounted PV system. Siemens installed four PV systems, one of which was a thin-film solar roof application in Louisiana, and two solar thermal (hot water) systems.

The scale of this work was possible mainly due to two approaches to use of ESPC financing: first, the careful use of ARRA funds to leverage investment in renewable energy; and second, the bundling of long payback renewable energy conservation measures (ECMs) with ECMs of much shorter payback. As a result, the Region's energy team was able to accomplish $68 million worth of work in a total of 75 buildings, instead of being confined to working only on the original 27 buildings covered by the $36.1 million ARRA budget assigned to the Region.

This Region's approach to expenditure of its ARRA program funding using ESPC contracts had several advantages. Combining ARRA appropriations with private financing leveraged and supplemented the appropriations. It provided one stop shopping for a complete energy efficiency and renewable energy solution. It generated a list of possible energy conservation measures that could be implemented in an expanded number of buildings. Also, because an ESPC is a design-build (with a performance guarantee) much of the project performance risk is allocated to the ESCO and not to the government. Finally, private financing can help overcome one of the most frequently encountered challenges of PV projects: the upfront system cost.

PROJECT CHALLENGES

Before utilizing ESPCs under the ARRA program to deploy PV projects, the Region needed GSA headquarters approval. Securing this approval was the greatest challenge, and the Region overcame it by arguing that ESPCs were a great fit for delivering these projects, as ESPCs are turn-key design/build and have guaranteed savings and measurement and verification built in.

Interconnection agreements with the local electric companies are required when installing PV systems, if they are connected to the electric grid, which all of these systems were. Net metering agreements are also required, when there is excess generation. With so many systems being installed in diverse locations, there were many utility companies to deal with in a relatively short period of time. This required close communication with both the utility companies and with the Region's legal office, to ensure that the language in the agreements protected the government and did not contain indemnification language with which GSA could not agree.

Another challenge encountered with the roof-mounted systems involved getting the installation contractors to install sufficient power disconnects, so as not to jeopardize the safety of firefighters responding to a roof or building fire. PV systems can remain energized (by the sun) even if the main power supply to a building is disconnected. The multiple electrical disconnects had to be carefully located to meet fire safety codes, as well as the interpretations of those codes by the GSA fire protection engineers.

The thin-film PV system installation in Louisiana was combined with a roof replacement, and there were problems with the new roof leaking that had to be corrected before the PV panels could be adhered to the roof. This delayed the project schedule.

PERFORMANCE

Overall, the output of the PV systems has been as expected, and close to projections. The systems were tied into the building automation system (BAS) in each building, which allows the Region to monitor the output on a daily basis, if desired.

O&M

All of the facilities where PV systems were installed have operations and maintenance (O&M) contractors to maintain and operate the facilities. Under the ESPC contract requirements, the contractor held training for the O&M contractors upon completion of construction of the project. In addition, the contractor compiled a set of O&M manuals and provided them to the site staff. Maintenance of the PV systems is minimal, and mostly involves periodic cleaning of the panels.

LESSONS LEARNED

The lessons learned were derived from successes, rather than from failures or issues. Some of the lessons learned from this project include:

- It is possible to manage three ESPC contractors working in multiple buildings and locations by holding weekly telephone conference calls with the contractors and the Region's energy team and project managers.
- Contact with the local utility to resolve interconnection agreements, net metering agreements and other technical issues should be commenced early and pursued vigorously, as these can take considerable time to finalize. ESPC contractors generally lack experience working with utilities on these matters and they and their subcontractors will often merely pass along to the agency any agreements provided to them by the utility company for signature by the building owner. In many cases these standard-form contracts will contain terms that federal agencies cannot agree to without modification, such as indemnification clauses, grants of rights of way, ownership of RECs, prices to be paid for excess generation, or other matters that may require Counsel's Office approval prior to signing.

- Some utilities require one line and wiring diagrams and site sketches showing proposed equipment locations.
- Consider fire safety and locations of disconnects during the design phase.
- Ensure good coordination between roofing installers and solar panel installers so as not to void roofing warranties.
- Carefully review the qualifications of solar system subcontractors for quality of work. It may be advisable to obtain past performance references for these subcontractors during the selection process. There is a wide range of ability and capability among solar system suppliers, even those approved by local utility companies as solar installers.
- Sizing and location of arrays is a primary design consideration. In planning for the size or production capacity of the system, prospective system production profiles should be compared to the electrical load profile of the site. Having access to historical building load information allows the best decisions to be made regarding PV array sizing and output, as well as selecting the site at which to install them.
- Appropriate system capacity can be limited by economic considerations, technical constraints, or state or local policies or rules. There may not be a rule in place, for example, requiring the utility to give customer credit for exported power. In such cases, it may be best to limit system size so that power r production in excess of site load is limited or avoided. This is because larger and larger systems are typically more expensive but provide a diminishing rate of savings as more and more production capacity is utilized to generate electricity in excess of building load, to be exported to the utility for no utility bill credit. On the other hand, even with rules granting customers credit for exported power, existing or projected utility distribution system loads, topologies, or electrical coordination schemes may limit or preclude export of electricity. Often, the serving utility will conduct a system impact study to determine these constraints and any utility system modifications (if available) that would be required to accommodate exported generation. The costs of studies and system modifications are usually payable by the customer on whose facilities the generation is to be installed.
- State or local rules or policies can constrain system capacity. A net metering rule, for example, may state that systems must be 2MW in nameplate capacity or less to qualify for the net metering program. If the site electric consumption is in excess of what a 2MW system could produce, net, but the site load profile is such that a 2MW system would sometimes produce electricity in excess of instantaneous load, the economically optimal system might appear to be larger than 2MW when only consumption is considered, but considering the uncompensated export of electricity without the benefit of a net metering policy, a system larger than 2MW may not be economically optimal; a smaller system might have better financial performance.
- Other design and installation considerations include setbacks from roof perimeters, angles of orientation, use of tracking or fixed arrays, access for firefighters, approach to monitoring for solar panel failure, and metering and monitoring of generation output. If, based on the

site electric load profile and tentative system size, the system can be expected to export power at all, the results of the utility system impact study or utility policies about export should be considered in determining what the actual system capacity will be.

- Studies for solar orientation, shading, and structural support of roofs on which panels may be located are additional inputs to system capacity planning. Consider all possibilities of shading from surrounding structures throughout the year, when locating the system. Shading will reduce the annual power output and can create power production imbalances or outages within sections of the array that are connected in series.
- Some consideration should also be given to possible future high-rise construction in the area that could shade a property. Some states' laws allow filing of "solar easements or rights of way" to proscribe interference by a neighboring property owner with the sunlight falling on one's own property. Such real property interests can be useful for protecting sunlight access for a solar system, usually a considerable investment that only pays for itself if it is producing energy.
- Utilities and political jurisdictions vary widely in their favorability to PV. Policies, rules, and technical considerations range from technical and administrative hurdles that can introduce considerable delay and uncertainty in project implementation, various restrictions on system capacity, and very low or no financial credit granted for energy exported to the utility distribution system to utilities with procedures and requirements based on accepted standards and best practices and that (usually with renewable portfolio standards) will pay a premium for excess renewable generation. In considering a location for PV or selecting from different possible locations, these requirements and procedures as well as available financial incentives should be investigated and considered, and care taken to utilize all such incentives.
- Once installed, solar panels do not generally require a great deal of O&M. They may on occasion need to be washed and cleaned depending on where they are installed. They should, of course, be commissioned by the contractor or a third-party when installed. The owner should verify that the represented power output of the panels is as it was represented, and that production does not deteriorate beyond accepted industry standards and norms in the ensuing years of operation.
- Periodic inspection after hail or wind storms may be appropriate to insure equipment has not been damaged. Most of these systems are designed to be out in the weather elements and exposed. Nevertheless, this will not protect them from catastrophic events, and engineers and system designers ought to confirm the panel and system wind uplift ratings, giving consideration to the climate where they will be installed.
- Birds roosting on some panels at southern locations necessitated additional cleaning during the migratory period.
- In one project, there were issues related to the structural integrity of the roof on which solar panels were to be located. To overcome this challenge, PV panels were chosen that had a lower weight per square foot than the average panel available.

- Concerns over the useful life of solar inverters were encountered, since the typical inverter warranty is 5 to 10 years, and for PV panels, it's usually 25 years, so there's a mismatch.
- In one state, the State Historical Preservation Officer informed the project teams that, for historic buildings, the PV panels were not allowed to be seen from the ground or from a distance. This required placing them away from the perimeter of the roof.
- Water was ponding on the one thin film roofing installation, which could have potentially caused deterioration of the thin film panels, creating leaks. The underlying roof had to be corrected before the project could be accepted.

GOOD PRACTICES

- The Region set a precedent for using ESPCs to deliver the PV systems. ESPC projects were delivered faster than traditional projects that are designed by one firm, advertised, and awarded to another firm for construction, because ESPCs are performance-based, design-build contracts, virtually eliminating change orders and shortening the time from inception to construction completion.
- ESPCs allowed bundling of PV systems with other, shorter payback energy conservation measures.
- Weekly coordination meetings between the ESPC contractor and the government allowed any potential issues or challenges to be raised and solved relatively quickly.
- An experienced "Energy Team" in the Region was formed to review and monitor all phases of the projects. The team embodied many disciplines, and included an energy engineer, equipment specialists, building automation specialists, and contracting officers.

CONCLUSION

Overall, the PV installations were very successful, and this region has the largest number of PV systems installed out of all eleven GSA Regions. Since the Greater Southwest Region is located in an area of the U.S. with some of the highest solar resources, it is well suited for PV system installations.

Overall, the use of an ESPC contract can be a valuable tool for advancing agency goals and objectives. Like any government contract, an ESPC must be carefully designed and managed to accomplish the objectives sought. The ESPC can provide "one-stop shopping", which can be easier than procuring many ECMs separately, but it can also have challenges. Many government contracting offices lack familiarity with this contracting vehicle. ESPCs also require a great deal of up-front work putting the agreements into place and working out the appropriate mix of ECMs.

ESPCs require careful oversight by the government because the potential complexity and number of items in the contract can permit excessive charges to go unnoticed. There are many bases for charges, including charges for the equipment and for labor, charges for overhead and profit, finder's fees for financing and interest charges, and costs for measurement and verification. These costs must be considered in light of the current cost of utilities, the escalation rate to be applied to the utilities rates to calculate savings as a basis of payments under the ESPC, and the term of the contract, which determines how long the agency will make ESPC payments on the basis of savings derived from the escalated current utility rates.

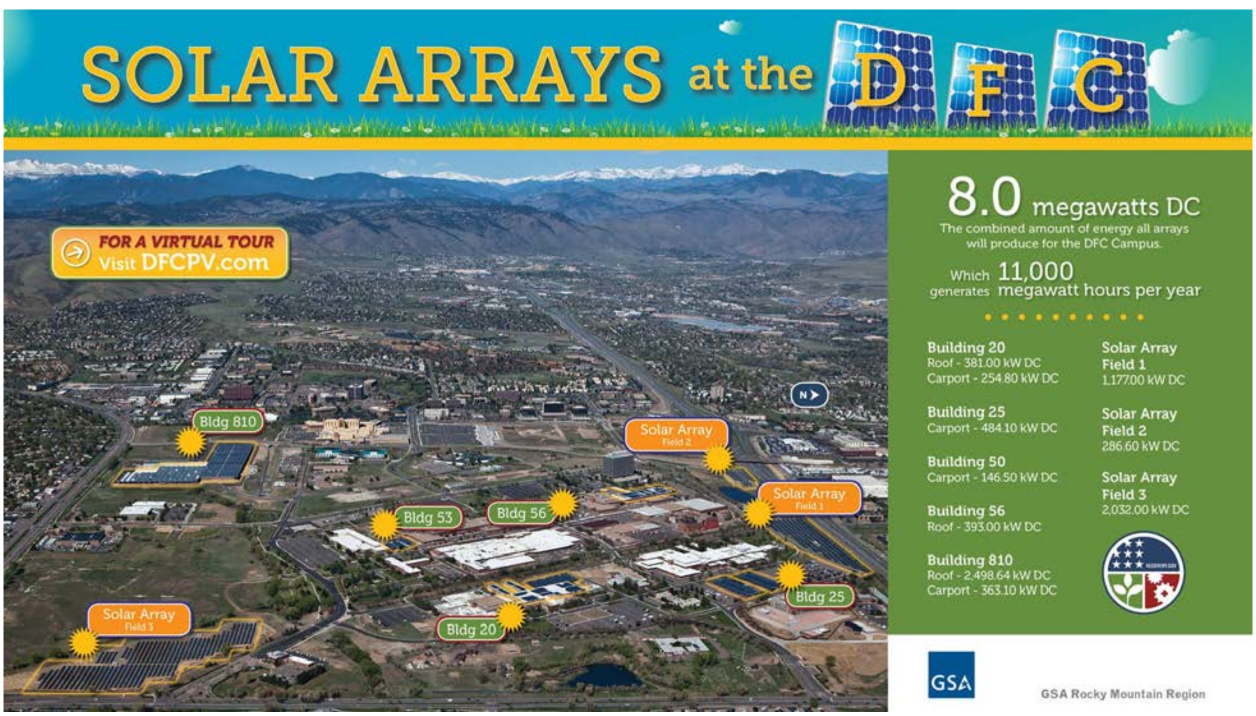
The appropriate allocation of various risks between the parties can also affect costs and should be worked out so as to balance meeting agency objectives while keeping costs reasonable. Despite these numerous considerations, current budget constraints make ESPC contracts a useful approach to replacing inefficient equipment and accomplishing needed work in our federal buildings.

The Region considered using power purchase agreements (PPAs) to fund some of the PV projects but there was insufficient time to address and resolve all the legal and contractual issues involved, given the urgent spending deadlines and short time frames for use of ARRA funds. The PPA approach to funding utilizes private financing and private ownership of the generation assets and uses the sale of electricity by the owning entity to recover invested capital and provide a return on investment to the owner. A PPA can provide additional economic value to a project by allowing for the capture of tax credits (for which GSA has no appetite) by the private owner entity. Some portion of the tax credits' value can be monetized in the form of a lower per kWh power purchase price to the government. It is recommended that, in the future, PPAs be considered for the economic and risk allocation benefits that they are capable of providing. This action must be carefully done in consultation with the ESCO and its tax counsel, and in light of OMB memorandums regarding PPAs.

CASE STUDY 5: DENVER FEDERAL CENTER: ROCKY MOUNTAIN REGION (REGION 8)

Facility name:	The Denver Federal Center (DFC)
Location:	Denver, Colorado
Construction year:	1941 – 1943
Size:	4 million gsf; 48 buildings in the complex Buildings B-20 & B-56: 2 flrs Building B-810: 1 floor
Construction style:	Concrete frame with concrete or brick and stone exterior walls
Roof: **(Also 3 ground arrays and 4 carport systems)**	Bldgs B-20 & B-56: Flat reinforced concrete roof and wide column spacing beneath the roof. B-810: Barrel roof on concrete frame with concrete exterior walls.
Project funding:	Phase1: GSA Energy Center appropriations Phases 2 & 3: American Recovery & Reinvestment Act (ARRA)
Project inception:	Phase 1: March 2007 on ground in a vacant field Phase 2: March 2010 on 3 building roofs Phase 3: January 2011 on 4 carport roofs & 2 fields
Project completion:	Phase 1: December 2007 on ground in a vacant field Phase 2: December 2010 on 3 building roofs Phase 3: August 2011 on 4 carport roofs and November 2011 in 2 more vacant fields
Project features:	Phase 1: 35,494 mono- and polycrystalline panels and 17 inverters feeding 2,641 combiner boxes with12 to 30 strings of 13 – 16 panels per string (PPS)
Considerations:	Due to logistic and tenant concerns, the azmith on various arrays varies from 90 to 270 degrees and the tilt varies from 5 to 25 degrees.
PV area (m^2):	Phase 1: 9,258 Phase 2: 23,811 Phase 3: 24,629
System capacity (kWp):	Phase 1: 1,176 kW Phase 2: 3,273 kW Phase 3: 3,567 kW TOTAL 8,016 kW

Estimated energy output (kWh/year):	10,970,000 kWh/year
PV yield (kWh/kWp/year):	1.3685
Impact:	Offsets 17% of the complex's electric use.
Warranty:	25 years for PV panels, 10 years for inverters and a 20 year output warranty allowing a 1% per year diminishment
Maintenance:	Performed by the site high voltage electrical contractor.
Incentive(s) and revenue for excess generation:	The Region sold RECs for Phase 1 to get to a SIR of 1, and it is strictly net metering for Phase 2 and 3.
Utility rates:	$0.06 per kWh, $12.10 per peak kW The blended rate is approximately $0.075/kWh.
Collaboration:	The National Renewable Energy Laboratory (NREL) is using the site for a year-long study.



Aerial view of the Denver Federal Center photovoltaic installations

PROJECT DESCRIPTION

As the largest federal complex outside of Washington, DC, the Denver Federal Center (DFC) encompasses nearly one square mile at the gateway to the Rocky Mountains. The DFC includes 48 active buildings that house 6,000 federal tenants from 28 different agencies and bureaus. In total, the campus represents nearly four million rentable square feet of office, laboratory and warehouse space. Most of the buildings were constructed in 1941 for the Denver Ordnance Plant that produced ammunition in support of World War II. For the past 68 years, the DFC has been used by numerous federal agencies.

To comply with federal legislation regarding on-site production of renewable energy, the DFC has installed eight megawatts (MW) of direct current (DC) photovoltaic (PV) panels on building and carport roofs, and in three vacant fields on the campus. The first 1.176 MW PV array, installed in Field One, began producing power in December 2007. The second project phase included 3.567MW in installments on the roofs of three buildings: B-20, B-56 and B-810, and came online in December 2010. The last phase included 1.248 MW of PV arrays on the roofs of four carports in the parking lots of buildings B-20, B25, B-50/53 and B-810, and came online in August 2011. This phase also included 2.3 MW of arrays in two more vacant fields, Field Two and Field Three, which came online in November 2011.

The DFC has a net metering agreement with XCEL Energy. All of the DFC PV systems, except the B-50 and B-810 carports, are connected to the campus-wide 13,800 KVA medium voltage system. The B-50 and B-810 carports are connected directly to their respective buildings' 480 voltage systems. For redundancy and maintenance, the site has two electrical power feeds – an X and a Y feed – with three legs on each. Usually, half the complex's 48 buildings run on each feed, but all buildings can be run on one feed if the other one is down for maintenance.

All of the DFC PV systems have ion-based advanced metering systems (AMS) and a web-based production diagnostic and monitoring system which generates text or email message alarms, should any part of the 35,494 panel system fail. The diagnostic and monitoring system is critical because of the system's large size – 17 inverters feeding 2,641 combiner boxes which have from 12 to 30 strings with13 to 16 panels per string. It is possible that with a system this large, a portion of the site could fail without it becoming readily apparent on an AMS. The public-facing portion of the diagnostics and monitoring web site (www.DFCPV.com) has three live camera views and a virtual tour. The site can be monitored remotely using any computer or a Blackberry, Android or iPad app.

PROJECT CHALLENGES

The biggest challenge was coordinating the logistics with several other large projects that were underway at the same time at the DFC complex, especially for the installations on the four large carports. While the photovoltaic project was underway, the DFC had ongoing projects to replace most of the underground infrastructure, install a light rail station, and construct a large new data center. Parking lots and roads were closed as the projects progressed, requiring extensive communication with DFC tenants and between project managers.

PERFORMANCE

Following completion of each phase, the systems performed as predicted by PV Watt software developed by the National Renewable Energy Laboratory (NREL) in Golden, Colorado. The PV systems produce approximately 17% of the electricity that the DFC consumes: production is about 11 gigawatts per year, and campus consumption is 65 gigawatts per year. The DC peak equals about 40% of the DFC's kilowatt (kW) peak. On weekends, when there is a lower energy demand at the complex and the system is generating more energy than is needed, two or three of the legs on one of the feeds spin backwards, sending energy back to the utility. The system sends power back at the same rate the complex pays for it, which is a better deal than most net metering agreements.

O&M

The O&M for the DFC PV system was incorporated into the contract for maintaining the overall DFC electrical infrastructure. The O&M contractor is responsible for normal maintenance of the inverters, transformers, and so on, as well as responding to system generated alarms when a device fails.

COMMISSIONING

A third-party commissioning agent (CxA) conducted a complete performance verification commissioning of the entire system.

LESSONS LEARNED

- Start communication with the local utility company as soon as possible to ensure a net metering or other agreement is approved and documented before award.
- Pick suppliers that have solid financial footings. The inverter supplier (Satcon) filed for bankruptcy during our project. The phase one panel supplier (Evergreen) went out of business two years after completion of the first phase.
- Carports with slopes as low as 5° still need a snow bar to prevent snow from sliding off the PV panels in large clumps. Most production occurs during the long days of warmer weather in Colorado anyway.

GOOD PRACTICES

- For large systems, install a monitoring system that will generate alarms so that problems can be identified and corrected as soon as possible.
- For ground arrays, keep the lowest point at least two feet above ground level so any plant life or snow build-up will not shade the panels.
- Install bird guards on any lights installed under carports.
- Areas where many large birds congregate, such as wharfs, are probably not the best locations for solar panels.

CASE STUDY 6: SUITLAND FEDERAL CENTER, NATIONAL CAPITAL REGION (REGION 11)

Facility name:	National Oceanic and Atmospheric Administration (NOAA), Suitland Federal Center
Location:	Suitland, Maryland
Construction year:	2000
Construction style:	The PV system was mounted on a steel structure on the ground.
Project funding:	Appropriations
Project completion:	2000
PV system failed:	2002
Project features:	The ground-mounted photovoltaic system consisted of 2800 43-Watt Solarex Millennia (MST-43MV), thin film panels, a 100 kW inverter, and a 112.5 kVA 208-480 Volt transformer.
Considerations:	Unknown
PV area (m^2):	Spread out over 7500 m^2
PV system capacity(kWp):	100 kW
Estimated energy output (kWh/year):	Unknown
PV yield (kWh/kWp/year):	Unknown
Impact:	Unknown
Warranty:	Warranty for equipment, unknown; warranty for installer's workmanship, one year
Maintenance:	Unknown
Incentive(s) and revenue for excess generation:	Unknown
Utility rates:	Unknown

Ground-mounted PV installation at the NOAA Building at the Suitland Federal Center

PROJECT DESCRIPTION

This case study describes a ground-mounted photovoltaic system that failed two years after it was installed. It was a 100kW system, intended as a demonstration project, installed on the grounds of the National Oceanic and Atmospheric Administration (NOAA) Building at the Suitland Federal Center in Maryland. The system was comprised of 2800 thin film panels mounted at a fixed tilt angle of 30 degrees and supported by a steel structure. The life cycle design of the system was 25 years.

The output of the transformer (480 Volt winding) was tied into the electric distribution system of the former heating and cooling plant for the Suitland Federal Center, and any energy produced by the PV system would have offset some of the load demand of the plant. However, approximately two years after the PV system was installed, it failed.

In 2012, after the system had been non-functional for approximately 10 years, additional funding was obtained to attempt to bring it back online. The output feeder circuit was rerouted from the abandoned heating and cooling plant and rewired into the electric distribution system of the NOAA Satellite Operations Facility, approximately 800 feet to the east of the PV array.

After the restoration efforts were underway, it was discovered that the panels were defective and almost all of the 2800 panels were severely delaminating. The manufacturer provided 100 replacement panels and then refused to provide any more; shortly thereafter, the company was reported to have gone out of business.

GSA abandoned restoration efforts and subsequently, funding became available under ARRA to remove the old system and install a new, advanced 333kW system on the same footprint as the former system.

PROJECT CHALLENGES

Why the system went off-line 10 years ago is not known, as sources which provided the data on the system have since retired from GSA. However, ownership over the 25-year life cycle was never effectively established.

PERFORMANCE

Data on the system's performance is unavailable.

O&M

O&M information is unavailable.

COMMISSIONING

Commissioning information is unavailable.

LESSONS LEARNED

- Successful life cycle management of solar photovoltaic systems starts by establishing and clarifying internal and external O&M responsibilities. Successful PV investments are not simply the result of hiring a contractor to perform O&M and then expecting the system to deliver a return on investment over the next 25 years.
- Internal responsibilities include managing and tracking performance data after base-lining the performance of the system's individual strings, which is done during commissioning. This will provide the primary data for tracking the performance degradation of the panels during the system's life cycle, and establish a clean baseline for any future warranty claims that may arise.
- The SOW for the O&M contractor should include, at a minimum:
    - Annual sweeps of the strings through I-V curve tracing, providing the data back to the owner
    - Thermal imaging of all electrical connections
    - Panel cleaning
    - Inverter inspections and diagnostics
    - Metering and monitoring (shared between the owner and the O&M contractor)
    - Filter cleaning for inverters equipped with cooling fans
    - System repairs

GOOD PRACTICES

- Implement an internal life cycle management action plan, with responsibilities assigned that assure base-lining of the system strings, monitoring performance of the panels, and managing the system warranty.

- Capture data about system performance and store it in a GSA database. Perform a comparative analysis against the previous baseline each time an annual or biannual baseline/I-V curve trace is performed. This is essential to successfully managing the warranty and tracking performance of system components, specifically the panels.
- Consider using a contracting venue such as a power purchase agreement (PPA), in which case the system's performance rests on the shoulders of the PV contractor. In order to protect their investments, contractors will perform life cycle management functions themselves because, after all, they only get paid for the energy that they deliver, so it's in their best interest.

CONCLUSION

This case study demonstrates the need for the system owner to have a good life cycle management plan in place. PV systems require continual monitoring for optimal performance.

APPENDIX F: GSA PV PROJECT LESSONS LEARNED AND GOOD PRACTICES

Lessons learned and good practices recommended by GSA project team members are listed here, so that future PV project implementers might benefit from the knowledge gained from these projects. They are organized by the top five challenge categories established by the NREL survey, beginning with the category where the greatest number of challenges occurred: project management, site, interconnection, technical and economic. Challenges that fell into other survey categories have been folded into the top five categories, wherever they fit best. These challenges include weather, lack of expertise, procurement, state or local laws and regulations, net metering, other utility issues, conflicts with agency or site mission, and incentives.

PROJECT MANAGEMENT

LESSONS LEARNED

- **Conduct due diligence and feasibility study early in the planning process for PV project,** covering site characteristics, policy landscape, interconnection agreements, and utility rates.
- **Form an integrated GSA project team early in the planning process.** The team should be capable of addressing technical and other potential issues that may be encountered. Key internal team members would include an architect, engineer, lawyer, contracting officer, estimator, energy expert, facility manager, and executive level champion. It is important to define roles and have a clear communication plan in place early in the process.
- **Notify state and local entities of the project early.** During the project planning phase, the team should notify state and local entities that will have an interest in the project, including inspectors, the fire department, etc., because they may have specific requirements such as setbacks and/or disconnects, among others. For example, the Denver Federal Center was under a state compliance order, which increased the cost and effort associated with the digging involved in locating PV systems in open fields.
- **Address safety and health concerns early.** Ideally, address all safety and health concerns during the pre-planning stage. For the Bean Center project in Indiana, safety and health issues were discussed prior to issuing the Notice To Proceed, and the GSA Occupational Safety and Health (OSH) Team was able to partner with the contractor's OSH Team and agree on solutions (sometimes unconventional ones) to significant potential problems, e.g., fall protection, debris removal, crane/helicopter lifting procedures, tenant impact, electrical shutdown and switchover. This partnership increased project efficiency and reduced the time required for specific tasks.
- **Ensure that property managers are properly trained on O&M procedures for PV systems that are owned by GSA.** Introduce the property management staff to the PV system early, during the design phase, and make sure they receive training and operating manuals. They will need to know how to keep the system clean (from bird residue, for example) and generally understand how to properly maintain the system.
- **Complete the design and a thorough scope of work before putting the project out to contractors for bidding.** Changes and modifications can be costly and delay the project.

- **Specify that the PV installation crew must be knowledgeable** about the work involved, in the solicitation for the construction contractor. The contractor's submission should include proof of experience. It is possible for workers to learn on the job and complete the installation efficiently, but it is preferred that they are experienced and prepared.
- **Have the contractor and subcontractors submit work plans that focus on solutions for minimizing disruption to building tenants during the project.** Planning ahead is crucial for avoiding pitfalls.
- **Clearly define 'minimal disruption' in discussions with property management staff, and in specifications and presentations to construction contractors and subcontractors prior to bidding.** The definition may affect the contractors' means and methods, price, schedule, work shifts, and other variables.
- **Get commitments from suppliers.** The standard solar industry procurement process uses a "solar integration" company that designs, procures and installs the PV system. As a result, solar suppliers generally will not communicate directly with the A/E regarding design, costs, lead times, etc. It may be necessary for GSA and the A/E to visit solar supplier manufacturing facilities together to gain commitments from suppliers, prior to completing 100% construction documents. In some cases, the supplier may require a fee from the construction contractor to "manage" the solar panel installation process in an oversight role, as a prerequisite to their commitment.
- **Anticipate delays in supplier shop drawings.** Solar companies might not commit to a schedule that includes shop drawings. Because they prefer to do their own layouts, regardless of what the A/E provides in the drawings, they may not provide the correct submittal information. During the bidding process, the project team needs to communicate clearly with the supplier about the project requirements, and include enough time in the schedule for shop drawing submission, revision and approval.
- **Allow ample time for product delivery.** Solar companies will not always commit to a schedule for manufacturing and delivery of panels at the time they bid on a project. Be sure to add an appropriate amount of time for panel fabrication and delivery into the project schedule. For example, at the Bean Center, solar companies would not provide delivery dates until after the contract was signed, and then they refused to commit on an actual delivery date until 30 days before delivery. Order additional panels at bid time to replace panels broken in shipment, because replacement panels are not rushed through manufacturing and it can take months to receive replacements.
- **Build in time for GSA IT equipment scanning requirements.** The A/E and contractor should be aware that GSA's Office of the Chief Information Officer (OCIO) requires scanning all equipment that will be connected to the GSA network. During the design phase, the A/E needs to understand exactly what equipment must be scanned by the OCIO and the time requirements involved.
- **Allow enough time for contractor's employees to obtain federal security clearances before beginning work.** This process can take months, so early planning is crucial.

- **Prepare for lobby display graphics early.** If a lobby or similar display will be part of the project, the design of the display screens should begin early in the project process.
- **Take into account cold weather considerations.** Installing solar panels in a cold climate can delay the schedule. Considerations include the safety issue of workers slipping on the roof, potential damage to the PV panels and roof, and potential work stoppages. Possible solutions include creating detailed work plans for solar panel installation in the event of snow and ice storms, and using a glycol system under blankets to melt thick ice. An R-50 roof does not allow the heat from below to melt snow or ice on the roof.
- **Take into account hot weather considerations.** Because of a project delay at the Calexico Border Station in California, the project had to be accomplished at the hottest time of the year, so the contractor did the work at night, when it was a bit cooler.

GOOD PRACTICES

- **Use the GSA Energy Center of Expertise for guidance in crafting the design and performance scope of work, and other technical aspects of the project.** This is new territory for most project managers and every project is unique.
- **Add external consultants to the team who are critical to the project's success.** These may be employees of the local utility company or state public utility commission, renewable energy developers or industry experts, renewable energy lawyers, and renewable energy experts at one of the national labs.
- **Request a project lead at GSA's Office of the Chief Information Officer (OCIO).** For the sake of efficiency, the project team should designate a point of contact to work with OCIO. The project team should also request a project lead at OCIO, so the team does not have to coordinate with multiple individuals about issues such as equipment scanning requirements, interconnection and net metering, and other IT requirements that may arise.
- **Educate building occupants in advance and during the project.** Before construction begins, the team should work with the property management staff to educate building occupants about the project plans, timing, and expected impacts, such as noise, smells, and parking issues. The project manager may issue progress reports and notification of anticipated smells or noise through the property manager via email or a newsletter.
- **Have the contractor and subcontractors submit work plans that address how they plan to work around potential weather issues.** For example, during re-roofing at the Bean Center, the contractor worked around rain days by working 12 hours every day it didn't rain, for a maximum of 14 days at a time. When installing solar panels there during the winter, the contractor worked overtime on weekends and developed a plan to remove snow off the roof and thaw ice buildup, to enable work to continue.
- **Require subcontractors to provide a full-time on-site safety manager when there are over 25 workers.** Request subcontractors to maintain direct communication with the GSA Safety & Health expert throughout the project. Additional good practices include having subcontractors conduct frequent safety training for employees and installing a safety railing

around the perimeter of the roof, in lieu of using tie-offs. Installing such a railing on the RSF building saved time.

- **Inspect the site frequently,** or designate a team member to do it. For example, the PV project manager for the Amalie Ron De Lugo Federal Building in the Virgin Islands was located in Newark, NJ. A local GSA project manager was designated to make site visits, which eased collaboration and saved time and cost.
- **Conduct educational meetings for the project team** to present mock-ups of critical parts of the project and to invite material manufacturers to describe details of equipment and products and how quality tests are performed.
- **Utilize the Department of Energy's (DOE) expertise.** Try to involve DOE in the project from the beginning of the design phase, to benefit from its technical knowledge and consulting experience. Furthermore, DOE has great industry relationships and can facilitate communication with solar suppliers.
- **Partner with other organizations.** One of the most innovative aspects of the Bean Federal Center project is the partnership with the DOE and Sandia National Laboratory. In addition to the main PV system, there are four smaller laboratory PV systems, each using a different photovoltaic material, construction or design. These small test labs don't generate much energy, but they do provide invaluable data for analyzing how different technologies perform in the Midwest climate.

SITE

LESSONS LEARNED

- **Evaluate the roof structure.** Conduct an engineering evaluation of the existing roof structure to make sure it is in good condition and can support the weight of new solar equipment. Such an analysis at the Bean Federal Center in Indiana determined that the PV panels should utilize light-weight framing and should be installed at a 5 degree angle.
- **Consider the roof's age and condition.** Ideally, a PV project would coincide with the installation of a new roof. When a new roof is not immediately necessary, the project team must weigh the cost and benefits of an early roof replacement versus installing PV on an existing roof. At the Bean Center in Indiana, for example, GSA could have kept portions of the existing roof for an additional five years, but eventually a costly removal and reinstallation of the PV system would be required when the roof was replaced, so roof replacement was part of the PV project.
- **Maintain a safe roof for emergency responders.** Carefully locate and label disconnection switches and energized runs of conduit line. This must be done for the protection of emergency responders, such as firemen. Involve GSA fire protection engineers, GSA safety and health experts, and the local authorities to facilitate this process.

- **Conduct studies of solar orientation and shading on roofs where panels may be located.** These studies will yield additional information for planning system capacity and avoiding performance issues.
- **Be aware of physical space limitations, especially on roofs of high-rise buildings.** Allow the contractor access to the building and staging areas, particularly in urban settings where there is limited area around the building for contractor's storage, staging, and material handling. Bringing in cranes and chutes can be expensive and complicated.
- **Recognize that locating PV projects on the ground represents new development of undeveloped land.** Make sure that adequate time is allowed to work with local entities, such as the planning commission.
- **For ground arrays, keep the lowest point at least two feet above ground level so any plant life or snow build-up will not shade the panels.** These considerations will be affected by the specific installation location and type of system.
- **Specify restoration of ground cover around PV installations.** Where PV systems were installed in open fields at the Denver Federal Center, contract specifications did not call for restoration of native grasses under and around the array, and tall weeds grew around the panels and shaded them until a landscaping crew was hired to cut them down and restore the grasses. Maintenance costs were incurred.
- **Coordinate the project with other work planned or in progress at the site.** Other projects may create competition for parking, staging, storage and utility work, and good communication between the project teams is necessary to avoid any conflicts.
- **Consult with GSA's Historic Preservation Specialist and Environmental Programs Expert.** Environmental and historic preservation considerations are generally addressed through the environmental assessment (EA) process, which should fulfill the statutory requirements imposed by the National Energy Policy Act (NEPA) on all federal and federally funded projects. It is important to note the findings from the EA process and ideally, to discuss them with regional historic preservation and environmental program experts. PV panels should be placed for optimal performance, while respecting sight lines and historical preservation constraints.

GOOD PRACTICES

- **When investigating possible locations for PV projects, give priority to geographic areas where they are most likely to be cost effective.** Locations with good solar resource, high electricity rates and attractive incentives such as rebates, production-based incentives, and valuable solar RECs are generally most attractive. Since system prices and state incentives have trended down recently, areas of excellent solar resource should also be a focus for investigation.
- **Consider the possibility of future high-rise construction in the vicinity of a planned PV project that could potentially shade a property.** Some states' laws allow filing of "solar easements or rights of way" to prevent a neighboring property owner from interfering with

the sunlight falling on one's own property. Such real property interests can be useful for protecting sunlight access for a solar system, which is usually a considerable investment that only pays for itself if it is producing energy.

INTERCONNECTION, NET METERING, OTHER UTILITY

LESSONS LEARNED

- **Recognize that electric utilities may have little experience with PV.** Some electrical utilities have little or no experience with the design and equipment requirements, scheduling priorities, or ICA associated with purchasing solar power. However, utility interconnection standards for PV are well-developed.
- **Utilities and political jurisdictions vary widely in their favorability to PV.** Policies, rules, and technical considerations can introduce considerable delay and uncertainty in project implementation.
- **Work with the utility company from the project start to understand its interconnection process and technical requirements, as well as its net metering regulations and other policies.** In many cases, their standard contracts will contain terms that federal agencies cannot agree to without modification. Contractors generally lack experience working with utilities on these matters and they and their subcontractors often will merely pass along to the agency any agreements from the utility company that require the building owner's signature.
- **Start negotiating the ICA between GSA and the utility company during the design phase,** because it could take several months to complete. Most utilities require an ICA before PV systems can be connected to the grid and operated. These agreements often contain provisions which can present challenging contracting barriers to federal government implementers, such as indemnification clauses, grants of rights of way, ownership of RECs, prices to be paid for excess generation, or other matters that may require legal approval prior to signing. Even with the full support of the utility company, it is very important to start working on the various agreements early enough so that the utility company lawyers and the government lawyers have enough time to agree on specific wording.
- **In determining the PV system capacity, consider the utility's policies about exporting power, in addition to the results of the system impact study.** In planning for a system that is expected to export power, based on the site electric load profile and tentative system size, first consult the utility's policies and the system impact study to aid in determining what the actual system capacity will be.
- **Consult the utility company during the design process to be sure the correct equipment is included in the contract documents.** For example, at the Cotter Federal Building in Connecticut, a new, smaller inverter had to be ordered because the original one was too large for the utility's capacity.
- **Some utilities require one line and wiring diagrams, and also site sketches showing proposed equipment locations.** During the design phase, the designer should work with the

construction contractor to lay out specific diagrammatic information that explains how the power generated by the PV system will feed into the building's power.

- **State or local rules or policies can constrain system capacity.** A net metering rule, for example, may state that systems must be 2MW in nameplate capacity or less to qualify for the net metering program.

GOOD PRACTICES

- **Identify a single point of contact at the utility company.** Working with one person who is knowledgeable about the PV project should ensure accountability and avoid delays and confusion.
- **During construction, invite the utility company contact to coordination meetings** in lieu of communicating via phone calls or email.
- **Fully engage the utility.** For the Simon Building project in Illinois, the local utility was engaged and specifically involved in the joint design, development and commissioning of the interconnection and other utility-specific project components. This action enabled the team to avoid the delays and extra costs that would have been incurred if the completed system failed to meet the interconnection requirements of the local utility company.
- **Have agency lawyers and contracting officials review the interconnection agreement** and consult the GSA Energy Center of Expertise if there are concerns regarding ICA terms and conditions.

TECHNICAL

LESSONS LEARNED

- **Sizing and location of arrays is a primary design consideration.** Related design and installation considerations include setbacks from roof perimeters, angles of orientation, use of tracking or fixed arrays, access for firefighters, approach to monitoring for solar panel failure, tying into the electrical system, and metering and monitoring of generation output.
- **Protect the roof.** Coordinate closely with roofing contractors and installers so that roofing membrane warranties are not voided by putting solar equipment on the roof. Steps should be taken to protect the roof at all times.
- **Monitor roof installation and understand potential issues.** At the CMS HQ Complex in Maryland, the roof coating produced significant odors that disrupted tenants, and an extensive area of the coating delaminated due to improper preparation of the roof surface. Using a full-time roofing inspector is a good idea.
- **Pre-planning for technical details is important.** Do not leave any technical details unresolved until the project is in progress. At the Federal Courthouse in Davenport, Iowa, for example, trying to find an interior route to run the utility lines from the roof down to the location of the disconnect box at ground level was an unexpected challenge.

- **Know fire safety requirements.** If a PV system is installed without meeting fire safety requirements, there could be an additional cost for bringing it into compliance. At some of the buildings in the Southwest Region, each system needed multiple disconnects to meet the requirements outlined by GSA fire protection engineers. See Appendix G: GSA Fire Safety Guideline for Photovoltaic System Installations.
- **Anticipate solar product upgrades and pricing changes.** Due to frequent changes in PV technology, types of solar panels and pricing change quickly, and the solar suppliers may fail to notify PV project teams of these changes. Newer panels may be more efficient but also more expensive. During the design phase, the A/E should discuss this with the supplier and find out when the panels will be upgraded.
- **Obtain warranty information from solar product suppliers.** Solar product suppliers may not be forthcoming regarding warranty information, and in one project, the supplier initially refused to provide the A/E with required warranties. Understanding the details of the warranty is crucial.
- **Solar panel suppliers are reluctant to reveal their quality control procedures.** The solar panel suppliers may not want the PV project team to visit their manufacturing site and review their quality control procedures, due to proprietary concerns. Possible solutions include having the A/E include this requirement in the project specification, and/or having GSA and the A/E visit the solar manufacturing site during the design phase, to determine whether the solar supplier will be invited to bid on the project.
- **Solar panels should be kept clean and checked regularly for damage.** Extra attention to cleaning may be needed during bird migratory periods and after severe weather events. Periodic inspections should be conducted, especially after snow, hail or wind storms.
- **Engineers and system designers should confirm the solar panel and system wind uplift ratings, giving consideration to the climate where they will be installed.** This is crucial in areas of the country that are subject to high winds from tornados or hurricanes.
- **The SOW for the O&M contractor should include, at a minimum:**
    - Annual sweeps of the strings through I-V curve tracing, providing the data back to the owner.
    - Thermal imaging of all electrical connections.
    - Panel cleaning.
    - Inverter inspections and diagnostics.
    - Metering and monitoring (shared between the owner and the O&M contractor).
    - Filter cleaning for inverters equipped with cooling fans.
    - System repairs.

GOOD PRACTICES

- **Install advanced metering to monitor PV system performance.** For larger PV systems, it is advisable to specify a diagnostics system which will automatically alert the system manager if there is a problem with the system. On very large systems, it is advisable to establish monitoring capability down to the string level, or at least to the combiner box level. These additional systems can usually be justified by less down time and reduced O&M labor hours.
- **Conduct continual commissioning.** The specification for the photovoltaic system at the Simon Building in Carbondale, Illinois required a Data Analysis System, including a DSL service line and initial one year basic service contract. Without this system, it would be difficult to determine when a fault develops in a particular photovoltaic panel.
- **Specify an extended warranty.** The specification for the PV system at the Simon Building in Carbondale, Illinois required that, at a minimum, a three-year initial operations and maintenance service agreement be included in the contract. The O&M agreement covered all solar array equipment, inverters and other components needed to maintain total system operation. The government reserved the right to extend the O&M agreement beyond the initial three years. This action should be recognized as a best practice because remote locations such as Carbondale, Illinois are not likely to have an abundant supply of maintenance workers skilled in photovoltaic systems.
- **Specify a Long-Term Guarantee.** The specification for the PV system at the Simon Building in Carbondale required a warranty which provided that the system would continue to be capable of meeting a minimum of 80% of the intended DC output/ capacity for a period of no less than 20 years. This action is a good practice because GSA would want the photovoltaic system to last as long as the roof it is installed on.
- **Provide a leak detection system.** The specification should require a leak detection system, such as an Electric Field Vector Mapping (EFVM) system, to ensure that the roof is 100% water tight. This type of system identifies the precise location of leaks without destructive testing of installed materials. It may be employed while the roofing subcontractor is still on site for the PV installation, or anytime afterward.
- **Have a good temporary roof plan.** Consider whether the A/E should specify and detail the temporary roof approach or whether it should be left to the roofing subcontractor's means and methods. Require the roofing subcontractors to submit a detailed description of a temporary roof approach with their bids. Ensure there is a detailed plan in place for covering all open roof areas in case of a surprise storm. Be sure the amount of temporary roof area is minimized at all times to mitigate leaks into the building during construction.

ECONOMIC

LESSONS LEARNED

- **Examine all project funding alternatives.** If appropriations are not available for a desired PV project, project funding vehicles such as ESPCs, UESCs, or PPAs should be explored as alternatives. They offer a number of benefits, such as absence of requirement for upfront capital, predictable energy pricing, and mitigation of O&M risk for the agency.

- **Understand the utility rates early in the process.** Opportunities and limitations presented by the local utility rate structure may significantly impact the financial viability of the project. For example, at the Bean Federal Center in Indiana, GSA was able to take advantage of the utility's Renewable Energy Production rate, which allowed GSA to sell solar generated electricity to the utility, provided GSA also sold Renewable Energy Credits (REC) to the utility. As a result, the building's electric costs are among the lowest in the country.
- **Consider registering the project as a Qualified Facility with the Federal Energy Regulatory Commission (FERC).** A Qualified Facility may sell energy to the utility company at either the utility company's avoided (wholesale) cost or at a negotiated rate, and may also purchase additional services from the utility company, such as back-up power. This is a good strategy for larger systems, up to 80 MW, that generate more energy than the host site consumes at any given time, and that are too large to be eligible for the utility's net metering program. Registration as a qualifying facility is actually an exemption from burdensome FERC reporting requirements (similar or equivalent to those imposed on public electric utilities) that are otherwise required for all exporting generators connected to the grid. GSA registered the Simon Building in Illinois as a Qualified Facility to avoid restrictions under the utility's net metering policy.
- **Ensure that construction contractor has 100% final construction documents.** Work that is not designed needs an adequate allowance.
- **In determining whether double shifts or night work is best for the project, realize that this is more expensive than daytime work.** Project management and construction staff will be needed to manage extra shifts.
- **Consider budgeting for the construction contractor to provide personnel with federal security clearances and badges to escort subcontractor workforce,** in case of delays in obtaining GSA security clearances.
- **Successful life cycle management of solar photovoltaic systems starts by establishing and clarifying the internal and external O&M responsibilities.** Successful PV investments are not simply the result of hiring a contractor to perform O&M and then expecting the system to deliver a return on investment over the next 25 years.

GOOD PRACTICES

- **Research all available incentives, rebates and special rates.** Taking advantage of special rates, rebates, and incentives offered by the private sector is crucial for providing taxpayers with the greatest return on investment for capital intensive renewable energy projects. With third-party ownership approaches, such as PPAs, the owner/contractor may be able to take advantage of investment tax credits, accelerated depreciation, and other available incentives, potentially passing those benefits on in the form of lower pricing for the site.

- **The project manager and construction contractor should review costs together on a weekly basis, to avoid escalation.** Track all costs and planned expenditures, to avoid surprises.
- **Capture data about system performance in a GSA database and perform a comparative analysis against the previous baseline each time an annual or biannual baseline/I-V curve trace is performed.** This is essential to successfully managing the warranty and tracking performance of system components, specifically the panels.
- **Consider using a contracting venue such as a power purchase agreement (PPA), in which case the system's performance rests on the shoulders of the PV contractor.** In order to protect their investments, contractors will perform life cycle management functions themselves because, after all, they only get paid for the energy that they deliver, so it's in their best interest.

APPENDIX G: GSA FIRE SAFETY GUIDELINE FOR PHOTOVOLTAIC SYSTEM INSTALLATIONS

PURPOSE

The intent of this guideline is to provide information necessary to ensure safety at GSA federal buildings equipped with photovoltaic systems.

SCOPE

This guideline is applicable to all photovoltaic systems, regardless of size, for GSA federal buildings.

DEFINITIONS

Array: Any number of photovoltaic modules connected together to provide a single electrical output.

Inverter: Devices that convert DC electricity (single or multiphase), either for standalone systems (not connected to the grid) or for utility-interactive systems, from solar power to the AC electricity for use in the building's electrical system or the grid, or both.

Photovoltaic (PV) System: The total components and subsystems that, in combination, convert solar energy into electric energy suitable for connection to utilization load.

BACKGROUND

The installation of PV systems presents concerns for safety (energized equipment, trip hazards, etc.) and fire fighting operations (restricting venting locations, limiting walking surfaces on roof structures, etc.). This guideline addresses these issues while embracing the environmental advantages of this technology.

ROLES AND RESPONSIBILITIES

GSA PROJECT MANAGER

- Prior to the PV system installation, the GSA Project Manager shall coordinate a meeting with the Contractor, GSA Property Manager, GSA Fire Protection Engineer, GSA Safety Specialist, and local fire official to ensure the proposed PV system design and layout is acceptable to all parties.
- Prior to the acceptance of the PV system, the GSA Project Manager shall confirm that the PV system has been tested. All testing shall be witnessed and documented by a qualified independent third party test entity.

THIRD PARTY TEST ENTITY

- The third party test entity shall have an advanced understanding of the installation, operation, and maintenance of the PV system installed. Third party test entities shall be licensed (certified) where required by applicable codes and standards.

- At completion of witnessing the PV system testing, the third party test entity shall provide to the GSA Project Manager documentation verifying that the PV system is in compliance with the design and specifications and all applicable codes and standards.

REQUIREMENTS

The installation of PV systems at GSA federal buildings shall comply with the requirements in the International Building Code and National Fire Protection Association (NFPA) 70, National Electrical Code, and the following requirements:

A. **Marking**. PV systems shall be marked in accordance with NFPA 70, Article 690, and the following:

1) **Direct Current (DC) Circuits**. All interior and exterior DC conduits, raceways, enclosures, cable assemblies, and junction boxes associated with the PV system shall be marked to alert individuals that DC power is present. The marking shall be placed every ten (10) feet or fraction thereof, at turns and above and below penetrations, and on all DC combiner and junction boxes.

a) **Content.** The marking shall contain the text **"CAUTION: PV CIRCUIT ENERGIZED"** in capital letters a minimum of 3/8 inches in height with white letters on a red background. The materials used for marking shall be reflective and weather resistant in accordance with UL 969 that is suitable for the environment.

2) **Stairway access to roofs**. Signage is required on all stairway doors providing access to the roof where PV systems are installed. Each stairway door providing access to the roof shall have a sign affixed to the interior side of the stairway door.

a) **Content**. The signage shall contain the text **"CAUTION PHOTOVOLTAIC SYSTEM INSTALLED ON ROOF".** The sign shall consist of letters having a principal stroke of not less than ¾ inch wide and be at least six (6) inches high on a contrasting background.

B. **Fire Department Access, Pathways, and Smoke Ventilation**. Access and spacing requirements shall be maintained and provided in order to ensure the following is provided on roofs with PV systems:

1) **Access**. There shall be a minimum six (6) foot wide clear perimeter around the edges of the roof.

Exception: If either axis of the building is 250 feet or less, there shall be a minimum four (4) feet wide clear perimeter around the edges of the roof.

2) **Ground Ladder Access.** In low-rise buildings, ground ladder roof access shall correspond with roof pathways and shall not be located over an opening (i.e., windows or doors). Ground ladder access points shall be located at strong points of the building construction and not in conflict with overhead obstructions (i.e., tree limbs, wires or signs).

3) **Pathways.** The PV system shall be designed such that designated pathways are provided on the roof. The pathways shall meet the following requirements:

a) The pathway shall be located over structural roof members.

b) The center line axis pathways shall be provided in both axes of the roof. The center line axis pathways shall be located on structural members or located on the next closest structural member nearest to the center lines of the roof.

c) Each pathway shall be a straight line and not less than four (4) feet in clear width to skylights and/or ventilation hatches.

d) Each pathway shall be a straight line and not less than four (4) feet in clear width to each roof standpipe outlet.

e) Each pathway shall provide not less than four (4) feet clear width around each roof access hatch with at least one pathway not having less than a four (4) feet clear width to the parapet or roof edge.

4) **Smoke Ventilation.** The PV system shall be designed such that smoke ventilation opportunity areas are provided on the roof and meet the following requirements:

a) Each array shall be no greater than 150 x 150 feet in distance in either axis.

b) Ventilation options between array sections shall meet one of the following:

(1) A pathway eight (8) feet or greater in width;

(2) A pathway four (4) feet or greater in width that borders on existing roof skylights or ventilation hatches; or

(3) a pathway four (4) feet or greater in width bordering 4' x 8' "venting cutouts" every 20 feet on alternating sides of the pathway.

C. **Location of DC Conductors**. Exposed conduit, wiring systems and raceways for PV circuits shall be located as close as possible to the ridge or hip or valley on the roof to reduce trip hazards and maximize ventilation opportunities.

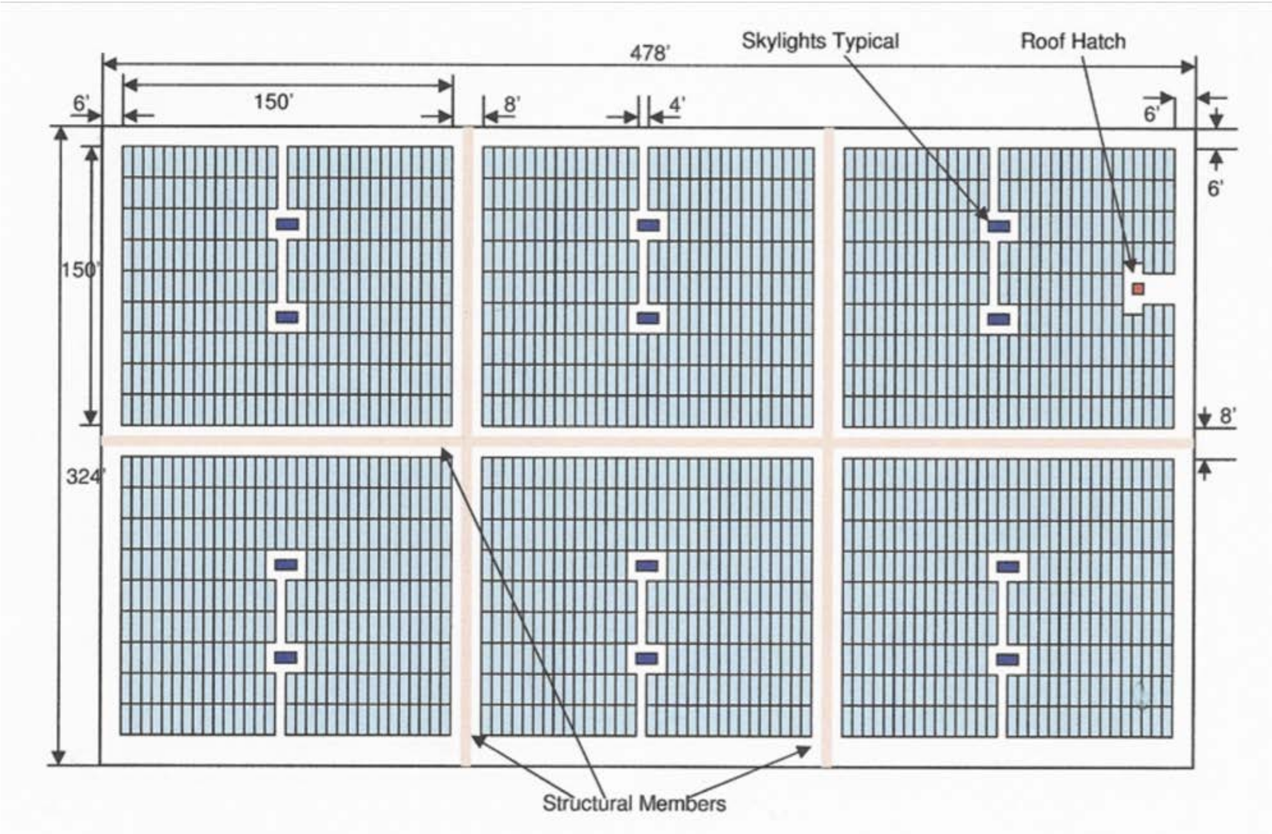
Conduit runs between sub-arrays and conduit runs to DC combiner boxes shall be designed in a manner that minimizes total amount of conduit on the roof. The DC combiner boxes shall be located such that conduit runs are minimized in the pathways between arrays.

To limit the hazard of cutting live conduit in fire department venting operations, DC wiring shall be run in metallic conduit or raceways when located within enclosed spaces in a building and shall be run, to the maximum extent possible, along the bottom load-bearing members.

D. **Ground mounted PV arrays**. Ground mounted PV arrays shall also comply with the above applicable requirements. Setback requirements do not apply to ground-mounted, free standing PV arrays, however, a clear brush area of ten (10) feet on all sides is required for ground mounted PV arrays.

E. **PV Array Example**

Large Commercial Building (Axis > 250 ft) 8 ft Walkways

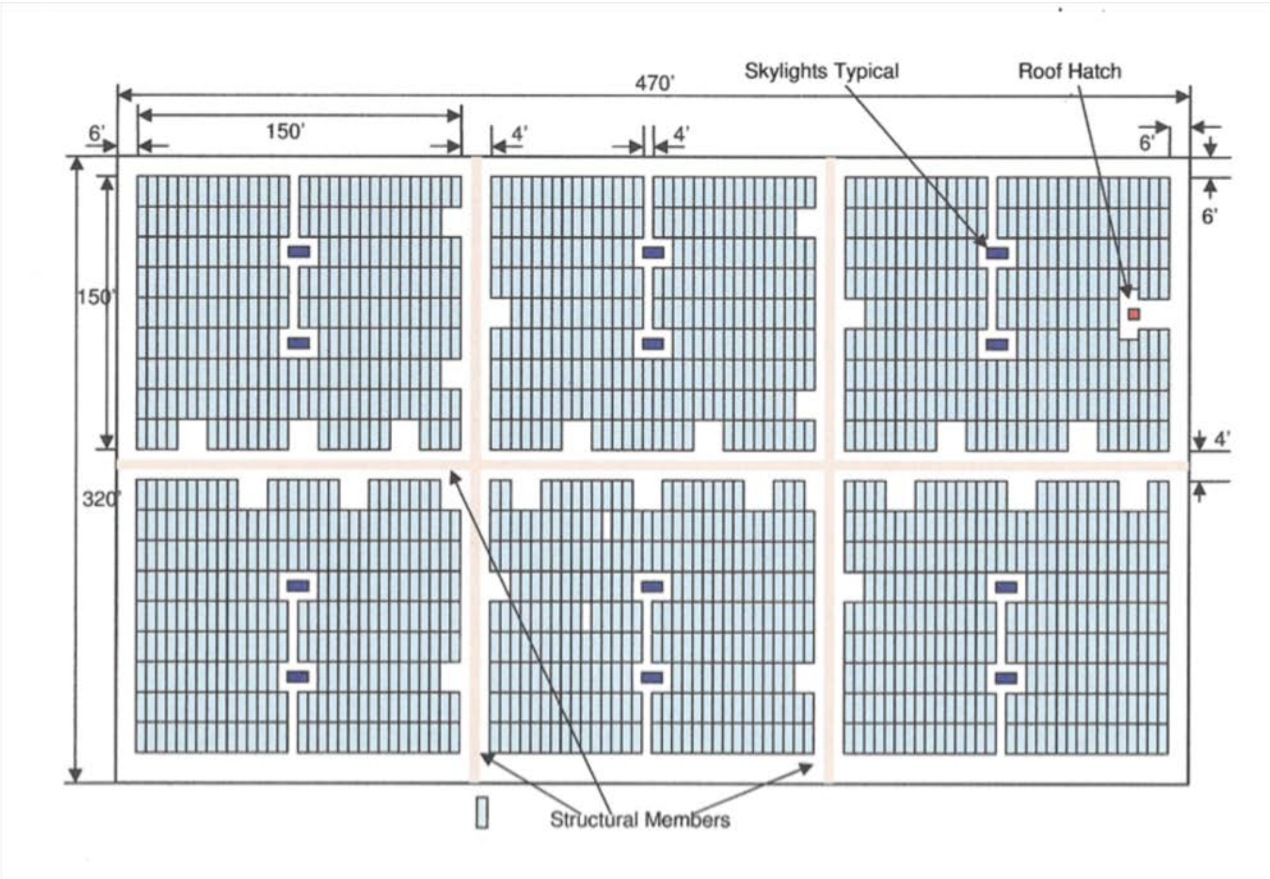


PV Array Example

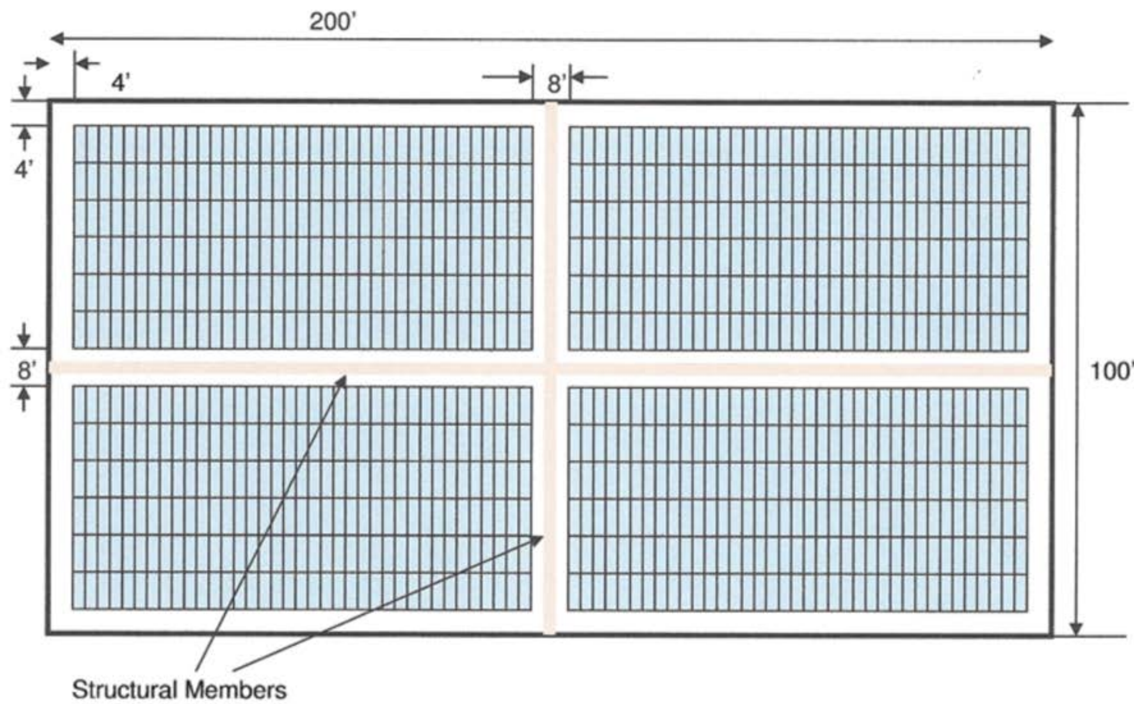
Large Commercial Building (Axis > 250 ft)

4 ft Walkways

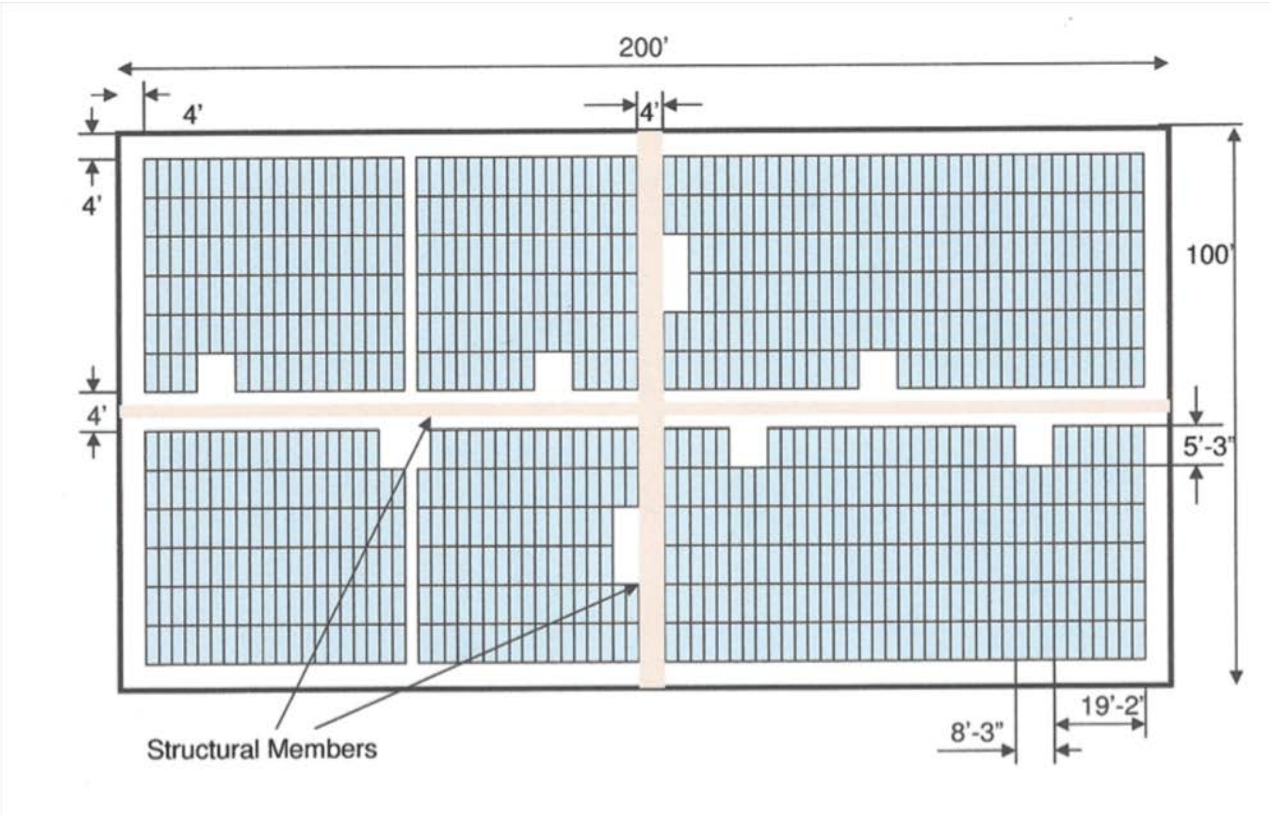
8 ft x 4 ft Venting Opportunities Every 20 ft Along Walkway



PV Array Example
Small Commercial Building (Axis < 250 ft)
8 ft Walkways



PV Array Example
Small Commercial Building (Axis < 250 ft)
4 ft Walkways
8 ft x 4 ft Venting Opportunities Every 20 ft Along Walkway



Office of Energy and Environment (PMAB)
Fire Protection & Life Safety Program

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